Individual differences in affective, cognitive, and neural responses to interpersonal and social motivation: Novel methodological perspectives

Maria Stavrou

Supervisors
Prof. Alan Pickering
Dr. Andrew Cooper

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Declaration

Declaration of Authorship
I, Maria Stavrou, hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

Signed: ______________________

Date: 04 / 01 / 2022

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Dedication

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Abstract

Research in this thesis manipulated approach motivation via social / interpersonal incentives, to measure the effects on mood and learning of social perceptions via neural, behavioural and psychometric measures, while also interrogating how these effects might be moderated by personality. Two initial studies explored whether motivational videos work as appetitive mood inductions by inducing activated affect. These studies also tested an online line bisection task as an index of left frontal activation, which putatively represents approach motivation and activated affect. On average, compared with control videos, motivational videos induced changes specific to activated affect without inducing changes in pleasant affect. However, there was considerable heterogeneity across participants in the induced mood changes, but without clear-cut relationships between these changes and personality (extraversion, neuroticism, and conscientiousness were tested as possible moderators). Line bisection was not affected by motivational videos relative to control videos. The third study replaced line bisection with an EEG measure of approach motivation (i.e., frontal alpha asymmetry, FAA). Measuring EEG itself was likely mood altering and complicated the pattern of mood changes observed. The expected mood induction effects were not found, although FAA did unexpectedly increase significantly after watching the control video. The final two studies evaluated probabilistic reinforcement learning in a social context via a novel artificial social interaction (ASI) task using on-screen faces of characters who varied in the amount of social reward (smiles) they gave. The reinforcing characters who smiled more throughout the ASI were rated as more likely to be befriended, more likeable, more extraverted, more agreeable, and less neurotic than the non-reinforcing characters who smiled less. These studies also showed that the participants extraversion, neuroticism, agreeableness, and autistic traits significantly moderated the character reinforcement effects on the social-perception measures listed above. The methods used throughout this thesis show that considerable promise and solid foundations now exist for future developments in both areas of research.

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Chapter 1

Introduction

Ranging from a simple smile, to likes and comments for personal content on social media platforms, social rewards are one of the most prominent, intangible type of reward in many aspects of human interaction, be it in person or virtual. With the onset of a technological revolution an increase in forms of social incentives has emerged, and become embedded into daily life, as well as in academic and industrial research. The dawn of this technological advancement also allowed for the inception of a role for individual differences in data acquisition and interpretation. This has been led by the drive for the technology industry to benefit from collecting big data. Examples include personality research in Facebook use (e.g., Facebook personality research; Moore & McElroy, 2012; Ross et al., 2009; Sindermann, Duke, & Montag, 2020), and online behaviours exposed by other social media platforms and their influence, such as Facebook likes (Kosinski et al., 2013), Tweets (Golbeck et al., 2011), Instagram pictures (Segalin et al., 2017), and click-through rates (Matz et al., 2017). Field studies by Matz et al. (2017) used psychologically tailored advertising, reaching over 3.5 million individuals, to test the effects of psychological persuasion on people's behaviour in an ecologically valid setting. They found that matching the content of persuasive appeals to individuals' personality significantly altered their behaviour in terms of click-through rates and purchases. Such research highlights the importance of adapting the way the effects of virtual and/or technological social rewards are measured. It also raises questions over what the outcome might be for those with aberrant social reward processing in an ever-rising interactive world. This thesis, therefore, includes a series of new studies that utilise innovative methods to measure the effects of social and interpersonal incentives and how these effects are moderated by individual differences, with a focus on the personality trait of extraversion in particular.

1.1 The dimensions of motivation

Prior to specifying the role of social reward processing and incentives in this thesis, it is fitting to first define the dimensions of motivation and reward processing, and which of its facets relate to the mechanisms likely to be at play in the series of experiments reported. It also needs to be noted at this point that much of our daily life is driven by the prospects of rewards, therefore it is informative to address the classical distinction between primary and secondary rewards. Primary rewards (e.g., food, sex, shelter) have an innate value and are essential for the maintenance of homeostasis and for the reproduction of an organism. Secondary rewards are not directly related to survival but gain value through learned association with lower-level (i.e., primary) rewards (Schultz, 2000; Sescousse et al., 2013). It is tempting to speculate that probable evolutionary differences in these types of rewards may mean that they are phylogenetically distinct and processed in partly differing brain regions (Knutson & Bossaerts, 2007). However, much of the animal research provides evidence for a centralized reward processing system in the brain. Core brain regions that are traditionally considered to play a role in reward processing are the ventral striatum (VS), ventral tegmental area (VTA), nucleus accumbens (NAcc), amygdala, anterior cingulate cortex (ACC), and ventromedial prefrontal cortex (PFC), as well as the orbitofrontal cortex (OFC; Berridge, 2003; Hikosaka et al., 2008; Kable & Glimcher, 2009; Knutson et al., 2001; Satterthwaite et al., 2007; Schultz, 2006; for a meta-analysis see Bartra et al., 2013). The validity and generalisability of the studies that measure discrepancies between the brain activity involved in primary and secondary reward processing goes beyond the scope of this thesis. Nevertheless, it is evident from the definition of secondary rewards that social rewards often fall within this category (Spreckelmeyer et al., 2009).

The term "reward processing" is an umbrella term for an array of features of appetitively motivated behaviour, and the term is often used interchangeably with reinforcement, primary appetitive motivation or hedonia (for a discussion see Cannon & Bseikri, 2004; Salamone & Correa, 2012). This array of features can also reflect the different phases (i.e., the reward cycle) in which motivated behaviour occurs. Motivated behaviour has both directional and phasic dimensions (Salamone & Correa, 2012). Behaviour is directed towards a desired goal or stimulus, or it is used to withdraw from, or avoid, an aversive stimulus. Initially there is an activation component, in which the organism experiences appetitive desire or "wanting" for the reward and works to obtain the desired goal or stimulus. As there is typically some physical or psychological distance between the organism and the reward, some level of effort is usually required to obtain the reward. Thus, the organism may need to plan and execute a type of behaviour at the necessary level to procure the goal or stimulus. This phase involves some overlap between the psychological elements of wanting or valuing the reward and the physical requirements necessary to obtain the reward (e.g., motor control and energy).

Finally, there will be the consummation of the reward; the organism obtains the reward and, in turn, experiences the outcome of this reward (e.g., satiety if the reward was food, or feeling satisfied after receiving positive interpersonal feedback; Rømer Thomsen et al., 2015; Furl et al., 2012). Throughout the reward cycle, the organism will also learn something about the reward or reward process. For example, considering the value of the reward and the relative effort they expended to obtain it, organisms are likely to modulate the degree of learned association they form between a given stimulus cue plus action combination and the particular reward outcome (e.g., Duke et al., 2018). This learning will inform their future reward-related behaviour and behavioural decision making when they encounter similar situations and/or possible rewards.

As highlighted in Figure 1.1, a variety of terms are associated with these disparate phases of reward processing: the initial stage may be termed “appetitive”, “approach”, “seeking” “anticipatory”, “instrumental” or “wanting”. Effort expenditure or willingness to work for the reward, is typically encompassed in this initial approach stage, the aim of which is to increase the likelihood of obtaining the reward. The second phase sees completion of reward-seeking and is usually referred to as the “consummatory” or “liking” phase. Finally, the third stage is considered “satiation” or “learning” (Berridge et al., 2009).

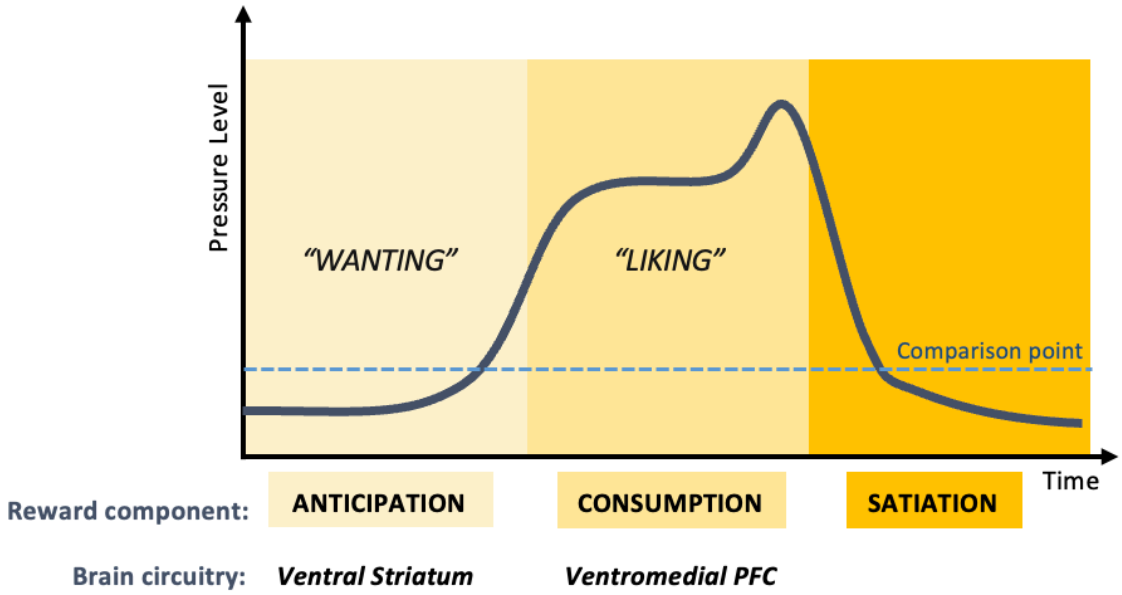


Figure 1.1: Adapted from Kohls et al. (2012), this figure outlines the reward cycle in a temporal dimension and in terms of hedonia. The initial phase of reward is characterised by wanting a reward and represents the anticipation component, which also encompasses behaviours that are motivated toward the reward. The next phase of the cycle focusses on what occurs once the reward has been acquired; the consumption of the reward, which is characterised by liking or enjoyment of the reward. Behaviours during this phase are focused on consuming, absorbing, and enjoying the reward (depending on what type of reward it is). The final phase of the reward cycle, satiation, is related to learning. Here, a healthy organism learns the value associated with the obtained reward, which will inform subsequent cycles of reward processing in similar environments (including related behaviours and decision making).

This thesis will focus on the initial stage of approach and the learning component of reward processes and motivation, specific to social and interpersonal incentives, and rewarding virtual environments. This series of experiments uses different methodological approaches to address the two facets of motivated behaviour, as well as using a combination of complementary theories adopting a wholistic theoretical approach to the underlying factors that can be accounted for. Specifically, there are two key themes running along the spine of this thesis, which will be addressed throughout the entirety of this literature review. The first of which, approach motivation, utilizes a newly considered appetitive mood induction procedure, one that involves interpersonal incentives thought to induce approach motivation and provide the affective arousal needed to prepare for the acquisition of a goal. The second theme concerns reinforcement learning and how computerised interpersonal interactions with probabilistic rewarding feedback can influence learned perceptions of characters.

1.2 Introducing motivational videos as an appetitive mood induction

Beginning with the first theme of the thesis, motivational videos are presented as a recently created and deployed source of induction of appetitive motivation. There are approximately 68 million search results for motivational videos (Google.com), to date, on online platforms like YouTube, indicating how widely the art of motivational speaking is being embraced by masses of online users. This trend may have arisen in parallel with the contemporary increases in online access and internet use, but nevertheless is a trend moving steadily upward (Gonzalez et al., 2011). These videos usually involve a speaker, often one who is deemed inspirational, talking to a group of people or directly to a camera about ways in which their audience can enhance their life (e.g., success, fitness, health, happiness etc.). This is likely to include activating language, gestures, visual scenes, and music. There is some anecdotal evidence to suggest that these videos work (for example, on physical performance; Damali, 2014), perhaps by uplifting the viewers' mood due to inducing approach motivation. However, to date, very little research has been conducted to validate these effects and, if they do occur, to investigate possible mechanisms by which they operate. One possible account, explored in more detail below, is the notion that motivational videos are a source of an appetitive mood induction and emphasising rewarding incentives, though there is no empirical evidence testing this idea. Considering Berridge's account above, an assumption in this thesis is that motivational videos present desirable goals to the viewer, hence activating the initial "wanting" phase of motivational behaviour.

To highlight people's generalised intrinsic sensitivity to rewarding situations, researchers in the past have set out to show that states of approach motivation and activated affect (e.g., feelings of arousal) are not only induced by the objective presence of reward stimuli, but even by the mere mental imagery of a rewarding situation (Smillie et al., 2012). In order to achieve this activated state, experimental approaches have often tested the effectiveness of appetitive mood induction procedures through vignettes, guided imagery, and reflection on one's life events (e.g. Gomez et al., 2000; Helmers et al., 1997; Larsen & Ketelaar, 1989; 1991; Smillie et al., 2012). Additionally, mood induction studies over the years have developed optimization strategies to enhance the induction of the targeted state, namely by playing mood-congruent music during the induction process. For example, the Mazurka from "Coppelia" by Delibes is widely used for a positive mood induction (e.g., Smillie et al., 2012;

Westermann et al., 1996). Considering the characteristics of motivational videos described above, it therefore seems reasonable to suggest that motivational videos are analogous to such appetitive mood induction procedures and may generate similar effects.

There is a small amount of research that has that has been conducted on motivational speeches (in the context of videos). This has mostly measured the effects that these measures have on sporting performance, and by using a loose theoretical basis involving inspiration and social psychological concepts, such as self-efficacy (e.g., Vargas- Tonsing & Bartholomew, 2006). Such research has resulted in the conceptual differentiation between inspiration and motivation (Roberts, 2001). The elusive definition of inspiration derives from the subjectivity of the concept, however it is though of as being an evoked sense of energy from a source that implies motivation. Motivation, however, involves the regulation, direction, and approach directly behind one's behaviour (Roberts, 2001). Owing to its long tradition of theory, research, and data on which we can draw, motivation can be considered a more tangible construct than inspiration.

Considering this generalised definition of motivation and approach behaviour, one can analyse the role of rewards within this internal process. In Ryan and Deci's account of the taxonomy of motivation, extrinsic motivation occurs due to a separate external outcome (i.e., a tangible reward), while intrinsic motivation involves inherent pleasure associated with an activity without a tangible reward (Ryan & Deci, 2000). However, external motivation can become internalised through learned behaviours from an initial, external regulation of reward, where behaviour is conducted to achieve a particular end, such as positive social feedback (sometimes in a token form, such as a trophy in sport settings) or monetary rewards. Similarly, external regulation can occur through risk aversion to avoid negative outcomes of behaviour. Theoretically, this external regulation then goes through a process of internalisation by learned associations of behaviour and its outcomes, and reaches the final stage of integrated regulation, which is experienced when an individual begins to make decisions because they find internal value in the external demands of the activity (Ryan & Deci, 2000). A study using psychometric measure as an indication of integrated regulation found that a scores of integrated regulation items predicted exercise behaviour (i.e., willingness to exercise) and levels of physical self-worth (Wilson et al., 2006).

We are specifically interested in the rewarding effects of extrinsic goals in a social context, which are somewhat tangible but do depend on the contingent reaction of another person and are considered to be a means to another end. General examples of extrinsic goals are acquiring financial success (money) or social recognition, or an appealing appearance, each of which may result in positive social feedback (Kasser & Ryan 1996). These goals seem much like the ones that are likely to be pursued by people who watch motivational videos. In these videos specific statements often address exactly these sorts of goals (e.g., "*whatever it is that you decide you want to make come true in your life, you can do that", "you've got to develop your skill set"*). Such extrinsic goals can be likened, by definition, to examples of secondary rewards (Bhanji & Delgado, 2014; Izuma et al., 2008; Lin et al., 2012; Spreckelmeyer et al., 2009). Conversely, intrinsic motivation or goals pertains to activities or behaviour executed for the inherent interest and/or enjoyment of the individual (Deci & Ryan, 2000). Motivational videos rarely refer directly to intrinsic motivation or inherent interest, and so we consider the appeal to extrinsic motivation as one of their key features.

Vallerand (1997; 2001) considered the reinforcing effects of extrinsic and intrinsic motivation and developed a hierarchical model (the hierarchical model of intrinsic and extrinsic motivation; HMIEM) with three levels; global, contextual and situational motivation. Global motivation is the most generalized form of motivation, spanning across a wide time period, while contextual motivation refers to motivation in specific contexts. Then, there is the most specific form of motivation, situational motivation. This is the most relevant with regard to reward effects, as it describes motivation that is directed towards a goal at that particular moment in time (Vallerand, 2002). The HMIEM proposes that a state of motivation can also be fostered by a social environment, through adequate reward-rich feedback and initiative-promoting speech (Mageau & Vallerand, 2003), much like the approaches taken in online motivational videos. A central assumption made in this thesis is that the interpersonal aspects of the motivational speaker (e.g., eye contact, and personally-directed speech; Kennis et al., 2013) and the goal-directed content of the language used (Smillie et al., 2012) work to socially incentivise the rewards being pursued by the viewer, in turn endorsing situational motivation (Vallerand, 2002) and subsequently increasing activated affect (Smillie et al., 2012).

While we appreciate the implications of more social accounts of motivation like those described above, combining them with neurobiological accounts of approach motivation, appetitive inductions, and rewarding stimuli, should bring a more comprehensive understanding of the effects of motivational videos.

1.2.1 The Reinforcement Sensitivity Theory and appetitive motivation

Within biologically-inspired theories of reward processing and learning, such as the Reinforcement Sensitivity Theory (RST; Pickering et al., 1995; Smillie et al., 2006), the term ‘appetitive motivation’ (often used interchangeably with ‘approach motivation’) is described as energizing approach behaviour, with an accompanying state of activated affect (e.g., feelings of alertness; Davidson et al., 1990; Smillie et al., 2012). Appetitive motivation occurs when the prospect of rewarding stimuli triggers the activation of the dopaminergic system and other subcortical areas that respond to reward cues and/or are involved in associative learning (for a review, see Hikosaka et al., 2008).

Interpersonal social rewards can be broadly defined as positive experiences with other people (Bhanji and Delgado, 2014). Social reward stimuli include happy face expressions, and even online positive social feedback (e.g., number of Facebook likes; Marengo, Poletti, & Settani, 2020). Animal studies suggest that social interaction is naturally rewarding itself (Insel, 2003). By using a combination of neuroimaging, eye-tracking, and behavioural tasks, the mesocorticolimbic reward circuits have been shown to be active in humans when they are interacting with one another (e.g., during eye-gaze social behaviour; Pfeiffer et al., 2014).

Altered neural responses to social incentives have been linked to interpersonal motivational deficits. Individuals with low social proficiency (Gossen et al., 2014), schizophrenia (Hanewold et al., 2017; Strauss et., 2014), autism (Kohls et al., 2013), or social anxiety disorder (Richey et al., 2014) all showed reduced engagement of the striatum, particularly the NAcc, when presented with social reward stimuli in fMRI studies. A neuroimaging study of mood disorders also found reduced bilateral 3T BOLD fMRI activation of the VS in response to social rewards (e.g., facial affective feedback expressing either happy or angry expression in response to subjects guessing correctly or not) in patients with bipolar depression (Sharma et al., 2016). With clinical deficits forming one end of the spectrum, these findings point towards a range of individual differences in the neural sensitivity to social rewards. In fact, one might go as far as to say that if one believes there are individual differences in sensitivity to rewards in general (see below), there is no reason to suppose that similar individual differences might not map onto social reward sensitivity as well. As personality dispositions can potentially increase the reinforcing value of social incentives, engaging in social interactions might well be experienced as more rewarding for those with a heightened inclination to seek social rewards (Buss, 1983).

In Gray's (1970, 1990) biopsychological theory of personality, now usually termed Reinforcement Sensitivity Theory (RST; Pickering et al., 1995; Smillie et al., 2006), a specific neurobiological emotional system, the Behavioural Activation System (BAS) underlies the sensitivity to, pursuit of, and strength of response to rewards. The BAS underlies approach motivation and guides responses to stimuli such as smiling faces and upcoming rewards (Kennis et al., 2013). The BAS has, therefore, been conceptualized as a stimulus-sensitive, motivational system, and has been argued to underpin some of the variation in the trait of extraversion (Eysenck, 1990; Smillie et al., 2006). The activation of approach behaviour to rewards is then likely to contribute to positive affective states (Smillie et al., 2012). Along these lines, individuals with a highly reactive BAS (extraverts) would be predicted to activate reward-related circuits in response to positive stimuli more easily than those with less reactive BAS (introverts; Kennis et al., 2013).

The affective-reactivity hypothesis (ARH; Gross, Sutton, & Ketelaar, 1998) conceptualises findings from BAS research and states that extraverts should be more susceptible to the induction of positive affect. A series of experiments by Smillie and colleagues (2012) confirmed that extraverts showed greater affective-reactivity, but only in response to clearly *appetitive* stimuli and situations (e.g., where rewards or desirable goals are being pursued), as opposed to merely *pleasant* stimuli and situations. They also demonstrated that it is specifically *activated* affect (e.g., feelings of alertness), rather than pleasantly *valenced* affect (e.g., feelings of contentment), that characterizes the affective-reactivity of extraverts. Based on the work by Smillie et al (2012), and their refinement of the ARH, the prediction is that if motivational videos promote activated mood specifically, then the size of the motivational video effect would be moderated by extraversion (with larger effects for extraverts and smaller for introverts). Smillie et al.'s (2012) central study will be reviewed in more detail in Chapter 2 of this thesis.

In Gray and McNaughton's (2000) revised model of the brain systems underlying RST, the fight, flight, or freeze system (FFFS), is thought to mediate responses to all aversive stimuli (not just unconditioned stimuli; Gray & McNaughton, 1996; 2000), while the behavioural inhibition system (BIS) is described as a goal conflict detection and resolution device. When activated by goal conflict, BIS-engagement inhibits ongoing behaviour (both BAS and FFFS mediated), while simultaneously directing arousal and attentional resources toward the source of the stimuli giving rise to the conflict. The personality traits proposed to relate to variations in BIS reactivity are trait anxiety and neuroticism (Barlow et al., 2014). Both trait neuroticism and BIS have been linked to negative emotional reactivity, a propensity for generally unpleasant experiences, and promote the induction of many unpleasant emotions (e.g., fear, sadness, anger, disgust; Gray, 1981). Therefore, Gray (1994) identified anxiety as resulting from an active BIS. This association is evident in the context of mood induction studies. For example, Thake and Zelenski (2013) used mood-inducing film clips and found that high neuroticism and scores of BIS-anxiety predicted participants' reactivity to fear and sadness inductions. Moreover, while investigating behaviours in a social context using qualitative ranking-based measures, a relationship was found between neuroticism and susceptibility to social influence (Oyibo & Vassileva, 2019), which could enhance a reaction to the interpersonal aspects of a motivational video. If the motivational videos may signal threat to some viewers, as well as acting as an appetitive incentive for others, then those scoring higher on a BIS-linked trait, such as neuroticism, may perceive them as more threatening, as opposed to incentivising, with the potential to induce more negatively-valenced affect. For example, Rafienia et al. (2008) used guided imagery of positive or negative vignettes while playing pleasant or unpleasant music, respectively, and found that individuals high in neuroticism made more negative judgements and interpretations in a perceived negative mood condition.

Some research involving neuroticism and mood inductions have provided mixed findings. For example, Ng and Diener (2009) found that high neuroticism individuals, as compared to those low in neuroticism, were in fact less affected by a negative mood induction that involved imagining themselves in a series of negative scenarios. The relationship between BIS-related neuroticism and negatively-valenced *activated* affect remains unclear, as most research has focused on neuroticism and its relationship with negatively-valenced emotional reactivity to relevant stimuli, generally, as a function of avoidance motivation and behaviour (e.g., Deckersbach et al., 2006; Ebmeier et al., 1994; Fischer et al., 1997; Johnson et al., 1999; Kim et al., 2008; O'Gorman et al., 2006).

1.2.2 Approach/avoidance motivation and asymmetric frontal cortical activity

There is an abundance of literature on the relationship between asymmetric frontal cortical activity and approach/avoidance motivation (for reviews see Harmon-Jones & Gable, 2018; Kelley et al., 2017). According to the motivational direction theory (Harmon-Jones et al., 2013) the term approach motivation is most commonly described as behaviour that is motivated towards achieving a goal, often accompanied with feelings of arousal, alertness, and feeling energised, and is typically associated with greater left (relative to right) frontal activation. Avoidance motivation, often used interchangeably with withdrawal, is most commonly described as behaviour motivated to avoid punishments, undesired outcomes, or negative goals, often accompanied with feelings of fear, and is typically associated with greater right (relative to left) frontal activation.

The concept of frontal asymmetry was first framed by Davidson (Davidson, 1984) who postulated that the approach system is associated with greater activity in the left dorsolateral PFC relative to the right dorsolateral PFC. The withdrawal or avoidance system is associated with greater activity in the right dorsolateral PFC relative to the left dorsolateral PFC (Davidson 1984, 1998). This asymmetric frontal cortical activity is often measured by comparing alpha (8-13 Hz) power between areas on both the left and right brain hemispheres, where difference scores are calculated. Alpha power is thought to be inversely proportional to regional brain activity. This view is based on research that has combined EEG with hemodynamic measures (Cook et al., 1998) and behavioural tasks (Davidson et al., 1990). The method of calculating the difference of activity between hemispheres has been historically justified by pharmacological, lesion, and transcranial magnetic stimulation research that suggests that one hemisphere may be inhibiting the opposite hemisphere (Schutter, 2009; Schutter et al., 2001). Schutter and Harmon-Jones (2013) posit that there is interhemispheric functional connectivity of the corpus callosum that may encourage crosstalk between hemispheres that is associated with approach or avoidance motivation. It is the norm for researchers within this field to first log-transform the alpha power values to normalise distributions, and subtract localised left frontal alpha power (e.g., at EEG location F3) from right frontal alpha power (e.g., at the homologous EEG location F4). The result of this calculation will then be referred to as relative left or relative right frontal activity, depending on whether the numeric value result is more positive or more negative, respectively.

In relation to the reinforcement sensitivity theory, early research primarily suggests that scores on BAS trait questionnaires positively correlate with resting state EEG measures of greater left frontal activation, while scores on trait BIS positively correlate with resting state EEG measures of relative greater right frontal activation (e.g., Coan & Allen, 2003; Harmon-Jones & Allen, 1997; Shackman et al., 2009; Sutton & Davidson, 1997). Through further research (Hewig et al., 2004, 2005, 2006) a discrepancy has been found between the approach and avoidance/withdrawal systems and how they relate to left and right frontal activation, specifically concerning BAS-related approach motivation and active withdrawal motivation and BIS-related passive avoidance. The BAS is considered to react to both positive and negative reinforcement cues, while the BIS reacts to conditioned punishment stimuli, as well as novel and/or instinctually fearful stimuli. Hewig et al., (2004, 2005, 2006) used frontal activation and its relationship to the BAS to extend the motivational direction model with a specific relation to the execution of behaviour. Using aggregated resting EEG data (Hewig et al., 2004, 2006) and task-induced frontal alpha activation patterns (using go/no-go tasks; Hewig et al., 2005), they eventually discovered an association of BAS with bilateral frontal activity, as opposed to greater relative left frontal activation. This BAS-related bilateral frontal activity is argued to reflect that energising active behaviour of the BAS is common to both approach and withdrawal and should be activated for both positive and negative reinforcement (Hewig et al., 2004, 2005, 2006).

Extensive research conducted by Wacker and colleagues, linked the revised RST (Gray & McNaughton, 2000) to frontal asymmetry (Wacker et al., 2008; Wacker et al., 2003) with the inclusion of the (revised) flight-fight freezing system (FFFS). The revised reinforcement sensitivity theory suggests that the (revised) BIS is a goal conflict monitor that, for example, reacts to a simultaneous activation of the (revised) BAS, linked to approach motivation and rewards, and the (revised) FFFS, linked to reactions to aversive stimuli. The (revised) BIS shifts attention to the source of the double activation. Wacker et al. (2003), used mental imagery scripts to find relatively greater right frontal activation for subjective negative valence with approach orientation of the scripts, as well as greater right frontal activation for subjective positive valence with avoidance orientation of the script. In a second study, Wacker et al. (2008) used additional mental imagery scripts that were designed to target the BIS. They found a positive correlation between the self-reported activation of the (revised) BAS and the (revised) FFFS to the respective scripts and left anterior activation. Using BIS trait measures, they found that participants high on trait BIS who rated the script in a more

FFFS-like manner showed relatively more left frontal brain activation than those high on trait BIS but who rated the script in a more conflicted BIS-like manner. Wacker and colleagues' research supports the hypothesis that relative right anterior brain activation is linked to activation of the (revised) BIS and represents the conflict and subsequent inhibition of the (revised) BAS and (revised) FFFS. The (revised) BAS and (revised) FFFS are both associated with relative left anterior brain activation and are both systems that lead to behavioural outcomes (Wacker et al., 2003, 2008, 2010). A significant addition of Wacker's model is the implication that greater left frontal cortical activity is related to the FFFS, which also includes withdrawal-like behaviour.

A notable study that considers an aggregated account of the above, based on overlapping theories and models, was conducted by Hewig, Rodrigues and colleagues. In Rodrigues et al. (2018), they formulated a novel desktop virtual reality (VR) task that was used to induce motivational states, involving participants navigating through a virtual T maze via a joystick. During the VR paradigm the participants were able to react to stimuli with their own chosen behaviour in real-time, while their EEG was recorded. They experienced different events during the maze that were partly linked to acquiring credits. There were multiple types of trials designed to induce different motivational states, including negative events, positive events, control events, approach-avoidance conflicts, approach-approach conflicts, and conflict control events. It was, therefore, possible to measure frontal activation patterns while the participants were experiencing approach and avoidance motivation or conflict, as well as while they were executing virtual approach and avoidance behaviours or choosing to do nothing. They also measured trait levels of BAS-BIS tendencies, trait anxiety, and trait positive and negative affect. As expected, they found greater relative left frontal activation during approach behaviour and greater relative right frontal activation for withdrawal behaviour of any kind. There was, also, more bilateral frontal activation when actually engaging in behaviour compared to doing nothing. The study also found that participants showed more relative right frontal activation in the motivational state when trying to avoid negative events, where trait positive affect, trait anxiety, and trait sadness/frustration account for the difference of the execution of actual behaviour, regardless of the frontal asymmetry pattern. This supports the understanding that frontal asymmetry is associated with the general motivation to conduct certain behaviours, while executing certain behaviours is not so dependent on frontal asymmetry but is influenced by relevant traits. This study is in full support of the notion that frontal asymmetry heavily relates to behavioural approach or avoidance motivation, while bilateral frontal activation heavily relates to actual behaviour (Rodrigues et al., 2018).

Rodrigues et al.'s (2018) study uses a combination of the trait-based approach and state-based approach on EEG asymmetry, which draws upon the capability model (Coan, Allen, & McKnight, 2006). The capability model conceptualises the relationship between frontal asymmetry, trait measures and trait-relevant situations. It proposes that the relationship between trait measures and EEG asymmetry will emerge more effectively when resting state EEG is recorded under trait-relevant situations. However, it has more recently been argued, that if the task or manipulation is sufficiently overpowering and has features strongly targeting the volition phase of motivation (implementation of intention), then the experimental effect may overshadow the moderation effects of individual differences in response to the task or induction (Rodrigues et al., 2021).

Rodrigues et al. (2021) examined differences in experimental design (e.g., manipulation and induction methods) and EEG recording methods in trait-related and state-related asymmetry. The nature of the study raises a compelling argument for the meticulousness needed to address the many parameters involved when designing experiments that measure individual differences in the neural indices of approach motivation. They used different situational paradigms, namely a virtual T-maze task, mental imagery and movies, and different EEG methods to measure frontal asymmetry, which were mostly related to the reference scheme of the alpha power (i.e., what reference electrodes are used when extracting alpha waves from multiple sites). Specifically, they examined the difference between current source density (CSD) transformation (see Hagemann, 2004 for referencing recommendations for alpha power) against mastoid referencing. The study also takes into account the duration of the EEG frequency measurement, relating to different phases of motivation. It is argued that frontal asymmetry is most prominent in the volition phase, where intentions are formed and approach motivation means a preparation to act or begin to execute the relevant behaviour.

One can also distinguish between frontal asymmetry accompanying an expectation of a reward and the presence of a reward (see Hewig, 2018). It should also be noted that the evaluation of the reward activation process follows the volition phase and is often accompanied with a weaker frontal asymmetry, and it is sometimes measured in longer timeframes after an induction (see Wacker et al., 2008). Rodrigues et al. (2021) predicted that more powerful situational manipulations (virtual T-maze, frontal asymmetry measured as event-related desynchronisation) would eclipse relationships between relevant traits (trait positive and negative affect, trait BIS-BAS) and resting state frontal asymmetry, whereas weaker manipulations (mental imagery and movies), measured during extended time periods, would enhance the association with these relevant traits and resting state frontal asymmetry. This view would increase our expectation of finding trait correlations when measure the neural effects of motivational videos in Chapter 4. Their results indeed confirmed their predictions while simultaneously suggesting an inversion of the capability model to an inverted U-shaped quadratic relationship with frontal asymmetry. The findings stress the importance of the induction characteristics, including the stimuli used, as well as the other methodological implications, like relevant trait measures and recording methods, and highlights the sensitive nature of this process.

Considering the nature of motivational videos, as described above, we assume that the goal-directed content, perceived eye-contact, and interpersonal language used, are stimuli that induce the volition phase of motivation. Considering our earlier description of motivated behaviour phases, the volition phase of motivation can be rationalised as the first “wanting” or “appetitive” stage of the reward process (Berridge et al., 2009). The volition that occurs while watching the video forms intentions that, as Hewig (2018) suggests, have a cognitive component as a mental representation of the intended effect (e.g., the goal of studying enough hours to achieve good exam results) and the affective-motivational component, which is the feeling of determination to act and gaining the energy to perform the necessary action, even when the specific situation or environment does not necessarily facilitate the actions involved. While the study conducted by Rodrigues et al. (2021) previously described used a positive emotional video (an amusing film clip) and a negative emotional video (a fear film sequence from a horror movie), it could be that their weaker frontal asymmetry results associated with the movie video induction were due to an ineffective manipulation of approach-motivation and the intentions involved in the volition phase of motivation.

1.2.3 Activated affect and asymmetric frontal cortical activity

Much like the studies described above, within research on frontal asymmetry, the dopaminergic system, reward processing, and approach motivation, it has been widely accepted that, overall greater left frontal activation relative to right is associated with the experience of positively-valenced affect (e.g., pleased, cheerful), while greater right frontal activation is associated with the experience of negatively-valenced affect (e.g., fear, sadness, disgust; Davidson, 2004; Harmon-Jones, 2003; Harmon-Jones et al., 2010). However, research on the relationship between frontal asymmetry and BAS (i.e., the mesocorticolimbic dopamine system and its dopaminergic projections; see Figure 1.2) has considered a distinction between merely positive affect, and so-called activated affect. Activated affect concerns states that are arousing or energizing (e.g., to feel alert, to feel vigorous). Studies in affective neuroscience suggest that the neural processes involved with the BAS, mainly explored through the effects of psychostimulants and dopaminergic modulation, are more likely to be associated with the experience of activated affect and not merely pleasant affect (Berridge, 2006; Davidson, 2004). This view is the bedrock of the three studies in this thesis that employ motivational video as a mood induction tool: we assume that such videos will primarily increase activated affect.

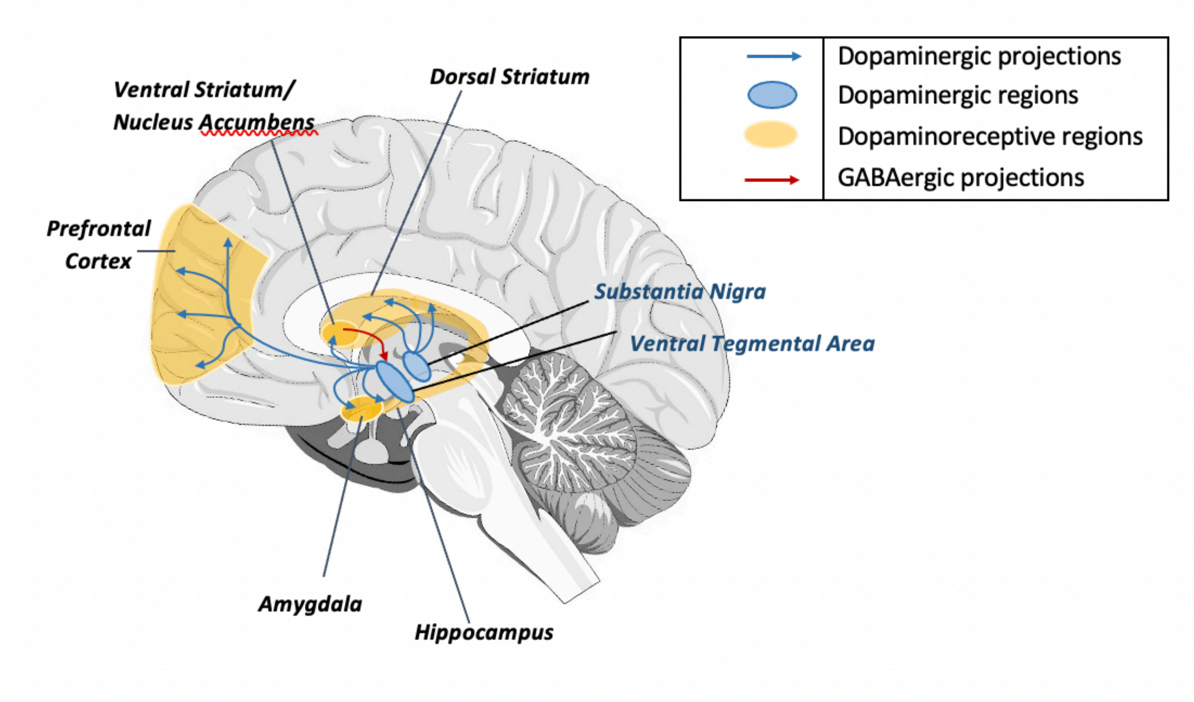


Figure 1.2: A schematic diagram adapted from Telzer (2016), showing the dopaminergic pathways in the brain that are related to reward sensitivity, including dopaminergic and dopaminoceptive pathways, as well as dopaminergic projections. GABAergic projections are also included here as GABAergic neurotransmission in local microcircuits of the NAcc were found to mediate motivated and affective behaviour (Telzer, 2016).

Further supporting this distinction between activated and pleasure-related affect is research within this domain that involves the influence of state anger, which has been associated with greater left frontal activation but is considered to be negatively-valenced affect. Studies have induced a state of anger using interpersonal manipulations, like being insulted (Harmon-Jones and Sigelman, 2001; Jensen-Campbell et al., 2007; Verona et al., 2009) and social rejection (Harmon-Jones et al., 2009), and have found that the induction of anger results in greater left frontal activation. A study (Harmon-Jones et al., 2003) attempted to induce anger in participants with an event that meant that their university tuition fees were being increased. Some participants were told that they could act on their anger by taking actions (approach-related action) that might resolve the anger-inducing event (i.e., signing a petition), while others were told that they could not do anything about it. While both groups may have experienced anger, only participants in the “action-possible” condition had greater relative left frontal activity than those who thought they would be unable to engage in approach-related action. Interestingly, those in the action-possible condition were also more motivated to engage in further approach-related behaviour, like encouraging more people to sign the petition (Harmon-Jones et al., 2003). The combination of these findings may mean that approach-motivation processes are involved with the experience of anger as a form of activated affect (negatively-valenced).

As the above research has suggested that the asymmetric cortical activation of BAS-related approach motivation might reflect activated affect, regardless of valence, then watching motivational videos could induce a state of activated affect accompanying greater left-frontal activation, regardless of whether it is pleasant or unpleasant.

1.2.3.1 A proxy measure of left frontal activation

A widely used behavioural measure of relative cerebral hemispherical asymmetry is the line bisection task (Jewell & McCourt, 2000), where participants are asked to indicate the perceived midpoints of a series of horizontal lines. Tendencies toward rightward versus leftward errors in midpoint estimations are deemed to reflect relative primacy of right versus left visual fields, respectively, and corresponding neural activity in the contralateral hemisphere, i.e., greater activation of the left vs. right hemisphere (Milner, Brechmann, & Pagliarini, 1992). Nash and colleagues (2010) used neuroimaging, self-esteem measures, and challenge manipulations to demonstrate that line bisection bias is specifically related to baseline, approach-related, prefrontal EEG alpha asymmetry. As previously described, alpha band power (8-12Hz) is an inverse indication of cortical activation where, generally, higher levels of alpha power mean less cortical activation and vice versa.

Nash et al (2010) used logarithmically transformed alpha power to calculate prefrontal asymmetry scores. Specifically, they computed this as right-site minus homologous left-site log alpha power, for all homologous frontal pairs. Using these values, they found that at the degree of rightward bias in line bisection correlated with relatively greater left frontal cortical activation from the EEG data, assuming an inverted relationship between cortical activation and alpha power. Specifically, greater rightward line bisection bias corresponded to greater right minus left log alpha power. Furthermore, they found that this rightward bias in line bisection was heightened by the same situational factors (e.g., responding to a memory of overcoming an approach-motivated challenge) that enhance approach-related prefrontal EEG alpha asymmetry.

In this thesis we have attempted to adapt the line bisection task into a digital version, executed on an online survey platform (described in Chapters 2 and 3). If found to produce results consistent with those obtained with the paper and pencil version of the task, then our digital version might provide a proxy measure of frontal asymmetry that should be better suited to novel and technologically inclined data collection methods. If the motivational videos are shown, by other results in our study, to activate appetitive brain systems, but do not produce appropriate shifts in line bisection, then we might tentatively conclude that the line bisection task we used was not a suitable index of approach-avoidance lateralisation. Alternatively, we might suggest that the approach-avoidance lateralisation account may be wrong or incomplete in some way (e.g., such lateralisation effects are not created by all kinds of appetitive system activations).

1.2.4 Individual differences and frontal cortical activity

The connection between the RST and approach/avoidance motivation discussed above, lends an explanation for the connection between BAS-related extraversion (Smillie et al., 2006) and BIS-related neuroticism (Barlow et al., 2014). A meta-analysis by Kuper et al. (2019) provided a comprehensive review of the relationship between resting state EEG frontal asymmetry and personality traits, without experimental manipulation. Data from 79 independent samples (overall N=5700) revealed that less than a 0.4% of the variance in extraversion and neuroticism could be explained by resting frontal asymmetry. This small effect did not withstand the adjustment for publication bias, and they concluded that the validity of resting frontal asymmetry as a marker for personality is not supported. Nevertheless, following the relationship between BAS and extraversion, and between BIS and neuroticism previously described, it might be expected that these traits will moderate the mood inducing effects of the motivational videos related to approach motivation and dopaminergic indices of reward processing, (i.e., frontal asymmetry), and thus robust relationship with extraversion and neuroticism might not be expected to be seen with resting state frontal asymmetry.

A study by Wacker (2018), applied the notion that the link between positive emotions and trait extraversion reflects dopamine-based individual differences in approach motivation. The study independently manipulated positive emotion (high approach wanting-expectancy vs. low approach warmth-liking) using imagery and film clips, as well as dopamine (placebo vs. DA D2 blocker sulpiride), and their effects on changes in frontal asymmetry were examined. They found that extraversion was indeed associated with state-related changes in frontal asymmetry, where those who were asked to imagine their future goals or eagerly awaited activities displayed a greater relative left frontal asymmetry that was positively correlated with scores of extraversion for those under the placebo but not under the DA D2 blocker. Wacker's outcome of no significant association between extraversion and baseline resting asymmetry also provides support of frontal asymmetry being an indicator of motivational *states* (as opposed to underlying trait measures). Of course, such states are differently activated in relevant situational contexts depending on relevant trait levels, as suggested by the capability model (Coan et al., 2006). Wacker's (2018) additional conceptualisation of a modulating effect on frontal asymmetry of experimentally manipulated dopamine activity provides evidence for the link between extraversion and indices of the dopaminergic system.

With regards to BIS-related neuroticism and frontal asymmetry, Uusberg et al. (2015) highlight that anterior functional brain activity and its relations with the Five Factor Model personality traits (Goldberg, 1993; McCrae & Costa, 2003; McCrae & John, 1992) remain unclear. Uusberg et al. (2015) investigated the effects of variable degrees of social contact induced by eye gaze on anterior EEG alpha asymmetry. They were particularly interested in the moderating effects of neuroticism. Their results revealed that higher levels of neuroticism were associated with relatively greater right frontal activity. The indication that neuroticism moderated avoidance-related neural markers (such as right frontal asymmetry) in response to induction of social contact was further supported by behavioural direct gaze avoidance and subjective averted gaze preference. A possible neurobiological explanation for the association between avoidance motivation and neuroticism might be based on the findings that individuals scoring high on neuroticism tend to have higher levels of activity and lower arousal thresholds in various areas of the brain (e.g., striatum, basal ganglia, thalamus, prefrontal cortex, cingulate cortex). Lowered thresholds in these areas should produce greater emotional reactivity to relevant stimuli (Deckersbach et al., 2006; Ebmeier et al., 1994; Fischer et al., 1997; Johnson et al., 1999; Kim et al., 2008; O'Gorman et al., 2006). Projections from these areas of heightened activity could generate low frequency amplitude fluctuations in the right posterior frontal lobe, which in turn could then be positively correlated with neuroticism (Wei et al., 2014).

1.3 The measure of mood

Considering the dynamic role of individual differences depicted so far, it is clear that a central objective of this thesis is to unveil why and how different people with differing traits affectively respond to the same stimuli in divergent ways. Deciphering latent discrepancies in seemingly similar affective states (e.g., the distinction between activated affect and positively-valenced affect described above) could lead to an operational approach in rationalising such effects. In doing so, it is important for this thesis to include an all-encompassing measure of affect that reflects the space formed by underlying mood dimensions. Circular ("circumplex") rather than simple structures of core affect have been popular for some time (Fabrigar et al., 1997; Remington et al., 2000; Yik, 2009; Yik et al., 2002). Yik et al.'s (2011) 12-Point Affect Circumplex (12-PAC) of Core Affect model was developed for this purpose. The 12-PAC adopts a dimensional perspective within a circular space (considered to cover all core affect) and defines narrow slices of this affect circle as a core affect segments, each representing 30 degrees of a circle (see Figure 1.3). Each segment consists of quantifiable self-report adjectives, which are descriptive of core affect. The horizontal axis of the circumplex captures what is considered to be the traditional idea of the positive-negative valence dimension; what feels good versus what feels bad and is dubbed the pleasure-displeasure axis. The vertical axis captures the finding that a major dimension of mood and emotion involves arousal (Cacioppo et al., 2000; Thayer, 1996; Zillmann, 1983). Here arousal refers to how energetic (activated) one feels, independent of whether that feeling is necessarily positive or negative (e.g., excited vs. agitated). One can also feel deactivated in a positive (e.g., placid) or negative (e.g., sluggish) way. The vertical axis is therefore dubbed the activation-deactivation axis.

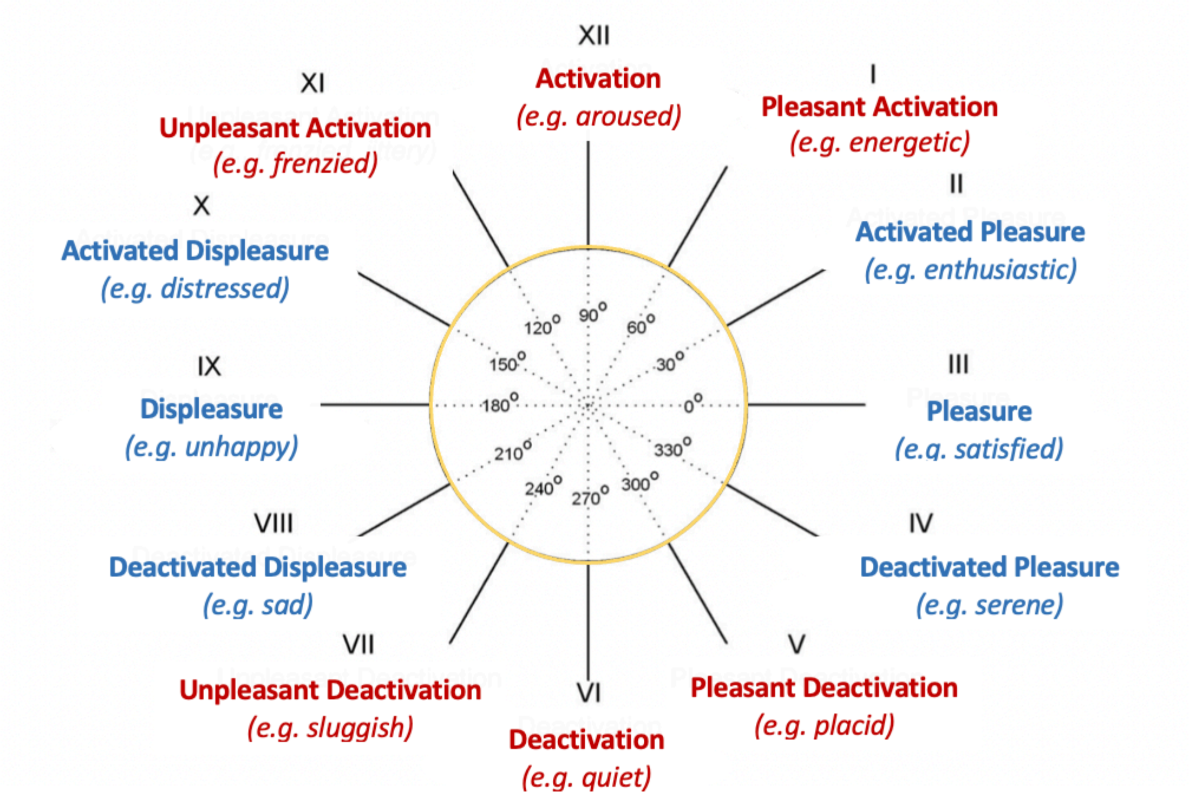


Figure 1.3: A figure from Yik et al. (2011) of a schematic diagram of the 12-Point Affect Circumplex (12-PAC), with the locations and types of core affect segments, as well as examples of their adjectives.

A circumplex structure of core affect overcomes fundamental flaws of scales derived from more linear dimensions of mood and emotion. For example, such dimensions are often defined by a small number of overly broad clusters of diverse states (e.g., Watson & Tellegen, 1985). In order to formulate a more refined core affect circumplex, Yik et al. (2011) conducted four correlational studies using scales that integrated major dimensional models of mood and emotion. They cross-validated for core affect felt during current and remembered moments and found the 60 adjectives that were significantly related to core affect.

The cartesian nature of the 360-degree circumplex of core affect allows us to use trigonometric equations to predict a precise pattern of relationships between mood changes at various points around the circumplex (see chapters 2-4). The pleasure-displeasure and activation-deactivation axes are at right angles to one another so, very usefully, this means that any induction of affect change along one of these axes will produce no change at all along the other axis.

1.4. Data modelling considerations

This thesis attempts to take a detailed and contemporary approach to data modelling, and we deploy recent developments such as Bayesian Model comparison and selection and general estimating equations (GEE) to supplement the familiar ANOVA/regression approaches using the general linear model. These latter analyses use Bayes factors (Morey et al., 2016). A precise formulation of the predicted mood changes under a circumplex model permit us to deploy such models in the studies in chapters 2, 3 and 4. These rising methods from Bayesian inference are of exceptional importance to the contemporary objectives of this thesis, particularly with regards to measuring individual differences in responses to affect manipulations.

Modern studies that correlate individual differences with performance on various tasks to uncover common latent processes (e.g., Stroop, flanker, and implicit attitude tasks) often find lower than expected correlations (e.g., Hedge et al., 2018; Ito et al., 2015; Rey-Mermet et al., 2018; Stahl et al., 2014). A recent proposition by Rouder & Haaf (2019) considered whether the attenuated correlations reflect statistical considerations (e.g., lack of individual variability on tasks) or substantive considerations (e.g., the considered latent factor in different tasks is not a unified concept). They demonstrated that the challenge is compounded by the tendency for researchers within this domain to aggregate performance across trials to calculate overall individual-by-task scores. Using data from Hedge et al. (2018), Rouder & Haaf (2019) indeed found that aggregation did attenuate measures of effect size and correlation in Stroop and flanker tests. They proposed an alternative hierarchical analysis of task performance that accounts for trial-by-trial variability along with covariation of individuals' performance across tasks. Using a Bayes-factor analysis they were able to support a lack of correlation between the Stroop and flanker task, indicating a lack of latent factor unification. While the exact experimental questions of Rouder & Haaf's (2019) study are not directly related to the objectives of this thesis, their work emphasises the importance of using the most powerful and appropriate statistical modelling methods in order to more precisely uncover latent effects. This is of particular importance when considering psychometric measures, like measures of core affect.

In later chapters where we analyse experimentally induced mood changes, we give detailed consideration of the level of modelling which we adopted. Following, Rouder and Haaf (2019) and Haines et al (2020) we also move away from the dominant use of averaging to produce "individual by task scores". In chapter 2 we explain why we stop short of a fully hierarchical approach to data modelling, using an approach known as single subject maximum likelihood estimation (SSMLE). However, our intermediate level approach, coupled with Bayesian Model Selection (BMS) and GEE analyses, allowed us to unearth results that would have been entirely missed by the traditional averaging to give "individual by task scores". To foreshadow our findings in chapters 2, 3, and 4, the wide variety of mood induction effects shown by different participants using these analytic methods could be seen as one of the most important general outcomes from this thesis.

1.5 Learning from artificial social interactions

Now that we have conceived the extent to which we can understand the effects of a novel appetitive mood induction, let us return to the second theme of this thesis, addressing the third aspect of motivated behaviour: reinforcement learning. In particular, we study manipulating perceptions of characters encountered in virtual interpersonal interactions using variations in the social reinforcement experienced during those interactions. Social interactions, where there is an exchange of social stimuli and feedback between individuals, seem likely to share key cognitive processes with those involved in reinforcement learning (RL). RL involves learning through loops of stimuli association, decision making, and feedback processing based on the presence of a reward (Daw et al., 2011; Sutton & Barto, 1998). In a social cognition context, social interactions allow individuals to learn about others through trial and error, while engaging and learning from their responses to behavioural exchanges and the presence of social rewards (Hackel & Amodio, 2018). In common with other rewards, social rewards have been shown to activate dopamine-related mesocorticolimbic pathways (Spreckelmeyer et al., 2009), including dopamine projections of the ventral tegmental area to the striatum (Satoh et al., 2003) and cortical-subcortical circuitry passing through the basal ganglia (Izuma et al., 2008; Knutson et al., 2001; Schultz et al., 1997; Zink et al., 2004). These regions have been associated with appetitive stimuli and reward responses in general (Knutson et al., 2000; McClure et al., 2007). The social reward responses activating dopamine-related pathways are thought to have evolved to facilitate reproductive behaviour, thus motivating social interactions (Kelley & Berridge, 2002). Social rewards and positive social feedback are considered to be present in a range of stimuli, such as beautiful or smiling faces (Aharon et al., 2001; Spreckelmeyer et al., 2009), Facebook likes (Marengo, Poletti, & Settani, 2020), and even include the concept of sharing resources (Hackel et al., 2020). The inferences made from such interactions are often abstract cognitions about others' traits in a way that guides decisions concerning possible future behaviours and returning for interactions with the same individuals (Hackel, Doll, & Amodio, 2015; Hackel et al., 2020).

1.5.1 Social reinforcement learning

The value of a social interaction is estimated from the human ability to attribute stable traits to others that can be used to predict their future behaviour and associated rewarding outcomes (for a review, see Amodio, 2019). In a study investigating the neural correlates of instrumental learning of traits and rewards and its effect on choice, it was found that the participants learned to use both reward and trait information when choosing partners for future interactions as a reinforced choice (Hackel, Doll & Amodio, 2015). Correspondingly, they found neural activity in the ventral striatum during task execution, a region consistently linked to RL (for a review, see Garrison et al., 2013).

There is an abundance of existing literature that compares the effects of social and non-social rewards, supporting a consensus that the anticipation of both reward types activates common brain structures constituting the brain reward system, including the VS (e.g., Rademacher et al., 2010; Spreckelmeyer et al., 2009). However, there are questions over the ecological and construct validity of some research using social rewards. This is because research, conducted on existing models of reinforcement and using social rewards, is often carried out in a non-social context. Typically, tasks measuring the effects of social reward use rewarding social stimuli to reinforce behaviours, like speeded response choices, in response to a target stimulus associated with levels of rewarding feedback to a successful response. An example is the monetary incentive delay task (Knutson et al., 2000) that was adapted to form the social incentive delay task (Spreckelmeyer et al., 2009). Similarly, Izuma and colleagues (2008) used reaction times in a decision-making task comparing monetary and social rewards to understand their effects on RL. In the monetary task they were asked to choose one of three cards and were given 0, 30 or 60 yen depending on the chosen card. They had to choose the card within 2 seconds. For the social reward task, a picture of the subject was shown along with an item indicating the impressions of themselves made by others, and the subject was asked to rate the desirability of the item within 3 seconds (Izuma et al., 2008). The use of reaction time or response latency tasks rests on the following reasoning: as cues become reliably associated with the receipt of a reward, the manual responses to these cues quicken over the acquisition of learning (O'Doherty et al., 2003; McClure et al., 2003). This highlights the lack of social context involved in this type of research. While such performance tasks may contribute to our understanding of the anticipatory and activating effects of social rewards, they do not particularly inform our insights into interpersonal perceptions and the social cognition involved in a social environment.

1.5.2 The need for social context

In attempts to overcome the oversimplification of human social behaviour in response latency tasks, a key study used a conjunction of measures in a probabilistic reward task (Jones et al., 2011). Traditionally, probabilistic reward tasks have been utilised to generate prediction error signals, i.e., discrepancies between the expected outcome of a cue and the actual outcome, in RL (Rescorla & Wagner, 1972). In this novel probabilistic social reward task, participants learned to differentiate between three supposed peers, each associated with a probability of social reinforcement (33%, 66%, or 100% of trials), presented in the form of socially accepting feedback to a personal survey that the participants had previously completed. The socially accepting feedback was whether the participant received a note from a peer indicating their positive interest in interacting with the participant based on the personal information that the participant had previously given in a survey. Throughout the task, social RL processes were evaluated at three levels of analysis: preference ratings (i.e., the likeability of the peers), response latencies (i.e., the reaction time of a single button response during cue presentation), and neural responses measured using fMRI. It was concluded that the brief, positive social interactions, based on the probability of their appearance, significantly shaped the social learning across all three measures. Not only were there faster responses to peers who more frequently provided positive social reinforcement, indicating differences in approach behaviours that are based on learning from prior social feedback, but there was also an increase in ratings of likeability throughout the task for the more reinforcing peers. These ratings highlighted the significance of positive social interactions in social preferences and biasing behaviour (Jones et al., 2011). The findings also support previously established neural correlates of prediction error learning and behavioural changes in RL, namely activation in the ventral striatum and orbital frontal cortex (Bray & O'Doherty, 2007; Valentin & O'Doherty, 2009; Lin et al., 2011).

Another key and more recent study conducted by Hackel, Meride-Siedlecki, and Amodio (2020) used social RL to make inferences about social perception as a way to uncover a functional role of social cognition in RL. They examined whether social contexts transform how people learn from feedback versus how they learn in non-social interactions, by testing whether participants had a preference for generous humans (trait-based learning) or rewarding slot machines (reward-based learning), relative to their less generous counterparts, after a RL task. Some humans and slots offered larger amounts of money (displaying high reward value) and, independently, some offered larger proportions of available money (indicating trait-level generosity). Larger proportions of available points shared by the target (e.g., sharing 10 out 25 points, as opposed to 20 out of 100 points) indicated higher levels of generosity. They were then asked to rate how much they liked each human or slot machine that they interacted with (depending on their assigned learning condition), in order to test how learning related to explicit evaluations. They were also asked about the extent to which they thought about each target's personality and the number of points offered by each target, testing whether they used a particular learning strategy. The results revealed that when interacting with humans, participants relied more on generosity (trait) information, based on the proportion of shared points given as feedback. On the other hand, they relied more on reward information (the value of the reward) when interacting with slot machines. With regard to the liking ratings, there was an emphasis on the likeability of generous humans and rewarding slot machines, showing a discrepancy between different criteria for associations made with humans versus non-human interactions. Hackel, Meride-Siedlecki, and Amodio (2020) conclude that participants learned more from traits than rewards when interacting with humans as opposed to slot machines, indicating the role social framing plays on influencing what people learn from reinforcement. The participants demonstrated enhanced learning from generosity feedback specifically in social interactions, consistent with the view that they inferred trait characteristics by which they determined the value of the partner they were interacting with.

1.5.3 Putting a smile on someone's face

Although Hackel, Meride-Siedlecki, and Amodio's (2020) contemporary study neatly demonstrates how learning from social interactions can shape the social perception regarding traits, it does not address the impact that physical or, merely, visual social interactions may have. As previously outlined, such social reward stimuli (e.g., smiling or happy faces) have been used to measure rewarding effects on somewhat non-social measures (e.g., Knutson et al., 2000; Izuma et al., 2008; Spreckelmeyer et al., 2009). However, there is other existing research that demonstrates how social behaviour and cue-action associations can be reinforced with positive facial expressions, particularly smiles, as they are deemed to be intrinsically high in reward value in social settings (Averback & Duchaine, 2009; Furl, Gallagher, & Averback, 2012; Heerey, 2014). Such social cues are thought to serve two functions simultaneously. Firstly, they are communicative as they provide the receiver with information about the sender's states via feedback about how well-received their recent actions have been (Ekman, 1992; Fridlund, 1991). Secondly, social cues allow people to optimise their behaviour to achieve desirable and highly anticipated outcomes through a decision-making process guided by RL (Heerey, 2014). For example, a receiver might choose to view a change in smile as an indicator of change in the social climate, highlighting how, if a smile were to disappear, continuing with a particular social strategy or behaviour would be unwise. Furthermore, using simple smiles for RL, but in a way that represents social context, adds to the fundamental argument of the necessity to use technology for valid and reliable mass data collection methods. The two studies in this thesis that use smiles as reinforcers in the present thesis are a small step towards this goal.

Heerey (2014) implemented a modified decision-making task (Kringelback & Rolls, 2003), where participants had to select different smiling faces (either genuine or polite) based on their comparative value. Heerey (2014) found that when a social cue is more valuable (genuine) compared to a previously seen one, people showed a bias to repeat the associated action. In line with the previously described key studies, it is inferred that the degree of flexibility in learning from, and responding to, social cues suggests that those cues allow recipients to evaluate the outcomes of recent actions. Social cues may also allow the recipient to predict the quality of a social partner's likely responses to possible future actions. Heerey's (2014) study went further than other studies in highlighting how the ability to learn from social rewards is an important contribution to individual differences in social ability. Heerey also emphasized the importance of reinforcement as a means for guiding behaviour in social situations and as an aspect of social functioning. Specifically, by using an autistic traits scale (Autism-spectrum Quotient Scale; ASQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), Heerey found that the ability to detect a masked contingency from social feedback correlated with self-reported social-communicative ability. Specifically, those scoring lower on the ASQ (reporting fewer autistic-like traits) were more likely to be able to articulate whether a smile was genuine or polite, compared to those scoring higher on the ASQ.

1.5.4 The role of individual differences in social reinforcement learning

Research in RL has shown that the importance of implementing individual differences in social RL can be derived from its very own description. RL states that people attribute abstract, yet stable characteristics to both humans and objects, and learn from rewards involving both humans and objects (Lin et al., 2011). Traits in social RL, however, provide a richer representation of conceptual information, which may help people flexibly choose social partners relevant to an individual's current goals, as deemed by their own intrinsic experience (Amodio, 2019; Hackel et al., 2019). Individual experience and its relationship with goals, motivation, and preferences is highly dependent on traits and personality. As noted previously, the RST (Pickering et al., 1995; Smillie et al., 2006) provides a biological account for why some personality traits may both be derived from, and lead to, a propensity to respond to rewards in differing ways to their counterparts. Traits from the Big Five personality dimensions (McCrae & Costa, 1991) that are characteristically associated with reinforcement sensitivity are extraversion and neuroticism (Eysenck, 1990).

Trait extraversion is described as being sociable, warm, assertive, fun-seeking, bold, talkative, and is usually associated with positive emotionality, compared to introverted counterparts (Butt & Phillips, 2008; Wilt & Revelle, 2019). Extraversion is a trait that has been repeatedly associated with the behavioural activation system (Eysenck, 1990; Smillie et al., 2006), general reward processing (Depue & Collins, 1999; DeYoung, 2013; Pickering & Gray, 2001; Rammsayer, 1998), and reward-prediction-error neural signalling, dubbed

Reward Positivity (Smillie et al., 2019; Smillie, Cooper, & Pickering, 2011) in RL. The reward-processing theory of extraversion (a sub-component of the broader RST) holds that the traits characteristics and behaviours associated with extraversion can be partly attributed to differential sensitivity to the motivational impact of rewarding stimuli, and the drive to obtain such stimuli. Specifically, boldness and talkativeness may be viewed as expressions of reward-directed behaviour, and positive emotionality can be seen as affective responses to reward pursuit and attainment (DeYoung, 2010; Smillie, 2013; Wilt, Bleidorn, & Revelle, 2017).

A study by Smillie, Cooper, and Pickering (2011) used an associative learning paradigm (Potts et al., 2006) that uses sequential visual cues to represent expected financial rewards 80% of the time and unexpected non-reward outcomes 20% of the time. Another sequence of the cues signalled expected non-reward 80% of the time and unexpected reward 20% of the time. The reward positivity phenomenon is the more positive EEG response, over frontal brain sites, to unexpected rewards especially when compared with responses to unexpected non-rewards. Smillie et al. (2011) found that the Reward Positivity was larger in extraverts compared to their introverted counterparts. This greater Reward Positivity in extraversion was replicated and extended in a study that found contrasting relations between Reward Positivity and trait measures of reward sensitivity, impulsivity and extraversion, where this effect was found only for extraversion but not impulsivity (Cooper et al., 2014). Similarly, a more recent and larger study (N=100) replicated Reward Positivity for different measures of extraversion and confirmed that other big five traits were not significantly related to Reward Positivity (Smillie et al., 2019). Adapting this model of extraversion for the effects of social stimuli and utilising different event-related potential (ERP) methodology, a study by Fishman, Ng, and Bellugi (2011) found that higher scores on extraversion were associated with higher amplitudes of the P300 component the ERPs elicited by human facial stimuli, suggesting that social stimuli carry enhanced motivational significance for those that are characterised as having high trait extraversion.

Neuroticism, however, is a trait that is characterized by emotional instability and individuals being generally anxious, nervous, angry, and fearful (Heinström, 2003). With regards to the RST, it has been most commonly associated with the sensitivity/reactivity of the behavioural inhibition system (BIS), which functions as a goal conflict and resolution device (Barlow et al., 2014). Classical studies on reward processing in neuroticism have sometimes found that the trait is negatively correlated with conditioned responses to appetitive (rewarding) stimuli (Corr, 2004; Paisey & Mangan, 1988). In a social learning context, it has been found that individuals who score high on neuroticism are more likely to be susceptible to social influence strategies than those who are low on neuroticism (Oyibo & Vassileva, 2019). Though this provides some evidence for the associations that neuroticism may have with social cognition, to our knowledge there has been no empirical evidence testing how the effects of RL using social stimuli are moderated by neuroticism as a trait measure of anxiety and/or BIS functioning. This thesis, therefore, attempts to offer completion to this research.

The involvement of social reward processing and learning during social interactions, which are perpetual throughout daily life, gives rise to considerations of the possible hampering effects for those who have aberrant social reward processing. Individuals with clinical disorders characterised by aberrant social reward processing may show extreme variation within the continuum of reward sensitivity that encompasses typical social reward processing. Alternatively, they may have qualitatively as well as quantitatively distinct disturbances in their processing of social reward. Aberrant social reward processing is recognised to be a product of a number of disorders, most commonly schizophrenia (Catalano, Heerey, & Gold, 2018), depression (Pechtel et al., 2013), social anxiety (Cremers et al., 2015), and autism spectrum disorders (Cox et al., 2015; Delmonte et al., 2012), including comorbidities of these disorders (e.g., Bejerot, Eriksson, & Mörtberg, 2014). Generally, reward responsiveness is seen to be blunted and this can lead to detrimental effects on an individual's self-image, emotion, cognition, and general well-being (Makkar & Grisham, 2011). It highlights the importance of developing a paradigm using reinforcement learning with fundamental social feedback, while assessing trait moderation effects. If the paradigm used in this thesis where we manipulate perceptions of virtual characters using social RL proves successful then, in future work, can be effectively manipulated into neuroimaging and even clinical tests. Including autism spectrum at the trait level in this thesis offers a consideration of these effects of aberrant social reward processing.

1.6 Aims and research questions

The overall goal of this thesis is to consider the measurement of trait-like aspects of approach motivation and reinforcement learning for interpersonal social rewards and incentives, using a combination of neural, behavioural and psychometric measures. Individual differences in approach motivation and reinforcement learning have significant implications for a range of methodologies. Nevertheless, a lot of the research reviewed in this introduction takes for granted that measures evolving from different theoretical perspectives, and assessing discrete aspects of reward processing, are tapping related constructs. This thesis adapts and applies a combination of established reward processing and trait theories but tests them in experiments that use innovative methods for measuring the effects of social rewards and interpersonal incentives. Specifically, the broad aims of the thesis are as follows:

1. To explore whether motivational videos work as appetitive mood inductions by inducing activated affect, associated with approach motivation.
2. To use personality traits as measures of sensitivity to appetitive mood inductions, and to investigate if they indeed moderate the affective response to the motivational videos.
3. To test a digital version of the line bisection task as a proxy for left frontal activation representing approach motivation and activated affect.
4. To examine if appetitive and activating effects of the motivational videos can be detected in EEG measures of approach motivation (i.e., as changes in frontal alpha asymmetry).
5. To apply reinforcement learning in a social context to a novel artificial social interaction (ASI) task that uses probabilistic learning with characters that vary in the amount of social reward they give (via smiles). The outcome measures from the task focus on aspects of interpersonal perception.
6. To use the ASI to investigate how relevant participant personality traits moderate the extent to which participants perceive and rate the socially rewarding vs socially non-rewarding characters they interact with.

This programme of research will begin in chapter 2 with an attempt to test the mood-inducing properties of a motivational video compared to a control video. In line with previous research using reward-based mood inductions (e.g., Smillie et al., 2012) activated affect, as opposed to positive valence, will be considered as the focal dependent variable. This will be analysed using model-specific contrasts, derived from trigonometric equations of the circumplex of core affect (12-PAC; Yik et al., 2011). Bayesian Model selection methods will be used to compare the degree to which different circumplex models fit the mood changes reported by each individual after exposure to either a motivational or control video. General estimating equations (GEE) will robustly estimate the average changes for the whole group of participants in a particular video condition. The personality traits of extraversion and neuroticism will be measured to investigate whether they moderate the change of affect as a function of video type. Extraversion is included due to the proposed dependence of extraversion on BAS functioning (Smillie et al., 2012). As reviewed previously, there is no direct empirical evidence for BIS-mediated effects on activated affect, but rather a focus on the effect of negative mood inductions on negative affect in general. Because of this, predictions involving neuroticism will be considered more tentatively. Nevertheless, neuroticism is considered as a predisposition for negative emotional reactivity (e.g. Deckersbach et al., 2006; Ebmeier et al., 1994; Fischer et al., 1997; Johnson et al., 1999; Kim et al., 2008; O'Gorman et al., 2006; Rafienia et al., 2008). A digital proxy measure for left frontal asymmetry (adapted from Nash et al., 2010) is also introduced here. Chapter 2, therefore, tests the following hypotheses:

1. Relative to the control video, the motivational video will increase, from pre- to post-test, all segments of mood (segments refer to subdivisions of circumplex models of mood; Yik et al, 2011) that involve activated affect; such segments are described as *pleasant activation, activation,* and *unpleasant activation*. The precise pattern of mood change around the circumplex will be described by a specific trigonometric model that captures the degree of similarity of the moods in terms of the angle between them around the circumplex.
2. Viewing the motivational video will also be accompanied by a decrease in segments of deactivated affect (labelled *unpleasant deactivation, deactivation, pleasant deactivation*), and these changes will be greater than those seen after the control video.
3. We construct an equivalent, rival hypothesis that, relative to the control video, the motivational video will increase from pre to post-test all segments of mood that involve pleasant affect and decrease those segments that relate to unpleasant affect. It should be noted that support for this rival hypothesis would be at odds with the research reviewed above (e.g., Smillie et al, 2012).
4. The effects of the motivational video on activated affect are predicted to be greater for those who score high on extraversion.
5. We also make an equivalent rival hypothesis that the effect of the motivational video on pleasant affect is predicted to be greater for those who score high on extraversion.

Once again, support for the rival hypothesis would contradict the findings of Smillie et al. (2012).

6. It is (tentatively) predicted that these video by affect effects (both activated and pleasant affect) may be greater in those who score low on neuroticism relative to those who score high on this trait.
7. It is hypothesized that motivation and increased activated affect will be accompanied by a rightward line bisection bias for those watching the motivational video, indicating greater left frontal activation (relative to right frontal activation), whereas this pattern will not be seen in those who have watched the control video.
8. We make a rival hypothesis that increased pleasant affect will be accompanied by a rightward line bisection bias for those watching the motivational video relative to the control video, which is at odds with the literature reviewed above.

Study 2 (in chapter 3) was designed and conducted as a means of overcoming the key limitations of Study 1. Study 2 utilizes the same basic pre-post between-subjects experimental design as study 1, while refining the experimental manipulation with a better matched control video. The researcher hired and directed a small film crew to replicate the motivational video used in study 1 and the designed and directed a well-matched new control video. By achieving better matching of the videos, study 2 also attempts to home in on the features of the motivational video that might account for any increase in activated affect. The following labels are given to the videos in this study: original motivational video - OMV, replicated motivational video – RMV, and new control video – NCV. RMV was a close replica of the OMV but made by the author and her film crew. The only substantive difference between the RMV and OMV was in the identity of the speaker: a non-famous English actor used in the RMV versus a reasonably well-known American YouTube motivational speaker in the OMV. The NCV was also directed by the author and used the same actor, music and lighting as the RMV as well. The hypotheses for chapter 3 closely resemble those of chapter 2, with the following supplement:

1. There will be no significant difference, between the main effects of the two motivational videos.
2. The effects of both motivational videos on activated affect are predicted to be greater for those who score high on extraversion.

3. It is (tentatively) predicted that the video by affect effects (both activated and pleasant affect) may be greater in those who score low on neuroticism relative to those who score high on this trait.

Chapter 4 uses the same theoretical framework and mostly the same methodology as chapters 2 and 3, although the OMV was not used in study 3 as study 2 revealed that it produced very similar mood changes to the RMV. In study 3 we replaced a proxy measure of left frontal activation (the line bisection task, used in studies 1 and 2) with a direct measure of cortical activity, derived from resting state EEG. In light of approach motivation research on neural indices of reward previously reviewed (e.g., Schutter & Harmon-Jones, 2013; Wacker et al., 2003), an EEG measure of frontal alpha asymmetry was implemented. Drawing on findings from chapters 2 and 3, which lead to the exclusion of the OMV in this study, the hypotheses for chapter 4 are as follows:

1. Relative to the NCV (control video), the RMV (motivational video) will on average increase, from pre- to post-test, those segments of emotion (circumplex models divide mood up into segments; Yik et al, 2011) that involve activated affect (*pleasant activation, activation, unpleasant activation*). The precise pattern of mood change around the circumplex will be described by a specific trigonometric model that captures the degree of similarity of the moods in terms of the angle between them around the circumplex.
2. Relative to the NCV, the RMV will also, on average, produce a decrease in segments of deactivated affect (*unpleasant deactivation, deactivation, pleasant deactivation*).
3. We construct an equivalent, rival hypothesis that, relative to the NCV, the RMV will increase from pre to post-test all segments of mood that involve pleasant affect and decrease those segments that relate to unpleasant affect.
4. The effects of the RMV on activated affect are predicted to be greater for those who score high on extraversion.
5. We also make an equivalent rival hypothesis that the effect of the RMV on pleasant affect is predicted to be greater for those who score high on extraversion. Once again, support for the rival hypothesis would contradict the findings of Smillie et al. (2012).
6. It is (tentatively) predicted that these video by affect effects (both activated and pleasant affect) effects may be greater in those who score low on neuroticism relative to those who score high on this trait.

7. We hypothesise that there will be a change in frontal asymmetry after watching the RMV, where there will be greater left frontal activation, compared to the NCV.
8. The activation-deactivation circumplex model coefficients will correlate with levels of frontal alpha activity, where overall greater relative left frontal activation will have a positive relationship with more positive activation circumplex coefficients.
9. We make a rival hypothesis that pleasure-displeasure circumplex model coefficients will correlate with levels of frontal alpha activity, where overall greater relative left frontal activation will have a positive relationship with more positive pleasure circumplex coefficients.
10. The effects of the RMV on left frontal activation are predicted to be greater for those who score high on extraversion.
11. It is (tentatively) predicted that these video by left frontal activation effects may be greater in those who score low on neuroticism relative to those who score high on this trait.

The study in chapter 5 formulates the ASI by combining the functions of social probabilistic learning (Jones et al., 2011), trait learning (Hackel, Mende-Siedlecki, & Amodio, 2020), the use of smiles as social rewards in positive feedback (Heerey, 2014), and trait associations of the reinforcement sensitivity theory (Corr, 2004). The main aim was to test if smiles as responses within an artificial social interaction are a type of social reward that can induce learning in a probabilistic task. A second aim was to test if this learning is greater for extraverts.

Further to this, the study addressed a possible process by which a biological propensity to learn more from salient social rewards than others, might lead to someone becoming more extraverted using the following reasoning: (i) perceptions about other people are affected by associative learning (with social rewards) and this will be greater in individuals with heightened reward sensitivity; (ii) those individuals then find socially-rewarding people more likeable and judge them as more extraverted to a greater extent than people with lesser levels of reward sensitivity; (iii) as a result they find people's company more enjoyable than do people who are less reward sensitive, and thereby act in an extraverted fashion (by seeking out social interactions to a greater extent).

Further related trait measures were added to test as moderators of the reinforcing effects. Neuroticism was included due to its association with the reinforcement sensitivity theory and trait anxiety (Barlow et al., 2014). A measure of autistic traits was included due to previous associations with social ability and responsiveness (Jones et al., 2011). Agreeableness was added as an exploratory measure simply because of its characterisation of friendliness, compassion, and empathy (de Oliveira et al., 2003). Chapter 6 attempts to replicate the findings in chapter 5, while counterbalancing the trials of the ASI. The ASI task was developed to test the following hypotheses:

1. Characters who smile more throughout the artificial interactions (reinforcing characters) will be rated by participants as people they would be more likely to befriend, as being more likeable, and as being more extraverted and agreeable than the characters who smile less (non-reinforcing characters).
2. Assuming that the effects of social reinforcement extend beyond person perception and social cognition, the names of the reinforcing characters will be recognised more accurately, in a surprise delayed name memory test, than the non-reinforcing characters.
3. These character-type (reinforcing vs. non-reinforcing) effects on characters' rated personality, likeability and befriending likelihood will be moderated by participants levels of extraversion. More tentatively, we suggest they may be moderated neuroticism, agreeableness, and autistic traits.

For the reader's ease, Figure 1.4 below is a colour-coded visual representation of how the chapters are grouped in terms of the key themes of the thesis that are described above.

Chapter 1: Introduction

Chapter 2: Motivational Video Study 1

- Individual differences in approach motivation
- Motivational videos as appetitive mood inductions
- Activated vs. pleasant affect
- Line bisection task

Chapter 3: Motivational Video Study 2

- Individual differences in approach motivation
- Motivational videos as appetitive mood inductions with better matched control
- Activated vs. pleasant affect
- Line bisection task

Chapter 4: Motivational Video Study 3

- Individual differences in approach motivation
- Motivational videos as appetitive mood inductions
- Activated vs. pleasant affect
- EEG alpha asymmetry

Chapter 5: ASI Study 1

- Individual differences in social reinforcement learning
- Probabilistic task testing reinforcing effects of smiles on social perception and name memory

Chapter 6: ASI Replication Study 2

- Individual differences in social reinforcement learning
- Counterbalanced probabilistic task testing reinforcing effects of smiles on social perception & name memory

Chapter 7: Discussion

Figure 1.4: A diagram showing the dissection of chapters relative to the main themes of the thesis, which are colour-coded accordingly. The yellow boxes include a broad literature review (Introduction) and general discussion of all common themes of the thesis. The blue boxes follow the first key theme of the thesis; the effects interpersonal approach motivation (first phase of motivated behaviour). The red boxes follow the second key theme of the thesis; the effects of reinforcement learning in a social context (third phase of motivated behaviour).

Chapter 2

Do “motivational videos” operate by means of providing interpersonally rewarding incentives? A novel study exploring the individual differences in the effects of these videos on mood and a proxy for left frontal activation.

2.1 Introduction

In chapter 1 we noted the growing popularity of so-called “motivational videos” on YouTube. These videos usually involve a speaker, often one who is deemed inspirational, talking to a group of people or directly to a camera about ways in which their audience can enhance their life (e.g., success, fitness, health, happiness, etc.). This is likely to include activating language, gestures, visual scenes, and music. This study is the first of three studies in this thesis which will explore the notion that motivational videos are a source of a positive mood induction by inducing approach motivation and emphasising positive (rewarding) incentives.

2.1.1 Appetitive mood inductions

Researchers in the past have set out to show that states of approach motivation and activated affect (e.g., feelings of arousal) are not only induced by the objective presence of reward stimuli, but even by the mere mental imagery of a rewarding situation (Smillie et al., 2012). Experimental approaches have often tested the effectiveness of appetitive mood induction procedures through vignettes, guided imagery, and reflection on one’s life events (e.g. Gomez et al., 2000; Helmers et al., 1997; Larsen & Ketelaar, 1989; 1991; Smillie et al., 2012). Mood induction studies over the years have developed optimization strategies to enhance the induction of the targeted state, for example by playing mood-congruent music during the induction process (e.g., Smillie et al., 2012; Westermann et al., 1996). Considering the characteristics of motivational videos described above, it therefore seems reasonable to suggest that motivational videos are analogous to such appetitive mood induction procedures and may generate similar effects.

The current study sets out to be the first of its kind to test if online motivational videos can be used as a mood induction source. The assumption is that the interpersonal aspects of the motivational speaker (e.g., eye contact, and personally-directed speech; Kennis et al., 2013) and the goal-directed content of the language used (Smillie et al., 2012), work to socially incentivise the rewards being pursued by the viewer, in turn endorsing situational motivation (Vallerand, 2002) and subsequently increasing activated affect (Smillie et al., 2012).

In this study we will look in fine-grained detail at the precise nature of the mood changes that a motivational video might induce. Specifically, we will analyse whether a motivational video (relative to a control video) exerts its effect by changes in activated/deactivated mood or by changes in pleasant/unpleasant mood. Exploring potential individual differences moderators of the effects of motivational videos may give us an indication of why these videos vary in their effectiveness across the range of people who watch them.

The distinction between activating and pleasant mood effects has been emphasized by Smillie et al. (2012) who, in a series of studies found that energetic arousal (i.e., activated affect) increased after an appetitive mood induction (e.g., buying a lottery ticket and winning), with no change in hedonic tone (i.e., pleasant affect), compared to a pleasant mood induction (e.g., laying in the sun on a tropical beach). The series of studies also showed that extraversion moderated the effects of appetitive mood inductions (on activated mood) while extraversion had no effect on hedonic tone mood inductions which enhanced pleasant moods (Smillie et al., 2012).

To anticipate the research that will follow we will present an experiment comparing the effects of motivational versus control videos on affect ratings (among other variables), in which we make specific predictions for the nature of the interaction between the nature of the video and affect type.

2.1.2 Associations with the Reinforcement Sensitivity Theory

As outlined in chapter 1, within the Reinforcement Sensitivity Theory (RST; Pickering et al., 1995; Smillie et al., 2006), the term ‘appetitive motivation’ is described as energizing approach behaviour, with an accompanying state of activated affect (e.g., feelings of alertness; Davidson et al., 1990; Smillie et al., 2012). Appetitive motivation occurs when the prospect of rewarding stimuli triggers the activation of the dopaminergic system and other subcortical areas that respond to reward cues (for a review, see Hikosaka et al., 2008), including social stimuli and incentives (Insel, 2003; Marengo et al., 2020; Pfeiffer et al., 2014). As personality dispositions can increase the reinforcing value of social incentives, engaging in social interactions might be experienced as more intrinsically rewarding for those with a heightened inclination to seek social rewards (Buss, 1983).

In the RST (Pickering et al., 1995; Smillie et al., 2006), the BAS underlies approach motivation and guides responses to stimuli such as smiling faces, and upcoming rewards (Kennis et al., 2013). The BAS has, therefore, been conceptualized as a stimulus-sensitive, motivational system, and has been argued to underpin some of the variation in the trait of extraversion (Eysenck, 1990; Smillie et al., 2006). The activation of approach behaviour to rewards is then likely to contribute to positive affective states (Smillie et al., 2012). Along these lines, individuals with a high functioning BAS would be predicted to activate reward-related circuits in response to positive stimuli more easily than those with lower functioning BAS (Kennis et al., 2013).

The affective-reactivity hypothesis (ARH; Gross, Sutton, & Ketelaar, 1998) conceptualises findings from BAS research in relation to affect and states that extraverts should be more susceptible to the induction of positive affect. Smillie et al.'s (2012) experiments confirmed that extraverts showed greater affective-reactivity, but only in response to clearly *appetitive* stimuli and situations, as opposed to merely *pleasant* stimuli and situations. They also demonstrated that it is specifically *activated* affect (e.g., feelings of alertness), rather than pleasantly *valenced* affect (e.g., feelings of contentment), that characterizes the affective-reactivity of extraverts. We will explore, in the experiments below, whether this change (in activated rather than in pleasantly valenced affect) characterises the changes to mood profiles induced by watching a motivational versus a control video. The potentially differential profile of mood change for extraverts and introverts will also be used to investigate whether motivational videos exert their effects through appetitive, rather than merely affective, mechanisms.

We now state the above suggestion in a completely explicit fashion: if we assume that motivational videos operate on specifically appetitive processes then, in our experiment below, we would predict that the mood inducing effect of the video seen (i.e., motivational vs. control) would be maximal along the dimension running from activated to deactivated mood. As a contrast, one might argue that motivational videos generate mood change that would be maximal along the dimension running from pleasant to unpleasant affect. In addition to characterising where the mood-changing effects of motivational videos are seen most strongly, we will also explore whether these mood change effects are moderated by extraversion. Based on the work by Smillie et al (2012), and their refinement of the ARH, we predict that if motivational videos promote activated mood specifically, then the size of the motivational video effect would be moderated by extraversion (with larger effects for extraverts and smaller for introverts).

The personality traits proposed to relate to variations in BIS reactivity are trait anxiety and neuroticism (Barlow et al., 2014). Both trait neuroticism and BIS have been linked to negative emotional reactivity, a propensity for generally unpleasant experiences, and promote the induction of many unpleasant emotions (e.g., fear, sadness, anger, disgust; Gray, 1981). Therefore, Gray (1994) identified anxiety as resulting from an active BIS. This association is evident in the context of mood induction studies. For example, Thake and Zelenski (2013) used mood-inducing film clips and found that high neuroticism and scores of BIS-anxiety predicted participants' reactivity to fear and sadness inductions. A relationship was also found between neuroticism and susceptibility to social influence (Oyibo & Vassileva, 2019), which could enhance a reaction to the interpersonal aspects of a motivational video. In light of these findings, the current study will also explore how neuroticism interacts with the effects of interpersonal motivational videos. Motivational videos are often somewhat ambiguous, and so it seems likely, for example, that people may react differently when someone with a perceived superior status (or someone acting in a superior or expert fashion) forcefully tells them what they need to do to succeed. Some people may perceive this as condescending or even mildly threatening, while others may perceive it as the positive strategic and motivational push they need. If the videos may signal threat to some viewers, as well as acting as an appetitive incentive for others, then those scoring higher on a BIS-linked trait, such as neuroticism, may perceive them as more threatening, as opposed to incentivising, with the potential to induce more negatively-valenced affect (e.g. Rafienia et al., 2008). The relationship between BIS-related neuroticism and negatively-valenced *activated* affect remains unclear, as most research has focused on neuroticism and its relationship with negative-valenced emotional reactivity to relevant stimuli (e.g., Deckersbach et al., 2006; Ebmeier et al., 1994; Fischer et al., 1997; Johnson et al., 1999; Kim et al., 2008; O'Gorman et al., 2006).

2.1.3 Left frontal activation: Line bisection

Reflecting the neurobiological standpoint of the RST, the balance between activity in the left and right frontal cortex, commonly referred to as asymmetric frontal cortical activity, has been widely used as a proxy for an organism's motivational orientation; in short it is claimed that there are approach-avoidance laterality effects (Davidson et al., 1990). Relatively stronger left frontal cortical activity is thought to be associated with approach motivation, while relatively stronger right frontal cortical activity, is associated with avoidance motivation (for a review, see Kelley et al., 2017).

A widely used behavioural measure of relative cerebral hemispherical asymmetry is the line bisection task (Jewell & McCourt, 2000), where participants are asked to indicate the perceived midpoint of multiple horizontal lines. Tendencies toward rightward versus leftward errors in midpoint estimations are deemed to reflect relative primacy of right versus left visual fields, respectively, and corresponding neural activity in the contralateral hemisphere, i.e., greater activation of the left versus right hemisphere (Milner, Brechmann, & Pagliarini, 1992). Nash and colleagues (2010) used neuroimaging, self-esteem measures, and challenge manipulations to demonstrate that line bisection bias is specifically related to baseline, approach-related, prefrontal EEG alpha asymmetry. They used logarithmically transformed alpha power to calculate asymmetry scores. Specifically, they computed this as right-site minus homologous left-site log alpha power, for all homologous pairs. Using these values, they found that greater rightward line bisection bias corresponded to greater right minus left log alpha power (described in detail in chapter 1, section *1.2.3.1 A proxy measure of left frontal activation*).

In the study reported here, we use line bisection (as a proxy for asymmetric frontal activation) to again test whether motivational videos exert their possible effects via enhancing appetitive motivation. If a motivational video activates appetitive brain systems, then it should induce a relative increase in left frontal cortical activation, which in turn will be associated with a rightward bias in line bisection. If the motivational videos are shown, by other results in our study, to activate appetitive brain systems, but do not produce appropriate shifts in line bisection, then we can tentatively conclude that the line bisection task we used was not a suitable index of approach-avoidance lateralisation or conclude that the effects predicted by approach-avoidance lateralisation are absent or weak.

2.1.4 The Present Study

In the current study the test of a motivational video's mood-inducing properties was operationalised using a pre-post experimental design, with two randomly assigned independent groups of subjects. One group watched a typical online motivational video, and the other watched a control video. In line with previous research using reward-based mood inductions (e.g., Smillie et al., 2012) activated affect, as opposed to positive valence, will be considered as the focal dependent variable. The experimental hypotheses are that, overall, the motivational video will increase, from pre- to post-test, all segments of mood (segments refer to subdivisions of circumplex models of mood; Yik et al, 2011) that involve activated affect; such segments are described as *pleasant activation, activation,* and *unpleasant activation*. Viewing the motivational video will also be accompanied by a decrease in segments of deactivated affect, labelled *unpleasant deactivation, deactivation, pleasant deactivation*. The motivational video, by this prediction, will produce relatively smaller changes in both pleasant affect (*pleasure, activated pleasure, deactivated pleasure*) and unpleasant affect (*displeasure, activated displeasure, deactivated displeasure*). Specifically, we can describe this prediction as a specific pattern of interaction between affect segments and video condition (more details are given below). Additionally, we chose the control video with the intention that there would be no difference between the two videos in intrinsic motivation scores, which are used as a control measure. This outcome would ensure that, if the motivational video does have a different mood-inducing effect from the control video, it is not due to the participants' interest levels in the content of the videos, but rather due to the mood-altering interpersonal incentives specifically emphasised via the content of the motivational video.

The personality traits extraversion and neuroticism will be measured to investigate whether they moderate the change of affect as a function of video type, where the effects of the motivational video on activated affect are predicted to be greater for those who score high on extraversion, due to the proposed dependence of extraversion on BAS functioning. It is predicted that extraversion and neuroticism will enter into specific relationships with interactions between affect segment and video type. The specificity of the prediction for extraversion derives directly from the clear pattern reported by Smillie et al (2012) in which extraversion specifically moderated the changes in activated affect that they induced. In light of the existing literature on neuroticism and a predisposition for negative emotional reactivity (e.g. Deckersbach et al., 2006; Ebmeier et al., 1994; Fischer et al., 1997; Johnson et al., 1999; Kim et al., 2008; O'Gorman et al., 2006; Rafienia et al., 2008), it is also predicted that these video by affect effects may mean more negatively-valenced affect for those scoring higher on neuroticism, though the moderator effects for neuroticism are predicted more tentatively. As reviewed above, there is no direct empirical evidence for BIS-mediated effects on activated affect, but rather a focus on the effect of negative mood inductions on negative affect in general. The way that these specific mood by video type effects are analysed will be described in detail below. Finally, it is hypothesized that motivation and increased activated affect will be accompanied by a rightward line bisection bias for those watching the motivational video, indicating left frontal activation, whereas this pattern will not be seen in those who have watched the control video.

2.2 Method

2.2.1 Sample

115 first year undergraduate psychology students at Goldsmiths, University of London participated in the study (*M* age = 21.1, *SD* = 5.28, *rang*e = 18-52, 20 males). 124 participants were initially recruited, but 9 participants were excluded from the original sample due to extensive missing data. A further 17 of the 115 participants had >50% of missing data points on the pre and/or post mood ratings (see below for how these missing data were treated). The recruitment source was a university research participation scheme, where student participation was exchanged for course credits as partial completion of the course. Informed consent was provided prior to the commencement of the experiment, in accordance with the ethical approval given by the Psychology Department Ethics Committee at Goldsmiths, University of London. All the participants were tested simultaneously in a large, silent lecture hall, with each participant watching the video and responding to the questionnaires via an online Qualtrics link. Each participant carried out the study on their own laptop or smart device and wore headphones throughout the study. The students were randomly assigned to a video type using an automatic randomisation feature, which was triggered upon opening the Qualtrics link.

2.2.2 Personality, mood, and motivation measures

Within this pre-post manipulation design, explicit psychometric measures of mood, personality, and motivation were used. To measure pre-post differences in mood the affect adjective list from the 12-Point Circumplex Structure of Core Affect (12-PAC; Yik, Russell, and Steiger, 2011) was administered twice: before and after watching the video. The 60 adjectives of core affect included in the 12-PAC are divided into 12 segments, each representing a state of emotion (see Figure 2.1). These segments and examples of items included in each segment are as follows (in the order by the numbering of the segments around the clockface starting with segment number 12): pleasant activation (*e.g. energetic*), activated pleasure (e.*g. enthusiastic*), pleasure (*e.g. happy*), deactivated pleasure (*e.g. peaceful*), pleasant deactivation *(e.g. relaxed*), deactivation (*e.g. still*), unpleasant deactivation (*e.g. bored*), deactivated displeasure (*e.g. gloomy*), displeasure (*e.g. troubled*), activated displeasure (*e.g. tense*), unpleasant activation (*e.g. anxious*), and activation (*e.g. hyperactive*),. All 60 adjectives were included in the experiment, and participants were required to rate the extent to which they were feeling each item at that moment in time.

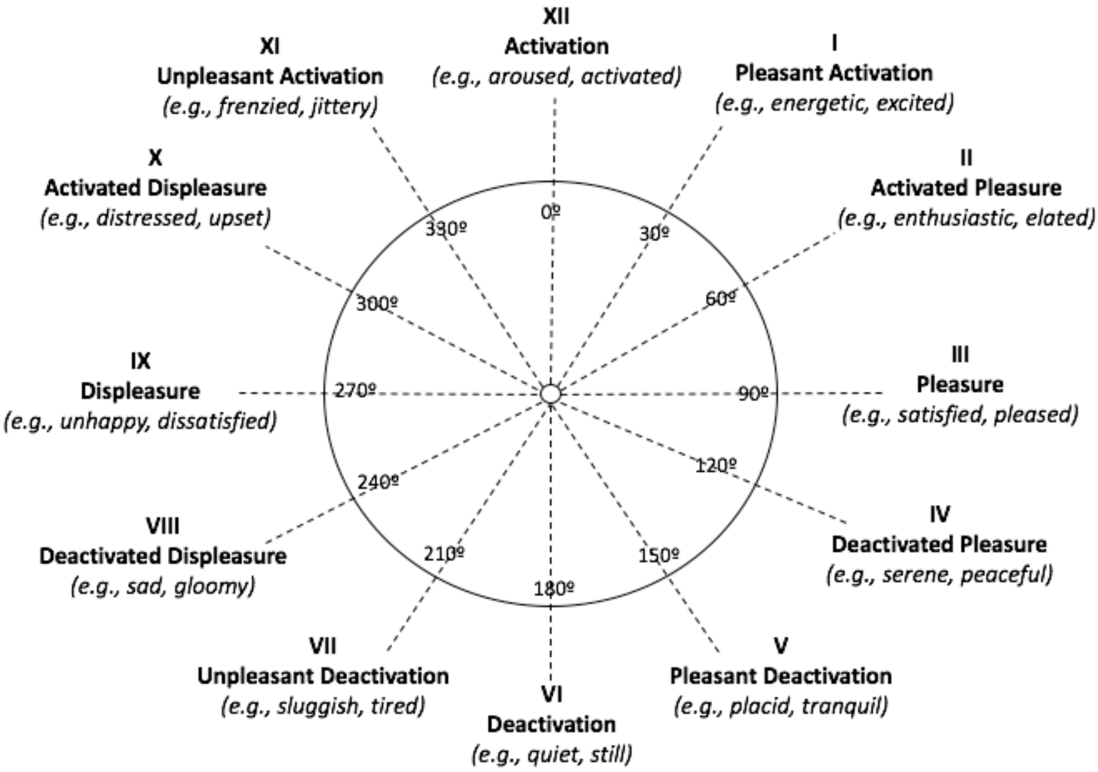


Figure 2.1: 12-Point Affect Circumplex (12-PAC; redrawn from Yik et al., 2011). Shows a schematic diagram of the hypothetical locations of the 12 segments of Core Affect.

The Big Five Aspects Scale (BFAS; DeYoung et al., 2007) was used to measure levels of extraversion and neuroticism. These trait measures were given before participants watched the video. Extraversion has been found to be associated with reward sensitivity and appetitive mood induction, particularly with social reward (e.g., Buss, 1983; Smillie et al., 2012), while neuroticism has been shown to have propensity to react to negative mood inductions (e.g., Larsen & Ketelaar, 1989; Thake & Zelenski, 2013).

Additionally, the state motivation items of the Dundee Stress State Questionnaire (DSSQ; Matthews et al., 2002) were adapted and used to test the intrinsic motivation of the participants as a control measure, i.e., they were asked to rate the extent to which they were interested in the content of the motivational video, and how motivated they were to continue watching the video. Ideally, there should not be a significant difference in this variable between the two videos. All seven of the intrinsic motivation items were used, examples included *"watching the video was worthwhile", "I found the video boring"* (note that this item is reverse-keyed). This questionnaire was given post-manipulation only, i.e., after the video was shown.

An addition of one item from the success motivation facet of the DSSQ (Matthews et al., 2002) was adapted and included, as it was deemed to be of use for explicitly representing approach motivation (*"the video brought out my competitive drives"*). However, this was excluded from the sum of the intrinsic motivation scores and was treated as a separate dependent variable in the analysis. Significantly higher competitive drive scores were predicted for the motivational video. This item can be considered a manipulation check, as the motivational video, by definition, should produce a greater increase in this single item than the control video.

2.2.3 Motivational video

Both the motivational video and control video used were acquired via the video platform YouTube.com. Participants' assignment to the video was randomised (N = 55 watched the motivational video). The motivational video *"You Can Do It – One Of The Best Motivational Videos Ever Created For Students, Success And Studying"* was created by motivational speaker Tom Bilyeu, and was acquired from the YouTube channel *"Motivation2Study"* (link to video: https://www.youtube.com/watch?v=wXkryZEZ68s&t=1s). Its duration was 3:20 minutes. After reviewing many examples of motivational videos from YouTube, this particular video was chosen by the author as a very typical video of the genre, produced by a speaker with many followers, while being short enough to work in an experimental study. In accordance with other mood induction procedures (e.g., Mayer et al., 1995; Smillie et al., 2012; Westermann et al., 1996), the motivational video already included a background soundtrack with music that was intended to be as inspirational, which in this case was *"Galaxy Falling"* by Really Slow

Motion. The video presented the male speaker talking directly to the camera, displaying perceived eye contact with the viewer, while scenes of people undergoing hard work in various forms flashed up intermittently. The content of the speech expressed the actions needed to be taken (*e.g., hard work, perseverance)* in order to achieve the reward of being successful in the (life) goals of the viewer, while also giving positive feedback about the viewer's limitless potential to achieve these goals.

To test the effects of the social incentive and intrinsic motivation aspects of the video, a control video was included in the between-subjects experimental design. The video *"Would You Like To Become A Clinical Psychologist? – Video 2 Train at UCD Work In The USA"* was found on the YouTube channel *UCD Psychology* (link to video: https://www.youtube.com/watch?v=UL9vkwvLY98). Its duration was 3:07 minutes. The video shows a female clinical psychologist being interviewed and describing her experience working in Boston following graduation from the UCD Doctoral Programme in Clinical Psychology. No overtly approach-related language was expressed, and the speaker's eye-gaze was directed away from the camera at all times, thereby avoiding perceived eye contact with the viewer. In addition to its lack of overt approach-related language and direct eye gaze, this particular video was also selected as the control video, after reviewing many candidates on YouTube, because it was close to the motivational video in length and was likely to be intrinsically interesting to the participants (psychology undergraduates).

In order to partially control for the effects of the inspirational music on the mood induction, the control video was edited so that the soundtrack from the motivational video was added. It must be noted that it was particularly difficult to match exactly the volume of the background music with that of the motivational video, without drowning out the voice of the psychologist; therefore, the music in the control video was slightly quieter than in the motivational video.

2.2.4 Line bisection task

The line bisection task (as adapted from Nash, McGregor, & Inzlicht, 2010) was administered as an indicator of differences in left frontal asymmetry. The task was digitalised and adapted into an online version, where it was conducted on the Qualtrics online survey platform (Qualtrics, Provo, UT). 30 scale bars were displayed one at a time and the participants' task was to line up their cursor, by pointing a mouse (or their finger if their device had a touchscreen), to where they thought the centre of the bar was, and then click (or touch the screen if their device had a touchscreen). The bar was presented in the same position, the centre of the screen, for every line bisection trial. However, the pointer's starting position was randomised to be either on the far left or right of the bar. After the participant had made their selection, the pointer then appeared where they perceived the midpoint to be and marked where they had bisected the bar. While the participants were asked to do this as quickly as possible, without overthinking, they were still able to adjust their response after selecting by repointing and clicking (or tapping), as there was no option to remove this on the software.

Based on the scale given by Qualtrics (where a score on the right-most extreme of the bar equalled 100, and the left most extreme equalled 0), the real midpoint value of 50 was subtracted from their scores, so that a positive result indicated a rightward bias in line bisection. A mean line bisection deviation score was then measured by averaging the scores across the 30 lines. Positive values, indicating a rightward bisection shift are consistent with an assumption of relatively greater left than right hemispheric activation (Jewell & McCourt, 2000; Nash, McGregor, & Inzlicht, 2010). A reliability analysis of the 30 lines determined an acceptable Cronbach's alpha coefficient of .78 (Coolican, 2009).

Figure 2.2 is a schematic diagram showing the order that the scales and measures were given before and after the participants views either video.

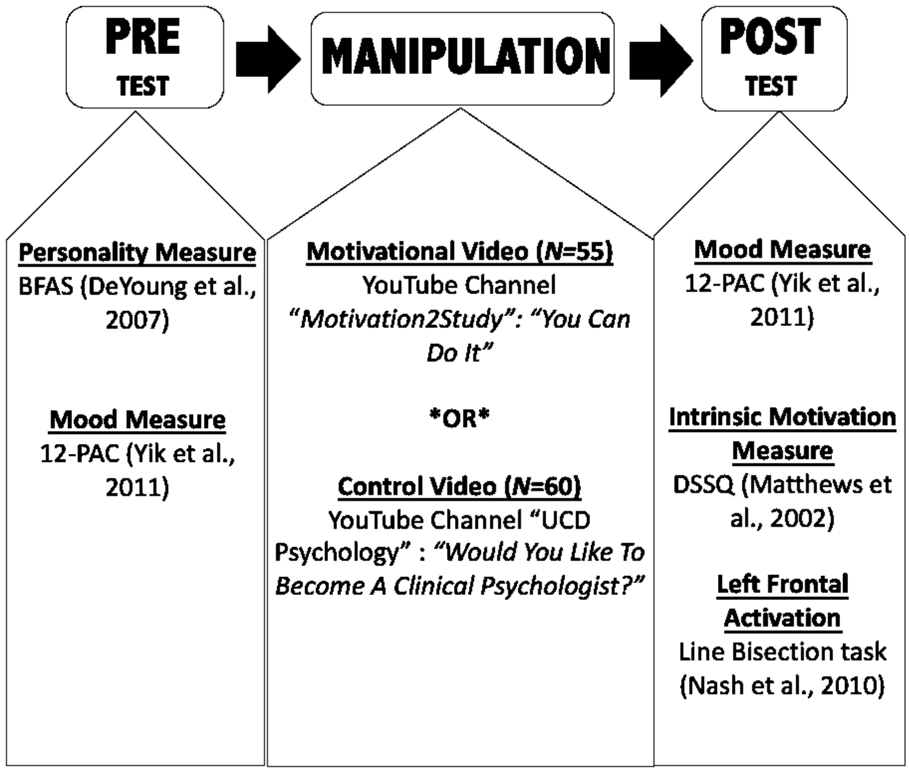


Figure 2.2: A schematic diagram showing the order of the scale and tests before and after the video manipulation. In the pre-, and post-, phases the order of measures was from top (given earlier) to bottom (given later).

2.2.5 Data analyses

Data were analysed using SPSS version 23.0 or 24.0. Additionally, MATLAB version R2019b with the VBA Toolbox (Daunizeau, Adam, & Rigoux, 2014) was used to conduct Bayesian model comparisons, using a bespoke script that implemented the circumplex models on the participants' data and called the functions provided by the VBA toolbox.

2.2.5.1 Mood induction effects

Means for pre-test and post-test affect adjectives were computed for each of the 12 core affect segments (Yik et al., 2011). The main dependent variables here were the change in affect segment scores, which was calculated by subtracting the pre-test scores from the post-test; therefore, positive scores indicate an increase in the affect levels for that segment.

The study attempted to test and compare two specific models, which we will refer to as model 1 and model 2. Model 1 supposes that motivational videos act on affect primarily along the axis running from point XII in the circumplex in Figure 2.1 above (activation; maximum effect; at 0 degrees) through to point VI (deactivation; minimum effect; at 180 degrees [= π radians]). We were particularly interested to contrast this with model 2, in which the effects of the video are supposed to act along the axis from point III (pleasure; maximum effect; at 90 degrees [= π/2 radians]) to point IX (displeasure; minimum effect; at 270 degrees [= 3*π/2 radians]). If the points along the x-axis are arranged from left to right in the order I to XII as in Figure 2.1, then the predicted effect sizes of affect changes in the motivational video condition, under the two models, can be easily determined. Specifically, we can write θ_k to represent the angle of each affect segment around the circumplex, where k goes from 1 to 12 (the values of these angles in degrees are given in Figure 2.1). The expected mood segment change, E_{1k}, of any manipulation acting according to model 1 on mood segment k, is given by:

$$E_{1k} = a_1 + b_1 * \cos(\theta_k) \qquad (2.1)$$

where b_1 is an amplitude scaling constant for the circumplex effect under model 1, and a_1 is an intercept term reflecting a constant change in mood irrespective of the affect segment concerned. Similarly, the analogous effect under model 2 is given by:

$$E_{2k} = a_2 + b_2 * \cos(\theta_k - \pi/2) \qquad (2.2)$$

A graphical representation of the model effects is shown in Figure 2.3 with $a_1=a_2=0; b_1=b_2=1$ and the affect segments numbered 1-12 (following the numbering in Figure 2.1).

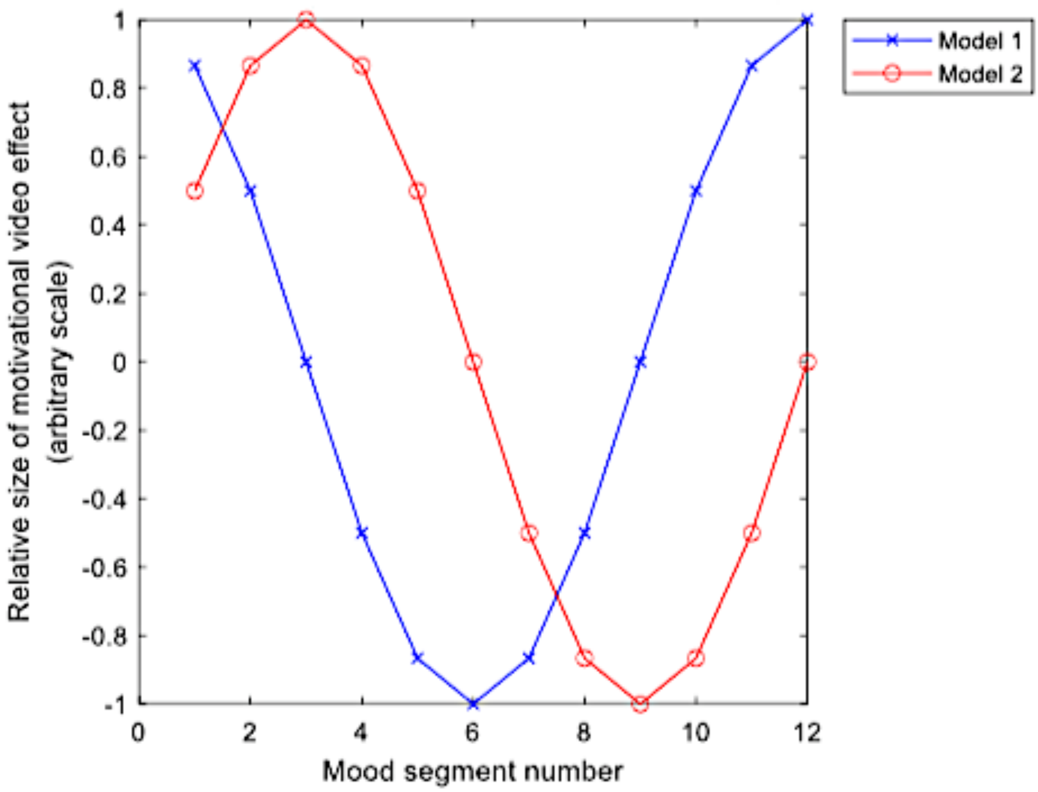


Figure 2.3: Predicted affect change effects under model 1 and model 2 as a function of mood segment around a circumplex.

To test these models, we created repeated measures trend contrasts across the repeated-measures affect segments reflecting the above circumplex models. The values plotted in Figure 2.3 are the basis for these contrast coefficients. The values in Figure 2.3 sum to zero across each model already, and the values for each model are orthogonal to one another over model segments. The latter is true because the two model plots are phase-shifted by $\pi/2$ radians (90 degrees) with respect to each other, meaning that the effect measured by one contrast is orthogonal to (i.e., is uncorrelated with) the other effect. However, we also normalized the values from Figure 2.3 (by dividing each value by 2.4495, the L2 norm of the 12-element vectors formed from the values in Figure 2.3); it is conventional that sets of contrasts used in an ANOVA are orthonormal.

The contrast analyses just described use so-called fixed effects techniques: the mean contrast value estimated across all the participants is tested (to see if it is significantly different from 0). The effect is fixed for all cases and the error term used reflects the random error variation across participants.

To refine the model comparisons still further, variational Bayesian inference techniques with random effects modelling (based on an extension of the mood circumplex models noted above) were implemented in a MATLAB script that was able to utilise routines from the VBA toolbox (Daunizeau et al., 2014). The first key difference is that each mood item is considered separately as an equivalent measure of the mood change relating to its specific segment. The fit of the circumplex models is determined for each participant individually. In the earlier fixed-effects analyses one score for each mood segment was used per participant (based on the average across the items relating to that segment) and a common circumplex model equation was found across all the participants in each condition.

Strictly speaking, the approach we described above (with Bayesian inference) is not random effects modelling in its conventional form. In standard random effects models (also known as mixed models) the data from each of the individual participants are typically all fit simultaneously and the coefficients obtained are constrained to come from a specified (random) distribution. This means that the error term and fit of one participant is affected by the error term and fit of every other participant. This approach would often be referred to as hierarchical random effects modelling or just hierarchical modelling (e.g., Katahira 2016). Recent work (e.g., Katahira 2016) has shown that hierarchical modelling offers improved reliability over non-hierarchical approaches (such as fixed effects modelling).

Although our approach also considers that the parameters are random effects across participants, in contrast to hierarchical modelling, we estimate the model parameters for each participant separately. This approach has been called single-subject maximum likelihood estimation (SSMLE) or MLE at the individual level (Katahira, 2016; Ahn et al, 2011). Hierarchical models have been shown to offer better estimation than our approach in simulation studies, but specifically "*when the parameters for individual subjects are assumed to be drawn from a population distribution that is shared by all subjects within a group*" (Katahira, 2016, pp. 39). In our current study we do not know that a population level version of model 1 (or model 2) will describe the mood change behaviour of all the participants in our sample. Indeed, either model might be an accurate reflection of the behaviour of just a subset of our participants, or none, and other models might capture the responses of yet other participants. For this reason, we preferred to start with the more conservative single-subject maximum likelihood estimation approach (henceforth SSMLE). This approach seems intuitively more suited to our analytical goals, where want to estimate the fit of each participant independently of every other participant. This also means that our distribution of fitted parameters is not guaranteed to conform to a specific random distributional form. We will describe a third analytic strategy (using general estimating equations, see below).

To do this SSMLE modelling, we continue to denote that there are k = 1:12 mood segments (approx. 5 items for each segment) theoretically arranged at evenly-spaced angles ($\frac{\pi}{6} \leq \theta_k \leq 2 * \pi$) around the circumplex (now using radians rather than degrees; see Figure 2.1 above). We are interested in which of two random effects models fit our data the best (we referred to these as model 1 and model 2 above). These models can be represented in a general form using Equation 2.3 below:

$$\Delta mood_{ik} = a_i + b_i * \cos(\theta_k + \varphi) \quad (2.3)^1$$

where i denotes the ith case and k denotes any of the individual mood items relating to the kth segment. The activation-deactivation model (model 1) proposes that the maximum (minimum) mood changes will occur at k = 1; $\theta_k = 0$ (k = 6; $\theta_k = \pi$). This can be represented by setting the phase term, φ, in equation 2.3, to 0. The pleasure-displeasure model (model 2) is phase shifted by $\frac{\pi}{2}$ and thus is captured by equation 2.3 with $\varphi = -\frac{\pi}{2}$. The pleasure-displeasure model therefore has a maximum (minimum) mood change at k=3 (k=9). For both models 1 and 2, the maximum and minimum points can be swapped over to reflect deactivation-activation or displeasure-pleasure models respectively (where the first named mood segment is that with the maximal value under the model fit, and the second named segment is that with the minimal value). These "swapped models" simply differ in the sign of the coefficient b_i. For example, we will fit model 1 to an individual participant's mood change across all 60 items. The best fitting version of model 1 for that participant may have a positive or negative value of b_i. If the value is positive, then we would describe their model 1 as an activation-deactivation model fit; if the value is negative, we would describe it as a deactivation-activation model fit (but either fit is a fit for model 1). The equivalent point applies to fits obtained using model 2.

[1] The cosine values were L2 normalised before the use in this equation, matching the fixed effects contrast analyses above.

For comparison with models 1 and 2, we also consider an intercept-only model (model 0) in which $b_i = 0$ for all participants (see Appendix A for all comparisons made with the intercept model and related analyses).

As noted, these models were fit at the level of each individual participant, estimating the values of a_i and (for models 1 and 2) b_i for each participant (where different cases are denoted by the subscript *i*). This is possible because there are several different mood adjectives used to estimate the mood change for each of the *k* mood segments. Bayesian model selection (BMS; Rigoux et al., 2014; Stephan et al., 2009) is used to estimate which model, from a group of models being compared, fits best across the sample and it also provides information for each case about which model best fits their individual performance.

2.2.5.2 Key hypotheses and statistical considerations for the fixed-effects and SSMLE mood induction analyses

Hypothesis 1A (1A means relating to model 1, but *not* including personality effects) is that the mood change induced by motivational video will be greatest along the activation-deactivation axis of the mood circumplex, and the effect along this axis will be greater for the motivational video than for the control video. The statistical tests of this hypothesis form a single family of tests and we adjust the Type 1 error (alpha) rate of each test in this family to preserve the so-called familywise error rate (the probability of making at least one type 1 error in that family; Lakens et al., 2018; Lakens, n.d.). The tests are traditional null hypothesis significance tests, except where stated. The six statistical tests that are in this family are listed below, each of which is expressed in terms of H1 (the alternative hypothesis):

i) A test of the model 1 fixed-effects circumplex contrast by condition interaction. This test assesses whether the mean contrast value is further away from zero in the motivational video condition compared with the control condition.[2]

[2] We used two-tailed tests here even though we had clear directional predictions as a further degree of protection against Type 1 errors.

ii) A test of the model 1 fixed-effects circumplex contrast in the motivational video condition alone. This test assesses whether the mean contrast value is not equal to zero in this condition.

iii) An equivalence test of the model 1 fixed-effects circumplex contrast in the control condition alone. This test assesses whether the mean contrast value is relatively close to zero (i.e., lies between two specified bounds either side of zero) in this condition. Equivalence testing is explained briefly below.

iv) A test of the model 1 contrast by condition interaction using the circumplex contrast (coefficient) values obtained for each subject individually via SSMLE estimation. This test assesses whether the mean contrast value is further away from zero in the motivational video condition compared with the control condition.

v) A test of the model 1 contrast in the motivational video condition alone using the circumplex contrast (coefficient) values obtained for each subject individually using SSMLE estimation. This test assesses whether the mean contrast value is not equal to zero in this condition.

vi) An equivalence test of the model 1 circumplex contrast, obtained using SSMLE estimation in the control condition alone. This test assesses whether the mean contrast value is relatively close to zero (i.e., lies between two specified bounds either side of zero) in this condition.

It should be noted that we include all these 6 tests in one family as they are testing the same hypothesis using two sets of 3 tests, with each set based on different contrast estimation methods. We had not decided before the experiment which contrast estimation methods to use and therefore, we pay a price for this in our alpha adjustment. Given that there are 6 key tests of our single scientific hypothesis (1A), then the adjusted alpha level per test is $\alpha = \frac{.05}{6} = .0083$.

For the equivalence tests, the two one-sided tests (TOST) procedure can be used to test the null hypothesis that the true effect is at least as extreme as the smallest effect size of interest. Equivalence tests are an important extension of the traditional statistical tools researchers currently use, enabling them to falsify predictions about the presence, and/or declare the absence, of meaningful effects (Lakens et al., 2018). As already noted, we treated all the analyses that test hypothesis 1A as a family of tests, whether they were traditional statistical tests or equivalence tests. We did the same for a separate family of tests which address hypothesis 2A. To perform the TOST procedure, we used the *jamovi* software (version 1.6.21) using the TOSTER module.

Hypothesis 1B (1 denotes model 1, and B denotes a personality-related hypothesis) is that each of two personality traits (extraversion or neuroticism) will moderate the overall effects predicted under hypothesis 1A. The statistical tests of this hypothesis are a single family and need alpha adjustment as discussed above. The six statistical tests that are in this family are listed below:

i) A test of the correlation between extraversion and the interaction between video condition and the model 1 fixed-effects circumplex contrast. Hypothesis 1B predicts that this correlation will be different from zero.

ii) A test of the correlation between extraversion and the fixed-effects model 1 circumplex coefficients for the motivational video condition alone. Hypothesis 1B predicts that this correlation will be different from zero.

iii) An equivalence test of the correlation between extraversion and the fixed-effects model 1 circumplex coefficients for the control video condition alone. This test assesses whether the correlation is relatively close to zero (i.e., lies between two specified bounds either side of zero), as predicted by hypothesis 1B.

iv) A test of the correlation between neuroticism and the model 1 interaction between video condition and model 1 fixed-effects circumplex contrast. Hypothesis 1B predicts that this correlation will be different from zero.

v) A test of the correlation between neuroticism and the fixed-effects model 1 circumplex coefficients for the motivational video condition alone. Hypothesis 1B predicts that this correlation will be different from zero.

vi) An equivalence test of the correlation between neuroticism and the fixed-effects model 1 circumplex coefficients for the control video condition alone. This test assesses whether the correlation is relatively close to zero (i.e., lies between two specified bounds either side of zero), as predicted by hypothesis 1B.

It should be noted that although our primary interest is in the trait of extraversion, and the predictions for neuroticism under hypothesis 1B are more tentative as noted above, we are conservatively treating all of these 6 tests as a single family addressing a single hypothesis.

Therefore, given there are 6 tests in this family, the adjusted alpha level is $\alpha = \frac{.05}{6} = .008$. For reasons that will be made clear below we are not including any correlation tests relating to circumplex contrasts estimated using SSMLE methods at this point.

Hypothesis 2A is directly analogous to hypothesis 1A except that it relates to the contrast coefficients under model 2 rather than model 1. Hypothesis 2A proposes that the mood change induced by motivational videos will be along the pleasure-displeasure (model 2) axis of the mood circumplex and argues that this effect will be greater for the motivational video than the control video (although this hypothesis is written as an alternative hypothesis, based on Smillie's research, we didn't expect this result to occur). The statistical tests of this hypothesis are a single family and need alpha adjustment. The six statistical tests that are in this family are listed below:

i) A test of the model 2 fixed-effects circumplex contrast by condition interaction. This test assesses whether the mean contrast value is further away from zero in the motivational video condition compared with the control condition.
ii) A test of the model 2 fixed-effects circumplex contrast in the motivational video condition alone. This test assesses whether the mean contrast value is not equal to zero in this condition.
iii) An equivalence test of the model 2 fixed-effects circumplex contrast in the control condition alone. This test assesses whether the mean contrast value is relatively close to zero (i.e., lies between two specified bounds either side of zero) in this condition.
iv) A test of the model 2 contrast by condition interaction using the circumplex contrast (coefficient) values obtained for each subject individually via SSMLE estimation. This test assesses whether the mean contrast value is further away from zero in the motivational video condition compared with the control condition.
v) A test of the model 2 contrast in the motivational video condition alone using the circumplex contrast (coefficient) values obtained for each subject individually using SSMLE estimation. This test assesses whether the mean contrast value is not equal to zero in this condition.
vi) An equivalence test of the model 2 circumplex contrast (coefficient), obtained using SSMLE estimation in the control condition alone. This test assesses whether the

mean contrast value is relatively close to zero (i.e., lies between two specified bounds either side of zero) in this condition.

Given that there are 6 key tests of our single scientific hypothesis (2A), then the adjusted alpha level per test is $\alpha = \frac{.05}{6} = .0083$.

Hypothesis 2B (2 denotes model 2, and B denotes a personality-related hypothesis) is that each of two personality traits (extraversion or neuroticism) will moderate the overall effects predicted under hypothesis 2A. The statistical tests of this hypothesis are a single family and need alpha adjustment as discussed above. The six statistical tests that are in this family are listed below:

i) A test of the correlation between extraversion and the interaction between video condition and the model 2 fixed-effects circumplex contrast. Hypothesis 2B predicts that this correlation will be different from zero.

ii) A test of the correlation between extraversion and the fixed-effects model 2 circumplex coefficients for the motivational video condition alone. Hypothesis 2B predicts that this correlation will be different from zero.

iii) An equivalence test of the correlation between extraversion and the fixed-effects model 2 circumplex coefficients for the control video condition alone. This test assesses whether the correlation is relatively close to zero (i.e., lies between two specified bounds either side of zero), as predicted by hypothesis 2B.

iv) A test of the correlation between neuroticism and the interaction between video condition and model 2 fixed-effects circumplex contrast. Hypothesis 2B predicts that this correlation will be different from zero.

v) A test of the correlation between neuroticism and the fixed-effects model 2 circumplex coefficients for the motivational video condition alone. Hypothesis 2B predicts that this correlation will be different from zero.

vi) An equivalence test of the correlation between neuroticism and the fixed-effects model 2 circumplex coefficients for the control video condition alone. This test assesses whether the correlation is relatively close to zero (i.e., lies between two specified bounds either side of zero), as predicted by hypothesis 2B.

Given that there are 6 key tests of our single scientific hypothesis (2B), therefore the adjusted alpha level is $\alpha = \frac{.05}{6} = .0083$.

2.2.5.3 A third type of analysis: using General Estimating Equations (GEE)

Above we have outlined two types of analytic strategy to use with the mood induction data in this thesis: the fixed effects approach (widely used in personality research) and a more novel and sophisticated individual subject analysis (SSMLE). However, we felt it was important to use another approach which can also test the scientific questions we wish to address. To that end we will also use the so-called "marginal model" for our key regressions, and that model (as opposed to a fixed-effects or random effects modelling) can be conveniently estimated using general estimating equations (GEE; first described by Zeger & Yiang, 1986). The relative merits of the GEE approach for estimating the marginal model, relative to other regression modelling methods (fixed-effects or random effects modelling), have been widely discussed. One of the clearest accounts, even though written within the field of epidemiology, is by Hubbard et al (2010). These authors concluded that a GEE approach offers several key advantages making it a "compelling alternative" (p.473). In particular, random effects models are sensitive to a misspecification of the underlying model, whereas the GEE approach is not. Hubbard et al (2010) argue that a misspecification of the model is very likely in many situations. Given our above discussion of possible heterogeneity of the data generating process across different individuals, model misspecification is potentially a real issue for the present data, and so this makes GEE an attractive choice. Moreover, in the case of a linear model (our scenario) these authors also note that, when the data do conform to the assumptions of the mixed model, a GEE approach will yield "practically the same estimator of the parameters" (p. 469) as those obtained using a mixed effects model.

We used the GEE module in SPSS, although the analyses can be run in many other packages. For our data, the dependent variable is, of course, the mood change score from pre to post video exposure, for which we have (a maximum of) 60 responses for each participant. All participants are analysed together and each case thus has 60 lines of data. Each of these mood change responses is coded as being made to one of the 12 specific mood segments on the circumplex (see above). We also generated a model 1 (or model 2) circumplex predictor of the mood change using the equations 2.1 to 2.3 above. For each model, these circumplex predictors thus have 12 specific values depending on the mood segment, and the predictor values are the same for each case. Using model 1 and model 2 in separate analyses, we used these 12 circumplex predictor values in a linear model predicting the mood change observed for those item segments. The model circumplex predictor value is thus used as a repeated-measures predictor of mood change. Our prediction model also uses the between-subjects predictors of video condition (categorical predictor) and personality trait scores (a covariate predictor). Separate analyses are carried out with extraversion and neuroticism scores as predictors in this chapter.

The above analytic approach allows us to test all the key hypotheses discussed. In addressing hypothesis 1A or 2A (the hypotheses without personality stated earlier) we carry out a GEE analysis in which the model 1 (or model 2) circumplex values and video condition are predictors, along with the interaction between these two terms. We predict an interaction between these two predictors under hypothesis 1A in that we expect the motivational video to produce mood changes, along the activation-deactivation axis, as reflected by the model 1 circumplex values for each mood segment. We do not expect the control video to induce mood changes in this way, thereby leading to an interaction. Subsequent analyses, in each video condition separately, will confirm whether the predicted specific pattern of interaction was obtained.

Hypothesis 2A is directly analogous to hypothesis 1A except that it relates to the circumplex values computed under model 2 rather than model 1. Hypothesis 2A proposes that the mood change induced by motivational videos will be along the pleasure-displeasure (model 2) axis of the mood circumplex and argues that this effect will be greater for the motivational video than the control video. Thus, a video by circumplex predictor values interaction is predicted under hypothesis 2A.

Moving on to consider the personality related hypotheses (1B and 2B above), we can include the scores on extraversion or neuroticism as an additional predictor in the GEE analyses. The simplest way to do this is to include the trait score as an additional predictor in the analyses carried out in the two video conditions separately. We include a main effect of extraversion (or neuroticism) and an interaction between extraversion (or neuroticism) and the model 1 circumplex predictor values. If the personality by circumplex predictor interaction is significant in the motivational video condition this is consistent with hypothesis 1A as it indicates that extraversion moderates the relationship between the model 1 circumplex values and the mood changes in the motivational video condition. Hypothesis 1B leads us to not expect the same personality by circumplex interaction in the control video condition. If there is a significant personality by circumplex interaction in the motivational video condition, but not in the control video condition, then we can test whether there is a significant three-way interaction between video condition, circumplex predictor and personality in a final analysis combining data from both video conditions.

We treat the GEE analyses as separate families of analyses from those we used for the fixed effects and SSMLE analyses above. When testing Hypothesis 1A (or 2A) we have three key statistical tests in the family using GEE: the test of the interaction between the appropriate (model 1 or model 2) circumplex predictor and video condition; the test of the circumplex predictor in the motivational video condition; and the test of the circumplex predictor in the control condition. Following our earlier logic, the final test should be an equivalence test. We do not have access to software to perform this equivalence test for GEE. Nevertheless, we used an adjusted level of $\alpha = \frac{.05}{3} = .017$ for the two tests we were able to perform and will report a traditional hypothesis test for the third member of the family.

When using GEE to test the personality related hypotheses (1B or 2B) we have a family of three statistical tests for each personality trait: a test of the interaction between the trait and the circumplex predictor in each video condition separately, plus a test of the three-way interaction between the trait, the circumplex predictor, and video condition. Thus, we have a family of six tests (for each of hypothesis 1B and 2B) and use and adjusted Type 1 error rate of $\alpha = \frac{.05}{6} = .008$. Once again, following our earlier logic, two of these tests would be equivalence tests (trait by circumplex predictor interactions in the control condition) but we do not have access to software to perform these two tests in the family.

A technical aspect of GEE concerns which so-called working correlation matrix (WCM) one should use in the calculations (several choices are available in SPSS, and other packages). The WCM describes the estimated correlations between the different individual mood items being tested. There are many papers considering possible criteria for choosing the WCM (e.g., Shults et al, 2009), although the studies often do not provide clear evidence for adopting one criterion rather than another, and many popular criteria give misleading results without additional corrections or adjustments that are not routinely provided by mainstream packages.

As the mood items were given in the same order to all participants, a natural choice for WCM is the so-called autoregression-1 (AR-1) structure. The AR-1 structure proposes that the correlation between sequential items is maximal and it falls off exponentially as the items get further apart in the test item list. The AR-1 WCM will be the default choice in the analyses below. We will routinely check other WCM choices to see whether the results are similar to those obtained with the AR-1 WCM. It should be noted that we will avoid the "unstructured" WCM as this is the most generic choice and involves estimating by far the largest number of parameters. Recent work (e.g., Westgate & Burchett, 2017) has shown this choice for the WCM can be problematic. Importantly, and from the outset of the description of GEE methods (e.g., Zeger & Yiang, 1986), it has been noted that GEE analysis is generally robust, even when the WCM is incorrectly specified.

2.2.5.4 Psychometric measures

The extraversion and neuroticism scores from the BFAS (DeYoung et al., 2007), and the intrinsic motivation scores from the DSSQ (Matthews et al., 2002) were calculated. We correlated these personality scores with the key dependent variables (DVs) in each video condition separately. In particular, we were interested in whether the specific patterns of the mood change after watching a video, reflected in the model-based contrast analyses described above, were associated with these traits.

2.2.5.5 Line bisection scores

As the line bisection task was administered post-experimentally only, between group differences in the mean line bisection deviation were tested using a one-way ANOVA, where a positive score represents a rightward bias in line bisection, putatively indicating left frontal activation. The moderation effects of the extraversion and neuroticism on the line bisection was also tested.

2.3 Results

2.3.1 Mood induction video effects: Fixed-effects circumplex contrast analysis

A mixed 12x2 ANOVA was conducted on the pre-post changes in affect rating using specific contrast coefficients designed to capture the effects under models 1 and 2 as described above. The mean mood change scores for each mood segment are shown, separated by video condition, in Figure 2.4. Any missing data from the individual adjectives were imputed as averages within the affect segments. Following the logic outlined earlier, to deal with multiple testing, we adjusted the per comparison Type 1 error rate for each family of statistical tests that tested a specific scientific hypothesis. We used a Bonferroni adjustment to preserve the familywise Type 1 error rate for each family of tests. Each time we note that a result (in a test family) is significant, below we put the uncorrected significance level and the adjusted level against which its significance should be judged. Other tests are not directly relevant to our hypotheses and are reported unadjusted. The model 1 contrast across affect segments, overall, was significant [$F(1,97) = 25.114$, $p < .001$, $\eta p^2 = .206$]. The interaction between the model 1 contrast across affect segments and video type was also significant [$F(1,97) = 17.229$, $p < .001$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .151$].[3] The model 2 contrast across affect segments, overall, was also significant, but with a much smaller effect size than for model 1 [$F(1,97) = 4.414$, $p = .038$, $\eta p^2 = .044$]. The interaction between the model 2 contrast across affect segments and video type was non-significant [$F(1,97) = 2.240$, $p = .138$, $\eta p^2 = .023$].

[3] This ANOVA contrast by group interaction is equivalent to a two-tailed between-groups t-test of the null hypothesis that the model 1 contrast mean is the same in each of the 2 video groups.

The data in Figure 2.4 reveal that, on average, the motivational video acted on mood primarily along the axis from point XII in Figure 2.3 (activation; maximum effect; at 0 degrees) through point VI in Figure 2.3 (deactivation; minimum effect; at 180 degrees), as opposed to the orthogonal pattern predicted by model 2. To see this clearly one can compare the data in Figure 2.4 with models 1 and 2 in Figure 2.3. Note that the blue lines in each figure have a very similar shape.

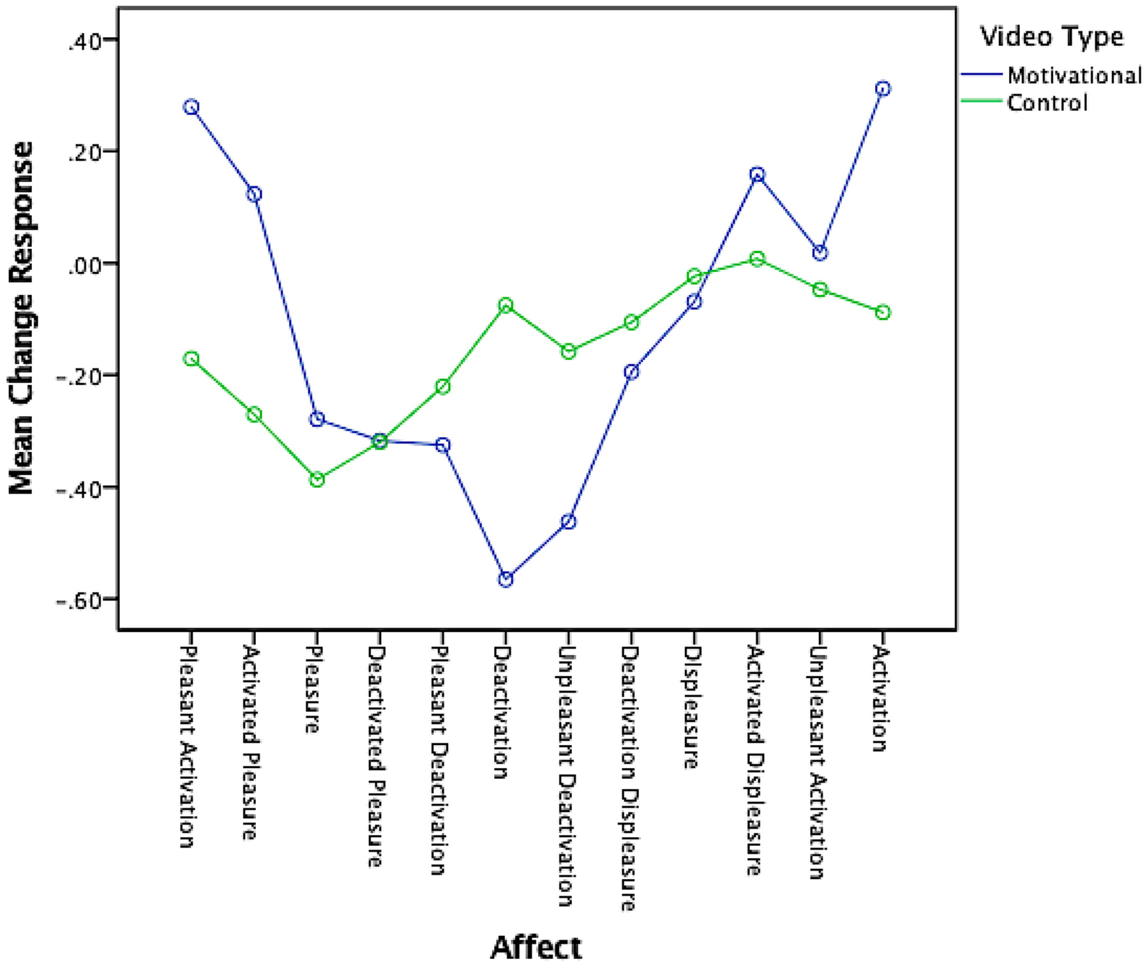


Figure 2.4: The mean change in affect across the two video groups, based on the order of affect in the circumplex. This plot is to be compared against the theoretical plots under model 1 and 2, as depicted above in Figure 2.3.

On average, the effect of the control video on mood ratings pre to post was much less marked, and by inspection did not seem to follow strongly the patterns of either model 1 or model 2 (as depicted in Figure 2.3). There is a hint that the average profile in the control condition follows model 2 but with a negative circumplex coefficient (i.e., the displeasure-pleasure model).

To explore these results further, we conducted a one-way ANOVA for each video type separately by using the repeated measures contrasts for model 1[4]. This showed that the model 1 contrast was significantly different from zero for the motivational video group [$F(1,45) = 29.778$, $p < .001$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .398$], but not significantly different from zero for the control video group [$F(1,52) = .549$, $p = .462$, $\eta p^2 = .010$], as predicted. Lakens et al (2018) describe several methods by which the equivalence bounds may be selected. In the absence of a previous study to work from (as in this case; see example 5 in their paper), they recommend setting the equivalence bounds to an effect size that the study would have had reasonable power to detect for the sample size concerned. In the control condition of the current study the sample size was 53. Using an adjusted type 1 error rate of .008, a two-tailed 1-sample t-test would require an effect size of Cohen's $d = .5$ in order to have 80% power. Therefore, we used bounds of [-.5, .5] for the equivalence test. The equivalence test, here, shows that the data support equivalence in the control group for the model 1 circumplex contrast ($M = .08$, $SD = .83$), in that this small effect lies between the TOST upper bound (0.5) $t(52) =-2.90$, $p = .003$ and the TOST lower bound (-0.5), [$t(52) = 4.38$, $p < .001$ (c.f. adjusted $\alpha = .008$)].

When conducting a one-way ANOVA for each video type by using the repeated measures contrasts for model 2, we found that the model 2 contrast was not significant for the motivational video group [$F(1,45) = .137$, $p = .713$, $\eta p^2 = .003$], as predicted based on the results of Smillie et al (2012). However, in line with the visual inspection of Figure 2.4, the average model 2 contrast in the control group alone appears to be non-zero [$F(1,52) = 8.854$, $p = .004$, $\eta p^2 = .145$]. Hypothesis 2A (that the motivational video will exert mood changes along the pleasure-displeasure axis and will do so to a greater extent than the control video) predicts that the model 2 contrast value in the control condition should be close to zero (and closer to zero than that for the motivational video). As noted, we had planned to test this using an equivalence test with an adjusted alpha level. Clearly, the data reject hypothesis 2A without the need for an equivalence test. To our surprise, something about this control video seems, on average, to have induced a mood change along the pleasure-displeasure axis. The sign of the contrast for model 2 applied to the control video was negative. As noted above, this negative sign means that, on average, the model 2 contrast for the control video reflected a displeasure-pleasure circumplex contrast.

[4] Note: this is equivalent to a 2-tailed 1-sample t-test of the null hypothesis that the contrast mean equals zero.

2.3.2 Mood induction video effects: SSMLE fitting and Bayesian Model Selection

As with the fixed effects analyses the key test of both hypothesis 1A and 2A are whether the relevant contrast, i.e., the circumplex coefficient estimated by single-subject maximum likelihood estimation (SSMLE) (coefficient b_i; see Equation 3), differed between the two video conditions. To give the clearest overall picture of the SSMLE fitting results we decided to present the findings for each condition separately first and so we must delay giving these key tests of the hypotheses until the results for each video condition have been presented separately.

In each video condition, the SSMLE analyses below were based on slightly smaller numbers of participants than the fixed effects analyses above. In order to get reliable estimates of the circumplex coefficients for each participant, we needed as many observations as possible at each mood segment. Therefore, we used a conservative criterion by which cases were retained only when they had fewer than 4 missing adjective responses for any segment.

We first analyse the motivational video condition, for which the sample, after applying the above conservative criterion was 42 cases. The mean number of mood items (adjectives) out of 60 used per case for these 42 cases in the motivational video condition was 59.6.

In the motivational video condition, the overall data and model fits averaged across participants are as shown in Figure 2.5 below.

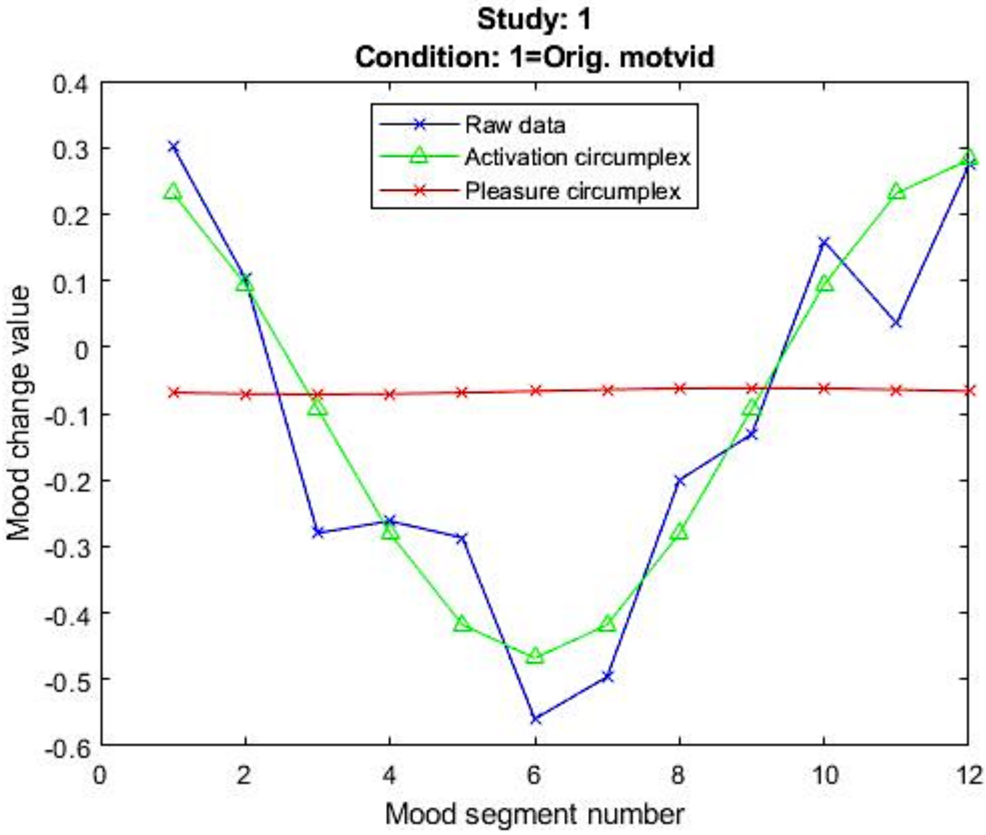


Figure 2.5: Data and best-fitting models averaged across all participants in the motivational video condition (N=42).

In Figure 2.5 it is immediately clear that there is a very close resemblance between the average data across all participants, and the average of the best fits, for individual subjects, under model 1 (the activation-deactivation circumplex model). The averaged best fits of model 2 (the pleasure-displeasure circumplex model) do not resemble the averaged data well and it should be noted that the best fits for the pleasure-displeasure model are associated with *b* coefficient values (in equation 2.1) which on average are very slightly negative.

First, we confirmed the fixed effects results by testing whether the coefficients (a_i and b_i; see Equation 3) differed from zero across participants in the motivational video condition alone. For the activation-deactivation model (model 1) we found that the mean intercept coefficient ($\bar{a}$) was -.093, with 95% CIs = (-.150, -.037); t =-3.32, df = 41, p = .0019. The mean circumplex coefficient ($\bar{b}$) was 2.01, significantly different from zero, with 95% CIs = (1.28, 2.74); t=5.54, df= 41, p =.000002 (c.f. adjusted α = .008). We repeated this for the pleasure-displeasure model

(model 2) and found that the mean intercept coefficient ($\bar{a}$) was -.066, with 95% CIs = (-.124, -.009); t =-2.32 df= 41, p=0.025. The mean circumplex coefficient ($\bar{b}$) was .028, not significantly different from zero, with 95% CIs = (-.835, .779); t =-.07, df= 41, p=.94. The equivalence test, here, shows that the data support equivalence in the motivational video group for model 2 circumplex coefficient (M = -.03, SD = 2.59), in that this small effect lies between the TOST upper bound (0.5) $t(41) = -3.31$, $p < .001$ and the TOST lower bound (-0.5), $t(41) = 3.17$, $p = .001$ (c.f. adjusted α = .008). These analyses confirm that only the activation-deactivation model generated circumplex coefficient values which differ significantly from zero across the whole sample who viewed the motivational video. It also confirms that the circumplex coefficients were non-significantly negative for the pleasure-displeasure model, as already noted, and just about visible in Figure 2.5.

However, these analyses and graphs conceal a wide range of individual variation in model fits within this sample. This observed variation (see below) justified our choice to use the SSMLE approach to fitting. In Bayesian comparison we can express the relative fits of a pair of models using (log) Bayes factors. The log of the Bayes factor for model 1 relative to model 2 would is denoted by $\log(BF_{12})$, with a value of +2.3 or above is taken as strong evidence in favour of model 1 over model 2 (Jeffreys, 1961). A value of -2.3 or below is taken as strong evidence in favour of model 2 over model 1.[5]

Within the data from the motivational video condition of this study, we found several individuals with a $\log(BF_{12})$ well above +2.3 (favouring model 1 strongly), as well as a similar number of individuals whose $\log(BF_{12})$ was well below -2.3 (strong evidence in favour of model 2). Figures 2.6 through to 2.8 show some examples.

[5] Other authors use different arbitrary cut-offs for "strong evidence"; some are more stringent, others more lenient (for a review see Kass & Raftery, 1995)

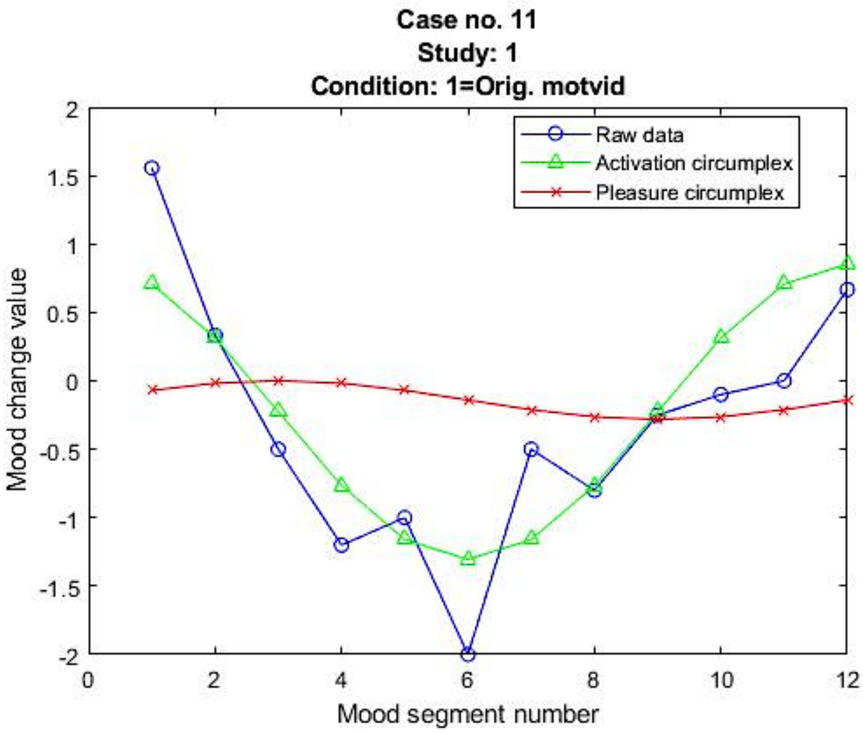


Figure 2.6: A participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex); $\log(BF_{12})$= 15.3.

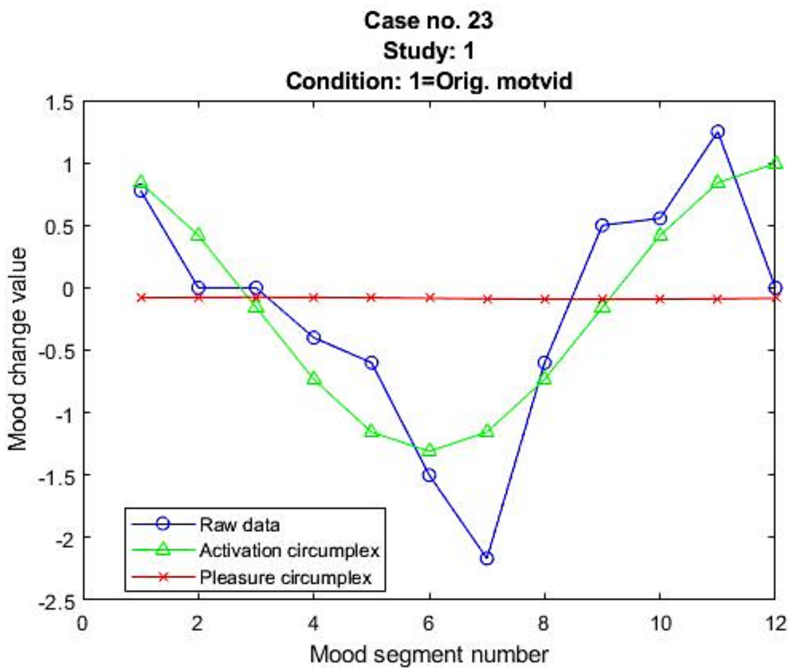


Figure 2.7: Another participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex); $\log(BF_{12})$= 16.2.

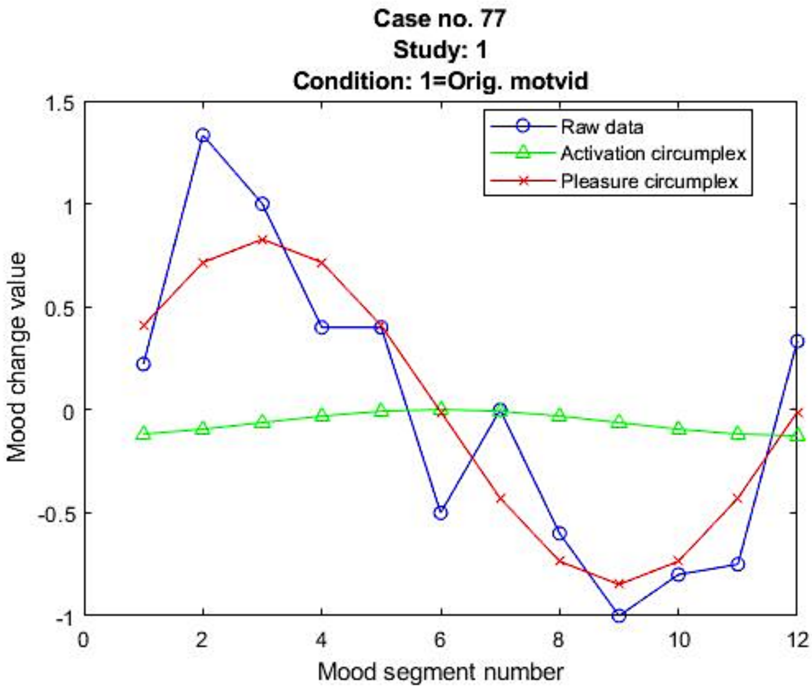


Figure 2.8: A participant whose mood change scores were well fit by model 2 (pleasure-displeasure circumplex) relative to model 1 (activation-deactivation circumplex); $\log(BF_{12}) = -12.5$.

The $\log(BF_{12})$ values for each participant showed wide variation as seen in Figure 2.9 below, but were slightly skewed in favour of the activation-deactivation model as the mean $\log(BF_{12})$ was above zero. However, there were strong relative fits for model 1 in 10/42 cases and for 11/42 cases for model 2 at an individual subject level.

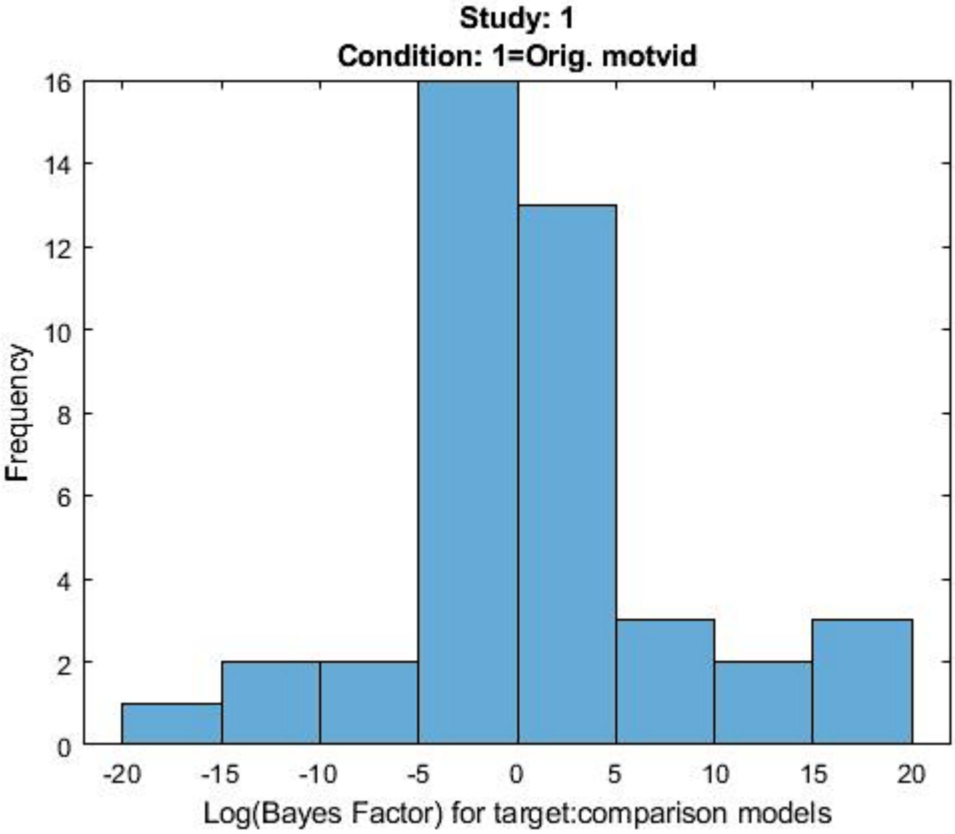


Figure 2.9: Histogram of log(BF_{12}) values. These values compare the strength of evidence for model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex). A log(BF_{12}) value of 0 provides evidence that favours neither model; more positive log (BF_{12}) values favour model 1 and more negative log(BF_{12}) values favour model 2. Log(BF_{12}) values above +2.3 and below -2.3 are taken as strong evidence in favour of model 1 and model 2 respectively. For the whole sample the mean log(BF_{12}) = .941.

The final output from the VBA toolbox routines is shown in Figure 2.10 below.

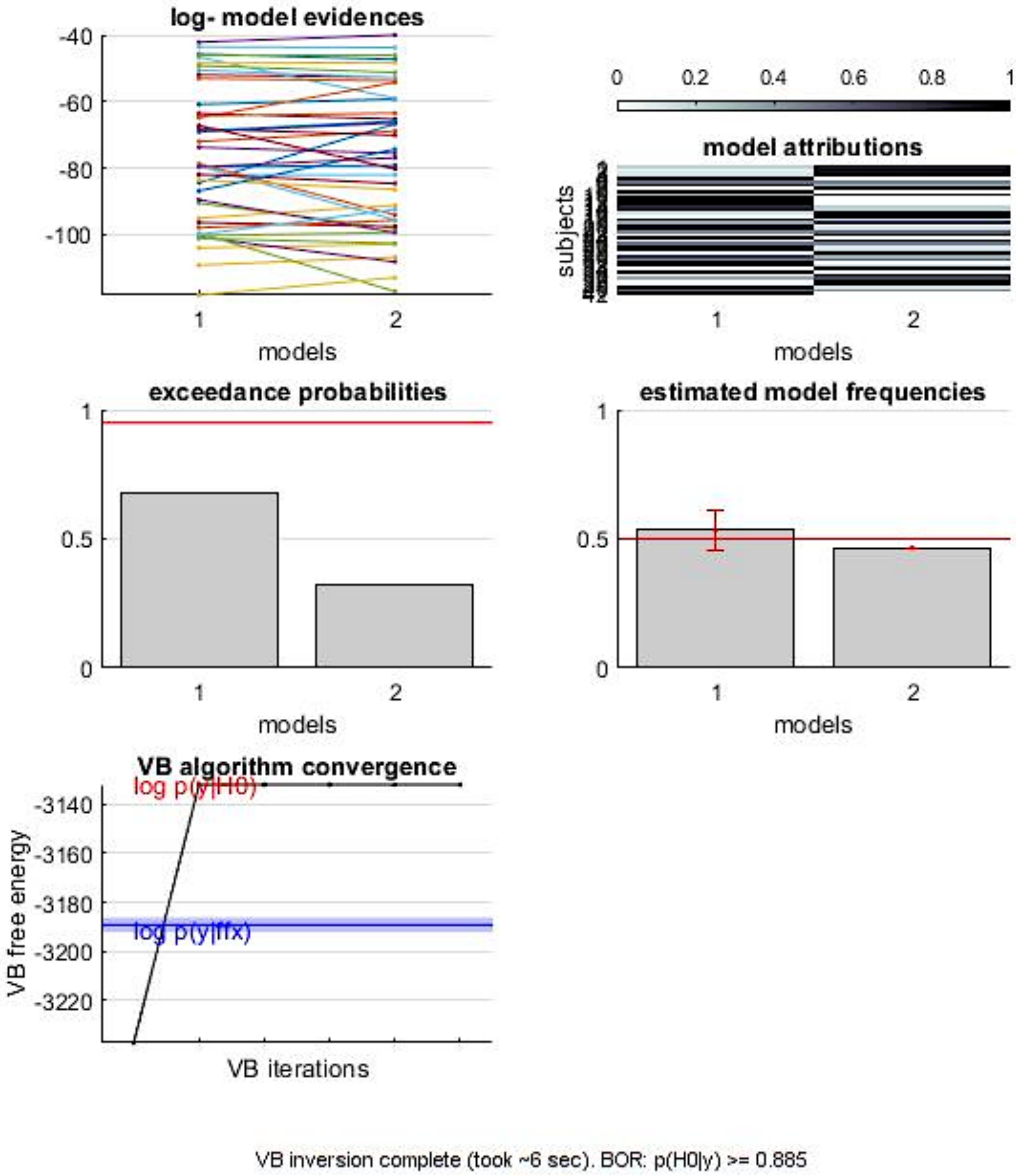


Figure 2.10: The main output window from the VBA toolbox for the motivational video condition.

The key results shown in Figure 2.10 offer confirmation that model 1 is slightly more frequently the better account of the data relative to model 2. The exceedance probability (EP) of model 1 over model 2 is .65, but the protected exceedance probability (PEP) allows for the possibility that the EP is due to chance; the PEP was 0.52, and the expected frequency of model 1 was .53. These summary statistics show that the advantage of model 1 over model 2, across the whole sample, is very small indeed. In keeping with this outcome, the Bayesian Omnibus

Risk (BOR) is ≥ .89 (the BOR is the posterior probability that the frequencies of the two models are equal across this whole dataset).

Before going on to consider the Bayesian model selection (BMS) for the control video condition in this study, there is a small paradox that needs resolving. There is clear evidence that, on average across all subjects in this motivational video condition, the activation-deactivation circumplex effect produces a robust significant positive effect on mood changes while there is no significant corresponding effect for the pleasure-displeasure circumplex (it is weakly and non-significantly negative on average; see Figure 2.5). By contrast, there is little evidence from our BMS applied to the random SSMLE fitting results that the activation circumplex is most frequently the best fitting model for the data.

The reason for this becomes clear when we draw histograms (Figure 2.11) for the circumplex model coefficients (b_i). We can see that there is a similarly wide range of coefficients under either model. However, for the activation-deactivation model the coefficients are clearly skewed such that the average value is above zero. For the pleasure-displeasure model the distribution of individual coefficients is centred close to zero. There are some people in this motivational video condition for whom the pleasure-displeasure model (model 2 with positive circumplex coefficients) is a good fit and an equivalent number for whom the displeasure-pleasure model (model 2 with negative circumplex coefficients) is a good fit, with other subjects not fit well by the model. By contrast, there are some people who are well fit by the activation-deactivation model (model 1 with positive circumplex coefficients) but a much smaller number who are well fit by the deactivation-activation model (model 1 with negative circumplex coefficients). This pattern of data from the individual participant level analysis shows why the average results contrast so strongly with the group level results and create the paradox referred to above. This also means that the averaged group results are, therefore, somewhat misleading as to the effects of the mood manipulations on individual participants.

The above analysis leads to another important conclusion: if either circumplex model is a good fit for the mood responses of only a fraction of the people in this video condition, then it perhaps does not make very good sense to correlate specific model-derived measures with personality traits across the whole sample in a particular condition. The predictions for the relationships with personality traits such as extraversion (or neuroticism) are made assuming that individuals' behaviours are caused by processes captured by the specific model (such as the activation-deactivation circumplex). It might therefore make better sense to test those predictions only for cases where we have evidence that the model concerned is a good description of the individual's behaviour. The correlational analyses would thus possibly be more appropriate if they were restricted to those participants who have the best fitting circumplex coefficients under a particular model although there will be a serious loss of power given the modest proportions (well under 50% of the sample) who are well fit by any specific model (see below for more on this).

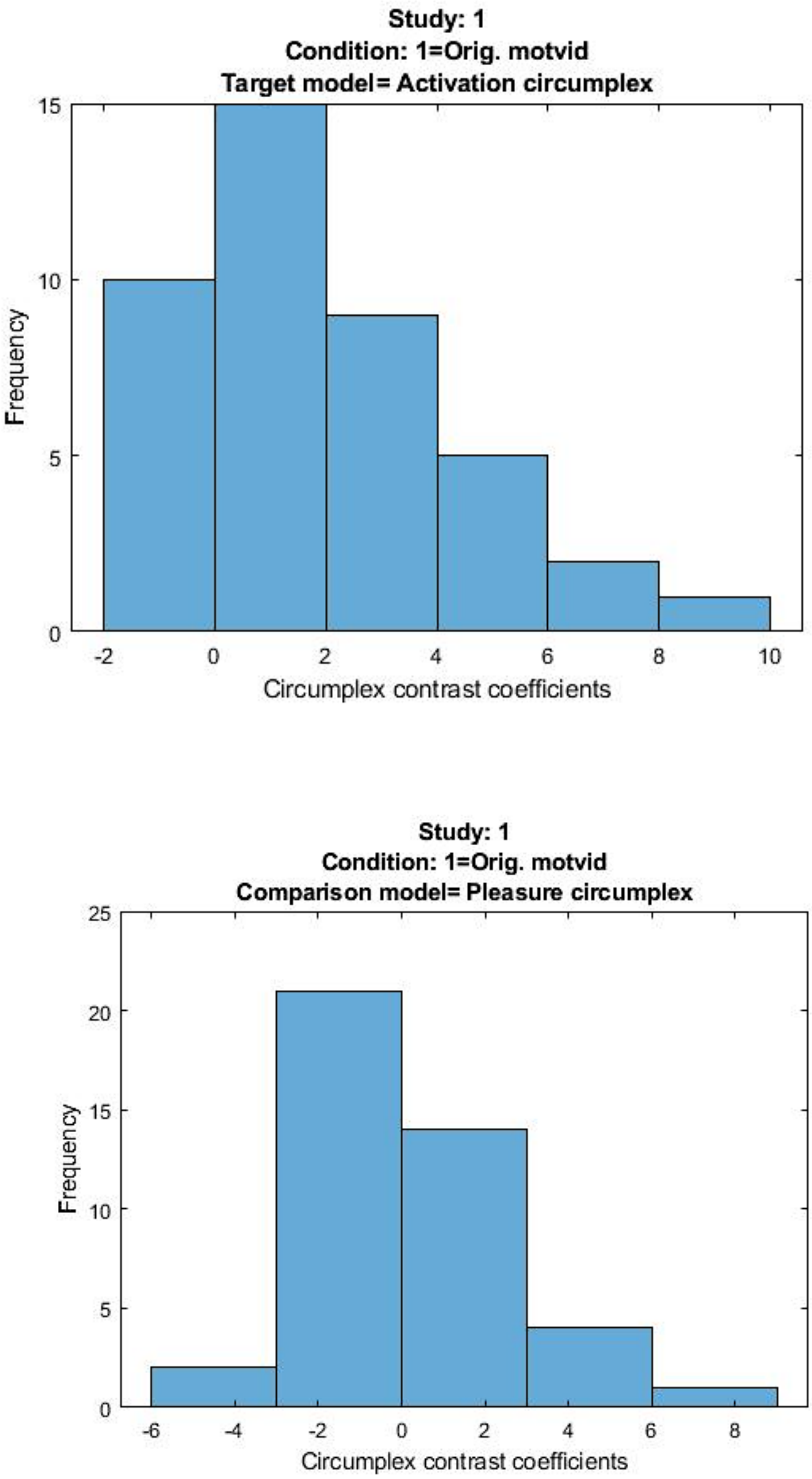


Figure 2.11: The frequencies of best-fitting coefficients (denoted by b_i in Equation 3) for the circumplex models across participants. The upper panel is for the activation-deactivation circumplex model (M = 2.007, SD = 1.72); the lower panel is for the pleasure-displeasure circumplex model (M = -.028, SD =1.50).

In the control video condition, we again applied the same conservative criteria relating to missing data. This resulted in the elimination of a number of participants from the original number of cases; the final sample here was N=52. The mean number of mood items (adjectives) out of 60 used per case control condition was 59.9. The overall data and model fits averaged across participants are as shown in Figure 2.12 below:

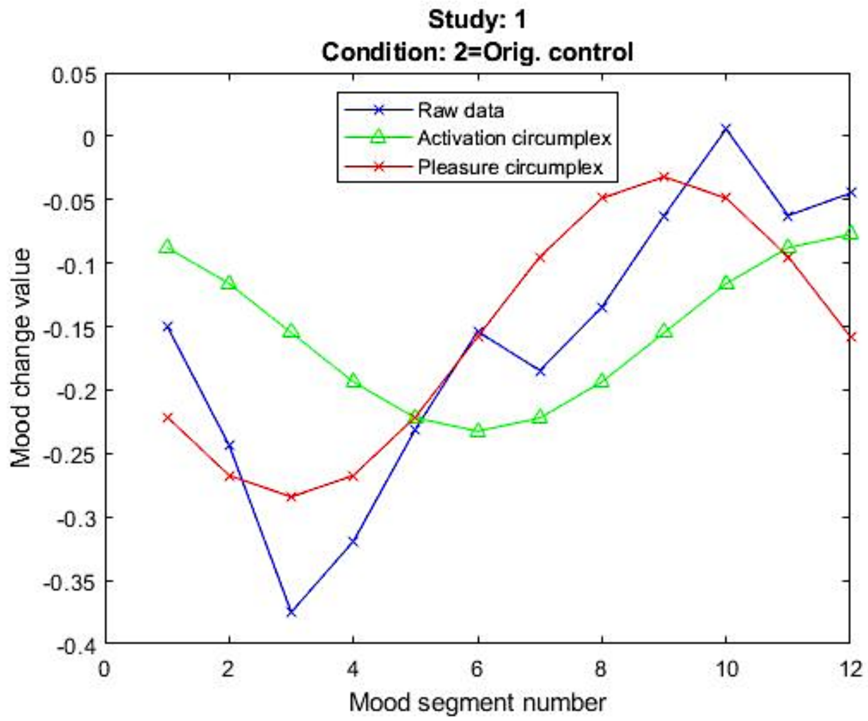


Figure 2.12: Data and best-fitting models averaged across all participants in the control video condition (N=52).

In Figure 2.12 it is clear that there is a fairly close resemblance between the average data across all participants, and the average of the best fits for individual subjects using model 2 (the pleasure-displeasure circumplex model with negative coefficients). The averaged best fits under model 1 (the activation-deactivation circumplex model) do not resemble the averaged data at all well.

First, before exploring the data from the control video condition alone, we are now at the point where we can compare the circumplex coefficients (under both model 1 or model 2) across the two video conditions. As mentioned earlier this comparison is the most important test of hypotheses 1A and 2A. These comparisons between motivational versus control video conditions were carried out using between-subjects t-tests on the circumplex coefficient values for each participant estimated under model 1 and model 2. The results are very clear-cut and reproduce very closely the results found using the fixed effects contrast analyses reported above.

For model 1, there was a large and significant difference between the circumplex coefficients (b_1 see Equation 3) across the two video conditions (motivational video: M = 2.01, SD = 2.35; control video: M = .42, SD = 2.02), judged using our adjusted Type 1 error rate of .008 (the explanation for this adjustment was given earlier), [t(90) = 3.533, p = .001]. *For the participants considered as a whole, this result strongly supports hypothesis 1A.*

For model 2, there was no evidence of any difference between the circumplex coefficients across the two video conditions (and this would have been the case even if we had not applied our Type 1 error rate adjustment), [t(90) = 1.408, p = .071]. *For the participants considered as a whole, this result rejects hypothesis 2A.*

Next, we analyse the control condition data alone. We confirmed the fixed effects results by testing whether the coefficients (a_i and b_i; Equation 3) differed from zero across participants in the control video condition. For the activation-deactivation model (model 1) we found that the mean intercept coefficient ($\bar{a}$) was -.155, with 95% CIs = (-.208, -.1020; t =-5.84 df= 51, p=.0000004. However, the mean circumplex coefficient ($\bar{b}$) was .416, with 95% CIs = (-.146, .977); t=1.48 df= 51, p=.14. The equivalence test, here, shows that the data does not support equivalence in the control video group for model 1 circumplex coefficient (M = .416, SD = 2.02), in that the equivalence fails at the TOST upper bound (.5) [t(51) = -2.12, p = .019 (c.f. adjusted α = .008)]. Therefore, the null hypothesis that the effect size might lie outside these bounds cannot be rejected. We repeated this for the pleasure-displeasure model (model 2) and found that the mean intercept coefficient ($\bar{a}$) was -.158, with 95% CIs = (-.213, -.103); t =-5.74 df= 51, p=.0000005. The mean circumplex coefficient ($\bar{b}$) was -.704, with 95% CIs = (-1.28, -.13); t =-2.46, df= 51, p=.02 (here, the hypothesis 2A has already been rejected by the fixed-effects contrast analysis, so no equivalence test is needed). We had predicted under hypothesis 2A that the circumplex coefficient would be close to zero (and closer to zero than that in the motivational video condition). Once again, a result showing a "significant" difference from zero (using an unadjusted type 1 error rate) rejects Hypothesis 2A here without the need for an equivalence test and repeats the same pattern shown for the fixed effects analyses above where this coefficient was more robustly non-zero (p=.004, unadjusted). These analyses confirm that only the pleasure-displeasure model has circumplex coefficient values which differ significantly from zero (in fact they were negative) across the whole sample. It also confirms that the circumplex coefficients were, on average, non-significantly positive using the activation-deactivation model.

The SSMLE analyses in the control condition also conceal a wide range of individual variation in model fits within this sample. In a Bayesian model comparison of the individual subject fits for model 1 (activation-deactivation) versus model 2 (pleasure-displeasure) we found several individuals with log Bayes factors [denoted by log(BF_{12}), the log of the Bayes factor for model 1 relative to model 2 exceeding +2.3 (a value taken as strong evidence in favour of model 1 versus model 2; Jeffreys, 1961). Indeed, we found several individuals whose log(BF_{12}) was well below -2.3 (strong evidence in favour of model 2). Figures 2.13 through to 2.14 show some examples.

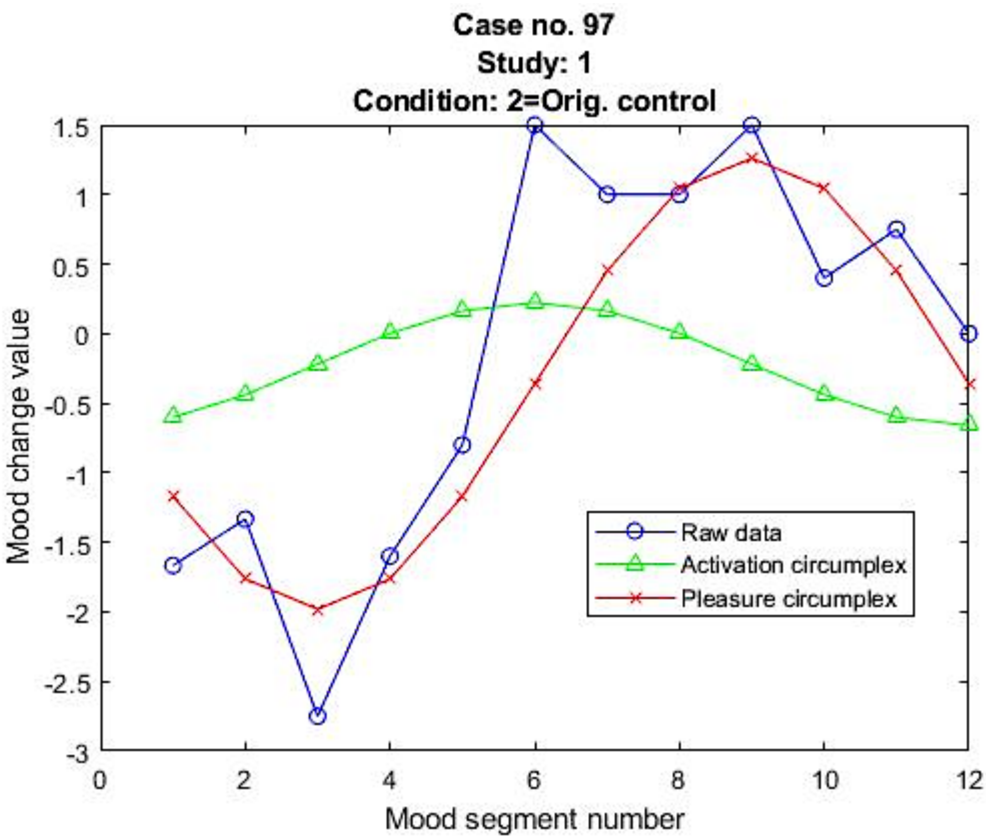


Figure 2.13: A participant whose mood change scores were well fit by model 2 (pleasure-displeasure circumplex) relative to model 1 (activation-deactivation circumplex); log(BF_{12})= -20.5.

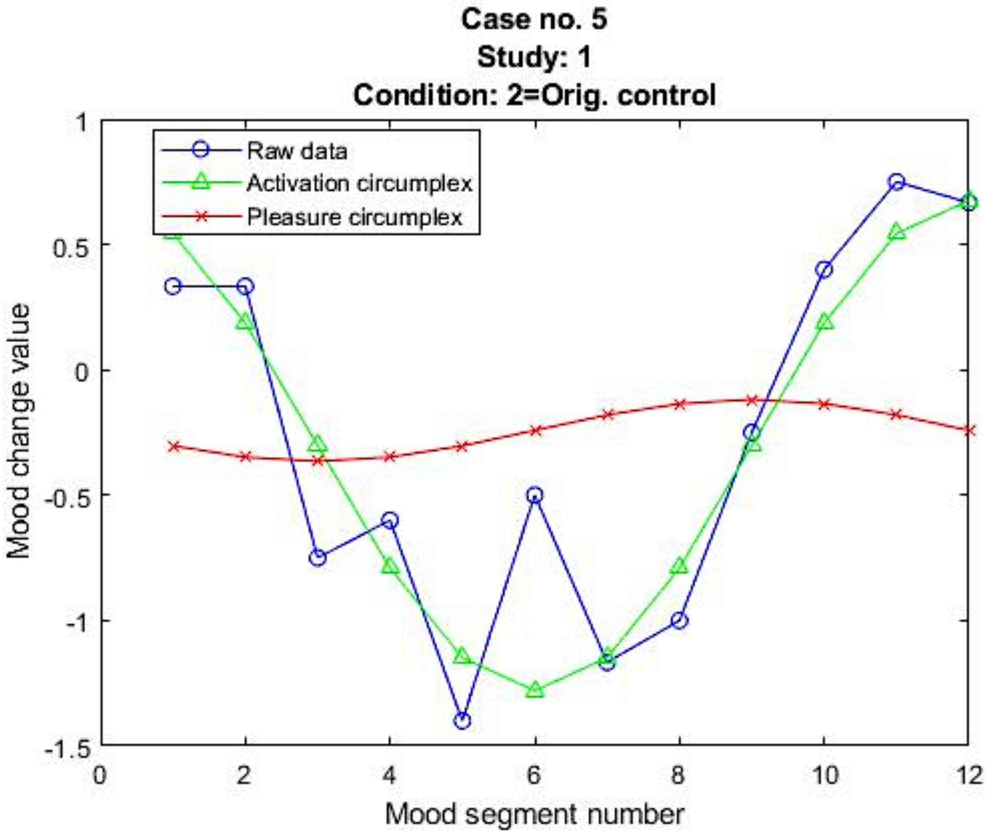


Figure 2.14: Another participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex); $\log(BF_{12})= 17.9$

The $\log(BF_{12})$ values for each participant showed wide variation as seen in Figure 2.15 below. There were strong relative fits for model 1 in 9/52 cases and for 10/52 cases for model 2 at an individual subject level.

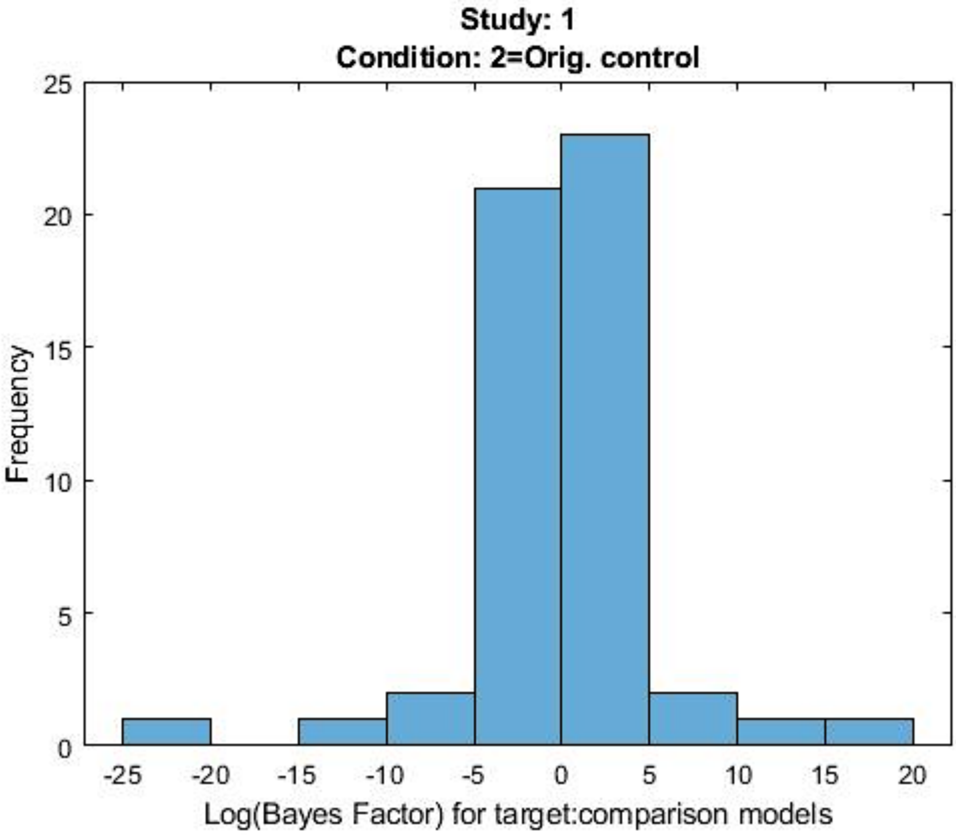


Figure 2.15: Histogram of $\log(BF_{12})$ values. These values compare the strength of evidence for model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex). A $\log(BF_{12})$ value of 0 provides evidence that favours neither model; more positive log (BF_{12}) values favour model 1 and more negative $\log(BF_{12})$ values favour model 2. $\mathrm{Log}(BF_{12})$ values above +2.3 and below -2.3 are taken as strong evidence in favour of model 1 and model 2 respectively. For the whole sample the mean $\log(BF_{12}) = -.08$.

The final output from the VBA toolbox routines is shown in Figure 2.16 below.

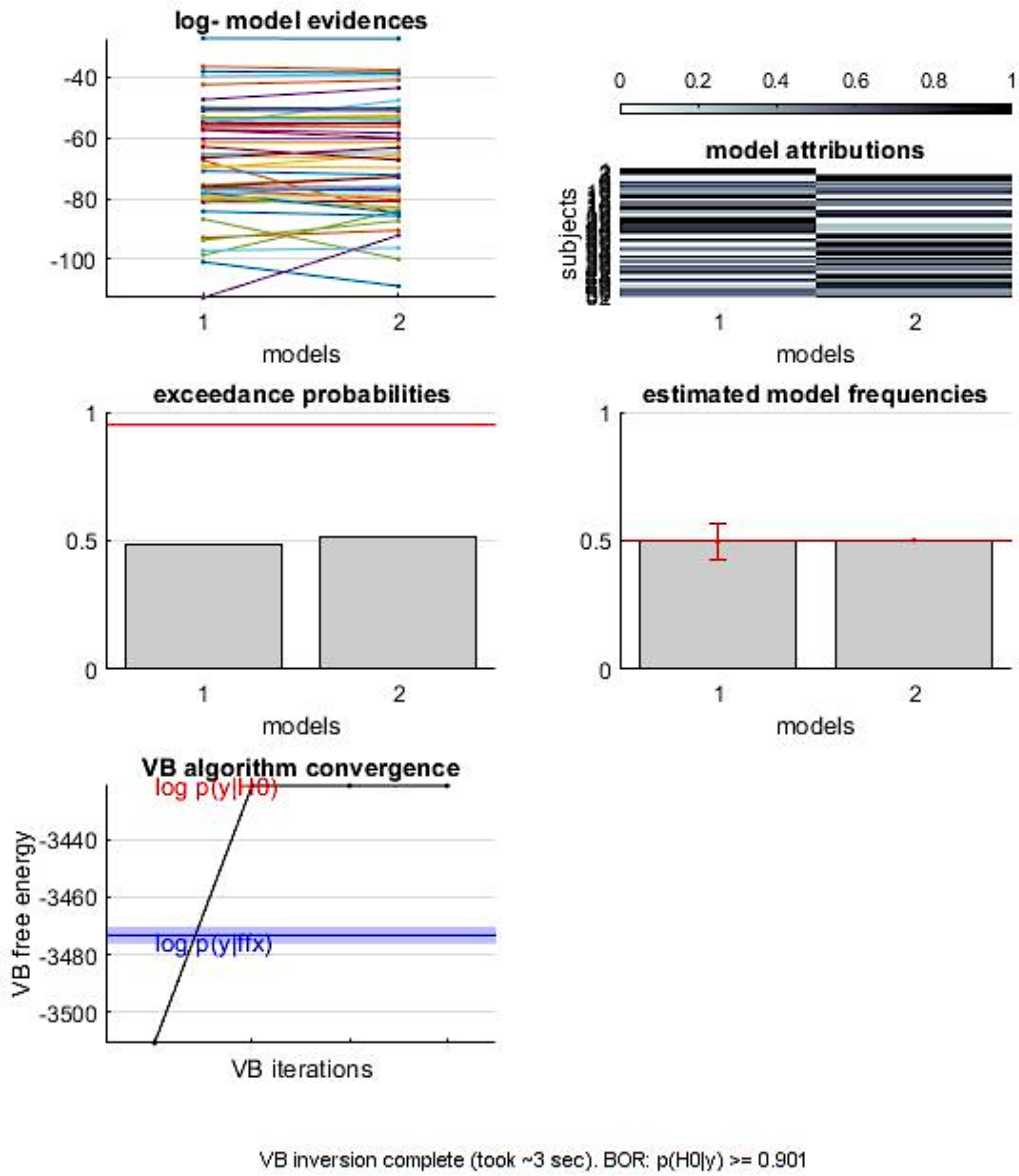
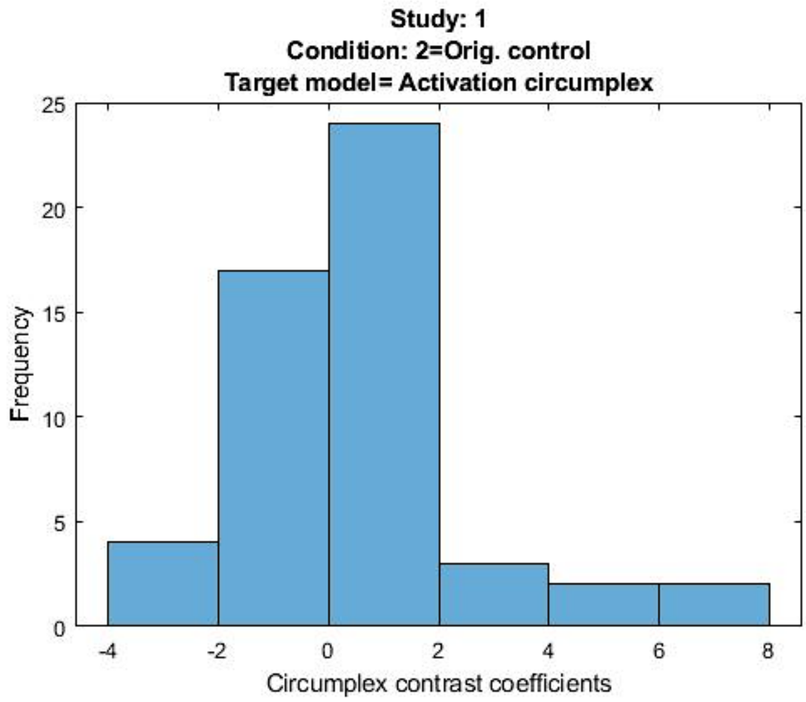


Figure 2.16: The main output window from the VBA toolbox for the control condition.

The key results shown in Figure 2.16 offer confirmation that model 2 is not more frequently a better account of the data relative to model 1. The exceedance probability (EP) is .49, but the protected exceedance probability (PEP) allows for the possibility that the EP is due to chance; the PEP was .50, and the expected frequency of model 1 was .50. Accordingly, the Bayesian

Omnibus Risk (BOR) is ≥ .90 (the BOR is the posterior probability that the frequencies of the two models across the sample are equal).

The histograms drawn for the for the circumplex model coefficients (b_i), show that there is a similarly wide range of coefficients under either model (Figure 2.17). However, for the pleasure-displeasure model there is a bias towards negative coefficients; for the activation-deactivation model the distribution of individual coefficients vary widely also but it is centred close to zero. The fit for model 2, averaged across all participants, is reasonable but at the individual level neither model 1 nor 2 model fits better than the other as shown by the BOR and the expected model frequencies. This pattern of data from the individual participant level analysis shows why the average results contrast so strongly with the individual level results and create a similar paradox to that previously mentioned in relation to the motivational video. This also means that the averaged group results are, therefore, misleading as to the effects of the mood changes induced by the control video on individual participants.



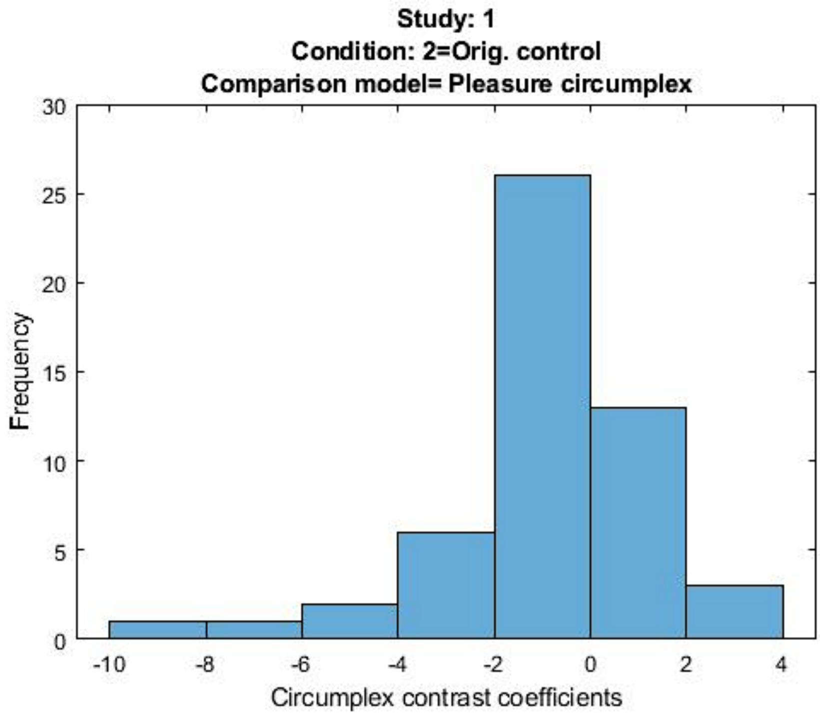


Figure 2.17: The frequencies of b_i coefficients of the circumplex model across participants. The upper panel is for the activation-deactivation circumplex model (M = .416, SD = 5.45); the lower panel is for the pleasure-displeasure circumplex model (M = -.704, SD = 3.37).

To conclude the Bayesian model selection process, we conducted a cross-tabulation of video condition by model (0, 1, and 2). Model 0 is the intercept model. Cases better fit by model 0 were such that neither model 1 nor model 2 had a strong fit relative to model 0. Here we also used a value of 9 to represent the participants who are better fit both by models 1 and 2 than model 0, but where neither model 1 nor 2 is a better fit than the other (see Table 2.1).

Table 2.1: Cross-tabulation for condition by model frequencies of cases.

Condition	**Model**				
	0	**1**	**2**	**9**	**Total**
Motivational	19	10	11	2	42
Control	34	9	9	0	52
Total	53	19	20	2	94

To test whether the distribution of these frequencies differs across these categories of models as a function of the condition we conducted a chi squared test, which was non-significant [$X^2(3, N = 94) = 5.50, p = .139$].

2.3.3 Analysing mood changes using the GEE approach

As explained above, we next used GEE methods to look at the effect of the videos on mood. The predictors were video condition, the model-based circumplex predictors (each used in separate analyses) and the video by circumplex interaction term. We also entered an intercept term, plus the mood checklist item number (1-60, reflecting the order in which they were presented) as a covariate predictor so that we could specify a WCM for the analysis (we used an AR-1 WCM as explained above).

From the sample of 115 participants, we eliminated all the cases who had large amounts of missing data. A small group of participants had 50% or more missing data on the mood checklist, while the rest completed all, or almost all, the items as we noted in our presentation of the SSMLE results above. This resulted in the removal of 17 further cases from the sample. After these removals, the overall amount of missing mood data was 1.6%.

When using the model 1 circumplex predictor (based on activation-deactivation), the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as .235. From the parameter estimates of the GEE model, which are regression coefficients (B), neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change before to after watching the video (p>0.1 in either case, with small B coefficients, close to zero). However, the critical interaction between video condition and circumplex predictor was robustly significant [B=.743, SE= .209, 95% CIs= (.33, 1.15); p < .001]. We know from Figures 2.4 and 2.5 above that this interaction reflects the fact that, on average, the activation-deactivation circumplex predicts mood changes significantly more strongly in the motivational video condition than in the control video condition. In line with these figures, we know from the sign of the B coefficient (and the way that the video condition was coded) that this result reflects a significantly more positive relationship between the model 1 circumplex predictor and mood change in the motivational video condition compared with the control video condition. This means that the most positive change in mood was obtained for the activation mood segment and the most negative was obtained for the deactivation segment (as in Figures 2.3-2.5). As expected, based on experience with GEE analyses, we obtained very similar results when using the exchangeable or independent WCMs.

To further confirm this, we ran the analyses in each video condition separately, using just the circumplex value as the predictor of mood change (plus the usual intercept term and the mood checklist item number). As predicted under Hypothesis 1A, the activation-deactivation model 1 circumplex was a robustly significant predictor in the motivational video condition [B= .941, SE= .17, 95% CIs = (.62, 1.23); p<.001]. The autocorrelation between adjacent items was estimated to be 0.240 (very similar to the results across both video conditions), and the percentage of missing data was 3.2%. In the control video condition, by contrast, the model 1 circumplex did not significantly predict the mood changes (B=.200, SE= .13, 95% CIs = (-.05, .45); p = .11). The autocorrelation between adjacent items was estimated to be .229 (very similar to the results across both video conditions), and the percentage of missing data was 0.2%.

The GEE results above then robustly confirm Hypothesis 1A, at least for the sample of participants considered as a whole. The GEE results are completely consistent with the results obtained using fixed effects or SSMLE modelling presented above.

When using the model 2 circumplex predictor (based on pleasure-displeasure), the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as 0.246. From the parameter estimates of the GEE model neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change before to after watching the video (with small B coefficients). The critical interaction between video condition and circumplex predictor was also not significant [B= .249, SE= .21, 95% CIs = -.16, .66); p = .23]. We know from Figure 2.5 above that this interaction reflects the fact that, on average, the pleasure-displeasure circumplex does not predict mood changes differentially across the two video conditions.

Again, to further confirm this, we ran the analyses in each video condition separately, using just the circumplex value as the predictor of mood change (plus the usual intercept term and the mood checklist item number). The pleasure-displeasure model 2 circumplex was not significant predictor in the motivational video condition [B= -.005, SE= .18, 95% CIs = (-.35, .34); p = .976]. The autocorrelation between adjacent items was estimated to be .27 and the percentage of missing data was 3.2%. In the control video condition, the model 2 circumplex relationships with the mood changes was significantly different from zero using an unadjusted significance level [B= -.274, SE= .12, 95% CIs = (-.51, -.03); p = .024). However, this effect is predicted to be close to null under hypothesis 2A and so this hypothesis is rejected. The autocorrelation between adjacent items was estimated to be 0.22 and the percentage of missing data was 0.2%. This result closely parallels the earlier findings: the equivalent analysis using fixed-effects contrasts had a p-value of .004 and the analysis using SSMLE analyses had a p-value of .02.

2.3.4 Personality effects using fixed-effects contrasts

Although we argued above that the correlations with circumplex derived mood changes were likely not to be particularly informative when computed across all participants in a video condition, we report them here for completeness. To test if the personality traits of extraversion and neuroticism moderate the effects of video type on changes in affect, two separate analyses were conducted for each trait. The overall fixed effect contrast scores under model 1 and model 2 were computed for each participant in each video condition separately. The correlations between the contrast score and the personality variables were computed.

We first tested the correlation between extraversion and the interaction contrast between video condition and the model 1 fixed-effects circumplex contrast, as well as the correlation between neuroticism and the model 1 fixed-effects interaction contrast. The correlation was not significant for extraversion [$r(93)$[6] = .018, p = .865], nor was it significant for neuroticism [$r(96)$ = -.113, p = .269]. We computed the same correlation between extraversion and the interaction contrast between video condition and the model 2 fixed-effects circumplex contrast, as well as the correlation between neuroticism and the model 2 fixed-effects interaction contrast. The correlation was not significant for extraversion [$r(93)$ = .049, p = .63], nor was it significant for neuroticism [$r(96)$ = .048, p = .639].

There were no significant correlations for the model 1 contrasts of the changes in affect with extraversion [$r(41)$ = -.129, p = .408] nor with neuroticism [$r(43)$ = -.088, p = .566] in the motivational video group. The lack of a significant correlation with extraversion did not support the predictions we derived above from the work by Smillie et al (2012). There were no significant correlations for the model 1 contrasts of the changes in affect with extraversion [$r(50)$ = -.250, p = .074] nor neuroticism [$r(51)$ = .197, p = .158] in the control video group either. Using an adjusted type 1 error rate of .008, a two-tailed bivariate correlation would require an effect size of r = .243 in order to have 80% power. Therefore, we used equivalent bounds of [-.5, .5] for the equivalence test. The equivalence test shows that the data does not support equivalence in the control video group for model 1 contrasts correlations with extraversion, in that the equivalence fails at the TOST lower bound (-.5) [r = -.250, p = .020 (c.f. adjusted α = .008)]. Therefore, the null hypothesis that the effect size might lie outside these bounds cannot be rejected. However, the equivalence test for the control video group for model 1 contrasts correlations with neuroticism shows that the data does support equivalence, in that this small effect lies between the TOST upper bound (.5) [r = .197, p = .007] and the TOST lower bound (-.5) [r = .197, p < .001 (c.f. adjusted α = .008)]. Nevertheless, the lack of significant correlations in the control video condition was expected given that there was intended to be no appetitive or aversive system engagement by the control video. However, the earlier analyses revealed that some participants did show strong fits for one of the two circumplex models, so these correlational analyses were potentially of more interest than originally anticipated.

[6] The value in parentheses gives the d.f. for the significance test for the correlation

When applying the model 2 contrasts for the changes in affect, again there were no significant correlations for the changes in affect with extraversion [$r(41) = -.083$, $p = .598$] nor with neuroticism $r(43) = .122$, $p = .426$ in the motivational video group. There were also no significant correlations for the model 2 contrasts of the changes in affect with extraversion [$r(50) = -.165$, $p = .242$] nor neuroticism [$r(51) = .008$, $p = .955$] in the control video group[7] (see Table 2.2). The equivalence test for the control video group for model 2 contrasts correlations with extraversion shows that the data does support equivalence, in that this small effect lies between the TOST upper bound (.5) [$r = -.165$, $p < .001$] and the TOST lower bound (-.5) [$r = -.165$, $p = .004$ (c.f. adjusted $\alpha = .008$)]. The equivalence test for the control video group for model 2 contrasts correlations with neuroticism shows that the data does support equivalence, in that this small effect lies between the TOST upper bound (.5) [$r = .008$, $p <.001$] and the TOST lower bound (-.5) [$r = .008$, $p < .001$ (c.f. adjusted $\alpha = .008$)]. The lack of significant correlations with extraversion using model 2 contrasts is consistent with the data of Smillie et al (2012) in which extraversion repeatedly showed no association with the change in positive hedonic tone (i.e., pleasurable mood) induced by mildly pleasurable but non-appetitive stimuli.

Table 2.2: Group correlations of extraversion and neuroticism with model 1 and model 2 contrasts for the motivational and control video groups.

	Motivational Video						**Control Video**					
	Model 1 Contrasts			**Model 2 Contrasts**			**Model 1 Contrasts**			**Model 2 Contrasts**		
	r	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***
Extraversion	-.129	.408	41	-.083	.598	41	-.250	.074	50	-.165	.242	50
Neuroticism	-.088	.566	43	.122	.426	43	.197	.158	51	.008	.955	51

2.3.5 Personality effects using contrast estimates based on the SSMLE analysis

Before using Bayesian Model Selection to extract the good fit cases, we first conducted univariate ANOVAs to investigate whether there was a significant main effect of model fit groups (0,1, and 2; see Table 2.1 above) on extraversion or neuroticism as DVs, and whether

[7] The df values *($df = N–2$)* of the correlations vary slightly due to missing cases in the personality data.

there were interaction effects of model groups as a function of video condition. The outcome was that there were no significant main effects of model group on extraversion [$F(2,86) = .855$, $p = .429$], nor interaction effects of model group and video condition on extraversion [$F(2,86) = .445$, $p = .642$]. There were also no significant main effects of model group on neuroticism [$F(2,86) = 1.381$, $p = .257$], nor interaction effects of model group and video condition on neuroticism [$F(2,86) = 1.490$, $p = .231$].

As explained in the *Bayesian Model Selection* section of this chapter, using Bayesian methods potentially allows for a more meaningful correlation between fitting circumplex coefficients and personality traits. Therefore, the circumplex coefficients (b_i) of the cases with log(BF_{12}) values greater than +2.3, representing a good fit with model 1 (activation-deactivation circumplex), were extracted and correlated with trait extraversion and neuroticism. The numbers for these analyses in any one study are very small but are reported briefly here for completeness. There was a family of 4 correlations and so the per comparison Type 1 error rate was adjusted to $\alpha = \frac{.05}{8} = .006$. With such small sample sizes and adjustment for multiple comparisons, these analyses are extremely underpowered and so should be treated with extreme caution.

For those in the motivational video group, in the 10 cases with strong model 1 fits, there were no significant correlations between the model 1 circumplex coefficients and extraversion [$r(8) = -.306$, $p = .390$] or neuroticism [$r(8) = .076$ $p = .835$]. The circumplex coefficients were also extracted for the 11 cases with log(BF_{12}) values below -2.3 that showed a good fit to model 2 (pleasure-displeasure circumplex), and were correlated with extraversion and neuroticism. Again, there were no significant correlations between the model 2 circumplex coefficients and extraversion [$r(9) = .254$, $p = .540$] nor with neuroticism [$r(9) = .370$, $p = .263$].

The same procedure was conducted for the control video group. There were 9 cases who showed strong evidence for model 1 relative to model 2. Amongst those cases, the correlation with extraversion was non-significant [$r(7) = -.035$, $p = .928$], as was the correlation with neuroticism [$r(7) = .498$ $p = .172$]. It should be noted that we tentatively predicted a negative correlation between neuroticism and the activation axis in the motivational video; however, as the control video seems to produce activation-deactivation effects for some cases, these correlations aren't particularly unexpected at this point. The circumplex coefficients were also extracted for the 10 cases with log(BF_{12}) values below -2.3 that showed a good fit to model 2 (pleasure-displeasure circumplex), and were correlated with extraversion and neuroticism. There was no significant negative correlation between the model 2 circumplex coefficients and extraversion [$r(8) = -.386$, $p = .270$], nor with neuroticism [$r(8) = -.194$, $p = .591$] (see Table 2.3). Of course, neither of these correlations achieved significance against the adjusted alpha level (.006).

Table 2.3: Correlations of extraversion and neuroticism with circumplex coefficients (bi) of cases well fit by either model 1 and 2 in the motivational and control video groups.

	Motivational Video						**Control Video**					
	Model 1 b_i			**Model 2 b_i**			**Model 1 b_i**			**Model 2 b_i**		
	r	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***
Extraversion	-.306	.390	8	.254	.540	9	-.035	.928	7	-.386	.270	8
Neuroticism	.076	.835	8	.370	.263	9	.498	.172	7	-.194	.591	8

2.3.6 Personality effects on mood changes using the GEE analysis

As outlined above, we can easily add personality predictors to our GEE analyses to see if the traits of extraversion or neuroticism moderate the mood-inducing effects of the motivational video. We begin with adding extraversion as a predictor to the analyses for the motivational video condition (where the mood changes, for the sample as a whole, conformed to hypothesis 1A). We centered extraversion (by standardizing the scores) for all the participants included in the GEE analysis.

We start using the model 1 circumplex as the predictor. The key test is whether extraversion moderates (interacts with) the prediction by the model 1 circumplex values in the motivational video condition. As in the GEE analysis without personality above, the model 1 circumplex predictor robustly and positively predicts the mood changes [B= .928, SE= .16, 95% CIs = (.61,1.25); $p < .001$). The main effect of extraversion was not significant [B= -.017, SE= .03, 95% CIs = (-.08, .04); $p > .5$]. The interaction between extraversion and the model 1 circumplex predictor was not significant [B= -.195, SE= .12, 95% CIs = (-.43, .46); $p = .10$]. It should also be noted that, as well as being non-significant the B coefficient was in the opposite direction than that predicted by hypothesis 1B.

We repeated the above analyses in the control video condition where we have found that, for the sample as a whole, the model 1 circumplex values do not significantly predict mood change. Under hypothesis 1B we do not expect that extraversion will act as a moderator in this condition. This was what the analysis revealed: the main effect of the model 1 circumplex predictor was not significant in the control video condition: [B= .208, SE= .13, 95% CIs = (-.04,.46); p = .10] and neither was the main effect of extraversion [B= -.034, SE= .03, 95% CIs = (-.10,.03); p = .30] or the interaction of extraversion and the model 1 circumplex predictor [B= -.121, SE= .15, 95% CIs = (-.41,.17); p = .42].

The next key test is whether neuroticism moderates (interacts with) the prediction by the model 1 circumplex values in the motivational video condition. As in the analysis including extraversion the model 1 circumplex predictor robustly and positively predicts the mood changes [B= .940, SE= .17, 95% CIs = (.62,1.27); p < .001]. The main effect of neuroticism, however, was not significant [B= -.016, SE= .03, 95% CIs = (-.08,.05); p = .61]. The interaction between neuroticism and the model 1 circumplex predictor was also not significant [B= -.056, SE= .21 95% CIs = (-.47,.36); p = .791].

We repeated the above analyses in the control video condition where under hypothesis 1B we do not expect that neuroticism will act as a moderator in this condition. This was what the analysis revealed: the interaction of neuroticism and the model 1 circumplex predictor was not significant [B= .158, SE= .12, 95% CIs = (-.08,.40); p = .19]. However, the main effect of neuroticism had a significant B coefficient [B=.049, SE= .02, 95% CIs = (.01,.10); p = .03]. This means that the (post-pre) mood changes across the whole 12-PAC mood inventory tended to be larger for participants who scored higher on neuroticism. We had no predictions about this effect.

Now using the model 2 circumplex as the predictor, a key test is whether extraversion moderates (interacts with) the prediction by the model 2 circumplex values in the motivational video condition. As in the GEE analysis without personality above, the model 2 circumplex predictor does not significantly predict the mood changes [B= .001, SE= .17, 95% CIs = (-.34,.34); p = .99]. The main effect of extraversion was not significant [B= -.18, SE= .03, 95% CIs = (-.72,.03); p = .49], nor was there a significant interaction between extraversion and the model 2 circumplex predictor [B= .097, SE= .19, 95% CIs = (-.28,.47); p = .61].

We repeated the above analyses in the control video condition where we have found that, for the sample as a whole, the model 2 circumplex values do not significantly predict mood change. The main effect of the model 2 circumplex predictor was very similar to that seen in the GEE analyses without personality above: [B= -.272, SE= 12, 95% CIs = (-.50, -.04); p = .02]. The main effect of extraversion was not significant [B= -.039, SE= .03, 95% CIs = (-.12,.03); p = .26] and nor was the key interaction term for extraversion and the model 2 circumplex predictor [B= -.037, SE= .11, 95% CIs = (-.26,.19); p = .74].

The next key test is whether neuroticism moderates (interacts with) the prediction by the model 2 circumplex values in the motivational video condition. The main effect of neuroticism was not significant [B= -.014, SE= .03, 95% CIs = (-.08,1.05); p = .65]. The interaction between neuroticism and the model 2 circumplex predictor was not significant [B= .075, SE= .17, 95% CIs = (-.26,.41); p = .66].

We repeated the above analyses in the control video condition. The analysis revealed the same finding with respect to the non-significant main effect of neuroticism that we saw above when using the model 2 circumplex predictor [B= .054, SE= .02, 95% CIs = (.01,.10); p = .02]. The interaction of neuroticism and the model 2 circumplex predictor was also non-significant [B= .025, SE= .08, 95% CIs = (-.13,.18); p = .75].

All GEE analyses were repeated using exchangeable and independent WCMs, where the outcomes were similar each time, without any notable differences.

2.3.7 Intrinsic motivation effects

As expected, there was a significant difference between scores on the "competitive drives" item, where those who watched the motivational video had a higher average score (M = 2.94, SD = 1.20) than those who watched the control video (M = 2.00, SD = 1.17) [$F(1,110) = 17.65$, $p < .001$, $\eta p^2 = .14$]. This is consistent with our predictions because competitive drives are hypothesized to be one of the key features that enables motivational videos to exert appetitive effects. As noted above, inclusion of this item served as a simple manipulation check that the motivational video was indeed significantly more motivating for those who watched it relative to the control video.

A univariate ANOVA was performed to examine the effects of video type on the level of intrinsic motivation across the two video groups. The difference between the total intrinsic motivation scores of those who watched the motivational video (M = 30.39, SD = 6.51) was significantly higher than those who watched the control video (M = 26.14, SD = 7.12) [F(1,111) = 10.93, p = .001, ηp^2 = .09]. As previously explained, it was hoped that the videos would not differ in this property, as a lack of difference in the intrinsic motivation of the two videos would allow us to ascribe the mood effects more confidently to the appetitive rather than interest-related aspects of the motivational video. It might be suggested that we could statistically adjust for the differences in the level of intrinsic motivation of the two videos used in this study. This could in theory be attempted by adding the intrinsic motivation score as a covariate in our key analyses of the mood changes induced by the videos. However, this use of ANCOVA methods is generally regarded as unsound, perhaps except for the situation where the group difference in the nuisance variable (here, intrinsic motivation) can only have arisen by chance; that is, by sampling variation (see Miller & Chapman, 2001, for an excellent discussion). We do not feel confident that the difference in intrinsic motivation between the motivational video and our control video is a chance finding and so we did not carry out such analyses here, preferring instead to attempt to create a control video for use in future studies which is better matched to the motivational video (see Chapter 3).

2.3.8 Line bisection data

The difference between the average line bisection deviation of the two video groups, measured at post-test only, was tested for significance using a one-way ANOVA. This showed that the difference in the average line bisection between the two video groups was not significant [F(1,108) = 2.063, p = .154]. However, a one-sample t-test showed that the average line bisection significantly deviated from zero (in the direction of a rightward shift) in the motivational video group [t(50) = 2.183, p = .017] (M = .55, SD = 1.78), but did not do so for the control group [t(58) = .277, p = .391] (M = .063, SD = 1.74). These data therefore showed a significant degree of rightward bias in line bisection only for those who watched the motivational video. However, this is a very small effect (less than half a unit on the Qualtrics scale); i.e., about 1% of the maximal possible rightward shift a subject could make. Furthermore, the critical finding is that the degree of rightward bias after watching the motivational video was not significantly greater than that observed after watching the control video.

It can be argued that in the motivational video condition, those who show a good fit to the activation model in their mood data based on their positive circumplex coefficients (with $\log(BF_{12})$ values greater than +2.3) are those whom we expect to show the greatest degree of rightward shift. We, therefore, took the motivational video cases fit by model 1 and compared those subjects with those who are not fitted by the activation model. Those who are fit by model 2 are excluded here as they are fitted by the pleasure-displeasure model and so might produce a shift in line bisection if it is this type of mood induction that induces cortical asymmetry. It should be noted that as the number of cases that meet all the given criteria are few, the power of this analysis is relatively low. A one-way ANOVA showed that there was not a significant difference in line bisection deviation in the motivational group between the cases fit by model 1 (M = .52, SD = 1.22) compared to those who are not fitted by model 1 (M = .38, SD = 1.51) [$F(1, 28)$ = .063, p = .804]. The same procedure was done to test the line bisection shift for those who are well fit by model 2 (with $\log(BF_{12})$ values less than -2.3) to examine whether or not the pleasure-displeasure model produces a shift in line bisection. Again, there was no significant difference in line bisection deviation in the motivational group between the cases fit by model 2 (M = .20, SD = 1.18) compared to those who are not fitted by model 2 (M = .39, SD = 1.51) [$F(1, 27)$ = .094, p = .762].

Two general linear model analyses were used to test the moderating effect of extraversion or neuroticism on the video effects on the average line bisection score, and it was found that there was not a significant interaction between the video type and extraversion [$F(2,101)$ = 1.288, p = .208]. Similarly, the interaction was also not significant for video type and neuroticism [$F(2,103)$ = .436, p = .648].

2.4 Discussion

At the group level, the primary predicted results of this initial study were confirmed. To test that our motivational video was producing different motivation from the control video we used the single competitive drives item administered after watching the video. We found that those who watched the motivational video did significantly score higher on competitive drives than those who watched the control video, implying that the motivational video did indeed bring out their competitive drives. This confirmation of the manipulation allows us to consider the primary results of the study, the effects of the motivational video on mood. Through fixed-effects contrast analyses, SSMLE circumplex model fitting, and GEE regression analyses, average pre-to-post changes in core affect were observed along the activation-deactivation axis of the circumplex in the group who watched the motivational video, and this effect was significantly greater than that observed in those who had watched the control video. This was in contrast to the non-significant average outcomes in core affect along the pleasure-displeasure axis for the motivational video group. Specifically, there was an increase in activated affect and pleasant activation for those who watched the motivational video, compared to the control video, meaning participants felt more aroused, energetic, and alert. In light of these effects attributable to the motivational video, one can suggest that the motivational video acted as an appetitive mood induction source, leading to effects that are consistent with those produced by appetitive mood inductions. Hypothesis 1A was robustly confirmed for the sample of participants as a whole.

As expected, the control video did not produce any significant changes on the activation-deactivation axis of the core affect circumplex, though there was a clear indication that, on average, the control video produced mood changes along the displeasure-pleasure axis (written this way to convey the direction of the effect). These findings therefore specifically rejected hypothesis 2A. This hypothesis stated that the effects of motivational videos on mood would be observed maximally along the pleasure-displeasure circumplex axis, and this effect was predicted to be greater in the motivational video than that seen in the control group. Moreover, this pattern revealed that the more negative changes in mood appeared in the pleasure segments, with less negative changes in the displeasure segments of core affect (see Figure 2.12), indicating that some of the participants simply did not really enjoy the control video. This can also perhaps be explained by the intrinsic motivation scores being significantly lower for the control video than the motivational video. Despite selecting the control video carefully in the hope that its content (about clinical psychology training) would have high intrinsic motivation for psychology students this finding is a potentially serious confound that provides an additional point of an undesirable difference between the videos. The participants may have found the motivational video merely more engaging, and this could explain the differential pattern of mood changes that the video produced.

Though the summary of these results of this novel study at the group average level seems very promising, limitations need to be taken into account. While there were influential effects of the motivational video on affect, the SSMLE fitting results clearly showed that there were a majority of cases of participants who watched the motivational videos that were not well fitted to the activation-deactivation model. This may signal that, instead of the interpersonal incentivisation of social rewards that characterize the motivational video, it is, in fact, the discrepancy from the relative dullness of the control video accounting for these effects, which may be indicated by the difference in intrinsic motivation scores. That said, the same music was used in both the control video and the motivational video, and the content of both was deemed relevant to the sample population (i.e., psychology students should be interested in both how to study and perform better, as well as the contents of the control video which reports the experience of a clinical psychologist). However, it could be that the control video was less engaging than the motivational video, in a way that does not derive from the presence of rewarding social stimuli, but from the editing of the videos itself. For example, it proved to be a challenge matching the volume of the background music on the control video, so as not to drown out the speaker.

Similarly, the gender of the speaker was female in the control video and male in the motivational video, which may have also influenced the impact of the videos. A better way to test the parameters of the rewarding effects of motivational videos would be to have a control video that is better matched to the motivational video in terms of features that are not related to appetitive motivation. Ideally, such a control video would have the same level of impact and interest for the participant. It may be that more than two videos need to be deployed. This way one can in principle disentangle whether it is the language used, the facial expressions and eye contact, or the video edit (including the music) that truly influence motivation and generate the emotional, neural, and cognitive effects associated with this. In light of this, the study in chapter 3 attempts to overcome concerns of validity by providing a better matched pair of motivational and control videos and also these effects in a sample that contained a large proportion of non-students. Overall, we will attempt to address these issues directly by using a film production team to create a control video that matches the motivational video much more closely in several features, including the levels of intrinsic motivation it produces.

The results from the SSMLE fitting showed that a clear fit of the specific mood circumplex models was present in only a minority of the cases. In the motivational video condition, by using a log(Bayes Factor) of +/-2.3 (BF=+/-10) as the criterion for strong evidence for one circumplex model over the other, there were 10 cases (out of 42) who showed strong evidence for the activation circumplex model and 11 cases (out of 42) who showed strong evidence for the pleasure circumplex model. In the control video condition, there were 9 cases (out of 52) who showed strong evidence for the activation circumplex model and 10 cases (out of 52) who showed strong evidence for the pleasure circumplex model. The remaining 21 cases (out of 42) that watched the motivational video did not show strong evidence for either circumplex models. There was also a result that, in either condition, both model 1 or 2 were much better fits than model zero (no variation in mood change around the circumplex) in almost all participants in either video condition (see Appendix A).

This is an important finding as it shows that the mechanism by which a specific experience affects mood is probably different for different people. These results show that it is not the case that a single mechanism is at work and individuals simply differ in the strength of that mechanism; rather some people respond in one way and others respond equally strongly but in an entirely different (and uncorrelated) way. This finding endorses the need to explore individual differences but, as discussed below, complicates the process of determining which personality traits might map on to which mechanisms. Our findings add to the perpetual argument on the issues of methodological and statistical approaches taken within individual differences research. For example, a review by Yarkoni and Braver (2010) highlights the limitations and the hindering reductionism of direct brain-behaviour correlations when implementing effects of group averages, which includes a disregard for the interaction of trait-state effects. Our results show that we should not look at average performance alone, nor rely exclusively on fixed effects analyses, when studying individual differences. This general point has been gaining traction in the individual differences' literature (e.g., see Haines et al., 2020). How many other individual differences studies might have not uncovered interesting results because they did not consider each case's data separately. Here, hypothesis 2A, looks to be clearly rejected by the averaged data in the motivational video condition and yet 11/42 cases in this sample show good fit for this model. We only see evidence, on average, for a good fit for model 1 in this video condition because the distribution of circumplex contrast values is skewed to have a non-zero mean.

We also reported the moderator effects of personality traits, extraversion and neuroticism, on the change in affect, via the correlations between the trait scores and contrast and circumplex coefficients of the activation-deactivation and pleasure-displeasure models. Using all the available data, separately for each video condition, the correlations of the contrast coefficients of the activation-deactivation model with extraversion or neuroticism were small. The same was true of the corresponding correlations between the pleasure-displeasure model contrast coefficients and extraversion or neuroticism. We did not set much store by the tests of significance for these correlations for the following reason: if the observed mood changes for the majority of cases were not accurately described by the activation (or pleasure) circumplex model it is unlikely that one would be able to find correlations between personality and mood changes that are hypothetically predicted based upon that circumplex model, at least when the correlations are assessed in the whole sample (tested in a particular condition). Given that the majority of studies in the literature use fixed effects models and do not attempt to try to establish whether the hypothesized behavioural changes are present in all participants, then this may well contribute to why many predicted personality correlations with behavioural models are small and/or unreliable and/or hard to replicate (see Haines et al, 2020, for a similar point).

Moreover, the use of BMS allowed us to extrapolate the individuals' cases whose data were good fits for either of the models in either condition. This meant that we could (in theory) perform the trait correlations on just the well-fitting cases to see if there was a relationship between the effects of watching the motivational video with either extraversion or neuroticism. This approach would allow for a focused way to test the relationship of individual differences in approach motivation after appetitive mood inductions. However, the numbers of cases available for such an analysis were so small (around N=10) in the restricted analyses that they severely lacked power to detect correlations.

The GEE analyses were also used to address personality relationships across the group as a whole. As GEE uses a robust method of estimation it is possible that such methods might be able to detect personality effects across the whole group even when they are present in only a fraction of the whole sample. However, in the motivational video condition, there was only very limited evidence (a weak statistical trend) for a moderation by extraversion of the prediction of mood changes by the activation-deactivation circumplex. This moderation effect operated in the opposite direction to that predicted by Hypothesis 1B (i.e., extraverted subjects tended to show slightly *less* moderation of the mood changes induced by the activation-deactivation circumplex, and not more as expected under hypothesis 1B). Whether this effect, and its direction, are real must await replication attempts in subsequent chapters, especially given the absence of any evidence for moderation by extraversion here using the other types of analysis.

The remaining GEE analyses showed no evidence for a moderation by neuroticism of the prediction of the mood changes by the activation-deactivation circumplex in neither the motivational nor control video conditions. There was also no evidence for a moderation by extraversion nor neuroticism of the prediction of the mood changes by the pleasure-displeasure circumplex in either video condition.

It is therefore impossible to draw any firm conclusions from these analyses or to derive any clear implications for theories of individual differences in approach motivation, like the ARH (Gross et al., 1998) and RST (Smillie et al., 2006). The fact that Smillie et al. (2012) obtained reliable correlations for extraversion with their mood induction procedures could suggest that those procedures may be inducing mood changes via the same mechanism in the majority of participants in those studies. Perhaps the fact that classic mood induction methods use highly overlearned social scenarios with familiar mood-congruent music may enable a more homogeneous mechanism of response that those mechanisms engaged by the motivational and control videos used here.

Furthermore, there are other notable studies that have yielded mix support for the ARH for extraversion. For example, Lucas and Baird (2004, Study 1) used guided imagery scenarios from Larsen & Ketelaar's (1991) study but wanted to additionally measure the effects of both pleasant valence and activation, including moderation effects of extraversion. They indeed found a significant extraversion by mood interaction effect when predicting activation, but no such effect was found when predicting pleasant valence. It is, therefore, tempting to conclude, as Smillie et al. (2012) did, that the ARH may apply specifically to activated affect. However, when attempting to replicate such a finding, Lucas and Baird (2004) could only do so in two out of five further studies that used different mood induction stimuli (humorous video clips and paper-and-pencil test format). It could be that the ARH is contingent on certain induction methods, including the stimuli used and level of appetitive relevance for the individual. Perhaps the unreliability of the extraversion correlation with activated affect change is a product of a wide variation in mood induction mechanisms, operating in a single sample given the same mood induction procedures. This variation was clearly observed in this chapter. Controlling for personal relevance of the video, which might be a factor contributing to variation in the mechanisms induced, is approached in chapter 3.

Finally, there was a non-significant effect of the video type used online bisection performance. Assuming rightward line bisection bias is an accurate proxy for left frontal cortical activation, then the main effect of video type on line bisection is the key test of the hypothesis that the motivational video induces an increase in left hemisphere asymmetry in cortical activation. This, as noted, was non-significant. Nonetheless, the line bisection data showed that those who watched the motivational video displayed a significant rightward bias in line-bisection, whereas those who watched the control video did not show a significant bias. This result is in line with previous studies (e.g., Nash et al., 2010), in showing greater left frontal activation in those participants in the approach-motivated condition. The rightward line bisection bias in the participants who saw the motivational video does provide weak support for appetitive processes in response to the motivational video. However, we must note this very cautiously as the effect in the motivational video condition was not significantly different from the line bisection performance in the control video condition. Also, the rightward shift in the motivational video group was tiny on average, only about 1% of the total rightward shift that could be made. One can suggest that if this is an effect of the video it might be very weak and speculate that this is because of the time lag from the end of the video to the start of the line bisection (which was filled with other activities such as mood ratings). We used a fixed order of testing because the mood changes were our primary endpoint and we wanted to give them the maximum chance of showing a response to the video, so we administered them first after the video. Furthermore, the lack of a pre-test measure of line-bisection caused by unavoidable testing time constraints, reduced our power to detect changes in performance as a function of video type. Nevertheless, the ease of the digitalisation into an online version of the line bisection task could benefit this research in terms of large sample online testing methods. However, it will need to be investigated further and tested against direct indices of frontal asymmetry (e.g., EEG frontal alpha asymmetry).

In addition to the lack of a main effect of video type online bisection, line bisection performance in the motivational video condition was not moderated by extraversion, making it difficult to argue strongly for a specific effect of appetitive motivation (delivered via the motivational video alone) on this proxy for left frontal activation.

Once again, we should consider the possible issue of diversity of the mechanism of changes induced by the videos we used. If a left hemisphere activation is produced by a mechanism that induces activated affect, then we might expect to see a rightward shift in line bisection performance only in those people in the motional video condition whose induced mood changes were well fit by an activation circumplex model. While the line bisection deviation was slightly higher (more rightward) for those whose mood data were better fitted by the activation-deactivation model compared to those who were not well fit by either model, this was a non-significant difference. On the other hand, if the differential left versus right hemispheric activation is produced by a mechanism that induces changes in pleasurable affect (positive hedonic tone), then one might expect to see a shift in line bisection only in those people whose mood data were well fit by a pleasure-displeasure model. Again, there was no significant difference between the line bisection deviation between those who were better fit by the pleasure-displeasure model compared to those who were not well fit by either model. This analysis was performed on a very small sample size due to the limited number of cases that met the model-fitting criteria and was, therefore, probably substantially underpowered to detect such an effect.

2.4.1 Conclusion

A widely watched example of a motivational video (1.4 million views) with an inspirational speaker aiming to motivate students to work hard to achieve “greatness” was used to test whether or not motivational videos can be used as an appetitive (activated affect) mood induction technique. The argument underlying this test was that the videos employ interpersonal reward incentives, which possibly work by inducing activating affect but not pleasant affect (hedonic tone). By employing the circumplex structure of core affect, we were able to effectively use fixed-effects contrast analyses, SSMLE fitting and Bayesian model selection methods, plus GEE regression methods, to test whether motivational videos induced mood changes along the activation-deactivation axis, as opposed to the pleasure-displeasure axis. We also tested whether the effect was significantly greater than the corresponding effects induced by the control video, as well as in comparison to the control video (an interview with a clinical psychologist about her experience). The results showed that, on average, the motivational video did induce mood changes along the activation-deactivation axis which were greater than those induced by the control video. The control video (but not the motivational video) did also appear to induce some mood changes along the pleasure-displeasure axis. However, the BMS results (which fit the data for each participant individually) showed that there was considerable heterogeneity in the mood induction mechanisms (models 1, 2 or other) that were at work in each video condition. This raises potentially strong implications for our ability to detect correlations between personality and behavioural measures of mood change derived from a specific model, given that the individuals we studied varied not only in the degree to which a particular experience induced a specific kind of mood change, but also in what type of mood changes were induced by that experience. This shows how individualised fitting methods and model selection methods might offer big advantages over standard fixed effects modelling of behavioural data.

A novel proxy measure of left frontal activation, an online line bisection task, while producing somewhat weak findings here, has raised the possibility to collect behavioural indices of frontal asymmetry using methods of mass online data collection. However, experimentation with greater power is first needed to validate online line bisection as a measure. Overall, the findings from using a motivational video, including an induction of competitive drives, are consistent with the effects produced by appetitive mood inductions, however a better matched control is needed to fully corroborate the effects of the motivational video.

Chapter 3

Do "motivational videos" operate by means of providing interpersonally rewarding incentives? A replication of study 1 with improved methodology.

3.1 Introduction

This chapter will present a continuation of study 1 (in chapter 2) with the aim of improving on the methodology developed in study 1. Study 1, although limited by the methodological factors noted in chapter 2, clearly revealed very promising and interesting results. Therefore, study 2 (reported below) was designed and conducted as a means of overcoming the key limitations of the first study, particularly those pertaining to the imperfect matching of the experimental control video. The present study attempts to disentangle the features of the motivational video that account for the increase in activated affect. Study 2 utilizes the same basic pre-post between subjects experimental design as study 1, while refining the experimental manipulation with a better matched control video, which includes replicating many features of the original motivational video.

To do this, it was decided that the original motivational video (OMV), used in the first study, should be professionally recreated by the author, using a team of experts (actor, cameraman, soundman, editor, and producer), who were reimbursed for their time. This recreated motivational video is abbreviated to RMV. The same actor was also to be used in a new control video (NCV), created by the author and the same team. The NCV was constructed to closely match the RMV on many dimensions that were uncontrolled by study 1. The OMV will also be used in study 2, thus meaning that three videos were used in study 2. To ensure that the motivational video was accurately replicated, the effects of the OMV and the RMV will be compared against each other. The details of the ways in which the NCV was better matched to the control video are given below.

For the purpose of these investigations of motivational videos, it is important to note that we have been adopting the concept of the self-determination theory (SDT; Deci & Ryan, 1985; 2000) of intrinsic and extrinsic motivation, as it seems likely to be particularly relevant to understanding the role of reward processing and approach motivation in the context of motivational videos (see chapter 2 for a brief summary of the features of these videos). We are specifically interested in the rewarding effects of extrinsic goals, which are somewhat tangible but do depend on the contingent reaction of another person and are considered a means to another end. Examples of extrinsic goals are acquiring financial success (money), or social recognition, or an appealing appearance, each of which may result in positive social feedback (Kasser & Ryan 1996). These goals are much like the ones being possibly pursued by people who watch motivational videos; in these videos specific statements often address exactly these sorts of goals (e.g., "*whatever it is that you decide you want to make come true in your life, you can do that"*, *"if you want to be great you have to become capable of greatness", "you've got to develop your skill set"*). Such extrinsic goals can be likened, by definition, to examples of secondary rewards (Bhanji and Delgado, 2014; Izuma et al., 2008; Lin et al., 2012; Spreckelmeyer et al., 2009). Conversely, intrinsic motivation or goals pertain to activities or behaviour executed for the inherent interest and/or enjoyment of the individual (Deci & Ryan, 2000). Motivational videos rarely refer to intrinsic motivation or inherent interest, and so we consider the appeal to extrinsic motivation as one of their key features. This is why we felt that motivational videos were likely to increase activated affect in the ways described by Smillie et al. (2012).

To refine the experimental understanding of the effects of the motivational videos and thus the key features in which they should differ from the control video, we adopted a subsidiary of the SDT (Deci & Ryan, 1985; 2000), which is known as the effects of goal contents (Deci & Ryan, 2000; Vansteenkiste et al., 2004). Goal contents theory was formulated as a way to understand how the content of a goal can lead to differential outcomes of behaviour and motivation (Deci & Ryan, 2000). It proposes that a goal focuses on what a person is expecting to obtain as a function of behavioural participation (e.g., I study for more hours to get better grades). The effect of goal contents was employed to explore the personal relevance the content of the video had for the individual as a function of their personal aims and goals. The use of goal contents here derives from its emphasis on the importance of goals, aspirations, desires, and motives when determining the response to stimuli that may hold extrinsic motivational value (Deci & Ryan, 2000). We will, therefore, measure personal relevance as another manipulation check in addition to the competitive drives item already used in study 1. We thus included a rating after the video about its personal relevance to the viewer. It is hypothesised that those who watched either of the motivational videos will agree more with the target personal relevance questions than those watching the control video. As just noted, this is another manipulation check, along with the competitive drives item that was used in study 1.

We also measured the perceptions that the participants had about the speaker in the video, albeit in an exploratory fashion. We did this because we wanted to eliminate the possibility that our motivational videos might be changing activated mood simply because the video speaker was perceived to possess more desirable features than the control video speaker, rather than being anything to do with the appetitive nature of the motivational videos' goal-setting contents. This was thus an important check on a potential nuisance variable. We did this using questions regarding interpersonal perception: namely ratings of the video speaker on desirable physical and personal characteristics. It is hypothesised that, if our control video and motivational videos are well matched, there should be no difference in the ratings of the desirable characteristics of the speakers.

The experimental hypotheses of the current study resemble those of the first study, however with the addition of the effects of the three videos (OMV, RMV, and NCV) being tested against each other, as well as additionally measuring the effects of speaker perception (as a check on video matching) and personal relevance (as a manipulation check). The same reasoning of the first study was used to formulate the hypotheses of the current study. The reasoning once again is that motivational videos work as a form of mood induction.

The assumption is that the interpersonal aspects of the motivational speaker (e.g., eye contact, and personally-directed speech; Kennis et al., 2013) and the goal-directed content of the language used (Smillie et al., 2012), work to socially incentivise the rewards being pursued by the viewer, in turn endorsing situational motivation (Vallerand, 2002) and subsequently increasing activated affect (Smillie et al., 2012).

Overall, it is hypothesised that, relative to a control video, both motivational videos (OMV and RMV) will on average, from pre- to post-test, increase those segments of emotion (circumplex models divide mood up into segments; e.g., Yik et al, 2011) that involve activated affect (*pleasant activation, activation, unpleasant activation*). The motivational videos will also, on average, produce a decrease in segments of deactivated affect (*unpleasant deactivation, deactivation, pleasant deactivation*), while on average leading to non-significant changes in pleasant affect (*pleasure, activated pleasure, deactivated pleasure*) and unpleasant affect (*displeasure, activated displeasure, deactivated displeasure*). We have refined these hypotheses in light of the results from study 1, which on average showed exactly these results. However, the result of study 1 also showed that the specific effects on activated affect were clearly present only in a sub-group of those participants who watched the motivational video. There are subjects for whom a specific increase in activation and decrease in deactivation provided a very good individual fit for their mood response (i.e., this is not a mere weak resemblance). There were even some participants who found the motivational video deactivating. We also continue to expect that, as in study 1, there will be some participants who respond to the motivational videos with specific increases in pleasurable affect rather than activated affect, and yet others who respond with increases in displeasurable affect. Our fitting of models to individual participants' mood change data in study 2 is predicted once again to uncover these marked individual differences in mood change profiles across participants.

It should be noted that changes in mood profiles were also observed for the control video in study 1. On average it was found to induce mildly unpleasant affect, although this effect was driven primarily by a minority subset of the participants watching this video, where some found it pleasurable, others activating, and yet others found it deactivating. Our interpretation was that, on average, this video was quite dull for psychology undergraduate participants even though it was about clinical psychology training opportunities. In the current study, the better matching of the control video in terms of intrinsic interest (see below) is tentatively expected to reduce the mood changing effects in those who watched the control video.

As just noted, the design of the new control video was intended to mean that there will be no difference in intrinsic motivation between those who watched the motivational videos and those who watched the control video. As in the study 1, intrinsic motivation is used as a control measure here, intended to confirm that any mood inducing effects of the motivational videos (compare with control videos) is not due to the greater interest levels that the participants have in the content of the motivational videos, but rather is due to the approach towards interpersonal incentives and goals that the motivational videos stress. A "nuisance" difference in intrinsic motivation between the control and motivational video was found in the previous chapter and this was a potential issue for the interpretation of the findings.

As in the previous chapter, these average-level predictions will be confirmed by a significant interaction between video type and the affect type contrasts calculated under the activation-deactivation circumplex model (model 1), but not when the contrasts are computed using the pleasure-displeasure circumplex model (model 2). However, as in chapter 2, we will continue to test the hypothesis that mood changes in the motivational video will on average operate along the pleasure-displeasure mood axis. This hypothesis (hypothesis 2A in chapter 2) was not supported in study 1, nor in the work of Smillie et al. (2012).

Furthermore, using implications from the RST (Pickering et al., 1995; Smillie et al., 2006) and ARH (Gross, Sutton, & Ketelaar, 1998), and their understanding of the BAS and BIS, the personality traits of extraversion and neuroticism are predicted to be potential moderators of the specific changes of affect as a function of video type. The average-level effects are predicted above are expected to be greater for those who score high on extraversion, and for those that score low on neuroticism. Both personality predictions are made somewhat more tentatively in this chapter since the key associations with both extraversion and neuroticism were not significant in the first study. In chapter 2 we suggested that the lack of significant relationships with extraversion and neuroticism, across whole samples of participants in a particular video condition, might not be unexpected even if Smillie et al.'s (2012) account of mood induction effects and personality was correct. This argument followed from the observation that only a minority subset (about a quarter) of the participants who watched the motivational videos showed a clear induction of activated affect. By assessing the correlations across all participants in a video condition, this means that any relationships with personality in the subset who have increased activated affect will be seriously diluted by the majority of subjects who respond to the motivational videos in a different way. While we believe this argument is likely to continue to hold in study 2, we will still report the whole group personality correlations. This is another reason why we make our personality predictions rather tentatively in this chapter.

In this chapter, conscientiousness was added as a potential moderator variable in an exploratory fashion, using the following reasoning. Conscientiousness is defined as the need for achievement, commitment to working, and one's moral cautiousness, and includes facets of competence, dutifulness, order, achievement striving, self-discipline and deliberation (Costa et al., 1991). One might argue, merely from face validity, that conscientiousness could moderate the activating effects of motivational videos. This is because these videos exhort people to work harder and make maximal effort, something that conscientious people are trying to do in general. This is primarily a common-sense prediction that is therefore applied tentatively.

Although there have been no studies, to date, that account for a specific biobehavioural mechanism for the role of conscientiousness in approach motivation, a study conducted by Cao and Xia (2020) demonstrates how conscientiousness mediates the link between brain structure and one's consideration for future consequence. The term *consideration of future consequence* is defined as 'the extent to which people value the long-term outcomes of their current behaviours and the extent to which they are affected by these outcomes' (Strathman et al., 1994, p. 743). Cao and Xia (2020) found that conscientiousness mediated the relationship between prefrontal activation and consideration of future consequence, supporting accounts of neural indices of conscientiousness and its role in goal orientation and discipline (Bjørnebekk et al., 2013; DeYoung et al., 2010).

In this chapter we again use line bisection as a proxy for asymmetric frontal activation. We use line bisection responses to test whether motivational videos exert their possible effects via enhancing appetitive motivation. If a motivational video activates appetitive brain systems (e.g., the prefrontal frontal cortex) then, according to the proposal of Davidson et al. (1990), it should induce a relative increase in left frontal cortical activation. Such a boost to left frontal activation is predicted, in turn, to be associated with a rightward bias in line bisection (Nash et al., 2010). It is hypothesized that motivation and increased activated affect will be accompanied by a rightward line bisection bias for those watching either motivational video, indicating left frontal activation, where this pattern will not be seen in those who have watched the control video. This is because relatively stronger left frontal cortical activity is thought to be associated with approach motivation, while relatively stronger right frontal cortical activity, is associated with avoidance motivation (for a review, see Kelley et al., 2017). This finding is predicted more tentatively in this chapter given the nonsignificant results of the line bisection task in the previous chapter. We also suggest that the line bisection shift will be observed only amongst those who clear show an increase in activated affect after watching the motivational video. This is, again, a tentative prediction given the nonsignificant results of this pattern in chapter 2.

Overall, it is hypothesised that there will be no significant difference, on any account, between the main effects of the two motivational videos. This prediction follows because the RMV was a close replica of the OMV but made by the author and her film crew. The only substantive difference between the videos was in the identity of the speaker: an English actor used in the RMV versus a reasonably well-known American YouTube motivational speaker in the OMV. Participants were also asked if they recognised the speaker and if they knew his name to explore any effects this may have.

3.2 Method

3.2.1 Sample

A sample of 184 participants (M age = 27.7, SD = 9.07, 50% male) mainly recruited from Prolific (www.prolific.co), an online participant recruitment platform and were each reimbursed £3.33 for their time. 55 participants were recruited from Goldsmiths, University of London, as first year undergraduate students exchanging participation for course credits. Overall, 95 participants were students (34 of which were also employed), 65 were in employment only, and 23 were unemployed, meaning 48% of the sample were not students. Informed consent was provided prior to the commencement of the experiment, in accordance with the ethical approval given by the ethics committee at Goldsmiths, University of London.

3.2.2 Materials and procedure

The procedure and all psychometric and line bisection measures were identical to that of first study in chapter 2, excluding the added personal relevance and speaker perception ratings for the current study. All participants were tested individually via an online Qualtrics link. Each participant carried out the study remotely on their own laptop or smart device and were requested to wear headphones throughout the study (see Figure 3.1 for a schematic diagram showing the order that the scales and measures were given before and after the participants views either video).

To measure pre-post differences in mood the affect adjective list from the 12-Point Circumplex Structure of Core Affect (12-PAC; Yik, Russell, and Steiger, 2011) was administered twice: before and after watching the video. The 60 adjectives of core affect included in the 12-PAC are divided into 12 segments, each representing a state of emotion. All 60 adjectives were included in the experiment, where participants were required to rate the extent of which they were feeling each item at that moment in time.

The Big Five Aspects Scale (BFAS; DeYoung et al., 2007) was used to measure levels of extraversion, neuroticism, and conscientiousness. These trait measures were given before participants watched the video.

Additionally, the state motivation items of the Dundee Stress State Questionnaire (DSSQ; Matthews et al., 2002) were adapted and used to test the intrinsic motivation of the participants as a control measure. Ideally, there should not be a significant difference in this variable between the two videos. This questionnaire was given post-manipulation only, i.e., after the video was shown.

An addition of one item from the success motivation facet of the DSSQ (Matthews et al., 2002) was adapted and included, as it was deemed to be of use for explicitly representing approach motivation (*"the video brought out my competitive drives"*). However, this was excluded from the sum of the intrinsic motivation scores and was treated as a separate dependent variable in the analysis. Significantly higher competitive drive scores were predicted for the motivational video. As noted previously, this item served as a manipulation check for the motivational video.

On opening the Qualtrics study, the survey flow randomiser randomly assigned participants to watch one of the three videos (N = 63 watched the OMV, 62 the RMV, and 59 the NCV). To ensure the videos were accurately matched, the OMV used in Experiment 1 was replicated in a professional-quality video directed by the author. It used a British speaker (a life coach recruited by the researcher) and was filmed by a film crew and directed by the researcher (links to videos: OMV-https://www.youtube.com/watch?v=wXkryZEZ68s&t=1s;
RMV-https://www.youtube.com/watch?v=9IH3Mj8J5Q0;
NCV- https://www.youtube.com/watch?v=x0Byaq1P0l0&t=1s). The RMV was filmed and edited in the same way as the OMV and included an identical script and background soundtrack (*"Galaxy Falling"* by Really Slow Motion). Its duration was 3:30 minutes. The only difference between the two videos was the speaker, with a British accent for the RMV, as opposed to American for the OMV. Having an in-house production of the RMV allowed a well-matched NCV to be created and produced by the author. The NCV involved the actor giving a short bespoke lecture on theories of motivation written by the author. The lecture was matched in length to the RMV and OMV.

The better matched NCV also used the same speaker, eliminating any individual speaker effects, such as the gender difference in Experiment 1. As with the previous control video, the NCV was filmed in an "interview" style, with the speaker's eye-gaze averted away from the camera and point of view of the viewer. The NCV's duration was 4:10 minutes. To ensure that the NCV was indeed controlling for the interpersonal incentive, the personally-directed speech and use of second person pronouns and verb forms was absent in the NCV. At the same time, the NCV maintained very similar linguistic context to that used in the motivational videos. This was possible because the lecture about motivation allowed the inclusion of the same verbs associated with taking action and approach behaviours. However, using this linguistic content in an academic context meant that these words were very unlikely to induce appetitive motivational behaviour.

The Linguistic Inquiry and Word count (LIWC2015) program (Pennebaker et al., 2015) was used to conduct a language analysis that empirically verified the desirable similarities and differences of the two scripts. The analysis divided the scripts into output percentages of word type categories. Appropriate target word type categories were selected by the researchers, and the draft control video script was then edited until the word count, and percentage of verbs and words related to drive, achievement, motion, and work were not significantly different from the motivational script, while almost fully excluding the use of the pronoun "you" from the control video script.

On having watched one of the three videos, and after completing the post-mood questionnaires, the line bisection task, and intrinsic motivation questionnaires, participants were asked to rate the speaker on eight adjectives reflecting interpersonally attractive qualities or desirable characterises, half of which were negatively keyed (*successful, uninspiring, intelligent, unattractive, hardworking, dull, healthy, poor*), using a 10-point scale. Following this, they answered eight personal relevance items, half of which were posited to be unaffected by the videos (see Table 3.1), on a 5 point Likert-type scale. The scale for the targeted personal relevance items was tested for internal consistency (Cronbach's alpha = .83).

Table 3.1: The targeted and non-targeted items in the personal relevance measure.

	Item
Targeted	• *The video made me feel like I need to read/study more.* • *The video made me feel that I need to put more effort into my work/study tasks.* • *The video made me feel that I should be healthier by eating better and exercising more.* • *The video made me want to strive for success in everything that I do.*
Non-targeted	• *The video made me feel inspired to take up a new hobby.* • *The video made me want to travel more.* • *The video made me feel that I should write things down and take more notes.* • *The video made me feel that I should socialise more.*

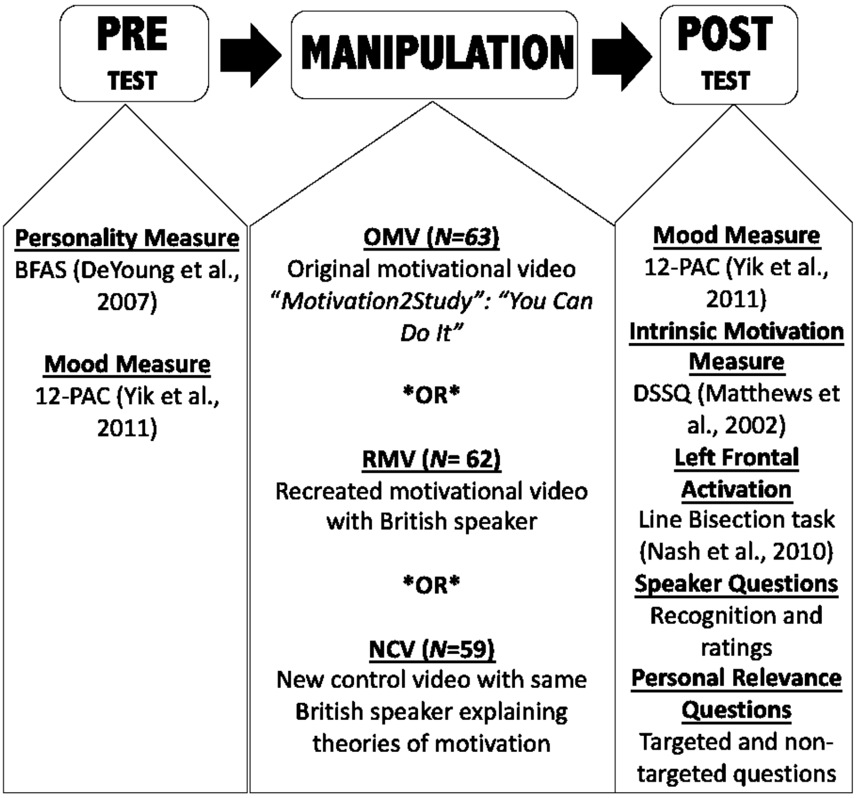


Figure 3.1: A schematic diagram showing the order of the scales and tests before and after the video manipulation. In the pre-, and post-, phases the order of measures was from top (given earlier) to bottom (given later).

3.2.3 Data analyses

Data were analysed using SPSS version 23.0, and a specially constructed MATLAB script that was able to utilise routines from the VBA toolbox (Daunizeau et al., 2014) to carry out the Bayesian Model Selection. The same process of analysis was used as the chapter 2 experiment.

3.2.3.1 Mood induction effects

Means for pre-test and post-test affect adjectives were computed for each participant for each of the 12 core affect segments (Yik et al., 2011), and change in affect was calculated by subtracting the pre-test scores from the post-test, where positive scores indicate an increase in the affect levels for that segment. Any missing data from the individual adjectives were imputed as averages within the affect segments. These data were subject to a traditional fixed-effects ANOVA with specific circumplex repeated-measures contrasts (see details below).

As before, the study attempted to test and compare model 1 and model 2, where model 1 represents the proposal that motivational videos act on affect primarily along the axis running from point XII in the circumplex (activation; maximum effect; at 0 degrees) through to point VI (deactivation; minimum effect; at 180 degrees [= π radians]). We contrasted this with model 2 in which the effects of the video are thought to act along the axis from point III (pleasure; maximum effect; at 90 degrees [= $\pi/2$ radians]) to point IX (displeasure; minimum effect; at 270 degrees [= $3 * \pi/2$ radians]). The expected mood change, E_{1k}, of any manipulation acting according to model 1 on mood segment k, is given by:

$$E_{1k} = a_1 + b_1 * \cos(\theta_k) \qquad (3.4)$$

The analogous effect under model 2 is given by:

$$E_{2k} = a_2 + b_2 * \cos(\theta_k - \pi/2) \qquad (3.5)$$

A graphical representation of the model effects is shown in Figure 3.1 with $a_1=a_2=0$; $b_1=b_2=1$ and the affect segments numbered 1-12 (following the numbering in Figure 2.1).

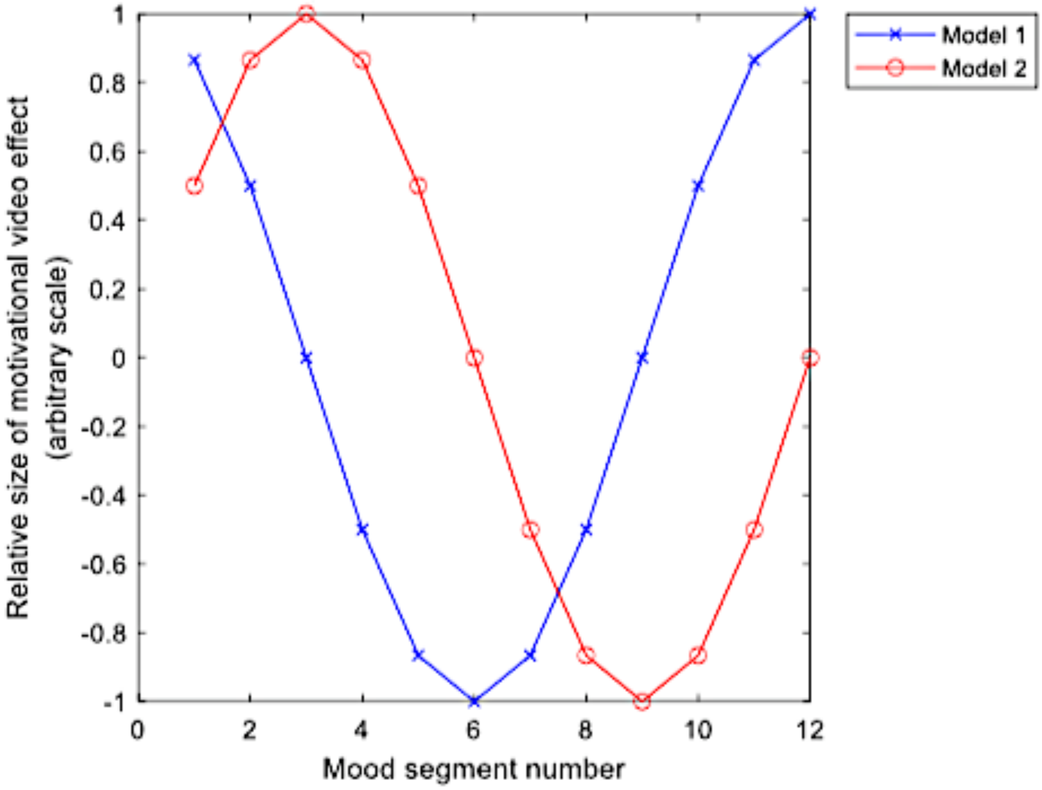


Figure 3.2: Predicted affect change effects under model 1 and model 2 as a function of mood segment around a circumplex. This figure is the same as Figure 2.3, but it is reproduced here for convenience.

To test these models, we created repeated measures trend contrasts across the repeated-measures affect segments, using the values plotted in Figure 3.2. The values in Figure 3.2 sum to zero across each model already, and the values for each model are orthogonal to one another over model segments. We also normalized the values from Figure 3.2 (by dividing each value by 2.4495, the L2 norm of the 12-element vectors formed from the values in Figure 3.2); it is conventional that sets of contrasts used in an ANOVA are orthonormal.

The contrast analyses just described use so-called fixed effects techniques: the mean contrast value estimated across all the participants is tested (to see if it is significantly different from 0). The effect is fixed for all cases and the error term used reflects the random error variation across participants.

To refine the model comparisons still further, variational Bayesian inference techniques with random effects modelling (based on an extension of the mood circumplex models noted above) were implemented in a MATLAB script, utilising routines from the VBA toolbox (Daunizeau et al., 2014). The first key difference is that each mood item is considered separately as an equivalent measure of the mood change relating to its specific segment. The fit of the circumplex models is determined for each participant individually. We called this technique single-subject maximum likelihood estimation (SSMLE) in chapter 2. In the earlier fixed-effects analyses one score for each mood segment was used per participant (based on the average across the items relating to that segment) and a common circumplex model equation was found across all the participants in each condition. Strictly, this approach is not random effects modelling in its conventional form. In standard random effects models the data from each of the individual participants are typically all fit simultaneously and the coefficients obtained are constrained to come from a specified (random) distribution. This means that the fit of one participant is affected by the fits of every other participant. Our approach is arguably more suitable for our analytical goals, where we want to estimate the fit of each participant independently of every other participant. This also means that our distribution of fitted parameters is not guaranteed to conform to a specific random distributional form.

To do this modelling, we continue to denote that there are k = 1:12 mood segments (approx. 5 items for each segment) theoretically arranged at evenly-spaced angles ($\frac{\pi}{6} \leq \theta_k \leq 2 * \pi$) around the circumplex (now using radians rather than degrees; see Figure 3.2 above). We are interested in which of two random effects models fit our data the best and the model fits were assessed at the level of the individual participants. These models can be represented as Equation 3 below:

$$\Delta mood_{ik} = a_i + b_i * \cos(\theta_k + \varphi) \quad (3.6)^{8}$$

where i denotes the ith case and k denotes any of the individual mood items relating to the kth segment. The activation-deactivation model (model 1) proposes that the maximum (minimum) mood changes will occur at k = 1; $\theta_k = 0$ (k = 6; $\theta_k = \pi$). This can be represented by setting the phase term, φ, in equation 3, to 0. The pleasure-displeasure model (model 2) is phase shifted by $\frac{\pi}{2}$ and thus is captured by equation 3 with $\varphi = -\frac{\pi}{2}$. The pleasure-displeasure model therefore has a maximum (minimum) mood change at k=3 (k=9). For both models 1 and 2, the

[8] The cosine values were L2 normalised before the use in this equation, matching the values used in fixed effects contrast analyses above.

maximum and minimum points can be swapped over to reflect deactivation-activation or displeasure-pleasure models respectively (where the first named mood segment is that with the maximal value under the model fit, and the second named segment is that with the minimal value). These "swapped models" simply differ in the sign of the coefficient b_i. For example, we will fit model 1 to an individual participant's mood change across all 60 items. The best fitting version of model 1 for that participant may have a positive or negative value of b_i. If the value is positive, then we would describe their model 1 as an activation-deactivation model fit; if the value is negative we would describe it as an deactivation-activation model fit (but either fit is a fit for model 1). The equivalent point applies to fits obtained using model 2.

For comparison with models 1 and 2, we also consider an intercept-only model (model 0) in which $b_i = 0$ for all participants (see Appendix for all comparisons made with the intercept model and related analyses).

These models were fit at the level of each individual participant, estimating the values of a_i and b_i (for models 1 and 2) for each participant (where different cases are denoted by the subscript i), which is possible due to the several different mood adjectives used to estimate each of the k segments. Bayesian model selection (BMS; Rigoux et al., 2014; Stephan et al., 2009) is used to estimate which model fits best across the sample and also provides information for each case about which model best fits their individual performance.

To adjust for multiple comparisons in the fixed-effects analyses comparing the circumplex contrasts between video groups, the Bonferroni method was utilised, and the adjusted α-values were applied accordingly. We planned 3 comparisons: the RMV vs. the NCV; the combined MVs (OMV+RMV) vs. the NCV; and the RMV vs. the OMV. We are also interested in the effect of the two motivational video conditions separately, using one-way ANOVAs. This gives 6 tests for each of the 2 models overall, leading to an adjustment by 12 $\alpha = \frac{.05}{12} = .004$. The same logic is followed when using general estimating equations (GEE; see below).

Within the Bayesian model selection, we consider each of the 3 groups separately and for each of the 2 models. We will also report the comparisons of the Bayesian model selection extracted circumplex coefficients in the 3 group by coefficient interactions. These tests give an adjusted critical value of $\alpha = \frac{.05}{12} = .004$.

Furthermore, we will conduct equivalence tests to test the null hypothesis that the true effect is at least as extreme as the smallest effect size of interest, we used the two one-sided (TOST) procedure (Lakens et al., 2018) using the TOSTER module in *jamovi* software (version 1.6.21). We conduct an equivalence test of the model 1 fixed-effects circumplex contrast in the control condition alone, as well as the model 1 circumplex contrast obtained using the SSMLE estimation. This test assesses whether the mean contrast value is relatively close to zero (i.e., lies between two specified bounds either side of zero) in this condition. Equivalence tests were also conducted for the model 2 contrasts on the control video.

3.2.3.2 General Estimating Equations (GEE)

Following the approach taken in chapter 2 in the first motivational video study we will also use the so-called "marginal model" for our key regressions, and that model (as opposed to a fixed-effects or random effects modelling) can be conveniently estimated using general estimating equations (GEE; first described by Zeger & Yiang, 1986). We used the GEE module in SPSS. For our data, the dependent variable is the mood change score from pre to post video exposure, for which we have (a maximum of) 60 responses for each participant. All participants are analysed together, and each case thus has 60 lines of data. Each of these mood change responses is coded as being made to one of the 12 specific mood segments on the circumplex. We also generated a model 1 and model 2 circumplex predictor of the mood change using the equations 3.1 to 3.3 above. For each model, these circumplex predictors thus have 12 specific values depending on the mood segment, and the predictor values are the same for each case. Using model 1 and model 2 in separate analyses, we used these 12 circumplex predictor values in a linear model predicting the mood change observed for those item segments. The model circumplex predictor value is thus used as a repeated-measures predictor of mood change. Our prediction model also uses the between-subjects predictors of video condition (categorical predictor) and personality trait scores (a covariate predictor). Separate analyses are carried out with extraversion, neuroticism, and conscientiousness scores as predictors in this chapter.

We predict an interaction between the group and circumplex predictors in that we expect OMV and RMV to produce mood changes, along the activation-deactivation axis, as reflected by the model 1 circumplex values for each mood segment. Hypothesis 1A states that we do not expect the NCV to induce mood changes in this way, thereby leading to an interaction. Subsequent analyses, in each video condition separately, will confirm whether the predicted specific pattern of interaction was obtained. It is also proposed (hypothesis 2A) that the mood change induced by the combined OMV and RMV will be along the pleasure-displeasure (model 2) axis of the mood circumplex and argues that this effect will be greater for the motivational video than the control video. Thus, a video by circumplex predictor values interaction is predicted. Once again, based on the findings of Smillie et al. (2012), and the results from study 1, we do not expect that these hypothesis 2A predictions will be supported.

Moving on to consider the personality related hypotheses, we can include the scores on extraversion, neuroticism, or conscientiousness as an additional predictor in the GEE analyses. The simplest way to do this is to include the trait score as an additional predictor in the analyses carried out in each of the video conditions separately. We include a main effect of extraversion, neuroticism, or conscientiousness and an interaction between extraversion, neuroticism, conscientiousness, and the model 1 (or model 2) circumplex predictor values. If the personality by circumplex predictor interaction is significant in the motivational video conditions it indicates that extraversion, neuroticism, or conscientiousness moderates the relationship between the model 1 circumplex values and the mood changes in the motivational video conditions. The hypothesis leads us to not expect the same personality by circumplex interaction in the control video condition. If there is a significant personality by circumplex interaction in the motivational video condition, but not in the control video condition, then we can test whether there is a significant three-way interaction between video condition, circumplex predictor and personality in a final analysis combining data from both video conditions.

We treat the GEE analyses as separate families of analyses from those we used for the fixed effects and SSMLE analyses above. We have 12 key statistical tests in the family using GEE: the test of the interaction between the appropriate (model 1 or model 2) circumplex predictor and video condition (OMV and RMV combined vs. NCV); the test of the circumplex predictor in the OMV and RMV combined condition; the test of the circumplex predictor in the NCV; the test of the interaction between the appropriate (model 1 or model 2) circumplex predictor and video condition (OMV vs. RMV); the test of the circumplex predictor in the OMV condition; the test of the circumplex predictor in the RMV; the test of the interaction between the appropriate (model 1 or model 2) circumplex predictor and video condition (RMV vs. NCV). We, therefore, used an adjusted level of $\alpha = \frac{.05}{12} = .004$.

When using GEE to test the personality related hypotheses we have a family of three statistical tests for each of the three personality traits, extraversion, neuroticism, and conscientiousness (conscientiousness is an exploratory test so is not included in the adjustment for multiple comparisons): a test of the interaction between the trait and the circumplex predictor (model 1 or model 2) in each video condition separately (OMV and RMV combined, and NCV). Thus, we have a family of 8 tests and use and adjusted Type 1 error rate of $\alpha = \frac{.05}{8} = .006$.
. If the pattern of trait by circumplex predictor differs, a test of the three-way interaction between the trait, the circumplex predictor, and video condition.

A technical aspect of GEE concerns which so-called working correlation matrix (WCM) one should use in the calculations. The WCM describes the estimated correlations between the different individual mood items being tested. As the mood items were given in the same order to all participants, a natural choice for WCM is the so-called autoregression-1 (AR-1) structure. The AR-1 structure proposes that the correlation between sequential items is maximal and it falls off exponentially as the items get further apart in the test item list. The AR-1 WCM will be the default choice in the analyses below. We will routinely check other WCM choices to see whether the results are similar to those obtained with the AR-1 WCM.

3.2.3.3 Psychometric measures

The extraversion, neuroticism, and conscientiousness scores from the BFAS (DeYoung et al., 2007), and the intrinsic motivation scores from the DSSQ (Matthews et al., 2002) were calculated. We correlated these personality scores with the key DVs in each video condition separately. We were particularly interested in whether the specific patterns of the mood change after watching a video, reflected in the model-based contrast values, were associated with these traits. A Bonferroni correction was also added here to adjust for the multiple planned comparisons: 2 trait measures (extraversion and neuroticism) by 2 circumplex contrasts by 2 video conditions (NCV; RMV and OMV combined), with an adjusted critical value of

$\alpha = \frac{.05}{8} = .006$. The correlations with trait conscientiousness once again are not included in this adjustment as they were made using common sense and are more exploratory.

Equivalence tests were conducted for the correlations between the personality traits and the fixed-effects model 1 circumplex coefficients for the control video alone. This was to assess whether the correlation is relatively close to zero (i.e., lies between two specified bounds either side of zero). The equivalence tests were repeated for the correlations between the personality traits and the fixed-effects model 2 circumplex coefficients in the control condition.

3.2.3.4 Line bisection scores

As the line bisection task was administered post-experimentally only, between group differences in the mean line bisection deviation were tested using a one-way ANOVA. It should be noted that an additional planned test of the line bisection data was limited to those who showed positive activation circumplex coefficients and a good activation model fit versus those who did not show a good activation or pleasure model fit.

3.3 Results

Means for all the dependent variables were calculated and difference scores of all mood segments were calculated by subtracting the pre-test mean mood scores from the post-test. The trait measures, extraversion, neuroticism, and conscientiousness were standardized to z-scores.

3.3.1 Mood induction video effects: Fixed-effects Contrast Analysis

Mixed 12x2 ANOVAs were conducted on the pre-post changes in affect ratings and specific contrast coefficients were used to capture the effects of models 1 and 2. First the effects of the two motivational videos, the OMV and the RMV combined were compared to the effects of the NCV. Next, the effects of the RMV were compared to the effects of the OMV, and then the RMV was compared to the NCV.

Over all participants, the model 1 contrasts across affect segments, was significant [$F(1,146) = 40.028$, $p < .001$, $\eta p^2 = .215$]. However, when using model 2 contrast coefficients, the model

2 contrast across affect segments was not significant overall [$F(1,146) = 1.388$, $p = .241$, $\eta p^2 = .009$]. Theses analyses show that, on average, the videos act on affect primarily along the axis from point XII (activation; maximum effect; at 0 degrees) through VI (deactivation; minimum effect; at 180 degrees) of the circumplex (compare Figure 3.3 with Figure 3.2), as opposed to the axis from point III (pleasure; at 90 degrees) to point IX (displeasure; at 270 degrees).

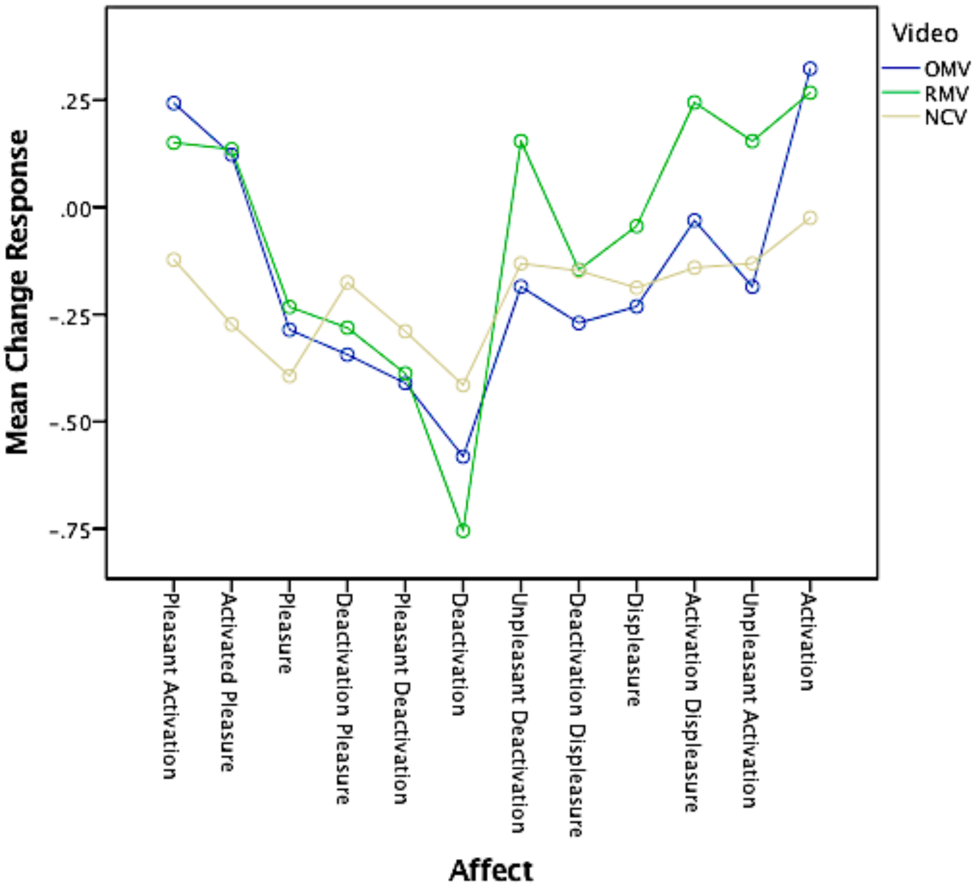


Figure 3.3. The mean change in affect across the three video groups, based on the order of affect in the circumplex. This plot is to be compared against the theoretical plots for model 1 and 2, as depicted above in Figure 3.1.

Testing the combined effects of the OMV and RMV vs the effects of the NCV, the interaction between the model 1 contrasts across affect segments and video condition was not significant when judged against the conservatively adjusted significance level (c.f. adjusted $\alpha = .004$) but was a trend [$F(1,146) = 8.245$, $p = .005$, $\eta p^2 = .053$]. The interaction between the model 2 contrast across affect segments and video type was not significant [$F(1,146) = .056$, $p = .814$].

Testing the effects of the RMV vs. the OMV, the interaction between the model 1 contrasts across affect segments and video type was not significant [$F(1,146) = .016$, $p = .898$], as expected. Correspondingly, the interaction between the model 2 contrasts across affect segments and video type was, also, not significant [$F(1,146) = 1.401$, $p = .239$].

Testing the effects of the RMV vs. the NCV, the interaction between the model 1 contrasts across affect segments and video type was not significant when judged against the conservatively adjusted significance level (c.f. adjusted $\alpha = .004$) [$F(1,146) = 6.710$, $p = .011$, $\eta p^2 = .044$]. The interaction between the model 2 contrasts across affect segments and video type was not significant [$F(1,146) = .143$, $p = .706$], as expected.

Conducting further one-way ANOVAs individually for each motivational video, OMV and RMV by using the repeated measures contrasts for model 1, showed that the model 1 contrasts were significant for the OMV [$F(1,48) = 17.337$, $p < .001$, $\eta p^2 = .265$], and for the RMV [$F(1,52) = 20.434$, $p < .001$, $\eta p^2 = .282$]. However, the repeated measures contrasts for model 1 were not significant for the NCV [$F(1,46) = 3.952$, $p = .053$]. In the NCV condition the sample size was 59. Using an adjusted type 1 error rate of 0.05/12, a two-tailed one-sample t-test would require an effect size of Cohen's $d = .5$ in order to have 80% power. Therefore, we used bounds of [-.5, .5] for the equivalence test. The equivalence test, here, shows that the data does not support equivalence in the NCV group for model 1 circumplex coefficient ($M = .2$, $SD = .69$), in that the equivalence fails at the TOST upper bound (.5) [$t(46) = -1.44$, $p = .078$]. Therefore, the null hypothesis that the effect size might lie outside these bounds cannot be rejected.

When conducting a one-way ANOVA for each video type by using the repeated measures contrasts for model 2, we found that the model 2 contrast was not significant for the OMV group [$F(1,48) = .056$, $p = .814$], nor for the RMV group [$F(1,52) = 1.51$, $p = .225$], as expected. The model 2 contrasts were also non-significant for the NCV group [$F(1,46) = 1.451$, $p = .235$]. The equivalence test, here, shows that the data does not support equivalence in the NCV group for model 2 circumplex coefficient ($M = -.21$, $SD = 1.00$), in that the equivalence fails at the TOST lower bound (.5) [$t(48) = 2.07$, $p = .022$ (c.f. adjusted $\alpha = .004$)]. Therefore, the null hypothesis that the effect size might lie outside these bounds cannot be rejected.

3.3.2 Mood induction video effects: Bayesian Model Selection

In the OMV video condition (referred to as “orig. motvid” in the graphs below) the sample size was 45; the reason for the smaller number of cases when we were fitting the models to the individual participants was that these used a more conservative criterion for eliminating a number of participants relative to the fixed effects analyses: each of the 12 segments for each participant had to have fewer than 4 missing adjective responses. The overall data and model fits averaged across participants are as shown in Figure 3.3 below. The mean number of mood items (adjectives) out of 60 used per case for the OMV condition was 59.7.

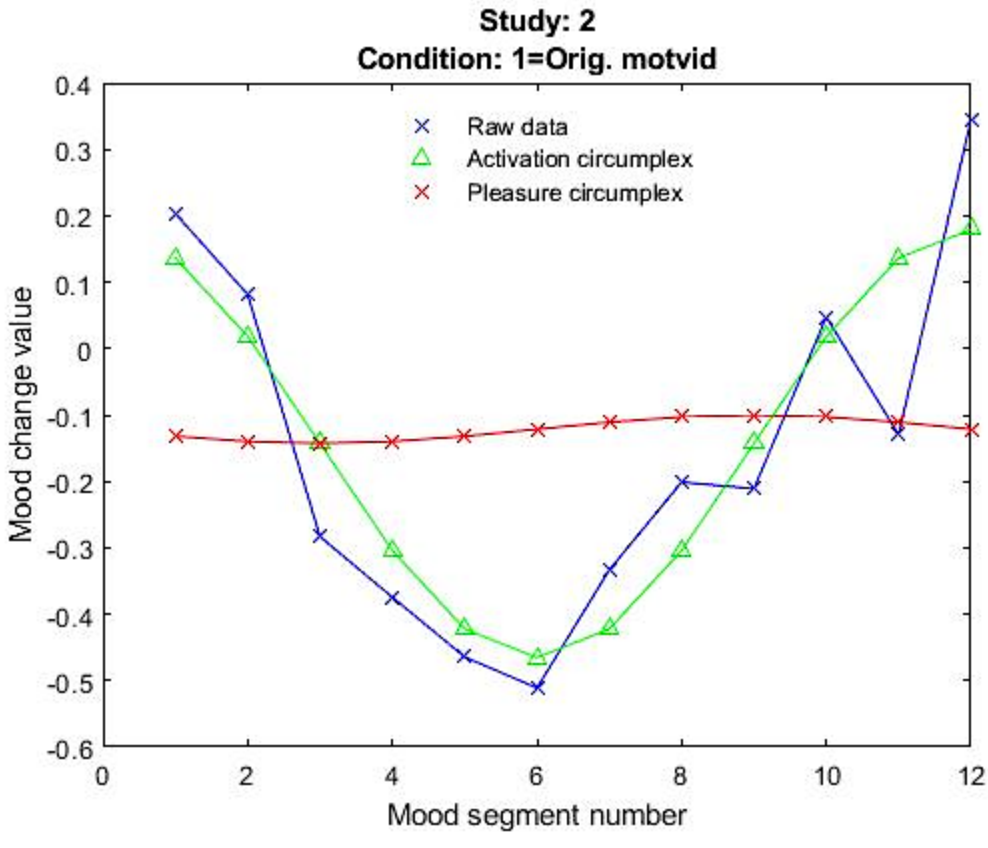


Figure 3.4: Data and best-fitting models averaged across all participants in this study and condition (OMV; N=45).

In Figure 3.4 it is immediately clear that there is a very close resemblance between the average data across all participants, and the average of the best fits, for individual subjects, of model 1 (the activation-deactivation circumplex model). The averaged best fits of model 2 (the pleasure-displeasure circumplex model) do not resemble the averaged data well and it should be noted the best fits for the pleasure-displeasure model are associated with *b* coefficient values (in equation 3.1) which on average are slightly negative. This means that the maximum mood changes under the model are actually found for displeasure and the minimum changes are found for pleasure (so, as noted in chapter 2, we might actually refer to the average model fits as a displeasure-pleasure circumplex model).

First, we confirmed the fixed effects results by testing whether the coefficients (a_i and b_i; Equation 3) differed from zero across participants in this condition. The significance level here is based on an adjustment for 12 comparisons (2 models by 6 tests for the 3 video conditions; RMV and OMV combined vs. NCV, RMV vs. NCV, and RMV vs. OMV), thus the adjusted per comparison alpha is .004. For the activation-deactivation model (model 1) we found that the mean intercept coefficient ($\bar{a}$) was -.155, with 95% CIs = [-.220, -.0658]; t =-3.73 df= 44, p = .0005. The mean circumplex coefficient ($\bar{b}$) was 1.73, with 95% CIs = [.77, 2.68]; t=3.63 df= 44, p=.0007 (significantly above zero c.f. adjusted α = .004). We repeated this for the pleasure-displeasure model (model 2) and found that the mean intercept coefficient ($\bar{a}$) was -.121, with 95% CIs = [-.206, -.037]; t =-2.90 df= 44, p=.006. The mean circumplex coefficient ($\bar{b}$) was -0.120, with 95% CIs = [-.963, .724]; t =-.28, df= 44, p= .78, which is clearly not significantly below zero. These analyses confirm that only the activation-deactivation model has circumplex coefficient values which differ significantly from zero across the whole sample of participants who viewed the OMV. It also confirms that the circumplex coefficients were non-significantly negative for the pleasure-displeasure model, as already noted.

However, as already reported in chapter 2, these analyses conceal a wide range of individual variation in model fits within this sample. In a Bayesian comparison of the individual subject fits for model 1 (activation-deactivation) to model 2 (pleasure-displeasure) we found several individuals with log Bayes factors [denoted by log(BF_{12}), the log of the Bayes factor for model 1 relative to model 2] far exceeding +2.3 (a value taken as strong evidence in favour of model 1 versus model 2; Jeffreys, 1961), as well as a smaller number of individuals whose log(BF_{12}) was well below -2.3 (strong evidence in favour of model 2). Figures 3.5 through 3.7 show some examples.

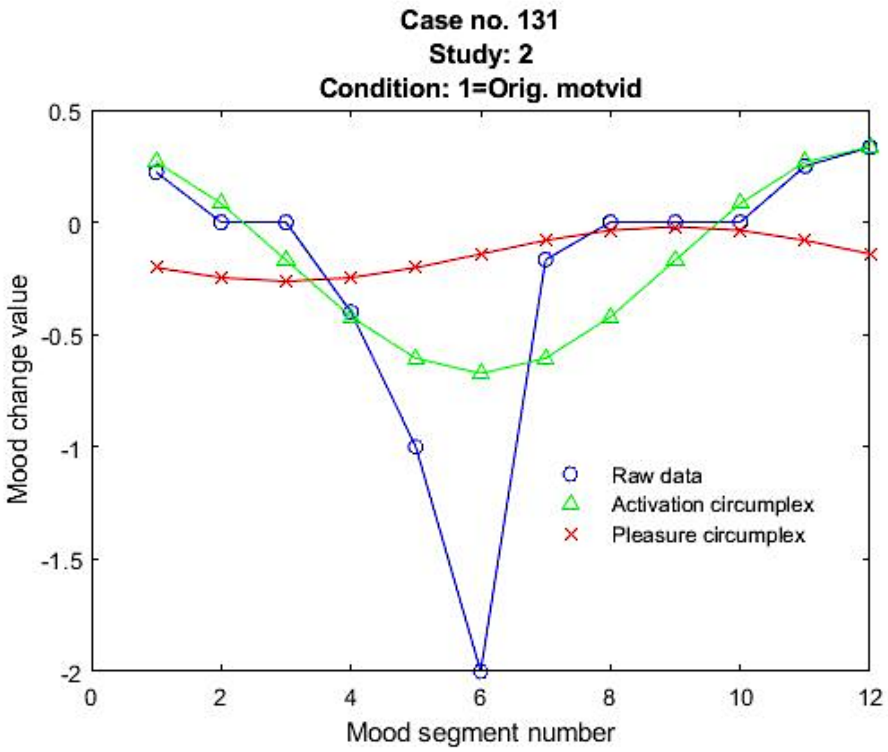


Figure 3.5: A participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex; $\log(BF_{12})= 10.4$) in the OMV condition.

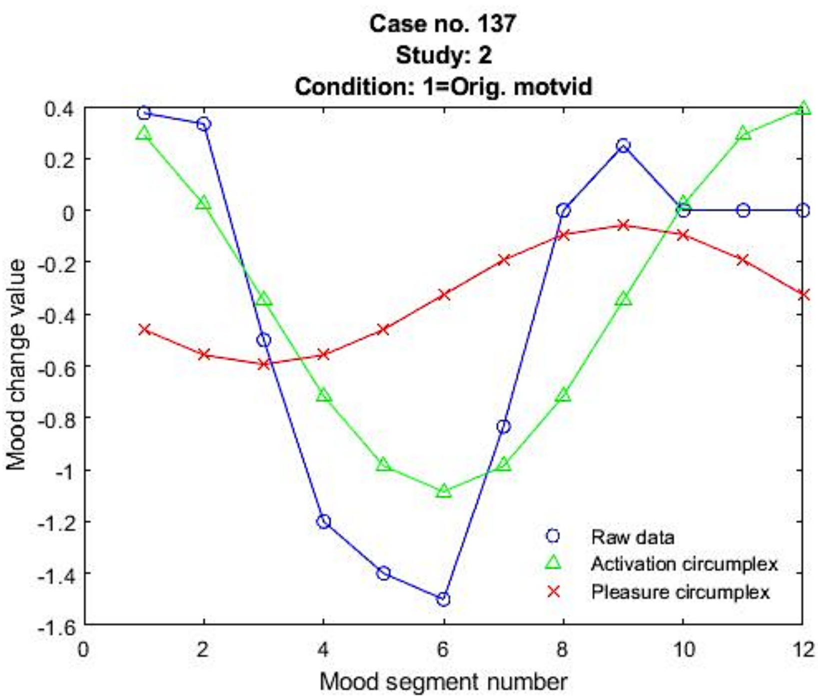


Figure 3.6: Another participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex; $\log(BF_{12})= 12.5$) in the OMV condition.

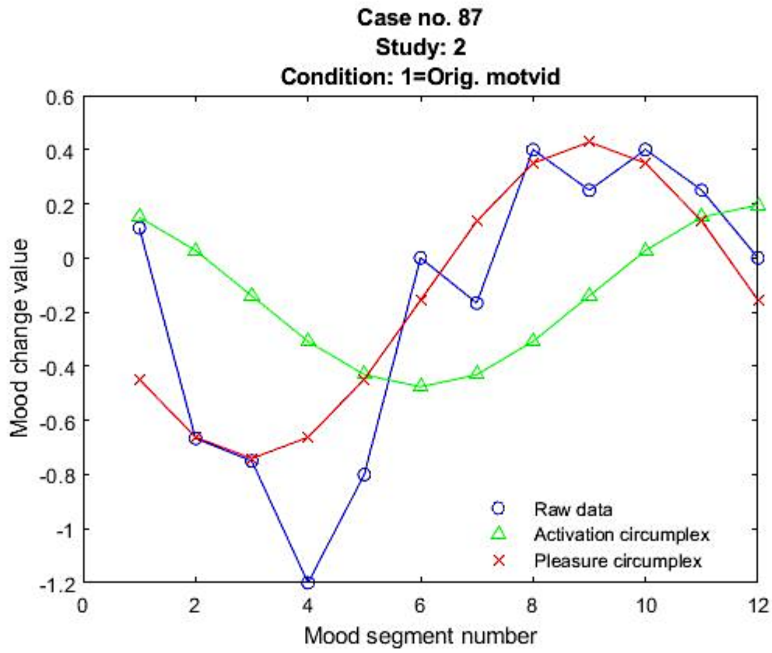


Figure 3.7: A participant whose mood change scores were well fit by model 2 (pleasure-displeasure circumplex) relative to model 1 (activation-deactivation circumplex; log(BF_{12})= -6.9) in the OMV condition. Note that this participant has the maximum positive mood change in the vicinity of displeasure (segment 9) and largest negative mood change in the vicinity of pleasure (segment 3) and so has a negative coefficient for the pleasure-displeasure circumplex.

The log(BF_{12}) values for each participant showed wide variation as seen in Figure 3.8 below, but skewed in favour of the activation-deactivation model. At an individual subject level, there were strong relative fits for model 1 in 13/45 cases, and in 10/45 cases for model 2.

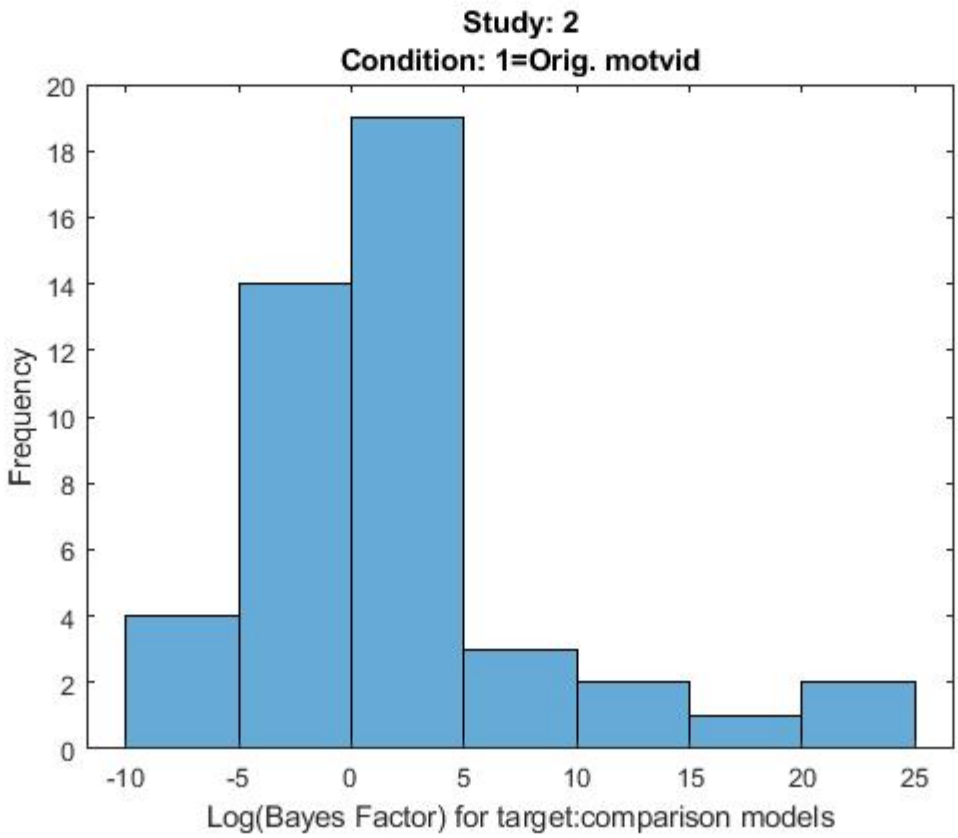


Figure 3.8: Histogram of log(BF_{12}) values in the OMV condition. These values compare the strength of evidence for model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex). A log(BF_{12}) value of 0 provides evidence that favours neither model; more positive log (BF_{12}) values favour model 1 and more negative log(BF_{12}) values favour model 2. Log(BF_{12}) values above +2.3 and below -2.3 are taken as strong evidence in favour of model 1 and model 2 respectively. For the whole sample the mean log(BF_{12}) = 2.04.

The final output from the VBA toolbox routines is shown in Figure 3.9 below.

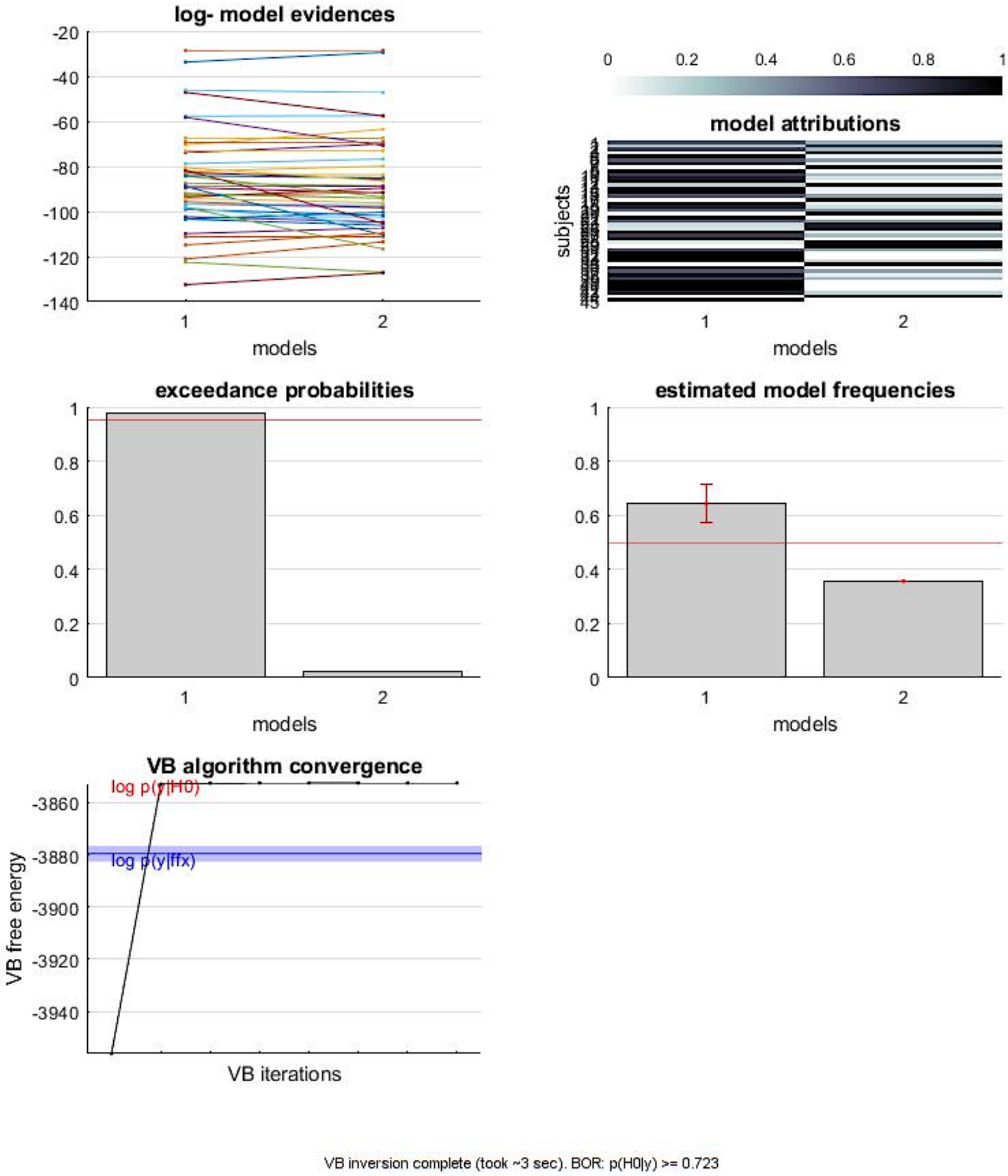


Figure 3.9: The main output window from the VBA toolbox for the OMV condition.

The key results shown in Figure 3.9 offer some weak evidence that model 1 is more frequently the better account of the data relative to model 2. The exceedance probability (EP) is above .95, but the protected exceedance probability (PEP) is preferred as it allows for the possibility that the EP is due to chance. The PEP was .63, and the expected frequency of model 1 was .64, with confidence limits (see Figure 3.9) which do not include .5. However, by contrast, the

Bayesian Omnibus Risk (BOR) is ≥ .72 (the BOR is the posterior probability that the frequencies of the preferred model are equal over the sample).

The histograms drawn for the circumplex model coefficients (b_i) in Figure 3.10 show that there is a wide range of coefficients under either model. However, for the activation-deactivation model the coefficients are clearly centred around a value above zero. For the pleasure-displeasure model the distribution of individual coefficients is centred close to zero (but is slightly negative). There are some people in this condition and this study for whom the pleasure-displeasure model (model 2 with positive circumplex coefficients) is a good fit and a roughly equivalent number for whom the displeasure-pleasure model (model 2 with negative circumplex coefficients) is a good fit, with many subjects not fit well by the model. By contrast, there are some people who are well fit by the activation-deactivation model (model 1 with positive circumplex coefficients) but a smaller number who are well fit by the deactivation-activation model (model 1 with large negative circumplex coefficients).

The above description confirms the notion, already advanced in chapter 2, at if the circumplex model is a good fit for the mood responses of only a fraction of the people in this video condition, then it does not make sense to correlate model-derived measures with personality trait across the whole sample in a particular condition. More logical would be to correlate the model-derived measures with the personality traits of the cases or participants that have the best fitting circumplex coefficient and are therefore a better fit for the model.

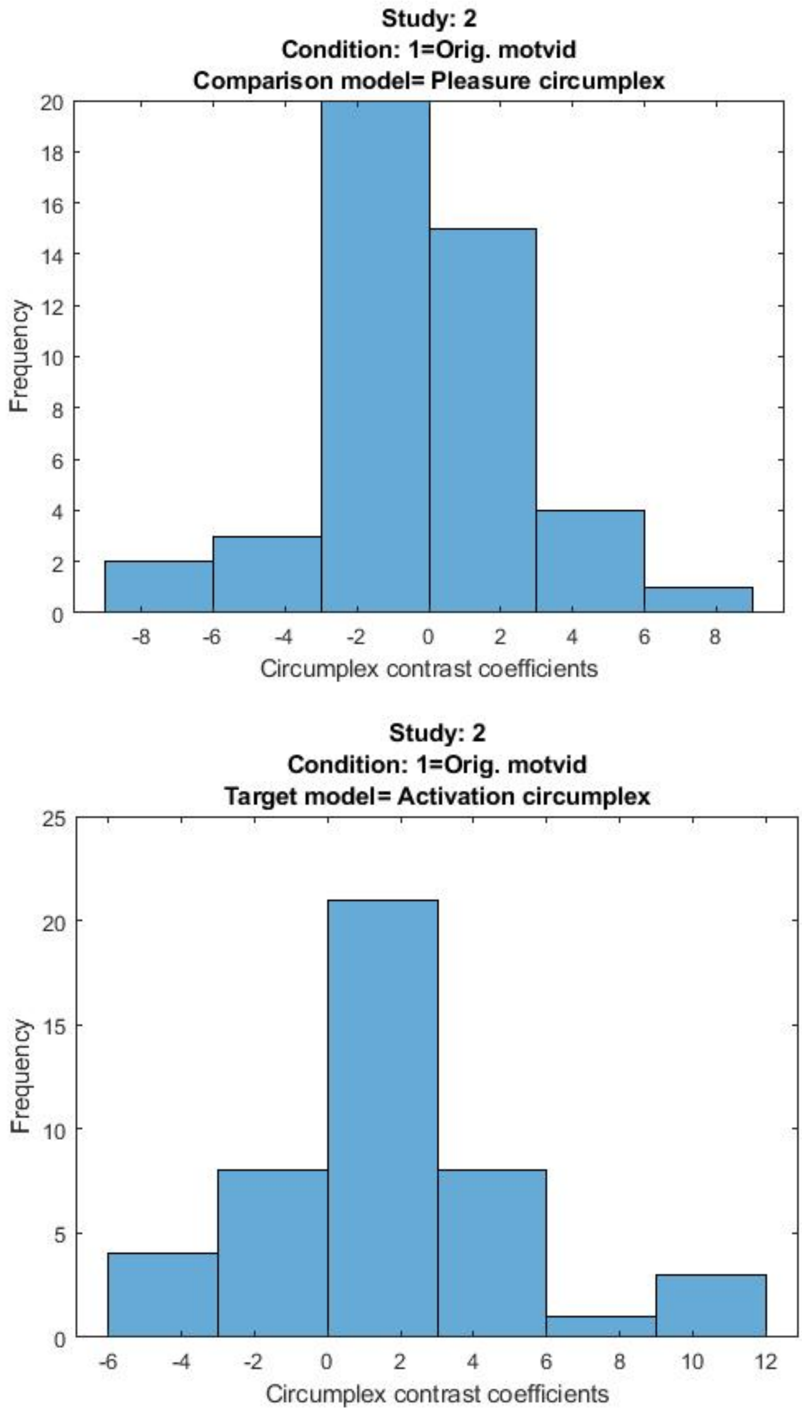


Figure 3.10: The frequencies of b_i coefficients of the circumplex model across participants viewing the OMV. Upper panel is for the activation-deactivation circumplex model (M = 1.726; SD = 3.53); the lower panel is for the pleasure-displeasure circumplex model (M = -.119, SD = 5.61).

For the RMV condition (referred to as "new motvid" in the graphs below), we again applied the same conservative missing data criteria resulting in a final sample here of N=50. The overall data and model fits averaged across participants are as shown in Figure 3.11 below. The mean number of mood items (adjectives) out of 60 used per case for the RMV condition was 59.8.

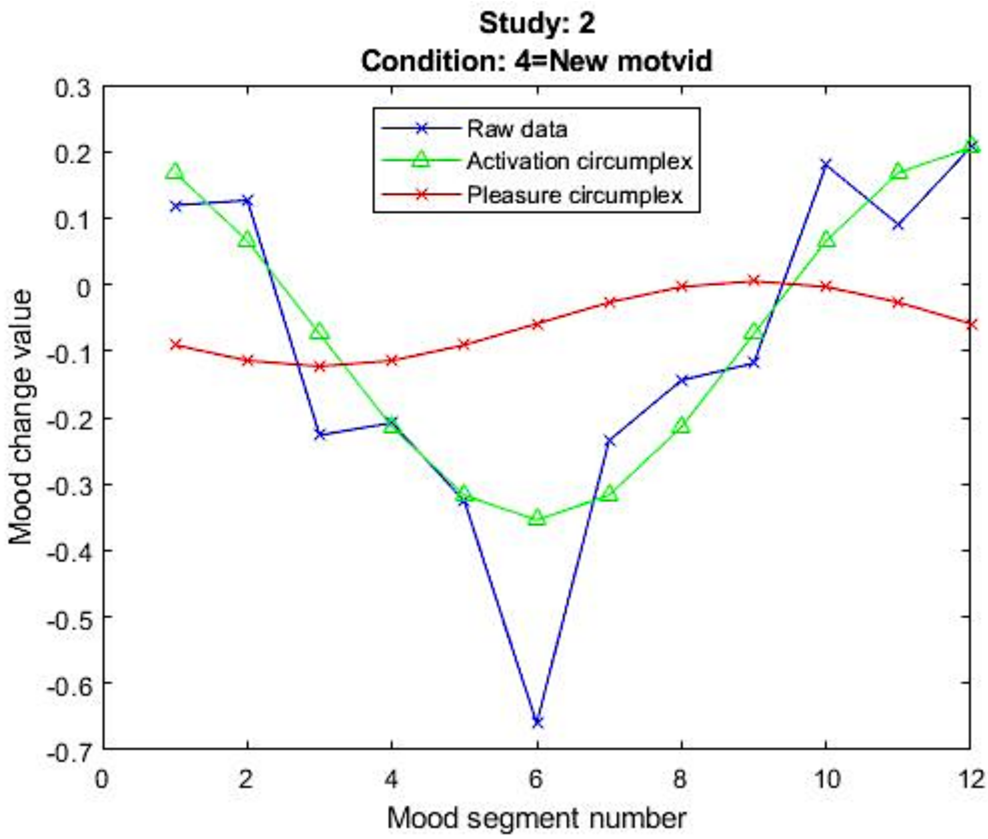


Figure 3.11: Data and best-fitting models averaged across all participants in this study and condition (RMV; N=50).

In Figure 3.11 it can be seen that there is a rather close resemblance between the average data across all participants, and the average of the best fits for individual subjects using model 1 (the activated-deactivated circumplex model with negative coefficients). The averaged best fits under model 2 (the pleasure-displeasure circumplex model) do not resemble the averaged data very well, but do show a slightly negative value for average of the pleasure-displeasure circumplex model best fits.

We confirmed the fixed effects results by testing whether the coefficients (a_i and b_i; Equation 3) differed from zero across participants in this condition. For the activation-deactivation model (model 1) we found that the mean intercept coefficient ($\bar{a}$) was -.074, with 95% CIs = [-.187, .039]; t =-1.32 df= 49, p=.19. The mean circumplex coefficient ($\bar{b}$) was 1.50, with 95% CIs = [.836, 2.160.]; t=4.55 df= 49, p=.00004 (significantly above zero c.f. adjusted α = .004). We repeated this for the pleasure-displeasure model (model 2) and found that the mean intercept coefficient ($\bar{a}$) was -.059, with 95% CIs = [-.173, .055]; t =-1.04 df= 49, p=.30. The mean circumplex coefficient ($\bar{b}$) was -.359, with 95% CIs = [-1.39, .67]; t =-.699, df= 49, p=.49. These analyses confirm that only the activation-deactivation model has circumplex coefficient values which differ significantly from zero across the whole sample of participants who viewed the RMV. It also confirms that the circumplex coefficients were, on average, non-significantly negative using the pleasure-displeasure model.

However, these analyses once again conceal a wide range of individual variation in model fits within this sample. In a Bayesian model comparison of the individual subject fits for model 1 (activation-deactivation) versus model 2 (pleasure-displeasure) we found several individuals with log Bayes factors [denoted by log(BF_{12}), the log of the Bayes factor for model 1 relative to model 2] exceeding +2.3 (a value taken as strong evidence in favour of model 1 versus model 2; Jeffreys, 1961). Indeed, we found several individuals whose log(BF_{12}) was well below -2.3 (strong evidence in favour of model 2). Figures 3.12 and 3.13 show some examples.

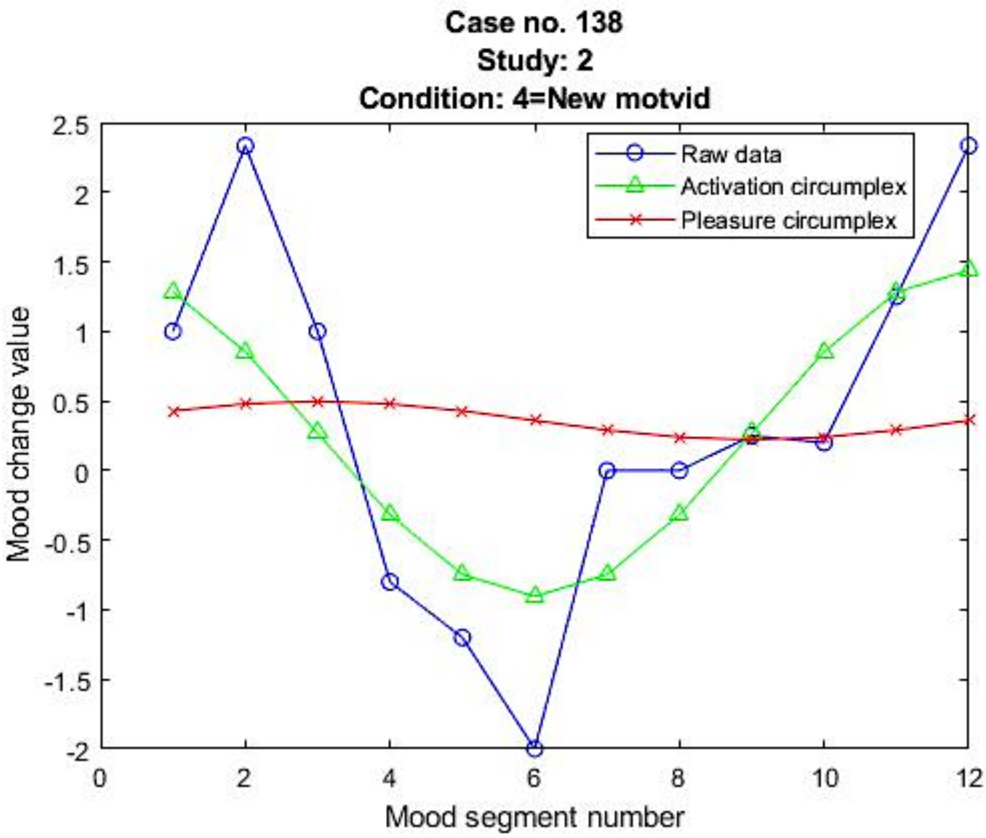


Figure 3.12: A participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex; $\log(BF_{12})= 14.3$) in the RMV condition.

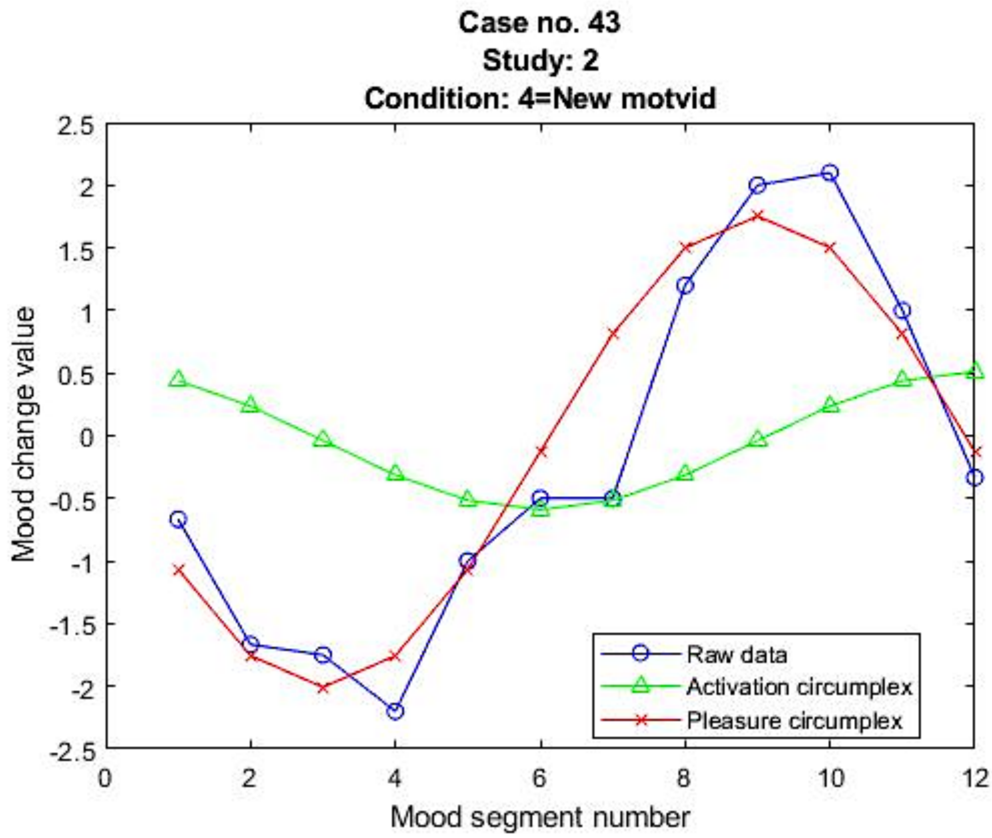


Figure 3.13: A participant whose mood change scores were well fit by model 2 (pleasure-displeasure circumplex) relative to model 1 (activation-deactivation circumplex; $\log(BF_{12})$= -29.1) in the RMV condition. Note this participant had a negative pleasure-displeasure circumplex coefficient.

The $\log(BF_{12})$ values for each participant showed wide variation as seen in Figure 3.14 below, but appears to be skewed slightly in favour of the pleasure-displeasure model. At an individual subject level, there were strong relative fits for model 1 in 11/50 cases and for 17/50 cases for model 2.

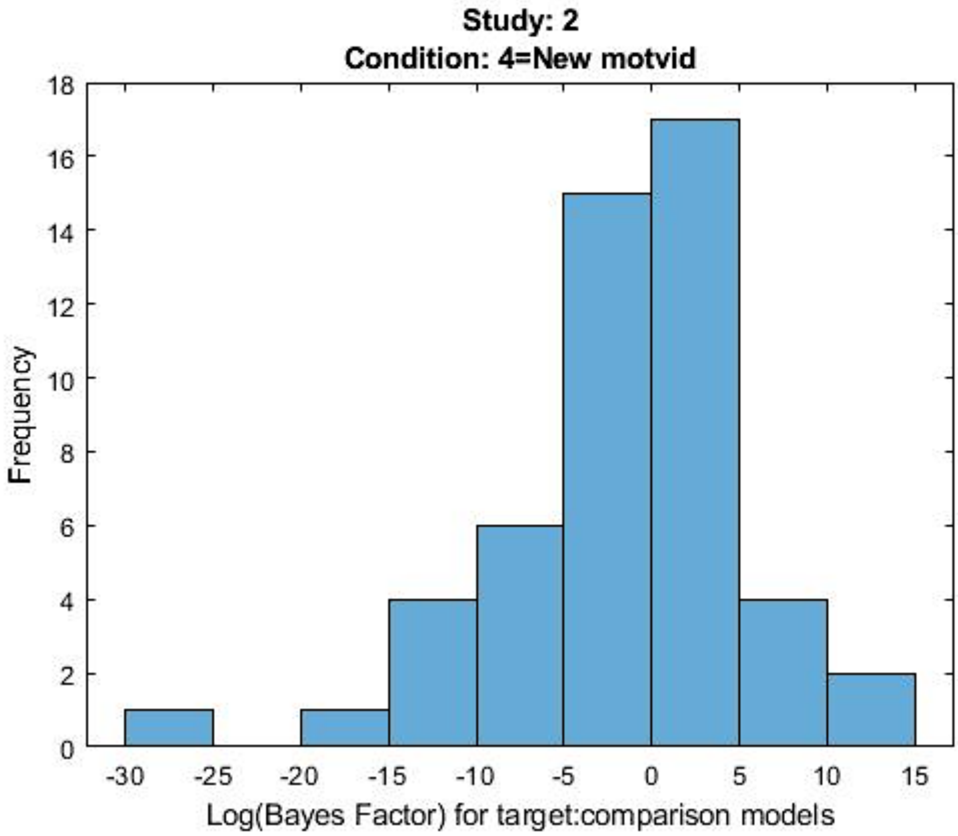


Figure 3.14: Histogram of log(BF_{12}) values in the RMV condition. These values compare the strength of evidence for model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex). For the whole sample the mean log(BF_{12}) = -1.63.

The final output from the VBA toolbox routines is shown in Figure 3.15 below.

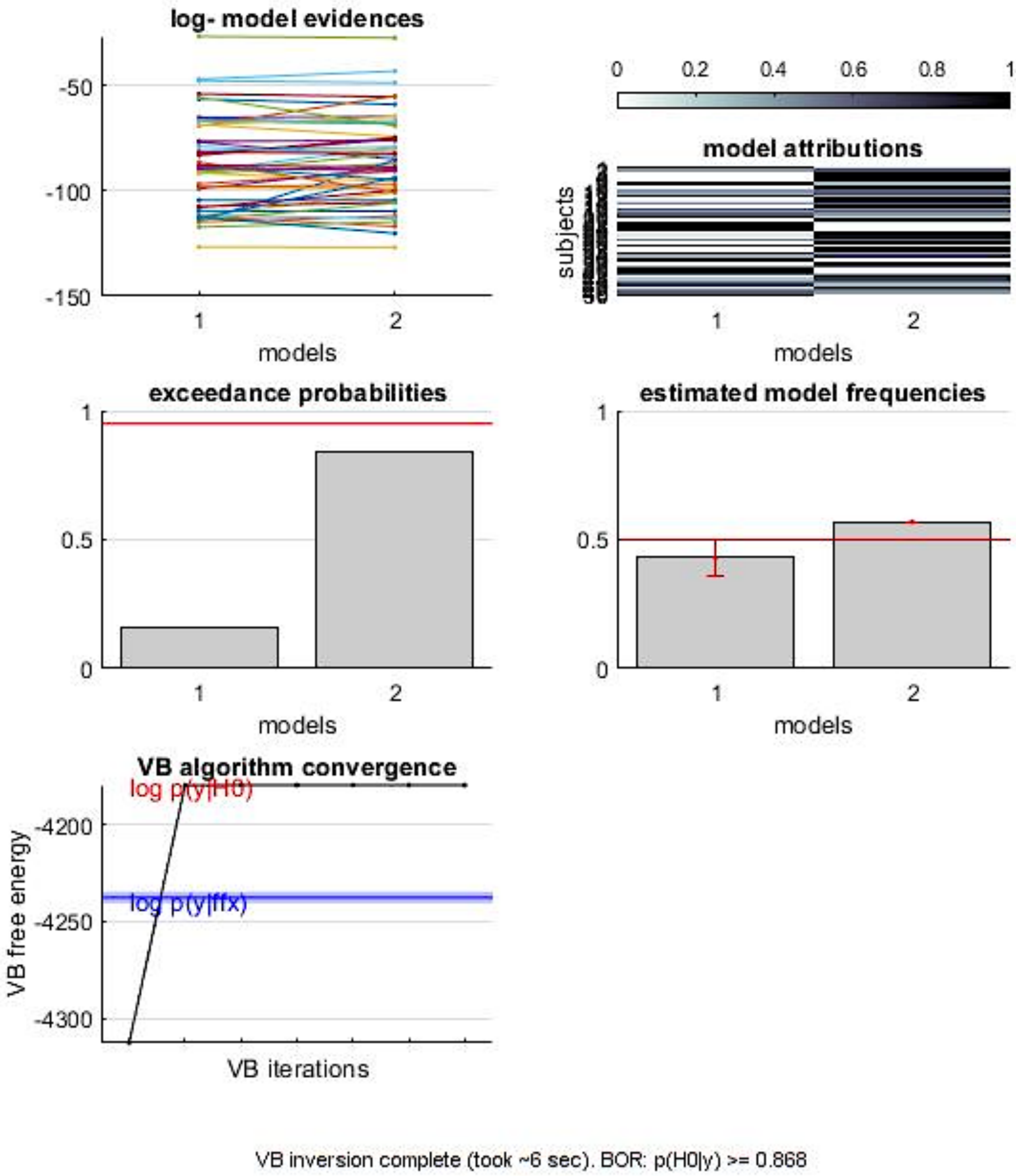
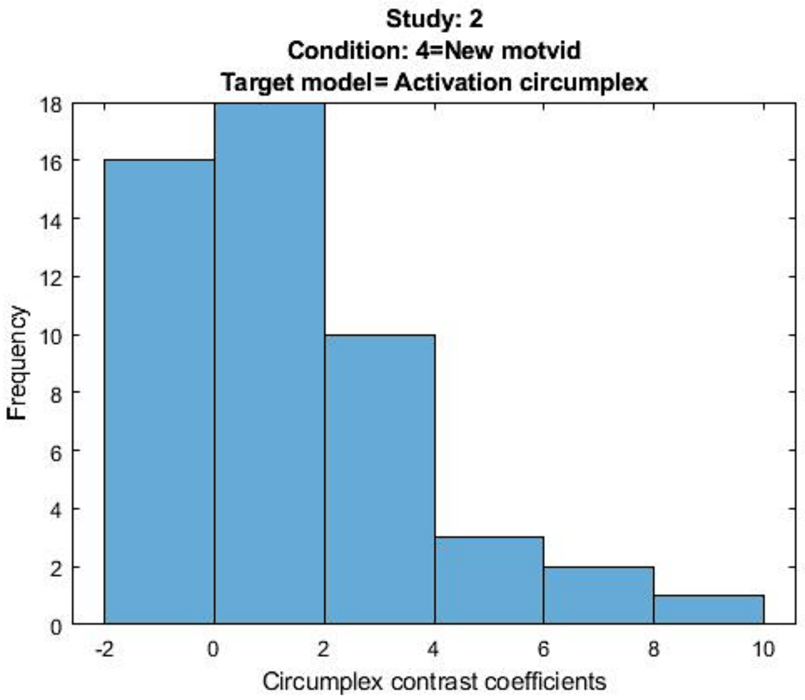


Figure 3.15: The main output window from the VBA toolbox for the RMV condition.

The key results shown in Figure 3.15 offer a modest suggestion that model 2 is more frequently the better account of the data relative to model 1. The exceedance probability (EP) for model 2 is around .83, but the protected exceedance probability (PEP) is preferred as this allows for the possibility that the EP variation is due to chance; the PEP for model 2 was .54, and the expected frequency of model 2 was .57. The confidence limits of the expected frequency of model 1 (see Figure 3.15) marginally include .5. However, the Bayesian Omnibus Risk (BOR) is ≥ .87 (the BOR is the posterior probability that the frequencies of the better fitting models are equal over the whole sample).

The histograms drawn for the circumplex model coefficients (b_i), show that there is a similarly wide range of coefficients under either model (Figure 3.16). However, for the activation-deactivation model there is a bias towards positive coefficients; for the pleasure-displeasure model the distribution of individual coefficients, although varying widely, is centred close to zero. This pattern of data from the individual participant level analysis show why the average results contrast so strongly with the individual level results and create the tension between the two ways of analysing data that has been mentioned previously in chapter 2. This also means that the averaged group results are, therefore, somewhat misleading as to the effects of the mood manipulations on individual participants.



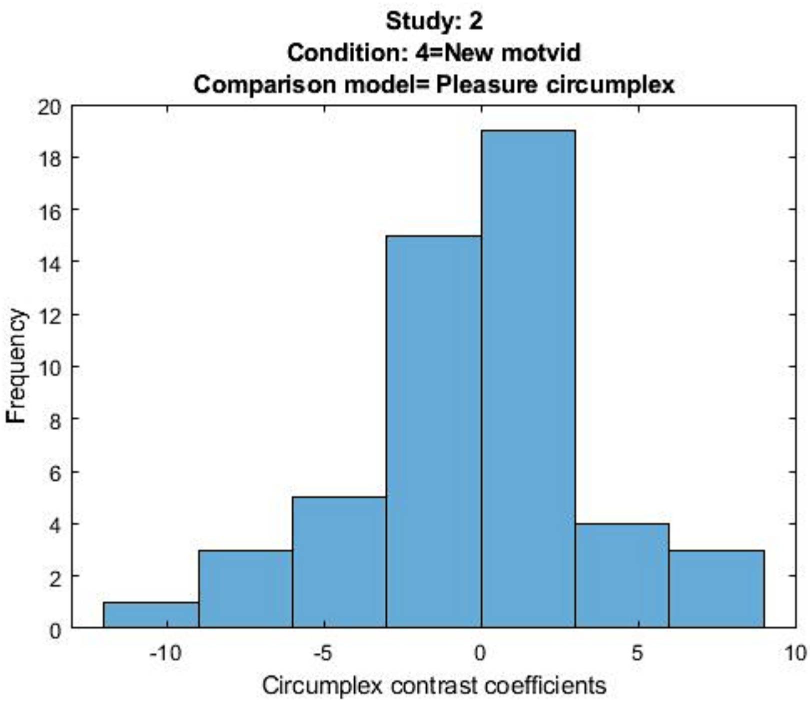


Figure 3.16: The frequencies of b_i coefficients of the circumplex model across participants viewing the RMV. Upper panel is for the activation-deactivation circumplex model (M = .128, SD = 3.18); the lower panel is for the pleasure-displeasure circumplex model (M = -.425, SD = 4.76).

In the NCV condition (referred to as “new control” in the graphs below), we again applied the same conservative criteria for missing data; the final sample here was N=43. The mean number of mood items (adjectives) out of 60 used per case for the NCV condition was 59.7. The overall data and model fits averaged across participants are as shown in Figure 3.17 below.

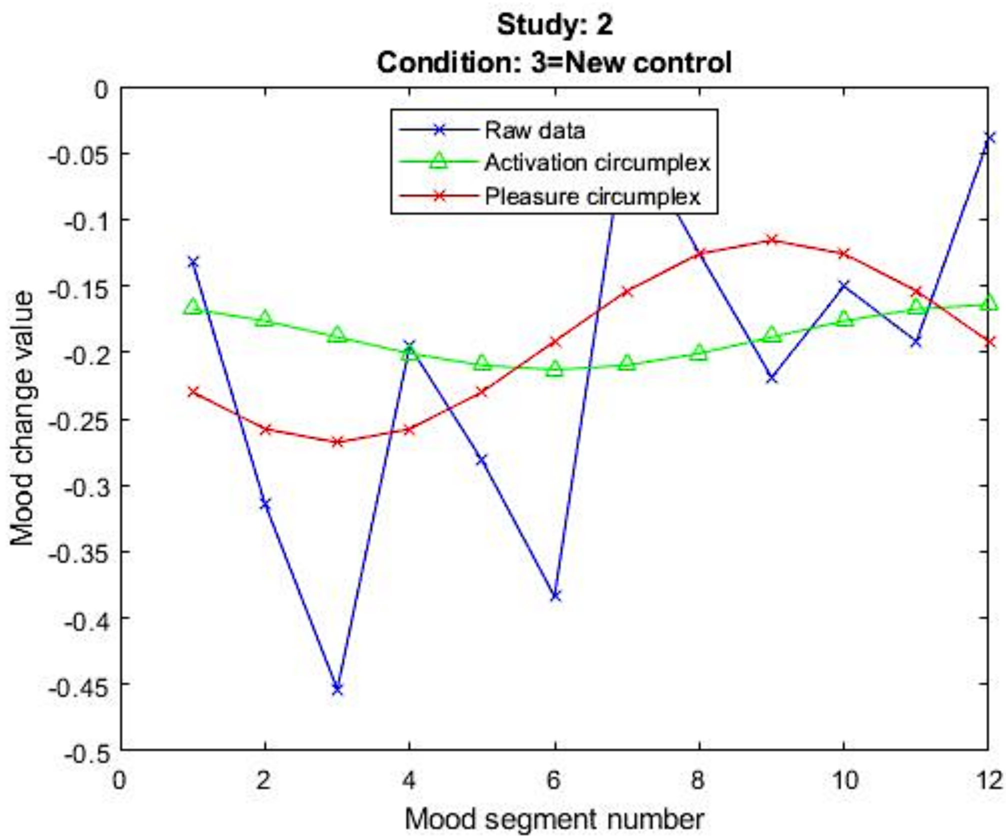


Figure 3.17: Data and best-fitting models averaged across all participants in this study and condition (NCV; N=43).

In Figure 3.17 there is no clear resemblance between the average data across all participants, and the average of the best fits for individual subjects using either model.

We confirmed the fixed effects results by testing whether the coefficients (a_i and b_i; Equation 3) differed from zero across participants in this condition. For the activation-deactivation model (model 1) we found that the mean intercept coefficient ($\bar{a}$) was -.188, with 95% CIs = [-.260, -.117]; t =-5.30 df= 42, p=.000004. However, the mean circumplex coefficient ($\bar{b}$) was .128, with 95% CIs = [-.362, .618]; t=.53 df= 42, p=.60. The equivalence test, here, shows that the data support equivalence in the control group for the model 1 circumplex contrast (M = .13, SD = 1.59), in that this small effect lies between the TOST upper bound (.5) $t(42)$ =-2.25, p = .004 and the TOST lower bound (-.5), $t(42)$ = 3.81, $p < .001$ (c.f. adjusted α = .004). We repeated this for the pleasure-displeasure model (model 2) and found that the mean intercept coefficient ($\bar{a}$) was -.192, with 95% CIs = [-.267, -.117]; t =-5.16 df= 42, p=.000006. The mean circumplex coefficient ($\bar{b}$) was -.425, with 95% CIs = [-1.158, .307]; t =-1.17, df= 42, p=.25. The equivalence test, here, shows that the data does not support equivalence in the control video group for model 2 circumplex coefficient (M = -.425, SD = 2.38), in that the equivalence fails at the TOST lower bound (.5) $t(42)$ = -2.11, p = .021 (c.f. adjusted α = .004). These analyses confirm that neither model 1 nor model 2 has circumplex coefficient values which differ significantly from zero across the whole sample of participants who viewed the NCV.

However, these analyses once again conceal a wide range of individual variation in model fits within this sample. In a Bayesian model comparison of the individual subject fits for model 1 (activation-deactivation) versus model 2 (pleasure-displeasure) we found some individuals with log Bayes factors [denoted by log(BF_{12}), the log of the Bayes factor for model 1 relative to model 2] exceeding +2.3 (a value taken as strong evidence in favour of model 1 versus model 2; Jeffreys, 1961). Indeed, we also found some individuals whose log(BF_{12}) was well below -2.3 (strong evidence in favour of model 2). Figures 3.18 and 3.19 show some examples.

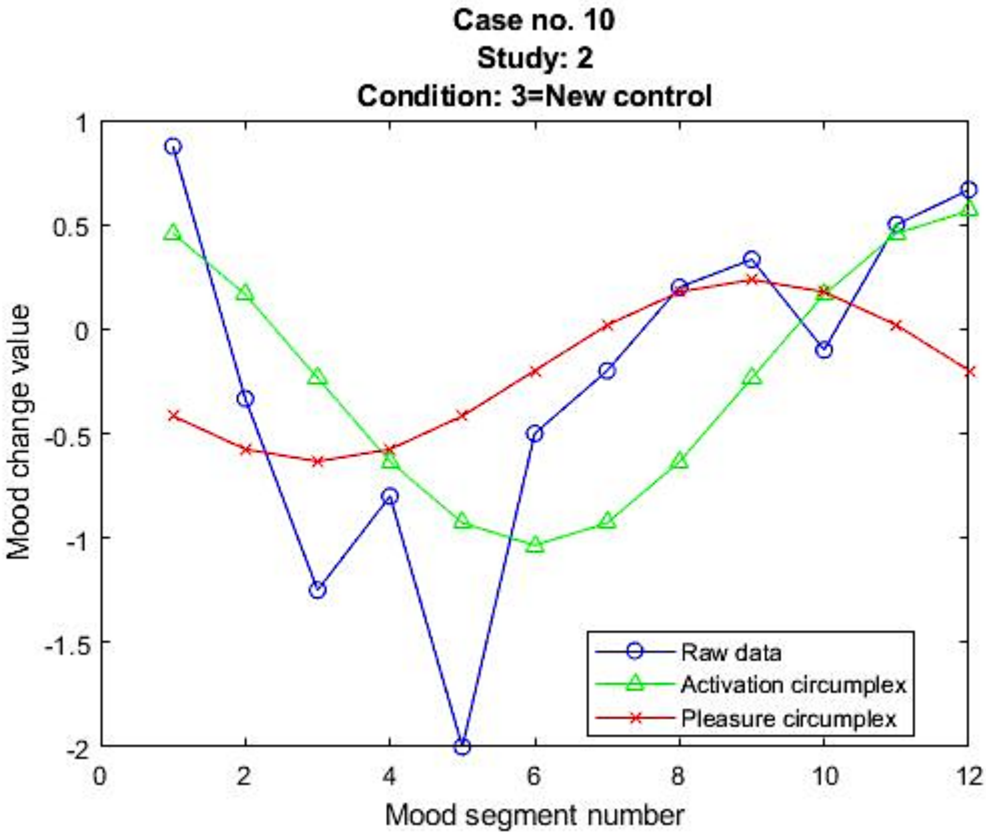


Figure 3.18: A participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex; $\log(BF_{12}) = 5.3$) in the NCV condition.

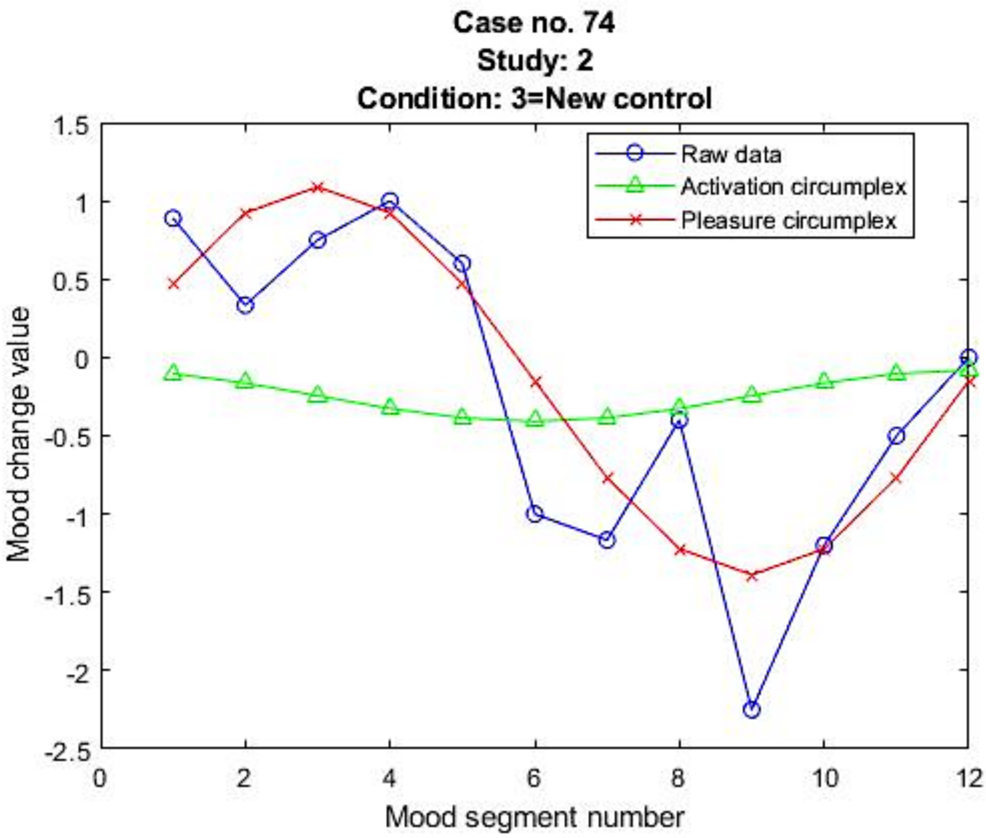


Figure 3.19: A participant whose mood change scores were well fit by model 2 (pleasure-displeasure circumplex) relative to model 1 (activation-deactivation circumplex; $\log(BF_{12})= -8.7$) in the NCV condition.

The $\log(BF_{12})$ values for each participant showed wide variation as seen in Figure 3.20 below. There were strong relative fits for model 1 in only 2/43 cases but in 10/43 cases for model 2 at an individual subject level.

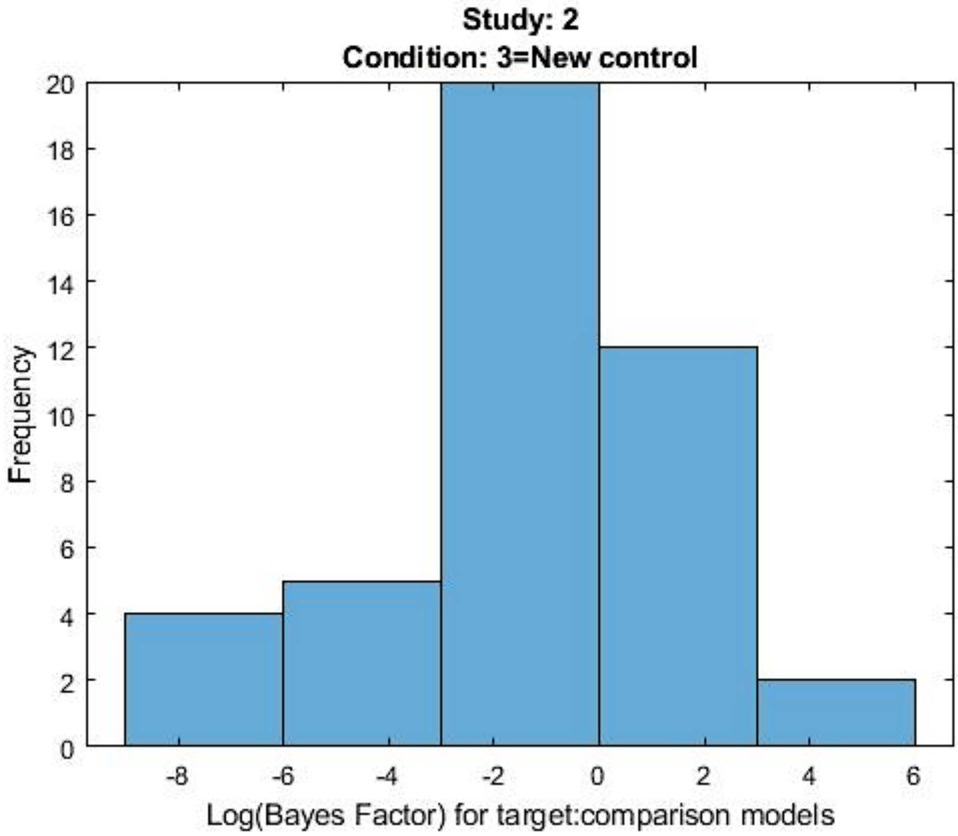


Figure 3.20: Histogram of $\log(BF_{12})$ values in the NCV condition. These values compare the strength of evidence for model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex). For the whole sample who viewed the NCV the mean $\log(BF_{12}) = -1.20$.

The final output from the VBA toolbox routines is shown in Figure 3.21 below.

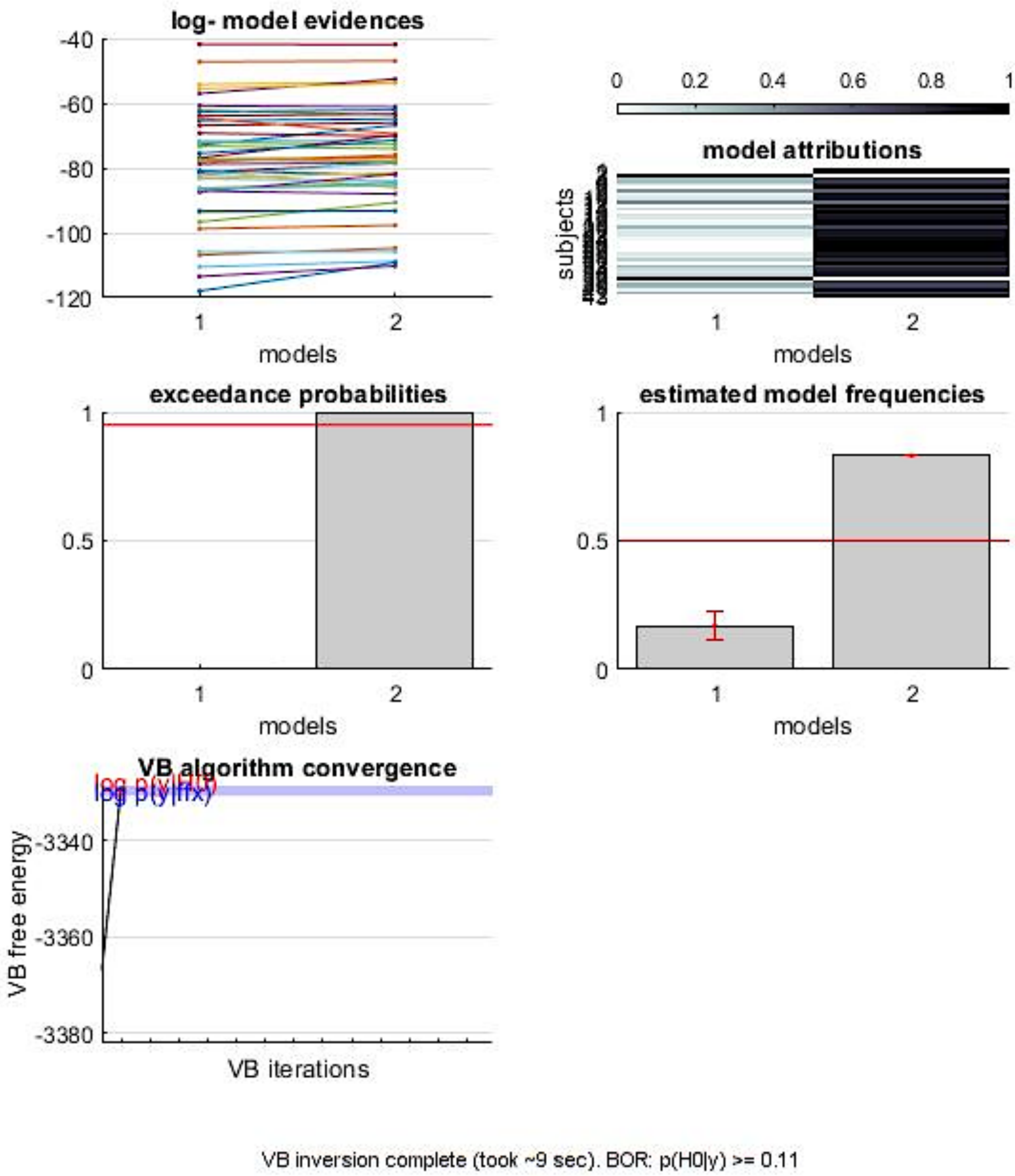


Figure 3.21: The main output window from the VBA toolbox for the NCV condition.

The key results shown in Figure 3.20 offer some confirmation that model 2 is more frequently the better account of the data relative to model 1. The exceedance probability (EP) is 1.0, the PEP was .94, and the expected frequency of model 1 was .17. The Bayesian Omnibus Risk (BOR) is ≥ .11, which reveals that after the modelling the data there is only an 11% chance that the frequencies of the preferred model are equal across this sample watching the NCV. This is evidence in keeping with the 2/43 cases fit to model 1 versus the 10/43 cases fit to model 2.

The histograms drawn for the for the circumplex model coefficients (b_i) the range of coefficients under either model (Figure 3.22). The distributions of individual coefficients are in this case centred relatively close to zero for both models. Here, the group average results suggest neither model had a circumplex model contrast that differs from zero, as does the individual level results. However, it is clear that model 2 fits the data better here, even though there is neither a clear predominance of positive or negative pleasure-displeasure circumplex coefficients, making the average not significantly different from zero. While the model 2 group average results are similar to the previous analyses with regards to the spread of circumplex coefficients, model 1 does not fit very well here in any way. In the motivational video conditions model 1 appeared to be the dominant model when we looked at the group average results but, in fact, was not at an individual level. Here, in the NCV condition it is not even dominant at the group average level. Once again, the group average results are misleading with regards to the effects of the mood manipulations on individual participants.

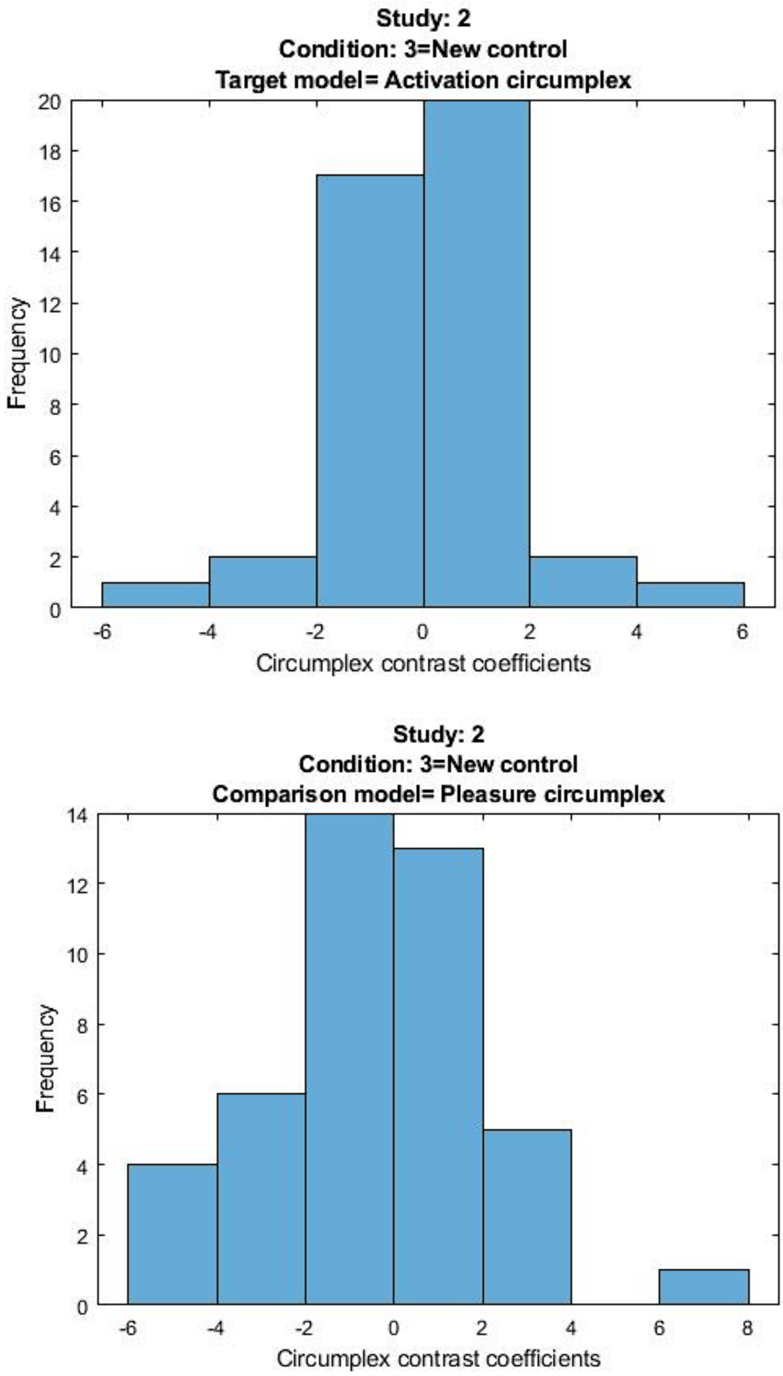


Figure 3.22: The frequencies of b_i coefficients of the circumplex model across participants in the NCV condition. Upper panel is for the activation-deactivation circumplex model (M = 1.498, SD = 2.06); the lower panel is for the pleasure-displeasure circumplex model (M = -.359, SD = 7.27).

To complete this set of analyses by combining across the video conditions and using the BMS, ANOVAs were conducted to compare the model 1 circumplex contrasts of video conditions. In the fixed-effects contrasts analysis above, it was found that the key interaction between the combined OMV and RMV versus the NCV could not withstand the conservative adjusted alpha, and was therefore a trend, as was the key interaction between the RMV versus the NCV. The fixed-effects contrast analysis also found that the model 1 circumplex contrasts analysis interaction between the RMV versus the OMV was non-significant, as expected. All model 2 circumplex coefficient interactions in the fixed effects analyses were non-significant as expected. The outcomes using the BMS contrasts are more compelling than the fixed-effects results as they are cleaner estimates and likely to give more power, despite losing some subjects owing to exclusions. As expected, the results of the model 1 circumplex contrasts of the combined OMV and RMV versus the NCV were significant [$F(1{,}137) = 10.73$, $p = .001$, $\eta p^2 = .073$], as were the results for the RMV versus the NCV [$F(1, 93) = 10.61$, $p = .002$, $\eta p^2 =$ 104]. The BMS model 1 contrasts for the RMV versus the OMV analysis were non-significant [$F(1, 93) = .160$, $p = .690$], as expected. BMS contrasts for model 2 were also tested, and it was found that model 2 circumplex contrasts of the combined OMV and RMV versus the NCV were non-significant [$F(1{,}136) = .105$, $p = .746$], as were the results for the RMV versus the NCV [$F(1{,}91) = .010$, $p = .919$], as well as the results for the RMV versus the OMV [$F(1{,}93) = .128$, $p = .722$].

To conclude the Bayesian model selection process, we conducted a cross-tabulation of video condition by model (0, 1, and 2). Model 0 is the intercept model. Model 0 in Table 3.2 below means that neither model 1 nor model 2 had a strong fit (BF > 2.3) relative to model 0. Here we also used a value of 9 to represent the participants who are better fit both by models 1 and 2 than model 0, but where neither model 1 nor 2 is a better fit than the other (see Table 3.2).

Table 3.2: Cross-tabulation for condition by model frequencies of cases.

Condition	**Model**				
	0	**1**	**2**	**9**	**Total**
OMV	19	13	11	2	45
RMV	18	11	17	4	50
NCV	26	2	10	5	43
Total	63	26	38	11	138

To test whether the distribution of these frequencies differs across these categories of models as a function of the condition we conducted a chi squared test, which was significant [$X^2(6, N = 138) = 13.1, p = .041$]. The main reason for this test outcome is that a selective good model 1 fit is vey rare in the NCV (2 out of 43 cases) but much more common in the motivational video conditions (24 out of 95 cases). More than half the participants were not fit well by either model 1 or model 2 (26 out of 43 cases) where only (37 out of 95 cases) were not in the motivational video conditions.

3.3.3 Analysing mood changes using the GEE approach

As explained above, we next used GEE methods to look at the effect of the videos on mood. The predictors were video condition, the model-based circumplex predictors (each used in separate analyses) and the video by circumplex interaction term. We also entered an intercept term, plus the mood checklist item number (1-60, reflecting the order in which they were presented) as a covariate predictor so that we could specify a WCM for the analysis (we primarily used an AR-1 WCM as explained above).

From the sample of 184 participants, we eliminated all the cases who had large amounts of missing data. Some participants had more than 10 (out of 60) missing items data on the mood checklist, while the rest completed all, or almost all, the items as we noted in our presentation of the SSMLE results above. This resulted in the removal of 41 further cases from the sample. After these removals, the overall amount of missing mood data was 0.8%.

For the analysis of OMV and RMV combined versus NCV, when using the model 1 circumplex predictor (based on activation-deactivation), the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as .246. From the parameter estimates of the GEE model (regression coefficients, B) neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change before to after watching the video ($p > .1$ in either case, with small B values, close to zero). The critical interaction between video condition and circumplex predictor was robustly significant [B=.695, SE=.18, 95% CIs = (.35, 1.05); $p < .001$ (c.f. adjusted $\alpha = .004$)]. We know from Figure 3.4 above that this interaction reflects the fact that, on average, the activation-deactivation circumplex predicts mood changes significantly more strongly in the motivational video conditions than in the NCV condition. In line with these figures, we know from the sign of the B coefficient (and the way that the video condition was coded) that this result reflects a significantly more positive relationship between the model 1 circumplex predictor and mood change in the motivational video conditions compared with the NCV condition. As expected, based on experience with GEE analyses, we obtained very similar results when using the exchangeable or independent WCMs.

For the analysis of the RMV versus the NCV, when using the model 1 circumplex predictors, the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as .246. From the parameter estimates of the GEE model (which are regression coefficients, B) neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change before to after watching the video (in either case, with small B values, close to zero). The critical interaction between video condition and circumplex predictor was robustly significant [B=.644, SE=.19, 95% CIs = (.26, 1.03); p = .001 (c.f. adjusted α = .004)].

To further confirm these findings, we ran the analyses in each video condition (OMV, RMV, and NCV) separately, using just the circumplex value as the predictor of mood change (plus the usual intercept term and the mood checklist item number). As predicted, the activation-deactivation model 1 circumplex was a robustly significant predictor in the OMV condition [B=.766, SE=.20, 95% CIs = (.37, .16); p < .001 (c.f. adjusted α = .004)]. The autocorrelation between adjacent items was estimated to be 0.245, and the percentage of missing data was 1.3%. Similarly, in the RMV condition, the model 1 circumplex also significantly predicted the mood changes [B=.717, SE=.17, 95% CIs = (.38, 1.05); p<.001 (c.f. adjusted α = .004)]. The autocorrelation between adjacent items was estimated to be .295, and the percentage of missing data was 0.7%. The GEE results above then robustly confirm the hypotheses, at least for the sample of participants considered as a whole. The GEE results are completely consistent with the results obtained using fixed effects or SSMLE modelling presented above

In the NCV condition, by contrast, the model 1 circumplex did not significantly predict the mood changes [B=.053, SE=.11, 95% CIs = (-.17, .27); *p*=0.64][9]. The autocorrelation between adjacent items was estimated to be 0.152, and the percentage of missing data was 0.6%. The GEE results above then robustly confirm the hypotheses, at least for the sample of participants considered as a whole. The GEE results are completely consistent with the results obtained using fixed effects or SSMLE modelling presented above.

When using the model 2 circumplex predictor (based on pleasure-displeasure) in this OMV and RMV combined versus NCV test, the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as 0.26. From the parameter estimates of the GEE model neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change before to after watching the video (with small B values). The critical interaction between video condition and circumplex predictor was also not significant [B = .044, SE=.21, 95% CIs = (-.37, .46); *p* = .834]. We know from Figure 3.5 above that this interaction reflects the fact that, on average, the pleasure-displeasure circumplex does not predict mood changes differentially across the video conditions.

For the RMV versus NCV analysis, when using the model 2 circumplex predictor, the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as 0.259. From the parameter estimates of the GEE model neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change before to after watching the video (with small B values). The critical interaction between video condition and circumplex predictor the was also not significant [B = -.057, SE = .25, 95% CIs = (-.55, .43); *p* = .819], as expected.

Again, to further confirm this, we ran the analyses in each video condition separately, using just the circumplex value as the predictor of mood change (plus the usual intercept term and the mood checklist item number). The pleasure-displeasure model 2 circumplex was not significant predictor in the OMV condition [B=.029, SE=.17, 95% CIs (-.30, .35); *p* = .862]. The autocorrelation between adjacent items was estimated to be 0.259 and the percentage of missing data was 1.3%. In the RMV condition, the model 2 circumplex also did not

[9] If we followed the same process as we used with the fixed effects testing above, we could use an equivalence test to test whether the effect of the model circumplex lies within narrow limits. This is not possible with the software we have at our disposal. Moreover, as the results are really clear-cut, it would not add much here.

significantly predict the mood changes [B=-.215, SE=.22, 95% CIs = (-.64, .21); p = .324]. The autocorrelation between adjacent items was estimated to be 0.313 and the percentage of missing data was 0.7%. This result closely parallels the earlier findings: the equivalent analysis using fixed-effects contrasts and the analysis using SSMLE analyses.

In the NCV condition, the model 2 circumplex also did not significantly predict the mood changes [B=-.146, SE=.16, 95% CIs (-.46, .17); p = .357]. The autocorrelation between adjacent items was estimated to be 0.15 and the percentage of missing data was 0.6%. This result closely parallels the earlier findings: the equivalent analysis using fixed-effects contrasts and the analysis using SSMLE analyses.

For the analysis of OMV versus RMV, when using the model 1 circumplex predictor (based on activation-deactivation), the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as 0.271. From the parameter estimates of the GEE model the main effect of the video condition was non-significant ($p>0.1$ in either case, with a small B value). However, the circumplex predictor had a significant effect on mood change before to after watching the video, regardless of the video condition [B=.723, SE=.17, 95% CIs = (.39, 1.11); $p < .001$ (c.f. adjusted $\alpha = .004$)]. The critical interaction between video condition and circumplex predictor was not significant [B=.042, SE=.26, 95% CIs= (-.48, .56); p=.875)]. As expected, based on experience with GEE analyses, we obtained very similar results when using the exchangeable or independent WCMs.

When using the model 2 circumplex predictor (based on pleasure-displeasure) in this OMV versus RMV test, the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as .287. From the parameter estimates of the GEE model neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change before to after watching the video (with small B values). The critical interaction between video condition and circumplex predictor was also not significant [B = .233, SE=.25, 95% CIs = (-.31, .77); p = .396)]. We know from Figure 3.5 above that this interaction reflects the fact that, on average, the pleasure-displeasure circumplex does not predict mood changes differentially across the two video conditions.

3.3.4 Personality effects for all cases in each video condition

To test if the personality traits extraversion and neuroticism moderate the effects of each video on changes in affect, two separate sets of analyses for model 1 and model 2 were conducted for each trait. The overall contrast scores under model 1 and model 2 were computed for each participant. The correlations between the contrast score and the personality variables were computed. As the between-subjects contrasts have shown that the OMV and RMV are similar in terms of the induction of activated contrasts and pleasure contrasts effects, we will present only the correlations of the trait measures with the combined OMV and RMV samples, as well as with the NCV sample. As explained before, the significance level here is based on an adjustment for 8 comparisons (2 traits by 2 samples by 2 contrasts), thus the adjusted per comparison alpha is .006. Conscientiousness was not included in the adjustment as it was used in an exploratory correlation.

When combining the OMV and the RMV groups, here were no significant correlations for the model 1 contrasts of the change in affect with extraversion [$r(100) = -.160$, $p = .109$], nor with neuroticism [$r(100) = .062$, $p = .563$]. When using the model 2 contrasts, there were also no significant correlations between the change in affect and extraversion [$r(101) = .075$, $p = .453$], nor neuroticism [$r(101) = .215$, $p = .029$] (see Table 3.3).

For the NCV, there were no significant correlations for the model 1 contrasts of the change in affect with extraversion [$r(45) = -.014$, $p = .923$], nor with neuroticism [$r(45) = .034$, $p = .821$]. Using an adjusted type 1 error rate of $\alpha = \frac{.05}{8} = .006$, a two-tailed bivariate correlation would require an effect size of $r = .243$ in order to have 80% power. Therefore, we used equivalent bounds of [-.5, .5] for the equivalence test. The equivalence test for the NCV group for model 1 contrasts correlations with extraversion shows that the data does support equivalence, in that this small effect lies between the TOST upper bound (.5) [$r = -.014$, $p < .001$] and the TOST lower bound (-.5) [$r = -.014$, $p < .001$] (both tests c.f. adjusted $\alpha = .006$). The equivalence test for the NCV group for model 2 contrasts correlations with extraversion shows that the data does support equivalence, in that this small effect lies between the TOST upper bound (.5) [$r = .034$, $p < .001$] and the TOST lower bound (-.5) [$r = .034$, $p < .001$] (both tests c.f. adjusted $\alpha = .006$).

When using the model 2 (pleasure-displeasure) contrasts, the correlation between extraversion [$r(46) = -.215$, $p = .142$] was not significant. However, the equivalence test shows that the data does not support equivalence in the control video group for model 1 contrasts correlations with extraversion, in that the equivalence fails at the TOST lower bound (-.5) [$r = -.215$, $p = .013$] (c.f. adjusted $\alpha = .006$). There was a significant correlation with neuroticism [$r(46) = .392$, $p = .006$] (note that this survives the Bonferroni adjustment just if we exclude conscientiousness or is a trend if we include conscientiousness in the adjustment figures; see Table 3.3).

Further exploratory analyses (with unadjusted p values) showed that there was a positive correlation between the change scores of pleasure and neuroticism [$r(53) = .361$, $p = .007$], and deactivated pleasure and neuroticism [$r(55) = .350$, $p = .008$], meaning that the higher the neuroticism values were associated with relatively smaller decreases in pleasure and deactivated pleasure, after watching the NCV (see Figure 3.23).

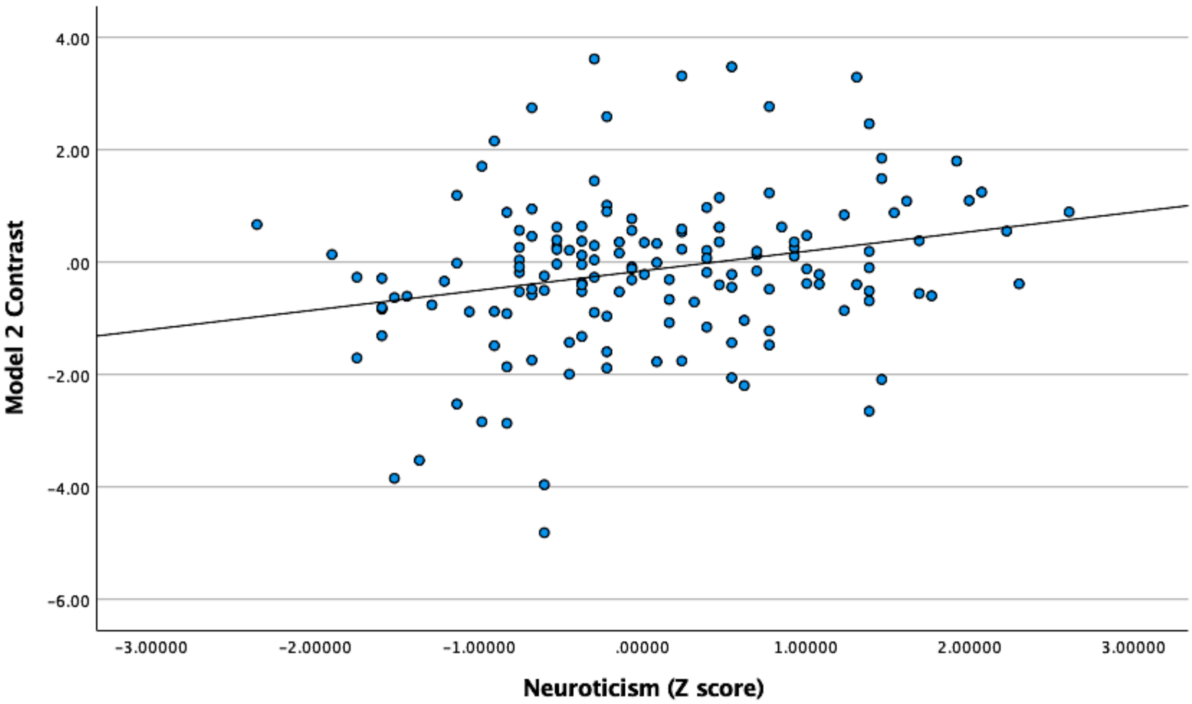


Figure 3.23: Scatter plot showing the positive correlation between neuroticism and model 2 contrasts of the pleasure-displeasure axis.

For completeness we report the exploratory corelations for conscientiousness. Note that, as discussed above, we are not adjusting the per comparison Type 1 error rates for these correlations. If any are significant then we must interpret them very cautiously. When combining the OMV and the RMV groups, there was no significant correlation for the model 1 contrasts of the change in affect with conscientiousness [r(100) = .016, p = .874]. When using the model 2 contrasts, there was also no significant correlation between the change in affect and nor conscientiousness [r(101) = -.138 p = .166]. For the NCV, there was no significant correlation for the model 1 contrasts of the change in affect with conscientiousness [r(45) = -.187, p = .207]. The equivalence test for the control video group for model 1 contrasts correlations with conscientiousness shows that the data does support equivalence, in that this small effect lies between the TOST upper bound (.5) [r = -.188, p < .001] and the TOST lower bound (-.5) [r = -.188, p = .009]. When using the model 2 contrasts, the correlation between conscientiousness [r(46) = -.068, p = .648] was not significant (see Table 3.3). The equivalence test for the control video group for model 2 contrasts correlations with conscientiousness shows that the data does support equivalence, in that this small effect lies between the TOST upper bound (.5) [r = -.068, p < .001] and the TOST lower bound (-.5) [r = -.068, p < .001].

Table 3.3: Group correlations of extraversion, neuroticism, and conscientiousness with model 1 and model 2 contrasts for the combined OMV and RMV, and NCV groups.

	OMV+RMV						NCV					
	Model 1 Contrasts			Model 2 Contrasts			Model 1 Contrast			Model 2 Contrasts		
	r	*p*	*df*	*r*	*p*	*df*	*r*	*p*	*df*	*r*	*p*	*df*
Extraversion	-.160	.109	100	.075	.453	101	-.014	.923	45	-.215	.142	46
Neuroticism	.062	.563	100	.215	.029	101	.034	.821	45	.392*	.006	46
Conscientiousness	.016	.874	100	-.138	.166	101	-.187	.207	45	-.068	.648	46

*Correlation is significant after adjustment for multiple comparisons (α = .006) for extraversion and neuroticism.

3.3.5 Personality effects for cases well fit by the circumplex models

Before using Bayesian Model Selection to extract the good fit cases, we first conducted univariate ANOVAs to investigate whether there was a significant main effect of model fit groups (0,1, and 2; see Table 3.1 above) on extraversion, neuroticism, or conscientiousness as DVs, and whether there were any interaction effects of model groups as a function of video condition. The outcome was that there were no significant main effects of model group on extraversion [F(2,127) = .471, p = .625], nor interaction effects of model group and video condition on extraversion [F(4,127) = 2.934, p = .024 (c.f. adjusted α = .008)]. There were no significant main effects of model group on neuroticism [$F(2,127) = 1.459$, $p = .237$], nor interaction effects of model group and video condition on neuroticism [$F(4,127) = .828$, $p = .510$]. There also were no significant main effects of model group on conscientiousness [$F(2,127) = 1.745$, $p = .179$], nor interaction effects of model group and video condition on neuroticism [$F(4,127) = .911$, $p = .460$].

As explained in the *Bayesian Model Selection* section of this chapter, using Bayesian methods potentially allows for a more meaningful correlation between fitting circumplex coefficients and personality traits. Therefore, the circumplex coefficients (b_i) of the cases with log(BF_{12}) values greater than +2.3, representing a good fit with model 1 (activation-deactivation circumplex), were extracted and correlated with trait extraversion, neuroticism and conscientiousness. The numbers for these analyses in any one study are very small and the correlations will thus severely lack power, but are reported briefly here for completeness. Because of the small number of cases in the motivational video groups included here, the cases from the two groups were combined and correlated with the trait measures. This is reasonable as the above analyses show that the two motivational videos performed very similarly in terms of inducing activated mood.

When combining the participants who watched the two motivational videos, there were no significant correlations between the model 1 circumplex coefficients and extraversion [$r(22) = -.060$, $p = .781$], neuroticism [$r(22) = -.171$, $p = .425$], nor conscientiousness [$r(22) = .029$, $p = .894$]. There was not a significant correlation between the model 2 circumplex coefficients and extraversion [$r(25) = .046$, $p = .819$], nor neuroticism [$r(25) = .388$, $p = .046$]. However, there was a moderate negative correlation between the model 2 circumplex coefficients and conscientiousness [$r(25) = -.582$, $p = .001$]. As this correlation is exploratory, we must treat it cautiously.

The same procedure was conducted for the NCV group. As there were only 2 cases who had strong evidence in favour of model 1, the correlational analysis cannot be performed here. For the correlation between the model 2 circumplex coefficients and the trait measures, there were non-significant correlations with extraversion [$r(8) = -.310$, $p = .383$] nor with neuroticism [$r(8) = .792$, $p = .017$]. However, the correlation with neuroticism is a trend, and matches the finding from the complete sample.

There was no correlation between the model 2 circumplex coefficients and conscientiousness [*r*(8) = .422, *p* = .240].

Table 3.4: Correlations of extraversion, neuroticism, and conscientiousness with circumplex coefficients (b_i) of cases fit by model 1 and 2 in the motivational and control video groups. The correlation analyses on the NCV model 1 b_i could not be performed as there were only 2 cases that were a good fit.

	OMV+RMV						**NCV**					
	Model 1 b_i			**Model 2 b_i**			**Model 1 b_i**			**Model 2 b_i**		
	r	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***
Extraversion	-.060	.781	22	.046	.819	25	X	X	X	-.310	.383	8
Neuroticism	-.171	.425	22	.388	.046	25	X	X	X	.792	.017	8
Conscientiousness	.029	.894	22	-.582*	.001	25	X	X	X	.422	.24	8

3.3.6 Personality effects on mood changes using the GEE analysis

As previously outlined, we can easily add personality predictors to our GEE analyses to see if the traits of extraversion, neuroticism, or conscientiousness moderate the mood-inducing effects of the motivational videos. We begin with adding extraversion as a predictor to the analyses for the OMV and RMV combined condition. We centred extraversion (by standardizing the scores) for all the participants included in the GEE analysis.

We start using the model 1 circumplex as the predictor. The key test is whether extraversion moderates (interacts with) the prediction by the model 1 circumplex values in the OMV and RMV combined condition. The model 1 circumplex predictor robustly and positively predicts the mood changes [B= .747, SE=.13, 95% CIs = (.14,1.00); *p*<.001]. The main effect of extraversion was not significant [B= -.025, SE=.03, 95% CIs = (-.08,.030); *p* = .350]. The interaction between extraversion and the model 1 circumplex predictor was not significant [B= -.183, SE=.11, 95% CIs = (-.39,.03); *p* = .08].

We repeated the above analyses in the NCV condition where we have found that, for the sample as a whole, the model 1 circumplex values do not significantly predict mood change. We do not expect that extraversion will act as a moderator in this condition. This was what the analysis revealed: the main effect of the model 1 circumplex predictor was not significant in the control video condition: [B= .053, SE=.11, 95% CIs = (-.17,.27); *p* = .64] and neither was the main effect of extraversion [B=-.005, SE=.04, 95% CIs = (-.08,.07); p = .89] or the interaction of extraversion and the model 1 circumplex predictor [B= .003, SE=.14, 95% CIs = (-.28,.28); p= .98].

The next key test is whether neuroticism moderates (interacts with) the prediction by the model 1 circumplex values in the OMV and RMV combined condition. As in the analysis including extraversion the model 1 circumplex predictor robustly and positively predicts the mood changes [B= .743, SE=.13, 95% CIs = (.48,.10); p<.001]. The main effect of neuroticism, however, was not significant [B= .05, SE=.03, 95% CIs = (-.01,.11); p=.10]. The interaction between neuroticism and the model 1 circumplex predictor was also not significant [B= .03, SE= .13, 95% CIs = (-.24,.29); p = .84].

We repeated the above analyses in the NCV condition where we do not expect that neuroticism will act as a moderator in this condition. This was what the analysis revealed: the interaction of neuroticism and the model 1 circumplex predictor was not significant [B= .053, SE= .11, 95% CIs = (-.17, .27); p = .63]. The main effect of neuroticism here was not significant [B= .04, SE= .03, 95% CIs = (-.02, .10); p = .19]. The interaction between neuroticism and the model 1 circumplex predictor for this condition was also not significant [B= .03, SE= .09, 95% CIs = (-.15, .20); p = .77].

Another, more exploratory test, is whether conscientiousness moderates the prediction by the model 1 circumplex values in the OMV and RMV combined condition. The model 1 circumplex predictor robustly and positively predicts the mood changes [B= .743, SE= .13, 95% CIs = (.48,1.00); p < .001]. The main effect of conscientiousness, however, was not significant [B= .020, SE= .04, 95% CIs = (-.07, .11); p = .65]. The interaction between conscientiousness and the model 1 circumplex predictor was also not significant [B= .085, SE= .13, 95% CIs = (-.17, .34); p = .52].

We repeated the above analyses in the NCV condition. The analysis revealed that the interaction of conscientiousness and the model 1 circumplex predictor was not significant [B= .048, SE= .11, 95% CIs = (-.16, 26); p = .66]. The main effect of conscientiousness here was not significant [B= .012, SE= .03, 95% CIs = (-.06, .08); p = .72]. The interaction between conscientiousness and the model 1 circumplex predictor for this condition was also not significant [B= -.207, SE= .14, 95% CIs = (-.49, .08); p=0.15].

Now using the model 2 circumplex as the predictor, a key test is whether extraversion moderates (interacts with) the prediction by the model 2 circumplex values in the OMV and RMV combined condition. As in the GEE analysis without personality above, the model 2 circumplex predictor does not significantly predict the mood changes [B= -.095, SE= .14, 95% CIs = (-.37, .18); p = .49]. The main effect of extraversion was not significant [B= -.028, SE= .03, 95% CIs = (-.09, .03); p = .49], nor was there a significant interaction between extraversion and the model 2 circumplex predictor [B= .099, SE= .12, 95% CIs = (-.13, .33); p = .40].

We repeated the above analyses in the NCV condition where we have found that, for the sample as a whole, the model 2 circumplex values do not significantly predict mood change. The main effect of the model 2 circumplex predictor was very similar to that seen in the GEE analyses without personality above: [B= -.152, SE= .16, 95% CIs = (-.46, .15); p = .33]. The main effect of extraversion was not significant [B= -.010, SE= .04, 95% CIs = (-.09, .07); p = .80] and nor was the key interaction term for extraversion and the model 2 circumplex predictor [B= -.180, SE= .16, 95% CIs = (-.50, .19); p = .27].

The next key test is whether neuroticism moderates (interacts with) the prediction by the model 2 circumplex values in the OMV and RMV combined condition. The main effect of neuroticism was not significant [B= .060, SE= .03, 95% CIs = (-.01, .13); p = .08]. The interaction between neuroticism and the model 2 circumplex predictor was not significant [B= .309, SE= .14, 95% CIs = (.03, .59); p = .30].

We repeated the above analyses in the NCV condition. The analysis revealed the same finding with respect to the main effect of neuroticism that we saw above when using the model 2 circumplex predictor [B= .052, SE= .03, 95% CIs = (-.01, .11); p = .10]. However, interestingly, the interaction of neuroticism and the model 2 circumplex predictor was significant and positive and withstands the conservative adjustment level [B= .401, SE= .13, 95% CIs = (.15, .65); p = .001], which supports the fixed effects analysis results above. However, a three-way interaction between the video group, model 2 predictor and neuroticism was non-significant [B= -.097, SE= .19, 95% CIs = (-.46, .27); p = .602].

Another exploratory test is whether conscientiousness moderates the prediction by the model 2 circumplex values in the OMV and RMV combined condition. The main effect of conscientiousness was not significant [B= .015, SE= .04, 95% CIs = (-.07, .10); p = .73]. The interaction between conscientiousness and the model 2 circumplex predictor was also not significant [B= -.253, SE= .15, 95% CIs = (-.56, .05); p = .73].

We repeated the above analyses in the NCV condition. The main effect of conscientiousness here was not significant [B= .003, SE= .04, 95% CIs = (-.07, .08); p = .93]. The interaction between conscientiousness and the model 2 circumplex predictor for this condition was also not significant [B= -.099, SE= .17, 95% CIs = (-.44, .24); p = .57].

All GEE analyses were repeated using exchangeable and independent WCMs, where the outcomes were similar each time, without any notable differences.

3.3.7 Intrinsic motivation effects

A univariate ANOVA was performed to examine the effects of video type on the level of intrinsic motivation across the three video groups. There was no significant difference in the mean difference in intrinsic motivation scores when comparing the effects of the OMV (M = 20.52, SD = 8.42), the RMV (M = 20.34, SD = 6.55), and the NCV (M =21.46 , SD = 6.15) [F(2,181) = .042, p = .959], neither was there a significant difference when comparing the effects of the OMV with the RMV [F(1,120) = .017, p = .895], nor when comparing the effects of the RMV with the NCV [F(1,118) = .920, p = .339]. This pattern of results is in line with the intentions behind the videos, namely that there should be no difference in interest levels across all three videos. This is a major improvement from the first study where the intrinsic motivation differences were found between the motivational and control videos used.

We tested the difference between the scores of the “competitive drives” item across video groups as a manipulation check: a difference between the motivational videos and the control video is expected if the motivational videos are “motivational” in their intended fashion. There was a significant difference when comparing the effects of the OMV (M =1.63, SD =1.36), the RMV (M =1.56, SD =1.21), and the NCV (M = .92, SD =1.12) [F(2,181) = 6.20, p = .002, $\eta p^2 = .064$]. Specifically, when comparing the RMV to the NCV there was a significant difference in the "competitive drives" item [F(1,119) = 9.37, p = .003, $\eta p^2 = .073$]. However, there was no significant difference when comparing the OMV to the RMV [F(1,123) = .09, p = .760]. This pattern of differences between the videos was exactly as predicted for competitive drives, which was an item motivational videos are designed to activate.

Ratings of the speaker's characteristics (e.g., *successful, uninspiring, intelligent, unattractive, hardworking, dull, healthy, poor)* were taken on a 10-point scale and were combined into a single score. The undesirable characteristics were negatively keyed items, so they were reversed and a sum of ratings for each participant was calculated. When comparing the participants' perception of the speakers present in the three videos, overall there were no significant differences in the ratings of the speaker's characteristics for the OMV (M = 52.92, SD = 13.61), RMV (M = 51.48, SD = 13.00), and NCV (M = 52.80, SD = 11.61) [F(2,181) = .240, p = .787]. When the video groups were tested individually against each other, again there were no significant differences; for the OMV versus the NVC [F(1,120) = .003, p = .957], the RMV versus the NVC [F(1,119) = .342, p = .560], and the OMV versus the RMV [F(1,123) = .364, p = .547].

We compared the scores of the personal relevance items across the three videos (see Figure 3.24). The targeted personal relevance items were another manipulation check: they tested whether the motivational videos produced higher levels of the need to study more, the need to put more effort into work/study, the need to be healthier, and the need to strive for success in everything, as expected. The non-targeted personal relevance items were a control set of items as there was no reason why the motivational videos should increase the feeling of being inspired to take up a new hobby, the need to travel more, the feeling to write things down and take more notes, or the need to socialise more.

There was a significant effect of the video type on the targeted personal relevance items between the three video groups overall [F(2,180) = 4.00, p = .020, ηp^2 = .043]. There was a significant effect of video type on the targeted personal relevance items for the OMV versus the NCV [F(1,119) = 6.107, p = .015, $\eta p^2 = .049$], and the RMV versus the NVC [F(1,118) = 6.352, p = .013, $\eta p^2 = .051$], whereby those who watched the OMV (M = 14.7, SD = 4.3) and the RMV (M = 14.7, SD = 4.0) had higher average scores than those who watched the NCV

(M = 12.9, SD = 3.9). There was no significant effect on video type on the targeted personal relevance items for the OMV versus the RMV [$F(1,123) = .001$, $p = .978$].

As expected, there was no significant effect of video type on the non-targeted personal relevance items [$F(2,181) = .658$, $p = .519$]. There was no significant effect for the OMV versus the NVC [$F(1,120) = 1.362$, $p = .246$], the RMV versus the NVC [$F(1,119) = .457$, $p = .500$], and the OMV versus the RMV [$F(1,123) = .215$, $p = .644$].

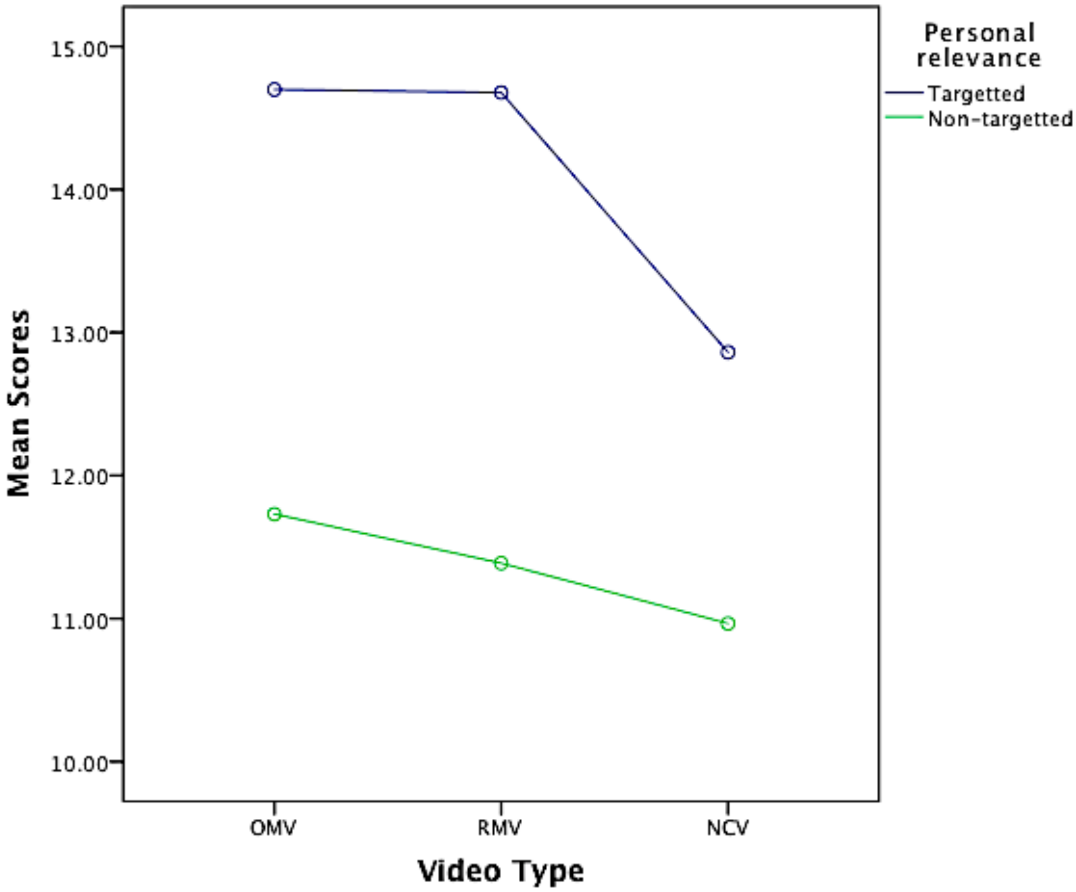


Figure 3.24: The mean scores of the targeted and non-targeted items relating to the personal relevance ratings given by participants in each video condition.

3.3.8 Line bisection data

The difference between the average line bisection deviation of the three video groups, measured at post-test only, was tested for significance using a univariate ANOVA. It showed that when comparing the three videos, there were no significant differences in the scores of the line bisection deviation from the centre $F(2, 181) = 1.413$, $p = .246$ for the OMV ($M = -.20$, $SD = 1.31$), RMV($M = -.27$, $SD = 1.43$), or NCV($M = -.60$, $SD = 1.41$), though all are slightly leftward to a greater or lesser extent. However, a one-sample t-test revealed that those who watched the NCV significantly deviated from zero [t(58) = -3.240, $p = .002$], indicating a slight leftward bias in line bisection, in turn indicating possible right (relative to left) hemispheric activation. When conducting one-sample t-tests for the other two video types, the line bisection scores were also negative but in neither case did they significantly deviate from zero for those who watched the OMV [t(62) = -1.193, $p = .237$], nor for those who watched the RMV [t(61) = -1.517, $p = .135$].

It can be argued that in the motivational video conditions, those who show a good fit to the activation model in their mood data based on their positive circumplex coefficients (with log(BF_{12}) values greater than +2.3) are those whom we expect to show the greatest degree of rightward shift. We, therefore, took the motivational video cases fit by model 1 and compared those subjects with those who are not fitted by the activation model. It should be noted that as the number of cases that meet all the given criteria are few, the power of this analysis is relatively low. A one-way ANOVA showed that there was not a significant difference in line bisection deviation in the motivational video conditions between the cases fit by model 1 ($M = -.30$, $SD = 1.46$) compared to those who are not fitted by model 1 ($M = -.12$, $SD = 1.28$) [$F(1, 94) = .319$, $p = .573$]. The same procedure was done to test the line bisection shift for those who are well fit by model 2 (with log(BF_{12}) values less than -2.3) to examine whether or not the pleasure-displeasure model produces a shift in line bisection. Again, there was no significant difference in line bisection deviation in the motivational group between the cases fit by model 2 ($M = -.18$, $SD = 1.21$) compared to those who are not fitted by model 2 ($M = -.16$, $SD = 1.37$) [$F(1, 94) = .004$, $p = .962$].

General linear model analyses were used to test the moderating effect of extraversion, neuroticism, and conscientiousness individually on the video effects on the average line bisection deviation. It was found that there was not a significant interaction between the video type and extraversion [$F(2,177) = 1.288$, $p = .931$], there was not a significant interaction between video type and neuroticism [$F(2,177) = .903$, $p = .407$], neither was there a significant interaction between video type and conscientiousness [$F(2, 177) = .786$, $p = .457$].

3.4 Discussion

By recreating the original motivational video used in study 1 in chapter 2, we were able to refine the experimental manipulation (mood induction) with a better matched control, which includes similar features of the original motivational video. To ensure that the motivational video was accurately replicated, the effects of the OMV and the RMV were compared against each other. At the group level, the primary predicted results of this follow-up study were confirmed. Overall, there were no significant differences between the OMV and RMV for all measures, including the mood induction effects, the intrinsic motivation effects, speaker characteristics score, personal relevance score, and line bisection measure. The RMV was, therefore, a successful replication of the OMV.

To test that the motivational videos (independently and combined) were producing different motivation from the better matched control video (NCV) we used the single competitive drives item administered after watching the video. We found that those who watched the motivational videos did significantly score higher on competitive drives than those who watched the NCV, implying that the motivational video did indeed bring out their competitive drives. This confirmation of the manipulation allows us to consider the primary results of the study, the effects of the motivational videos on mood as compared to the NCV.

Through fixed-effects contrast analyses, SSMLE circumplex model fitting, and GEE regression analyses, average pre-to-post changes in core affect were observed along the activation-deactivation axis of the circumplex in the groups who watched the motivational videos, and this effect was significantly greater than that observed in those who had watched the NCV. This was in contrast to the non-significant average outcomes in core affect along the pleasure-displeasure axis for the motivational video groups. Specifically, there was an increase in activated affect for those who watched the motivational videos, compared to the NCV, meaning participants felt more aroused, energetic, and alert. In light of these effects attributable to the motivational videos, the study 1 findings were supported in that the motivational videos acted as an appetitive mood induction source, leading to effects that are consistent with those produced by appetitive mood inductions. The idea that the content of the control video included analogous linguistic context relating to motivation and yielded the same intrinsic motivation scores, yet failed to promote higher levels of activated affect, is consistent with an influence of interpersonal social incentives on these effects in the motivational video conditions. This effect could indeed be due to the presence of eye-contact between the viewer and the speaker and/or the personally-directed speech. Furthermore, the participants scoring significantly higher on the targeted personal relevance items after watching the motivational videos, as opposed to the control, supports the theoretical influence of goal content on motivation (Kasser & Ryan, 1993, 1996).

As expected, the NCV did not produce any significant changes on the activation-deactivation axis of the core affect circumplex, though there was an indication in the SSMLE that, on average, it produced mood changes along the pleasure-displeasure axis. However, there is neither a clear predominance of positive or negative pleasure-displeasure circumplex coefficients, making the average inconclusive. On average, the circumplex coefficients indicated an increase in displeasure and a decrease in pleasure as in the control video from study 1.

As in study 1, the results from the SSMLE fitting showed that a clear fit of the specific mood circumplex models was present in only a minority of the cases in each video condition. In the OMV condition, by using a log(Bayes Factor) of +/-2.3 (BF=+/-10) as the criterion for strong evidence for one circumplex model over the other, there were 13 cases (out of 45) who showed strong evidence for the activation circumplex model and 10 cases (out of 45) who showed strong evidence for the pleasure circumplex model (similar proportions to study 1). In the RMV condition, there were 11 cases (out of 50) who showed strong evidence for the activation circumplex model and 17 cases (out of 50) who showed strong evidence for the pleasure circumplex model. In the NCV condition, there were 2 cases (out of 43) who showed strong evidence for the activation circumplex model and 10 cases (out of 43) who showed strong evidence for the pleasure circumplex model. The remaining cases that watched the motivational videos did not show strong evidence for either circumplex models. There was also a result that, in either condition, both model 1 or 2 were much better fits than model zero (no variation in mood change around the circumplex) in almost all participants in either video condition (see Appendix B).

Again, these are important findings as they show that the mechanism by which a specific experience affects mood is probably different for different people. These results show that it is not the case that a single mechanism is at work and individuals simply differ in the strength of that mechanism; rather some people respond in one way and others respond equally strongly but in an entirely different way (e.g., Haines et al., 2020; Yarkoni & Braver, 2010). As with the results in study 1, these findings highlight the need to explore individual differences but, as discussed below, complicates the process of determining which personality traits might map on to which mechanisms.

We also reported the moderator effects of personality traits, extraversion, neuroticism, and the exploratory effects of conscientiousness, on the change in affect, via the correlations between the trait scores and contrast and circumplex coefficients of the activation-deactivation and pleasure-displeasure models. Using all the available data, separately out the video conditions, the correlations of the contrast coefficients of the activation-deactivation model with extraversion, neuroticism, or conscientiousness were generally small. The same was true of the corresponding correlations between the pleasure-displeasure model contrast coefficients and extraversion, neuroticism, or conscientiousness. We were concerned about the ability of these correlations to detect any associations for the following reason: if the observed mood changes for the majority of cases were not accurately described by either circumplex model it is unlikely that one would be able to find correlations between personality and mood changes that are hypothetically produced by those circumplex models. Nevertheless, the correlations were mainly non-significant, except for a significant correlation between neuroticism and the pleasure-displeasure model contrast coefficients in the NCV condition. Higher scores of neuroticism were linked to an increase, or less of a decrease, in participant pleasure scores after watching the NCV, relative to lower scores on neuroticism. Given the way the circumplex scores work it could also be that higher neuroticism is linked to a decrease in displeasure or less of an increase in displeasure. This pattern was also found by the GEE analysis but not the BMS (where very few participants were included). While the reason for this correlation is unclear, one can speculate that it may involve the way the BIS-linked mechanisms might moderate the mood inducing effects of the video (e.g., Rafienia et al., 2008). Considering the content of the NCV (a documentary lecture of psychological theories of motivation), it could be that the informative nature of the NCV somehow put high neuroticism participants at ease, leading to this change in pleasure scores (item examples include feeling satisfied, secure, and at ease).

The use of BMS allowed us to extrapolate the individuals' cases whose data were good fits for either of the models in either condition. This meant that we could perform the trait correlations on just the well-fitting cases to see if there was a relationship between the effects of watching the motivational videos with either extraversion, neuroticism, or conscientiousness. This approach would allow for a focused way to test the relationship of individual differences in approach motivation after appetitive mood inductions. While the numbers of cases available for such an analysis were very small for detecting associations in study 1, the samples available for these analyses in study 2 were larger; and yet they were again almost certainly very underpowered.

It is difficult to draw any firm conclusions from these analyses or to derive any clear implications for theories of individual differences in approach motivation, like the ARH (Gross et al., 1998) and RST (Smillie et al., 2006). The fact that Smillie et al. (2012) obtained reliable correlations for extraversion with their mood induction procedures could suggest that those procedures may be inducing mood changes via the same mechanism in the majority of participants in those studies. Perhaps the fact that classic mood induction methods use highly overlearned social scenarios with familiar mood-congruent music may enable a more homogeneous mechanism of response that those mechanisms engaged by the motivational and control videos used here. Furthermore, a study conducted by Fox and Moore (2019) used mood induction procedures to find that increases in positive affect were associated with greater extraversion, but only for low neuroticism participants. When analysed independently this relationship was such that higher extraversion was associated with less increase in positive affect, and neuroticism was associated with larger decreases in negative affect. Fox and Moore's (2019) study highlights the need to include trait interactions as moderators to fully understand individual differences in mood induction effects, which, to our knowledge, has been relatively neglected in the field (e.g., Falkenberg et al., 2012). However, looking at extraversion by neuroticism effects here would require a further increase in sample size to be able to reliably detect the effects.

The evidence showing no observable, significant shift in line bisection and implied left frontal activation after watching the motivational video via an electronic version of the line bisection task could mean that the motivational videos did not activate left frontal regions or it could mean that this version of the line bisection task was not sensitive to any left frontal activation that the motivational videos did induce. It should also be noted that the delay in time until the line bisection task might mean that any left frontal activation induced was very short-lived. It should be noted that there was a significant leftward line bisection in those who had just watched the NCV. This result may not accurately imply that those who watched the NCV were experiencing right frontal activation due to their slight leftward line bisection bias. A key limitation to consider in the current study involves the online nature of assessments used. Experiments administered over the internet lack the degree of environmental control that is present in a laboratory studies, like in study 1 (even though this was also not a traditional laboratory environment). This may increase the likelihood of non-compliance, as participants may be more likely to disengage their attention from the study when they are not being directly observed by a researcher (Ferrer et al., 2015). However, in using an online mood induction, this study represents a potentially scalable intervention that could be administered cheaply to a large number of people, or in a “big data” fashion. A meta-analysis by Ferrer et al. (2015) showed that mood induction procedures administered online effectively induced general positive affect, general negative affect, but did not significantly induce happiness. Nevertheless, video inductions, specifically, resulted in greater effect sizes. However, there is a price to pay in these online studies in terms of missing data on the mood changes. We have noted that considerable numbers of subjects had to be excluded in the BMS and the GEE analyses because of vey incomplete mood change responses.

3.4.1 Conclusion

A widely watched example of an online motivational video was recreated in order to create a better matched control video with the same actor. These three videos were tested against each other to refine how motivational videos can be used as an appetitive (activated affect) mood induction technique and to provide further support for the previous initial study. The argument underlying this test was that the videos employ interpersonal reward incentives, which possibly work by inducing activating affect but not pleasant affect (hedonic tone). By employing the circumplex structure of core affect, we were able to effectively use fixed-effects contrast analyses, SSMLE fitting and BMS methods, plus GEE regression methods, to test whether the motivational videos induced mood changes along the activation-deactivation axis, as opposed to the pleasure-displeasure axis. We also tested whether the effect was significantly greater than the corresponding effects induced by the control video. The results showed that, on average, both motivational videos did induce mood changes along the activation-deactivation axis which were greater than those induced by the control video. However, the BMS results (which fit the data for each participant individually) showed, as in the previous study, that there was considerable heterogeneity in the mood induction mechanisms that were at work in each video condition. This raises potentially strong implications for our ability to detect correlations between personality and behavioural measures of mood change derived from a specific model, given that the individuals we studied varied not only in the degree to which a particular experience induced a specific kind of mood change, but also in what type of mood changes were induced by that experience.

The implications of positive findings from this refined experiment might mean the confirmation of a new and effective form of mood induction (at least for some people). Going further forward, this could help in refining our understanding of individual differences in responses to socially incentivized rewards and positive activated affect. One can also possibly utilize the effects of motivational videos to disentangle what aspects of the mood induction process can be accounted for by reward processes and approach motivation, at a neural level. However, to be able to do this, a more direct measure of left frontal activation, specifically EEG measures of frontal alpha asymmetry typically used in neural mood induction research, should be utilised (see chapter 4). Furthermore, more types of videos testing for the effects of different variables on reward processing and mood induction should be developed. For example, it would be interesting to see how effective a motivational video that contains personally-directed speech and goal content without any visual representation of social stimuli. This would allow for a model that detects the extent to which the visual social stimuli (e.g., perceived eye contact and vicarious learning) accounts for the mood induction effects, as opposed to the context of the language used.

Chapter 4

Individual differences in the effects of "motivational videos" on mood and left frontal activation: an EEG study.

4.1 Introduction

The previous chapters (2 and 3) of this thesis describe how the presentation of motivational videos can as we predicted mainfluence affect along the activation-deactivation axis of core affect (Yik et al., 2011). In the group average performance, this pattern is present only after watching motivational videos compared to a control video. After the effect was demonstrated in study 2 using a sub-optimal control video, in study 3 the same results were obtained using a control video that controlled for intrinsic motivation (level of interest) and language used, but where the interpersonal incentive to achieve goals has been removed.

Affect is a term that encompasses emotions and moods that reflect subjective experience (Harmon-Jones & Gable, 2018). Affect segments along the activation-deactivation axis are broadly characterised by core feelings of arousal and alertness, or the lack of these features, when considering deactivation. This can be contrasted with the pleasure-displeasure axis of core affect, which is described as positive or negative affective valence (Posner, Russell, & Peterson, 2005; Russell, 1980). The segments across both axes are differentiated with either a positive, negative or neutral tone to determine their position on the core affect circumplex (*pleasant activation, unpleasant activation, activation, pleasant deactivation, unpleasant deactivation, deactivation, activated pleasure, deactivated pleasure, pleasure, activated displeasure, deactivated displeasure, displeasure*; Russell, 1980; Yik et al., 2011), where the pleasure-displeasure axis runs at rights angles to the activation-deactivation. This proposed geometry is theoretically important in that it implies that the specific effects along one axis will be independent of the other (as described in earlier chapters).

This chapter presents a study that uses a proposed neural measure of approach motivation in the context of an appetitive mood induction via the use of a motivational video once again. It is grounded in the literature on asymmetric frontal cortical activity as an index of approach motivation, while focusing on the relationship with activated affect (for a review see Harmon-Jones and Gable, 2018). More specifically, the study seeks to validate the appetitive mood induction effects of the motivational video using more direct neural indices of activated affect and approach motivation, namely left frontal activation (Davidson et al., 1990, Harmon-Jones et al., 2008).

4.1.1 Approach/avoidance motivation and asymmetric frontal cortical activity

As reviewed in chapter 1, according to the motivational direction theory (Harmon-Jones et al., 2013) the term approach motivation is applied to behaviour that is motivated toward achieving a goal, often accompanied with feelings of arousal, alertness, and feeling energised, and is typically associated with greater left (relative to right) frontal activation. Avoidance motivation (or withdrawal) is most commonly described as behaviour motivated to avoid punishments, undesired outcomes, or negative goals, often accompanied with feelings of fear, and is typically associated with greater right (relative to left) frontal activation. It is posited that there is interhemispheric functional connectivity via the corpus callosum that may encourage or inhibit crosstalk between hemispheres that is associated with approach or avoidance motivation. More specifically, it may be interhemispheric inhibition as part of the functionality of the corpus callosum that may lead to this frontal asymmetry (Chiarello & Maxfield, 1996; Schutter & Harmon-Jones, 2013). This asymmetric frontal cortical activity is often measured by comparing alpha power (i.e., in the 8-13 Hz frequency range) in areas on both the left and right brain hemispheres, where difference scores are calculated to detect asymmetry. Alpha power is used as it is thought to be inversely proportional to regional brain activity (Cook et al., 1998; Davidson et al., 1990). Typically, researchers within this field first log-transform the alpha power values to normalise distributions, and subtract log left frontal alpha power (e.g., EEG in a left-hemisphere location F3) from log right frontal alpha power (e.g., EEG in the corresponding right hemisphere location F4). The result of this calculation will then be referred to as relative left or relative right frontal activity, depending on whether the numeric value result is more positive or more negative, respectively (Allen & Cohen, 2010). To reiterate, the index of frontal asymmetry formed from [log(right alpha power) - log(left alpha power)] is more positive to the extent that left frontal cortical activation is relatively greater than right frontal cortical activity. This is the principal index of frontal asymmetry that will be used in this chapter.

When relating motivational direction accounts of frontal asymmetry to the broader RST account of motivational systems, the picture becomes a little more complex, especially as the conceptualisation of the underlying systems in RST has shifted considerably over the years. The BAS is considered to react to both positive and negative reinforcement cues[10], while the BIS (in its original conceptualisation) reacts to conditioned punishment stimuli, as well as novel and/or instinctually fearful stimuli. Using aggregated resting EEG data (Hewig et al., 2004, 2006) and task-induced frontal alpha activation patterns (using go/no-go tasks; Hewig et al., 2005), Hewig and colleagues deduced that there is an association of BAS with bilateral frontal activity, as opposed to greater relative left frontal activation. This BAS-related bilateral frontal activity could be reflective of the BAS as a more superordinate system than originally conceived, where energising active behaviour is common to both approach and withdrawal, and should be activated by both positive and negative reinforcement (Hewig et al., 2004, 2005, 2006). Therefore, BAS stimuli may lead to bilateral cortical activation. Furthermore, other research supports the idea that relative right anterior brain activation is linked to the (revised) BIS and represents the conflict between, and inhibition of, the (revised) BAS and (revised) FFFS, as opposed to withdrawal motivation (Wacker et al., 2003, 2008, 2010).

A notable study applying the aggregated theoretical implications above (Rodrigues et al., 2018), using a virtual reality T-maze paradigm, found more bilateral frontal activation when actually engaging in approach behaviour (i.e., reaching targets in time to increase credits by moving forward in one of the arms of the T-maze). The study, also, found that participants showed more relative right frontal activation in the motivational state when trying to avoid negative events (i.e., by not going forward into the arms of the T-maze but by changing direction), where trait positive affect, trait anxiety, and trait sadness/frustration accounted for the difference of the execution of actual behaviour, regardless of the frontal asymmetry pattern. This supports the understanding that frontal asymmetry is associated with the *general motivation* to conduct certain behaviour, while *executing* certain behaviour is not so dependent on frontal asymmetry but is influenced by relevant traits. This study is in support of the notion that frontal asymmetry heavily relates to behavioural approach motivation, while bilateral frontal activation heavily relates to actual behaviour (Rodrigues et al., 2018).

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[10] A negative reinforcer may be the removal, reduction, or omission of an aversive event or stimulus, which would activate the BAS.

The capability model (Coan, Allen, & McKnight, 2006) proposes that the relationship between trait measures and asymmetry will emerge more effectively when resting state EEG is recorded under trait-relevant situations. For example, when resting state EEG is recorded after an approach induction, there will be a stronger relationship between trait BAS and left frontal activation, while when resting state EEG is recorded after an avoidance induction, there will be a stronger relationship between trait BIS and right frontal activation. However, it has more recently been argued, that if the task or manipulation is sufficiently overpowering and has features strongly targeting the volition phase of motivation, it may overshadow the moderation effects of individual differences in response to the task or approach induction (Rodrigues et al., 2021).

Rodrigues et al. (2021) examined differences in experimental design (e.g., manipulation and induction methods) and EEG recording methods on trait-related and state-related cortical asymmetry. They argued that frontal asymmetry is most prominent in the volition phase, where intentions are formed, and approach motivation means a preparation to act or beginning to execute the relevant behaviour. It should also be noted that the evaluation of the reward activation process follows the volition phase and is often accompanied with a weaker frontal asymmetry and is sometimes measured in longer timeframes after an approach induction (see Wacker et al., 2008). Rodrigues et al. (2021) predicted that more powerful situational manipulations of frontal asymmetry (virtual T-maze) would eclipse relationships between relevant traits (trait positive and negative affect, trait BIS-BAS) and frontal asymmetry, whereas weaker manipulations (mental imagery and movies), measured during extended time periods, would enhance the association with these relevant traits and resting state frontal asymmetry. Their results indeed confirmed their predictions and stress the importance of the induction characteristics, including the stimuli used, as well as the other methodological implications, like relevant trait measures and recording methods. This highlights the sensitive nature of this experimental process, where the motivational video we use in this chapter would fall into the weaker category of manipulations and thus might increase confidence that we would see induced frontal asymmetry and associations with traits.

Considering the nature of motivational videos, as described in previous chapters, we assume that the goal-directed content, perceived eye-contact, and interpersonal language used, are stimuli that induce the volition phase of motivation. As per Hewig's (2018) suggestions, the volition that occurs while watching the video reflects the formation of intentions with a cognitive representation of the intended behaviour and outcome (e.g., the goal of studying for enough hours to achieve high grades), and an affective-motivational component. The affective-motivational components include the feeling of determination to act and gaining the energy to perform the necessary action, even when the specific situation or environment does not facilitate this action. The study conducted by Rodrigues et al. (2021), previously described, used a positive emotional video (an amusing film clip) and a negative emotional video (a fear film sequence from a horror movie). They found weaker frontal asymmetry results compared to the more powerful T-maze manipulation. It could be that the weaker frontal asymmetry results associated with the movie video induction was due to a flawed manipulation of approach-motivation and the intentions involved in the volition phase of motivation. These factors may be more specifically activated in the motivational video presented in this experiment, as its appetitive characteristics, provide a more trait-relevant situation in terms of approach motivation, compared to positive or negative *valenced* movie clips.

4.1.2 Activated affect and asymmetric frontal cortical activity

Activated affect concerns states that are arousing or energizing (e.g., to feel alert, to feel vigorous). Studies suggest that the neural processes involved with the BAS, mainly via observing the effects of psychostimulants and dopaminergic modulation, are more likely to be associated with the experience of activated affect and not merely pleasant affect (Berridge, 2006; Davidson, 2004). Further supporting the potential significance of activated affect is research within this domain that involves the influence of state anger, which has been associated with greater left frontal activation but is considered a negatively-valenced affect (e.g., Harmon-Jones & Sigelman, 2001; Harmon-Jones et al., 2009; Jensen-Campbell et al., 2007; Verona et al., 2009). This may mean that approach-motivation processes are involved with the experience of anger.

A study (Harmon-Jones et al., 2003) attempted to induce anger in participants with an event that meant that their university tuition fees were being increased. The participants who could act on their anger (the "action-possible" condition) had greater relative left frontal activity than those who thought they would be unable to engage in approach-related action. Interestingly, those in the action-possible condition were also more motivated to engage in further approach-related behaviour, like encouraging more people to sign a petition (Harmon-Jones et al., 2003). Considering the described research here and in chapter 1, if the affective effects of state approach-motivation and neural correlates of this BAS are indeed specifically related to activated affect, regardless of the valence, then watching motivational videos should induce a state of activated affect with accompanying greater left-frontal activation, regardless of whether it is pleasant or unpleasant.

4.1.3 Individual differences and frontal cortical activity

As discussed in previous chapters, the RST proposes systems involved in approach/avoidance motivation and suggests that personality traits such as extraversion (Smillie et al., 2006) and neuroticism (Barlow et al., 2014) are related to the activation of these motivational systems. It is therefore reasonable to predict that these traits might further relate to observations of frontal asymmetry. In this chapter we will attempt to induce frontal lobe asymmetry using motivational versus control videos and thus might expect that traits such as extraversion and neuroticism to be involved. Two relevant studies are discussed below.

A study by Wacker (2018), independently manipulated positive emotion (high approach "wanting-expectancy" versus low approach "warmth-liking") using imagery and film clips, as well as a dopamine drug manipulation (placebo vs. DA D2 blocker sulpiride). The effects on changes in frontal asymmetry were examined. Through their pre-post experimental design, they found that extraversion was indeed associated with (or moderated) state-related changes in frontal asymmetry, where those who were asked to imagine their future goals or eagerly awaited activities displayed a greater relative left frontal asymmetry that was positively correlated with scores of extraversion. However, they found no significant association between extraversion and baseline resting asymmetry, highlighting that frontal asymmetry is perhaps an indicator of motivational *states* (as opposed to trait measures). These states are differently activated in relevant situational contexts depending on relevant trait levels, as suggested by the capability model (Coan et al., 2006).

With regards to BIS-related neuroticism and frontal asymmetry, anterior functional brain activity and its relations with the Five Factor Model personality traits (Goldberg, 1993; McCrae & Costa, 2003; McCrae & John, 1992) remain unclear. In the second study particularly relevant for this chapter, Uusberg et al. (2015) investigated the effects of variable degrees of social contact, induced by eye gaze, on anterior EEG alpha asymmetry. Direct eye gaze towards the viewer is an approach routinely employed in motivational videos. Uusberg et al.'s results showed that eye gaze induced avoidance-related, relative right-sided frontal asymmetry across subjects with higher levels of neuroticism. The indication that neuroticism moderates avoidance-related outcomes to social contact inductions was further supported by behavioural direct gaze avoidance and subjective averted gaze preference.

4.1.4 The present study

Combining the previously described literature on individual differences in approach motivation, activated affect, and frontal asymmetry, the present study attempts to use the appetitive stimuli in motivational videos to induce left frontal asymmetry, as measured directly by cortical EEG activity. We hypothesise that there will be an increase in relative left frontal activation, calculated as described above using a hemispheric difference in log transformed alpha activity, after watching the motivational video (RMV). The increase in left frontal activation will be greater than that induced by watching the control video (NCV).

Drawing on the combination of results in the preceding studies (see chapter 2 and chapter 3 for study 1 and 2, respectively), the study attempts to replicate the findings pertaining to the circumplex models used to explain the mod-inducing effects of the motivational versus the control video. It should be noted that, due to there being no differences between the OMV and RMV that are meaningful to the scope of this study, we decided to only test the effects of the RMV against the matched NVC. The selection of the RMV means that the NVC is a well-matched control, as both were directed and filmed by the same crew, in the same conditions, and the same speaker is present in both videos. It is hypothesised that, relative to the NVC, the RMV will on average increase, from pre- to post-test, those segments of emotion (circumplex models divide mood up into segments; Yik et al, 2011) that involve activated affect (*pleasant activation, activation, unpleasant activation*). The RMV will also, on average, produce a decrease in segments of deactivated affect (*unpleasant deactivation, deactivation, pleasant deactivation*), while on average leading to non-significant changes in pleasant affect (*pleasure, activated pleasure, deactivated pleasure*) and unpleasant affect (*displeasure, activated displeasure, deactivated displeasure*). These predictions are captured by using our circumplex models for mood changes described in previous chapters.

Similar to study 1 (see chapter 2), the results of study 2 also showed that the specific effects on activated affect were clearly present only in a sub-group of those participants who watched the motivational video. We also continue to expect that, as in study 2, there will be some participants who respond to the RMV with increases in pleasurable affect rather than activated affect, and yet others who respond with increases in unpleasant affect. Our fitting of models to individual participants' mood change data was predicted once again to uncover these marked individual differences in mood change profiles across participants, even those in the sample video condition. For the effects of the NCV, we follow the relevant findings in study 2, in that the average results will show that the NVC does not have an effect along the activation-deactivation axis, and that there will be no predominance of positive or negative effects on the pleasure-displeasure axis. In study 2 in chapter 3 there was an indication in the SSMLE analyses that the NCV produced mood changes along the pleasure-displeasure axis in some participants. However, because it induced pleasure (and decreased displeasure) in approximately as many cases as those in which it induced displeasure (and reducec pleasure), there was no predominant effect in the overall group average, making the average inconclusive.

As in the previous chapters, these average-level predictions will be confirmed by a significant interaction between video type and the affect type contrasts calculated under the activation-deactivation circumplex model (model 1), but not when the contrasts are computed using the pleasure-displeasure circumplex model (model 2).

Based on the literature revied above, we hypothesise that frontal alpha activity (frontal alpha asymmetry [FAA] scores) will be related to the activation-deactivation circumplex coefficients, where overall greater relative left frontal activation (LFA) will have a positive relationship with more positive activation circumplex coefficients. We predict that the positive or negative valence of the affect, as reflected in the pleasure-displeasure circumplex coefficients, will not have a significant relationship with the frontal asymmetry values.

Using implications drawn from RST (Pickering et al., 1995; Smillie et al., 2006), as argued above, the personality traits of extraversion and neuroticism are included yet again as potential moderators of changes of affect as a function of video type. As before, the average-level effects of mood change as predicted above are expected to be greater for those who score high on extraversion, and for those that score low on neuroticism. However, personality predictions are made more tentatively in this chapter since the key associations with both extraversion and neuroticism in chapters 2 and 3 were either non-significant or inconclusive. Our predictions are also tentative because we know that the clear induction of activated affect by the motivational video is present in only a minority of subjects who watch them, reducing our power to detect correlations.

Furthermore, research described above in section *4.1.3* leads to the hypothesis that extraversion will have a positive relationship with LFA as a measure of state motivation (e.g., Wacker, 2018), while neuroticism will have a negative relationship with LFA due to its relationship with state avoidance-related right frontal asymmetry (e.g., Uusberg et al., 2015). More specifically, we predict that extraversion and neuroticism, individually, will moderate the change in LFA between pre to post-test for those who watch the motivational video. There are no predictions for baseline LFA, due to insufficient evidence showing a direct relationship between resting-state FAA and trait measures (e.g., Wacker, 2018).

Additionally, after watching the videos, there will be no difference in intrinsic motivation between those who watched the RMV and those who watched the NCV. As in the studies 1 and 2, intrinsic motivation is used as a control measure here, intended to confirm that any mood inducing effects of the RMV (compared with the NCV) is not due to the greater interest levels that the participants have in the content of the motivational videos, but rather is due to the approach towards interpersonal incentives and goals that the motivational videos stress. The RMV and NCV were matched in terms of intrinsic interest in study 2. A measure of competitive drives was adapted an included as a manipulation check (on average) across the video conditions.

4.2 Method

4.2.1 Participants

Eighty-five participants (65 female; age range 18-47 years; M = 21.59 years, SD = 4.97 years; 76 right-handed) were recruited opportunistically at Goldsmiths, University of London. Two participants were subsequently excluded, due to current depressive and anxious illnesses leaving a final N = 83. 66 participants were first year undergraduates recruited via the Goldsmiths Research Participation Scheme and received 15 course credits, which contributed to passing the course. The remaining 17 participants were recruited opportunistically on campus and were given £15 upon completion of the experiment in compensation for their time. Overall, 74 participants were students (28 of whom were also in employment), while the remaining 9 were employed only. The study received ethical approval from the Psychology Department Ethics Committee at Goldsmiths, University of London. In addition, all participants gave separate written consent for the psychometric and EEG portions of the study.

4.2.2 Materials

Each participant completed several psychometric measures (see below). They participated in the EEG recording session, which included watching either the RMV or NCV. Each video condition was randomly allocated.

4.2.2.1 Psychometric Measures

To assess trait extraversion and neuroticism, and affect, several psychometric measures were administered electronically using Qualtrics software.

To measure pre-post differences in mood the affect adjective list from the 12-Point Circumplex Structure of Core Affect (12-PAC; Yik, Russell, and Steiger, 2011) was administered twice, once before and once after watching the video. The 60 adjectives of core affect included in the 12-PAC are divided into 12 segments, each representing a state of emotion. All 60 adjectives were included in the experiment, where participants were required to rate the extent of which they were feeling each item at that moment in time.

The Big Five Aspects Scale (BFAS; DeYoung et al., 2007) was used to measure levels of extraversion and neuroticism.

Additionally, the state motivation items of the Dundee Stress State Questionnaire (DSSQ; Matthews et al., 2002) were adapted and used to test the intrinsic motivation of the participants as a control measure. As in the previous studies, an addition of one item from the success motivation facet of the DSSQ (Matthews et al., 2002) was adapted and included, as it was deemed to be explicitly representing approach motivation (*"the video brought out my competitive drives"*). This was excluded from the sum of the intrinsic motivation scores and was treated as a separate dependent variable in the analysis. Significantly higher competitive drive scores were predicted for the motivational video. As noted previously, this item served as a manipulation check for the motivational video.

4.2.2.2 Video manipulation

Participants were randomly assigned to watch one of the two videos ($N = 41$ watched the RMV, and $N = 42$ the NCV). As in study 2, the RMV was filmed under the direction of the author to recreate the online motivational video *"You Can Do It – One Of The Best Motivational Videos Ever Created For Students, Success And Studying"* created by motivational speaker Tom Bilyeu, and available on the YouTube channel *"Motivation2Study"*. The RMV included a background soundtrack with music that was intended to be as inspirational, which in this case was *"Galaxy Falling"* by Really Slow Motion. The video presented the male speaker talking directly to the camera, displaying perceived eye contact with the viewer, while scenes of people undergoing hard work in various forms flashed up intermittently. The content of the speech expressed the actions needed to be taken (*e.g., hard work, perseverance)* in order to achieve the reward of being successful in the (life) goals of the viewer, while also giving positive feedback about the viewer's limitless potential to achieve these goals.

The matched NCV (also created and directed by the author) included the same speaker, eliminating any individual speaker effects. The NCV was filmed in an "interview" style, with the speaker's eye-gaze averted away from the camera and point of view of the viewer, while recording a short documentary about psychological theories of motivation. However, to ensure that the NCV was indeed controlling for the interpersonal incentive, the personally-directed speech and use of second person pronouns and verb forms (e.g. "you will do this") was absent in the NCV. At the same time, the NCV maintained very similar linguistic context to that used in the motivational videos. This was possible because the lecture about motivation allowed the inclusion of the same verbs associated with taking action and approach behaviours. However, using this linguistic content in an academic context meant that these words were unlikely to induce appetitive motivational behaviour (see chapter 3 for more details on the construction of these two videos).

4.2.3 Procedure

See Figure 4.1 below for a schematic of the overall procedure.

4.2.3.1 Psychometric data collection

Participants were seated in front of a PC in the Goldsmiths EEG lab. The researcher outlined the nature of the study in three parts: the psychometric measures, the EEG data collection, and the video. Participants were told that the study would take between 1.5-2 hours of their time and that they would be reimbursed either financially or with credits (see section 4.2.1 above for details) at the end of the experiment. At this point participants were given the option to withdraw from the study.

Participants first completed the psychometric portion of the study, with the exclusion of the mood measure, which was given after the EEG equipment had been applied on their head. Psychometric measures were presented online using Qualtrics software (www.qualtrics.com). An electronic consent form outlining the nature of the study was also administered through Qualtrics and participants were required to read and complete this to indicate their willingness to participate in the research. Participants were given a second consent form to indicate their willingness to undergo the EEG recording. Participants were initially asked to complete four psychometric measures, tapping aspects extraversion and neuroticism, but also anhedonia and depression, which were used in an MSc research project and are not reported here. Participants were given approximately 20-minutes to complete these questionnaire measures via Qualtrics.

4.2.3.2 EEG recording and pre-processing

Participants were then fitted with the EEG equipment. Continuous EEG data was obtained from 64 active Ag/AgCl electrode channels placed in accordance with the 10-20 system (Jasper, 1958) embedded in an Easycap® (Easy Cap, Munich, Germany) on the participants' scalp. To allow for the removal of eye-movement induced artifacts at analysis, two electrodes were placed on the sub- and supra-orbit of the right eye to monitor vertical eye movements (an electrooculogram, EOG), while an additional two electrodes recorded the horizontal EOG from the external canthi of each eye. Two additional reference electrodes were placed one on the lobe of each ear.

Once the set-up was complete, participants were sat in a shielded booth in low-lit conditions, and then asked to complete the pre-test 12-PAC, again using Qualtrics software. After completion of the pre-test 12-PAC, baseline resting state EEG was recorded. The experiment was run on a Dell PC with a Windows 7 operating system. All data were sampled at 512Hz and were amplified using a BioSemi ActiveTwo® amplifier with a 0.01Hz to 100Hz bandpass filter. EEG recording was continuously monitored by the experimenter throughout the experiment. The participants alternated between sitting with their eyes open for 5 minutes and closed for 5 minutes for a total of 10 minutes (the order in which the participants had their eyes open or closed first was counterbalanced across subjects). Participants were given an audio prompt indicating when they should open / close their eyes. During the eyes open state, participants were asked to look at a fixation point on a screen approximately 80cm in front of them. After the 10-minute baseline recording, participants inserted earphones supplied by the experimenter and watched either the RMV or NCV, depending on their randomly assigned condition. As soon as the video ended, the earphones were removed and post-test resting state EEG was recorded, with the same procedure as the baseline recording. Once the 10-minute post-test recording ended, participants were given the post-test 12-PAC to complete while they were still seated in the testing room, so as to prevent situational variables having a confounding effect (e.g., the possible feeling of relief after leaving the small, dark testing room). After completion of the experiment, participants were debriefed and paid for their time.

Eyes open and eyes closed baseline and post-test EEG data were pre-processed individually using the EEGLAB toolbox (Delorme & Makeig, 2004) on MATLAB version R2019b. An average reference, Cz, was applied. This was chosen as a reference as it does not fall within either hemisphere and it falls outside of the regions of interest for calculating LFA. A high pass filter of 0.5Hz and a low pass filter of 100Hz were applied with a band stop filter at 50Hz to remove power-line noise (Cohen, 2014). Next, channels showing excessive noise or flat-lined channels were interpolated (imputed based on the adjacent channels). Trial rejection was automated using the Harvard Automated Processing Pipeline for EEG (HAPPE; Gerbard-Durnam, Leal, Wilkinson & Levin, 2018) and eye movement artefacts were removed by using ICA automatic component rejection using HAPPE. A final visual inspection of the data was carried out to detect any artifacts that were undetected in previous steps. Data were segmented into two-second epochs, that overlapped by 50% to minimise data loss through ‘windowing’ (i.e., data attenuation) at segment boundaries. Using a Fast Fourier Transform (FFT) with a 100% Hann (also called Hanning) window, the EEG data were converted into power spectral densities (mV2/Hz). The segments for each EEG channel were averaged to produce a single power spectrum estimate per channel. Spectral power pertaining to the alpha frequency band (i.e., 8- 12.75Hz) was then log (ln) transformed.

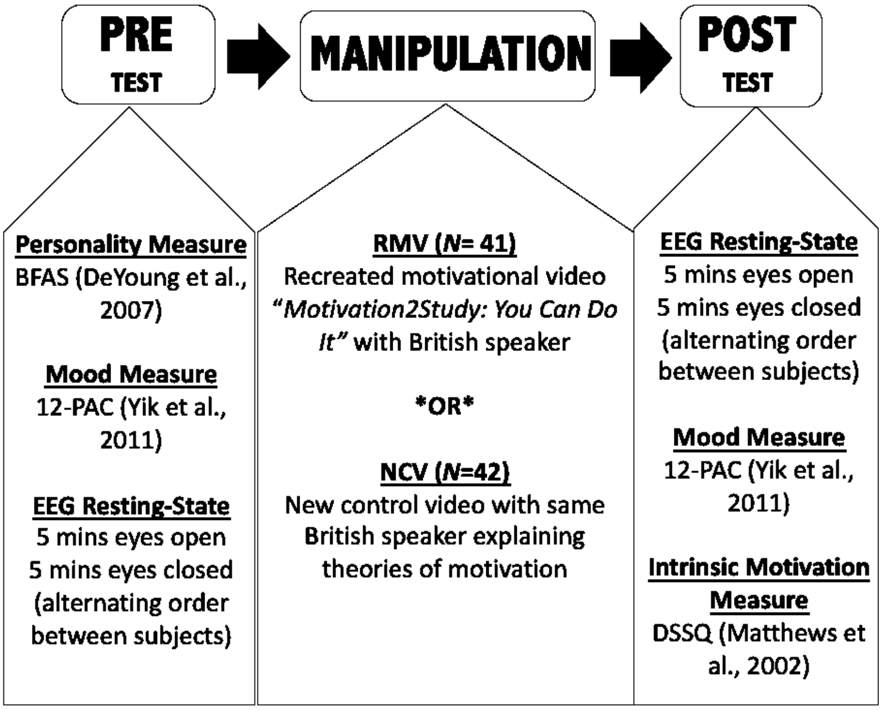


Figure 4.1: A schematic diagram showing the order of the scales and tests before and after the video manipulation. In the pre-, and post-, phases the order of measures was from top (given earlier) to bottom (given later).

4.2.4 Data analyses

Data were analysed using SPSS version 23.0. Additionally, MATLAB version R2019b with the VBA Toolbox (Daunizeau, Adam, & Rigoux, 2014) was used to conduct Bayesian model comparisons, and EEGLAB (Delorme & Makeig, 2004) for FAA.

4.2.4.1 Mood induction effects

The main dependent variables here were the change in affect segment scores, which was calculated by subtracting the pre-test scores from the post-test; therefore, positive scores indicate an increase in the affect levels for that segment. Means for pre-test and post-test affect adjectives were computed for each of the 12 core affect segments (Yik et al., 2011). When the circumplex models were fitted the analysis was carried out at the item level on change scores.

The study attempted to test and compare two specific models, which we will refer to as model 1 and model 2. Model 1 supposes that motivational videos act on affect primarily along the axis running from mood segment XII in the circumplex in Figure 4.2 below (activation; maximum effect; at 0 degrees) through to segment VI (deactivation; minimum effect; at 180 degrees [= π radians]). We were particularly interested to contrast this with model 2, in which the effects of the video act along the axis from segment III (pleasure; maximum effect; at 90 degrees [= π/2 radians]) to segment IX (displeasure; minimum effect; at 270 degrees [= 3*π/2 radians]). If the segments along the x-axis are arranged from left to right in the order I to XII as in Figure 4.2, then the predicted effect sizes of affect changes in the motivational video condition, under the two models, can be easily determined. Specifically, we can write θ_k to represent the angle of each affect segment around the circumplex, where *k* goes from 1 to 12 (the values of these angles in degrees are given in Figure 2.1 in chapter 2). The expected mood segment change, E_{1k}, of any manipulation acting according to model 1 on mood segment *k*, is given by:

$$E_{1k} = a_1 + b_1 * \cos(\theta_k) \qquad (4.7)$$

where b_1 is an amplitude scaling constant for the circumplex effect under model 1, and a_1 is an intercept term reflecting a constant change in mood irrespective of the affect segment concerned. Similarly, the analogous effect under model 2 is given by:

$$E_{2k} = a_2 + b_2 * \cos(\theta_k - \pi/2) \qquad (4.8)$$

A graphical representation of the model effects is shown in Figure 4.2 with $a_1 = a_2 = 0$; $b_1 = b_2 = 1$ and the affect segments numbered 1-12 (following the numbering in the circumplex figures in chapter 2).

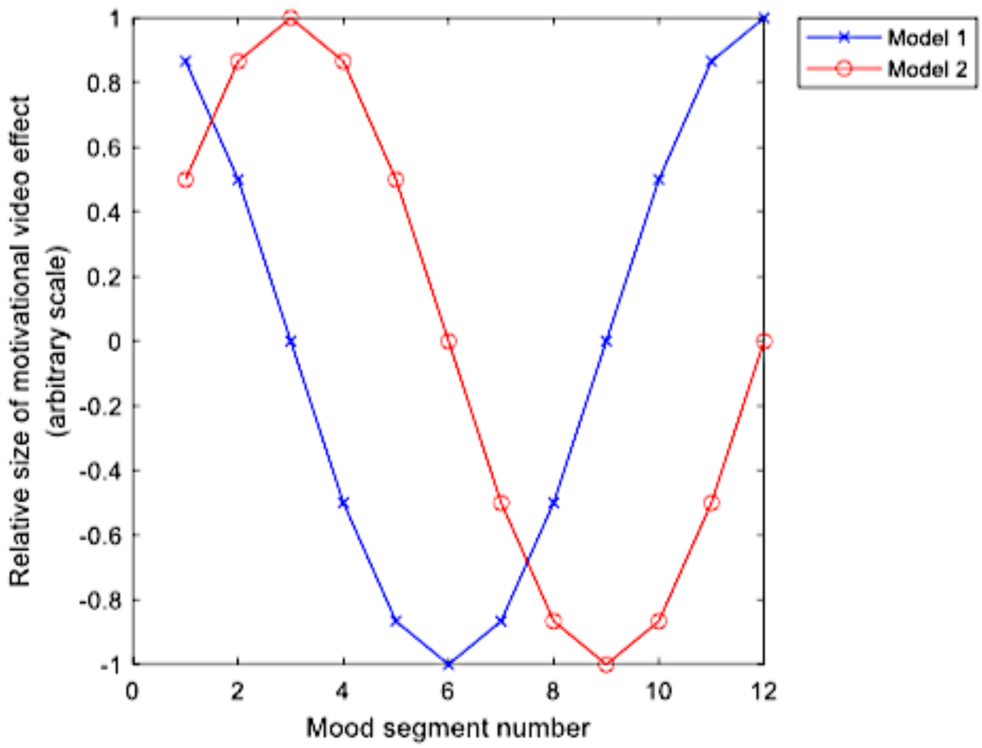


Figure 4.2: Predicted affect change effects under model 1 and model 2 as a function of mood segment around a circumplex.

To test these models, we used the same analytic approach that we have used in the previous two chapters. We repeat the analysis details briefly here for convenience. We created repeated measures trend contrasts across the repeated-measures affect segments reflecting the above circumplex models. The values plotted in Figure 4.2 are the basis for these contrast coefficients. The values in Figure 4.2 sum to zero across each model already, and the values for each model are orthogonal to one another over model segments. The latter is true because the two model plots are phase-shifted by $\pi/2$ radians (90 degrees) with respect to each other, meaning that the effect measured by one contrast is orthogonal to (i.e., is uncorrelated with) the other effect. However, we also normalized the values from Figure 4.2 (by dividing each value by 2.4495, the L2 norm of the 12-element vectors formed from the values in Figure 4.2); it is conventional that sets of contrasts used in an ANOVA are orthonormal.

The contrast analyses just described use so-called fixed effects techniques: the mean contrast value estimated across all the participants is tested (to see if it is significantly different from 0). The effect is fixed for all cases and the error term used reflects the variation across participants including random error. For details of the statistical adjustments for multiple comparisons see earlier chapter (*section 2.2.5.2* and *section 3.2.3.1*).

To refine the model comparisons still further, variational inference Bayesian model comparison techniques with single subject maximum likelihood estimation (SSMLE) modelling, based on an extension of the mood circumplex models noted above, were implemented in a MATLAB script that was able to utilise routines from the VBA toolbox (Daunizeau et al., 2014).

To do this modelling, we continue to denote that there are k = 1:12 mood segments (approx. 5 items for each segment) theoretically arranged at evenly-spaced angles ($\frac{\pi}{6} \leq \theta_k \leq 2 * \pi$) around the circumplex (now using radians rather than degrees; see Figure 4.2 above). We are interested in which of two random effects models fit our data the best. These models can be represented in a general form using Equation 4.3 below:

$$\Delta mood_{ik} = a_i + b_i * \cos(\theta_k + \varphi) \quad (4.9)$$[11]

where i denotes the ith case and k denotes any of the individual mood items relating to the kth segment. The activation-deactivation model (model 1) proposes that the maximum (minimum) mood changes will occur at k = 1; $\theta_k = 0$ (k = 6; $\theta_k = \pi$). This can be represented by setting the phase term, φ, in equation 3, to 0. The pleasure-displeasure model (model 2) is phase shifted by $\frac{\pi}{2}$ and thus is captured by equation 3 with $\varphi = -\frac{\pi}{2}$. The pleasure-displeasure model therefore has a maximum (minimum) mood change at k=3 (k=9). For both models 1 and 2, the maximum and minimum points can be swapped over to reflect deactivation-activation or displeasure-pleasure models respectively (where the first named mood segment is that with the maximal value under the model fit, and the second named segment is that with the minimal value). These "swapped models" simply differ in the sign of the coefficient b_i.

[11] The cosine values were L2 normalised before the use in this equation, matching the fixed effects contrast analyses above.

For comparison with models 1 and 2, we also consider an intercept-only model (model 0) in which $b_i = 0$ for all participants (see Appendix C for all comparisons made with the intercept model and related analyses).

As noted, these models were fit at the level of each individual participant, estimating the values of a_i and (for models 1 and 2) b_i for each participant (where different cases are denoted by the subscript i). This is possible because there are several different mood adjectives used to estimate the mood change for each of the k mood segments. Bayesian model selection (Rigoux et al., 2014; Stephan et al., 2009) is used to estimate which model, from a group of models being compared, fits best across the sample and it also provides information for each case about which model best fits their individual performance.

Furthermore, we will conduct equivalence tests to test the null hypothesis that the true effect is at least as extreme as the smallest effect size of interest, using the two one-sided (TOST) procedure (Lakens et al., 2018) from the TOSTER module in *jamovi* software (version 1.6.21). We propose conducting an equivalence test of the model 1 fixed-effects circumplex contrast in the control condition alone, as well as the model 1 circumplex contrast obtained using the SSMLE estimation. This test assesses whether the mean contrast value is relatively close to zero (i.e., lies between two specified bounds either side of zero) in this condition. Equivalence tests were also conducted for the model 2 contrasts on the control video.

4.2.4.2 General Estimating Equations (GEE)

Following the approach taken in chapters 2 and 3 in the previous motivational video studies we will also use the so-called "marginal model" for our key regressions, and that model (as opposed to a fixed-effects or SSMLE modelling) can be estimated using general estimating equations (GEE; first described by Zeger & Yiang, 1986). We used the GEE module in SPSS. To recap the GEE analysis approach: the DV is the mood change score from pre to post video exposure, for which we have 60 responses for each participant. All participants are analysed together, and each participant thus has 60 lines of data (one mood change score for each item on the PAC). Each of these mood change responses is coded as being made to one of the 12 specific mood segments on the circumplex. We also generated a model 1 and model 2 circumplex predictor of the mood change using the equations 4.1 to 4.3 above. For each model, these circumplex predictors thus have 12 specific values depending on the mood segment, and the predictor values are the same for each case. Using model 1 and model 2 in separate analyses, we used these 12 circumplex predictor values in a linear model predicting the mood change observed for those item segments. The model circumplex predictor value is thus used as a repeated-measures predictor of mood change. Our prediction model also uses the between-subjects predictors of video condition (categorical predictor) and personality trait or EEG values (as a covariate predictor). Separate analyses are carried out with extraversion, neuroticism, and LFA scores as predictors in this chapter.

We predict an interaction between the video condition and circumplex predictors in that we expect the RMV condition on average to produce mood changes (c.f. the NCV condition), along the activation-deactivation axis, as reflected by the model 1 circumplex values for each mood segment. Hypothesis 1A[12] states that we do not expect the NCV on average to induce mood changes in this way, thereby leading to an interaction. Subsequent analyses, in each video condition separately, will confirm whether the predicted specific pattern of interaction was obtained.

It is also proposed (hypothesis 2A) that the mood change induced by the RMV will be along the pleasure-displeasure (model 2) axis of the mood circumplex and argues that this effect will be greater for the motivational video than the control video. Thus, a video by circumplex predictor values interaction is predicted. Once again, based on the findings of Smillie et al. (2012), and the results from study 1 and 2 (see chapters 2 and 3), we do not expect that these hypothesis 2A predictions will be supported.

Moving on to consider the personality and alpha asymmetry related hypotheses, we can include the scores on extraversion, neuroticism, or LFA as an additional predictor in the GEE analyses. The simplest way to do this is to include the trait score and LFA score as an additional predictor in the analyses carried out in each of the video conditions separately. We include a main effect of extraversion, neuroticism, or LFA and an interaction between extraversion, neuroticism, LFA, and the model 1 (or model 2) circumplex predictor values. If the personality or LFA by circumplex predictor interaction is significant in the motivational video condition it indicates

[12] The number "1" or "2" in the hypothesis label denotes that it is based on either model 1 or model 2, respectively. Hypothesis labels that include the letter "A" are hypotheses without personality moderation effects, and those with the letter "B" are hypotheses that include personality moderation effects.

that extraversion, neuroticism, or LFA moderates the relationship between the model 1 circumplex values and the mood changes in the motivational video condition. The hypothesis leads us to not expect the same personality by circumplex interaction in the control video condition. If there is a significant personality by circumplex interaction in the motivational video condition, but not in the control video condition, then we can test whether there is a significant three-way interaction between video condition, circumplex predictor and personality or LFA in a final analysis combining data from both video conditions.

We have three key statistical tests in the family using GEE: the test of the interaction between the appropriate (model 1 or model 2) circumplex predictor and video condition; the test of the circumplex predictor in the RMV condition; and the test of the circumplex predictor in the NCV condition. The familywise adjustment for multiple comparisons for the three tests for each of the two models is, therefore, achieved by using an adjusted $\alpha = \frac{.05}{6} = .008$.

When using GEE to test the personality and LFA related hypotheses we have a family of three statistical tests for each personality trait or LFA score, repeated for each of the 2 models: a test of the interaction between the trait or LFA score and the circumplex predictor in each video condition separately, plus a test of the three-way interaction between the trait or LFA score, the circumplex predictor, and video condition. Thus, we have a family of six tests and use an adjusted Type 1 error rate of $\alpha = \frac{.05}{6} = .008$.

GEE analyses require a choice of a working correlation matrix (WCM) which captures the relationships between each item analysed and every other item. We adopt the AR-1 WCM as in previous chapters. However, we will routinely check other WCM choices to see whether the results are similar to those obtained with the AR-1 WCM.

4.2.4.3 Psychometric measures

The extraversion and neuroticism scores from the BFAS (DeYoung et al., 2007), and the intrinsic motivation scores from the DSSQ (Matthews et al., 2002) were calculated. We correlated these personality scores with the key DVs in each video condition separately. In particular, we were interested in whether the specific patterns of the mood change after watching a video, reflected in the model-based contrast analyses described above, were associated with these traits.

4.2.4.4 Left frontal activation

Left frontal activation (LFA) was calculated in the same manner as previous studies (e.g., Pizzagalli, Sherwood, Henriques & Davidson, 2005; Boksem, Smolders & De Cremer, 2012). Alpha power indices were extracted for each electrode channel, as described above in *section 4.2.3.2*. In line with previous research, (e.g., Van Der Vinne et al., 2017; Wacker, 2018) we focused on 2 electrodes to calculate frontal (F3, F4) asymmetry values. As noted, all values were log-transformed to correct for positive skew. For each recording phase, asymmetry values were computed as the difference of ln-transformed alpha power at all right and left homologous sites, whereas our hypotheses were focused on the midfrontal F4 and F3 sites, for which frontal alpha asymmetry (FAA) effects are typically reported (i.e., FAA = ln[alpha power@F4] - ln[alpha power@F3]). Figure 4.3 illustrates the electrodes selected for analysis. As alpha power is inversely related to cortical activity (Laufs et al., 2003), greater alpha power in one hemisphere (as compared to the other) indicates lower tonic cortical activity in that hemisphere. The result of the FAA calculation will then be referred to as relative left or relative right frontal activity, depending on whether the numeric value result is more positive or more negative, respectively (Allen & Cohen, 2010).

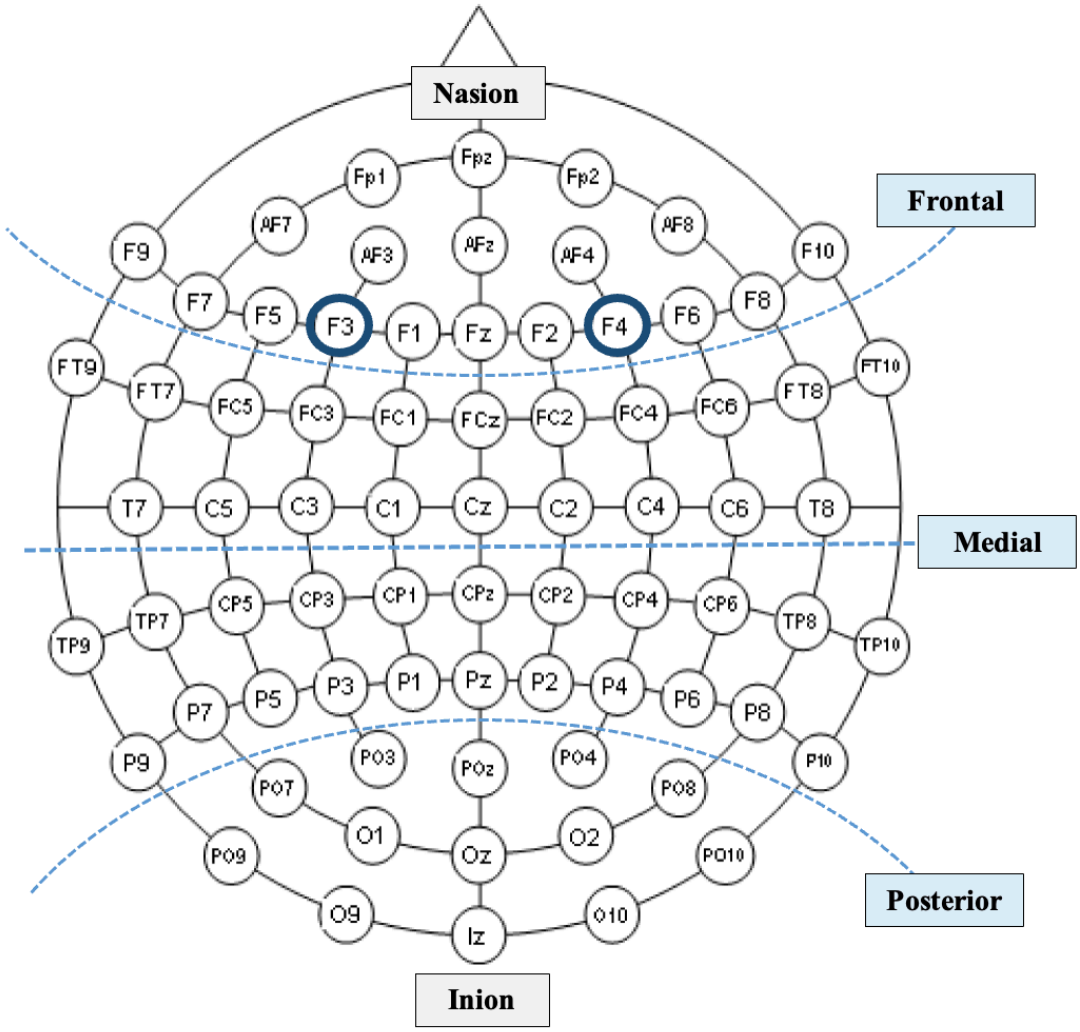


Figure 4.3: Topographical map of the electrode placements. Electrodes of interest are circled in bold on both hemispheres.

Separate asymmetry scores were obtained for the eyes open and eyes closed conditions and a 2 x 2 repeated measures ANOVA was carried out to check for main effects of eye condition, taking eye condition (open, closed) and time of recording (pre-, post-test) as the factors. No significant main effect of eye condition was observed [$F(1, 80) = 2.44$, $p = .122$], suggesting that results were similar across both conditions. Thus, both conditions were combined for each participant to provide a more robust estimate of asymmetry. Cronbach's alpha for the frontal asymmetry measures was high $\alpha = .82$, suggesting that the pairs of homologous sites at the frontal region were providing consistent estimates of alpha power.

4.3 Results

As noted above, the mood dependent variables were calculated as difference scores of all mood segments (or items) by subtracting the pre-test mood scores from the post-test. The trait measures, extraversion and neuroticism, and LFA scores were standardized to z-scores.

4.3.1 Mood induction video effects: Fixed-effects Contrast Analysis

Mixed 12x2 ANOVA were conducted on the pre-post changes in affect ratings and specific circumplex contrast coefficients were used to capture the fixed effects under models 1 and 2. The effects of the RMV were compared to the NCV. The mean mood change scores for each mood segment are shown, separated by video condition, in Figure 4.4. Any missing data from the individual adjectives were imputed as averages within the affect segments. Following the logic outlined earlier, to deal with multiple testing, we adjusted the per comparison Type 1 error rate for each family of statistical tests that tested a specific scientific hypothesis. We used a Bonferroni adjustment to preserve the familywise Type 1 error rate for each family of tests. Each time we note that a result (in a test family) is significant, below we put the uncorrected significance level and the adjusted level against which its significance should be judged.

The model 1 contrast across affect segments, overall, was significant [$F(1,82) = 9.699$, $p = .003$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .106$]. The interaction between the model 1 contrast across affect segments and video type was also significant [$F(1,82) = 11.723$, $p = .001$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .125$]. However, the model 2 contrast across affect segments, overall, was non-significant [$F(1,82) = 1.397$, $p = .241$]. The interaction between the model 2 contrast across affect segments and video type was also non-significant [$F(1,82) = 3.084$, $p = .083$].

In contrast to the results of previous studies in this thesis, the data in Figure 4.4 reveal that, on average, it was the NCV that produced the mood changes in this study. Furthermore, the NCV acted on mood primarily along the model 1 axis from point XII in Figure 4.2 (activation; maximum effect; at 0 degrees) through point VI in Figure 4.2 (deactivation; minimum effect; at 180 degrees), as opposed to the orthogonal pattern predicted by model 2. The Model 1 mood changes in Figure 4.4 is a reversed shape to that of Figure 4.2 (expected under model 1, the activation-deactivation circumplex model). This means that the maximum mood changes under the model are actually found for deactivation and the minimum (or negative) changes are found for activation, and so the model 1 circumplex coefficient will be negative. To see this clearly one can compare the data in Figure 4.4 with models 1 and 2 in Figure 4.2. On average, the effect of the RMV on mood ratings pre to post was much less marked, and by inspection did not seem to follow the patterns of either model 1 or model 2 (as depicted in Figure 4.2).

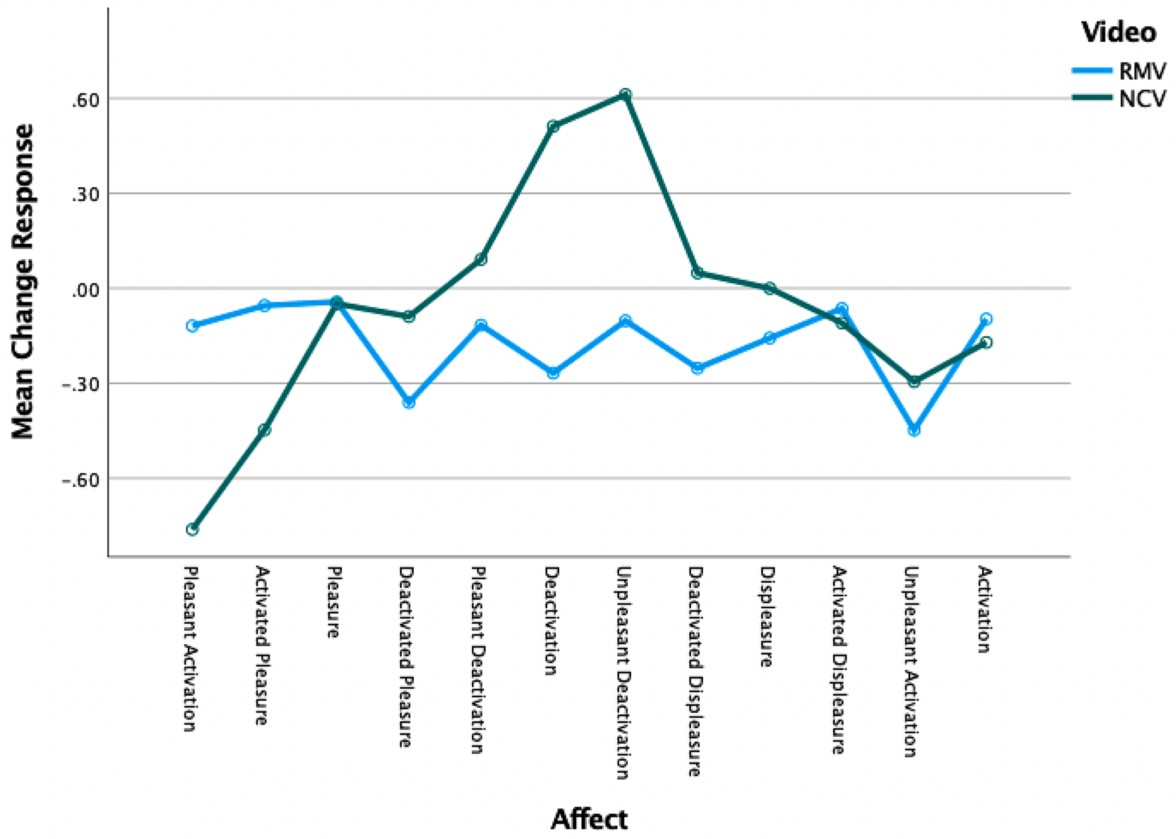


Figure 4.4: The mean change in affect across the two video groups, based on the order of affect in the circumplex. This plot is to be compared against the theoretical plots under model 1 and 2, as depicted above in Figure 4.2.

To explore these results further, we conducted a one-way ANOVA for each video type separately by using the repeated measures contrasts for model 1. This showed that the model 1 contrast was not significantly different from zero for the RMV group [$F(1,42) = .045, p = .834$], but was significantly different from zero for the NCV group [$F(1,40) = 23.298, p < .001$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .368$]. The equivalence test for the NCV condition effects (see section 4.2.4.1) is void here as we cannot reject the null hypothesis due to the significant effect.

When conducting a one-way ANOVA for each video type by using the repeated measures contrasts for model 2, we found that the model 2 contrast was not significant for the RMV group [$F(1,42) = .156$, $p = .695$], and neither was the model 2 contrast significant in the NCV group [$F(1,40) = 4.629$, $p = .038$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .104$]. Regarding the equivalence test here, Lakens et al. (2018) recommend setting the equivalence bounds to an effect size that the study would have had reasonable power to detect for the sample size concerned. In the NCV of the current study the sample size was 42. Using an adjusted type 1 error rate of $\alpha = .008$, a two-tailed one-sample t-test would require an effect size of Cohen's $d = .5$ in order to have 80% power. Therefore, we used bounds of [-.5, .5] for the equivalence test. The equivalence test, here, shows that the data does not fully support equivalence in the NCV group for the model 2 circumplex contrast ($M = -.39$, $SD = 1.16$), in that the small effect does not lie between the TOST upper bound (0.5) [$t(40) = -5.35$, $p < .001$] and the TOST lower bound (-.5), [$t(40) = 1.05$, $p = .150$] due to the non-significant p value of the lower bound.

4.3.2 Mood induction video effects: SSMLE fitting and Bayesian Model Selection

As with the fixed effects analyses the key test of both hypothesis 1A and 2A are whether the relevant contrast, i.e., the circumplex coefficient estimated by SSMLE modelling (coefficient b_i; see Equation 3), differed between the two video conditions. To give the clearest overall picture of the SSMLE fitting results we decided to present the findings for each condition separately first. In each video condition, the SSMLE analyses below were based on slightly smaller numbers of participants than the fixed effects analyses above. In order to get reliable estimates of the circumplex coefficients for each participant, we needed as many observations as possible at each mood segment. Therefore, we used a conservative criterion by which cases were retained only when they had fewer than 4 missing adjective responses for any segment.

We first analyse the RMV condition (referred to as “new motvid” in the graphs below), for which the sample, after applying the above conservative criterion was 41 cases. The mean number of mood items (adjectives) out of 60 used per case for these 41 cases in the motivational video condition was 59.3.

In the RMV condition, the overall data and model fits averaged across participants are as shown in Figure 4.5 below:

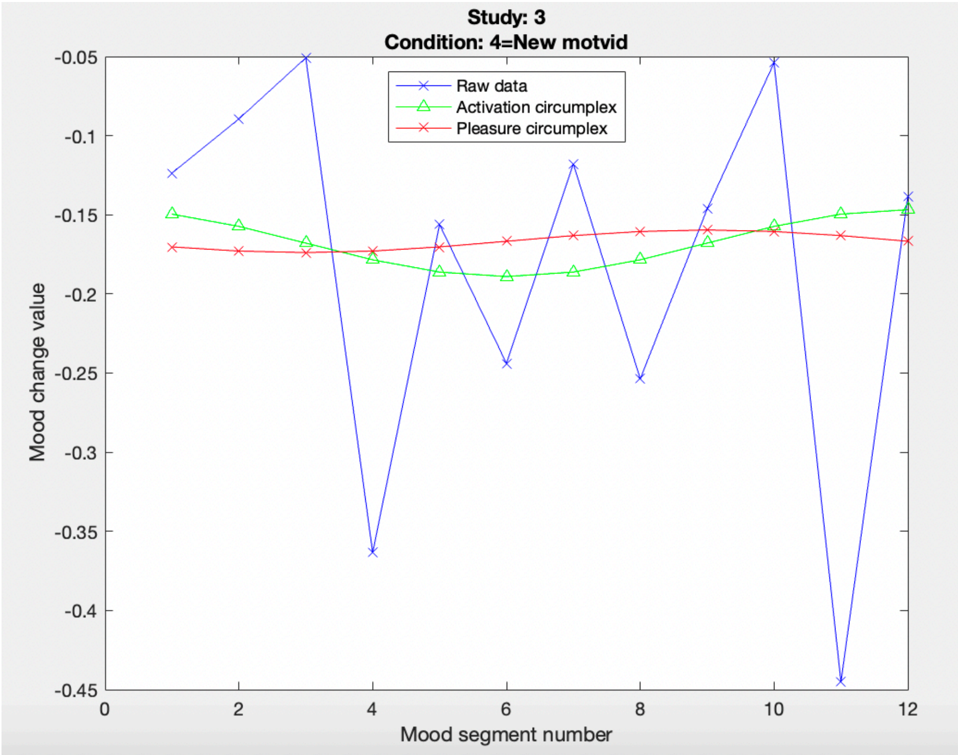


Figure 4.5: Data and best-fitting models averaged across all participants in the RMV condition (N=41).

In Figure 4.5 it is clear that there is not a particularly close resemblance between the average data across all participants, and the average of the best fits, for individual subjects, under model 1 (the activation-deactivation circumplex model), neither the averaged best fits of model 2 (the pleasure-displeasure circumplex model) associated with *b* coefficient values (in equation 4.1).

We confirmed the fixed effects results by testing whether the coefficients (a_i and b_i; see Equation 4.3) differed from zero across participants in the RMV condition alone. For the activation-deactivation model (model 1) we found that the mean intercept coefficient ($\bar{a}$) was -.168, with 95% CIs = [-.235, -.100]; t =-5.019 df= 40, p=.000012. The mean circumplex coefficient ($\bar{b}$) was .116, and was not significantly different from zero, with 95% CIs = [-.894, 1.126]; t=.233 df= 40, p=.817. We repeated this for the pleasure-displeasure model (model 2) and found that the mean intercept coefficient ($\bar{a}$) was -.167, with 95% CIs = [-.237, -.096]; t =-4.79 df= 40, p=.000023. The mean circumplex coefficient ($\bar{b}$) was -.034, not significantly different from zero, with 95% CIs = [-.939, .972]; t =-.76, df= 40, p=.94. These analyses confirm that neither the activation-deactivation model nor the pleasure-displeasure model generated circumplex coefficient values which differ significantly from zero across the whole sample who viewed the RMV.

However, these analyses and graphs as in the previous chapters conceal a wide range of individual variation in model fits within this sample. This observed variation (see below) justified our choice to use the SSMLE approach to fitting. The log of the Bayes factor for model 1 relative to model 2 would is denoted by $\log(BF_{12})$, with a value of +2.3 or above is taken as strong evidence in favour of model 1 over model 2 (Jeffreys, 1961)[13]. A value of -2.3 or below is taken as strong evidence in favour of model 2 over model 1.

Within the data from the RMV condition of this study, we found several individuals with a $\log(BF_{12})$ well above +2.3 (favouring model 1 strongly), as well as a number of individuals whose $\log(BF_{12})$ was well below -2.3 (strong evidence in favour of model 2). Figures 4.6 through to 4.8 show some examples.

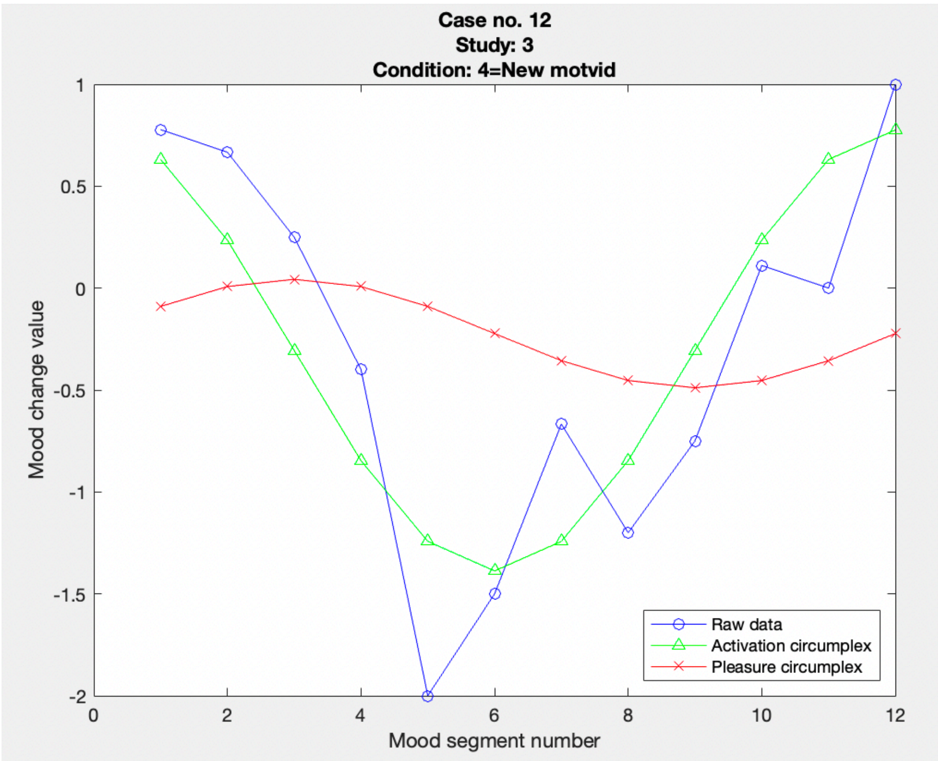


Figure 4.6: A participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex); $\log(BF_{12})$= 16.4 in the RMV condition.

[13] Note that a log(BF) of +2.3 corresponds to a BF value of 10.

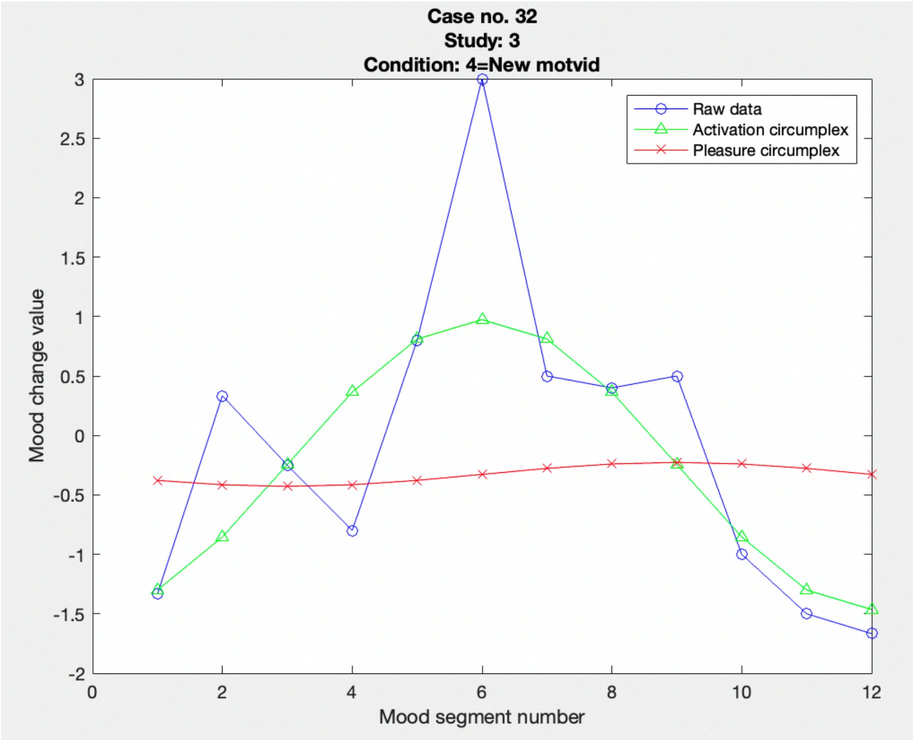


Figure 4.7: A participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex, but in an inverse direction (deactivation-activation); $\log(\underline{BF_{12}})$= 10.2 in the RMV condition.

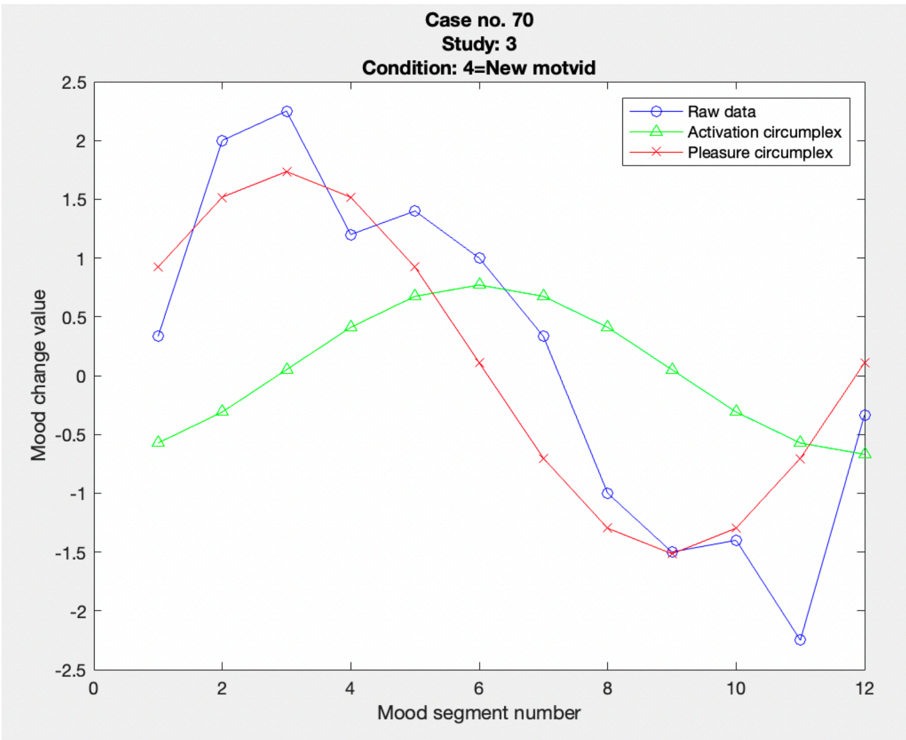


Figure 4.8: A participant whose mood change scores were well fit by model 2 (pleasure-displeasure circumplex) relative to model 1 (activation-deactivation circumplex); $\log(BF_{12})$= -17.0 in the RMV condition.

The $\log(BF_{12})$ values for each participant showed wide variation as seen in Figure 4.9 below, but were not skewed enough in favour of the activation-deactivation model as the mean $\log(BF_{12})$ was not significantly above zero. However, there were strong relative fits for model 1 in 14/41 cases and in 8/41 cases for model 2 at an individual subject level.

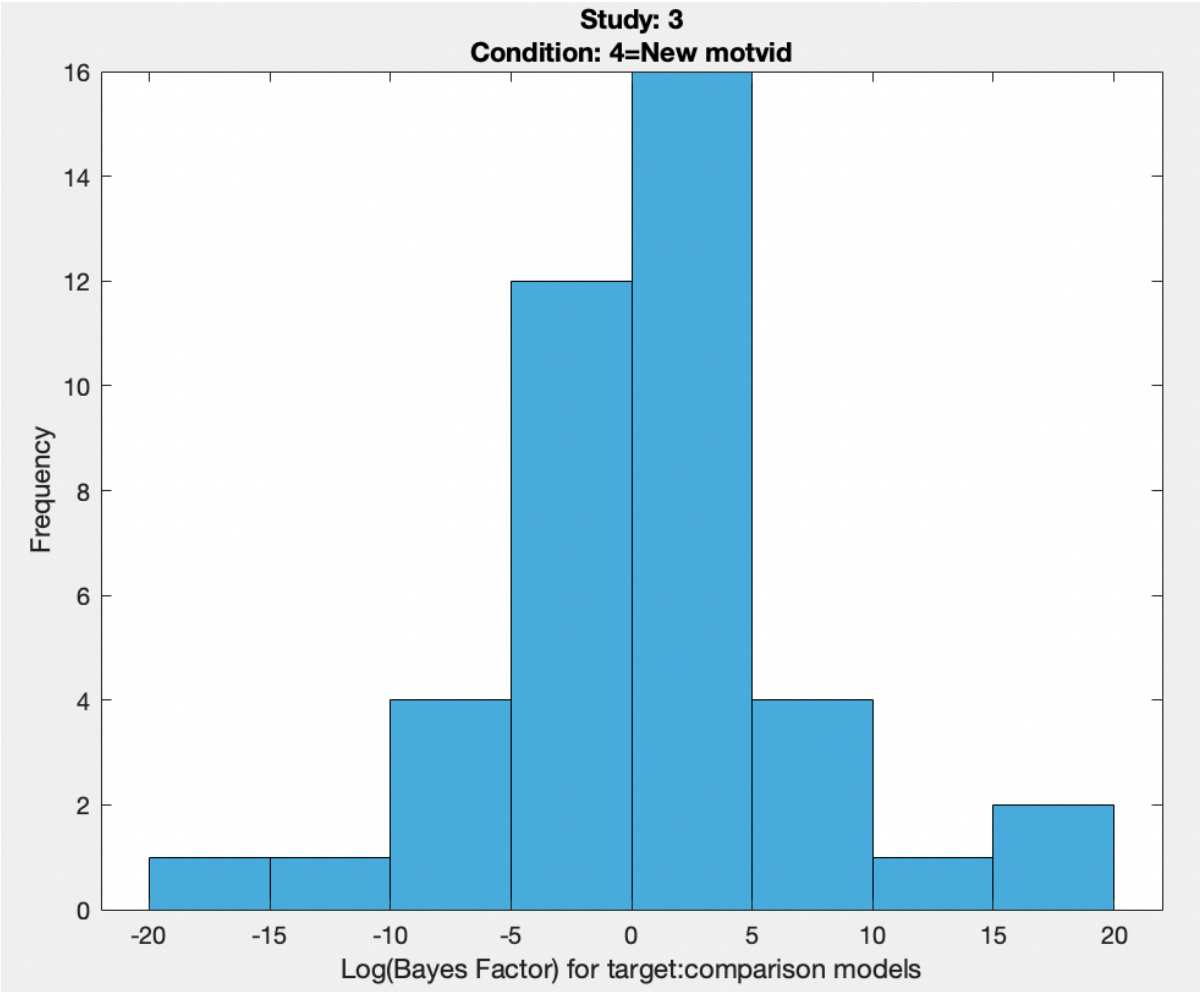


Figure 4.9: Histogram of $\log(BF_{12})$ values in the RMV condition. These values compare the strength of evidence for model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex). A $\log(BF_{12})$ value of 0 provides evidence that favours neither model; more positive log (BF_{12}) values favour model 1 and more negative $\log(BF_{12})$ values favour model 2. $\text{Log}(BF_{12})$ values above +2.3 and below -2.3 are taken as strong evidence in favour of model 1 and model 2 respectively. For the whole sample the mean $\log(BF_{12}) = .828$.

The final output from the VBA toolbox routines is shown in Figure 4.10 below.

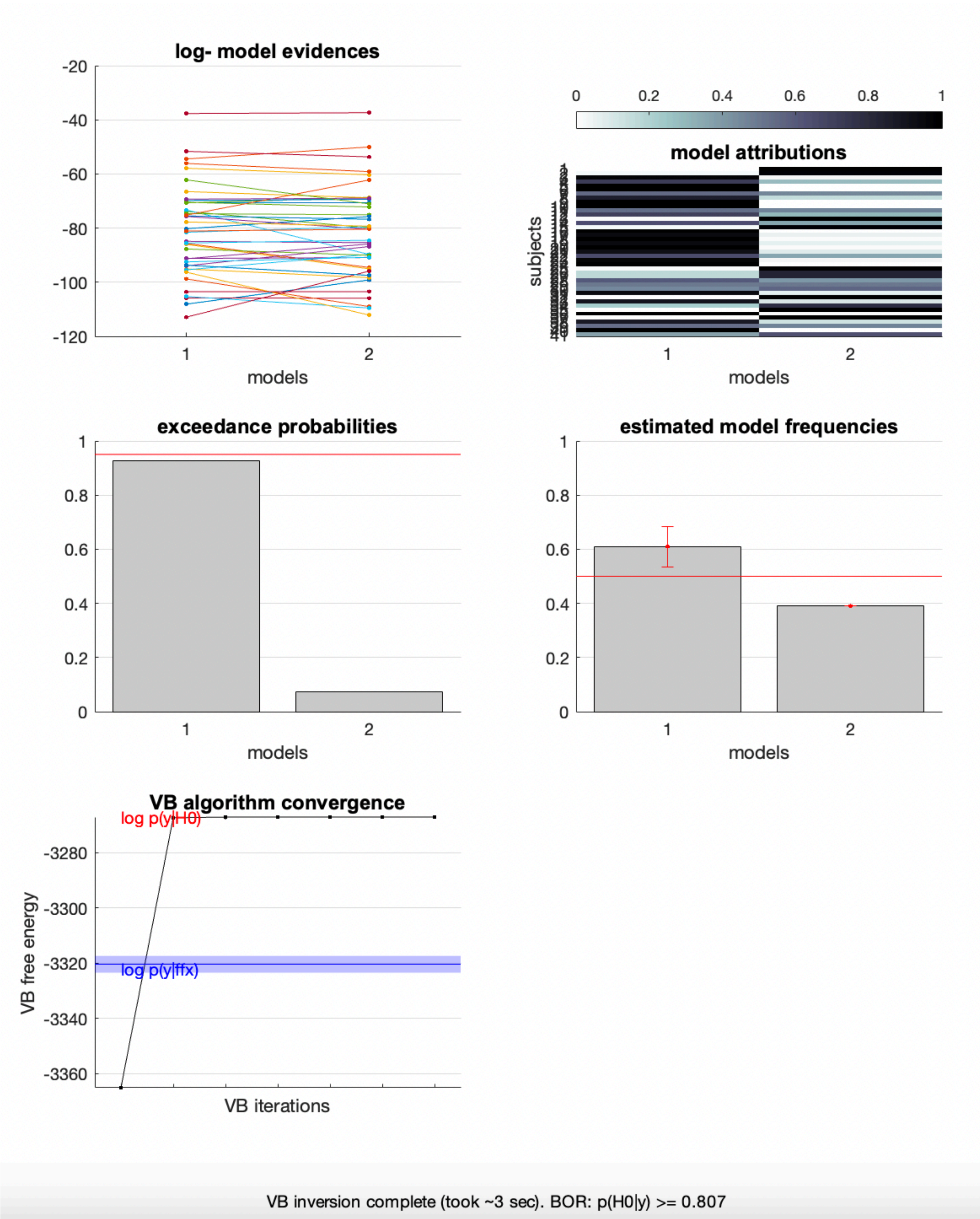
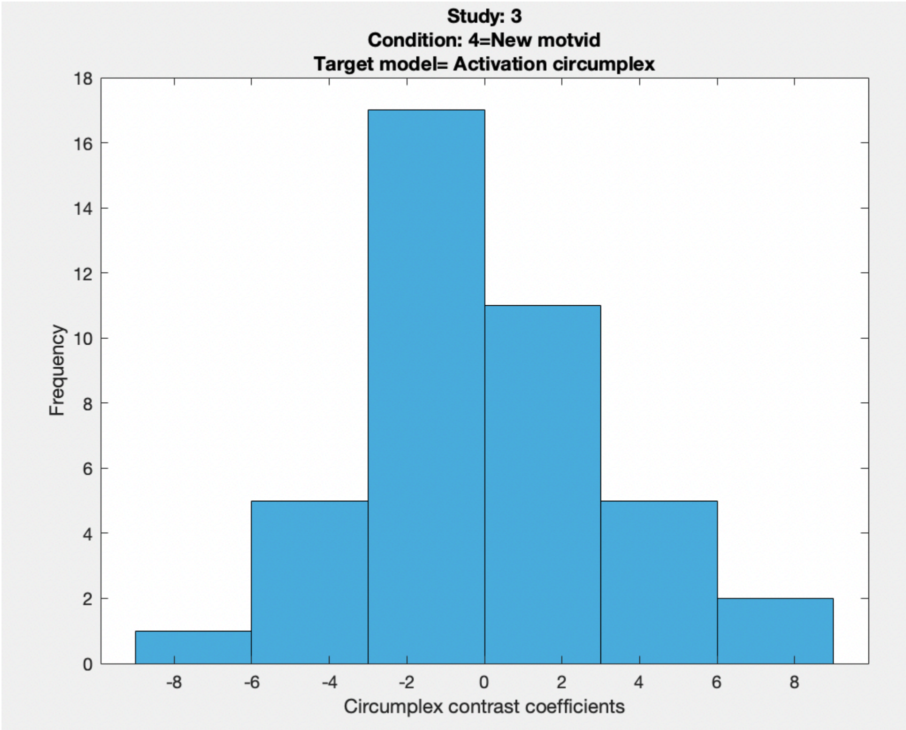


Figure 4.10: The main output window from the VBA toolbox for the RMV condition.

The key results shown in Figure 4.10 offer confirmation that model 1 is slightly more frequently the better account of the data relative to model 2. The exceedance probability (EP) of model 1 over model 2 is .93, but the protected exceedance probability (PEP) allows for the possibility that the EP is due to chance; the PEP was 0.58, and the expected frequency of model 1 was .61. These summary statistics show that the advantage of model 1 over model 2, across the whole sample, is very small indeed. In keeping with this outcome, the Bayesian Omnibus Risk (BOR) is ≥ .81 (the BOR is the posterior probability that the frequencies of the two models are equal across this whole dataset).

There is little evidence in the RMV condition, based on our BMS applied to the SSMLE fitting results, that the activation circumplex is most frequently the better fitting model. When we draw histograms (Figure 4.11) for the circumplex model coefficients (b_i), we can see that there is a wide range of coefficients under either model, and that the average is not different from zero for either model, although there was a tendency towards negative coefficients for model 2. As in earlier chapters, there is a mismatch between the average results and the range of individual performance demonstrated. This is the same as in other chapters but here, for the RMV condition, the average effect under either model is small (where it was large and significant under model 1 in chapters 2 and 3). This also means that the averaged group results are, therefore, somewhat misleading as to the effects of the mood manipulations on individual participants.



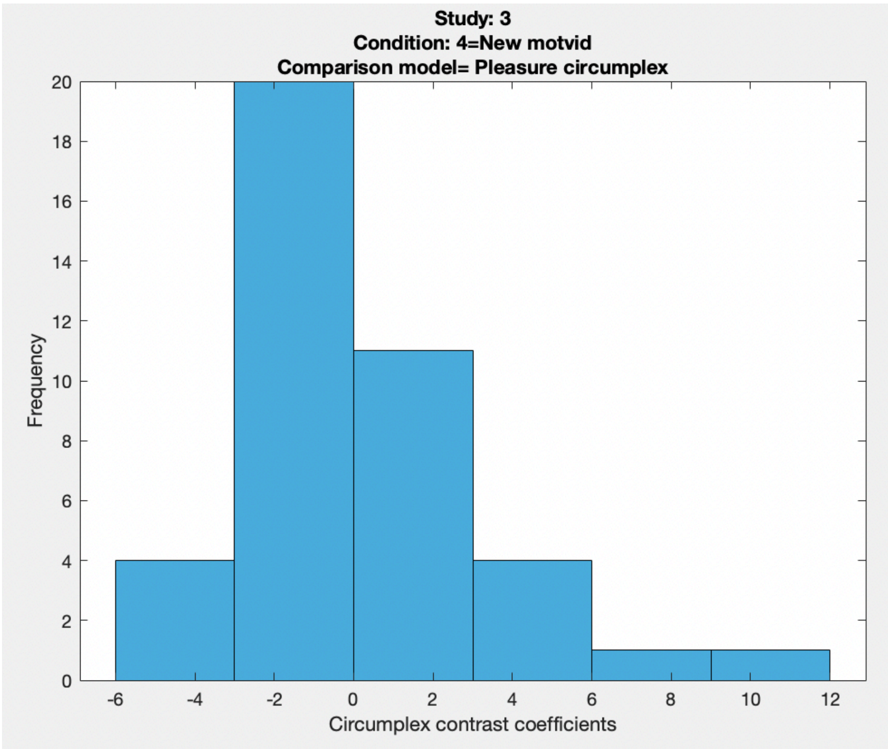


Figure 4.11: The frequencies of best-fitting coefficients (denoted by b_i in Equation 3) for the circumplex models across participants in the RMV condition. The upper panel is for the activation-deactivation circumplex model (M = .116, SD =3.20); the lower panel is for the pleasure-displeasure circumplex model (M = -0.034, SD = 2.87).

In the NCV condition, we again applied the same conservative criteria relating to missing data. This resulted in the elimination of a number of participants from the original number of cases; the final sample here was *N*=40. The mean number of mood items (adjectives) out of 60 used per case control condition was 59.4. The overall data and model fits averaged across participants are as shown in Figure 4.12 below:

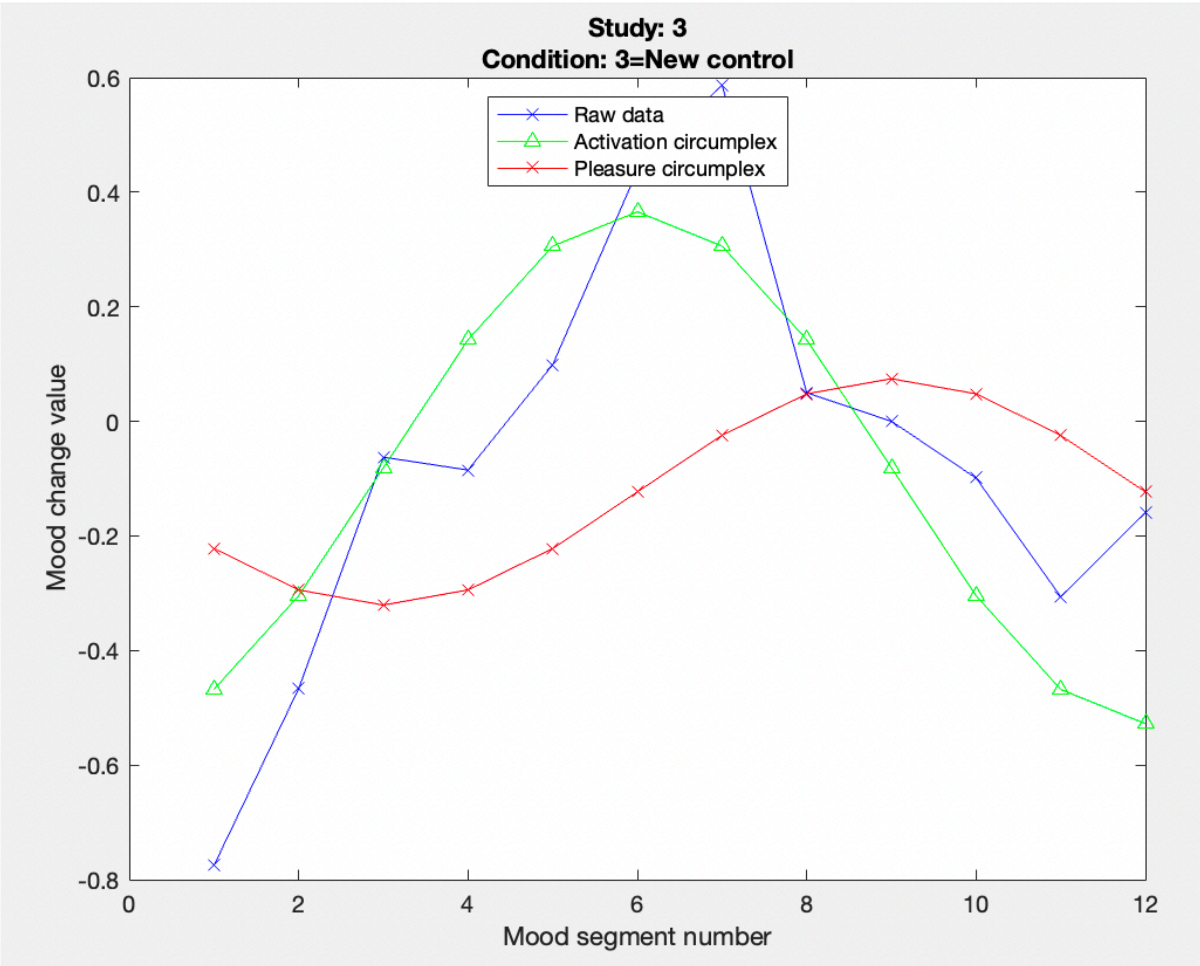


Figure 4.12: Data and best-fitting models averaged across all participants in the NCV condition (N=40). Note that the best fitting models under either model have negative coefficients.

In Figure 4.12 it is clear that there is a fairly close resemblance between the average data across all participants, and the average of the best fits for individual subjects using model 1 (the activation-deactivation circumplex model with negative coefficients). The averaged best fits under model 2 (the pleasure-displeasure circumplex model) do not resemble the averaged data at all well.

First, before exploring the data from the NCV condition alone, we are now at the point where we can compare the circumplex coefficients (under both model 1 or model 2) across the two video conditions. These comparisons between motivational versus control video conditions were carried out using between-subjects t-tests on the circumplex coefficient values for each participant estimated under model 1 and model 2. The results are very clear-cut and reproduce the results found using the fixed effects contrast analyses reported above.

For model 1, there was a large and significant difference between the circumplex coefficients (b_1 see Equation 3) across the two video conditions (RMV: *M* = .116, *SD* = 3.20; NCV: *M* = -2.38, *SD* = 3.00), judged against our adjusted Type 1 error rate of α = .008, [$t(79) = 3.625$, $p = .001$]. For model 2, there was no significant difference between the circumplex coefficients across the two video conditions (RMV: *M* = -.034, *SD* = 2.87; NCV: *M* = -1.09, *SD* = 2.85) [$t(79) = 1.667$, $p = .099$] (and this would have been non-significant even if we had not applied our Type 1 error rate adjustment).

Next, we analyse the NCV data alone. We confirmed the fixed effects results by testing whether the coefficients (a_i and b_i; Equation 3) differed from zero across participants in the NCV condition. For the activation-deactivation model (model 1) we found that the mean intercept coefficient ($\bar{a}$) was -.081, with 95% CIs = [-.162, .000]; t =-2.01 *df*= 39, *p*=.051. The mean circumplex coefficient ($\bar{b}$) was -2.385, with 95% CIs = [-3.345, -1.424]; t=-5.022 *df*= 39, *p*=.000012, significantly different from zero. We repeated this for the pleasure-displeasure model (model 2) and found that the mean intercept coefficient ($\bar{a}$) was -.123, with 95% CIs = [-.207, -.040]; t =-2.959 *df*= 39, *p*=.0052. The mean circumplex coefficient ($\bar{b}$) was -1.094, with 95% CIs = [-2.007, -0.182]; t =-2.43, *df*= 39, *p*= .020 (c.f. adjusted α = .008). These analyses confirm that only the activation-deactivation model has circumplex coefficient values which differ significantly from zero (in fact they were negative) across the whole sample who watched the NCV.

The SSMLE analyses in the NCV condition also conceal a wide range of individual variation in model fits within this sample. In a Bayesian model comparison of the individual subject fits for model 1 (activation-deactivation) versus model 2 (pleasure-displeasure) we found several individuals with log Bayes factors [denoted by $\log(BF_{12})$, the log of the Bayes factor for model

1 relative to model 2 exceeding +2.3 (a value taken as strong evidence in favour of model 1 versus model 2; Jeffreys, 1961). Indeed, we found several individuals whose $\log(BF_{12})$ was well below -2.3 (strong evidence in favour of model 2). Figures 4.13 through to 4.15 show some examples.

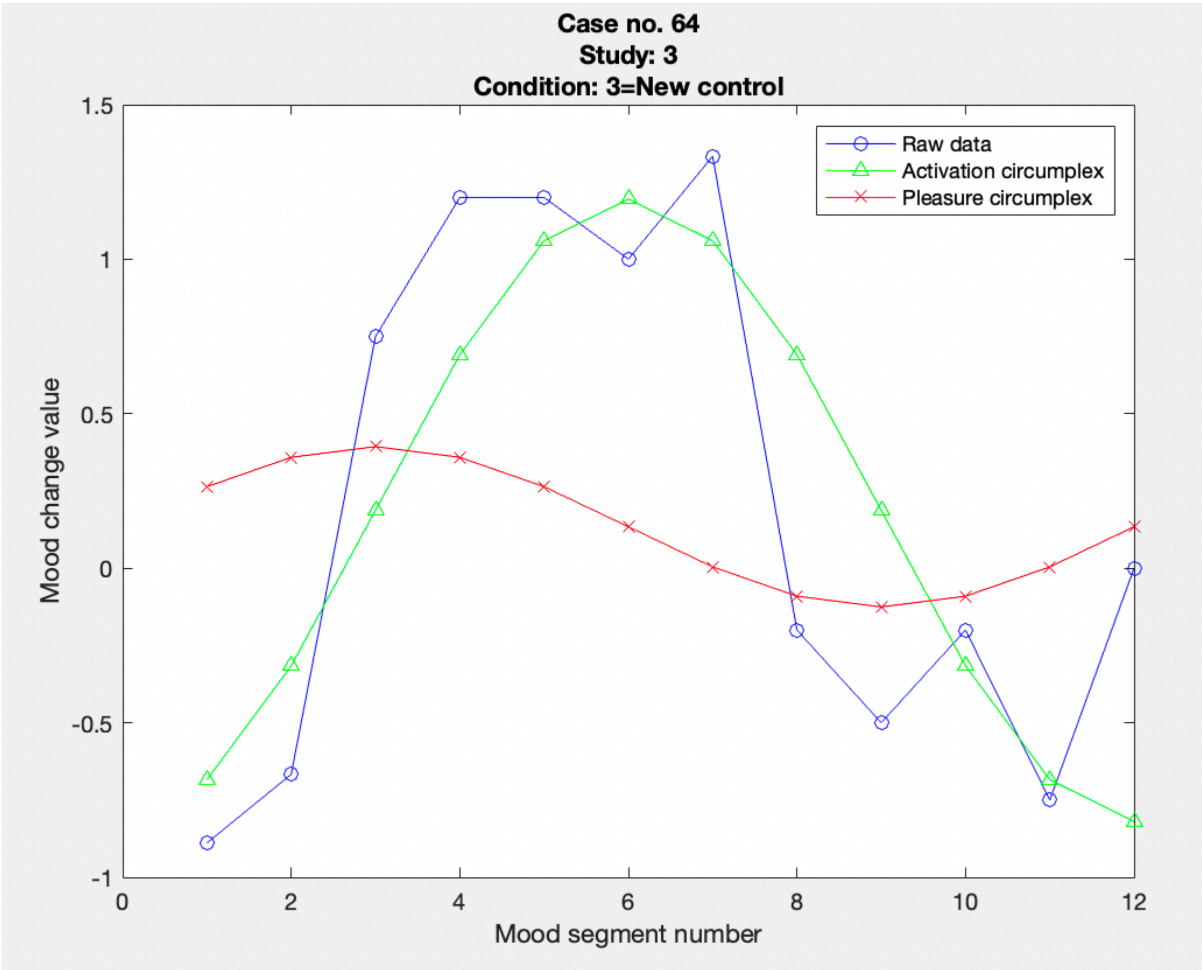


Figure 4.13: A participant whose mood change scores were well fit by model 1 (activation-deativation circumplex) relative to model 2 (pleasure-displeasure circumplex), but in an inverse direction (deactivation-activation); $\log(BF_{12})$= 17.1 in the NCV condition.

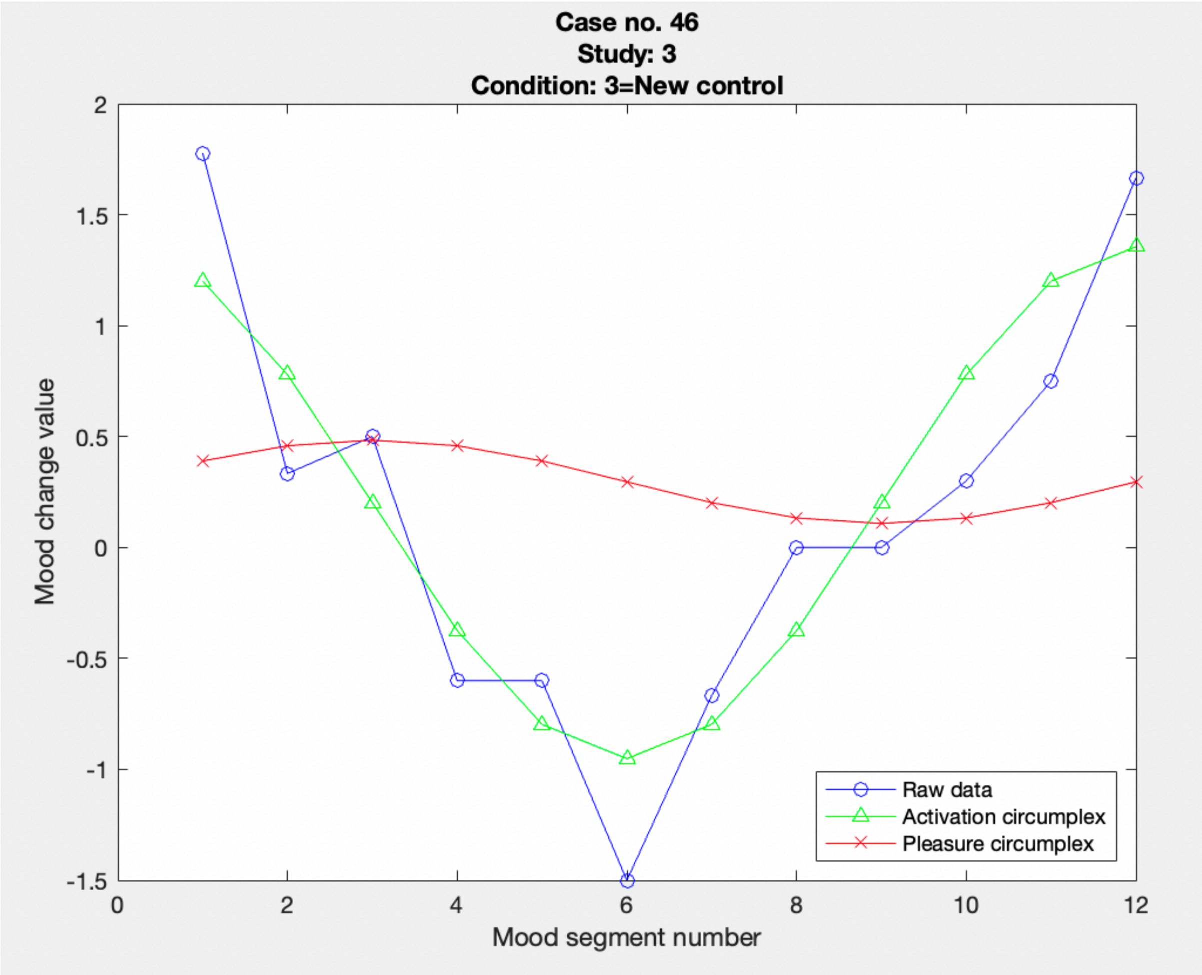


Figure 4.14: Another participant whose mood change scores were well fit by model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex); $\log(BF_{12})$= 18.1 in the NCV condition.

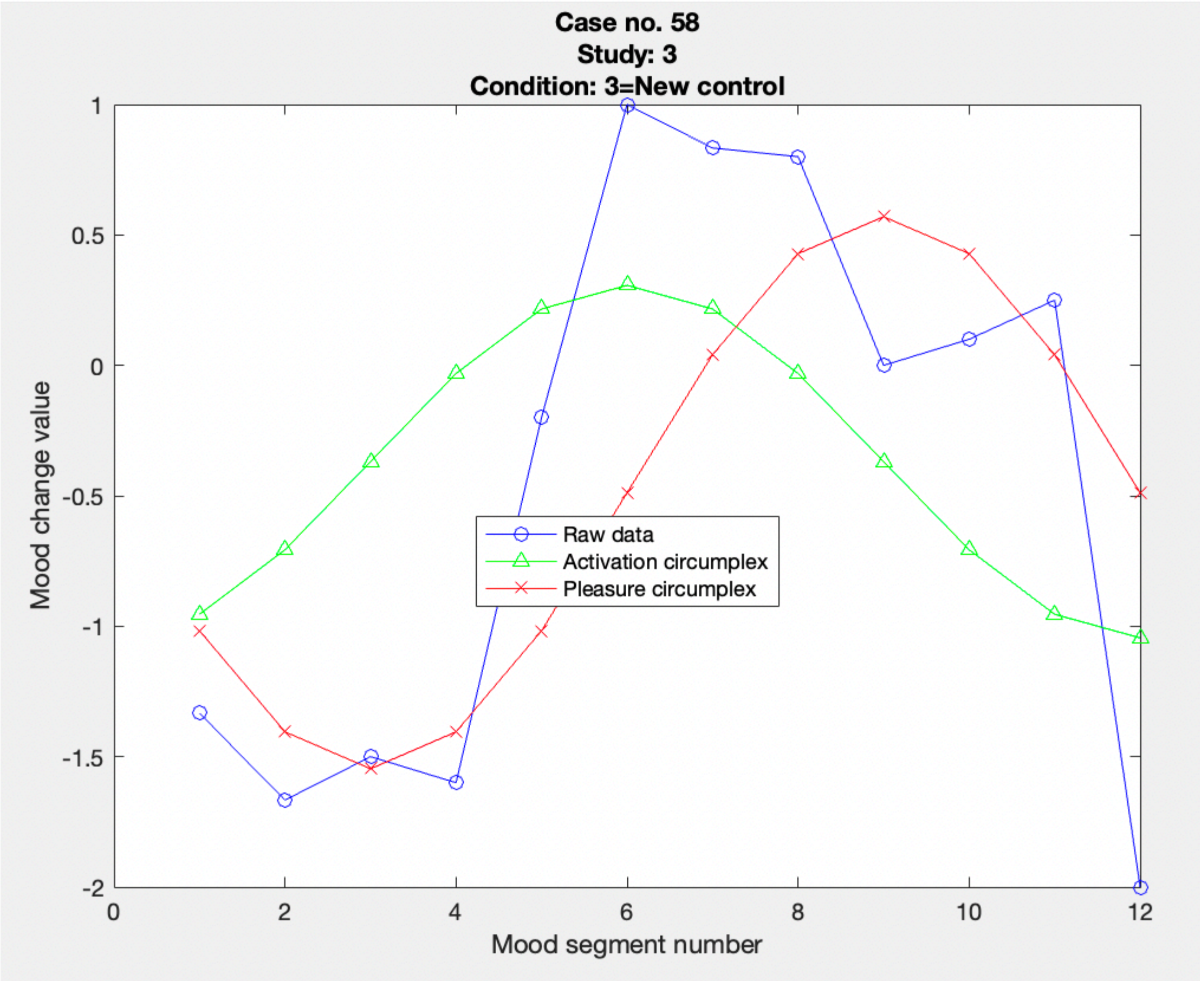


Figure 4.15: A participant whose mood change scores were well fit by model 2 (pleasure-displeasure circumplex) relative to model 1 (activation-deactivation circumplex); log(BF_{12})= -8.5 in the NCV condition.

The log(BF_{12}) values for each participant showed wide variation as seen in Figure 4.16 below. There were strong relative fits for model 1 in 19/40 cases and for 8/40 cases for model 2 at an individual subject level.

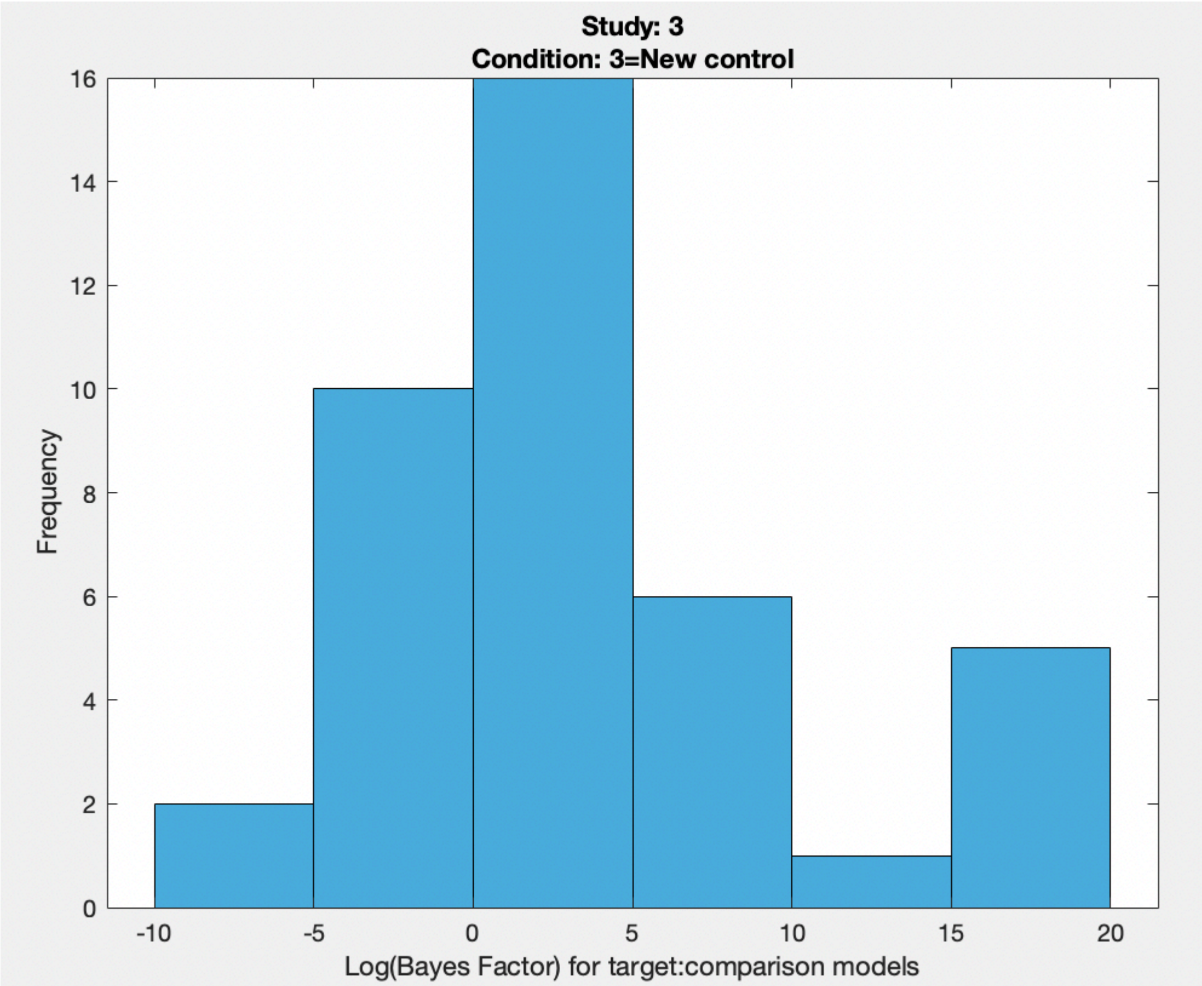


Figure 4.16: Histogram of log(BF_{12}) values in the NCV condition. These values compare the strength of evidence for model 1 (activation-deactivation circumplex) relative to model 2 (pleasure-displeasure circumplex). A log(BF_{12}) value of 0 provides evidence that favours neither model; more positive log (BF_{12}) values favour model 1 and more negative log(BF_{12}) values favour model 2. Log(BF_{12}) values above +2.3 and below -2.3 are taken as strong evidence in favour of model 1 and model 2 respectively. For the whole sample the mean log(BF_{12}) = 3.273.

The final output from the VBA toolbox routines is shown in Figure 4.17 below.

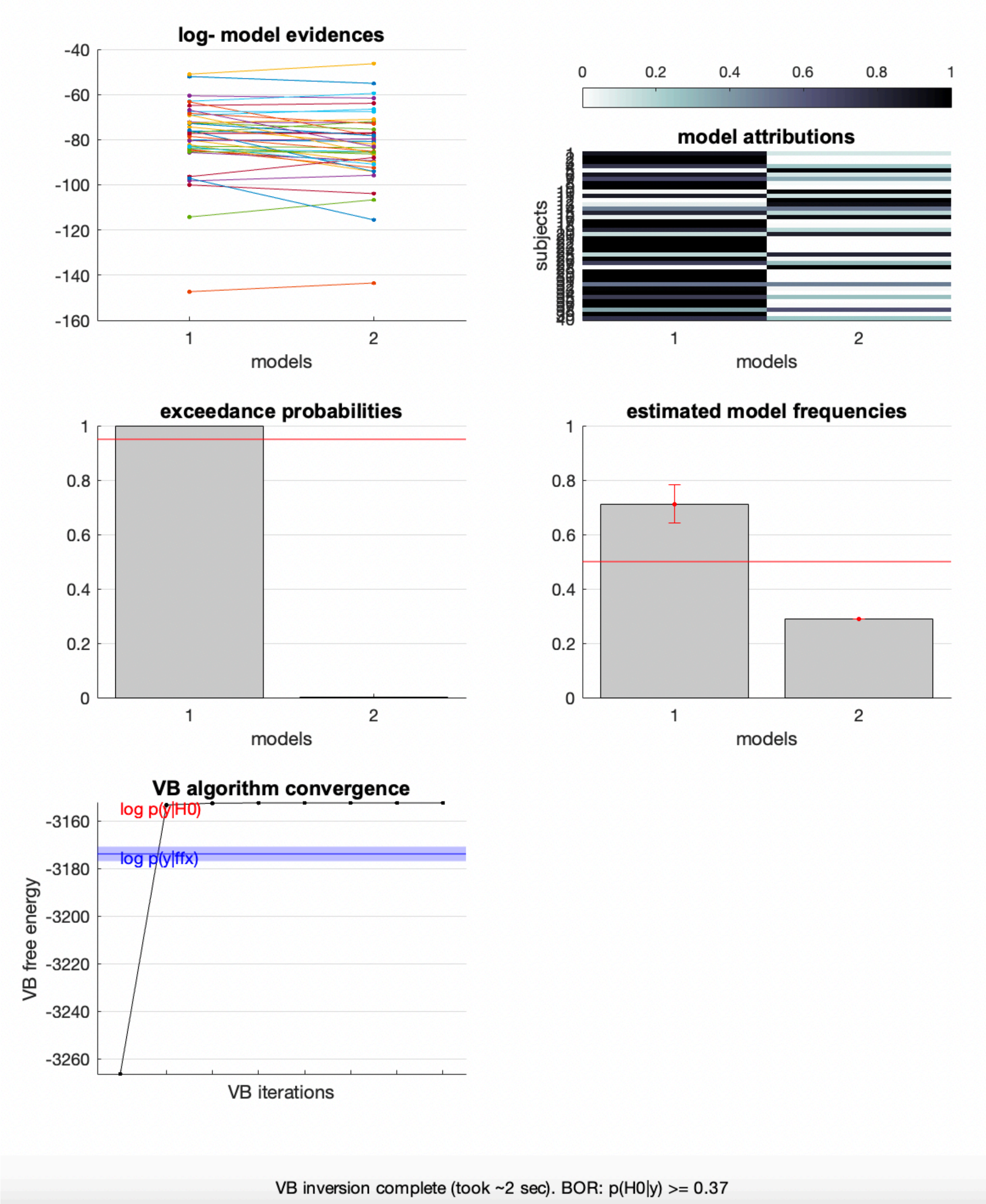


Figure 4.17: The main output window from the VBA toolbox for the NCV condition.

The key results shown in Figure 4.17 offer confirmation that model 1 is more frequently a better account of the data relative to model 2. The exceedance probability (EP) is 1.00, but the protected exceedance probability (PEP) allows for the possibility that the EP is due to chance; the PEP was .81, and the expected frequency of model 1 was .71. Accordingly, the Bayesian Omnibus Risk (BOR) is ≥ .37 (the BOR is the posterior probability that the frequencies of the two models across the sample are equal). Despite the tendency towards better fits for model 1, this figure is still not close to 0, once again confirming the heterogeneity of relative model fits in this study. The histograms drawn for the circumplex model coefficients (b_i), show that there is a similarly wide range of coefficients under either model (Figure 4.18). However, for the activation-deactivation model there is a bias towards negative coefficients; for the pleasure-displeasure model the distribution of individual coefficients vary widely also but it is centred close to zero.

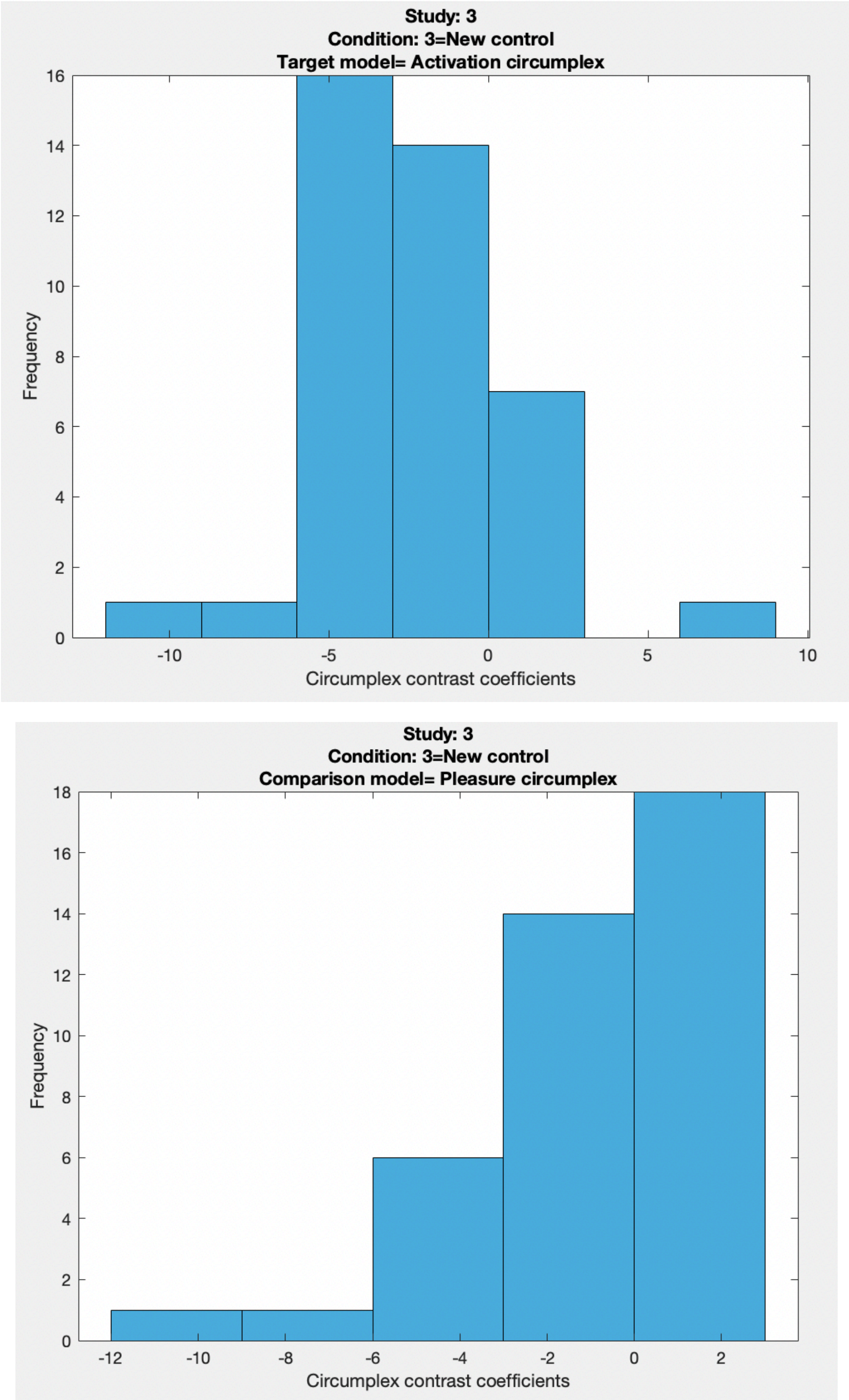


Figure 4.18: The frequencies of b_i coefficients of the circumplex model across participants in the NCV condition. The upper panel is for the activation-deactivation circumplex model (M = -2.38, SD = 3.00); the lower panel is for the pleasure-displeasure circumplex model (M = -1.09, SD = 2.85).

To conclude the Bayesian model selection process, we conducted a cross-tabulation of video condition by model (0, 1, and 2). Model 0 is the intercept model. Cases better fit by model 0 were such that neither model 1 nor model 2 had a strong fit relative to model 0. Here we also used a value of 9 to represent the participants who are better fit both by models 1 and 2 than model 0, but where neither model 1 nor 2 is a better fit than the other (see Table 4.1).

Table 4.1: Cross-tabulation for condition by model frequencies of cases.

Condition	**Model**				
	0	**1**	**2**	**9**	**Total**
RMV	16	14	8	3	41
NCV	12	19	8	1	40
Total	27	34	16	4	81

To test whether the distribution of these frequencies differs across these categories of models as a function of the condition we conducted a chi squared test, which was non-significant [$X^2(3, N = 81) = 1.79, p = .617$]. This table confirms that there is evidence for model 1 at the individual level consistent with the earlier clear evidence for model 1 on average in the NCV condition. For the RMV condition there is also some evidence for model 1 at the individual level (not significantly less than for the NCV in fact) and yet there is no hint of it at the average level in the earlier analyses.

4.3.3 Analysing mood changes using the GEE approach

We next used GEE methods to look at the effect of the videos on mood. The predictors were video condition, the model-based circumplex predictors (each used in separate analyses) and the video by circumplex interaction term. We also entered an intercept term, plus the mood checklist item number (1-60, reflecting the order in which they were presented) as a covariate predictor so that we could specify a WCM for the analysis (we used an AR-1 WCM).

From the sample of 85 participants, we eliminated 2 cases who had large amounts of missing data (more than 11 items out of 60), while the rest completed all, or almost all, the items.

When using the model 1 circumplex predictor (based on activation-deactivation), the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as 0.227 (a similar value to the estimates in the previous studies). From the parameter estimates of the GEE model, which are regression coefficients (B), neither the main effect of the video condition nor the circumplex predictor had a significant effect on mood change from before to after watching the video ($p > .1$ in either case, with small B coefficients, close to zero). However, the critical interaction between video condition and circumplex predictor was robustly significant [B=1.234, SE= .3220, 95% CIs= (.60, 1.87); $p < .001$ (c.f. adjusted $\alpha = .008$)]. We know from Figures 4.4 and 4.12 above that this interaction reflects the fact that, on average, the activation-deactivation circumplex predicts mood changes significantly more strongly in the NCV condition than in the RMV condition. In line with these figures, we know from the sign of the B coefficient (and the way that the video condition was coded) that this result reflects a significantly more negative relationship between the model 1 circumplex predictor and mood change in the NCV condition compared with the RMV condition. This means that the most positive change in mood was obtained for the deactivation mood segment and the most negative was obtained for the activation segment. As expected, based on experience with our earlier GEE analyses, we obtained very similar results when using the exchangeable or independent WCMs instead of the AR-1 WCM.

To further confirm this, we ran the analyses in each video condition separately, using just the circumplex value as the predictor of mood change (plus the usual intercept term and the mood checklist item number). The activation-deactivation model 1 circumplex was a robustly significant predictor in the NCV condition [B= -1.188, SE= .22, 95% CIs = (-1.63, -.75); $p < .001$]. The autocorrelation between adjacent items was estimated to be .225 (very similar to the results across both video conditions), and the percentage of missing data was 1%. In the RMV condition, by contrast, the model 1 circumplex did not significantly predict the mood changes [B=.044, SE= .23, 95% CIs = (-.41, .49); $p = .848$]. The autocorrelation between adjacent items was estimated to be .228 (very similar to the results across both video conditions), and the percentage of missing data was 1.5%. The GEE results are completely consistent with the results obtained using fixed effects or SSMLE modelling presented above and presented the same findings. Of course, these findings were unexpected based on the earlier studies in this thesis using motivational videos.

When using the model 2 circumplex predictor (based on pleasure-displeasure), the analysis estimated the autocorrelation (under the AR-1 WCM) between adjacent mood items as .234. From the parameter estimates of the GEE model the main effect of the video condition did not have a significant effect on mood change before to after watching either video [B= -.034, SE= .05, 95% CIs = (-.14,.07); p = .526]. The circumplex predictor had a significant effect on mood change regardless of the video type [B= -.563, SE= .21, 95% CIs = (-.97,-.16); p = .006 (c.f. adjusted α = .008)]. However, the critical interaction between video condition and circumplex predictor was not significant [B= .554, SE= .28, 95% CIs = (.01, 1.10); p = .046 (c.f. adjusted α = .008)]. We know from Figure 4.5 above that this interaction reflects the fact that, on average, the pleasure-displeasure circumplex does not predict mood changes differentially across the two video conditions.

Again, to further confirm this, we ran the analyses in each video condition separately, using just the model 2 circumplex value as the predictor of mood change (plus the usual intercept term and the mood checklist item number). The pleasure-displeasure model 2 circumplex was not significant predictor in the RMV condition [B= .003, SE= .19, 95% CIs = (-.37, .37); p = .989]. The autocorrelation between adjacent items was estimated to be 0.228 and the percentage of missing data was 1.5%. In the NCV condition, the model 2 circumplex relationships with the mood changes was significantly different from zero [B= -.575, SE= .21, 95% CIs = (-.99, -.17); p = .006 (c.f. adjusted α = .008)]. The autocorrelation between adjacent items was estimated to be .240 and the percentage of missing data was 1%. This result parallels the equivalent analyses using fixed-effects contrasts and the analysis using SSMLE analyses. However, it should be noted that there is a discrepancy between the p-values of the model 2 circumplex coefficients for the NCV groups in the fixed-effects analysis (p = .038) and the SSMLE analysis (p = .020), which were not significant against our strictly adjusted alpha level. The GEE analysis is significant, where a possible reason may be because it is more robust and, therefore, needs fewer assumptions to be met by the data.

4.3.4 Video effects on FAA

Mean FAA was calculated for pre-test and post-test resting state EEG, for both RMV and NCV groups. A 2 x 2 repeated measures ANOVA was carried out to test if there was a significant change in FAA after watching either video. The interaction between video type and pre and post FAA values was not quite formally significant [$F(1,79) = 3.520$, $p = .064$, $\eta p^2 = .043$]. However, t-tests showed that there was a significant change in FAA from pre ($M = .12$, $SD = .09$) to post-test ($M = .15$, $SD = .09$) after watching the NCV [$t(40) = -3.051$, $p = .004$], but not after watching the RMV [$t(39) = .014$, $p = .989$] (pre-test FAA: $M = .14$, $SD = .11$; post-test FAA: $M = .14$, $SD = .10$). There is, therefore, an increase in FAA, reflecting greater LFA after watching the NCV than before.

It can be argued that those who show a good fit to the activation model in their mood data based on their positive circumplex coefficients (with $\log(BF_{12})$ values greater than +2.3) are those whom we expect to show the greatest degree of change in FAA. We, therefore, took the cases fit by model 1 and compared those subjects with those who are not fitted by the activation model, in each video condition. To avoid any confounding effects to the analysis, those who are fit by model 2 are excluded here. It should be noted that as the number of cases that meet all the given criteria are fewer, the power of this analysis is reduced by this smaller sample size.

One-way ANOVAs showed, for those who watched the RMV, that there was not a significant difference in change in FAA between the cases whose mood changes well fit by model 1 specifically ($M = -.002$, $SD = .07$) compared to those whose mood changes were not well fit by either model 1 or model 2 ($M = .001$, $SD = .08$) [$F(1, 30) = .012$, $p = .912$]. Amongst those who watched the NCV, there also was a non-significant difference in change in FAA between the cases whose mood changes were well fit by model 1 ($M = .03$, $SD = .07$) compared to those whose mood changes were not well fit by model 1 or model 2 ($M = .04$, $SD = .04$) [$F(1, 30) = .235$, $p = .631$].

The same procedure was done to test the change in FAA for those who are well fit by model 2 (with $\log(BF_{12})$ values less than -2.3) to examine whether or not the pleasure-displeasure model produces a change in FAA. In the RMV group, there was no significant difference in change in FAA between the cases whose mood changes were well fit by model 2 ($M = -.001$, $SD = .10$) compared to those whose mood changes were not well fit by model 2 or model 1 ($M = .001$, $SD = .08$) $F(1, 23) = .001$, $p = .971$]. In the NCV group there was also a non-significant difference in change in FAA between the cases fit by model 2 ($M = .007$, $SD = .06$) compared to those who are not fitted by model 2 ($M = .036$, $SD = .04$) [$F(1, 20) = 1.941$, $p = .180$].

4.3.5 Personality as a predictor of change in FAA

General linear models were conducted to test if extraversion or neuroticism predicted the change in FAA scores (pre to post-test) overall and as a function of video type. It was found that the three-way interaction between pre to post-test FAA, video type, and extraversion was non-significant [$F(1,77) = .069$, $p = .794$]. Similarly, the two-way interaction between pre to post-test FAA and extraversion regardless of video type was also non-significant [$F(1,77) = .231$, $p = .632$]. It was also found that there was no main significant effect of extraversion on FAA, regardless of video type and averaged over the pre- and post-test timepoints [$F(1,77) = .334$, $p = .565$].

A similar pattern of results was found for neuroticism, where: the three-way interaction between pre to post-test FAA, video type, and neuroticism was non-significant [$F(1,77) = 1.341$, $p = .250$]; the two-way interaction between pre to post-test FAA and neuroticism regardless of video type was also non-significant [$F(1,77) = .136$, $p = .713$]; and the main effect of neuroticism on FAA regardless of video type and averaged over time points was also non-significant [$F(1,77) = .189$, $p = .665$].

Given that the NCV condition does produce an increase in LFA across all subjects, the moderating effects of extraversion and neuroticism on the NCV group change in FAA only were also explored. Scores of extraversion and neuroticism were first re-standardised for the subsample used in this analysis. It was found that the interaction between extraversion and change in FAA in the NCV group was not significant [$F(1,38) = 2.957$, $p = .094$], neither was the interaction between neuroticism and change in FAA in the NCV group [$F(1,39) = .370$, $p = .546$].

4.3.6 Personality and FAA effects on the fixed-effects mood contrasts

To test if the personality traits of extraversion and neuroticism, and the change in FAA moderate the effects of video type on changes in affect, two separate analyses were conducted for each trait. The overall fixed effect contrast scores under model 1 and model 2 were computed separately for each participant in either video condition. The correlations between the contrast score and the personality variables were computed. It should be noted that the samples here were the largest that were able to be obtained for this EEG study. Considering power calculations, if the correlation between a mood contrast and a predictor (either extraversion, neuroticism, or change in FAA) was 0.3, then a two-tailed test at alpha = .05 of this correlation with a sample of N=80 would have 78% and 48% for N=40 (in one condition). The equivalent figures for a correlation of 0.2 are 43% for N=80 and 24% for N=40. With these calculations, we acknowledge that the analyses are underpowered. The power would be even lower if we factored in an adjustment for multiple comparisons (e.g., .05/4 for 2 models and 2 video groups).

We first tested the correlation between extraversion and the model 1 fixed-effects circumplex contrast, as well as the correlation between neuroticism and the fixed-effects model 1 circumplex contrast, pooled across both video conditions. The correlation was not significant for extraversion [$r(83) = -.051$, $p = .646$], nor was it significant for neuroticism [$r(83) = .068$, $p = .540$]. The correlation between FAA levels and fixed effects model 1 circumplex contrasts was also non-significant [$r(79) = -.127$, $p = .261$]. We computed the same correlation between extraversion and the model 2 fixed-effects circumplex contrast, as well as the correlation between neuroticism and the model 2 fixed-effects interaction contrast. The correlation was not significant for extraversion [$r(83) = -.067$, $p = .643$], nor was it significant for neuroticism [$r(83) = .004$, $p = .968$]. The correlation between change in FAA and model 2 contrasts was also non-significant [$r(79) = .019$, $p = .866$].

In the RMV group, there were no significant correlations for the model 1 contrasts of the changes in affect with extraversion [$r(42) = -.007$, $p = .965$] nor with neuroticism [$r(42) = .096$, $p = .542$]. In the NCV group, the correlation between change in FAA levels and model 1 contrasts in the RMV group was also non-significant [$r(39) = -.055$, $p = .737$]. There were no significant correlations for the model 1 contrasts of the changes in affect with extraversion [$r(40) = -.042$, $p = .79$] nor neuroticism [$r(40) = -.028$, $p = .864$]. The correlation between FAA levels and model 1 contrasts in the NCV group were also non-significant [$r(39) = -.064$, $p = .696$].

When applying the model 2 contrasts for the changes in affect, again there were no significant correlations for the changes in affect with extraversion [$r(42) = -.281$, $p = .068$] nor with neuroticism [$r(42) = .135$, $p = .387$] in the RMV group. The correlation between FAA and model 2 contrasts in the RMV group was also non-significant [$r(39) = -.098$, $p = .549$]. There were also no significant correlations for the model 2 contrasts of the changes in affect with extraversion [$r(40) = .190$, $p = .234$] nor neuroticism [$r(40) = -.176$, $p = .271$] in the NCV group. The correlation between change in FAA and model 2 contrasts in the NCV group were also non-significant [$r(39) = .261$, $p = .103$] (see Table 4.2).

Table 4.2: Group correlations of extraversion, neuroticism, and FAA with model 1 and model 2 contrasts for the RMV and NCV groups.

	RMV						**NCV**					
	Model 1 Contrasts			**Model 2 Contrasts**			**Model 1 Contrasts**			**Model 2 Contrasts**		
	r	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***
Extraversion	-.007	.965	42	-.281	.068	42	-.042	.793	40	.190	.234	40
Neuroticism	.096	.542	42	.135	.387	42	-.028	.864	40	-.176	.271	40
FAA	-.055	.737	39	-.098	.549	39	-.064	.696	39	.261	.103	39

4.3.7 Personality and FAA effects using contrast estimates based on the SSMLE analysis

Before using Bayesian Model Selection to extract the good fit cases, we first conducted univariate ANOVAs to investigate whether there was a significant main effect of model fit groups (0,1, and 2; see Table 4.1 above) on extraversion, neuroticism, or change in FAA as DVs, and whether there were interaction effects of model groups as a function of video condition. The outcome was that there were no significant main effects of model group on extraversion [$F(2,71) = 1.072$, $p = .348$], nor interaction effects of model group and video condition on extraversion [$F(2,71) = .400$, $p = .672$]. There were no significant main effects of model group on neuroticism [$F(2,71) = .607$, $p = .548$], nor interaction effects of model group and video condition on neuroticism [$F(2,71) = .370$, $p = .692$]. There were no significant main effects of model group on FAA change [$F(2,67) = .240$, $p = .787$], nor interaction effects of model group and video condition on FAA change [$F(2,67) = .222$, $p = .802$].

Using Bayesian methods potentially allows for a more meaningful correlation between fitting circumplex coefficients and personality traits. Therefore, the circumplex coefficients (b_i) of the cases with $\log(BF_{12})$ values greater than +2.3, representing a good fit with model 1 (activation-deactivation circumplex), were extracted and correlated with trait extraversion, neuroticism, and change in FAA. The numbers for these analyses in any one study are very small but are reported briefly here for completeness. There was a family of 6 correlations and so the per comparison Type 1 error rate was adjusted to 0.05/6. With such small sample sizes and adjustment for multiple comparisons, these analyses are extremely underpowered and so should be treated with extreme caution.

For those in the RMV group, in the 14 cases with strong model 1 fits, there were no significant correlations between the model 1 circumplex coefficients and extraversion [$r(12) = -.005$, $p = .987$] or neuroticism [$r(12) = .249$, $p = .370$]. The correlation between the model 1 circumplex coefficients and change in FAA were also non-significant [$r(12) = -.187$, $p = .522$]. The circumplex coefficients were also extracted for the 8 cases with $\log(BF_{12})$ values below -2.3 that showed a strong fit to model 2 (pleasure-displeasure circumplex), and were correlated with extraversion and neuroticism and FAA changes. Again, there were no significant correlations between the model 2 circumplex coefficients and extraversion [$r(6) =-.661$, $p = .075$] nor with neuroticism [$r(6) = .507$, $p = .200$]. The correlation between the model 2 circumplex coefficients and change in FAA were also non-significant [$r(6) = -.089$, $p = .850$].

The same procedure was conducted for the NCV group. There were 19 cases who showed strong evidence for model 1 relative to model 2. Amongst those cases, the correlation with extraversion was non-significant [$r(17) = -.030$, $p = .904$], as was the correlation with neuroticism [$r(17) = .274$ $p = .257$]. The correlation between the model 1 circumplex coefficients and change in FAA were also non-significant [$r(17) = -.053$, $p = .835$]. The circumplex coefficients were also extracted for the 8 cases with $\log(BF_{12})$ values below -2.3 that showed a good fit to model 2 (pleasure-displeasure circumplex), and were correlated with extraversion and neuroticism. There was no significant negative correlation between the model 2 circumplex coefficients and extraversion [$r(6) = .584$, $p = .129$], nor with neuroticism [$r(6) = -.451$, $p = .262$] (see Table 4.3). The correlation between the model 2 circumplex coefficients and change in FAA were also non-significant [$r(6) = .066$, $p = .876$].

Table 4.3: Correlations of extraversion, neuroticism, and FAA with circumplex coefficients (bi) of cases well fit by either model 1 and 2 in the RMV and NCV groups.

	RMV						**NCV**					
	Model 1 b_i			**Model 2 b_i**			**Model 1 b_i**			**Model 2 b_i**		
	r	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***	***r***	***p***	***df***
Extraversion	-.005	.987	12	-.661	.075	6	-.030	.904	17	.584	.129	6
Neuroticism	.249	.370	12	.507	.200	6	.274	.257	17	-.451	.262	6
FAA	-.187	.522	12	-.089	-.850	6	-.053	.835	17	.066	.876	6

Examining Table 4.3 above, the *r* values for the correlation between extraversion and the model 2 circumplex coefficients and the correlation between neuroticism and the model 2 circumplex coefficients reveal an interesting pattern. While the correlations are not significant, the *r* values are large and have opposite signs for each video condition. Extraversion correlates negatively with the model 2 circumplex predictors in the RMV and positively in the NCV, while neuroticism correlates positively in the RMV and negatively in the NCV. To analyse if this interaction is significant for the good fitting model 2 cases, a general linear model was conducted. First, the extraversion and neuroticism scores were re-standardised for this subsample. There was indeed a significant interaction between extraversion and video condition on the model 2 circumplex coefficients for the good fitting model 2 cases [$F(1,12) = 7.572$, $p = .018$, $\eta p^2 = .387$]. However, the interaction between neuroticism and video condition on the model 2 circumplex coefficients for the good fitting model 2 cases was not significant [$F(1,12) = 3.660$, $p = .080$]. Nevertheless, this explorative analysis needs treating with extreme caution given its post hoc discovery and underpowered sample size.

4.3.8 Personality and FAA effects on mood changes using the GEE analysis

We can easily add personality predictors to our GEE analyses to see if the traits of extraversion, neuroticism, or change in FAA moderate the mood-inducing effects of the RMV and NCV. We begin with adding extraversion as a predictor to the analyses of mood changes for the RMV condition. We centred extraversion (by standardizing the scores) for all the participants included in the GEE analysis.

We start using the model 1 circumplex as the predictor. The key test of the pre-study predictions is whether extraversion moderates (interacts with) the prediction by the model 1 circumplex values in the RMV condition. As in the GEE analysis without personality above, the model 1 circumplex predictor does not significantly predict the mood changes [B= .047, SE= .23, 95% CIs = (-.40,.50); *p*=.838]. The main effect of extraversion was not significant (B= .026, SE= .04, 95% CIs = (-.06, .11); *p* = .539]. The interaction between extraversion and the model 1 circumplex predictor was not significant either [B= .035, SE= .18, 95% CIs = (-.31,.38); *p* = .843].

We repeated the above analyses in the NCV condition where we did not have a pre-study expectation for any effects of extraversion. This analysis confirmed the earlier reported result that the main effect of the model 1 circumplex predictor was significant [B= -1.191, SE= .22, 95% CIs = (-1.63,-.76); *p* < .001]. However, the main effect of extraversion [B= -.024, SE= .05, 95% CIs = (-.12,.07); *p* = .626] was non-significant; neither was the interaction of extraversion and the model 1 circumplex predictor [B= .042, SE= .22, 95% CIs = (-.39,.48); *p*=.850].

The next key test of pre-study predictions is whether neuroticism moderates (interacts with) the prediction by the model 1 circumplex values in the RMV condition. As in the earlier analysis including personality, the model 1 circumplex predictor does not significantly predict the mood changes [B= .027, SE= .22, 95% CIs = (-.41,.46); *p* = .902]. The main effect of neuroticism was not significant [B= -.040, SE= .03, 95% CIs = (-.10,.02); *p* = .197]. The interaction between neuroticism and the model 1 circumplex predictor was also not significant [B= .216, SE= .26, 95% CIs = (-.29,.72); *p*= .402].

We repeated the above analyses in the NCV condition where we had no pre-study expectation that neuroticism will act as a moderator in this condition. This was what the analysis revealed: the main effect of neuroticism was not significant [B=.052, SE= .05, 95% CIs = (-.04,.15); *p*=.276], and the interaction of neuroticism and the model 1 circumplex predictor was not significant [B= -.104, SE= .23, 95% CIs = (-.56,.36); *p* = .658].

The next key test is whether change in FAA moderates (interacts with) the prediction by the model 1 circumplex values in the RMV condition, where a significant relationship is expected as the RMV is expected to induce a change along the model 1 axis and FAA is supposed to relate to changes in activation-deactivation. However, the main effect of FAA was not significant [B= -.042, SE= .03, 95% CIs = (-.09,.01); p = .110]. The interaction between FAA and the model 1 circumplex predictor was also not significant [B= -.198, SE= .17, 95% CIs = (-.53,.14); p = .246].

We repeated the above analyses in the NCV condition, where we had no pre-study expectation of effects. However, unexpectedly the NCV condition produced a significant FAA increase from pre to post video manipulation. The analysis revealed that the main effect of FAA was not significant [B=-.014, SE= .05, 95% CIs = (-.11,.08); p = .773], neither was the interaction of FAA and the model 1 circumplex predictor was not significant [B= .057, SE= .21, 95% CIs = (-.35,.46); p = .784].

Next, we turn to using the model 2 circumplex as the predictor. Here a key test is whether extraversion moderates (interacts with) the prediction by the model 2 circumplex values in the RMV condition. Our pre-study expectation, based on the earlier work by Smillie et al (2012), was that this effect would be small. As in the GEE analysis without personality above, the model 2 circumplex predictor does not significantly predict the mood changes [B= -.029, SE= .18, 95% CIs = (-.38,.32); p = .868]. The main effect of extraversion was not significant [B= .016, SE= .04, 95% CIs = (-.07,.10); p = .693], however the interaction between extraversion and the model 2 circumplex predictor approached significance given the strict alpha adjustment imposed [B= -.396, SE= .16, 95% CIs = (-.71,-.08); p = .014 (c.f. adjusted α = .008)]. Note that this has a negative direction, like the correlation in Table 4.3 for this video condition and model.

We repeated the above analyses in the NCV condition. The main effect of extraversion was not significant [B= -.016, SE= .05, 95% CIs = (-.11,.07); p = .717] and nor was the key interaction term for extraversion and the model 2 circumplex predictor [B= .292, SE= .26, 95% CIs = (-.21,.80); p = .257]. Note that this has a positive direction, again as in Table 4.3.

The next key test is whether neuroticism moderates (interacts with) the prediction by the model 2 circumplex values in the RMV condition. The main effect of neuroticism was not significant [B= -.032, SE= .03, 95% CIs = (-.10,.03); p = .324]. The interaction between neuroticism and the model 2 circumplex predictor was not significant [B= .113, SE= .14, 95% CIs = (-.17,.39); p = .433].

We repeated the above analyses in the NCV condition. The analysis revealed the same finding with respect to the non-significant main effect of neuroticism that we saw above when using the model 2 circumplex predictor [B= .044, SE= .04, 95% CIs = (-.04,.13); p = .321]. The interaction of neuroticism and the model 2 circumplex predictor was also non-significant [B= -.243, SE= .26, 95% CIs = (-.76,.27); p = .351].

The next key test is whether change in FAA moderates (interacts with) the prediction by the model 2 circumplex values in the RMV condition, where an effect was not expected to be significant as the literature indicates that FAA reflects changes along the activation-deactivation (see *section 4.1.2*). The main effect of FAA was not significant [B= -.050, SE= .03, 95% CIs = (-.11,.01); p = .091]. The interaction between FAA and the model 1 circumplex predictor was also not significant [B= -.113, SE= .18, 95% CIs = (-.44,.18); p = .398].

We repeated the above analyses in the NCV condition where there were no pre-study expectations for effects but where FAA was increased overall pre to post-test. The analysis revealed that the main effect of FAA was not significant [B=-.003, SE= .05, 95% CIs = (-.11,.10); p = .963], and the interaction of FAA and the model 2 circumplex predictor was also not significant [B=-.432, SE= .21, 95% CIs = (.02,.84); p = .040 (c.f. adjusted α = .008)].

All GEE analyses were repeated using exchangeable and independent WCMs, where the outcomes were similar each time, without any notable differences.

4.3.9 Intrinsic motivation effects

As expected, there was a significant difference between scores on the “competitive drives” item, where those who watched the RMV had a higher average score (M = 3.19*,* SD = 1.26) than those who watched the NCV (M = 2.17*,* SD = 1.23) [$F(1,84) = 14.28$, $p < .001$, ηp^2 = .15]. This is consistent with our predictions because competitive drives are hypothesized to be one of the key features that enables motivational videos to exert appetitive effects. As noted above, inclusion of this item served as a simple manipulation check that the motivational video was indeed significantly more motivating, on average, for those who watched it relative to the control video.

A univariate ANOVA was performed to examine the effects of video type on the level of intrinsic motivation across the two video groups. There was no significant difference between the total intrinsic motivation scores of those who watched the RMV (*M* = 30.65*, SD* = 5.85) and those who watched the NCV (*M* = 30.30*, SD* = 5.36) [$F(1,83) = .081$, $p = .777$]. This replicates the results for this variable from study 2 in chapter 3. Therefore, one can confidently deduce that difference in affect changes between those who watched the RMV and those who watched the NCV was not attributable to how interesting the participants found each video.

4.4 Discussion

The current chapter uses the same theoretical framework and very similar methodology as chapters 2 and 3. This study (study 3) replaced a proxy measure of left frontal activation (the line bisection task) with a more direct measure of cortical activity, derived from resting-state EEG. Specifically, and in light of approach motivation research on neural indices of reward motivation previously reviewed (e.g., Schutter & Harmon-Jones, 2013; Wacker et al., 2003), we employed an EEG measure of left-right frontal alpha asymmetry. We hypothesised that relative to the NCV, the RMV will on average increase, from pre- to post-test, those segments of emotion that involve activated affect (*pleasant activation, activation, unpleasant activation*). We hypothesised that this would also be reflected in an increase in LFA after watching the RMV, compared to the NCV, and that the activation-deactivation mood changes (reflected by circumplex model regression coefficients) would be associated with asymmetry in levels of frontal alpha activity. Specifically, we predicted that overall greater relative LFA will have a positive relationship with more positive activation circumplex coefficients.

As expected, there was a significant difference between scores on the “competitive drives” item, where those who watched the RMV had a higher average score than those who watched the NCV. This was consistent with our predictions because competitive drives are hypothesized to be one of the key features that enables motivational videos to exert appetitive effects. As noted above and in the previous chapters, inclusion of this item served as a simple manipulation check that the motivational video was indeed significantly more motivating for those who watched it relative to the NCV in the control condition.

However, contrary to what was found in the previous chapters that studied motivational videos, in the current study, the activation-deactivation model was on average more associated with mood changes in those who watched the NCV as opposed to the RMV. Furthermore, the fixed effects model, found that on a group level deactivated affect (e.g., feeling quiet and still) increased after watching the NCV, while activated affect (e.g., feelings of arousal) decreased. Overall, change in affect acted along the activation-deactivation axis in a negative direction, and specifically for those who watched the NCV. At a group level, there were no significant differences in pleasure-displeasure affect for those who watched either video. However, the GEE analysis did find a significant overall effect for the model 2 circumplex predictor across both groups and an effect that was significant in the negative direction in the NCV group alone. Also, the effect for model 2 using SSMLE and fixed effect analyses showed weaker tendencies to this same pattern in the NCV group but did not reach significance against our adjusted alpha thresholds.

However, when using SSMLE and Bayesian Model Selection, it was found that some participants in the RMV group did respond along the activation-deactivation axis and were very well fitted by the associated circumplex model. As in the previous studies we found a wide variation in the relative fit of our two circumplex models across individuals within conditions. In the RMV condition there was some evidence that model 1 was the better fitting model (PEP = 0.58) but this was not sufficient for the average model 1 circumplex coefficient to diverge from zero significantly, because those fit by model 1 had a roughly equal mixture of positive and negative model 1 circumplex coefficients. In the NCV group there was also considerable heterogeneity of model fits at the individual level. However, there was some evidence that model 1 was the better fit (PEP = 0.81) but because those fit by model 1 tended to have negative model 1 circumplex coefficients, there was a robustly significant average fit for model 1 in this condition.

Altogether, the mood induction effects (with the exception of the competitive drives item) provide no further support for the specific motivational video inducing activated affect and a motivated state for the group of participants as a whole, which was the overarching aim of this research. To address this stark difference from the clear findings of our 2 previous studies with motivational videos, we need to consider the key methodological difference in the current experiment: the EEG resting-state measure.

To minimise the decay of the video effects on the neural activity measure after a delay, our protocol (described in *section 4.2.3.2*) meant that participants completed EEG resting-state measures (resting with eyes open and eyes closed, for 10 minutes in total) prior to completing the post-test mood measure. It could well be that going through the resting-state EEG measure in a dark room (and including 5 minutes with eyes closed) acts as a mood deactivating experience which counteracted any mood activating effects of the RMV. After watching a short lecture video in the control condition, the 10-minute EEG procedure could have exacerbated any deactivating effects produced by this video or might even be responsible for the deactivation itself. If the latter case were true, then the fact that the EEG procedure did not on average produce any deactivation in the motivational video condition might be suggestive that the motivational video produced activation to offset the deactivating effect of the EEG procedure. It should be noted that the above argument, while seemingly plausible, goes against Occam's razor, in that we are proposing two effects to explain the lack of an effect. However, this explanation would fit with the clear activating effects produced by the same or similar motivational videos used previously in this thesis. This proposal could be tested in future work by running a similar protocol to the procedure in the current study, but with no video at all, i.e. measuring baseline mood, then running the EEG protocol, waiting 4 minutes with no video at all, re-running the EEG procedure, and then re-testing mood.

To emphasise the state-sensitive nature of using EEG measures, fundamental research has explicitly considered the affective context of the EEG testing environment, including mood changes after EEG equipment preparation (e.g., EEG capping), and even gender differences of both the participant and experimenter (Blackhart et al., 2002; Wacker et al., 2013). The research highlights that all participants tend to show a shift toward a more negative mood state after undergoing EEG preparation, which in turn is likely to have confounding effects on frontal asymmetry (e.g., Blackhart et al., 2002). The research also highlights that differences in baseline frontal asymmetry and approach motivation may be due to interpersonal interactions during EEG preparation, for example, when a male participant is tested by a female experimenter that they find attractive (e.g., as suggested by Wacker et al., 2013). Such research underlines the confounding nature EEG measures have particularly when the key dependent variable is within the mood realm itself.

Regarding the FAA results, there was a trend (*p* = .06) for the pre to post-test FAA by video condition interaction, reflecting the fact that there was a significant change (*p* = .004) in FAA from pre (M = .12, SD = .09) to post-test (M = .15, SD = .09) after watching the NCV but no average change at all after watching the RMV (pre-test FAA: M = .14, SD = .11; post-test FAA: M = .14, SD = .10). The change in FAA value in the NCV shows an increase in LFA, which is inconsistent with the NCV inducing more deactivated than activated affect, as an increase with LFA has previously been found to be related to activated affect and approach motivation (see *section 4.1.1* and *4.1.1*). The significant increase in LFA from before to after watching the NCV is quite small and needs to be considered tentatively. Nevertheless, one possible explanation for this trend could be that the EEG measure picked up on the rewarding feeling of the participants that the NCV finally finished (reflecting how it may have been boring, as possibly suggested by the induction of deactivated affect) and that the experimental process was coming to an end (Blackhart et al., 2002). It seems unlikely that a brief uplift in mood after a 4 minute video would have produced a sustained change in FAA over the 10 minutes of EEG recording that followed. Furthermore, if it was the EEG procedure itself that induced the deactivated mood ratings post video manipulation (as suggested earlier) then then NCV may not have been boring per se. This would also mean that the change in FAA (indicating increased left hemisphere activation) after watching the NCV is not necessarily consistent with the mood changes induced in the NCV group as a whole.

The effects of the resting-state EEG process may not, however, directly account for the lack of *significant* change in FAA for either video group. We should consider the nature and validity of frontal alpha asymmetry measures as indices of approach motivation. As previously discussed, greater LFA in EEG measures has been attributed more to state effects as opposed to trait effects (e.g., Wacker et al., 2013). While this may be the case, Rodrigues et al. (2021) also consider the time of the EEG frequency measurement, relating to different phases of motivation. They argue that frontal asymmetry is most prominent in the volition phase, where intentions are formed and approach motivation means a preparation to act or begin to execute the relevant behaviour (for a review see Hewig, 2018). In this case, movies (or videos) as a state induction are considered to be weaker manipulations (compared to more proactive T-Maze virtual reality tasks). Thus, the effects of our motivational video manipulation may not translate into changes in frontal asymmetry (Rodrigues et al., 2021).

Heckhausen and Gollwitzer's (1987) model of motivation-based phases of action distinguishes between phases of motivation and volition, and related intention transitions, action phases and subjective experience. Volition mostly involves intention initiation, which is the preparation and execution of actions, leading to the experience of being determined / having the urge to act and feelings of being energised, respectively. Motivation phases, temporally placed before and after the volition phase in the model, mostly involve intent formation (before volition) and intent realisation (after volition). Intent formation (which also occurs at the initiation of the volition phase) is the deliberation of actions, leading to the experience of "considering to do things", while intent realisation is the evaluation of the process, including evaluative feelings. Heckhasuen and Gollwitzer (1987) suggested that absent or weaker FAA was associated with these motivation phases (intent formation and intent realisation; in keeping with later findings by Hewig, 2018 and Rodrigues et al., 2021).

While the mood effects in the previous motivational video studies (chapter 2 and chapter 3) could provide evidence for the induction of an approach motivated state after watching the motivational video, it could be that instead of activating the volitation phase of motivation where greater FAA would be detected, the effects of the RMV stop at intent formation and the mere consideration of certain actions. The conscious lack of ability to physically perform any such actions (being somewhat constrained to sit in a chair in a dark room) in that moment may have prevented any apparent transition to the volition phase, including any associated feelings of energy and arousal. This may also be attributed to the reasons why the average change in mood in the motivational video condition did not lie along the activation-deactivation axis, unlike the robust effect found in the previous study using the same video, where participants were not physically constrained to an EEG amplifier with wires attached to their head.

Another key finding was that changes in FAA after watching either video did not correlate with overall mood changes. The negative changes along the activation-deactivation axis for participants in the NCV group should have corresponded with changes in FAA if LFA was indeed an index of motivated state (or demotivated state in this case). Possible reasons for this decoupling of FAA from mood might be the likely relatively low power (in a sample of around 40 participants). It could also be attributed to the methodological weaknesses of resting-state EEG measures described above. Other reasons might be suggested by a further review of the existing research in affective functions of frontal cortical asymmetry (e.g., Harmon-Jones & Gable, 2018). A final possible explanation of the decoupling between FAA and changes in the activation-deactivation model could be the different time points of measurement. The FAA index is measured in the 10 minutes following the video and maybe influenced by the nature of the video. The mood is measured after the 10 minutes of the EEG recording has been completed and may have been influenced by the deactivating effects of undergoing the EEG procedure itself (as previously discussed).

We also reported the moderator effects of personality traits, extraversion and neuroticism, on the change in affect, via the correlations between the trait scores and contrast and circumplex coefficients of the activation-deactivation and pleasure-displeasure models. Using all the available data, separately for each video condition, the correlations of the contrast coefficients of the activation-deactivation model with extraversion or neuroticism were small. The same was true of the corresponding correlations between the pleasure-displeasure model contrast coefficients and extraversion or neuroticism. The use of BMS allowed us to extrapolate the individuals' cases whose data were good fits for either of the models in either condition. This meant that we could perform the trait correlations on just the well-fitting cases to see if there was a relationship between the effects of watching the motivational video with either extraversion or neuroticism. These correlations were also all non-significant. However, the numbers of cases available for such an analysis were so small in the restricted analyses that they severely lacked power to detect correlations. A post hoc exploratory analysis was also conducted on the relationship between the personality traits and the pleasure-displeasure circumplex coefficients across both video conditions, for the well fit cases only. It was found that extraversion (but not neuroticism) significantly moderated the effect of pleasure-displeasure mood change in the RMV (negatively) versus NCV (positively) conditions. However, given the underpowered sample size of well fit pleasure-displeasure model cases and post hoc nature of this discovery, this effect may not be particularly informative.

The GEE analyses were also used to address personality relationships across the group as a whole. As GEE uses a robust method of estimation it is possible that such methods might be better able to detect personality effects across the whole group even when they are present in only a fraction of the whole sample. However, the GEE analyses showed no evidence for a moderation by extraversion or neuroticism of the prediction of the mood changes by the activation-deactivation circumplex in either video conditions. There was also no evidence for a moderation by extraversion nor neuroticism of the prediction of the mood changes by the pleasure-displeasure circumplex in either video condition.

Similar to the previous motivational video studies, it is therefore impossible to draw any firm conclusions from these analyses or to derive any clear implications for theories of individual differences in approach motivation, like the ARH (Gross et al., 1998) and RST (Smillie et al., 2006). Methodological weaknesses for the lack of effect in this personality domain were explained in detail in the previous two chapters (*section 2.4* and *section 3.4*) and to avoid repetition will not be elaborated upon here.

It is possible that the findings from Fox and Moore's (2019) study may account for the lack of personality moderation effects in the current experimental design. They used mood induction procedures to find that increases in positive affect were associated with greater extraversion, but only for low neuroticism participants. When analysed independently this relationship was such that higher extraversion was associated with less increase in positive affect, and neuroticism was associated with larger decreases in negative affect. Fox and Moore's (2019) study highlights the need possibly to consider *interactions* between traits as moderators to not oversimplify neural, personality, and behavioural networks. Nevertheless, looking at extraversion by neuroticism effects here would require a further increase in sample size to be able to reliably detect the effects, which was not possible due to resource limitations.

Furthermore, the capability model (Coan, Allen, & McKnight, 2006) explains that the relationship between trait measures and frontal asymmetry will emerge more effectively when resting state EEG is recorded under trait-relevant situations. However, if the task or manipulation is sufficiently overpowering and has features strongly targeting the volition phase of motivation (implementation of intention), it may overshadow the moderation effects of individual differences in response to the task or induction (Rodrigues et al., 2021). This could in theory have explained the moderation effects of extraversion and neuroticism on LFA after watching the RMV, had the task manipulation been very strong an induced large LFA changes in the current study. The pre to post-test increase in LFA was small albeit robustly significant (p = .004) in the NCV condition and was completely absent in the RMV condition. Thus, any lack of personality effects cannot be easily attributed to an overpowering volition phase induction.

The proposed relationships between BAS and extraversion, and between BIS and neuroticism, led us to predict that these traits might moderate the mood inducing effects of the motivational videos and associated changes in frontal asymmetry. For example, Wacker (2018) found that extraversion was indeed associated with state-related changes in frontal asymmetry, where those who were asked to imagine their future goals or eagerly awaited activities displayed a greater relative left frontal asymmetry that was positively correlated with scores of extraversion. However, they found no significant association between extraversion and baseline resting asymmetry, highlighting that frontal asymmetry is considered an indicator of motivational *states* that are differently activated in relevant situational contexts depending on relevant trait levels, as suggested by the capability model (Coan et al., 2006). Therefore, the lack of extraversion and neuroticism effects in the results of the current study may simply be a case of an unsuccessful motivational state induction preventing any relevant trait moderation effects from being observed. The previous studies in this thesis appeared to induce an activated motivational state (as judged by mood changes) and yet no clear relationships with extraversion or neuroticism were observed. However, this preceding argument in counteracted by two points. First, the NCV participants did report a clear increase in deactivated mood after watching the video and having their post-test EEG measured, where any trait which may moderate deactivated mood induction had the opportunity to act. Second, the previous thesis studies showed clear activated mood in the motivational video conditions but still no extraversion or neuroticism effects. This suggests that the nature of the mood induction by motivational videos and/or its heterogeneity across subjects in the same experimental condition may be the reason for the lack of clear personality effects in the current study as well.

4.4.1 Conclusion

This study sought to build on the implications of the previous study in chapter 3, by incorporating a more direct measure of left frontal activation, specifically EEG measures of frontal alpha asymmetry which are frequently used in neural mood induction research. We used the same motivational video, and closely matched control video, that were used in chapter 3. The motivational video had previously been found to be an effective form of appetitive mood induction (across the group as a whole). It was intended to utilize the effects of motivational videos to clarify what aspects of the mood induction process can be accounted for by reward processes and approach motivation, at a neural level.

There was an unexpected outcome: on average the participants in the control video condition (NCV) reported robust increases in deactivated mood after watching the video and having their

EEG assessed. No clear changes in activated affect were observed, on average, for participants in the motivational video condition (RMV). These outcomes were starkly different from the previous research in this thesis (where average increases in activated affect were observed selectively in the motivational video conditions). This change in outcome seems likely to be due to methodological issues pertaining to adding EEG procedures to the basic study design. Most notably there was a long delay after the video, before reporting mood, during which the potentially deactivating EEG procedure was conducted. However, once again, the pattern of mood changes reported by individual participants (in either video condition) varied considerably and this means that the average group effects in each condition do not give a completely accurate picture of the mood changes that were produced. The lack of significant correlations between mood and frontal asymmetry changes, and those with personality, may also partly be the result of these issues with the inclusion of the EEG and/or the within-condition heterogeneity in induced mood changes.

There was a significant pre-to-post increase in the FAA measure for the NCV group, reflecting a clear increase in LFA. In the RMV group there was no change in FAA whatsoever. However, this fell just short of achieving a significant interaction with the video condition. The mismatch in these findings between the changes in FAA and mood measures calls for a reappraisal of resting-state EEG measures especially in relation to procedures being used to achieve mood induction and when exploring the moderating effects of individual differences.

Chapter 5

Artificial social interaction: The effects of personality on learning during computerised social interactions with smiling faces

5.1 Introduction

We pointed out in chapter 1 (section 1.5) that social interactions are likely to share several processes with reinforcement leaning (RL). Furthermore, we noted that the social rewards (such as smiling faces), generated within social interactions, seem to activate the same dopaminergic mesocorticolimbic brain regions that are activated by non-social rewards (Izuma et al., 2008; Knutson et al., 2001; McClure et al., 2007; Satoh et al., 2003; Schultz et al., 1997; Spreckelmeyer et al., 2009; Zink et al., 2004). Social rewards and positive social feedback are considered to be present in a range of stimuli, such as beautiful or smiling faces (Aharon et al., 2001; Spreckelmeyer et al., 2009), Facebook likes (Marengo, Poletti, & Settani, 2020), and even include sharing resources (Hackel et al., 2020). The inferences made from socially rewarded interactions are often abstract cognitions about others' traits in a way that guides decisions concerning possible future behaviours and interactions with the same individuals (Hackel, Doll, & Amodio, 2015; Hackel et al., 2020).

In the studies reported in this chapter and the next we use smiling faces as social reinforcers to explore how such rewards may alter participants' impressions of characters with whom they briefly interact within a simple computerised social interaction task.

5.1.1 Neural correlates of social rewards and reinforcement learning

The value of a social interaction is estimated from the human ability to attribute stable traits to others that can be used to predict their future behaviour and associated rewarding outcomes (for a review, see Amodio, 2019). Although abundant research demonstrates common neural pathways for both social and non-social rewards (see chapter 1, section 1.5.1), research with social rewards is often carried out in experiments that lack any social context (other than that of interacting with the experimenter). For example, Izuma and colleagues (2008) used reaction times in a decision-making task comparing monetary and social rewards to understand their effects on RL. Such response latency tasks rely on the reasoning that as cues become reliably associated with the receipt of a reward, the manual responses to these cues quicken over the acquisition of learning (O'Doherty et al., 2003; McClure et al., 2003). The artificial social interaction studies in this thesis are a first step to try to investigate the effects of social rewards within a hypothetical social context.

5.1.2 Social reinforcement learning in a social context

In chapter 1 we reviewed two of the rare studies that explored the influence of social rewards within an experiment that actually used a social cover story for the task. The first study (Jones et al, 2011) used a novel probabilistic social reward task, in which participants learned to differentiate between three supposed peers. The peers were each associated with a probability of social reinforcement (33%, 66%, or 100% of trials), which was presented in the form of socially accepting feedback to a personal survey that the participants had previously completed. Key findings were faster responses on button presses for peers who more frequently provided positive social reinforcement, indicating differences in approach behaviours that are based on learning from prior social feedback. It can be argued that response latency measures, even in a social context, may not be an ecologically valid way to measure genuine approach behaviour. However, there was also an increase in ratings of likeability (rated from 1-not very likeable to 10-very likeable) throughout the task for the more reinforcing peers. These ratings highlighted the significance of positive social interactions in shaping social preferences and biasing behaviour (Jones et al., 2011).

After the studies in this thesis were completed, a second more recent study was published (Hackel, Meride-Siedlecki, & Amodio, 2020). This study used social RL to examine whether social contexts transform how people learn from feedback versus how they learn in non-social interactions. They tested whether participants had a preference for generous humans (trait-based learning) or rewarding slot machines (reward-based learning), relative to their less generous/rewarding counterparts, after a RL task. Some humans and slots offered larger amounts of money (displaying high reward value) and, independently, some offered larger proportions of available money (indicating trait-level generosity). The key results revealed that when interacting with humans, participants relied more on generosity (trait) information when forming preferences. On the other hand, they relied more on reward information (the value of the reward) when interacting with slot machines. They rated the generous humans and rewarding slot machines as more likeable than their respective counterparts, showing a discrepancy between different criteria for associations made with humans versus non-human interactions. In particular, the participants demonstrated enhanced learning from generosity feedback specifically in social interactions, consistent with the view that they inferred trait characteristics by which they determined the value of the partner they were interacting with (Hackel, Meride-Siedlecki, & Amodio, 2020).

5.1.3 Smiles as rewards for social reinforcement learning

As previously outlined, social reward stimuli (e.g., smiling or happy faces) have been used to measure rewarding effects on generally non-social measures (e.g., Knutson et al., 2000; Izuma et al., 2008; Spreckelmeyer et al., 2009). However, there is other existing research (see chapter 1, section 1.5.3 for more examples) that demonstrates how social behaviour and cue-action associations can be reinforced with smiles, as they are deemed to be intrinsically high in reward value (Averback & Duchaine, 2009; Furl, Gallagher, & Averback, 2012; Heerey, 2014). Heerey (2014) implemented a modified decision-making task (Kringelback & Rolls, 2003), where participants had to select different smiling faces (either genuine or polite) based on their comparative value (genuine smiles were considered to have a higher value than polite). Heerey (2014) found that when a social cue is more valuable (genuine) compared to a previously seen one, people show a bias to repeat the associated action. It was inferred that cues allow recipients to evaluate the outcomes of recent actions, as well as allowing the recipient to predict the quality of a social partner's likely responses to possible future actions. Heerey's (2014) study highlighted how the ability to learn from social rewards is an important contribution to individual differences in social ability. By using an autistic traits scale (Autism-spectrum Quotient Scale; ASQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), Heerey found that the ability to detect a masked contingency (i.e., being able to recognise that a polite smile was not genuine positive feedback) from social cues correlated with self-reported social-communicative ability (i.e., ASQ scores). Specifically, those scoring lower on the ASQ (reporting fewer autistic-like traits) had greater detection rates for genuine smiles, compared to those scoring higher on the ASQ.

5.1.4 Individual differences in social reinforcement learning

RL states that people attribute abstract, yet stable characteristics (such as reward value) to both humans and objects, and learn from rewards involving both humans and objects (Lin et al., 2011). Traits in social RL can provide a richer representation of conceptual information, which may help people make decisions about social partners that are relevant to an individual's current goals and their own intrinsic experience (Amodio, 2019; Hackel et al., 2019). Individual experience and its relationship with goals, motivation, and preferences is highly dependent on traits and personality. As noted in earlier chapters, the reinforcement sensitivity theory (RST; Pickering et al., 1995; Smillie et al., 2006) provides a biological account for why some personality traits may both derive from, and lead to, a propensity to respond to rewards in differing ways from their counterparts.

As noted in previous chapters, people with high trait extraversion are described as being sociable, warm, assertive, fun-seeking, bold, talkative, and are usually seen as having higher positive emotionality, compared to their introverted counterparts (Butt & Phillips, 2008; Wilt & Revelle, 2019). The reward theory of extraversion (a specific sub-variant of RST) holds that the trait's characteristics and behaviours associated with extraversion can be partly attributed to differential sensitivity to the motivational impact of rewarding stimuli, and variation in the drive to obtain such stimuli. Namely, boldness and talkativeness may be viewed as expressions of reward-directed behaviour, and positive emotionality can be seen as affective responses to reward pursuit and attainment (DeYoung, 2010; Smillie, 2013; Wilt, Bleidorn, & Revelle, 2017). Smillie et al. (2011) adapted a probabilistic associative learning paradigm (Potts et al, 2006) and found that the EEG response, termed the Reward Positivity (Proudfit, 2015), was larger in extraverts compared to their introverted counterparts (a finding which was replicated by Cooper et al., 2004 and Smillie et al., 2019). Adapting this model of extraversion for the effects of social stimuli and utilising a different event-related potential (ERP) methodology, a study by Fishman, Ng, and Bellugi (2011) found that higher scores on extraversion were associated with higher amplitudes of the P300 component the ERPs elicited by human facial stimuli, suggesting that social stimuli carry enhanced motivational significance for those who are characterised as having high trait extraversion.

Neuroticism, however, is characterized by emotional instability and neurotic individuals are generally anxious, nervous, angry, and fearful (Heinström, 2003). With regards to the RST, Neuroticism is most commonly associated with the sensitivity/reactivity of the behavioural inhibition system (BIS; Barlow et al., 2014). Classical studies on reward processing in neuroticism have found that the trait is negatively correlated with conditioned responses to appetitive (rewarding) stimuli (Corr, 2004; Paisey & Mangan, 1988). In a social learning context, it has been found that individuals who score high on neuroticism are more likely to be susceptible to social influence strategies than those who are low on neuroticism (Oyibo & Vassileva, 2019). However, to our knowledge there has been no empirical evidence testing how the effects of RL using social stimuli are moderated by neuroticism as a trait measure of anxiety and/or BIS functioning. The current study, therefore, attempts to address this omission.

The involvement of social reward processing and learning during social interactions, which are perpetual throughout daily life, gives rise to considerations of the possible debilitating effects for those who have aberrant social reward processing. While showing possible heterogeneity within the continuum of reward sensitivity, aberrant social reward processing is recognised to be a feature of a number of disorders, most commonly schizophrenia (Catalano, Heerey, & Gold, 2018), depression (Pechtel et al., 2013), social anxiety (Cremers et al., 2015), and autism spectrum disorders (Cox et al., 2015; Delmonte et al., 2012). Typically, this is manifest as a blunted reward responsiveness, which can lead to detrimental effects on an individual's self-image, emotion, cognition, and general well-being (Makkar & Grisham, 2011). These clinical observations highlight the importance of developing a paradigm using reinforcement learning with fundamental social feedback. The current study assesses trait moderation effects that, in future work, might be effectively incorporated into neuroimaging and/or clinical studies. The present study addresses a possible role for aberrant social reward processing by the inclusion of the Autism Spectrum Quotient (ASQ-28; Hoekstra et al., 2011), as a further trait moderator in addition to extraversion and neuroticism.

5.1.5 The present study

The present study, therefore, builds on the above work to formulate a novel social probabilistic reinforcement task coined the Artificial Social Interaction (ASI) task. Functions of social probabilistic learning (Jones et al., 2011), trait learning (Hackel, Mende-Siedlecki, & Amodio, 2020), the use of smiles as social rewards in positive feedback (Heerey, 2014), and trait associations of the reinforcement sensitivity theory (Corr, 2004) set the rationale of this study. The main aim was to test if smiles as responses within an artificial social interaction are a type of social reward that can enhance learning in a probabilistic task, and if this learning is greater for extraverts. Further to this, the study addresses a possible process by which a biological propensity to learn more from salient social rewards than others, might lead to someone becoming more extraverted in the sense of more frequently engaging with other people socially. The argument uses the following reasoning: (i) perceptions about other people are affected by the associative learning of their "social reward value", which in turn will be greater in people with heightened reward sensitivity; (ii) the learner thus finds people more likeable and judges them as more extraverted to a greater extent than people with lower levels of reward sensitivity; (iii) as a result they find people's company more enjoyable than do people who are less reward sensitive, and so they self-identify as more extraverted on trait questionnaires.

As noted above, further trait measures were added to provide exploratory tests of their moderating effects on social reinforcement. Neuroticism was included due to its association with the reinforcement sensitivity theory and trait anxiety (Barlow et al., 2014). A measure of autistic traits was included due to previous associations with social ability and social reward responsiveness (Jones et al., 2011). Finally, agreeableness was added as an exploratory measure simply because of its characterisation as a trait that indexes friendliness, compassion, and empathy (de Oliveira et al., 2003).

Taking this reasoning, the computer based ASI task was developed to test the following predictions: (a) characters who smile more throughout the artificial interactions (reinforcing characters) will be rated as people the participants would be more likely to befriend, as more likeable, and as more extraverted and agreeable, but less neurotic, than the characters who smile less (non-reinforcing characters); (b) the names of the reinforcing characters will later be recognised more accurately than those of the non-reinforcing characters; and (c) these character-type effects (reinforcing vs. non-reinforcing) will be moderated by participants' levels of extraversion, neuroticism, agreeableness, and autistic traits. It should be noted that prediction (b) assumes that the associative learning between a visual face identity and their reinforcing or non-reinforcing nature spreads to association with more abstract aspects of the identity (such as their name; Amodio, 2019), even though the names are presented incidentally as part of the artificial social interaction task. It should also be noted that prediction (c) is made primarily for extraversion and is much more exploratory for neuroticism, agreeableness, and ASQ given the dearth of previous research. The moderation predictions by extraversion therefore form separate families of tests of specific hypotheses as explained below when considering alpha adjustments to protect the familywise Type 1 error rate.

5.2 Methods

5.2.1 Participants

148 (114 female; mean age M= 19.7 years, SD= 2.78 years) healthy first year psychology undergraduates of Goldsmiths, University of London, volunteered their time in exchange for course credits. Informed consent was provided prior to the commencement of the experiment, as required by the ethical approval given by the Psychology Department ethics committee at Goldsmiths, University of London. All the participants were tested simultaneously in a large, silent lecture hall, with each participant completing the tasks and responding to the questionnaires via an online Qualtrics link. Each participant carried out the study on their own laptop or smart device. The sample size here was determined by the first year undergraduate psychology class for this year. With normal levels of participation in these sessions we estimated around 150 students would take part. This was a prediction that turned out to be correct. With a correlation of .2 (or -.2) between a personality trait and a DV (difference in ratings for reinforcing characters and non-reinforcing characters) then, for a one-tailed test with an unadjusted type 1 error rate of 0.05, this effect size and sample would generate very close to 80% power. Correlations of 0.2 are typical in personality trait research.

5.2.2 Artificial Social Interaction task

The Artificial Social Interaction (ASI) task was implemented on Qualtrics. The learning phase of the ASI task composed of 5 sperate interactions with each of the 12 different characters (facial stimuli taken from the NimStim set of facial expressions; Tottenham et al., 2009). The interactions were across different descriptions of social contexts (blocks), resulting in a total of 60 trials (interactions) across the learning phase of the task. For each block of 12 trials (one interaction per character in each block), the social context was first described for that set of encounters (e.g., a house party or passing in the street), and participants had computerised "interactions" with each of the 12 characters. Taking the first encounter as an example (see Figure 5.1), the character's face was first presented for 3 seconds with a neutral expression along with a dialogue, printed on the screen, of them introducing themselves to the participant (e.g., "Hi, I'm James."). When both the face and text disappeared, the participant was then asked to actively select a typical, friendly response (e.g., "Hi James, I'm [your name]. It's nice to meet you."). Once they made the response and clicked next, they were then presented with how the character reacts to this interaction as feedback to their response. Feedback to this response was the same face being presented either with a smiling expression (opened mouthed smile) or with the same neutral expression for 2 seconds. For encounters 2, 3, 4, and 5, the interaction dialogue involved greeting each other (e.g., "Hi, it's nice to see you again.") and the names of the characters were not included in the third, fourth, or fifth encounters.

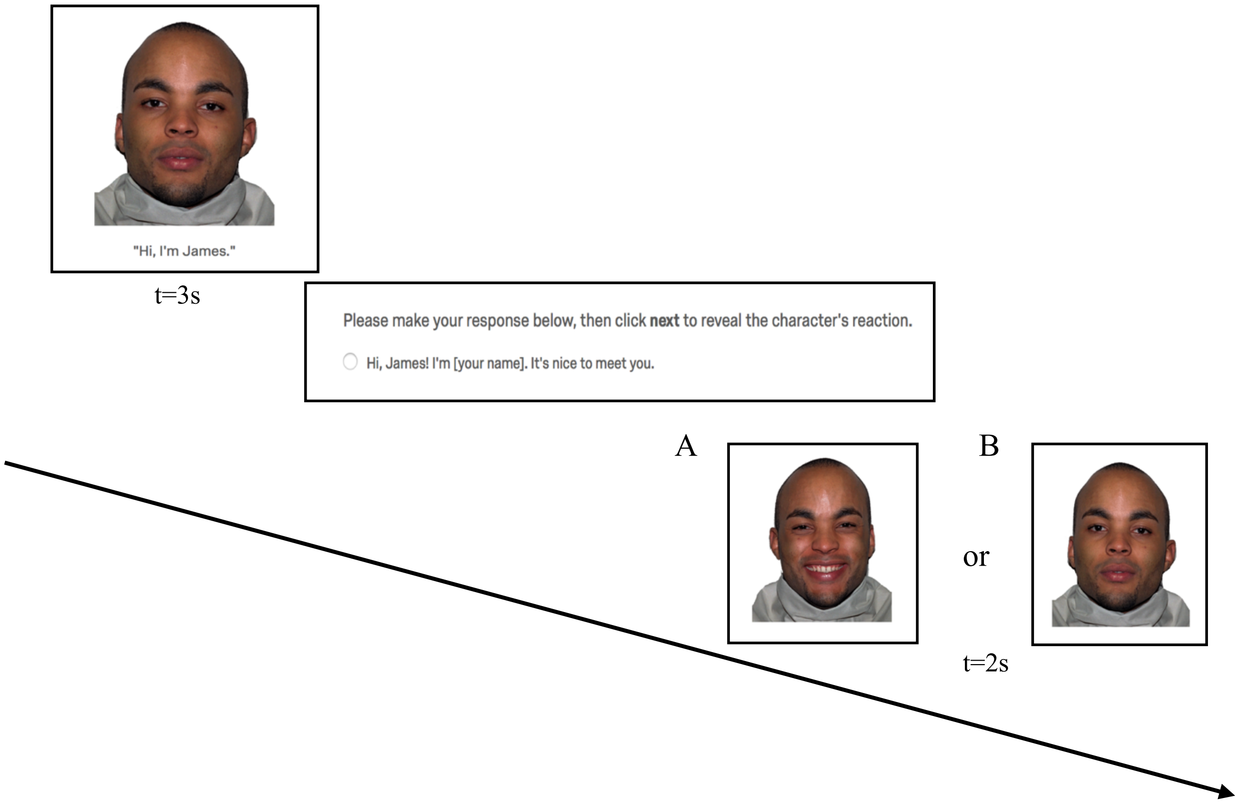


Figure 5.1: Diagram of an example of an interaction in the first encounter, showing stimulus presentation, response selection, and feedback stimulus.[14]

Half of the characters were designated as reinforcing and the other half as non-reinforcing stimuli. This was based on the probability of them giving feedback as either a smiling or neutral face, respectively, using an 80/20 probability ratio which has been used in other reward association learning paradigms (e.g., Potts et al., 2006; Smillie et al., 2019). Specifically, 6 characters were coded to give feedback to the participant's response with a smiling face for 80% of the encounters, while the 6 non-reinforcing characters gave a neutral expression as feedback 80% of the time, smiling only 20% of the time. There was an equal number of male

[14] James would be a reinforcing character if he more often responded as in panel A, or a non-reinforcing character if he more often responded as in panel B.

and female characters overall and equal numbers of each gender within the subsets of 6 reinforcing and 6 non-reinforcing characters. The reinforcing and non-reinforcing characters were the same for every participant and were not counterbalanced at this point, as this would have been awkward to implement in the experiment flow control in Qualtrics (this design issue is revisited in chapter 6). Given that each character was presented 5 times to the participant, this meant that reinforcing characters gave 4 instances of smiling feedback and 1 neutral with the complementary numbers for non-reinforcing faces (4 instances of neutral feedback and 1 smiling). The pattern of smiling was always presented in a random order, which was different for each character and encounter, and was also different for each participant.

Once having completed the learning phase of the task, participants were given a surprise name recognition memory task, where they were shown the neutral face of each of the 12 characters and were asked to select the correct name from a possible three presented below the stimulus. The two distractor names began with the same letter and a similar number of letters as the correct name in an attempt to avoid priming effects and to increase the difficulty of the task. In the example given above, the name James would be presented with Jason and Jacob. A complete list of character names and recognition memory test distractors is given in Appendix E.

Once they completed the name recognition memory task, the participants were shown the neutral faces of each of the 12 characters again, however this time they were asked to rate each of them on 8 adjectives derived from each of the Big Five Dimension facets and correlated trait adjectives (John and Srivastava, 1999). Each adjective belonged to a facet related to either extraversion (e.g., sociable), agreeableness (e.g., sympathetic), or neuroticism (e.g., moody), 3 of which were adapted to be negatively keyed (see Table 5.1). These ratings were obtained using a 10-point scale, representing the extent to which each adjective described the personality of the character based on the participant's interactions with them throughout all five encounters. Participants were then asked to rate each character on how much they liked them (likeability rating) and how likely they were to befriend them (befriending rating), again based on their interactions with each character. This was also done on a 10-point scale.

Table 5.1: The Big Five Dimension adjectives used to rate the characters' personalities on extraversion, neuroticism, and agreeableness (adapted from John and Srivastava, 1999).

Big Five Dimension	**Facet correlated trait adjective**
Extraversion	Sociable Outgoing Unenthusiastic (negatively keyed)
Neuroticism	Moody Tense Self-confident (negatively keyed)
Agreeableness	Sympathetic Stubborn (negatively keyed)

5.2.3 Psychometric measures

The Big Five Aspect Scale (BFAS; DeYoung et al., 2007) was used to measure the participants' levels of extraversion, neuroticism and agreeableness. The Autism Spectrum Quotient (ASQ-28; Hoekstra et al., 2011) was used to measure autistic traits. These measures were given after the ASI task was completed.

5.3 Results

Data were initially analysed using SPSS version 23.0. The sum scores of the extraversion, neuroticism, and agreeableness items from the BFAS (DeYoung et al., 2007), and the ASQ-28 (Hoekstra et al., 2011) were calculated for each participant. In order to test the influence of participant levels of extraversion, neuroticism, and agreeableness as moderators on the different character ratings, a series of general linear models was applied, with the moderators added as covariates separately in each analysis. The character type (reinforcing vs. non-reinforcing was used as a repeated-measures factor in this model. The interaction between the moderator and the reinforcement main effect offers the primary test of the individual differences predictions in this chapter. Moreover, this interaction corresponds to the correlation between the trait moderator and the difference score on the DV between reinforcing and non-reinforcing characters. The scores of all the trait measures were first standardized to z-scores. For the DVs, the mean character ratings (i.e., the extraversion, neuroticism, agreeableness, likeability and befriending ratings) were calculated and the means of the reinforcing and non-reinforcing character scores were separated. The mean number of reinforcing and non-reinforcing names recognised correctly were also calculated.

There are a set of three correlations (trait by reinforcement type interactions) that all test the hypothesis that the reinforcing effect of a character will affect rated personality on three rated traits (extraversion, neuroticism, agreeableness) and that the reinforcement effect will be moderated by the primary participant trait of interest, extraversion. This is a family of 3 tests and so should be tested at $\alpha = \frac{.05}{3} = .017$.

The other nine correlations (three trait rating differences moderated by the other three participant trait scores) are more exploratory in that we did not have such clear predictions about the moderator effects. They test a broader hypothesis that other potentially relevant participant personality traits (neuroticism, agreeableness and autism spectrum) may moderate the character type effect on the three personality ratings. We, therefore, adjust this set to an alpha of $\alpha = \frac{.05}{9} = .006$.

The two extraversion correlations for befriending and likeability ratings (social interaction ratings) test our hypothesis that extraversion will moderate the reinforcing character type effects on social interaction ratings. They will be tested at $\alpha = \frac{.05}{2} = .025$.

The remaining six correlations test our exploratory hypothesis that trait neuroticism, agreeableness, and ASQ may moderate the character type effect on social interaction ratings. They will be tested against $\alpha = \frac{.05}{6} = .008$.

The set of correlations that test the hypothesis that the reinforcing effect of a character will also influence name recognition memory (and that effect will be moderated by participant extraversion) were separated in the same way, where the effects of trait extraversion was tested against $\alpha = .05$.

The effects of trait neuroticism, agreeableness, and ASQ on name recognition memory was tested against $\alpha = \frac{.05}{3} = .017$. This logic of sorting statistical tests into families in relation to the scientific hypothesis that they test, and then adjusting alpha within families to protect the familywise alpha rate, is the recommended approach under the Neyman-Pearson logic of null hypothesis significance testing (Lakens, n.d.). Some researchers may argue that exploratory statistical tests should not be adjusted for multiple comparisons but we have adopted a more conservative approach in this chapter.

5.3.1 Character personality ratings

The general linear model showed a reinforcement type effect on character ratings where there was a significant difference between reinforcing and non-reinforcing faces on their rated extraversion [M = 5.75, SD = 1.21; M = 4.18, SD = 1.01 respectively; $F(1,147) = 176.84$, $p < .001$, $\eta p^2 = .55$], rated neuroticism [M = 3.92, SD = 1.23; M = 4.95, SD = 1.05 respectively; $F(1,147) = 92.36$, $p < .001$, $\eta p^2 = .39$], and rated agreeableness [M = 5.61, SD = 1.07; M = 4.43, SD = 1.21 respectively; $F(1,147) = 84.16$, $p < .001$, $\eta p^2 = .37$] (see Figure 5.2). Specifically, the reinforcing characters were rated as more extraverted and agreeable, and less neurotic than the non-reinforcing characters. It should be emphasized that these main effects of our reinforcement manipulation appear very robust (partial eta squared from .37 to .55).

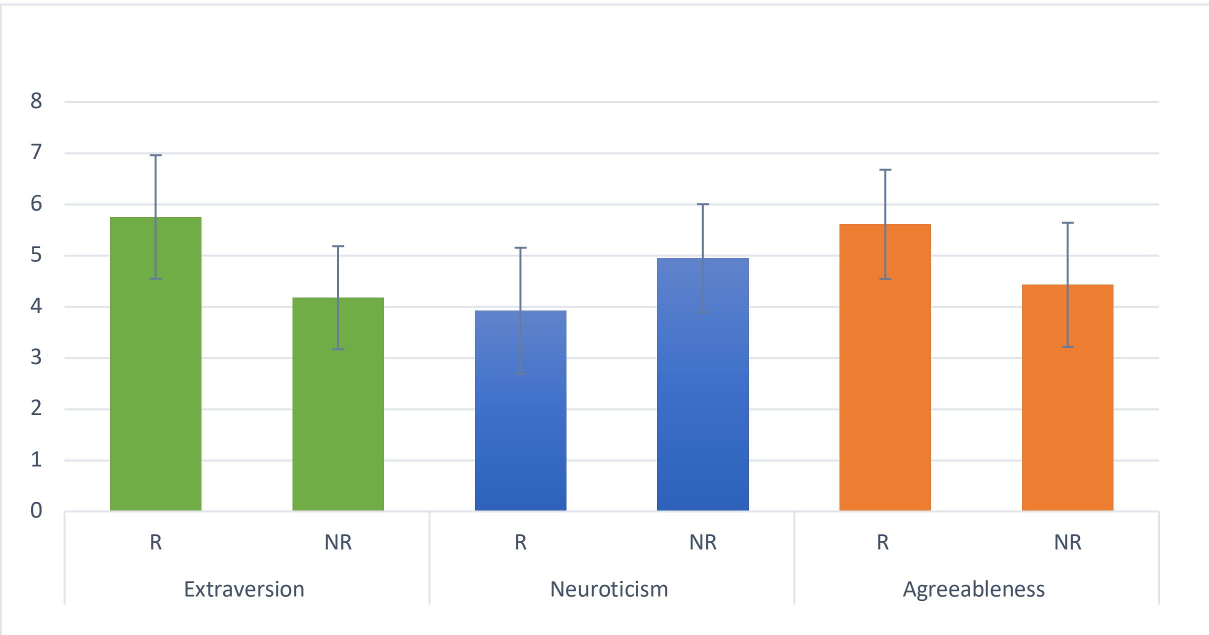


Figure 5.2: Mean scores and standard deviations for personality ratings of reinforcing (R) and non-reinforcing (NR) characters.

Separate general linear models were run with each participant trait as a predictor along with the character type for each personality rating. For participant trait extraversion, there was a significant interaction with the character type effect of rated extraversion [$F(1,141) = 5.23$, $p = .014$ (c.f. adjusted $\alpha = .017$), $\eta p^2 = .042$]. However, there were no significant interactions of participant trait extraversion with reinforcement type effect on rated neuroticism [$F(1,141) = .707$, $p = .402$, $\eta p^2 = .005$], nor an interaction between extraversion and rated agreeableness [$F(1,141) = 1.678$, $p = .197$, $\eta p^2 = .012$].

For participant trait neuroticism, the interactions with character type effect of rated extraversion [$F(1,140) = 6.02$, $p = .015$ (c.f. adjusted $\alpha = .006$), $\eta p^2 = .041$], rated neuroticism [$F(1,140) = 4.73$, $p = .031$ (c.f. adjusted $\alpha = .006$), $\eta p^2 = .033$], and rated agreeableness [$F(1,140) = 4.36$, $p = .039$ (c.f. adjusted $\alpha = .006$), $\eta p^2 = .030$] do not survive the adjusted alpha level. It should be noted that the effect of participant neuroticism as a moderator of the reinforcement type effect on rated extraversion has an almost identical effect size ($\eta p^2 = .041$) to the participant extraversion moderation effect on reh same DV ($\eta p^2 = .042$). The difference in formal significance against adjusted alpha levels thus reflects our a priori decisions about the way our hypotheses were addressed with families of statistical tests.

For participant trait agreeableness, the interaction with the character type effect of rated extraversion [$F(1,143) = 5.10$, $p = .025$ (c.f. adjusted $\alpha = .006$), $\eta p^2 = .034$] does not survive the adjusted alpha level. There is no significant interaction between trait agreeableness and the character type effect of rated neuroticism [$F(1,140) = 4.36$, $p = .039$ (c.f. adjusted $\alpha = .006$), $\eta p^2 = .030$]. However, there was a significant interaction between character type effect and participant agreeableness [$F(1,143) = 15.376$, $p < .001$, $\eta p^2 = .097$][15].

For participant autistic traits, the interaction with the character type effect of rated extraversion [$F(1,143) = 5.04$, $p = .026$ (c.f. adjusted $\alpha = .006$), $\eta p^2 = .034$] does not survive the adjusted threshold for significance. There is no significant interaction between autistic traits and the character type of rated neuroticism [$F(1,143) = 2.61$, $p = .109$, $\eta p^2 = .018$], nor agreeableness [$F(1,143) = 1.10$, $p = .295$, $\eta p^2 = .008$].

[15] The slight difference in error df values is due to a small variation in missing trait data.

To illustrate the direction of all the moderation effects of the participant trait measures on the character-type effect of the reinforcing and non-reinforcing faces, bivariate correlations were conducted. The non-reinforcing (lower) scores were subtracted from the reinforcing (higher) scores for ratings of extraversion and agreeableness (reinforcing advantage), while the reinforcing (lower) scores were subtracted from the non-reinforcing (higher) scores for ratings of neuroticism (non-reinforcing advantage). These correlations are reported and summarized in Table 5.2. Note once again that the tests on these correlations are identical to the interaction tests reported for the general linear models above. They include the alpha level adjustments for multiple comparisons described above.

Table 5.2: Correlational relationship between the character personality ratings and participant trait scores. Non-reinforcing ratings of extraversion and agreeableness were subtracted from reinforcing, while reinforcing ratings were subtracted from non-reinforcing ratings for neuroticism. Note that the tests on these correlations are identical to the interaction tests reported for the general linear models in the text. The row of extraversion correlations represents one family of tests; the other three rows represent a second family of tests as noted in the text.

Participant Personality Traits	**Character Personality Ratings**					
	Extraversion (reinforcing advantage)		**Neuroticism (non-reinforcing advantage)**		**Agreeableness (reinforcing advantage)**	
	r	**p**	**r**	**p**	**r**	**p**
Extraversion	.206*	.014	.071	.402	.108	.197
Neuroticism	-.203	.015	-.181	.031	-.174	.039
Agreeableness	.186	.025	.117	.161	.312**	<.001
ASQ	-.184	.026	-.134	.109	-.088	.295

** Correlation is significant tested against the .006 level (2-tailed).
* Correlation is significant tested against the .017 level (2-tailed).

The correlation of participant extraversion and ratings on character extraversion withstands the adjusted alpha level (see Table 5.2). Participant extraversion has a positive correlation with the degree to which reinforcing characters are given more extraverted personality ratings than non-reinforcing characters.

The exploratory correlation of participant agreeableness and ratings on traits also withstands the adjusted alpha level for the rated trait of agreeableness. Participant agreeableness has a positive correlation with the degree to which reinforcing characters are given higher agreeable personality scores than non-reinforcing characters. It is clear from table 5.2 that the moderation effects on rated extraversion are all of a very similar size (around 0.2 or -0.2) for each of the four moderating participant traits. As already noted above, the a priori decision to put the primary participant trait of interest (extraversion) into one family and the other three potential traits (neuroticism, agreeableness, and autistic traits) into another family of tests affects their formal significance against adjusted alpha thresholds. However, an obsession with whether a test falls one side or other of a significance threshold has been argued to be one of the main contributors of the reproducibility crisis in psychology (Maxwell et al., 2015; Wasserstein & Lazar, 2016).

To supplement these traditional correlational analyses, we also ran some Bayesian correlations using the jamovi software (version 1.6.21). In a Bayesian correlation one obtains an estimate of the correlation and its confidence intervals (known as credible intervals in Bayesian statistics) as well as a Bayes factor (BF) expressing the ratio of support for the alternative hypothesis (H1; a directional prediction that the correlation differs from zero in a specific direction) relative to the null hypothesis (H0; the correlation = 0), in light of the data collected. Thus, BF_{10} is used to refer to the Bayes factor for H1 relative to H0 (note that jamovi reports these Bayes factors as BF_{+0} for a one-tailed H1). We used Bayes factors in the analyses of the effects of motivational videos on mood in chapters 2, 3 and 4. A value $BF_{10}=1$ means that the data favour H1 and H0 equally and as this value rises above 1 the data provide more evidence in support of H1 relative to H0, and as BF_{10} falls from 1 towards 0 this represents increasingly strong evidence in favour of the null hypothesis. We commented previously that authors have suggested thresholds for different levels of Bayes factors. In our analyses of motivational video effects, we took a $BF_{10}>=10$ as “strong” evidence in favour of H1, following a popular scheme advanced by Kass and Raftery (1995). Other authors (e.g., Dienes, 2014) have used these same descriptors of the evidence thresholds but argued that a $BF_{10}>= 3$ (moderate evidence) is noteworthy and roughly corresponds to a standard p value cut-off of 0.05 in traditional statistics. These cut-offs are of course fairly arbitrary, and others (Evett, 1991) have, for example, recommended that the description of “strong evidence” should be used for BFs>=20.

Bayesian correlations can be one or two tailed and we opted for one-tailed correlations whenever we had clear predictions as to the direction (sign) of the predicted correlations. A very important feature of Bayesian analyses is the so-called prior distribution for the statistic under test. In the case of a first study of a phenomenon, as here, this would be the experimenters’ beliefs about the range of possible values (and their relative likelihood) for the correlations under test, before carrying out the experiment. In our earlier power-based sample size estimation, using experience of typical correlations with personality traits, we used a "fixed-point" value of 0.2 (or -0.2 where the correlation was expected to be negative). In Bayesian analyses we are not limited to a fixed-point estimate and can use a distribution of correlations values. Jamovi allows us to set a parameter (called the stretched beta distribution prior parameter value) which controls the shape of the prior distribution. The default value of 1 for this parameter means that all possible values of the corelation are equally likely. In the case of a 1-tailed (predicted positive) correlation this means that our prior distribution rates all correlations in the range 0 to +1 as equally likely (it creates a "uniform" prior). In our view this is not a sensible choice of prior for behavioural correlates with a personality trait. As previously noted, such corelations typically are around 0.2-0.3 across a huge range of studies. Given file drawer effects, many correlations are probably also in the range 0-0.2. We therefore decided to choose a value of the prior which puts much of prior expectation for the corelation in this range, and very little expectation that the correlation would be >+0.5, as correlations this large are very rare in behaviour-trait correlation studies. It turns out (see Figure 5.4 lower upper panel) that setting the stretched beta parameter to 0.15 creates a prior distribution for the correlation that fits our general expectations far better than the uniform distribution (obtained with the default beta parameter =1.0).

One point to note as a caution over the BF analyses here is that the logic of protecting alpha rates was developed for classic statistical hypothesis testing. It doesn't apply to Bayes factor analyses, and there is as yet no agreed way to take multiple testing into account. However, it is intuitively obvious that as more analyses are run then the chances that BF results will appear to support H1, even when H1 is not true, will increase (see Jefferys & Berger, 1992; Scott & Berger, 2006 for discussions).

We computed Bayesian correlations in jamovi between participant extraversion and rated character traits (extraversion, neuroticism, and agreeableness). The scatter plot for participant extraversion on the reinforcing advantage for rated extraversion (i.e., rated extraversion of the reinforcing characters minus the rated extraversion of the non-reinforcing characters) is shown below in Figure 5.3.

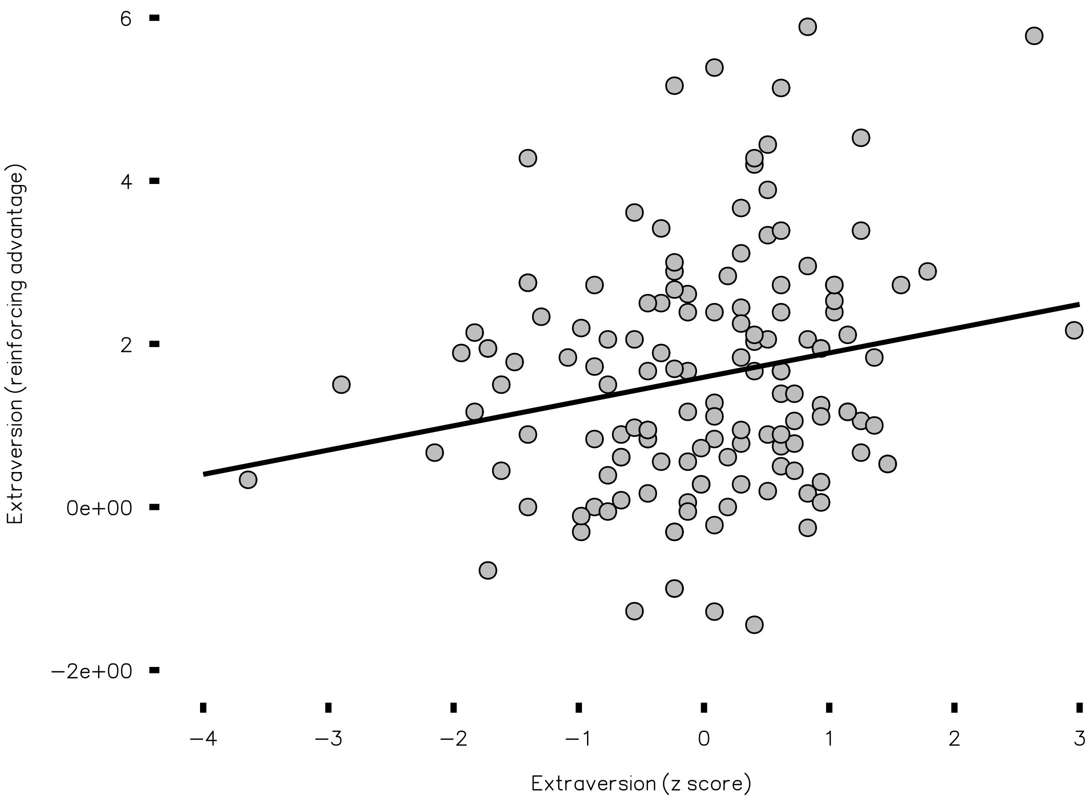
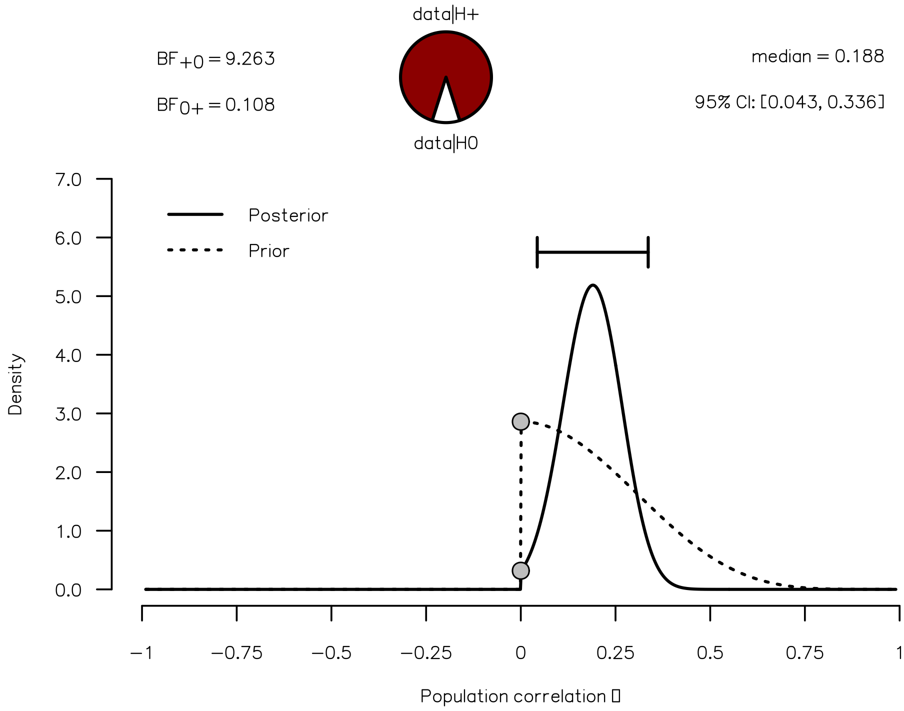


Figure 5.3: Scatter plot showing the z score of participant extraversion correlation with the reinforcing advantage for rated extraversion (r = +0.206).

In the case of participant extraversion correlation with reinforcing advantage on rated extraversion, the correlation was positive as predicted, and the Bayesian correlational analysis results can be depicted graphically.



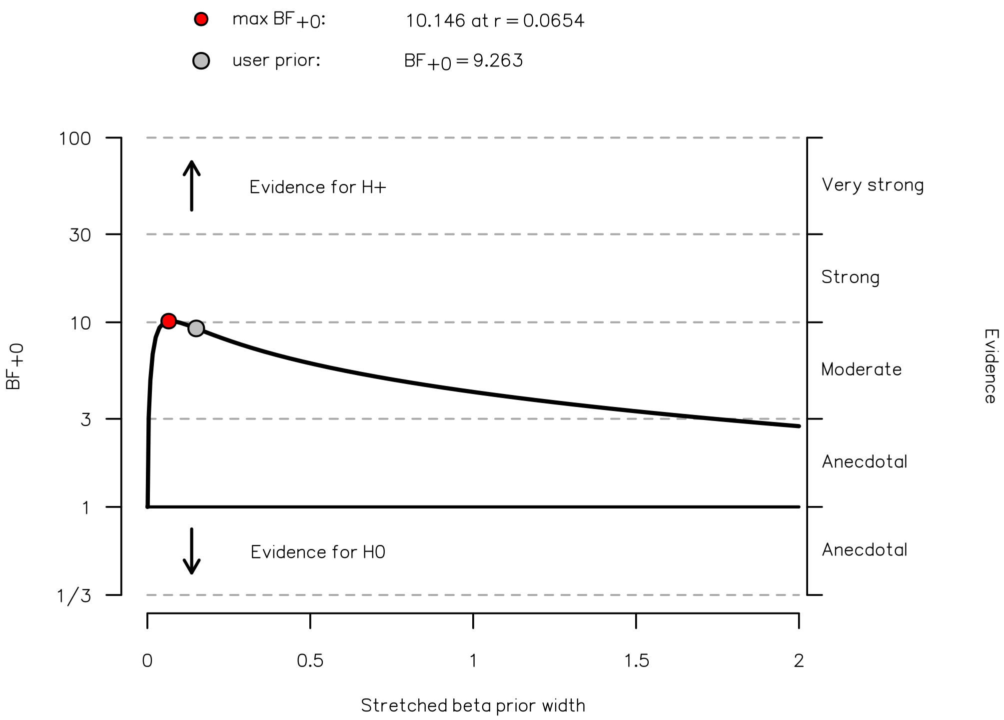


Figure 5.4: Upper panel: Posterior and prior distributions of correlation values (prior was set by a beta parameter of 0.15), for the correlation between participant extraversion and the reinforcing advantage of rated extraversion. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

The upper panel of the above figure (Figure 5.4) shows that the Bayesian correlation has a median value of 0.19 and the 95% credible interval (CredInt) is between .043 and 0.336. The Bayes Factor, BF_{10} (which is denoted as BF_{+0} in the above figure as it is one-tailed hypothesis) is 9.26, very close to the value of 10 which is often taken to indicate that the correlation provides strong support for H1 relative to H0 (zero correlation). The panel also shows a graphical description of the prior distribution of correlation values (dotted line) as set by the stretched beta parameter of .15. It is visible that most of the prior value lies between 0 and .25 and very little at all is above .5. The posterior distribution is the estimated distribution of the correlation after seeing the data (solid line) and shows the central tendency lies close to .2 with the 95% CredInt marked by a horizontal line above the posterior distribution.

The lower panel (of Figure 5.4) gives a robustness check for the BF, showing how it varies with different settings for the prior distribution parameter. With our a priori choice of beta parameter (.15) we get the BF as shown by a grey dot. A lower value for the beta parameter would have given a slightly higher BF, with a maximum of 10.15 (marked with a red dot) for a beta choice of .065. Although the BF decreases slowly for higher beta values, it should be noted that the BF is still well above 3 (moderate evidence for H1) even at the very unrealistic uniform prior (beta parameter=1, where BF = 4.2).

For the correlation of participant extraversion and the non-reinforcing advantage for rated neuroticism (i.e., rated neuroticism of the non-reinforcing characters minus the rated neuroticism of the reinforcing characters) the Bayesian correlation has a median value of .09 and the 95% CredInt is between .005 and .227. The Bayes Factor, BF_{10} is .63, indicating that the correlation actually tends to provide weak support for H0 relative to H1 (as the BF_{10} is smaller than 1). For the correlation of participant extraversion and the reinforcing advantage for rated agreeableness the Bayesian correlation has a median value of 0.11 and the 95% CredInt is between .009 and .256. The Bayes Factor, BF_{10} is 0.63, again indicating that the correlation actually tends to provide weak support for H0 relative to H1 (as the BF_{10} is smaller than 1).

We computed Bayesian correlations between participant neuroticism and rated character traits (extraversion, neuroticism, and agreeableness), where the correlations were predicted to be negative (and these see Table 5.2). For the correlation of participant neuroticism and the reinforcing advantage for rated extraversion the Bayesian correlation has a median value of -0.19 and the 95% CredInt is between -.334 and -.041. The Bayes Factor, BF_{10} is 8.44, indicating that the correlation provides moderate support for H1 relative to H0, but close to the threshold of 10 we are adopting as strong evidence in favour of H1. This reinforces the comment above that the moderation effect of participant neuroticism on rated extraversion is of similar strength to the moderation effect of participant extraversion on rated extraversion (albeit in the opposite direction).

For the correlation of participant neuroticism and the non-reinforcing advantage for rated neuroticism the Bayesian correlation has a median value of -.17 and the 95% CredInt is between -.316 and -.029. The Bayes Factor, BF_{10} is 4.74, indicating that the correlation provides moderate support for H1 relative to H0.

For the correlation of participant neuroticism and the reinforcing advantage for rated agreeableness the Bayesian correlation has a median value of -0.16 and the 95% CredInt is between -.310 and -0.026. The Bayes Factor, BF_{10} is 4.01, indicating that the correlation provides moderate support for H1 relative to H0.

We computed Bayesian correlations between participant agreeableness and rated character traits. For the correlation of participant agreeableness and the reinforcing advantage for rated extraversion the Bayesian correlation has a median value of 0.17 and the 95% CredInt is between .032 and .319. The Bayes Factor, BF_{10} is 5.58, indicating that the correlation provides moderate support for H1 relative to H0.

For the correlation of participant agreeableness and the non-reinforcing advantage for rated neuroticism the Bayesian correlation has a median value of .12 and the 95% CredInt is between .010 and .262. The Bayes Factor, BF_{10} is 1.29, indicating that the correlation provides only weak support for H1 relative to H0.

For the correlation of participant agreeableness and the reinforcing advantage for rated agreeableness the Bayesian correlation has a median value of .29 and the 95% CredInt is between .138 and .425. The Bayes Factor, BF_{10} is 457.9, indicating that the correlation provides very strong support for H1 relative to H0 (BF > 100 is considered decisive).

We computed Bayesian correlations between participant ASQ and rated character traits (extraversion, neuroticism, and agreeableness), where the correlations are predicted to be negative (see Table 5.2). For the correlation of participant ASQ and the reinforcing advantage for rated extraversion the Bayesian correlation has a median value of -.17 and the 95% CredInt is between -.318 and -.032. The Bayes Factor, BF_{10} is 5.43, indicating that the correlation provides moderate support for H1 relative to H0. Again, as noted above, the Bayesian correlation analysis shows that all 4 participant traits showed similar evidence for moderation effects on rated extraversion reinforcing advantage [BF_{10} range from to 5.43 (moderator = agreeableness) to 9.26 (moderator = extraversion)].

For the correlation of participant ASQ and the non-reinforcing advantage for rated neuroticism the Bayesian correlation has a median value of -0.128 and the 95% CredInt is between -.275 and -.013. The Bayes Factor, BF_{10} is 1.75, indicating that the correlation provides only weak support for H1 relative to H0.

For the correlation of participant ASQ and the reinforcing advantage for rated agreeableness the Bayesian correlation has a median value of -.10 and the 95% CredInt is between -.239 and -.007. The Bayes Factor, BF_{10} is .80, indicating that the correlation actually provides weak evidence for H0 relative to H1.

5.3.2 Character social interaction ratings

There was a significant character-type effect on ratings of likeability [$F(1, 146) = 172.17$, $p < .001$, $\eta p^2 = .54$] and befriending likelihood [$F(1, 145) = 126.53$, $p < .001$, $\eta p^2 = .47$], where participants rated the reinforcing characters as more likeable [$M = 5.48$, $SD = 1.46$] and were more likely to befriend them [$M = 4.93$, $SD = 1.50$] than the non-reinforcing characters [$M = 3.89$, $SD = 1.29$; $M = 3.45$, $SD = 1.33$ respectively] (see Figure 5.5). Again, these effects were very robust with similar effect sizes to the effects on the three trait ratings.

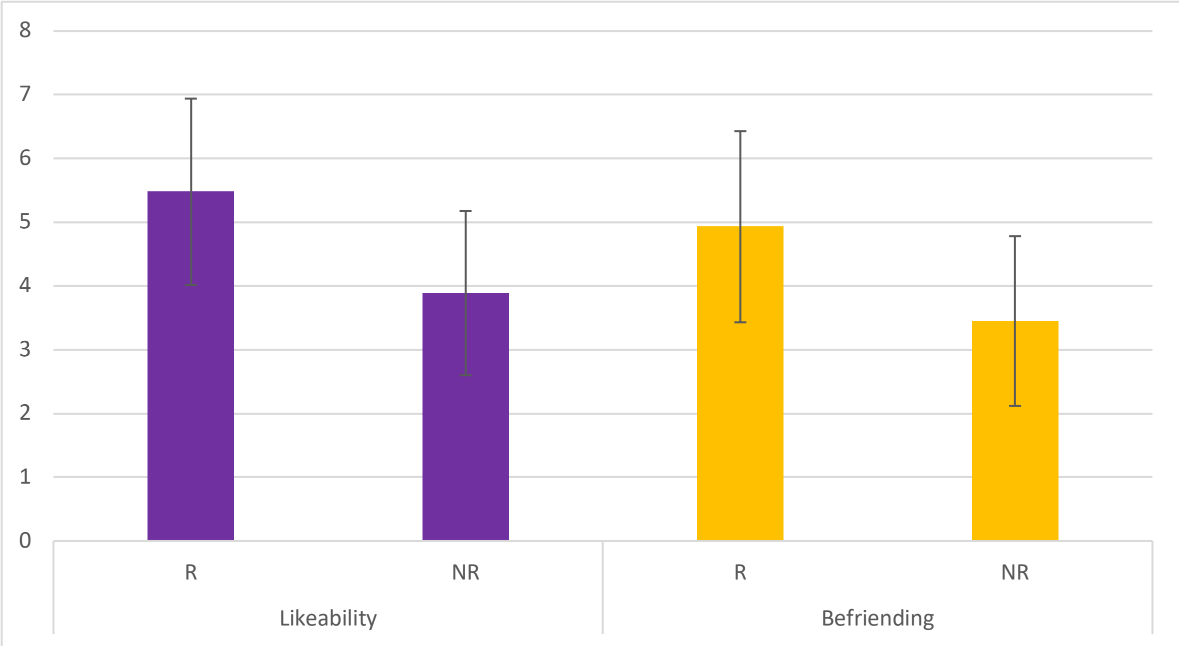


Figure 5.5: Mean scores and standard deviations of characters likeability and befriend likelihood of reinforcing (R) and non-reinforcing (NR) characters.

Separate general linear models were run with each participant trait as a predictor along with the character type for each social interaction rating. There were significant interactions of trait extraversion with character type effects of likeability [$F(1,141)= 10.18$, $p = .002$ (c.f. adjusted $\alpha = .025$), $\eta p^2 = .067$] and befriending likelihood [$F(1,140)= 7.49$, $p = .007$ (c.f. adjusted $\alpha = .025$), $\eta p^2 = .051$].

There were significant interactions of trait neuroticism with character type effects of likeability [$F(1,140)= 12.08$, $p = .001$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .079$] and befriending likelihood [$F(1,139)= 8.44$, $p = .004$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .057$].

However, no there were no significant interactions of agreeableness on character type effects of likeability [$F(1,143) = 1.835$, $p = .178$, $\eta p^2 = .013$] or befriending likelihood [$F(1,142)= 6.37$, $p = .013$ (c.f. adjusted $\alpha = .008$), $\eta p^2 = .043$], which did not survive the adjusted alpha level. There were also no significant interactions of autistic traits on character type effects of likeability [$F(1,143) = 1.582$, $p = .211$, $\eta p^2 = .01$] and befriending likelihood [$F(1,142)= 3.618$, $p = .059$, $\eta p^2 = .025$].

To illustrate the direction of all the moderation effects of the participant trait measures on the face-type effect of the reinforcing and non-reinforcing faces, bivariate correlations were conducted. The non-reinforcing (lower) scores were subtracted from the reinforcing (higher) scores for ratings of character likeability and befriending likelihood (reinforcing advantage). These correlations are reported and summarized in Table 5.3.

Table 5.3: Correlational relationship between the character social interaction ratings and participant trait scores. Non-reinforcing scores of the ratings were subtracted from reinforcing scores. Note that the tests on these correlations are identical to the interaction tests reported for the general linear models in the text. The row of extraversion correlations represents one family of tests; the other three rows represent a second family of tests as noted in the text.

Participants Personality Traits	**Character Ratings**			
	Likeability (reinforcing advantage)		**Befriending (reinforcing advantage)**	
	r	**p**	**r**	**p**
Extraversion	.260*	.002	.225*	.007
Neuroticism	-.282**	.001	-.239**	.004
Agreeableness	.113	.178	.207	.013
ASQ	-.105	.211	-.158	.059

** Correlation is significant tested against the 0.008 level (2-tailed).
* Correlation is significant tested against the 0.025 level (2-tailed).

Using the same method as for the rated character personality traits, we computed Bayesian correlations in jamovi between participant extraversion and social interaction ratings (likeability and befriending). The scatter plot for participant extraversion on the reinforcing advantage for rated likeability (i.e., rated likeability of the reinforcing characters minus the rated likeability of the non-reinforcing characters) is shown below in Figure 5.6.

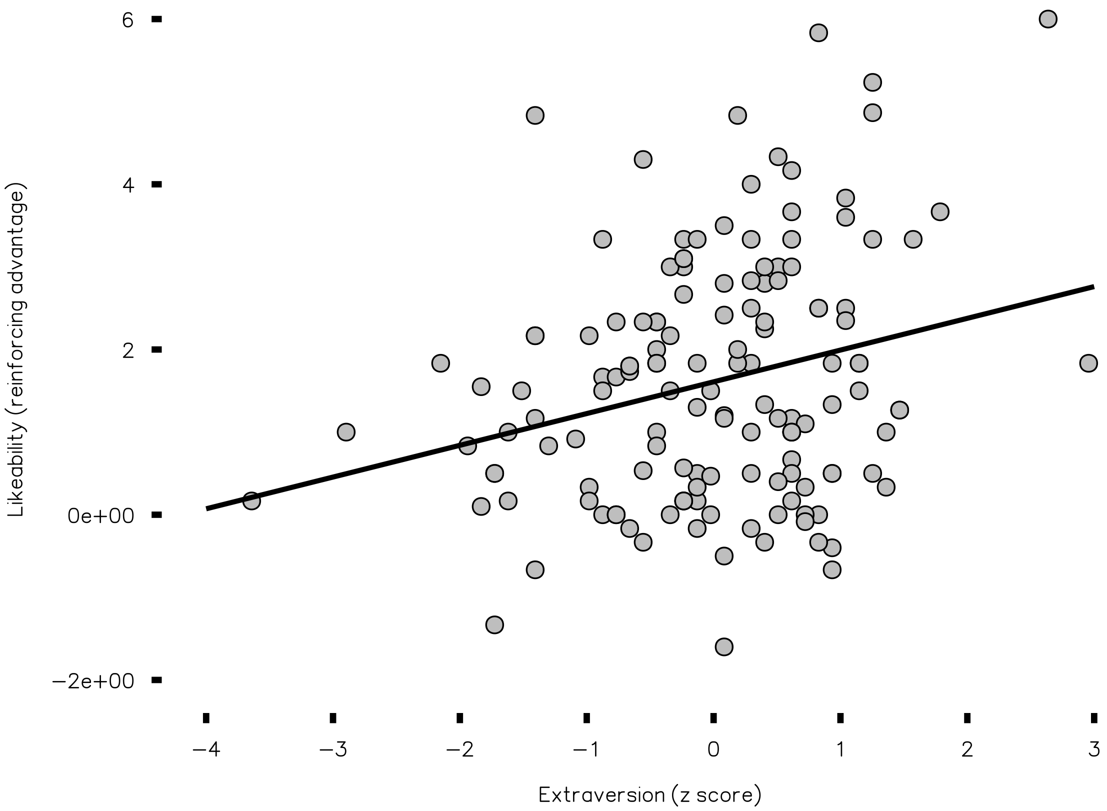


Figure 5.6: Scatter plot showing the z score of participant extraversion correlation with the reinforcing advantage for rated likeability (r = .260).

In the case of participant extraversion correlation with reinforcing advantage on rated likeability, the predicted correlation is positive, and the Bayesian correlational analysis results can be depicted graphically.

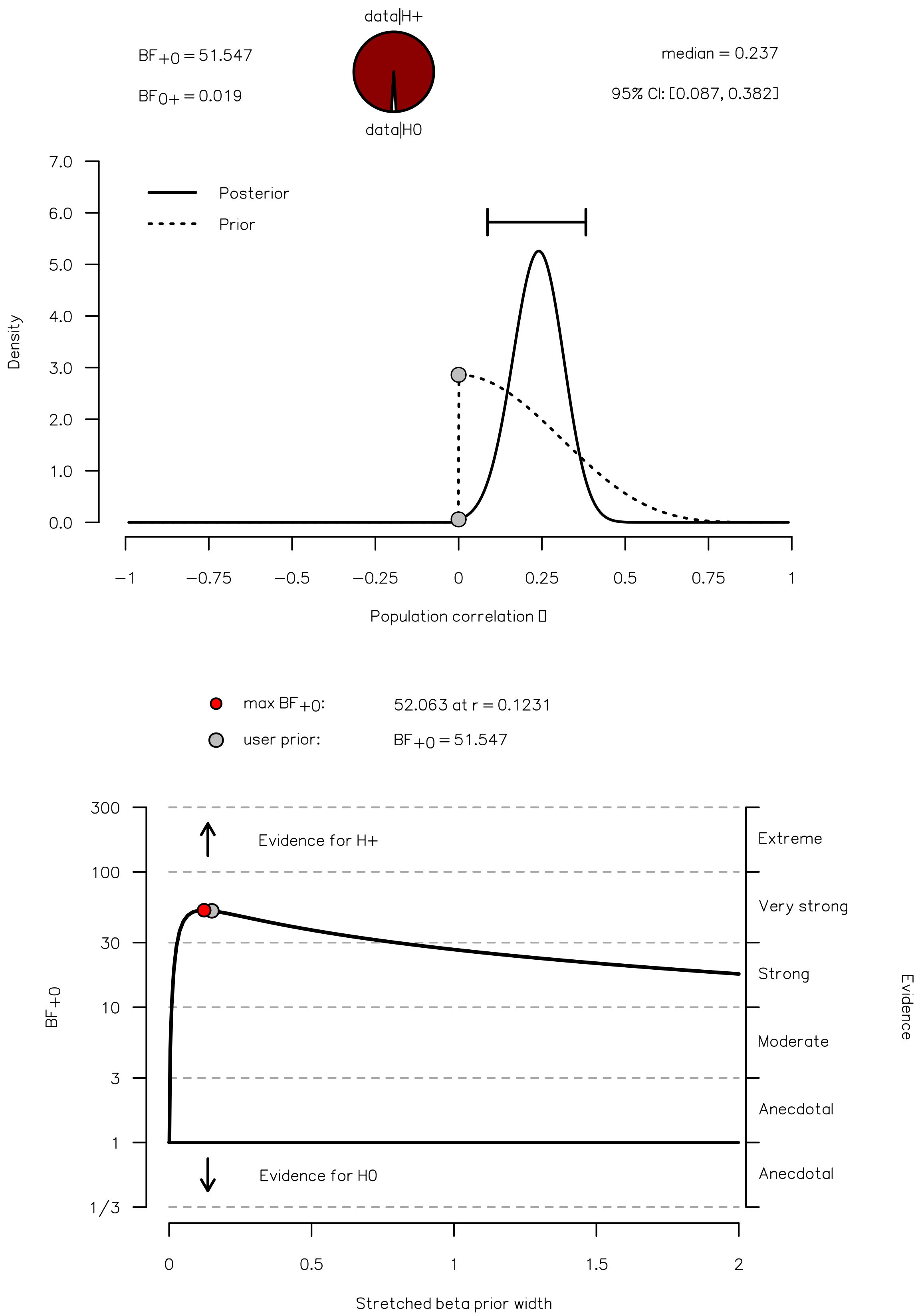


Figure 5.7: Upper panel: Posterior and prior distributions of correlation values (prior set by a beta parameter of .15), for the correlation between participant extraversion and the reinforcing advantage of rated likeability. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

The upper panel of the above figure (Figure 5.7) shows that the Bayesian correlation has a median value of .24 and the 95% CredInt is between 0.087 and 0.382. The Bayes Factor, BF_{10} (which is denoted as BF_{+0} in the above figure as H1 is a one-tailed hypothesis) = 51.55, indicating that the correlation provides very strong support for H1 relative to H0 (zero correlation). The panel also shows a graphical description of the prior distribution of correlation values (dotted line) as set by the stretched beta parameter of .15. It is visible that most of the prior value lies between 0 and .25 and very little at all is above .5. The posterior distribution is the distribution of correlations after seeing the data (solid line) and shows the central tendency lies close to .25 with the 95% CredInt marked by a horizontal line above the posterior distribution.

The lower panel (Figure 5.7) gives a robustness check for the BF, showing how it varies with different settings for the prior distribution. With our choice of beta parameter (.15) we get the BF as shown by a grey dot. A lower value for the beta parameter would have given a slightly higher BF, with a maximum of 52.06 (marked with a red dot) for a beta choice of .117. Although the BF decreases slowly for higher beta values, it should be noted that the BF is still well above 10 (strong evidence for H1) even at the very unrealistic uniform prior (beta parameter=1, where BF = 26.66).

The scatter plot for participant extraversion on the reinforcing advantage for rated befriending likelihood is shown below in Figure 5.8.

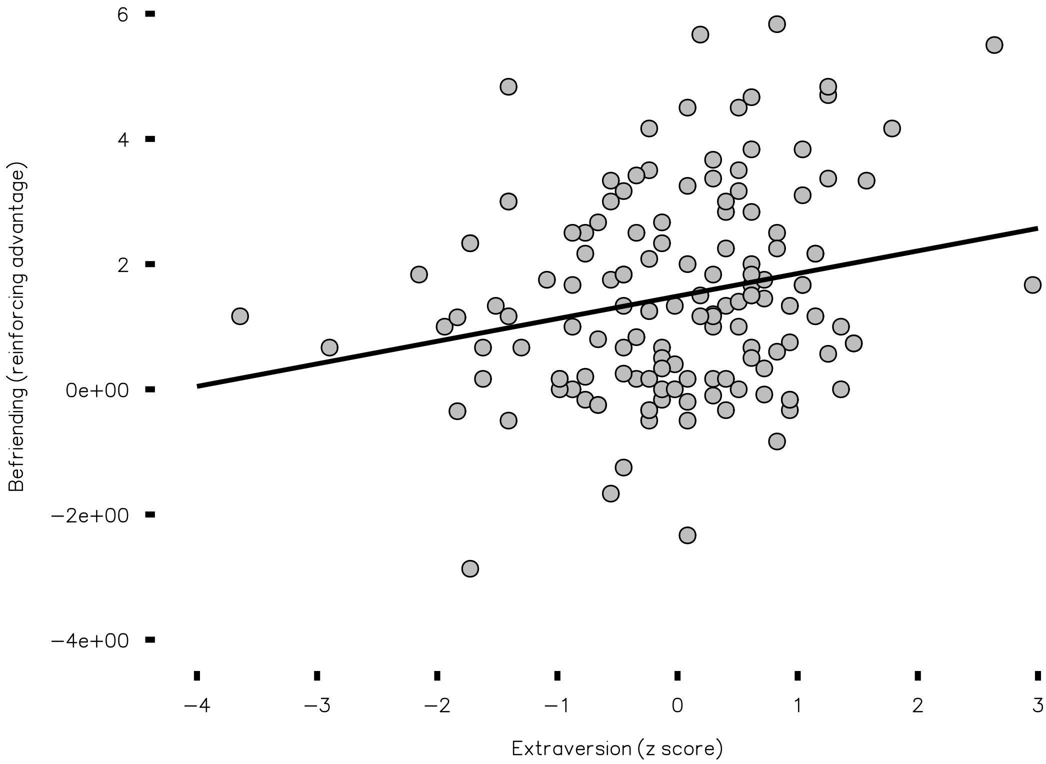


Figure 5.8: Scatter plot showing the z score of participant extraversion correlation with the reinforcing advantage for rated befriending (r = .225).

In the case of participant extraversion correlation with reinforcing advantage on rated befriending, the predicted correlation is positive, and the Bayesian correlational analysis results can be depicted graphically.

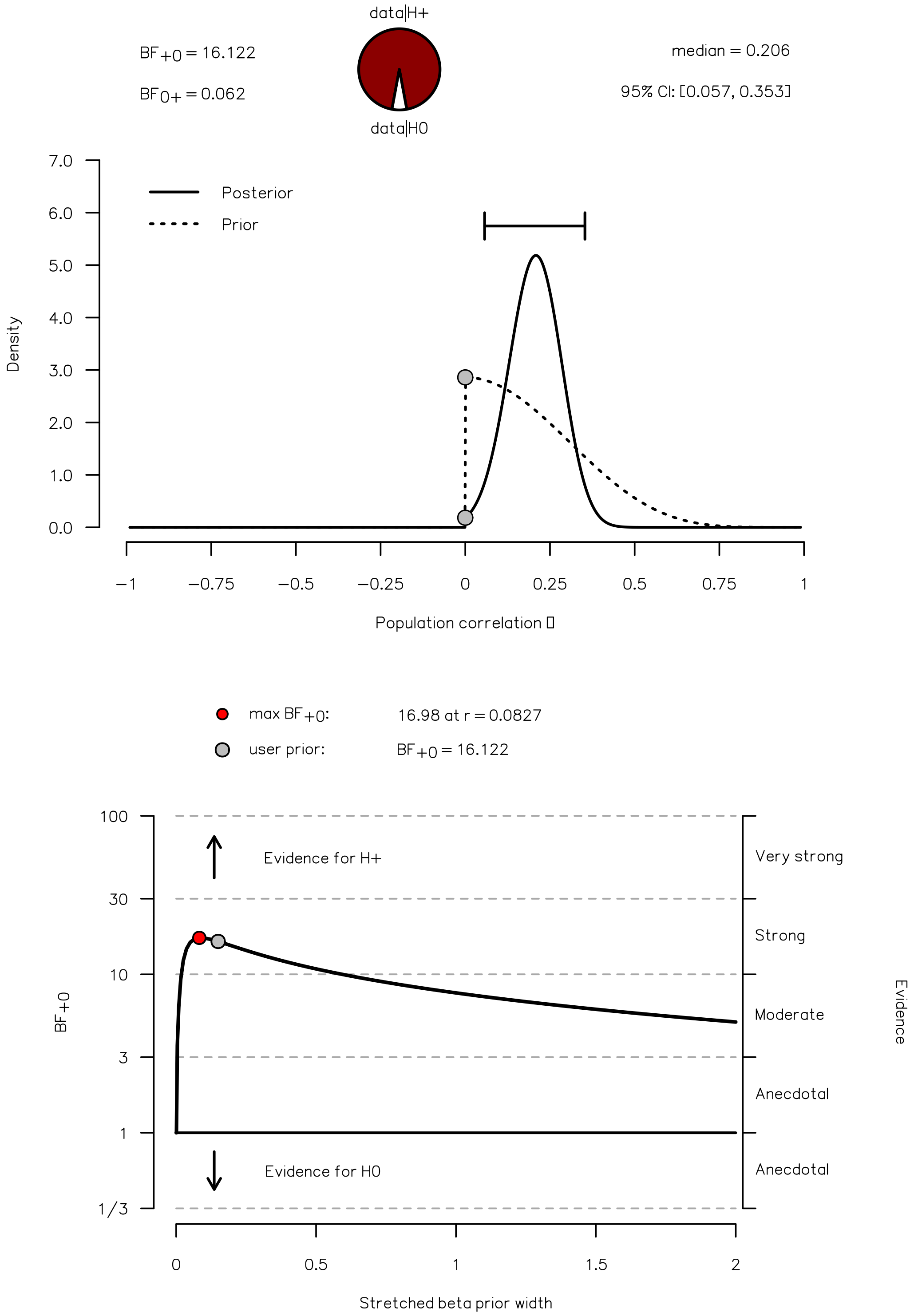


Figure 5.9: Upper panel: Posterior and prior distributions of correlation values as set by a beta parameter of .15, for the correlation between participant extraversion and the reinforcing advantage of rated befriending. Lower panel: Bayes factor robustness check as evidence of support of H1 (H+ in the figure) or H0 of the correlation.

The upper panel of the above figure (Figure 5.9) shows that the Bayesian correlation has a median value of .21 and the 95% CredInt is between .057 and .353. The Bayes Factor, BF_{10} (which is denoted as BF_{+0} in the above figure as H1 is a one-tailed hypothesis) is 16.12, indicating that the correlation provides strong support for H1 relative to H0. The panel also shows a graphical description of the prior distribution of correlation values (dotted line) as set by the stretched beta parameter of .15. It is visible that most of the prior value lies between 0 and +/-.25 and very little at all is above +/-.5. The posterior distribution is the distribution of correlations after seeing the data (solid line) and shows the central tendency lies close to .2 with the 95% CredInt marked by a horizontal line above the posterior distribution.

The lower panel (Figure 5.9) gives a robustness check for the BF, showing how it varies with different settings for the prior distribution. With our choice of beta parameter (0.15) we get the BF as shown by a grey dot. A lower value for the beta parameter would have given a slightly higher BF, with a maximum of 16.99 (marked with a red dot) for a beta choice of 0.085. Although the BF decreases slowly for higher beta values, it should be noted that the BF is still well above 3 (moderate evidence for H1) even at the very unrealistic uniform prior (beta parameter=1, where BF = 7.63).

We computed Bayesian correlations between participant neuroticism and social interaction ratings, where the correlations are predicted to be negative (confirmed in Table 5.3). For the correlation of participant neuroticism and the reinforcing advantage for rated likeability the Bayesian correlation has a median value of -0.26 and the 95% CredInt is between -.401 and -.107. The Bayes Factor, BF_{10} is 114.8, indicating that the correlation provides extremely strong support for H1 relative to H0 (BF > 100 is decisive). For the correlation of participant neuroticism and the reinforcing advantage for rated befriending the Bayesian correlation has a median value of -.22 and the 95% CredInt is between -.365 and -.068. The Bayes Factor, BF_{10} is 24.42, indicating that the correlation provides strong support for H1 relative to H0.

We computed Bayesian correlations between participant agreeableness and social interaction ratings. For the correlation of participant agreeableness and the reinforcing advantage for rated likeability the Bayesian correlation has a median value of 0.11 and the 95% CredInt is between .010 and .258. The Bayes Factor, BF_{10} is 1.19, indicating that the correlation provides only weak support for H1 relative to H0. For the correlation of participant agreeableness and the reinforcing advantage for rated befriending the Bayesian correlation has a median value of .19

and the 95% CredInt is between .045 and .337. The Bayes Factor, BF_{10} is 9.87, indicating that the correlation provides support, which approaches the strong cut-off of BF = 10.

We computed Bayesian correlations between participant ASQ and social interaction ratings, where the correlations are predicted to be negative (confirmed in Table 5.3). For the correlation of participant ASQ and the reinforcing advantage for rated likeability the Bayesian correlation has a median value of -.11 and the 95% CredInt is between -.252 and -.009. The Bayes Factor, BF_{10} is 1.04, indicating that the correlation provides almost exactly equal support for H1 and H0. For the correlation of participant ASQ and the reinforcing advantage for rated befriending the Bayesian correlation has a median value of -0.15 and the 95% CredInt is between -.296 and -.020. The Bayes Factor, BF_{10} is 2.84, indicating that the correlation provides only weak support for H1 relative to H0.

Table 5.4: For ease of reference, we have tabulated all the BF values for each trait correlation with character personality ratings and social interaction ratings. Values between 3 and 10 represent moderate support for H1 relative to H0, values between 10 and 30 represent strong support, values between 30 and 100 represent very strong support, and values greater than 100 represent extreme (decisive) support.

Participant Personality Traits	**Character personality and social interaction ratings**				
	Extraversion (reinforcing advantage)	**Neuroticism (non-reinforcing advantage)**	**Agreeableness (reinforcing advantage)**	**Likeability (reinforcing advantage)**	**Befriending (reinforcing advantage)**
	BF_{10}	**BF_{10}**	**BF_{10}**	**BF_{10}**	**BF_{10}**
Extraversion	9.26	0.63	0.63	51.55	16.12
Neuroticism (negative correlation)	8.44	4.74	4.01	114.8	24.42
Agreeableness	5.58	1.29	457.9	1.19	9.87
ASQ (negative correlation)	5.43	1.75	0.80	1.04	2.84

5.3.3 Name recognition memory task

A paired samples t-test showed that there were no significant differences in the number of reinforcing and non-reinforcing character's names participants recognised accurately in the name recognition memory task [$t(144) = -1.065$, $p = .288$]. On average, participants incorrectly selected approximately only 1 of the 6 reinforcing characters names, as well as 1 of the 6 non-reinforcing characters names. The high levels of performance in both conditions may obscure the ability to detect a difference due to ceiling effects.

Separate general linear models were run with each participant trait as a predictor along with the character type. There were no significant interactions between character type name recognition and participant extraversion [$F(1,138) = .585$, $p = .446$, $\eta p^2 = .004$], neuroticism [$F(1,137) = .285$, $p = .595$, $\eta p^2 = .002$], agreeableness [$F(1,140) = 1.255$, $p = .265$, $\eta p^2 = .009$], nor autistic traits [$F(1,140) = .054$, $p = .817$, $\eta p^2 = .000$]. In light of the very small moderation effect sizes for the name recognition memory variable, we did not run any Bayesian correlation analyses for this variable.

Table 5.5: Correlational relationship between the number of names recognised correctly in the name recognition task and participant trait scores. Non-reinforcing scores of the ratings were subtracted from reinforcing scores. Note that the tests on these correlations are identical to the interaction tests reported for the general linear models above.

Participants Personality Traits	**Number of names recognised correctly (reinforcing advantage)**	
	r	***p***
Extraversion	.065	.446
Neuroticism	.046	.595
Agreeableness	-.094	.265
ASQ	-.020	.817

5.3.4 Main effects of personality traits

Above we have focussed on the participant trait moderation of the reinforcement type effects. We did this because we had no clear predictions about trait main effects. We report the trait main effects on all DVs, regardless of whether the characters were reinforcing or not (character type), here for completeness and on exploratory basis. The alpha adjustments for multiple comparisons are as follows: the main effects of the four participant traits on the overall ratings of the three characters traits $\alpha = \frac{.05}{12} = .004$; the main effects of the four participant traits on the overall ratings of the two ratings of social interaction (liking and befriending) $\alpha = \frac{.05}{8} = .006$; the main effects of the four participant traits on the overall name recognition $\alpha = \frac{.05}{4} = .0125$.

The main effect of participant extraversion was non-significant for overall ratings of extraversion [$F(1,141) = .130, p = .719$], neuroticism [$F(1,141) = .568, p = .453$], agreeableness [$F(1,141) = .023$, p = .880], likeability [$F(1,141) = .048, p = .827$], or befriending likelihood [$F(1,140) = .051, p = .821$].

Participant neuroticism did not have a significant main effect on the overall rating of extraversion [$F(1,140) = 3.513, p = .063$ (c.f. adjusted $\alpha = .004$)]. The main effect of participant neuroticism on overall ratings of neuroticism was a trend although not formally significant against our conservatively adjusted alpha level [$F(1,140) = 6.188, p = .014, \eta p^2 = .042$ (c.f. adjusted $\alpha = .004$)]. The main effect of participant neuroticism on overall ratings of agreeableness was significant [$F(1,140) = 13.358, p < .001, \eta p^2 = .087$ (c.f. adjusted $\alpha = .004$)]. The main effect of participant neuroticism on overall ratings of likeability was also significant [$F(1,140) = 8.546, p = .004, \eta p^2 = .058$ (c.f. adjusted $\alpha = .006$)]. The main effect of participant neuroticism on overall ratings of befriending likelihood fell short of formal significance given the conservative alpha adjustment, but can be considered a trend [$F(1,139) = 7.296, p = .008, \eta p^2 = .050$ (c.f. adjusted $\alpha = .006$)].

The main effect of participant agreeableness was not significant for overall ratings of extraversion [$F(1,143) = .080, p = .025$ (c.f. adjusted $\alpha = .004$)], neuroticism [$F(1,143) = .077, p = .782$], agreeableness [$F(1,143) = .109, p = .742$], likeability [$F(1,143) = 2.827, p = .095$], or befriending likelihood [$F(1,142) = 1.532, p = .218$].

The main effect of participant autistic traits was not significant for overall ratings of extraversion [$F(1,143) = .025, p = .874$], neuroticism [$F(1,143) = .077, p = .782$], agreeableness [$F(1,143) = 1.245, p = .266$], likeability [$F(1,143) = .027, p = .869$], or befriending likelihood [$F(1,142) = .139, p = .710$].

Regarding the name recognition memory task, there were no main effects of participant extraversion [$F(1,138) = 1.754, p = .188$], neuroticism [$F(1,137) = .390, p = .533$], agreeableness [$F(1,140) = .552$, $p = .459$], or autistic traits [$F(1,140) = .873$, $p = .352$] on the number of character names they recognised accurately.

To illustrate the direction of all the main effects of the participant trait measures on the overall ratings and name recognition accuracy, bivariate correlations were conducted. These correlations are reported and summarized in Table 5.6. Note once again that the tests on these correlations are identical to the main effect tests reported for the general linear models above. They include the alpha level adjustments for multiple comparisons described above.

Table 5.6 Correlational relationship between participant trait scores and overall averages of DV scores, regardless of character type. Note that the tests on these correlations are identical to the main effects tests reported for the general linear models in the text above.

Participant Personality Traits	**Overall correlation on all DVs averaged across character type**											
	Extraversion		**Neuroticism**		**Agreeableness**		**Likeability**		**Befriending**		**Number of names recognised correctly**	
	r	***p***	***r***	***p***	***r***	***p***	***r***	***p***	***r***	***p***	***r***	***p***
Extraversion	-.030	.719	.063	.453	.013	.880	-.018	.827	-.014	.864	-.105	.205
Neuroticism	-.156	.063	.206	.014	-.295	<.001**	-.240	.004*	-.225	.007	-.036	.670
Agreeableness	-.024	.778	-.091	.274	-.028	.742	.139	.095	.101	.226	-.094	.266
ASQ	.013	.874	.023	.782	-.093	.266	-.014	.869	-.028	.740	.078	.351

** Correlation is significant tested against the .004 level (2-tailed).
* Correlation is significant tested against the .006 level (2-tailed).

5.4 Discussion

Combining traditional methods of associative, probabilistic, reinforcement learning (e.g., Potts et al., 2006; Smillie et al., 2011) with approaches driven by social perception (e.g., Hackel et al., 2020; Heerey, 2014), we were able to successfully use probabilistic learning with social stimuli to infer learned associations between social reinforcement and personality ratings and interpersonal perceptions. In doing so we were able to validate an artificial social interaction task that uses social RL properties in a social context with a primary social reward cue.

Using smiles as the associative reward in a probabilistic task, the computer based ASI task provided a novel test of our hypotheses. Revisiting these hypotheses here, we were indeed able to find that characters who smile more throughout the artificial interactions (reinforcing characters) were rated by the participants as people they would be more likely to befriend, and were rated as more likeable, more extraverted, more agreeable, and less neurotic than the characters that smile less (non-reinforcing characters).

Moreover, we were able to disentangle the individual differences which moderated the influence of the social reinforcement characteristics of the characters on the participants' perceptions of their personality and social characteristics. The primary moderating trait we studied was extraversion and was where we found that our key prediction was indeed supported. We found that the higher the participant levels of extraversion, the more likely they were to rate the reinforcing characters as more extraverted, more likeable, and felt they were more likely to befriend them than non-reinforcing characters. However, the moderating effect of extraversion was not significant on ratings of neuroticism or agreeableness. These traditional correlation effects were also supported by Bayesian correlations where there was strong (or close to strong) support for the moderating effects of trait extraversion on character ratings of extraversion, likeability, and befriending.

In the more exploratory family of tests that addressed the general hypothesis that other potentially relevant personality traits may moderate the effects of social reinforcement that we measured, we found that those who scored higher on agreeableness were more likely to rate reinforcing characters as more agreeable than non-reinforcing characters to a greater extent than those who score lower on agreeableness. This effect was robustly significant in the traditional correlation but was also found to be "decisive" (extreme evidence in favour of H1) in the Bayesian correlations. The Bayesian correlations also found that agreeableness had a moderating effect on rated extraversion (with moderate support), and on rated befriending (almost strong support).

Conversely, while no moderation effects of trait neuroticism and autistic traits survived the strict alpha adjustment in the traditional tests, Bayesian correlations found that they both correlated negatively with rated extraversion (with moderate support). These tests also found that the participants who scored higher on neuroticism, were more likely to rate the reinforcing characters lower on agreeableness (with moderate support), likeability (with decisive support), and befriending likelihood (with strong support). They were also more likely to rate the non-reinforcing characters lower on neuroticism with moderate support. It should be noted again that the effects of trait agreeableness, neuroticism, and autistic traits fail to be formally significant in part because of the strict alpha adjustment we applied on this family of tests. The adjustment was more penalising than the alpha adjustment on our primary trait of extraversion as explained above. Which relationships fall either side of the adjusted significance is a function, in part, of our a priori decisions on statistical test families. Emphasis should be placed on the fact that the effect sizes on rated extraversion and befriending were fairly similar for all participant trait moderators, as well as similar effect sizes for the moderating effects of participant extraversion and neuroticism on likeability.

With regard to the name recognition task and the hypothesis that the names of the reinforcing faces being recognised more accurately than the non-reinforcing faces, the success rate of participants correctly recognising the character's names was high, regardless of whether the face was reinforcing or not, and there was no overall reinforcing advantage on name memory. These probable ceiling effects make the lack of a reinforcing advantage uninformative. Based on these findings one cannot assume that the associative learning between a visual face identity and their reinforcing or non-reinforcing nature spreads (or does not spread) to associations with more abstract aspects of the character depicted (such as their name; Amodio, 2019). Understandably, and in light of the above, there were no moderation effects of any of the trait measures for character type name memory.

Nevertheless, these results add to the small literature that investigates social RL and social perception measured in a social context (e.g., Hackel et al., 2020; Heerey, 2014), but it does this in light of core personality traits that are most commonly associated with sociability and/or reinforcement learning (e.g., Corr, 2004; Smillie, 2013). The results shed light onto how feedback from interactions with characters (here seen as typical stimulus-response-reinforcement triplets) influence the interpersonal perceptions of those who themselves score high or low on these trait measures. These results make it likely that social RL has a differential impact as a function of an individual's personality.

Our results suggest the following broad conclusions: (i) perceptions about people are affected by others learning their social reinforcement "value" (e.g., whether they are more or less socially rewarding as indexed here by their tendency to smile during social interactions); (ii) specifically, those who have learned someone's social reward value judge people with higher social reward value to be more likeable, more extraverted, and also want to befriend them more, than they do people with lower learned social reward value; (iii) these effects of an individual's learned social reward value is more marked in people who are extraverted and as a result this probably leads extraverts to enjoy the company of others more than introverts (who are less influenced by other people's social reward value); (iv) this will be likely to contribute to an extravert's responses on certain extraversion scale items (e.g., those about how much they enjoy the company of others). In addition to the above conclusions, a question remains whether extraverts will, via this mechanism, also be more likely than introverts to execute related social behaviours (e.g., seeking out sociable situations). Based on a general understanding of the principles of motivation and reinforcement, this last speculative possibility seems quite likely. The conception described here is further supported by the exploratory analysis of the main effect of participant extraversion tested on all DVs overall, as no main effects were found regardless of character type. This means that the key effects of trait extraversion found in this study were linked to the reinforcement process.

Further to this, the additional inclusion of neuroticism allowed us to delve further into the understanding of individual differences in social perception and social RL. Not only is this a simple and new social probabilistic RL task, but it is the first of its kind to investigate the influence of a trait (neuroticism) that has previously been neglected in terms of its associations with social RL. While the research previously described (Oyibo & Vassileva, 2019) has touched on the subject, no research has yet attempted to uncover how those considered to be neurotic, with a propensity to develop social anxiety (Newby et al., 2017), perceive characters of a rewarding (or non-rewarding) predisposition, and how this in turn may continue to affect the behaviours related to neuroticism. We predicted that neuroticism would show a negative moderation of the effect where reinforcing (more frequently smiley) characters are rated as more extraverted. Such an effect, for which there was some evidence in the present results, possibly suggests high neuroticism translates to lowered reward sensitivity (perhaps via inhibition from increased punishment sensitivity) and so neuroticism would negatively moderate the reinforcing advantage for extraversion. This pattern is in line with classical studies on reward processing in neuroticism that have found that the trait is negatively correlated with conditioned responses to appetitive (rewarding) stimuli (Corr, 2004; Paisey & Mangan, 1988).

The obtained pattern of results may also be in line with a study that claims that there is a positive relationship with facets of neuroticism and sensitivity to punishment; specifically claiming that self-consciousness within neuroticism enhances individuals' sensitivity to ridicule, making them feel uncomfortable in interpersonal interactions and increasing their tendency to exhibit shy behaviour (Mitchell et al., 2007). This potential mechanism could also explain the observation of a negative moderation by participant neuroticism of the non-reinforcing advantage on rated neuroticism. It is conceivable that higher neuroticism participants might introspect about their own tendency to not smile a lot in social interactions, perhaps driven by self-consciousness, and thus not alter their ratings of character neuroticism very much across the reinforcing versus non-reinforcing manipulation. Lower neuroticism subjects, by contrast, would give neuroticism ratings that varied across reinforcement type.

Another possible explanation for the moderating effects of trait neuroticism could be that those who score higher on neuroticism have an already biased and somewhat fixed perception of characters that smile more, and these perceptions might not be susceptible to reinforcement. This would mean that the effect might not be due to the reinforcing properties of one set of characters compared to the other and is not an effect of reinforcement sensitivity, however more research is needed to discern this. A follow-up experiment to test if those with high neuroticism view smiley individuals in a different way would simply be to ask them to rate smiling faces versus neutral faces. This could show any biases that are not directly related to within-experiment reinforcing properties.

The proposal in the paragraph above is distinct from the trait main effects explored in the current study. The main effect of participant neuroticism tested on the DVs overall, regardless of character type, found that those scoring higher on neuroticism were more likely to rate characters as less agreeable and less likeable, regardless of whether they smiled more in interactions. Trends were also found indicating that those who are more neurotic are more likely to rate characters are more neurotic and are less likely to befriend them regardless of the amount they smile. These exploratory results may provide some insight into why people with higher trait neuroticism could have a susceptibility to develop social anxiety (Newby et al., 2017). However, this needs to be investigated further.

Next, we consider our results relating to agreeableness. There is even less existing RL, especially social RL, research that accounts for associations with agreeableness (e.g., Côté & Moskowitz, 1998; Mitchell et al., 2007). It is possible that agreeableness parallels high extraversion in being partly driven by increased reward sensitivity (a BAS mechanism). If this were the case then, assuming extraversion moderation effects are a marker for a BAS mechanism, we would expect the moderation effects for extraversion and agreeableness to be similar. While the moderation effects are similar for rated extraversion and befriending, the moderation effects of extraversion and agreeableness were quite different for rated likeability and are especially different for rated agreeableness. It may thus be that the agreeableness moderation effects on rated agreeableness and likeability are caused by another mechanism. Côté and Moskowitz's (1998) study that found agreeable individuals experienced more pleasant affect than their counterparts when engaging in agreeable behaviour and more unpleasant affect than their counterparts when engaging in confrontational behaviour. These findings are reconcilable from an RST perspective as this may be the result of a tendency for agreeable individuals to focus on potentially punishing interactions (e.g., interpersonal rejection from the lack of smiling from non-reinforcing characters), whereas acting cooperatively may be a way of avoiding confrontational social encounters (Mitchell et al., 2007). However, this needs to be explored further within a theoretical framework that focuses on social RL. Another explanation might be that agreeable people tend to have a cognitive bias towards perceiving faces as more agreeable in general (i.e., smiley and friendly) and are more prone to rate them as such. This may, in turn, be likely to affect agreeable peoples' ratings of agreeableness and likeability but possibly may not necessarily affect their ratings of extraversion and befriending. However, the notion described here was not supported by the exploratory analysis of the main effect of participant agreeableness tested on all DVs overall, as no main effects were found regardless of character type. This means that the key effects of trait agreeableness found in this study were attributed to the reinforcement process.

The negative moderating influence of autistic trait measures on rated extraversion supported our predictions that those who score higher on autistic traits would not impute as many extraverted characteristics to reinforcing (vs. non-reinforcing) characters, relative to their counterparts who score lower on autistic traits. High scorers on autistic traits were also less likely to show an increased befriending rating for the reinforcing faces c.f. the non-reinforcing faces. These effects of participant autistic traits may be due to the aberrant social reward processing often associated with these traits, and consequent blunted reward responsiveness. These characteristics can be considered similar to introversion in terms of social reward sensitivity and perception (Heerey, 2014; Makkar & Grishman, 2011). This possibility is highlighted by the similar moderation effects (but with reversed direction) for trait extraversion and autistic traits, on rated extraversion and befriending. Extraversion and autistic traits were less similar in their effects on the other dependent variables where the moderation effects for autistic traits were generally weaker. Further work is needed to see if there really is a difference in the size of the autistic trait moderation between extraversion, and the other DVs measured here. To statistically compare the sizes of the moderation effects for different participant traits, or to compare the size of moderation effects for a single trait on different DVs, would need much larger samples. Nevertheless, the exploratory analysis of the main effect of participant autistic traits tested on all DVs regardless of character type, meant that the key effects of autistic traits found in this study were attributed to the reinforcement process, as no main effects were found regardless of character type.

5.4.1 Limitations and future directions

While the implications of this novel study seem very promising the methodological aspects must be addressed, especially in terms of future research. Firstly, when trying to understand the effects of facial processing and the role of reward processing within it, it is important to consider the possibility that providing a rewarding environment through social perception and judgements could potentially induce a mood state. In turn, the order in which psychometric measures (the trait measures in particular) are administered, relative to the reward learning task, should be considered (e.g., Brown & Mankowski, 1993; Hibbert, 2018; Sedikides, 1995). Here we administered the psychometric questionnaires after the participants had completed the ASI task, including rating the characters on traits, likeability and befriending likelihood. The reason for this was to prevent the effects of participants rating themselves on certain traits potentially carrying over into how they perceived the characters, perhaps by inducing some sort of cognitive bias. However, this potentially could have been an issue for the design used in this first ASI study in that, if the ASI task induced a mildly positive mood state, at least in some participants, then they might have reported their own personality differently than when in a more typical and/or neutral mood state. This seems quite likely to have produced small effects at most but is nonetheless addressed in the design of a replication study in the next chapter (chapter 6). The evidence that supports possible mood induction effects on self-reported personality is reviewed for ASI study 2, where the order is reversed so that participants complete the trait measures before commencing the ASI task.

Furthermore, we must address the limitation that, at this stage, we did not counterbalance which faces were used across the reinforcing and non-reinforcing character types (i.e., which faces were coded to smile more or less throughout the task). This was a deliberate decision given the difficulties of controlling this process in the testing environment (large group testing) that was operative for this study. This opens up the possibility that variability in the baseline perception of the character faces (Morrison et al., 2017, Oosterhof & Todorov, 2008; Wang et al., 2016) might have been partly responsible for the rating differences between reinforcing and non-reinforcing characters. The evidence for the baseline difference is again reviewed in the subsequent chapter (chapter 6). Specifically, it is thus possible that, having not counterbalanced the assignment of faces to reinforcing vs. non-reinforcing repeated-measures factor, that the effect might be due to the six faces in the reinforcing character set being, on average, more likeable, and extraverted-seeming than the non-reinforcing character set, even in the neutral expression faces. This raises the possibility that the reinforcement (level of smiling) manipulation did not cause the reinforcement type effect. Nevertheless, this is addressed in the ASI study 2 (chapter 6) where the previously reinforcing characters serve as non-reinforcing characters and vice versa. If the overall effect of the repeated-measures manipulation and the personality moderation effects are similar in the subsequent follow up study, then we can conclude that possible baseline differences between the face sets (in their neutral poses) are unlikely to be exclusively responsible for the character effects in the current study.

Furthermore, we should note the limitation of group testing in large theatre hall, a potentially distracting environment, even though the participants were told to be as silent as possible and to complete the task independently. Monitoring during the study indicated that these instructions were generally observed but this is still a possible issue for the reproducibility of the effect. Again, this is addressed in our follow-up study in chapter 6 where participants were tested alone, and on-line.

With regards to the name recognition task a better (more challenging) test of the incidental name recall is need. This could be via a free recall test of all the character names to see if the reinforcing characters were better recalled than non-reinforcing. However, as this was a minor feature of the current study we did not change this feature in the next study inthis thesis, but it definitely is something for exploration in future work.

A more technical potential limitation of the ASI task is the question of the extent to which computerised social interactions are ecologically valid with respect to cues in natural interactions. Different forms of smiles (e.g., genuine vs. polite; Heerey, 2014) are common social cues, but have the potential to produce a large range of social behaviours and can subsequently produce a range of social perceptions (Ekman, 1992; Johnston et al., 2010). The cues present in natural interactions particularly have greater variability in appearance, as well as meanings that are more ambiguous and dependent on different contexts at that moment in time (Heerey, 2014). They also depend on dynamically changing facial features not just an all or none change from neutral to smiling. To empirically evaluate such a broad range of relevant variables is very difficult to evaluate, even in a long series of of experiments, and so it was not attempted in this thesis.

The experimental findings in the present study may provide evidence that social RL models may be a viable way of understanding people's ability to regulate social behaviour and perception. In particular, the findings suggest that people will use others' nonverbal cues in the real world and also suggest that their ability to do so is moderated by individual personality differences. This conclusion requires further evaluation under more naturalistic conditions.

An innovative way to overcome these ecological validity concerns would be to adapt the ASI paradigm into a virtual reality environment, in future research. This would provide a more naturalistic environment but would do so in an experimentally controlled way. Virtual reality (VR) is a computer-generated interactive environment where individuals can repeatedly experience situations in an immersive way (Freeman et al., 2017; 2018). A clear future set of studies after this thesis would be to reproduce the ASI task structure but using VR. The turn taking in a VR version of the task could be made more naturalistic too, as well as having the characters' faces responding more dynamically when they smile. In a systematic review of empirical studies, Freeman et al. (2017) found that using interactive and immersive technology for VR exposure-based treatments can reduce anxiety, and specifically social anxiety, with virtual environments that use social contexts. This highlights the future potential of the ASI paradigm for use as a diagnostic or therapeutic technological tool when working with those who have aberrant social processing, perhaps as a symptom of any one of a number of comorbid disorders (e.g., autism spectrum disorders).

5.4.2 Conclusion

A novel artificial social interaction task was developed using social RL properties in a social context. The task combined traditional methods of associative, probabilistic, reinforcement learning with approaches driven by social perception. We were able to successfully use probabilistic learning with smiling faces, which enabled participants to display an effect of a social reinforcement manipulation on personality ratings and interpersonal perceptions. We were to some extent able to disentangle the extent to which various individual differences, across the participants, moderated the effects of our social reinforcement manipulation. Once we have confirmed these results in a second study, this ASI paradigm could usher in promising applications in future research, particularly the realm of VR in psychological research and possibly therapeutic interventions.

Chapter 6

Artificial Social Interaction task: A follow-up study.

6.1 Introduction

The promising results of the novel artificial social interaction (ASI) task in the chapter 5 study, along with its limitations, called for a follow-up study. The first study was run in a large lecture hall, with all students tested simultaneously, which meant that it was difficult to administer the different counterbalanced versions required. We also needed to check that the character type effects in study 1 were indeed an effect of the experimentally manipulated reinforcement type of the faces and not due to reasons pertaining to any chance differences (affecting likeability, personality ratings etc) on average between the neutral and reinforcing faces, in their neutral poses. Therefore, the current follow-up study reversed the sets of characters that were used in the reinforcing and non-reinforcing conditions relative to the first ASI study in chapter 5. Another improvement was to counterbalance (reverse) the order that the psychometric measures were administered relative to the ASI task. The potential importance of why these counterbalancing manipulations were considered necessary will be explained with reference to evidence that highlights the effects of processing neutral faces and possible carryover effects of administering psychometric measures after a learning manipulation.

6.1.1 Reward value of neutral faces

To understand social perceptions of neutral faces, regardless of any experimental manipulation, studies using Principal Components Analyses (PCA) have denoted that social judgements of faces are, generally, underpinned by two perceptual components: valence and dominance (Oosterhof & Todorov, 2008; Wang et al., 2016). These perceptual components also play a role in the reward value of faces, which in turn affects social judgements (Morrison et al., 2017). Specifically, the valence component of neutral faces has been found to be positively correlated with traits of attractiveness, trustworthiness, emotional stability, and being responsible, caring and sociable. The dominance component has been found to be more positively correlated with traits of aggression, confidence, and of course dominance (Oosterhof & Todorov, 2008). The description of these perceptual components emphasizes the variability that neutral faces can have even under controlled experimental conditions.

Evidence from behavioural and neurobiological studies shows that faces considered to be high on traits that are associated with the valence and dominance components are rewarding and carry greater motivational salience. For example, using a key-press task, Wang et al., (2016) showed that faces that scored higher on the valence component were chosen to be viewed longer by participants, indicating possibly greater reward value and motivational salience. They also found that faces that scored higher on the dominance component also had greater reward value and motivational salience, as indicated by the key-press correlation. However, the effect was less marked than for valence. The finding on the rewarding value of dominant faces is in line with research investigating evolutionary and comparative explanations of face processing using macaques, which state that it may have arisen in order for an individual to monitor individuals that have the potential to be of high threat during social interactions (Deaner et al., 2005). The findings of Wang et al.'s (2016) study was successfully replicated by Morrison et al. (2017). However, their PCA revealed a third component (the so-called geekiness component) that correlated with ratings of IQ and weirdness, which was negatively related to the reward value of female faces. This evidence of variability in facial judgements adds to the salience of the processing of neutral faces on a first impression basis.

Furthermore, Wang et al. (2016) discuss that their work is also consistent with neural evidence of networks associated with reward processing, and how they overlap with those that are involved in the processing of facial attractiveness and trustworthiness (for a review see Hahn & Perrett, 2014). Specifically, the orbitofrontal cortex (OFC) has been considered a key component of reward circuitry and its association with reward value (Kringelbach & Radcliffe, 2005), but it also has effective connectivity to the fusiform face area (FFA; Fairhall & Ishai, 2007). It is because of the connectivity between the OFC and FFA that face-selective neurons have been detected in the OFC of monkeys (Thorpe et al., 1983). This connectivity suggests a possible role for this region in the aesthetic assessment of faces, including judgements of facial attractiveness (Ishizu & Zeki, 2011; Jacobson et al., 2006). There has also been research that demonstrates the activation of other brain regions involved with reward processing, like the prefrontal cortex (PFC) and the nucleus accumbens (NAcc) during facial perception and judgment (Senior, 2003). Again, this highlights the possible role of the reward-system for the processing of facial appearance, and not necessarily expression or emotion. Although the 12 faces used in chapter 5 were randomly allocated to the reinforcing and non-reinforcing sets, the above evidence makes it clear that some faces might be intrinsically more likeable and socially rewarding than others. It is thus conceivable that the two sets of 6 faces used in the previous chapter were not balanced in this respect in their neutral poses, and so the changes in the DVs might not be to do with the differential rates of smiling of the two sets during the task itself. We thus reversed the assignments in the study in this chapter to check that the effects reported previously were not wholly due to accidental differences between the face sets in attractiveness and likeability.

6.1.2 The influence of mood on self-report measures

Understanding the effects of facial processing and the role of reward processing within it, it is important to assess the possibility that providing a mildly rewarding environment through social perception and judgements could potentially induce a mood state (see chapters 2, 3, and 4). Therefore, it was important to consider (and control) whether the reward learning task was conducted before or after administration of the personality questionnaires. Below, we review research that investigates the influence of mood on self-reported measures, trait measures in particular (e.g., Brown & Mankowski, 1993; Hibbert, 2018; Sedikides, 1995).

The chapter 5 study administered the psychometric questionnaires after the participants had completed the ASI task, including rating the characters on traits, likeability and befriending likelihood. The reason for this was to prevent the possible effects of participants rating themselves on certain traits from carrying over into how they perceived the characters, by inducing some sort of cognitive bias. The idea is that rating their own personality may bias how they will rate the characters. For example, if they rate themselves high on agreeableness items and are then asked, almost immediately after, to rate how likely they are to befriend a "stranger", they may be more inclined to rate them higher on the scale. For other traits the influence of self-rating on other rating might work in the opposite direction. This potential effect might not only affect the ratings of all the faces used but conceivably it might differentially affect those who smile more during the interactions compared to those who smile less.

This choice for the ordering of the questionnaires and task in chapter 5 potentially could have been an issue for that study, in that, if the ASI task induced a mildly positive mood state, at least in some participants, then they might have reported their own personality differently than when in a more typical and/or neutral mood state. This seems quite likely to have produced small effects at most but nonetheless it is addressed in the design of the current study.

There are three sperate theories that have convergent predictions of how affect may influence the cognition and judgement required for self-report measures, which supports the idea that mood may influence self-reported personality. This means that personality may not be as stable as we thought, especially with regards to how it is measured. Note that the three theories may appear to be similar, but they are in fact different ways of conceptualising a similar overall effect. First, the mood congruent memory theory (Bower, 1981; Bower & Forgas, 2000) implies that a participant's current mood possibly increases the recall of memories associated with that particular mood state. In this case the mood-related bias in recall may impact the endorsement of some personality scale items during completion. The second and third theories, affect-as-information theory (Clore et al., 2001; Schwarz & Clore, 1983) and the affect infusion model (Forgas, 1995), both suggest that the participant's current mood may be formed into a heuristic cue when rating oneself. In doing so, the cue increases the endorsement of personality scale items in the direction of that mood state. Specifically, the affect-as-information theory considers the potential for individuals to mistake pre-existing affect as information for judgements made at that time. For example, induced mild positive affect can skew the judgement of an unrelated construct in a more positive direction, in this case self-report personality items.

A notable study, conducted by Hibbert (2018), used a mood induction procedure to assess the influence of mood on the Big Five personality traits (self-reported agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience). Hibbert randomly presented participants (N = 431) with a computerised "imagination task" (Rusting & DeHart, 2000), where they were asked to recall and write about a recent instance where they felt either upset (negative mood condition), happy (positive mood condition), or neutral (neutral mood condition). Hibbert then used the Big Five Inventory (BFI-44; Benet-Martinez & John, 1998; John et al., 1991) to assess their self-reported personality. Hibbert (2018) found that current mood state, based on the mood induction, did influence ratings of extraversion, agreeableness, and neuroticism, and also conscientiousness but to a lesser extent. Specifically, participants rated themselves as more extraverted, agreeable, conscientious, and less neurotic when in a positive mood state compared to a negative mood state. It should be noted, however, that while these findings were replicated in a second study (Hibbert, 2018) the effect sizes both times were relatively small, and the mood inductions used were likely to have been stronger than those potentially induced by the ASI task.

In light of the evidence that supports possible mood induction effects on self-reported personality and its theoretical backing, it is viable to assume the possibility of this having occurred in the chapter 5 study, where the trait measures were administered after the ASI task. The importance of reversing this order in the current study is thus important for confirming the validity and reliability of the participant traits moderating the character-type effects.

6.1.3 The present study

The current study attempts to replicate the findings of the ASI study in chapter 5 using the following hypotheses, with adjustments made in light of its outcomes: (a) characters who smile more throughout the artificial interactions (reinforcing characters) will be rated as people they would be more likely to befriend, as more likeable, and as more extraverted, more agreeable, and less neurotic than the characters who smile less (non-reinforcing characters); (b) these character-type effects (reinforcing vs. non-reinforcing) will be moderated by participants' levels of extraversion, neuroticism, agreeableness, and autistic traits. The name recognition task will be administered the same way as the previous study for continuity, while no character-type effects on names recognised are expected, due to the tiny effects observed in the previous chapter. The small effects seem quite likely to stem from a ceiling effect in name recognition performance across both character types.

The current study, however, will code the previously reinforcing characters as non-reinforcing, and the previously non-reinforcing as reinforcing, in order to check whether any possible baseline differences between the face sets (in their neutral poses) might have been solely responsible for the character effects observed in ASI study 1. Furthermore, the trait measures will be administered prior to the participants completing the ASI task, reversing the order of the ASI task and self-reported personality task with respect to ASI study 1, thereby addressing questions as to whether any trait moderation effects were accountable by mood carryover effects from task to self-rating of personality.

6.2 Method

The materials and procedure used for the present study closely resemble those of chapter 5. Differences include the sample population tested, the reversal (c.f. ASI study 1) of the reinforcing roles of the character sets, testing environmental change, and the reversal (c.f. ASI study 1) of the order of administration of the ASI task and the participants self-reported personality scales.

6.2.1 Participants

62 (43 female; mean age *M* = 34.5 years, *SD* = 10.6 years) healthy participants were recruited from the Prolific platform (www.prolific.co), an online participant recruitment platform and were each reimbursed £3.60 for their time. The Informed consent was provided prior to the commencement of the experiment, in accordance with the ethical approval given by the ethics committee at Goldsmiths, University of London. All the participants were tested individually, with each participant completing the tasks and responding to the questionnaires via an online Qualtrics link. Each participant carried out the study on their own computer, laptop, or smart device. The factors impacting on this choice of sample size are discussed below.

6.2.2 Artificial Social Interaction task

The Artificial Social Interaction (ASI) task had the same as structure and was administered in the same way as in chapter 5, except for the design changes discussed above. Here we give a brief recap. The ASI task was implemented on Qualtrics. The learning phase of the ASI task composed of 5 individual interactions with 12 different characters (facial stimuli taken from the NimStim set of facial expressions; Tottenham et al., 2009), across different descriptions of social contexts (blocks), resulting in a total of 60 trials (interactions) across the learning phase of the task. For each block of 12 trials (one interaction per character in each block), the social context was first described for that set of encounters (e.g., a house party or passing in the street), and participants had computerised "interactions" with each of the 12 characters. The character's face was first presented for 3 seconds with a neutral expression along with a dialogue, printed on the screen. The participant was then asked to actively select a typical, friendly response. After that, they were then presented with how the character reacts to this interaction as feedback to their response. Feedback to this response was the same face being re-presented either with a smiling expression or with the same neutral expression for 2 seconds. The names of the characters were not included in the third, fourth, or fifth encounters.

As in the ASI task in chapter 5, half of the characters were designated as reinforcing and the other half as non-reinforcing stimuli. Specifically, 6 characters were coded to give feedback to the participant's response with a smiling face for 80% of the encounters, while the 6 non-reinforcing characters gave a neutral expression as feedback 80% of the time, smiling only 20% of the time. There was an equal number of male and female reinforcing and non-reinforcing characters. The reinforcing and non-reinforcing characters were the same for every participant. However, for this follow-up study, the faces that were previously presented as reinforcing characters were now the non-reinforcing characters, and the faces that were previously presented as non-reinforcing characters were now reinforcing characters. The pattern of smiling responses was always presented in a random order, which was different for each character and encounter, and was also different for each participant.

As in chapter 5, once the participants completed the learning phase of the task, they were presented with a surprise name recognition memory task, where they were shown the neutral face of each of the 12 characters and were asked to select the correct name from a possible three presented below the stimulus. The two distractor names began with the same letter as the correct name in an attempt to avoid priming effects and to increase the difficulty of the task (see chapter 5 for examples).

Once they completed the name recognition memory task, the participants were shown the neutral faces of each of the 12 characters again, however this time they were asked to rate each of them on 8 adjectives derived from each of the Big Five Dimension facets, extraversion (3 adjectives), neuroticism (3 adjectives), and agreeableness (2 adjectives; John and Srivastava, 1999). These ratings were obtained using a 10-point scale, representing the extent to which each adjective described the personality of the character based on the participant's interactions with them throughout all five encounters. High scores meant higher levels of that trait. Participants were then asked to rate each character on how much they liked them (likeability rating) and how likely they were to befriend them (befriending rating), based on their interactions with each character. This was also done on a 10-point scale.

6.2.3 Psychometric measures

The Big Five Aspect Scale (BFAS; DeYoung et al., 2007) was used to measure the participants' levels of extraversion, neuroticism and agreeableness. The Autism Spectrum Quotient (ASQ-28; Hoekstra et al., 2011) was used to measure autistic traits. However, for this study these measures were given before the ASI task was completed, as opposed to after the task (the reverse of the order used in ASI study 1 in chapter 5).

6.2.4 Hypotheses and Statistical Considerations

The hypotheses, and the associated family of statistical tests to address those hypotheses, produced fairly clear results in ASI study 1.

In ASI study 1 the main effects of the reinforcing vs. non-reinforcing character type on rated personality, liking and befriending ratings produced very robust effect sizes (partial eta squared values ranged from 0.37 to 0.55). With such strong effects we should expect to have good power in ASI study 2, analysed in a stand-alone fashion, even with quite modest sample sizes.

However, in ASI study 1 the results from the analyses of the moderating effects of participant personality traits on these character reinforcement type effects produced more modest and variable effects. We used these moderation effects as the basis for our sample size estimation for ASI study 2. The sizes of these effects are captured by the size of the correlation between the participant personality traits and the difference in ratings for reinforcing vs. non-reinforcing characters. For rated extraversion differences between reinforcing and non-reinforcing characters the absolute size of the correlations with participant personality traits of interest were close to 0.2 for all participant traits (as predicted they were positive for extraversion and agreeableness; and negative for AS traits and neuroticism). For the reinforcement-related difference in ratings of likeability and likelihood of befriending, the correlations with extraversion and neuroticism were all greater than 0.2 or less than -0.2. So, we take 0.2 as rough point estimate of these effect sizes for ASI study 2.

We had 148 participants in ASI study 1. As explained in ASI study 1, this gave roughly 80% power, assuming moderation effect sizes were correlations of 0.2 (or -0.2) tested individually at a type I error rate of 0.05. Assuming that the true correlations are close to the size found in ASI study 1, the plan is to combine the study 1 and 2 participants together to test our key moderation hypotheses with greater power. Given that we adjusted the type 1 error rates to preserve familywise type 1 error rates, we require that our combined sample should have adequate power to test even the adjusted alpha rates. Taking our primary participant trait of extraversion, the adjusted alpha rates for the correlations with the three rated personality traits (extraversion, neuroticism, and agreeableness) were $\alpha = \frac{.05}{3} = .017$ and for the two social ratings (likeability and likelihood of befriending) of the characters they were $\alpha = \frac{.05}{2} = .025$. Using an adjusted alpha of $\alpha = \frac{.05}{3} = .017$ then a combined sample of 210 (=148+62) participants would give us 79% power to detect a correlation of +0.2 or larger. We therefore aimed for a further 60 or so participants in study 2. Although the research expenses budget remaining for this study, after completing all the other studies and PhD activities, would not cover these participants (at a £4 a head remuneration), we were fortunate enough to obtain a small amount of additional funding to pay these participants.

It is obvious from the above that any tests of the moderation effect correlations, if sample 2 participants were considered alone, would not have adequate power (power would be around 50% for correlations of 0.2 tested singly and one-tailed with a Type I error rate of .05 in a sample of 60 participants). However, given the clear results of study 1 it is not efficient to consider study 2 purely in isolation. We therefore investigated the correlations once again using Bayesian correlations. We started by considering Study 2 participants alone to see what kinds of Bayes factors were obtained. We used the same prior as we used in the Bayesian correlation analysis for study 1, even though this could be considered to be a conservative choice. If we look at the posterior correlation distributions obtained in study 1 these often gave quite sharply peaked distributions with central tendencies around +0.2 (or -0.2). If we used these posterior distributions from study 1 as priors for study 2, then the Bayes factors would (generally) have been larger than when using the beta=0.15 prior we used for study 1. However, *jamovi* currently does not allow the specification of a prior based on a previous study. Instead, after evaluating the correlations for study 2 alone, we used another feature that is available on *jamovi*, that of sequential testing (see Lakens, 2014).

Sequential analyses are used to allow one to inspect one's data in a statistically rigorous way, after collecting subsamples of participants, using appropriate stopping rules. If one achieves pre-defined statistical outcomes, before the maximum possible sample has been tested, then one can efficiently run the study more cheaply with fewer participants. It is important to stress that such analyses are pre-specified and apply statistical corrections to differentiate this approach from the questionable research practice of "sneaking a look" at the statistical test result and stopping whenever the outcome becomes significant (see Lakens, 2014, for details). We did not plan a formal sequential analysis at the outset with these two ASI studies and (strictly) could not have done so because we made small design changes between ASI study 1 and ASI study 2. However, we can use the sequential analysis window for *jamovi*'s Bayesian correlation module to look what happens to the BF when we add all the ASI study 2 cases to those from study 1.

6.3 Results

Data were analysed using SPSS version 23.0. The sum of the extraversion, neuroticism, and agreeableness scores from the BFAS (DeYoung et al., 2007), and the autistic trait scores from the ASQ-28 (Hoekstra et al., 2011) were calculated. In order to test the influence of participant levels of extraversion, neuroticism, and agreeableness as moderators on the different character ratings, a general linear model was applied, with the moderators added as co-variates. To do this, the scores of all the trait measures were, first, standardized to z-scores. The DVs were the mean character ratings (i.e., the extraversion, neuroticism, agreeableness, likeability and befriending ratings). These were calculated for each participant and the means of the reinforcing and non-reinforcing character scores were separated. The mean number of reinforcing and non-reinforcing names recognised correctly were also calculated for each participant as a final DV.

There are a set of 3 correlations that all test the hypothesis that the reinforcement type of a character will affect their personality on 3 rated traits (extraversion, neuroticism, agreeableness) and that effect will be moderated by the primary participant trait of interest, extraversion. This is a family of 3 moderation tests and so should be tested at $\alpha = \frac{.05}{3} = .017$.

The other nine correlations (reflecting moderation tests) are more exploratory in that we did not have such clear predictions about the effects[16]. They test a broad hypothesis that neuroticism, agreeableness and ASQ traits may moderate the character reinforcement type

[16] We may have used the results of ASI study 1 to reset our predictions and statistical adjustment. However, as study 2 was used to corroborate study 1 with minor design tweaks, we did not consider modifying our families of predictions appropriate at this stage.

effect on the three personality ratings. We, therefore, adjust this set to an alpha of $\alpha = \frac{.05}{9} = .006$.

The two correlations for befriending and likeability ratings (social interaction ratings) test our hypothesis that extraversion will moderate the character reinforcement type effects of social interaction ratings. They will be tested at $\alpha = \frac{.05}{2} = .025$.

The remaining six correlations test our exploratory hypothesis that trait neuroticism, agreeableness, and ASQ may moderate the two character type effect on social interaction ratings. They will thus be tested against $\alpha = 0.05/6 = 0.008$. The set of correlations that test the hypothesis that the reinforcing effect of a character will also moderate name recognition memory were separated in the same way, where the effects of trait extraversion was tested against $\alpha = .05$. The effects of trait neuroticism, agreeableness, and ASQ on name recognition memory was tested against $\alpha = \frac{.05}{3} = .017$.

We also report the participant trait main effects on all DVs, regardless of whether the characters were reinforcing or not (character type), for completeness and on an exploratory basis. As we had no clear predictions about trait main effects, the alpha adjustments for multiple comparisons are as follows: the main effects of the four participant traits on the overall ratings of the three character traits were tested using $\alpha = \frac{.05}{12} = .004$; the main effects of the four participant traits on the overall ratings of the two ratings of social interaction (liking and befriending) were tested using $\alpha = \frac{.05}{8} = .006$; the main effects of participant traits on the overall name recognition were tested using $\alpha = \frac{.05}{4} = .0125$.

As indicted above, the name recognition task results will be analysed as before but, given the results from the previous ASI study, no significant effects are expected.

6.3.1 Character personality ratings

A separate general linear model was run with each participant trait as a predictor along with the character reinforcement type. The general linear model showed a character type effect on character ratings where there was a significant difference between reinforcing and non-reinforcing faces on their rated extraversion [M = 6.01, SD = 1.10; M = 5.04, SD = .92 respectively; $F(1,61) = 38.04$, $p < .001$, $\eta p^2 = .39$]; rated neuroticism [M = 4.10, SD = 1.01; M = 4.84, SD = .91 respectively; $F(1,61) = 41.04$, $p < .001$, $\eta p^2 = .40$]; and rated agreeableness [M = 5.34, SD = 1.05; M = 4.85, SD = .82 respectively; $F(,161) = 12.91$, $p = .001$, $\eta p^2 = .18$] (see Figure 6.1). Specifically, the reinforcing characters were rated as more extraverted and agreeable, and less neurotic than the non-reinforcing characters. This pattern of findings was very similar to those found in ASI study 1 (chapter 5) as effect sizes of extraversion and neuroticism were very robust as in the previous study. However, the effect on agreeableness was more modest but was still significant even with a suitable alpha adjustment[17].

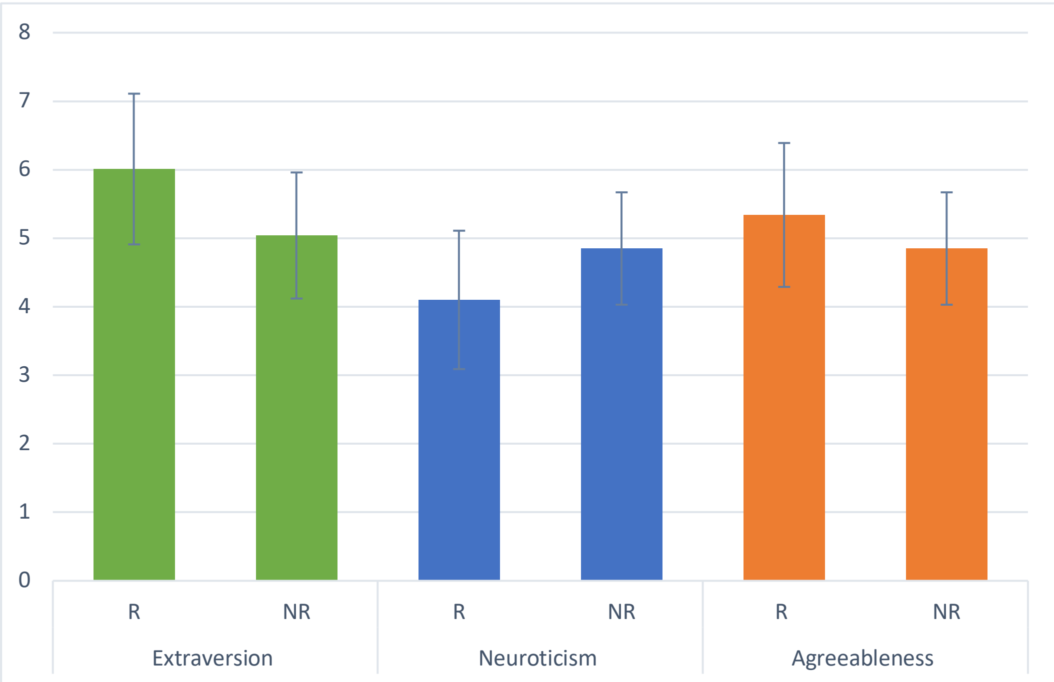


Figure 6.1: Mean scores and standard deviations for personality ratings of reinforcing (R) and non-reinforcing (NR) characters.

For completeness, and in a similar fashion to ASI study 1, separate general linear models were run with each participant trait as a predictor along with the character type. These analyses of the study 2 sample alone were expected to be underpowered, as discussed previously. For participant trait extraversion, there were no significant interactions with the character reinforcement type effect on rated extraversion [$F(1,60) = 3.29$, $p = .075$, $\eta p^2 = .052$], neuroticism [$F(1,60) = 1.94$, $p = .168$, $\eta p^2 = .031$], nor agreeableness [$F(1,60) = 1.46$, $p = .232$,

[17] Alpha adjustments were not discussed for the main effects of reinforcement type because all the effects are so robust.

ηp^2 = .024]. Given that these analyses are underpowered the significance or lack of significance should not be given great weight.

For participant trait neuroticism, there were no significant interactions with character type effect of rated extraversion [F(1,60) = 2.18, p = .145, ηp^2 = .035], neuroticism [F(1,60) = .354, p = .554, ηp^2 = .006], nor agreeableness [F(1,60) = .00, p = .983, ηp^2 = .00].

For participant trait agreeableness, there were no significant interactions with the character type effect of rated extraversion [F(1,60) = 3.07, p = .085, ηp^2 = .049], neuroticism[F(1,60) = 2.73, p = .104, ηp^2 = .044], nor agreeableness [F(1,60) = .76, p = .387, ηp^2 = .031].

For participant autistic traits, the interaction with the character type effects of rated extraversion does not survive the adjusted alpha level [F(1,60) = 4.46, p = .039 (c.f. adjusted α = .006), ηp^2 = .069]. The were no significant interactions of autistic traits on character type effects of neuroticism [F(1,60) = 2.67, p = .108, ηp^2 = .043], nor agreeableness F(1,60) = 2.30, p = .135, ηp^2 = .037].

While we did not necessarily expect significant interaction effects due to the smaller sample size, it is evident that the pattern of results is similar to those obtained in ASI study 1 in terms of the effect sizes of the moderation effects, especially for the moderation effects on rated extraversion. To determine the direction of all the moderation effects of the participant trait measures on the face-type effect of the reinforcing and non-reinforcing faces, bivariate correlations were conducted. The non-reinforcing (lower) scores were subtracted from the reinforcing (higher) scores for ratings of extraversion and agreeableness (reinforcing advantage), while the reinforcing (lower) scores were subtracted from the non-reinforcing (higher) scores for ratings of neuroticism (non-reinforcing advantage). These correlations are reported and summarized in Table 6.1. In Table 6.1 we compare the correlations drawn from the previous ASI study 1, and the correlation for the combined sample from the two studies. For completeness we include the correlations from the current study (ASI study 2) even though, as noted, they were underpowered.

Table 6.1: Correlational relationship between the character personality ratings and participant trait scores for ASI study 2, ASI study 1, and for the two studies combined. Non-reinforcing scores of extraversion and agreeableness were subtracted from reinforcing, while reinforcing scores were subtracted from non-reinforcing scores for neuroticism. Note that the tests on these correlations for study 2 are identical to the interaction tests reported for the general linear models above. The row of extraversion correlations represents one family of tests; the other three rows represent a second family of tests, as noted in the text.

Participant Personality Traits	**Character Personality Ratings**								
	Extraversion (reinforcing advantage)			**Neuroticism (non-reinforcing advantage)**			**Agreeableness (reinforcing advantage)**		
	Study 2 *r*	**Study 1** *r*	**Study 1+2** *r*	**Study 2** *r*	**Study 1** *r*	**Study 1+2** *r*	**Study 2** *r*	**Study 1** *r*	**Study 1+2** *r*
Extraversion	.228	.206*	.207*	.177	.071	.094	.154	.108	.114
Neuroticism	-.187	-.203	-.193**	-.077	-.181	-.153	.003	-.174	-.128
Agreeableness	.220	.186	.190**	.209	.117	.136	.112	.312**	.257**
ASQ	-.263	-.184	-.201**	-.206	-.134	-.148	-.192	-.088	-.107

** Correlation is significant tested against the 0.006 level (2-tailed).
* Correlation is significant tested against the 0.017 level (2-tailed).

As seen in Table 6.1 the ASI study 2 sample was too small to have any significant correlations between trait measures and character ratings. However, it is evident that correlations across the two studies were quite similar. For the combined sample, the correlation of participant extraversion, neuroticism, agreeableness, and autistic traits with the differences in ratings for character extraversion, as a function of character reinforcement type, withstands the adjustment to alpha level.

Participant extraversion has a positive correlation with the degree to which reinforcing characters are given more extraverted personality than non-reinforcing characters, as does participant agreeableness. Participant neuroticism has a negative correlation with the degree to which reinforcing characters are given more extraverted personality than non-reinforcing characters, as does the autistic traits of the participants.

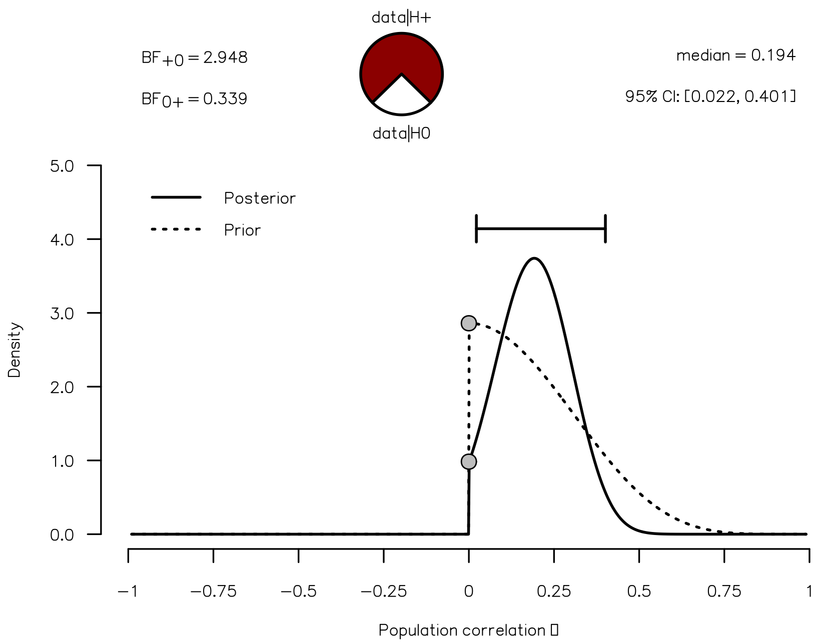
In the combined sample, the correlation of participant agreeableness and ratings on character agreeableness differences as a function of reinforcement type also withstood the adjusted alpha level. This effect in study 1 was the only one of the exploratory moderation tests which was significant after alpha adjustment. Participant agreeableness has a positive correlation with the degree to which reinforcing characters are given more agreeable personality than non-reinforcing characters. However, the effect was numerically considerably larger in study 1 than in study 2.

It is clear from Table 6.2 that the moderation effects on the advantage in rated extraversion for reinforcing characters, were all of a very similar size (around 0.2 or -0.2) across the 4 moderating participant traits. The *a priori* decision to put the primary participant trait of interest (extraversion) into one family and the other 3 potential traits (neuroticism, agreeableness, and autistic traits) into another family of tests affected their formal significance against adjusted alpha thresholds in Study 1 in chapter 5. Despite this, in the combined sample correlations, the moderating effects of all four participant traits on rated extraversion survive our conservative alpha adjustments. However, as noted previously, an obsession with whether a test falls one side or other of a significance threshold has been one of the main factors suggested as contributing to the reproducibility crisis in psychology (Maxwell et al., 2015; Wasserstein & Lazar, 2016).

To supplement these traditional correlational analyses, we also ran some Bayesian correlations using the *jamovi* software (version 1.6.21). In a Bayesian correlation one obtains an estimate of the correlation and its confidence intervals (known as credible intervals in Bayesian statistics) as well as a Bayes factor (BF) expressing the ratio of support for the alternative hypothesis (H1; a directional prediction that the correlation differs from zero in a specific direction) relative to the null hypothesis (H0; the correlation = 0), in light of the data collected. Thus, BF_{10} is used to refer to the Bayes factor for H1 relative to H0 (note that *jamovi* reports these Bayes factors as BF_{+0} for a one-tailed H1). A value BF_{10}=1 means that the data favour H1 and H0 equally and as this value rises above 1 the data provide more evidence in support of H1 relative to H0, and as BF_{10} falls from 1 towards 0 this represents increasingly strong evidence in favour of the null hypothesis. We commented previously that authors have suggested thresholds for different levels of Bayes factors. In our analyses of motivational video effects, we took a BF_{10}>=10 as “strong” evidence in favour of H1, following a popular scheme advanced by Kass and Raftery (1995). Other authors (e.g., Dienes, 2014) have used these same descriptors of the evidence thresholds but argued that a BF_{10}>= 3 (moderate evidence) is noteworthy and roughly corresponds to a standard p value cut-off of 0.05 in traditional statistics.

Bayesian correlations can be one or two tailed and we opted for one-tailed correlations whenever we had clear predictions as to the direction (sign) of the predicted correlations. As discussed in the previous chapter, a very important feature of Bayesian analyses is the so-called prior distribution for the statistic under test. In the case of a first study of a phenomenon, this would be the experimenters' beliefs about the range of possible values (and their relative likelihood) for the correlations under test, before carrying out the experiment. In our earlier power-based sample size estimation, using experience of typical correlations with personality traits, we used a "fixed-point" value of 0.2 (or -0.2 where the correlation was expected to be negative). In Bayesian analyses we are not limited to a fixed-point estimate and can use a distribution of correlations values. *Jamovi* allows us to set a parameter (called the stretched beta distribution prior parameter value) which controls the shape of the prior distribution. The default value of 1 for this parameter means that all possible values of the corelation are equally likely. In the case of a 1-tailed (predicted positive) correlation this means that our prior distribution rates all correlations in the range 0 to +1 as equally likely (it creates a "uniform" prior). In our view this is not a sensible choice of prior for behavioural correlates with a personality trait. As previously noted, such correlations typically are around 0.2-0.3 across a huge range of published studies. Given file drawer effects, many unpublished correlations are probably also in the range 0-0.2. We therefore decided to choose a value of the prior which puts much of prior expectation for the corelation in this range, and very little expectation that the correlation would be >+0.5, as correlations this large are very rare in behaviour-trait correlation studies. It turns out that setting the stretched beta parameter to 0.15 creates a prior distribution for the correlation that fits our general expectations far better than the uniform distribution (obtained with the default beta parameter =1.0). In light of the results of ASI study 1, for most of the correlations of interest, justified this choice of prior. As already discussed in this chapter (section 6.2.4), we might have used the effects of study 1 to set a more informed prior distribution, more sharply peaked around a correlation of +0.2 or -0.2. However, this is not possible in *jamovi* and, as our primary interest is in the results for the combined sample, it would not be entirely reasonable to set a prior for the combined sample based on the results from the first study.

We computed Bayesian correlations in *jamovi* between participant extraversion and rated character traits (extraversion, neuroticism, and agreeableness), first for study 2 alone.



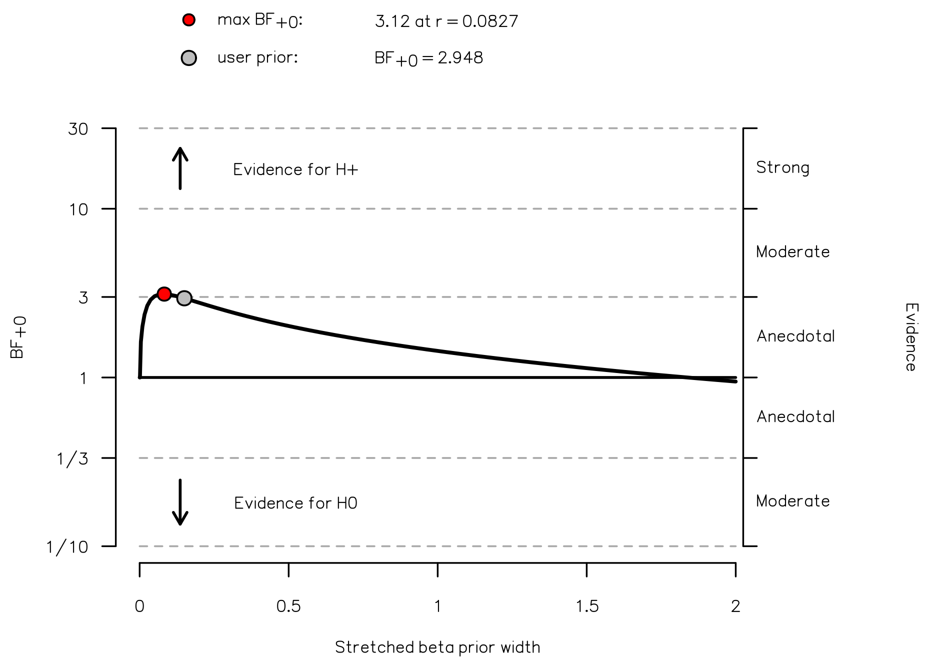


Figure 6.2: Upper panel: Posterior and prior distributions of correlation values (prior was set by a beta parameter of 0.15), for the correlation between participant extraversion and the reinforcing advantage of rated extraversion for ASI study 2. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

The results for the correlation between participant extraversion and the reinforcing advantage of rated extraversion for ASI study 2 above (Figure 6.2) show that the median correlation is 0.19 with 95% CredInts of 0.022 and 0.401. The BF is close to the moderate evidence threshold of 3 ($BF_{10} = 2.95$). It is not unexpected that this will be lower than that from study 1 because the sample size is much smaller. It is also worth noting again that the prior distribution choice for analysing study 2 alone was conservative (c.f. if we had used the prior based on the posterior distribution from study 1).

We now present the Bayesian correlation analysis between participant extraversion and the reinforcing advantage of rated extraversion for the combined ASI study 1 and 2 sample. The prior beta parameter was again set to 0.15.

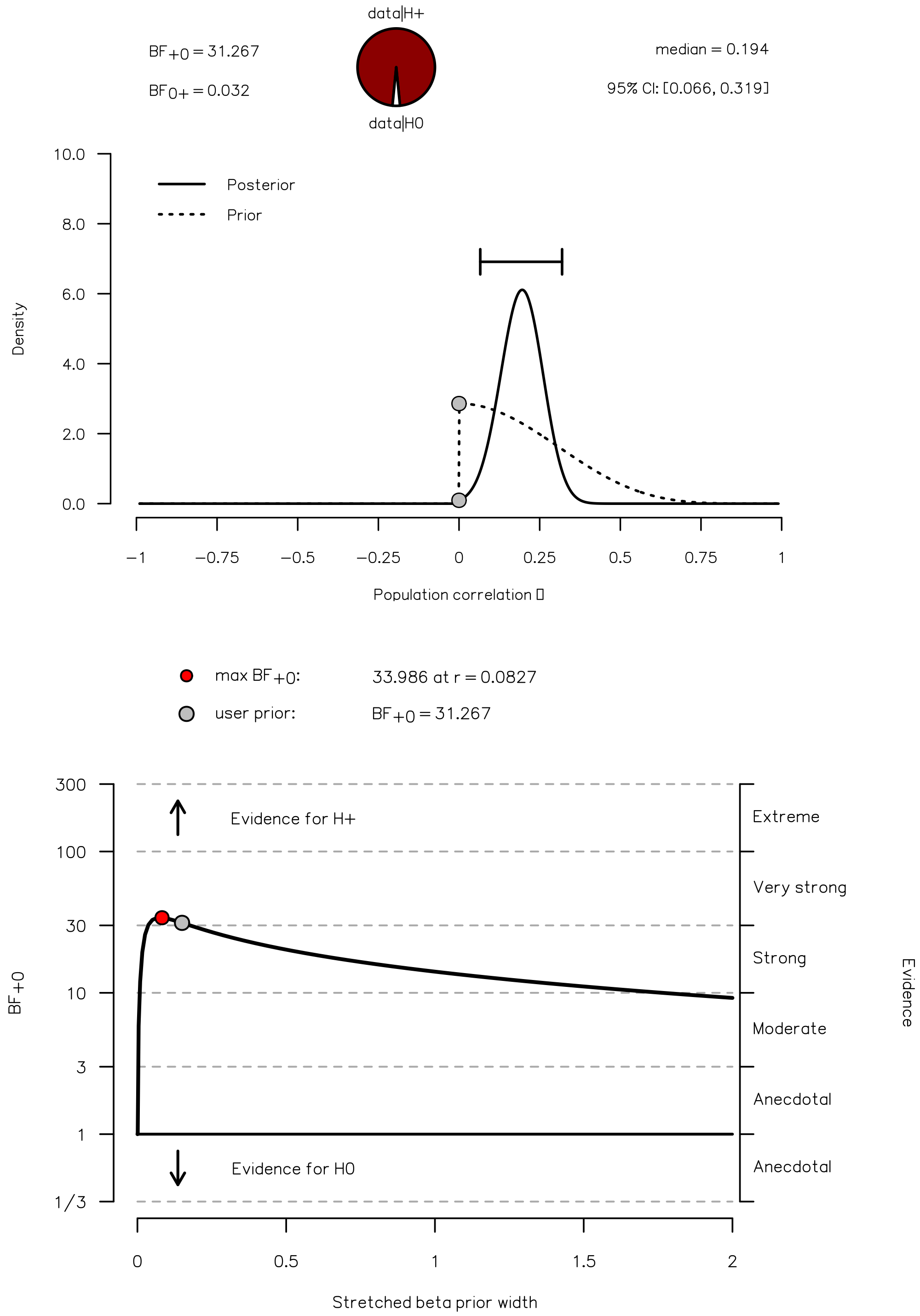


Figure 6.3: Upper panel: Posterior and prior distributions of correlation values (prior was set by a beta parameter of 0.15), for the correlation between participant extraversion and the reinforcing advantage of rated extraversion for the combined ASI study 1 and 2. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

It is clear to see in Figure 6.3 that the BF has moved into the very strong evidence range $BF_{10}>30$ and note that even with the unrealistic uniform prior (beta=1) here we can see from the robustness check, that the BF is still well in the strong (>10) range. In fact, the exact BF_{10} with that uniform prior is 14.10. The median correlation remains the same 0.19, however the CredInt is now 0.066 and 0.319.

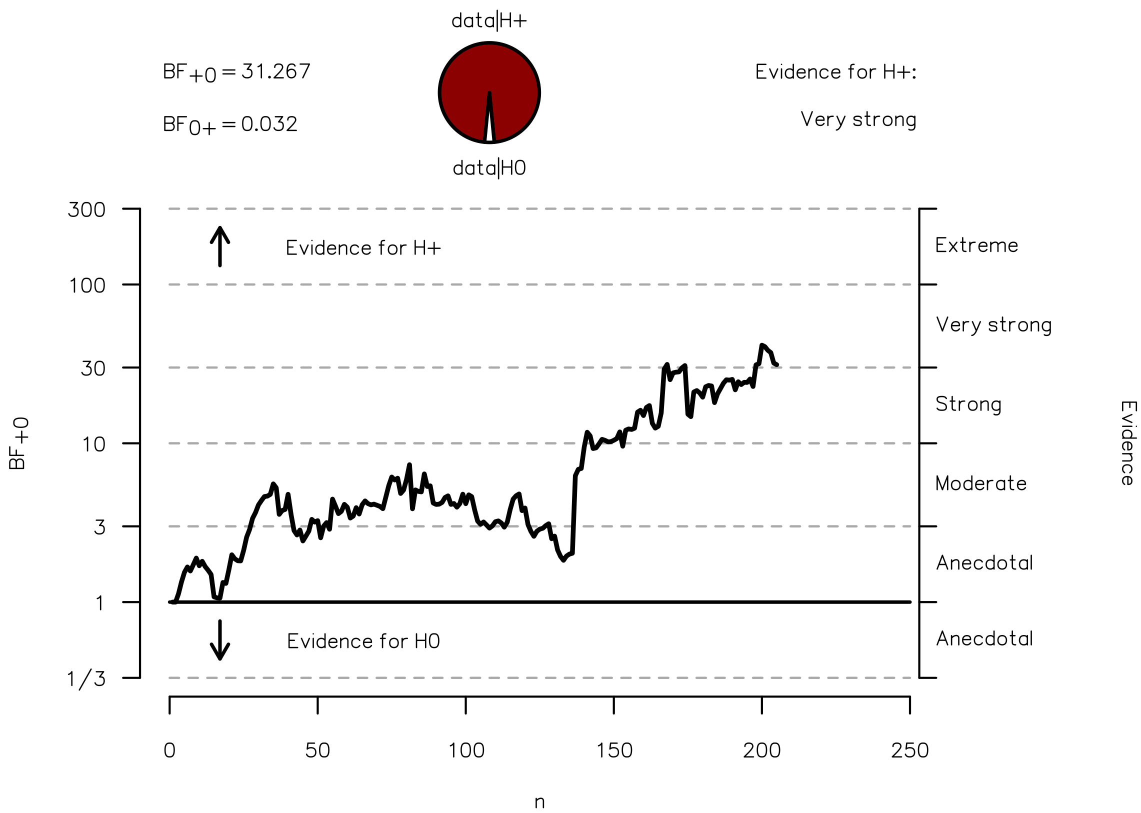


Figure 6.4: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of participant extraversion and the reinforcing advantage of rated extraversion. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

The sequential analysis (Figure 6.4) plots the BF after each participant is added (in the specific order they appear in the data file). Across the first 148 cases (from ASI study 1) we can see that the BF value never falls below 1 (in favour of the null hypothesis) and generally occupies the moderate evidence range (3-10) across most of the sample. It only passes into the strong range (>10) when the whole sample for study 1 is included. What is more interesting is what happens when ASI study 2 cases are added (again in the order of cases as in the data file). Note that these further cases steadily increase the BF_{10} from 10 to over 30 across the range and there is no persistent reduction of BF_{10} for the whole study 2 sample. This strongly suggests (as does the classic correlation analysis) that study 2 finds (for this particular correlation) a very similar result to that in study 1. This strongly suggests that the order of personality scales relative to ASI task is unlikely to have had much influence on this correlation, given that this factor was reversed between study 1 and study 2. For similar reasons, this also suggests that the assignment of the characters to reinforcing versus non-reinforcing experimental roles is unlikely to have had an effect on character ratings.

We repeated this process for all the Bayesian correlations between participant traits and character trait ratings, first for ASI study 2 alone, and then for the combined sample of study 1 and 2, with sequential analysis.

For the correlation between participant extraversion and the non-reinforcing advantage for rated neuroticism (i.e., rated neuroticism of the non-reinforcing characters minus the rated neuroticism of the reinforcing characters) for the ASI study 2 sample, the Bayesian correlation has a median value of 0.16 and the 95% CredInt is between 0.013 and 0.365. The Bayes Factor, BF_{10} is 1.64. Even when combining the samples, the BF_{10} remains low at 1.02, providing weak support for H1 relative to H0. The Bayesian correlation for the combined samples has a median value of 0.09 and 95% CredInt between 0.008 and 0.221.

For the correlation between participant extraversion and the reinforcing advantage for rated agreeableness for the study 2 sample, the Bayesian correlation has a median value of 0.15 and the CredInt is between 0.011 and 0.350. The BF_{10} is 1.30. Even when combining the samples, the BF_{10} remains low at 1.61, providing weak support for H1 relative to H0. The Bayesian correlation for the combined samples has a median value of 0.11 and 95% CredInt between 0.012 and 0.238.

Next, we consider the moderation effects on rated character personality traits by participant neuroticism. For the correlation between participant neuroticism and the reinforcing advantage of rated extraversion for the study 2 sample, the correlations were predicted to be negative. The Bayesian correlation has a median value of -0.17 and the CredInt is between -0.372 and -0.015. The BF_{10} is 1.82. However, when combining the samples, the BF_{10} becomes 17.97, which is evidence of strong support for the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.19 and 95% CredInt between -0.308 and -0.054.

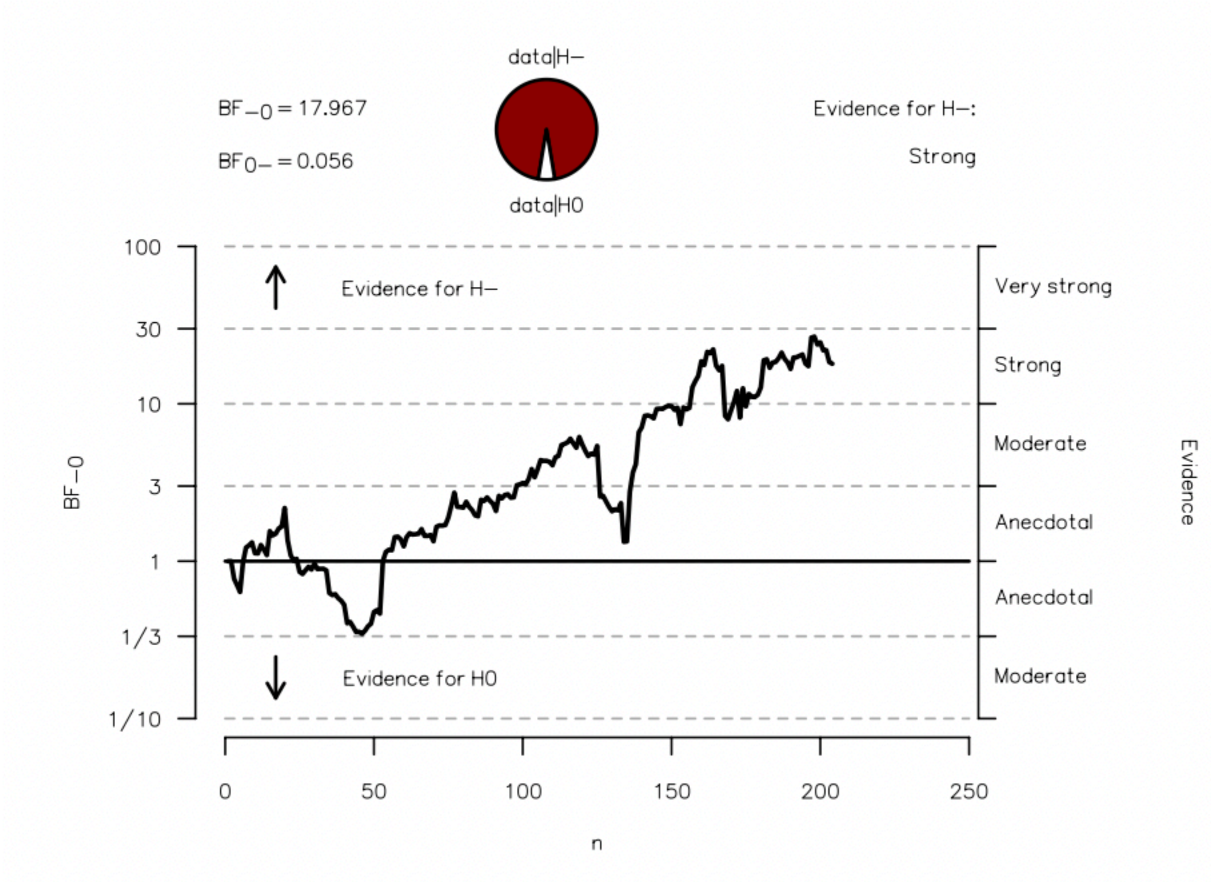


Figure 6.5: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of participant neuroticism and the reinforcing advantage of rated extraversion. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

The sequential analysis for the correlation of trait neuroticism with the reinforcing advantage for rated extraversion (Figure 6.5) plots the BF after each participant is added (in the specific order they appear in the data file). We can see that for the first 50 cases (from ASI study 1) the BF value falls below 1 (in favour of the null hypothesis) but then goes on to occupy the weak to moderate, or moderate to strong, evidence ranges across the rest of that sample. It passes into the strong range only when the sample for study 2 is included, and there is a steady growth in the BF across the participants from study 2.

For the correlation between participant neuroticism and the non-reinforcing advantage of rated neuroticism (again predicted to be a negative correlation) for the study 2 sample, the Bayesian correlation has a median value -0.11 and the CredInt is between -0.300 and -0.006. The BF_{10} is 0.68, which actually favours the null hypothesis. However, when combining the samples, the BF_{10} becomes 4.54, which is evidence for moderate support of the H1 relative to the H0. The

Bayesian correlation for the combined samples has a median value of -0.153 and 95% CredInt between -0.272 and -0.027.

For the correlation between participant neuroticism and the reinforcing advantage of rated agreeableness (again predicted to be a negative correlation) for the study 2 sample, the Bayesian correlation has a median value -0.08 and the CredInt is between -0.255 and -0.004. The BF_{10} is 2.68. However, when combining the samples, the BF_{10} remains in the evidence which provides weak support of the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.13 and 95% CredInt between -0.250 and -0.016.

Next, we consider the moderation effects on rated character personality by participant agreeableness. For the correlation between participant agreeableness and the reinforcing advantage of rated extraversion for the study 2 sample, the Bayesian correlation has a median value of 0.19 and the CredInt is between 0.020 and 0.396. The BF_{10} is 2.68 (weak evidence for H1). However, when combining the samples, the BF_{10} becomes 16.83, which is evidence of strong support for the H1 relative to the H0. The Bayesian correlation for the combined samples remains at a median value of 0.19 but with a 95% CredInt between 0.052 and 0.304.

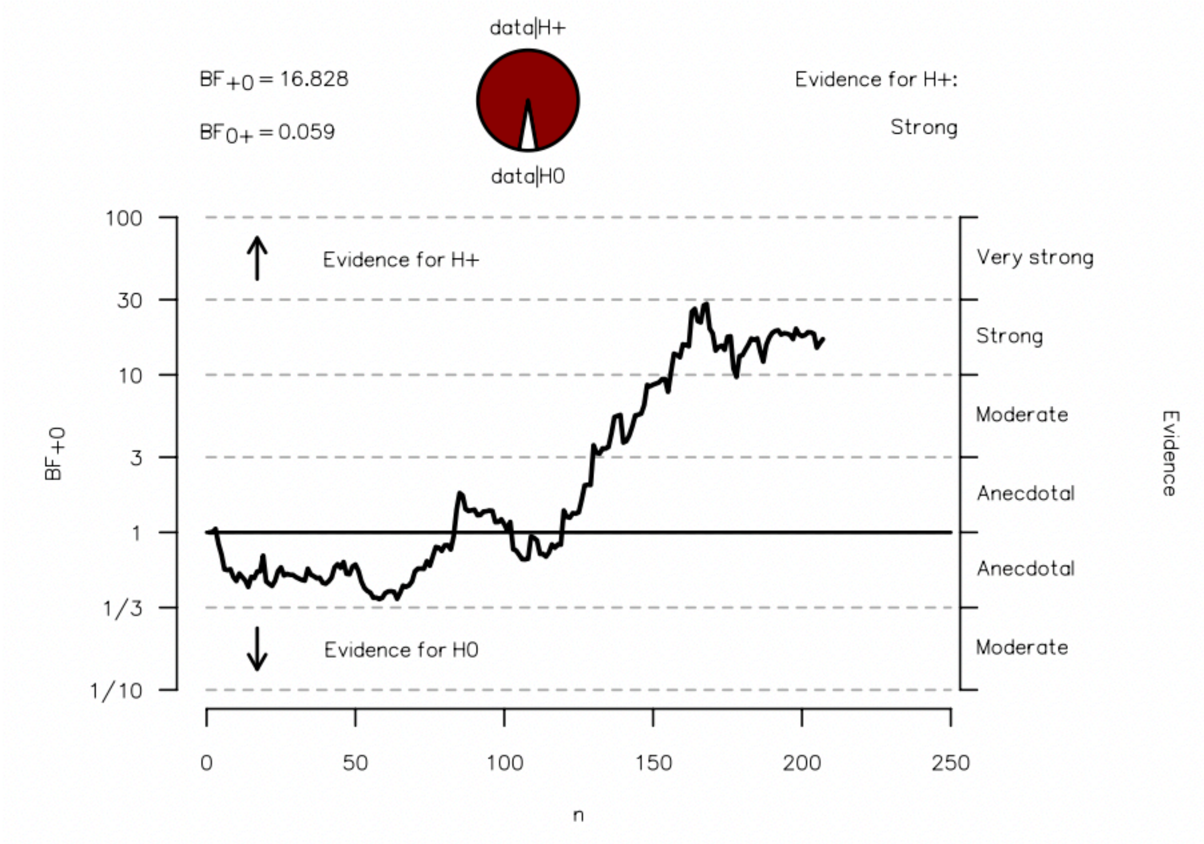


Figure 6.6: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of participant agreeableness and the reinforcing advantage of rated extraversion. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

The sequential analysis for the correlation of trait agreeableness with the reinforcing advantage of rated extraversion (Figure 6.6) plots the BF after each participant is added (in the specific order they appear in the data file). Again, we can see that for the first 50 cases (from ASI study 1) the BF value falls below 1 (in favour of the null hypothesis) but then goes on to occupy the moderate to strong evidence range by the time the whole study 1 sample has been included. It passes into the strong range only when the sample for study 2 is included. There is a period of decline in BF as the study 2 participants are added but the BF remains in the strong evidence range for the whole of study 2.

For the correlation between participant agreeableness and the non-reinforcing advantage of rated neuroticism for the study 2 sample, the Bayesian correlation has a median value 0.18 and the CredInt is between 0.018 and 0.387. The BF_{10} is 2.33 (weak evidence for H1). When combining the samples, the BF_{10} becomes 2.81, which is only slightly larger. This value approaches the threshold (BF_{10}=3) for moderate support of the H1 relative to the H0. The

Bayesian correlation for the combined samples has a median value of 0.14 and 95% CredInt between 0.019 and 0.256.

For the correlation between participant agreeableness and the reinforcing advantage of rated agreeableness for the study 2 sample, the Bayesian correlation has a median value 0.12 and the CredInt is between 0.008 and 0.322. The BF_{10} is 0.892. However, when combining the samples, the BF_{10} becomes 347.85, which is evidence of extreme support for H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of 0.26 and 95% CredInt between 0.114 and 0.363.

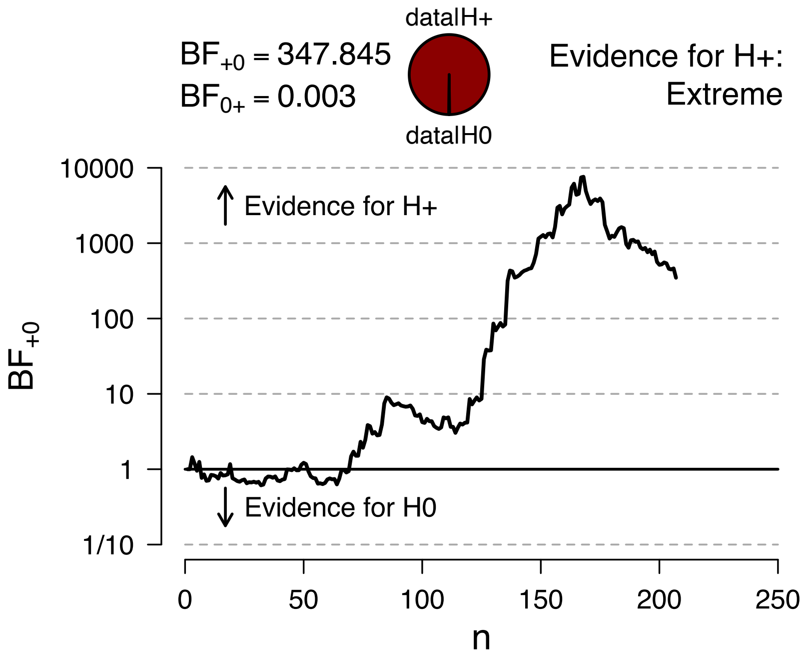


Figure 6.7: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of participant agreeableness and the reinforcing advantage of rated agreeableness. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

The sequential analysis for the correlation of participant agreeableness and the reinforcing advantage for rated agreeableness (Figure 6.7) plots the BF after each participant is added (in the specific order they appear in the data file). Across the first 148 cases (from ASI study 1) we can see that the BF value enters the strong evidence range ($BF_{10}>10$) and then the extreme (aka decisive) range ($BF_{10}>100$) by the time the whole of study 1 has been added. The BF value as the study 2 participants are added at first continues to grow but then reduces to end up with a value in the decisive range.

Finally, we consider the moderation effects of rated character personality traits by participant autistic traits. For the correlation between participant autistic traits and the reinforcing advantage of rated extraversion for the study 2 sample, the correlations were predicted to be negative. The Bayesian correlation has a median value of -0.22 and the CredInt is between -0.426 and -0.032. The BF_{10} is 4.74 (moderate evidence for H1). However, when combining the samples, the BF_{10} becomes 25.13, which is evidence of strong support for the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.20 and 95% CredInt between -0.313 and -0.061.

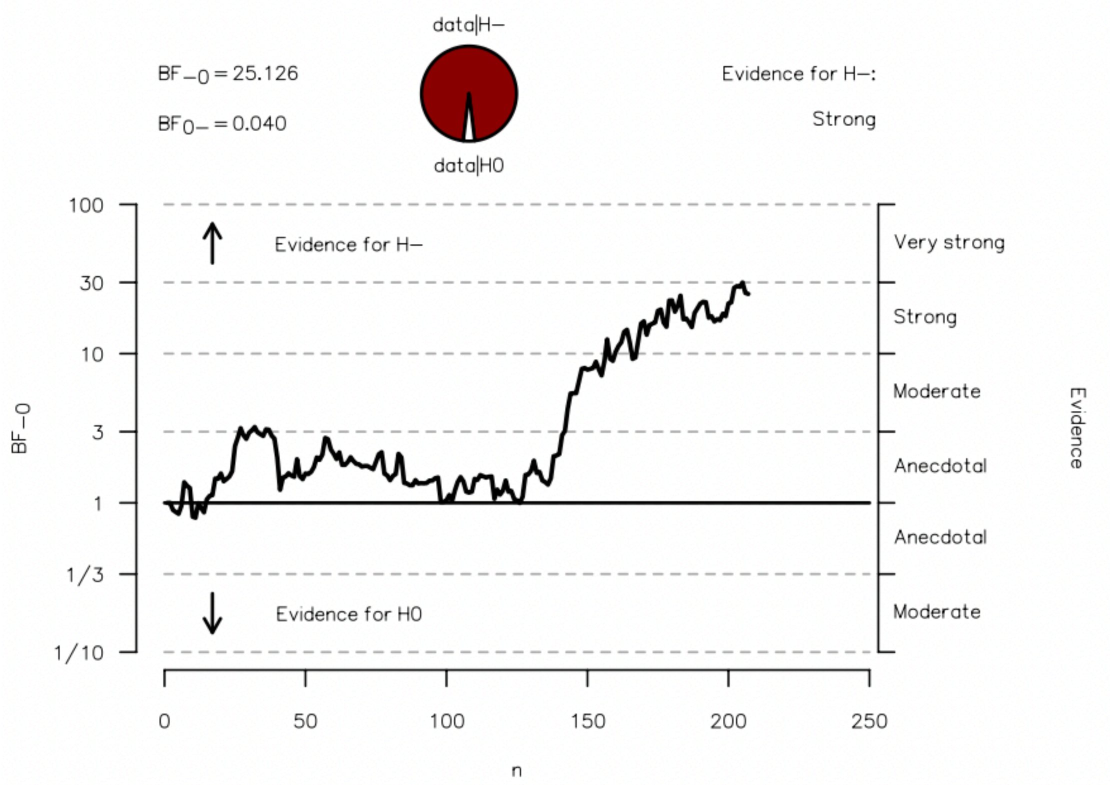


Figure 6.8: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of autistic traits and the reinforcing advantage of rated extraversion. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

The sequential analysis for the correlation of autistic traits and the reinforcing advantage for rated extraversion (Figure 6.8) plots the BF after each participant is added (in the specific order they appear in the data file). Across the first 148 cases (from ASI study 1) we can see that the BF value never falls below 1 (in favour of the null hypothesis) for sustained period, but generally occupies the anecdotal (weak) evidence range across most of the sample, rising close to the strong evidence range when the whole sample for study 1 is included. What is more interesting is what happens when ASI study 2 cases are added (again in the order of cases as in the data file): the evidence strengthens consistently and steadily across the sample.

For the correlation between participant autistic traits and the non-reinforcing advantage of rated neuroticism (again predicted to be a negative correlation) for the study 2 sample, the Bayesian correlation has a median value -0.18 and the CredInt is between -0.386 and -0.018. The BF_{10} is 2.27. However, when combining the samples, the BF_{10} becomes slightly larger at 3.97, which is evidence for moderate support of the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.15 and 95% CredInt between -0.267 and -0.024.

For the correlation between participant autistic traits and the reinforcing advantage of rated agreeableness (again predicted to be a negative correlation) in the study 2 sample, the Bayesian correlation has a median value -0.17 and the CredInt is between -0.376 and -0.015. The BF_{10} is 1.93. When combining the samples, the BF_{10} remains low at 1.37, which again provides anecdotal (weak) support for H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.11 and 95% CredInt between -0.232 and -0.011.

6.3.2 Character social interaction ratings

There was a significant character type effect on ratings of likeability [$F(1, 61) = 31.98$, $p < .001$, $\eta p^2 = .34$] and befriending likelihood [$F(1, 61) = 30.86$, $p < .001$, $\eta p^2 = .34$], where participants rated the reinforcing characters as more likeable ($M = 5.59$, $SD = 1.40$) and were more likely to befriend ($M = 5.73$, $SD = 1.37$) them than the non-reinforcing characters ($M = 4.63$, $SD = 1.44$; $M = 4.78$, $SD = 1.41$ respectively; see Figure 6.9). Again, this pattern of results is similar to what was found in ASI study 1 (chapter 5). The effects sizes here are robust and similar to those in ASI study 1, although slightly smaller.

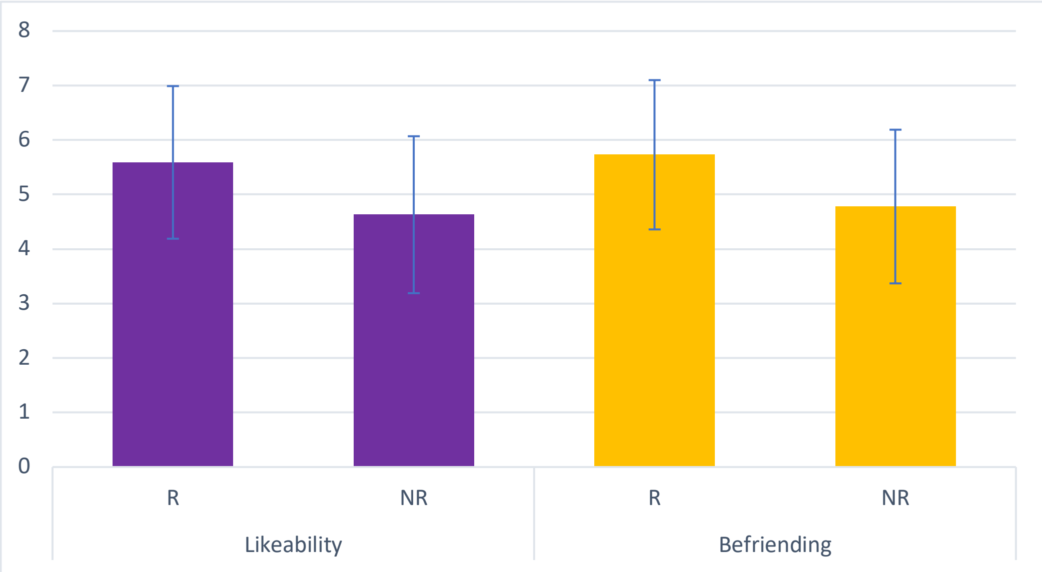


Figure 6.9: Mean scores and standard deviations of characters likeability and befriending likelihood of reinforcing (R) and non-reinforcing (NR) characters.

As noted above, the analyses of ASI study 2 alone are underpowered and so we did not expect expect significant interaction effects between participant traits and reinforcement type effects due to the smaller sample size. Separate general linear models were run with each participant trait as a predictor along with the character type for each social interaction rating. There were no significant interactions of participant trait extraversion on character type effect of likeability [F(1,60)= 3.51, p = .066, ηp^2 = .055], nor befriending likelihood [F(1,60)= 3.23, p = .077, ηp^2 = .051]. Based on our alpha adjustments, these effects would be formally significant in study 2, if the p-values fell below 0.025.

There were no significant interactions of trait neuroticism on character type effect of likeability [F(1,60)= .485, p = .489, ηp^2 = .008], nor befriending likelihood [F(1,60)= 1.12, p = .297, ηp^2 = .018]. There were no significant interactions of trait agreeableness on character type effect of likeability [F(1,60) = 1.92, p = .171, ηp^2 = .031], nor befriending likelihood [F(1,60)= 2.96, p = .090, ηp^2 = .047]. The interaction of autistic trait on character type effect on likeability ratings does not survive the alpha level adjustment [F(1,60) = 5.95, p = .018 (c.f. adjusted α = .008), ηp^2 = .090], and befriending likelihood [F(1,60) = 7.10, p = .010 (c.f. adjusted α = .008), ηp^2 = .106] (see Table 6.2).

Despite the low power for the ASI study 2 considered alone, it is clear that the pattern and strength of the effects is similar to those obtained in ASI study 1 in terms of the effect sizes of the moderation effects. To determine the direction of all the moderation effects of the participant trait measures on the face-type effect of the reinforcing and non-reinforcing faces, bivariate correlations were conducted. The non-reinforcing (lower) scores were subtracted from the reinforcing (higher) scores for ratings of character likeability and befriending likelihood (reinforcing advantage). These correlations are reported and summarized in Table 6.2, where we compare the correlations drawn from the previous ASI study 1, and the correlation for the combined sample from the two studies. For completeness we include the correlations from the current study (ASI study 2) despite them being underpowered.

Table 6.2: Correlational relationship between the reinforcing advantage for character social interaction ratings and participant trait scores for ASI study 2, ASI study 1, and for the two studies combined. Non-reinforcing scores of the ratings were subtracted from reinforcing scores. Note that the tests on these correlations are identical to the interaction tests reported for the general linear models above. The row of extraversion correlations represents one family of tests; the other three rows represent a second family of tests as noted in the text.

Participants Personality Traits	**Character Ratings**					
	Likeability (reinforcing advantage)			**Befriending (reinforcing advantage)**		
	Study 2 *r*	**Study 1** *r*	**Study 1+2** *r*	**Study 2** *r*	**Study 1** *r*	**Study 1+2** *r*
Extraversion	.235	.260*	.247*	.226	.225*	.222*
Neuroticism	-.090	-.282**	-.222**	-.127	-.239**	-.205**
Agreeableness	.176	.113	.127	.217	.207	.207**
ASQ	-.300	-.105	-.156	-.325	-.158	-.199**

**Correlation is significant when tested against the 0.008 level (2-tailed).
* Correlation is significant when tested against the 0.025 level (2-tailed).

All the correlations have the same sign in study 2 as study 1 and the primary moderator of interest (extraversion) has almost identical correlations in the two studies. When the data from both studies are combined into a single correlation extraversion significantly moderates both the likeability advantage and befriending advantage for reinforcing faces. This is the primary finding for these dependent variables. Neuroticism continues to significantly moderate the reinforcement advantage for either rating in the combined sample (as it did in study1), although the relationships were numerically weaker in study 2.

Agreeableness had similar correlations across study 2 and study 1 for either rating and, in the case of befriending, the combined sample gave a significant correlation which survived the correction for multiple comparisons. The autistic traits correlation with the befriending advantage was larger in study 2 than study 1 such that the combined sample correlation survived the correction for multiple correlation. Note that the size of the correlations for the reinforcing advantage for befriending is almost identical for all four moderators in the combined sample.

We computed Bayesian correlations in *jamovi* between participant extraversion and rated character social interaction ratings (likeability and befriending likelihood), first for study 2.

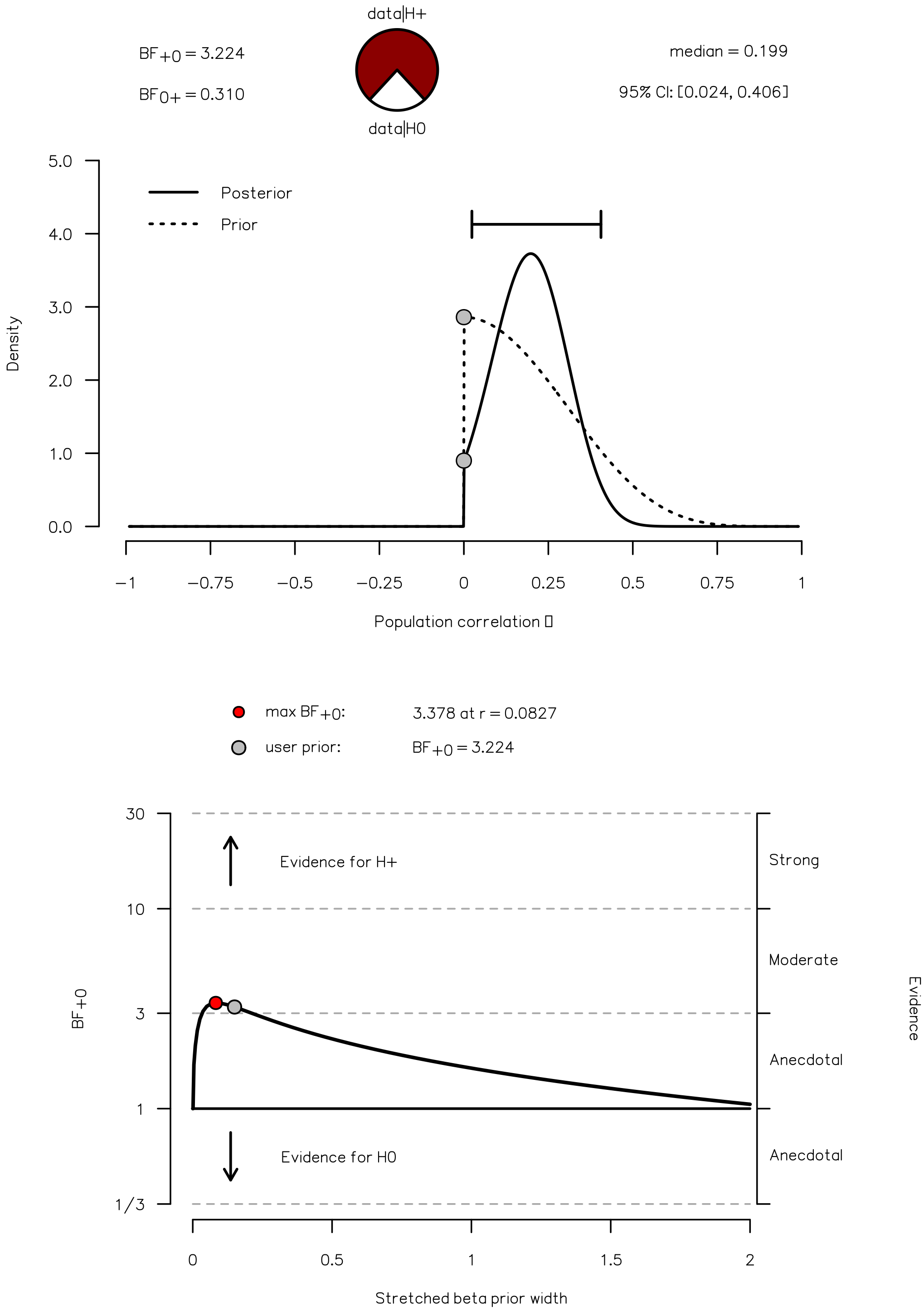
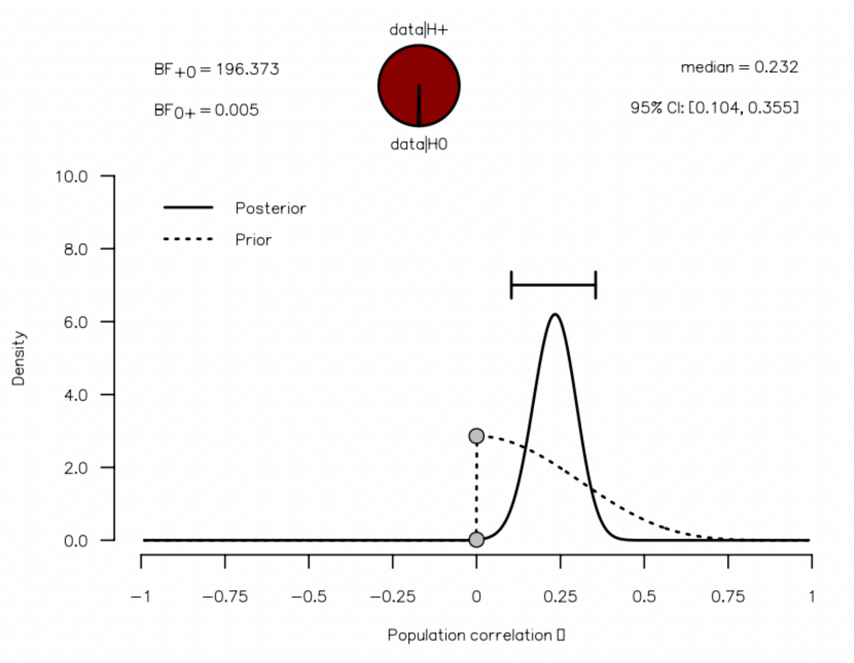


Figure 6.10: Upper panel: Posterior and prior distributions of correlation values (prior set by a beta parameter of 0.15), for the correlation between participant extraversion and the reinforcing advantage of rated likeability for ASI study 2. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

The results for the correlation between participant extraversion and the reinforcing advantage of rated likeability for ASI study 2 above (Figure 6.10) show that the median correlation is 0.20

with 95% CredInts of 0.024 and 0.406. The $BF_{10} = 3.22$, which shows evidence of moderate support of the H1 relative to H0. However, when including a combined sample of ASI study 1 and 2, it is clear to see in Figure 6.11 below that the BF has moved into the extreme evidence range $BF_{10} > 100$. In fact, the exact BF_{10} with a prior beta of 0.15 is 196.37. The median correlation is 0.23 with 95% CredInts of 0.104 and 0.355.



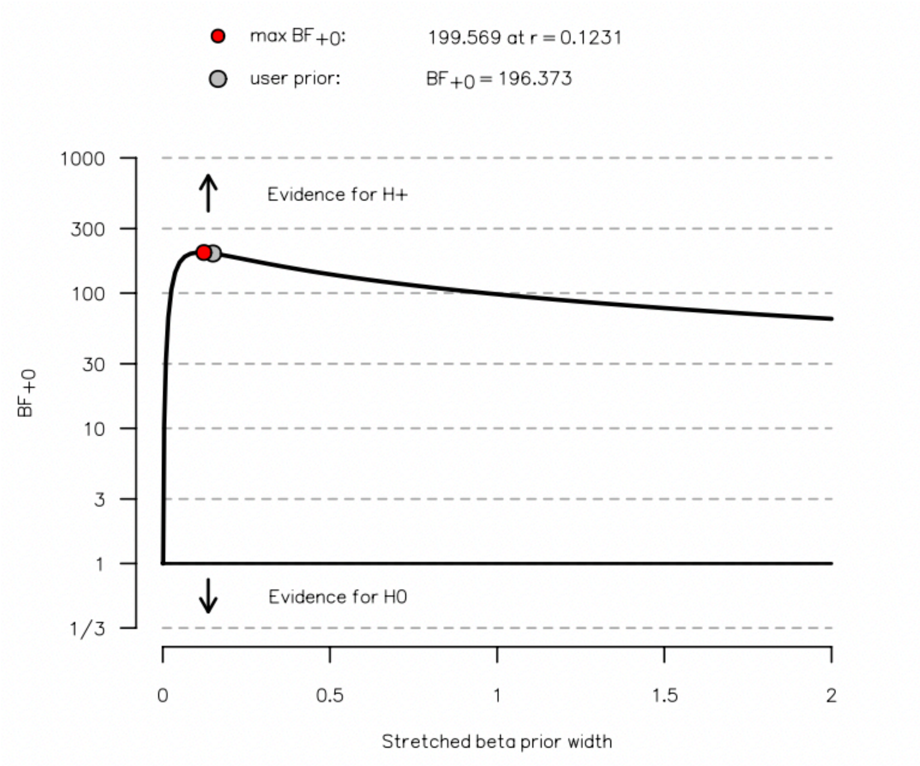


Figure 6.11: Upper panel: Posterior and prior distributions of correlation values (prior set by a beta parameter of 0.15), for the correlation between participant extraversion and the reinforcing advantage of rated likeability for the combined ASI study 1 and 2. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

The sequential analysis (Figure 6.12) plots the BF after each participant is added (in the specific order they appear in the data file). Across the first 148 cases (from ASI study 1) we can see that the BF value never falls below 1 (in favour of the null hypothesis) and generally occupies the moderate evidence range across most of the sample. It passes into the strong range only when the whole sample for study 1 is included. What is more interesting is what happens when ASI study 2 cases are added (again in the order of cases as in the data file). Note that these further cases steadily increase the BF_{10} from 10 to over 100 across the range and there is no persistent reduction of BF_{10} for the whole study 2 sample. This strongly suggests (as does the classic correlation analysis) that study 2 finds (for this particular correlation) a very similar result to that in study 1. Again, this strongly suggests that the order of personality scales relative to ASI task, as well as which faces were coded as reinforcing or non-reinforcing, are factors that are unlikely to have had much influence on this correlation given that these design features were changed between study 1 and study 2.

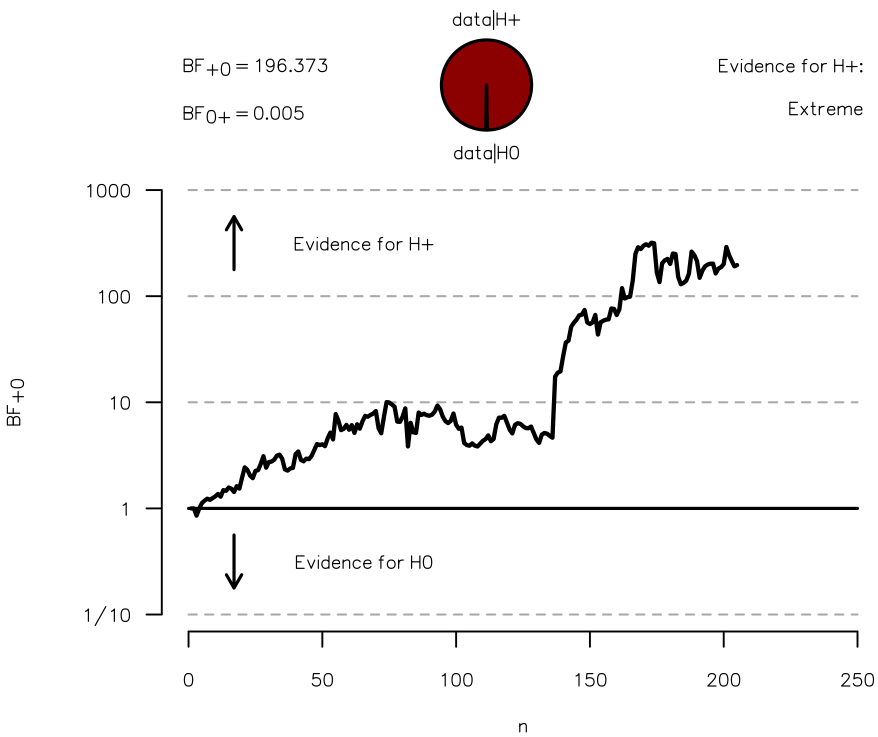
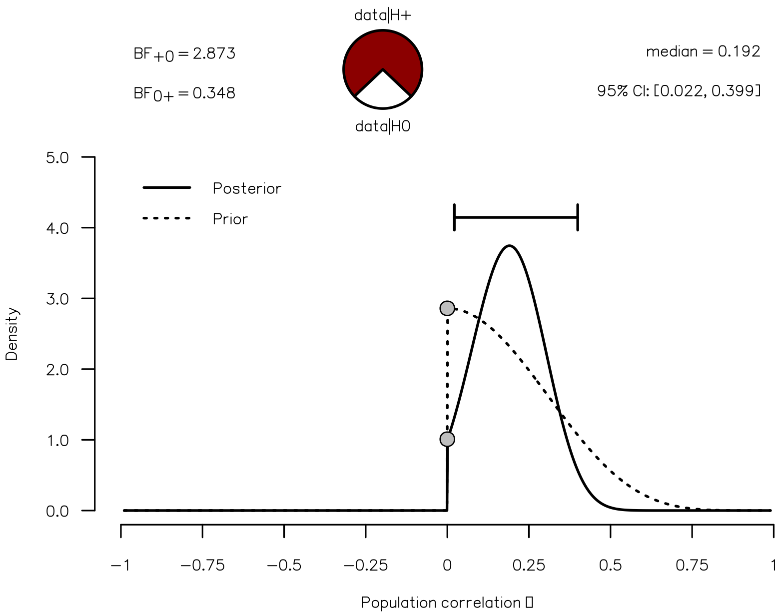


Figure 6.12: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of trait extraversion and the reinforcing advantage of rated likeability. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.



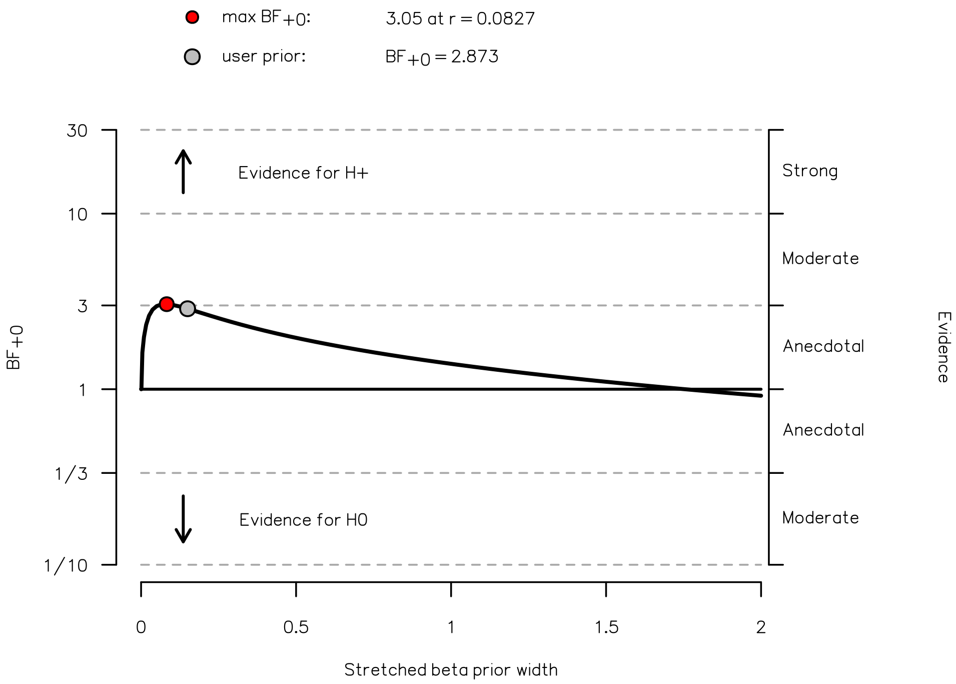


Figure 6.13: Upper panel: Posterior and prior distributions of correlation values (prior set by a beta parameter of 0.15), for the correlation between participant extraversion and the reinforcing advantage of rated befriending likelihood for ASI study 2. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

The results for the correlation between participant extraversion and the reinforcing advantage of rated befriending for ASI study 2 above (Figure 6.13) show that the median correlation is 0.19 with 95% CredInts of 0.022 and 0.399. The $BF_{10} = 2.87$, which approaches evidence of moderate support of the H1 relative to H0. However, when including a combined sample of ASI study 1 and 2, it is clear to see in Figure 6.13 below that the BF has moved into the very strong evidence range $BF_{10} > 30$. In fact, the exact BF_{10} with a prior beta of 0.15 is 57.89. The median correlation is 0.21 with CredInts of 0.079 and 0.333.

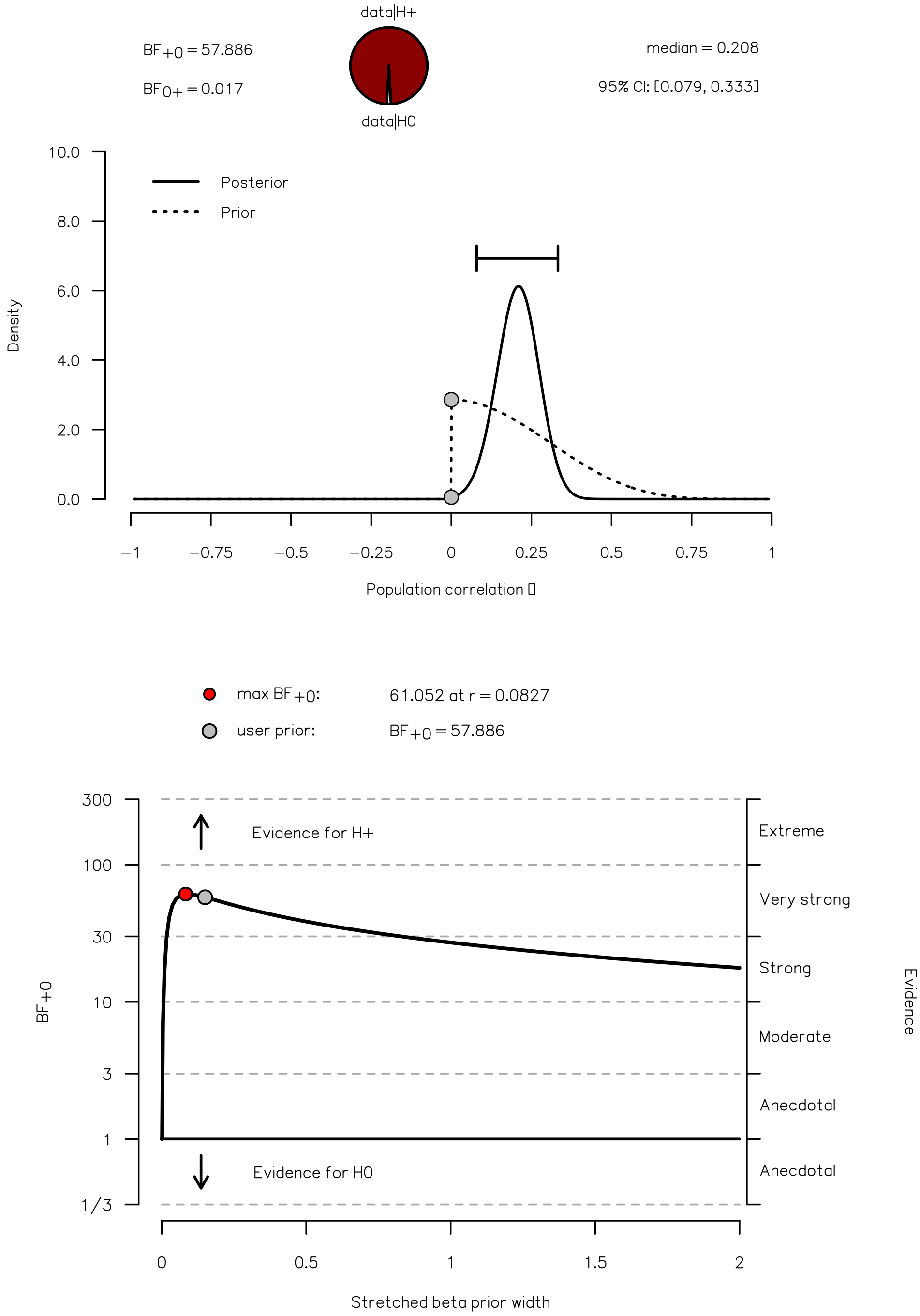


Figure 6.14: Upper panel: Posterior and prior distributions of correlation values (prior set by a beta parameter of 0.15), for the correlation between participant extraversion and the reinforcing advantage of rated befriending likelihood for the combined ASI study 1 and 2. Lower panel: Bayes factor robustness check as evidence for support of H1 (H+ in the figure) or H0 of the correlation.

Again, across the first 148 cases (from ASI study 1) we can see in the sequential analysis (Figure 6.15) that the BF value falls just below 1 (in favour of the null hypothesis) at the start and generally occupies the moderate evidence range across most of the sample. It passes into the strong range only when the whole sample for study 1 is included. When ASI study 2 cases are added these further cases steadily increase the BF_{10} from 10 to over 30 across the range and there is no persistent reduction of BF_{10} at any point during the addition of the study 2 sample. This strongly suggests (as does the classic correlation analysis) that study 2 finds (for this particular correlation) a very similar result to that in study 1. Again, this strongly suggests that the order of personality scales relative to ASI task, as well as which faces were coded as reinforcing or non-reinforcing, are factors unlikely to have had much influence on this correlation.

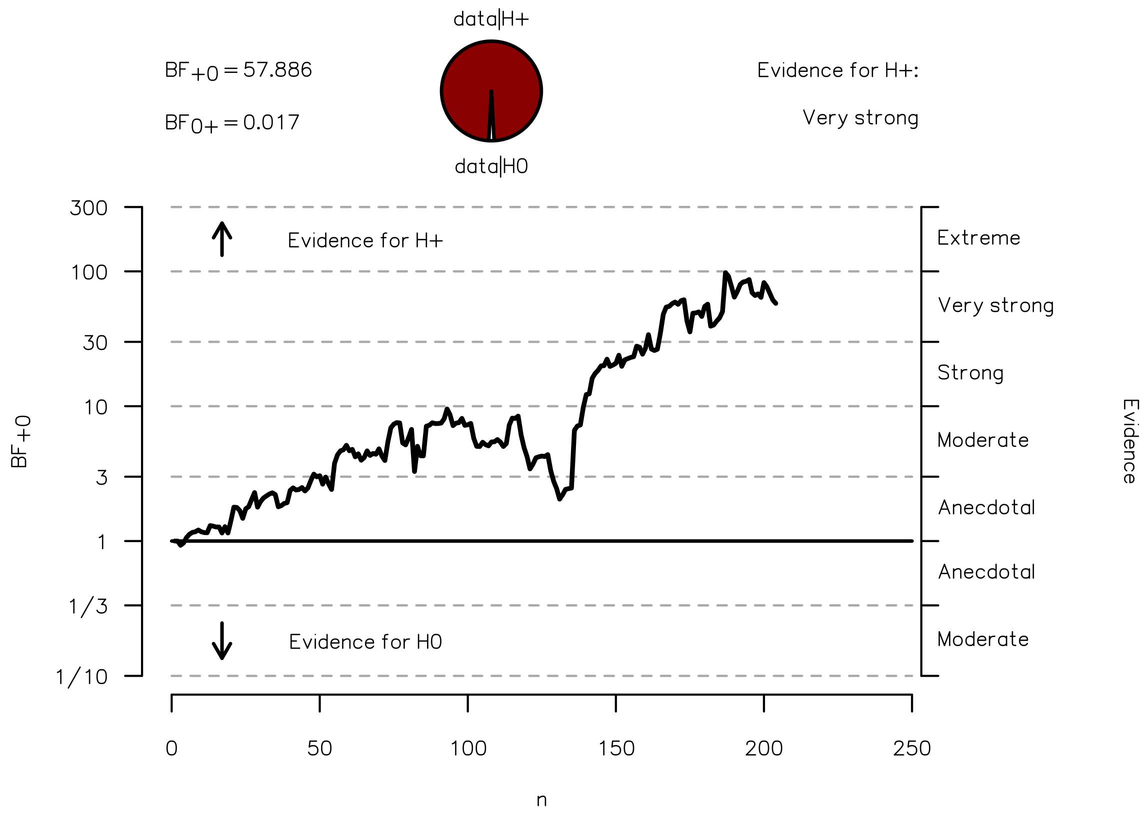


Figure 6.15: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of trait extraversion and the reinforcing advantage of rated befriending likelihood. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

We repeated this process for all the Bayesian correlations between the remaining participant traits and character social interaction ratings (likeability and befriending likelihood), first for ASI study 2 and then for the combined sample of study 1 and 2. For the correlation between participant neuroticism and the reinforcing advantage of rated likeability for the study 2 sample, the correlations were predicted to be negative. The Bayesian correlation has a median value of -0.11 and the CredInt is between -0.308 and -0.008. The BF_{10} is 1.01. However, when combining the samples, the BF_{10} becomes 59.00, which is evidence of very strong support for the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.22 and 95% CredInts between -0.333 and -0.080.

For the correlation between participant neuroticism and the reinforcing advantage of the befriending likelihood for study 2, again predicted to be negative, the median value is -0.12 and the CredInt is between -0.332 and -0.008. The BF_{10} is 1.01. However, when combining the samples, the BF_{10} becomes 28.49, which is evidence of strong support for the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.21 and 95% CredInts between -0.319 and -0.064.

Across the first 148 cases (from ASI study 1) we can see in the sequential analysis for trait neuroticism and reinforcing advantage in rated likeability (Figure 6.16) that the BF value does fall below 1 (in favour of the null hypothesis) but generally rises steadily and occupies the moderate evidence range across most of the sample. However, as the whole sample 1 is added the evidence in favour of H1 moves into the strong and then extreme range. When ASI study 2 cases are added these further cases cause fluctuation in the BF around the 100 value finally ended up close to 60, indicating very strong evidence in favour of the H1.

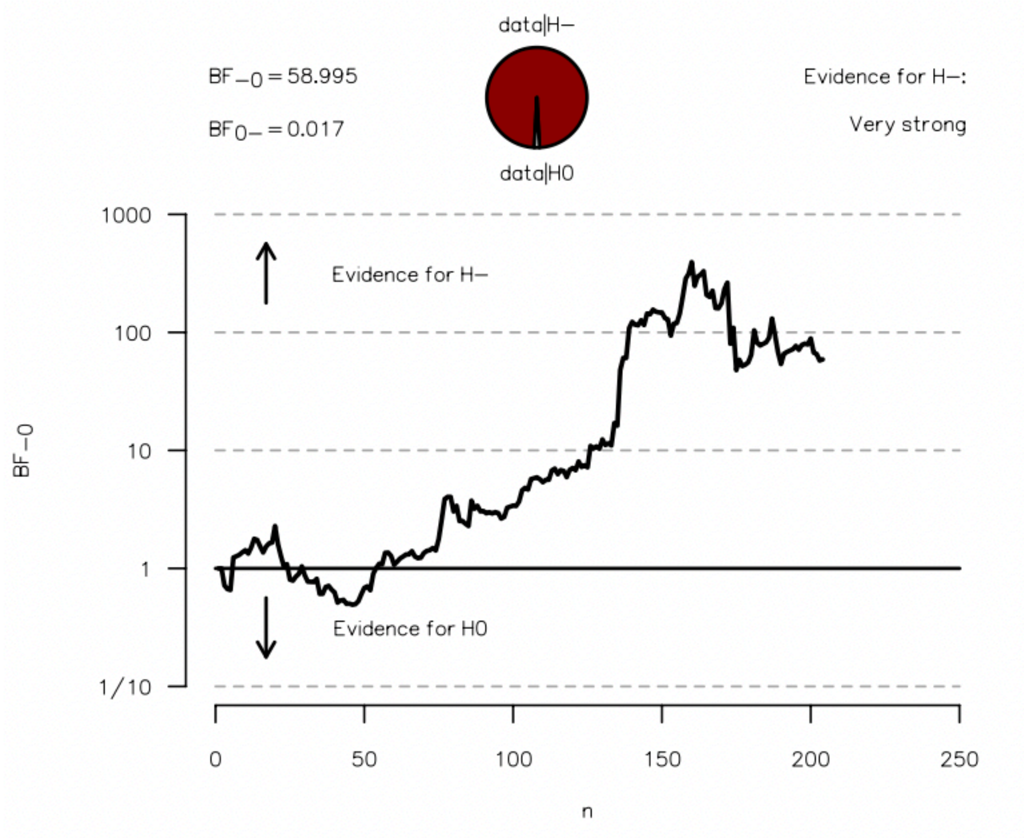


Figure 6.16: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of trait neuroticism and the reinforcing advantage of rated likeability. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

For trait neuroticism and rated befriending likelihood sequential analysis (Figure 6.17), there is a similar pattern (at slightly lower BF values). The BF touches 100 (extreme evidence in favour of H1) while the study 2 sample is added, ending up near 30 (the cut-off for very strong evidence in favour of H1).

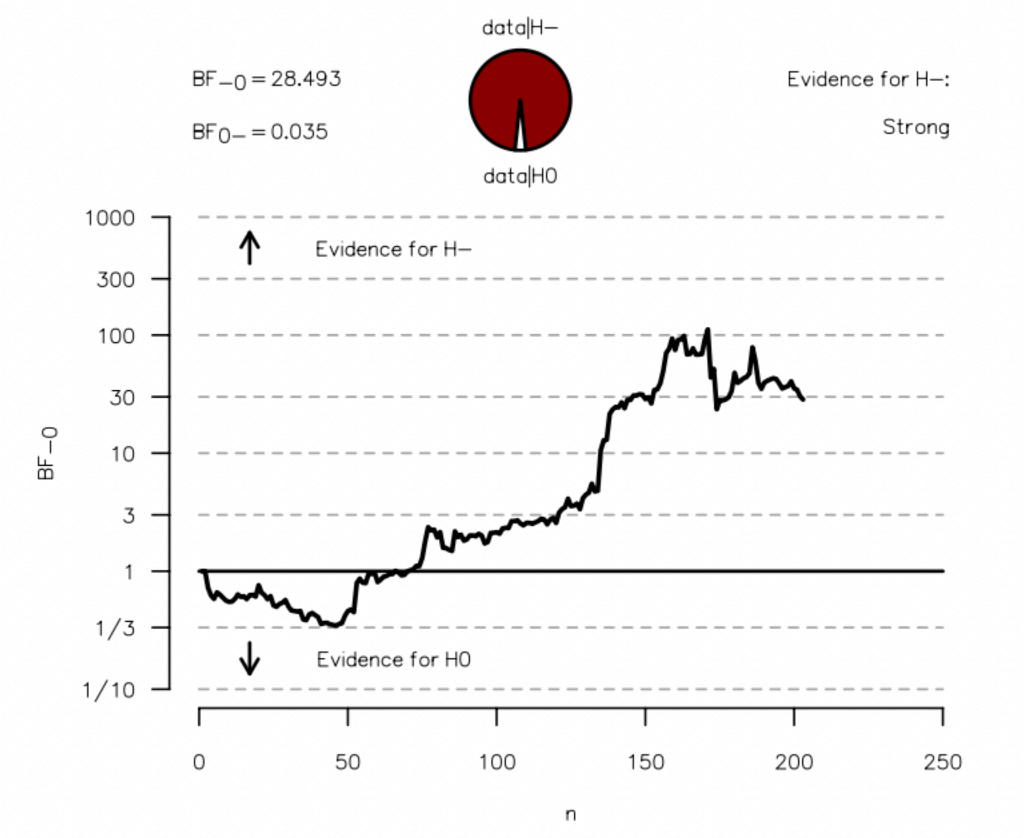


Figure 6.17: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of trait neuroticism and the reinforcing advantage of rated befriending likelihood. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

For the correlation between participant agreeableness and the reinforcing advantage of likeability for study 2, the Bayesian correlation has a median value of 0.16 and the CredInt is between 0.013 and 0.365. The BF_{10} is 1.62. However, when combining the samples, the BF_{10} rises slightly to 2.26, which remains as anecdotal (weak) support for H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of 0.13 and 95% CredInts between 0.016 and 0.149.

For the correlation between participant agreeableness and the reinforcing advantage of befriending for study 2, the Bayesian correlation has a median value of 0.19 and the CredInt is between 0.020 and 0.393. The BF_{10} is 2.57. However, when combining the samples, the BF_{10} becomes 31.77, which is evidence of very strong support for H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of 0.21 and 95% CredInts between 0.066 and 0.319.

Again, across the first 148 cases (from ASI study 1) we can see in the sequential analysis for the correlation of trait agreeableness and the reinforcing advantage for befriending likelihood (Figure 6.18) that the BF value very briefly falls below 1 a number of times during the early part of the sequence, but then steadily increases and ends up at the threshold for strong evidence in favour of H1 (BF_{10}>10). When ASI study 2 cases are added these further cases increase the BF_{10} to over 30 across the range, indicating very strong evidence in favour of H1.

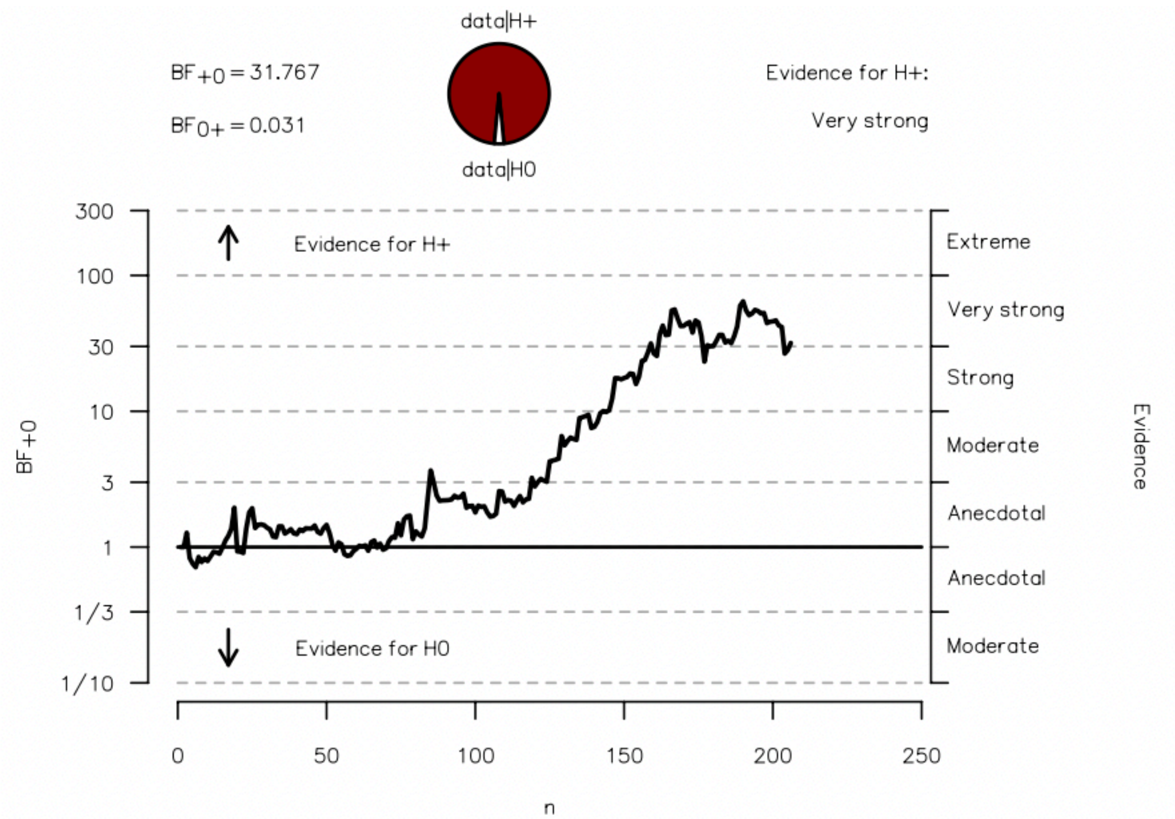


Figure 6.18: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of trait agreeableness and the reinforcing advantage of rated befriending likelihood. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

For the correlation between participant autistic traits and the reinforcing advantage of rated likeability for the study 2 sample, the correlations were predicted to be negative. The Bayesian correlation has a median value of -0.25 and the CredInt is between -0.453 and -0.048. The BF_{10} is 8.44, which is already moderate support for the H1 even in the relatively modest sample size of study 2. However, when combining the samples, the BF_{10} drops to 5.10, but still remains as evidence of moderate support for the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.16 and 95% CredInts between -0.274 and -0.028.

For the correlation between participant autistic traits and the reinforcing advantage of the befriending likelihood for study 2, again predicted to be negative, the median value is -0.27 and the CredInt is between -0.471 and -0.062. The BF_{10} is 12.99, which is again already strong support for the H1 again even in the relatively modest sample size of study 2. However, when combining the samples, the BF_{10} becomes 23.08, which is again evidence of strong support for the H1 relative to the H0. The Bayesian correlation for the combined samples has a median value of -0.20 and 95% CredInts between -0.312 and -0.059.

Again, across the first 148 cases (from ASI study 1) we can see in the sequential analysis for the correlation of autistic traits and befriending likelihood (Figure 6.19) that the BF value falls below 1 early in the sequence then rising steadily to around the threshold for moderate evidence once the whole of sample 1 had been added. When the ASI study 2 cases are added these further cases increase the BF_{10} steadily throughout the sample, soon moving to occupy 10 to 30 range, indicating strong evidence in favour of H1.

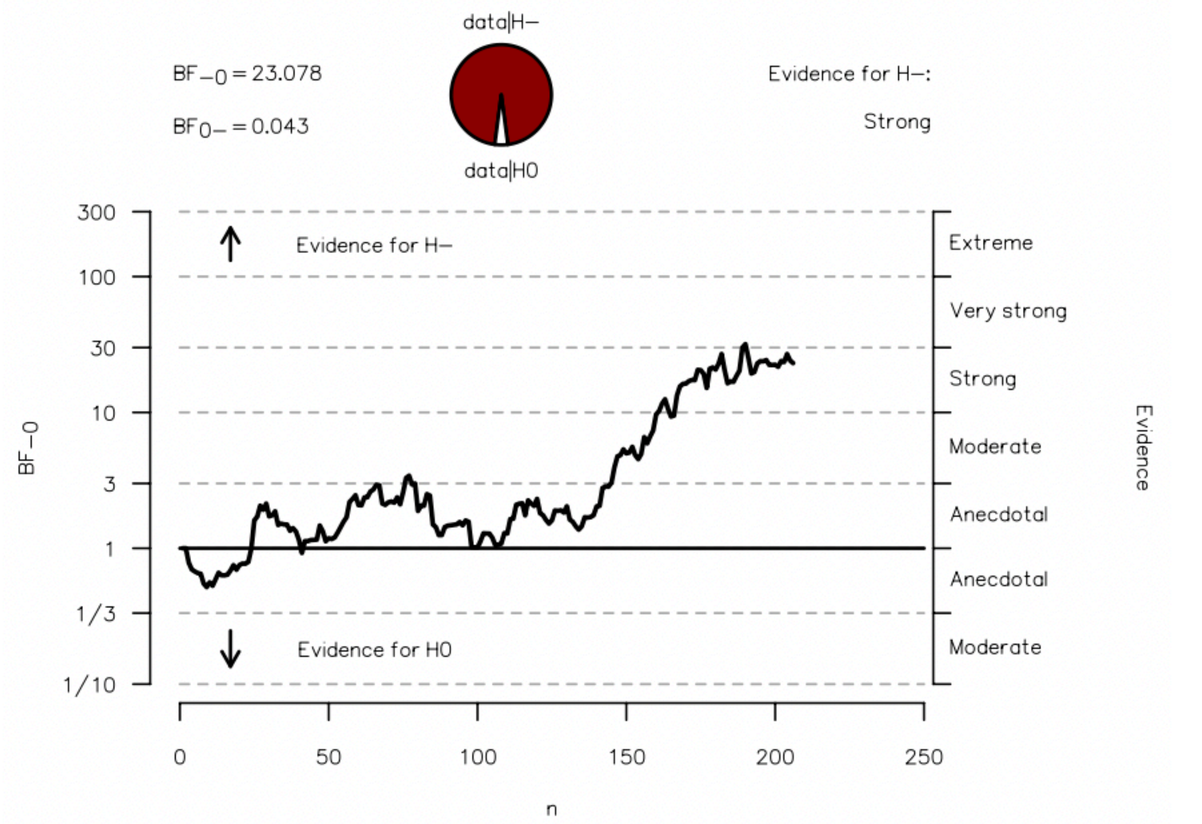


Figure 6.19: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of trait ASQ and the reinforcing advantage of rated befriending likelihood. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

Table 6.3 below shows the tabulated BF values for each trait correlation with all character ratings for the combined ASI studies 1 and 2. For comparison, the BF values of ASI study 1 have also been pulled from the previous chapter and included in the table. It should be noted that in the above Bayesian correlations the analyses for study 2 were conducted first and were then followed by the combined sample analyses. In the sequential analysis we first added the study 1 data, so as to obtain an approximate BF value after the first 148 cases from the sequential analysis graph by eye.

Table 6.3: For ease of reference, we have tabulated all the BF values for each trait correlation with character personality ratings and social interaction ratings for the combined ASI studies 1 and 2, along with the BF values from study 1 alone in brackets. Values between 3 and 10 represent moderate support for H1 relative to H0, values between 10 and 30 represent strong support, values between 30 and 100 represent very strong support, and values greater than 100 represent extreme (decisive) support.

Participant Personality Traits	**Character personality and social interaction ratings**				
	Extraversion (reinforcing advantage)	**Neuroticism (non-reinforcing advantage)**	**Agreeableness (reinforcing advantage)**	**Likeability (reinforcing advantage)**	**Befriending (reinforcing advantage)**
	BF_{10}	BF_{10}	BF_{10}	BF_{10}	BF_{10}
Extraversion	14.10 (9.26)	1.02 (0.63)	1.61 (0.63)	196.37 (51.55)	57.89 (16.12)
Neuroticism (negative correlation)	17.97 (8.44)	4.54 (4.74)	2.31 (4.01)	59.00 (114.8)	28.49 (24.42)
Agreeableness	16.83 (5.58)	2.81 (1.29)	347.85 (457.9)	2.26 (1.19)	31.77 (9.87)
ASQ (negative correlation)	25.13 (5.43)	3.97 (1.75)	1.37 (0.80)	5.10 (1.04)	23.08 (2.84)

6.3.3 Name recognition memory task

A paired samples t-test showed that there were no significant differences in the number of reinforcing and non-reinforcing character names that participants were able to recognise accurately in the name memory task [$t(61) = .099$, $p = .922$]. On average, participants incorrectly selected approximately only 1 of the 6 reinforcing characters names, as well as 1 of the 6 non-reinforcing characters names. The high levels of performance in both conditions may obscure the ability to detect a difference due to ceiling effects. These results are very similar to those found in the previous chapter.

Separate general linear models were run with each participant trait as a predictor along with the character type. There were no significant interactions between the reinforcing character type advantage for name recognition and participant extraversion [$F(1,60) = .025$, $p = .876$], neuroticism [$F(1,60) = 1.443$, $p = .223$], nor autistic traits [$F(1,60) = .106$, $p = .745$]. However, there was a significant interaction between the reinforcing character type advantage for name recognition and agreeableness [$F(1,60) = 6.410$, $p = .014$, $\eta p^2 = .098$ (c.f. adjusted $\alpha = .017$)]. In light of the very small moderation effect sizes for the name recognition memory variable for both samples, we did not run any Bayesian correlation analyses for this variable.

Table 6.4: Correlational relationship between the number of names recognised correctly in the name recognition task and participant trait scores for ASI study 2, study 1, and the two studies combined. Non-reinforcing scores of the ratings were subtracted from reinforcing scores. Note that the tests on these correlations are identical to the interaction tests reported for the general linear models above.

Participants Personality Traits	**Number of names recognised correctly (reinforcing advantage)**		
	Study 2 *r*	**Study 1** *r*	**Study 1+2** *r*
Extraversion	.020	.065	.049
Neuroticism	.155	.046	.047
Agreeableness	.313*	-.094	.084
ASQ	-.042	-.020	-.027

* Correlation is significant tested against the 0.017 level (2-tailed).

While the correlation of trait agreeableness and the reinforcing advantage of number of names recognised correctly may be significant [$r(59) = .313$, $p = .014$], it does not imply much given the study 1 findings (where the correlation had the opposite sign) and combined studies outcome (small positive correlation).

6.3.4 Main effects of personality traits

Above we have focussed on the participant trait moderation of the reinforcement type effects. We report the trait main effects on all DVs, regardless of character type, here for completeness and on an exploratory basis. First, we complete these analyses on the ASI study 2 data. It should be noted here that in study 1 (chapter 5) neuroticism had a significant negative effect on overall rated agreeableness and likeability (c.f. adjusted alpha levels .004 and .006, respectively).

The main effect of participant extraversion was non-significant for overall ratings of extraversion [$F(1,60) = 2.308$, $p = .134$], neuroticism [$F(1,60) = 4.951$, $p = .030$ (c.f. adjusted $\alpha = .004$)], agreeableness [$F(1,60) = 5.873$, $p = .018$ (c.f. adjusted $\alpha = .004$)], likeability [$F(1,60) = 5.391$, $p = .024$ (c.f. adjusted $\alpha = .004$)], or befriending likelihood [$F(1,60) = 5.400$, $p = .024$ (c.f. adjusted $\alpha = .004$)].

Participant neuroticism did not have a significant main effect on the overall rating of extraversion [$F(1,60) = .138$, $p = .712$]. The main effect of participant neuroticism on overall ratings of neuroticism was also not significant [$F(1,60) = .524$, $p = .472$]. The main effect of participant neuroticism on overall ratings of agreeableness was not significant [$F(1,60) = .000$, $p = .994$]. The main effect of participant neuroticism on overall ratings of likeability was not significant [$F(1,60) = .504$, $p = .481$], neither was the main effect of participant neuroticism on overall ratings of befriending likelihood [$F(1,60) = 1.106$, $p = .297$].

The main effect of participant agreeableness was not significant for overall ratings of extraversion [$F(1,60) = .326$, $p = .570$ (c.f. adjusted alpha level = .004)], neuroticism [$F(1,60) = 2.017$, $p = .161$], agreeableness [$F(1,60) = 1.896$, $p = .174$], likeability [$F(1,60) = 2.372$, $p = .129$ (c.f. adjusted $\alpha = .006$)], or befriending likelihood [$F(1,60) = 2.305$, $p = .134$].

The main effect of participant autistic traits was not significant for overall ratings of extraversion [$F(1,205) = .124$, $p = .726$], neuroticism [$F(1,60) = 1.206$, $p = .277$], agreeableness [$F(1,60) = 3.126$, $p = .082$], likeability [$F(1,60) = .006$, $p = .939$ (c.f. adjusted $\alpha = .006$)], or befriending likelihood [$F(1,60) = .378$, $p = .541$].

Regarding the name recognition memory task, there were no main effects of participant extraversion [$F(1,59) = .007$, $p = .935$], neuroticism [$F(1,59) = 2.200$, $p = .143$], agreeableness [$F(1,59) = .296$, $p = .589$], or autistic traits [$F(1,59) = 1.038$, $p = .313$] on the number of character names they recognised accurately.

To illustrate the direction of all the main effects of the participant trait measures on the overall ratings and name recognition accuracy, bivariate correlations were conducted. These correlations are reported and summarized in Table 6.5. Note once again that the tests on these correlations are identical to the main effect tests reported for the general linear models above. They include the alpha level adjustments for multiple comparisons described above.

Table 6.5 Correlational relationship between participant trait scores and overall averages of all DV scores, regardless of character type, for study 2. Note that the tests on these correlations are identical to the interaction tests reported for the general linear models in the text above.

Participant Personality Traits	**Overall correlation on all DVs averaged across character type**											
	Extraversion		**Neuroticism**		**Agreeableness**		**Likeability**		**Befriending**		**Number of names recognised correctly**	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Extraversion	.192	.134	-.276	.030	.299	.018	.287	.024	.287	.024	-.011	.935
Neuroticism	-.048	.712	-.093	.472	.001	.994	-.091	.481	-.135	.297	-.190	.143
Agreeableness	.074	.570	-.180	.161	.175	.174	.195	.129	.192	.134	-.071	.589
ASQ	-.045	.726	.140	.277	-.223	.082	-.010	.939	.079	.541	-.131	.313

We now complete the same analyses on the combined sample of ASI study 1 and study 2.

The main effect of participant extraversion was non-significant for overall ratings of extraversion [$F(1,203) = .224, p = .637$], neuroticism [$F(1,203) = .204, p = .652$], agreeableness [$F(1,203) = 1.901, p = .169$], likeability [$F(1,203) = 1.159, p = .283$], or befriending likelihood [$F(1,203) = 1.223, p = .270$].

Participant neuroticism did not have a significant main effect on the overall rating of extraversion [$F(1,202) = 2.901, p = .090$ (c.f. adjusted $\alpha = .004$)]. The main effect of participant neuroticism on overall ratings of neuroticism was also not significant [$F(1,202) = 3.038, p = .083$ (c.f. adjusted $\alpha = .004$)]. However, the main effect of participant neuroticism on overall ratings of agreeableness was significant [$F(1,202) = 9.227, p = .003$, $\eta p^2 = .044$ (c.f. adjusted $\alpha = .004$)]. The main effect of participant neuroticism on overall ratings of likeability was just shy of formal significance given the alpha adjustment we applied[$F(1,202) = 7.488, p = .007$ (c.f. adjusted $\alpha = .004$)], as was the main effect of participant neuroticism on overall ratings of befriending likelihood [$F(1,202) = 7.187, p = .008$ (c.f. adjusted $\alpha = .004$)]; they can both be considered trends.

The main effect of participant agreeableness was not significant for overall ratings of extraversion [$F(1,205) = .004, p = .949$], neuroticism [$F(1,205) = 2.788, p = .097$], agreeableness [$F(1,205) = .197$, $p = .658$], likeability [$F(1,205) = 4.886$, $p = .028$ (c c.f. adjusted $\alpha = .006$)], or befriending likelihood [$F(1,205) = 3.110$, $p = .079$].

The main effect of participant autistic traits was not significant for overall ratings of extraversion [$F(1,205) = .002$, $p = .961$], neuroticism [$F(1,205) = .632$, $p = .428$], agreeableness [$F(1,205) = 3.521$, $p = .062$], likeability [$F(1,205) = .031$, $p = .860$], or befriending likelihood [$F(1,204) = .349$, $p = .555$].

Regarding the name recognition memory task, there were no main effects of participant extraversion [$F(1,202) = 1.018$, $p = .314$], neuroticism [$F(1,201) = .046$, $p = .830$], agreeableness [$F(1,204) = .419$, $p = .518$], or autistic traits [$F(1,205) = .085$, $p = .771$] on the number of character names they recognised accurately.

To illustrate the direction of all the main effects of the participant trait measures on the overall ratings and name recognition accuracy, bivariate correlations were conducted. These correlations are reported and summarized in Table 6.6 and are to be compared to the study 2 data in Table 6.5 and the study 1 data in chapter 5 - Table 5.6.

Table 6.6 Correlational relationship between participant trait scores and overall averages of all DV scores, regardless of character type for the combined sample of ASI study 1 and study 2. Note that the tests on these correlations are identical to the interaction tests reported for the general linear models in the text above.

Participant Personality Traits	**Overall correlation on all DVs averaged across character type**											
	Extraversion		**Neuroticism**		**Agreeableness**		**Likeability**		**Befriending**		**Number of names recognised correctly**	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Extraversion	.033	.637	-.032	.652	.096	.169	.075	.283	.077	.270	-.071	.314
Neuroticism	-.199	.090	.122	.083	-.209	.003**	-.189	.007	-.185	.008	.015	.830
Agreeableness	.005	.949	-.116	.097	.031	.658	.153	.028	.122	.079	-.045	.518
ASQ	-.003	.961	.055	.428	-.130	.062	-.012	.860	-.041	.555	.020	.771

** Correlation is significant tested against the .004 level (2-tailed).

From the results of the main effects of the participant personality traits, particularly in the combined studies sample, we notice that the main effect of trait neuroticism presents the most interesting results. We know from the chapter 5 that ASI study 1 also shows that trait neuroticism has a significant effect on how participants rate the characters on agreeableness, regardless of whether they are reinforcing or not. The correlation above shows that higher scores of neuroticism is associated with lower ratings of character agreeableness. There are also similar trends for the main effect of neuroticism on ratings of likeability and befriending likelihood regardless of character type. Because of this pattern of results, we present the Bayesian sequential correlations to see if the main effects of neuroticism on ratings of agreeableness, likeability, and befriending likelihood from ASI study 1 are sustained as we add in the extra subjects from ASI study 2.

For the correlation between participant neuroticism and overall rated agreeableness (predicted to be a negative correlation) for the combined samples, the Bayesian correlation has a median value -.21 and the CredInt is between -.322 and -.068. The BF_{10} is 33.6, which provides very strong support of the H1 relative to the H0. It is noticeable from Figure 6.20 below, that the effect is sustained throughout both samples. After the whole sample from study 1 had been analysed the evidence in favour of H1 was extreme (BF_{10} >100) but after adding in all the cases from study 2 it dipped into the strong evidence range.

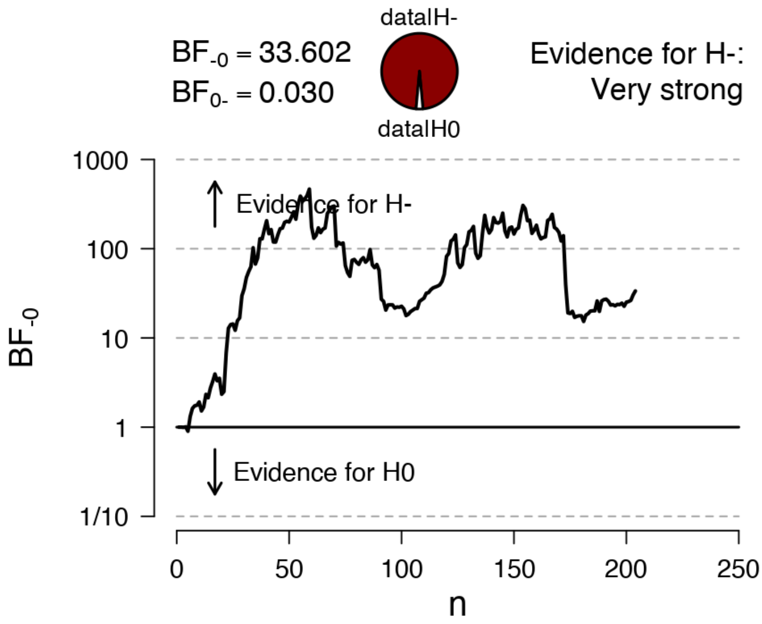


Figure 6.20: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of participant neuroticism and the overall rating of agreeableness. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

For the correlation between participant neuroticism and overall rating of likeability (predicted to be a negative correlation) for the combined samples, the Bayesian correlation has a median value -.19 and the CredInt is between -.304 and -.051. The final BF_{10} is 15.3, which provides strong support of the H1 relative to the H0. It is visible from Figure 6.21 below, that the effect was in the strong range (BF_{10} >10) after all the cases from study 1 had been analysed, and thereafter fluctuated between very strong, moderate and strong evidence as the study 2 sample is added.

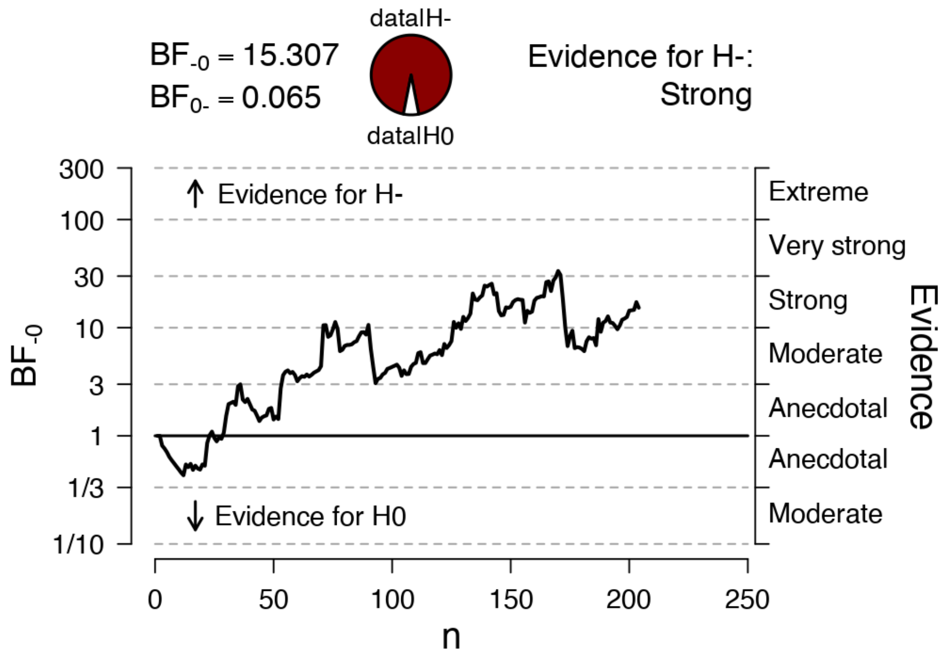


Figure 6.21: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of participant neuroticism and the overall rating of likeability. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

Finally, for the correlation between participant neuroticism and overall rating of befriending likelihood (predicted to be a negative correlation) for the combined samples, the Bayesian correlation has a median value -.19 and the CredInt is between -.301 and -.041. The BF_{10} is 13.3, which again provides strong support of the H1 relative to the H0. It is visible from Figure 6.22 below, that the evidence after all cases from study 1 had been analysed was around the strong evidence cut-off (BF_{10} =10), and hovered around that value, but was mostly in the strong range, as the study 2 sample was added.

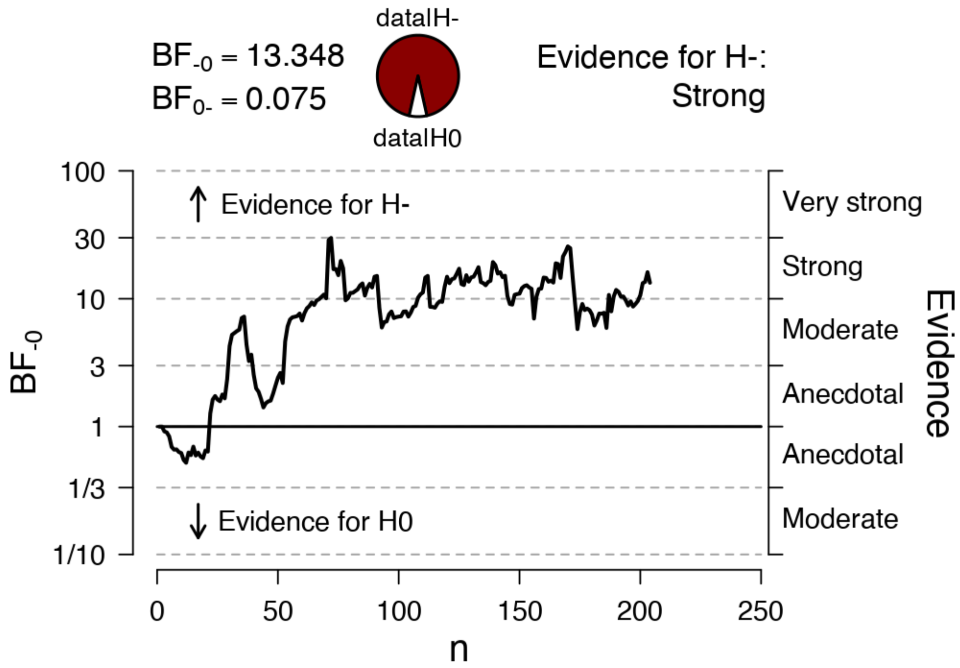


Figure 6.22: The sequential analysis showing the BF_{10} for each participant in the order that they appear in the data and how the evidence in support of H1 is affected for the correlation of participant neuroticism and the overall rating of befriending likelihood. The first 148 participants are from ASI study 1 and the remaining 62 are from study 2.

6.4 Discussion

The overall aim of this second ASI study was to replicate the findings of the first ASI study in chapter 5 in a way that controls for the experimental design issues discussed in chapter 5. One key design consideration was to reverse the order of administration of the participant self-report trait measures and ASI task (the displayed interactions with the characters and the subsequent request for character ratings and name recognition). In this second study, the participant trait measures were administered prior to the participants completing the ASI task to reduce the chance of any trait moderation effects being accountable for and/or influenced by carryover effects of the reinforcement manipulation during the task. A second key design consideration was to use the previously reinforcing characters as the non-reinforcing ones in this second study, and likewise using the previously non-reinforcing characters as reinforcing. This was done in order to address the possibility that baseline differences between the face sets was responsible for the apparent character type effects observed in ASI study 1. A final design consideration that we were able to tackle in this replication study was that participants were now tested individually (on-line in their homes), as opposed to group testing.

The results of the present study confirmed that the design considerations mentioned above did not influence the main effects (character type effects) of the reinforcing effects of the smiling faces, even with a smaller sample. As in the preceding study, the reinforcing characters were rated as more extraverted and agreeable, and less neurotic compared to the non-reinforcing faces. The reinforcing characters were also rated as more likeable, and with a higher likely of befriending, than the non-reinforcing characters. We were able to obtain a similar pattern of results and robust effect sizes of these main effects in this replication study, regardless of the sample size. The overall effect sizes were numerically a bit smaller in study 2, which may reflect the fact that the faces used as reinforcing characters in study 1 possibly had faces which appeared more extraverted, likeable, and worthy of befriending, even in the neutral expression versions.

In relation to the moderation effects of participant traits on the character type effects, the smaller sample size in study 2 led to underpowered tests of moderation in study 1 alone. It is thus not surprising that the effects were not significant for study 2 when these data are considered alone. However, traditional correlation analyses allowed us to detect a very similar pattern and size of moderation results to the previous study, albeit with a non-significant p value in the study data alone when using our strict alpha level adjustments. We combined data from participants across the two studies. In Table 6.1 it is clear that the correlations reflecting the moderation of the reinforcement advantage in character extraversion ratings were very similar in study 1 and study 2 and this similarity was observed for all four participant traits measured.

The finding that rated extraversion has the most stable and consistent pattern of personality moderation effects (across all four participant traits) for both studies, suggests that the testing order as a design consideration was not a major factor in the pattern of results obtained. The moderation pattern on rated neuroticism and agreeableness, however, is not as consistent across the four participant traits. Nevertheless, the other clear result across both studies is the finding that the rated reinforcement advantage for character agreeableness was moderated by participant agreeableness.

Table 6.2 clearly showed that the moderation effects of trait extraversion on the reinforcing advantage for rated likeability and befriending likelihood were also clear and consistent across the two studies. For the reinforcing advantage for liking ratings the moderation by participant neuroticism was weaker in study 2 than study 1, but in the combined sample was statistically significant even after adjustment for multiple testing. Although the size of the moderation effect on the reinforcing advantage for befriending ratings varied somewhat across the two studies for both participant neuroticism and participant autistic traits, the analysis of the combined sample suggested that the befriending rating was likely to have real moderation effects by all 4 participant traits, the same pattern that was observed for rated extraversion. Overall, the combined sample revealed that the reinforcement manipulation between character faces seems to more strongly affect rated extraversion, likeability, and befriending, where the effect is moderated positively by extraversion and agreeableness (apart from the correlation between trait agreeableness and the reinforcement advantage for likeability), and negatively by neuroticism and autistic traits.

As shown in Table 6.3, the Bayesian correlation analysis in the combined sample confirmed that the hypothesis of a positive correlations of trait extraversion with the reinforcing advantage for rated extraversion was strongly supported, the correlation of trait extraversion with the reinforcing advantage for rated likeability was decisively supported, and the correlation of trait extraversion with the reinforcing advantage for rated befriending was very strongly supported. The descriptors for the level of support are based on conventional Bayes factor cut-offs as explained above.

The hypotheses of negative correlations for trait neuroticism with the reinforcing advantage on rated extraversion, and with the reinforcing advantage for befriending, were both strongly supported, and the hypothesis of a negative correlation of trait neuroticism with the reinforcing advantage for likeability was very strongly supported. These results are generally similar to those for participant extraversion, except that the hypothesized correlations have the opposite sign (for participant extraversion positive, and participant neuroticism negative). Additionally, the hypothesis of negative correlation of trait neuroticism with rated neuroticism (non-reinforcing advantage) was moderately supported.

The hypothesis of positive correlations for trait agreeableness with the reinforcing advantage for rated extraversion, and with the reinforcing advantage for befriending, were strongly and very strongly supported, respectively. Once again, this a similar pattern to that found for participant extraversion, other than for rated likeability. However, there was also decisive evidence of support for a hypothesis of a positive correlation between trait agreeableness and the reinforcing advantage for rated agreeableness.

The hypothesis of negative correlations for autistic traits with the reinforcing advantage for rated extraversion, and for rated likeability, were both moderately supported, and the hypothesis of a negative correlation between autistic traits and the reinforcing advantage for befriending was strongly supported. There was also moderate evidence supporting a hypothesis of a negative correlation between autistic traits and the non-reinforcing advantage for character neuroticism.

With regards to the name recognition task, the hypothesis was that the names of the reinforcing faces would be recognised more accurately than those of the non-reinforcing faces. The results were similar to the first ASI study in showing no evidence in support of this hypothesis. The success rate of all participants correctly recognising the character's names again was high, regardless of whether the face was reinforcing or not and there was no overall reinforcing advantage on name memory. These probable ceiling effects make the lack of a reinforcing advantage for name recognition memory uninformative. In light of this, there were no moderation effects of any of the trait measures for the reinforcing advantage in name recognition memory, and this outcome remained the same when combining the samples of the two studies.

The main effects of all participant traits on all DVs averaged across character type were also explored. There were no main effects of trait extraversion, agreeableness, or autistic traits on any of the DVs regardless of whether the characters were reinforcing or not. The lack of main effects for these participant traits, both here and in study 1, suggests that the significant moderation of reinforcement effects by participant traits are indeed linked to the reinforcing differences between the two character types.

However, there was a main effect of participant neuroticism on overall rated agreeableness, overall rated likeability, and overall befriending likelihood, which were confirmed using Bayesian correlations. Those scoring higher on neuroticism were more likely to rate characters as less agreeable, less likeable, and less likely to befriend, regardless of whether they smiled more in interactions. As discussed in chapter 5, these exploratory results may provide some insight into why people with higher trait neuroticism could have a susceptibility to develop social anxiety (Newby et al., 2017). However, this needs to be investigated further. The main effects of participant neuroticism were additional to any moderation effects by neuroticism of the reinforcement type effects (on rated extraversion, neuroticism, likeability, and befriending likelihood).

6.4.1 Limitations and future directions

By reversing the design choices between the current study and the first ASI study, it would appear that we were able to resolve the relative potential design issues, as discussed in chapter 5. We were generally able to replicate the major effects of the ASI task successfully. However, there are further methodological limitations to consider before confidently applying the implications of these results to further replications and possible future VR enrichment of the task itself (discussed in chapter 5, section 5.4.1).

In this study, we tested the maximum number of subjects we could raise funds for. The combined sample size across the two studies had adequate power for the families of moderation tests for the extraversion moderator, even after applying conservative adjusted type 1 error rates. A future study should replicate the ASI again, using individual testing, and with within-study counterbalancing of the assignment of faces to reinforcing and non-reinforcing roles, plus within-study counterbalancing of the order of the task and participant trait ratings. Based on the findings from the two studies in this thesis we would have clear predictions that all 4 participant traits would moderate the reinforcing advantage of rated extraversion with an expected correlation of around +0.2 (or -0.2 depending on the moderator). To be conservative we might test all 4 of these predictions as a single family and test these relationships with an adjusted alpha of $\alpha = \frac{.05}{4} = .0125$. This would mean that the study would need a total of 234 participants for 80% power to test all of these directional predictions.

Again, based on the current findings from the combined sample, we would also expect similar correlations for the moderation of the reinforcing advantage for befriending by all 4 participant traits. If we treated these 4 moderation tests as another family then the above future study (with 230+ participants) would also have at least 80% power as well. We would also predict similar strength moderation effects for participant extraversion and neuroticism on the reinforcing advantage for rated likeability, and this family of two tests (using an adjusted alpha of $\alpha = \frac{.05}{2}$ = .025) would thus have better than 80% power in a sample of 230+ participants.

Based on the findings in this thesis, we have no predictions for significant moderation effects of trait neuroticism (at least none that we could test with adequate power in a future study with this sample size). Finally, we would predict that the reinforcing advantage for rated agreeableness would be positively moderated by participant agreeableness with a correlation of at least +0.2. As a single test the alpha rate, for this prediction, would be .05 and the power in a sample of 230 plus participants would be over 90%.

A question arises as to the extent to which the outcome measures of the reinforcing manipulation (i.e., the character ratings) are conscious behavioural choices, or whether they occur more implicitly (Greenwald & Banaji, 1995; Nosek et al., 2011). As it stands, the ASI task does not include a measure of explicit awareness of the reinforcement contingencies, and its nature could potentially make it susceptible to demand characteristics. For example, participants may notice that some faces smile more than others and then assume that this must be what they are supposed to respond to. Consequently, they may judge said characters in a way that reflects this assumption when rating them (e.g., as more extraverted and more likeable). Some individuals may also have tendencies to resist an "obvious" demand characteristic. Either way, responding to such an explicit assumption would mean that the expected ratings were not an effect of social RL on social perception. To overcome this uncertainty, the test phase of the ASI in future studies could be extended in several ways. First, it could include participants being asked to judge the probability that each character would smile in response to an interaction, which would be an interesting outcome measure either way. A second way could be to also incorporate recording response times, as response times might be less susceptible to the effects of demand characteristics. Jones et al.'s (2011) probabilistic social reward task, in which peers (characters) were associated with socially accepting feedback 33%, 66%, or 100% of the time, also assessed whether participants held explicit knowledge of the social reinforcement contingencies. Participants were asked whether any of the three peers provided positive feedback more often than others and if so, they were then asked to describe what pattern they noticed (i.e., they were scored on whether they accurately stated which peer provided the most, intermediate, and least positive social feedback). Jones et al. (2011) concluded that their outcome measures (likeability ratings and response latencies) did not appear to be conscious behavioural choices, as the majority of participants (93%) were unable to articulate the reinforcement patterns. This suggests that there is not much explicit (i.e., reportable) awareness of social RL contingencies of the kind used in our ASI task. If so, this highlights that social perception can be influenced after only brief encounters with individuals without explicit awareness. Such conclusions of rapid changes, together with the implications of the ASI task and the personality moderation effects, emphasise how positive social interactions are able to influence and effectively alter subsequent perceptions and/or behaviour.

Moreover, further methodological developments could be useful in order to validate further that the effects of the ASI are indeed effects of social RL, i.e., are accounted for by social reward processing. The ASI paradigm could be adapted and expanded to capture ERP measures of dopaminergic signaling that have been previously associated with probabilistic associative learning, such as the Reward Positivity in extraverts (Cooper et al., 2004; Smillie et al., 2011; Smillie et al., 2019) and the P300 component elicited by human facial stimuli (Fishman et al., 2011). However, it should be noted that each character would need to be exposed a large number of times to build up enough trials for ERP analysis. In the Pott's (2006) paradigm the stimulus associated at 80% with future reward (gold bar) is presented 180 times (144 leading to reward). So, to match the number of trials in the Pott's task, and if we used 18 reinforcing faces (rather than the 6 used here) in an expanded set of stimuli, then each would need to be presented in 10 interactions with 8 smiling outcomes and 2 non-smiling outcomes. The 18 non-reinforcing faces would also need to each be presented 10 times with 2 smiling outcomes. Additionally, this would be a better design to properly assess the name recognition memory task, as it may be less easy with so many names to recognise (if we maintained limited exposure to the names, such as using names on only 2 of the 10 trials).

Confirming our findings as an effect of social RL and reward processing is important for social perception research, due to the relationship between reward processing and BAS/BIS-related traits. Social perception, a complex feature of human interaction and social behaviour, could possibly be affected by individual differences in empathy and its neural correlates (see Banissy et al., 2012), in a way that goes beyond the fact that low empathy is a by-product of elevated autistic traits (Heerey, 2014). Specifically, the direct effects of empathy could be measured, not just inferring empathy levels via the ASQ. For example, Del Casale et al. (2017) conducted a meta-analysis (N = 568) on the neural functional correlates of empathic face processing and concluded that emotional face processing (vs. neutral) is a measure of empathy in itself. However, these effects were not directly tested against autistic traits. Future ASI studies could therefore include empathy as a predictor in its own right and one to be compared with autistic traits.

6.4.2 Conclusion

We were able to replicate the findings of a novel artificial social interaction task that was developed in ASI study 1 (chapter 5) using social RL in a social context. Our new task combines traditional methods of associative, probabilistic, reinforcement learning with approaches driven by social perception. We were able to demonstrate the effect of multiple individual differences in moderating the effect of our social reinforcement manipulation, with more clarity using a reasonably large, combined sample across the two studies. The main methodological queries discussed in the previous study were largely resolved because the patterns found in ASI study 2 were very similar to those reported in study 1. As a result, our studies with the ASI task had a generally clear and successful outcome. We conclude that this ASI paradigm could provide promising advances for future research, particularly with neural indices of measures involving social reward processing, like the reward value and perception of smiling faces. Based on our findings across both ASI studies in this thesis, we have made a clear set of predictions for a future further replication study.

Chapter 7

General Discussion

This chapter seeks to synthesise the findings presented in the preceding empirical chapters of this thesis (chapter 2, 3, 4, 5, and 6). These findings will be linked to the broad aims of the thesis (outlined in chapter 1) and will be contextualised in relation to the wider literature on interpersonal approach motivation (the first key theme of the thesis) and reinforcement learning in a social context (the second key theme of the thesis). Broad limitations of this doctoral research will be discussed. Finally, implications of this work for future research will be outlined.

7.1 Aims of thesis

The overall goal of this thesis was to consider the measurement of trait-like aspects of approach motivation and reinforcement learning for interpersonal social rewards and incentives, using a combination of neural, behavioural and psychometric measures. Individual differences in approach motivation and reinforcement learning have significant implications for a range of methodologies. This thesis aimed avoid the research that takes for granted that measures evolving from different theoretical perspectives, and assessing discrete aspects of reward processing, are tapping related constructs. This thesis adapted and applied a combination of established reward processing and trait theories and tested them in experiments that use innovative methods for measuring the effects of social rewards and interpersonal incentives. Specifically, the broad aims of the thesis were as follows:

1. To explore whether motivational videos work as appetitive mood inductions by inducing activated affect, associated with approach motivation.
2. To use personality traits as potential measures of sensitivity to appetitive mood inductions, and to investigate if they indeed moderate the affective response to the motivational videos.
3. To test a digital version of the line bisection task as a proxy for left frontal activation representing approach motivation and activated affect.
4. To examine if appetitive and activating effects of the motivational videos can be detected in EEG measures of approach motivation (i.e., frontal alpha asymmetry).

5. To apply reinforcement learning in a social context to a novel artificial social interaction (ASI) task that uses probabilistic learning with characters that vary in the amount of social reward they give (via smiles). The outcome measures mostly address aspects of interpersonal perception.
6. To use the ASI to investigate how relevant participant personality traits influence how they perceive and rate the socially rewarding versus socially non-rewarding characters they interact with.

7.2 Key findings

This section seeks to integrate the key findings from each chapter with the overall aims of the thesis. Each aim will be briefly outlined and the relevant findings from each chapter will be detailed. Following this, the findings will be integrated and briefly discussed in the context of the broader literature on interpersonal approach motivation and reinforcement learning in a social context, correspondingly.

7.2.1 Work addressing aim 1

Aim: To explore whether motivational videos work as appetitive mood inductions by inducing activated affect, associated with approach motivation.

The programme of research for this aim was formulated in chapters 2, 3 and 4. Beginning in chapter 2 with an attempt to test the mood-inducing properties of a motivational video compared to a control video, which was then refined in chapter 3. The original motivational video (OMV) was replicated (RMV) and then a well-matched new control video (NCV) was designed and directed. Chapter 4 used the same theoretical framework and mostly the same methodology as chapters 2 and 3, although the OMV was not used as chapter 3 revealed that it produced very similar mood changes in the RMV. Chapter 4 also included an EEG measure, which shows that the study's results for replicability might be very sensitive to temporal factors, however this will be discussed at a later point in the discussion.

In line with previous research using approach motivation mood inductions (e.g., Smillie et al., 2012), activated affect, as opposed to positive valence (pleasure), was considered as the focal dependent variable. This was analysed using model-specific contrasts, either as fixed effects (for the group of participants as a whole) or using the SSMLE method (which analyses the data for each subject individually). These contrasts were derived from equations based on the proposed geometric relationships within the circumplex of core affect (12-PAC; Yik et al., 2011). Bayesian Model Selection (BMS) methods were also used to compare the degree to which different circumplex models fit the mood changes observed in response to exposure to different videos, as was the general estimating equations (GEE) regression method.

On all occasions and at the group level, we found that those who watched the motivational video did significantly score higher on competitive drives than those who watched the control video, implying that the motivational video did indeed bring out their competitive drives (the measure used as a manipulation check). This confirmation of the manipulation allows us to consider the primary results of the study, the effects of the motivational video on mood. For chapters 2 and 3, through fixed-effects contrast analyses, SSMLE circumplex model fitting, and GEE regression analyses, average pre to post-test changes in core affect were observed along the activation-deactivation axis of the circumplex in the group who watched the motivational video, and this effect was significantly greater than that observed in those who had watched the control video. This contrasted with the non-significant average outcomes in core affect along the pleasure-displeasure axis for the motivational video group as a whole. Specifically, there was an increase in activated affect for those who watched the motivational video(s), compared to the control video, meaning participants felt more aroused, energetic, and alert. In light of these effects, attributable to the motivational video, one can suggest that the motivational video acted as an appetitive mood induction source, leading to effects that are consistent with those produced by previously used appetitive mood inductions.

Furthermore, the BMS methods used in chapters 2 and 3 highlighted that a clear fit of the specific mood circumplex models was present in only a minority of the cases in each video condition, yet an overall effect was found. This development is quite major as it emphasises the heterogeneity of affect induction produced both by the motivational and control videos. If you have a predicted pattern of responding in a psychobiological DV and it is present only in a fraction of the participants, then this impacts on the ability to find correlations with other measures thought to be influenced by the same underlying psychobiology. In other research this phenomenon has not had a chance to come to light because the field, strangely, has concentrated on fixed effects modelling. We have little idea how many other personality related effects in the literature might be similarly affected. It is particularly problematic when, as here, the average results show a good fit to the specific model effects which can trick researchers into thinking that the task has "worked". So, a major recommendation for the field might follow. The ability to model the DV specifically, at the level of the individual subject, is very useful.

The observed effects of the motivational videos on mood, and specifically activated affect is broadly in line with literature implicating that the characteristics of motivational videos are analogous to previously established appetitive mood induction procedures and may generate similar effects (e.g., Gomez et al., 2000; Helmers et al., 1997; Larsen & Ketelaar, 1989; 1991; Smillie et al., 2012). Motivational videos usually involve a speaker, often one who is deemed inspirational, talking to a group of people or directly to a camera about ways in which their audience can enhance their life (e.g., success, fitness, health, happiness etc.). This includes activating language, gestures, visual scenes, and music; plus, in line with Berridge's account (Berridge et al., 2009) described in chapter 1, motivational videos emphasize desirable goals (or secondary rewards; Bhanji & Delgado, 2014; Izuma et al., 2008; Lin et al., 2012; Spreckelmeyer et al., 2009) to the viewer, hence activating the initial "wanting" phase of motivational behaviour. The assumption is that the interpersonal aspects of the motivational speaker (e.g., eye contact, and personally-directed speech; Kennis et al., 2013) and the goal-directed content of the language used (Smillie et al., 2012), work to socially incentivise the rewards being pursued by the viewer, in turn endorsing situational motivation and subsequently increasing activated affect (Smillie et al., 2012). As the NCV used in chapters 3 and 4 was matched for language content but was without these interpersonal aspects, we can confidently conclude that the assumption described above was met. Moreover, the distinction between activating and pleasant mood effects where energetic arousal (i.e., activated affect) increased after an appetitive mood induction (e.g., buying a lottery ticket and winning), with no change in pleasant affect (Smillie et al., 2012), was also satisfied in our average pattern of results.

Contrary to what was found in chapters 2 and 3, in chapter 4, the activation-deactivation model was more associated with mood changes in those who watched the NCV as opposed to the RMV. The fixed effects model found that on a group level deactivated affect increased after watching the NCV, while activated affect decreased. Overall, significant change in affect acted along the activation-deactivation in a negative direction, but only for those who watched the NCV. At a group level there were no significant differences in changes in pleasure-displeasure affect for those who watched either video. However, when using SSMLE in Bayesian Model

Selection, it was found that some participants in the RMV group did respond along the activation-deactivation axis, however this was not significant (unlike chapters 2 and 3, where again only a minority of cases fit the activation-deactivation model but to the extent that the effect was significant). In the NCV group, on the other hand, there was a higher number of participants that responded along the activation-deactivation axis, with a negative contrast coefficient that was significantly different to zero, confirming the group level effects. Altogether, the mood induction effects provide no further support for the specific motivational video inducing activated affect and a motivated state, in chapter 4. However, the questionable replicability of the previous studies here may be due to the key methodological difference in the current experiment, the EEG resting-state measure being administered prior to the post-test mood measure. This possibility will be discussed at a later point.

7.2.2 Work addressing aim 2

Aim: To use personality traits as potential measures of sensitivity to appetitive mood inductions, and to investigate if they indeed moderate the affective response to the motivational videos.

In chapters 2, 3, and 4 the personality traits extraversion and neuroticism were measured to investigate whether they moderate the change of affect as a function of video type. Extraversion was the primary focus due to the proposed dependence of extraversion on BAS functioning (Smillie et al., 2012). Due to the lack of direct empirical evidence for BIS-mediated effects on activated affect, predictions involving neuroticism were considered more tentatively. Nevertheless, neuroticism was considered as a predisposition for negative emotional reactivity (e.g., Deckersbach et al., 2006; Ebmeier et al., 1994; Fischer et al., 1997; Johnson et al., 1999; Kim et al., 2008; O'Gorman et al., 2006; Rafienia et al., 2008). Chapter 3 also included conscientiousness as an exploratory moderator, due to its association with goal orientation and discipline (Bjørnebekk et al., 2013; Costa et al., 1991; DeYoung et al., 2010).

Using all the available data for each of the three motivational video studies and separately for each video condition, the correlations of the contrast coefficients the appetitive mood induction effects (i.e., the activation-deactivation model) with extraversion or neuroticism were small. The same was true of the corresponding correlations between the pleasure-displeasure model and extraversion or neuroticism. We did not set much store by the tests of significance for these correlations for the following reason: if the observed mood changes for the majority of cases were not accurately described by the activation (or pleasure) circumplex model it is unlikely that one would be able to find correlations between personality and mood changes that are hypothetically predicted based upon that model, at least when the correlations are assessed in the whole sample. Given that the majority of studies in the literature use fixed effects models and do not attempt to try to establish whether the hypothesized behavioural changes are present in all participants, then this may well contribute to why many predicted personality correlations with behavioural models are small and/or unreliable and/or hard to replicate (see Haines et al, 2020, for a similar point). However, even when extrapolating the individuals' cases whose data were good fits for the activation-deactivation model to see if the well-fitting cases held a relationship between the effects of watching the motivational video with either extraversion or neuroticism the numbers of cases available for such an analysis were so small in the restricted analyses that they severely lacked power to detect correlations. The overall GEE analyses also did not detect significant evidence for a moderation by extraversion or neuroticism of the prediction of the mood changes by the activation-deactivation circumplex after watching the motivational video. However, the GEE analyses test the so-called marginal model, albeit in a robust way, and the marginal model is assessed on group performance. Therefore, this effect is to be expected if the marginal model doesn't apply to the majority of cases. The related analyses testing the moderation effects of conscientiousness also showed no evidence for a moderation by conscientiousness of the prediction of the mood changes by the activation-deactivation circumplex. It is therefore impossible to draw any firm conclusions from these analyses or to derive any clear implications for theories of individual differences in approach motivation, like the Affective Reactivity Hypothesis (ARH; Gross et al., 1998) and Reinforcement Sensitivity Theory (RST; Smillie et al., 2006). Reasons for this may pertain to general limitations in the personality measures used, which are discussed in *Section 7.3.1.* Nevertheless, the reasons why motivational videos have an effect on some but not on others has yet to be accounted for.

7.2.3 Work addressing aim 3

Aim: To test a digital version of the line bisection task as a proxy for left frontal activation representing approach motivation and activated affect.

A widely used behavioural measure of relative cerebral hemispherical asymmetry is the line bisection task (Jewell & McCourt, 2000), where participants are asked to indicate the perceived midpoint of multiple horizontal lines. Tendencies toward rightward versus leftward errors in midpoint estimations are deemed to reflect relative primacy of right versus left visual fields, respectively, and corresponding neural activity in the contralateral hemisphere, i.e., greater activation of the left versus right hemisphere, which is argued to reflect the engagement of appetitive brain systems (Milner, Brechmann, & Pagliarini, 1992). This thesis attempted to adapt the line bisection task into a digitalised version, executed on an online survey platform (described in chapters 2 and 3), which could provide a proxy measure of frontal asymmetry that is better suited to technologically inclined data collection methods (and potentially large-scale studies).

Overall, the main effect of video type on line bisection was non-significant. Nonetheless, the line bisection data showed that those who watched the motivational video displayed a significant rightward bias in line bisection, whereas those who watched the control video did not show a significant bias. This result is in line with previous studies (e.g., Nash et al., 2010), in showing greater left frontal activation in those participants in the approach-motivated condition. The rightward line bisection bias in the participants who saw the motivational video does provide weak support for appetitive processes in response to the motivational video. However, the effect was small and was not replicated in chapter 3. There was also no evidence of an effect being present in those who showed good fit to the activation model of mood. We conclude that the digital line bisection task, in the context it was used for in this thesis, does not appear to be promising.

7.2.4 Work addressing aim 4

Aim: To examine if appetitive and activating effects of the motivational videos can be detected in EEG measures of approach motivation (i.e., frontal alpha asymmetry).

In chapter 4 we replaced a proxy measure of left frontal activation (the line bisection task) with a more direct measure of cortical activity, derived from resting state EEG. Literature on asymmetric frontal cortical activity as an index of approach motivation was utilised to predict a relationship with activated affect (for a review see Harmon-Jones and Gable, 2018). More specifically, the chapter sought to validate if the appetitive mood induction effects of the motivational video generate more direct neural indices of activated affect and approach motivation, namely left frontal activation (Davidson et al., 1990, Harmon-Jones et al., 2008).

In light of approach motivation research on neural indices of reward previously reviewed (e.g., Schutter & Harmon-Jones, 2013; Wacker et al., 2003), an EEG measure of frontal alpha asymmetry was implemented. We hypothesised that the approach motivation and activating affect induced by the motivational video would be reflected in an increase in LFA after watching the RMV, compared to the NCV, and that the activation-deactivation circumplex coefficients would correlate with levels of frontal alpha activity, where overall greater relative LFA will have a positive relationship with more positive activation circumplex coefficients.

A significant increase in FAA was found only in the NCV condition with no change at all observed in the RMV condition. The FAA change by video condition interaction was, however, just a trend that failed to reach significance. This suggested an increase if left sided cortical activation, which, on the face of it, was at odds with the increase in deactivated affect observed in the NCV condition. Nevertheless, one possible explanation for this pattern could be that the EEG measure picked up on the rewarding feeling of the participants that the NCV finally finished (reflecting how it may have been boring, as suggested by the induction of deactivated affect from the mood measure administered after the post-test EEG recording) and that the experimental process was coming to an end (Blackhart et al., 2002). The temporal separation between the recording of the LFA change and the later measurement of mood change may also be a possible source of the decoupling of the mood change and the FAA changes in the NCV condition.

Another key finding was that changes in FAA after watching either video did not correlate with overall mood changes. The negative changes along the activation-deactivation axis for participants in the NCV group should have corresponded with changes in FAA if LFA was indeed an index of activated state. Extraversion and neuroticism also did not significantly predict changes in FAA after watching either video. A number of possible reasons as to why no effects were found here can be suggested, including the methodological weaknesses of the resting-state EEG measures used to index FAA and FAA change (see the arguments described in *Section 7.3.2*).

The rationale of this aim implemented the motivational direction theory (Harmon-Jones et al., 2013), where the term approach motivation is most commonly described as behaviour that is motivated toward achieving a goal, often accompanied with feelings of arousal, alertness, and feeling energised, and is typically associated with greater left (relative to right) frontal activation. The motivational direction theory suggests that avoidance motivation, often used interchangeably with withdrawal, is most commonly described as behaviour motivated to avoid punishments, undesired outcomes, or negative goals, often accompanied with feelings of fear, and is typically associated with greater right (relative to left) frontal activation. However, when relating motivational direction accounts of frontal asymmetry to the broader RST account of motivational systems, the proposed picture has become more complex. BAS-related bilateral frontal activity could be reflective of energising active behaviour common in both approach and withdrawal and should be activated for both positive and negative reinforcement (Hewig et al., 2004, 2005, 2006). Therefore, according to the authors who advocate this view, BAS stimuli may lead to bilateral cortical activation. Further research supports that relative right anterior brain activation is linked to the (revised) BIS and represents the conflict between, and inhibition of, the (revised) BAS and (revised) FFFS, as opposed to withdrawal motivation (Wacker et al., 2003, 2008, 2010). Nevertheless, the pattern of change in FAA dependent on video condition in chapter 4 was not in line with any account of approach motivation and frontal alpha asymmetry. The theoretical framework that the neural processes involved with the BAS, mainly via observing the effects dopaminergic modulation, are more likely to be associated with the experience of activated affect and not merely pleasant affect (Berridge, 2006; Davidson, 2004), was also not empirically supported in this chapter, as the change in activation-deactivation mood did not correlate with the change in FAA, nor was the average change in the group the same in the NCV (the NCV was associated with increased LFA but deactivated mood). The deactivated mood, as argued above of course, may have been a product of the EEG process itself and so the LFA measure and the subsequently reported mood changes may have been decoupled.

As discussed in previous chapters, the RST proposes systems involved in approach/avoidance motivation and suggests personality traits such as extraversion (Smillie et al., 2006) and neuroticism (Barlow et al., 2014) which relate to the activation of these motivational systems. However, this was not supported in chapter 4, due to a lack of significant association with the change in FAA and the trait scores.

7.2.5 Work addressing aim 5

Aim: To apply reinforcement learning in a social context to a novel artificial social interaction (ASI) task that uses probabilistic learning with characters that vary in the amount of social *reward they give (via smiles). The outcome measures mostly address aspects of interpersonal perception.*

The study in chapter 5 formulates the ASI by combining the functions of social probabilistic learning (Jones et al., 2011), trait learning (Hackel, Mende-Siedlecki, & Amodio, 2020), the use of smiles as social rewards in positive feedback (Heerey, 2014), and trait associations of the reinforcement sensitivity theory (Corr, 2004). The main aim was to test if smiles as responses within an artificial social interaction are a type of social reward that can induce learning in a probabilistic task. Chapter 6 attempts to replicate the findings in chapter 5, while reversing the trials of the ASI (characters previously coded as reinforcing were coded as non-reinforcing in chapter 6, and vice versa). The order that the participant traits measures were give were also counterbalance.

We indeed found that characters who smile more throughout the artificial interactions (reinforcing characters) were rated by the participants as people they would be more likely to befriend, and were rated as more likeable, more extraverted, more agreeable, and less neurotic than the characters that smile less (non-reinforcing characters). The results of the replication study (with reversed design features) confirmed that the design features did not influence the main effects (character type effects) of the varying levels of reinforcement provided by the smiling faces, and the results were successfully replicated.

Combining traditional methods of associative, probabilistic, reinforcement learning (e.g., Potts et al., 2006; Smillie et al., 2011) with approaches driven by social perception (e.g., Hackel et al., 2020; Heerey, 2014), we were able to successfully use probabilistic learning with social stimuli to infer learned associations between social reinforcement and the personality ratings or interpersonal perceptions of the characters presented in the task. In doing so we were able to validate an artificial social interaction task that uses social RL properties in a social context with a primary social reward cue (smiling).

7.2.6 Work addressing aim 6

Aim: To use the ASI to investigate how relevant participant personality traits influence how they perceive and rate the socially rewarding versus socially non-rewarding characters they interact with.

Chapters 5 and 6 addressed a possible process by which a biological propensity to learn more from salient social rewards than others, might lead to someone becoming more extraverted using the following reasoning: (i) perceptions about people are affected by the associative learning of their reinforcing properties, which in turn will be greater in people with heightened reward sensitivity; (ii) such individuals then find people on average more likeable, and judge them as more extraverted to a greater extent, than people with lesser levels of reward sensitivity; (iii) as a result they find people's company more enjoyable on average than do people who are less reward sensitive, and thereby act in an extraverted fashion (by seeking out a greater level of social interaction). Further related trait measures were also added to test as moderators of the reinforcing effects. Neuroticism was included due to its association with the reinforcement sensitivity theory and trait anxiety (Barlow et al., 2014). A measure of autistic traits was included due to previous associations with social ability and responsiveness (Jones et al., 2011). Agreeableness was added as an exploratory measure simply because of its characterisation of friendliness, compassion, and empathy (de Oliveira et al., 2003).

Overall, we were able to clarify the individual differences which moderated the influence of the social reinforcement characteristics of the characters (based on how often the characters smiled in interactions) on the participants' perceptions of their personality and social characteristics. The primary moderating trait we studied was extraversion, and we found that the *higher* a participant's levels of extraversion were, the more likely they were to rate the reinforcing characters (characters who smiled more often) as more extraverted, more likeable, and more likely to befriend than non-reinforcing characters (characters who smiled less often). However, the moderating effect of extraversion was not significant on ratings of neuroticism or agreeableness. We found that the *lower* a participant's levels of neuroticism were, the more likely they were to rate reinforcing characters (c.f. non-reinforcing characters) as more extraverted, more likely to befriend, more likeable, and less neurotic. We also found that the *higher* a participant's levels of agreeableness were, the more likely they were to rate the reinforcing characters (c.f. non-reinforcing characters) as more extraverted, more agreeable, and more likely to befriend. Finally, we found that the lower a participant's level of autistic traits the more likely they were to rate the reinforcing characters (c.f. non-reinforcing characters) as more extraverted, less neurotic, more likeable, and more likely to befriend.

These findings add to the small literature that investigates social RL and social perception measured in a social context (e.g., Hackel et al., 2020; Heerey, 2014), but it does this in light of core personality traits that are most commonly associated with sociability and/or reinforcement learning (e.g., Corr, 2004; Smillie, 2013). The results shed light onto how feedback from interactions with characters (here seen as typical stimulus-response-reinforcement triplets) influence the interpersonal perceptions of those who themselves score high or low on these core trait measures. These results found in this thesis further confirm the likelihood that social RL has a differential impact as a function of an individual's personality.

Further to this, the additional inclusion of neuroticism allowed us to delve further into the understanding of individual differences in social perception and social RL. Not only is this a simple, yet newly validated, social probabilistic task of RL, but it is the first of its kind to investigate the influence of a trait (neuroticism) that has previously been neglected in terms of its associations with social RL. While the research previously described (Oyibo & Vassileva, 2019) has touched on the subject, no research has yet attempted to uncover how those considered to be neurotic, with a propensity to develop social anxiety (Newby et al., 2017), perceive characters of a rewarding (or non-rewarding) predisposition, and how this in turn may continue to affect the behaviours related to neuroticism. The pattern found is in line with classical studies on reward processing in neuroticism that have found that the trait is negatively correlated with conditioned responses to appetitive (rewarding) stimuli (Corr, 2004; Paisey & Mangan, 1988).

7.3 Limitations of the work presented in this thesis

A number of limitations should be acknowledged with respect to the work in this thesis. Specific limitations of the individual experimental designs were discussed in the corresponding chapter discussions. Here, two core limitations will be outlined with respect to sample size, power, and reproducibility and methodological issues in resting-state EEG frontal asymmetry. These limitations will be briefly outlined and discussed in relation to the work presented in this thesis.

7.3.1 Sample size, power and reproducibility

For the follow-up studies in this thesis (chapters 3 and 6) we were able to use the initial findings to conduct systematic a priori power analyses (using G*Power; Faul, Erdfelder, Buchner & Lang, 2009), which meant the required sample sizes were acquired (in the combined sample analyses in chapter 6). However, there were times where the nature of the design did not allow for a priori analyses and the sample size of certain analyses (e.g., correlational analyses with trait measures) were severely underpowered. For example, in the chapters 2, 3, and 4 motivational video studies the use of BMS allowed us to extrapolate the individuals' cases whose data were good fits for either of the models in either condition. This meant that we could (in theory) perform the trait correlations on just the well-fitting cases to see if there was a relationship between the effects of watching the motivational video with either extraversion or neuroticism. This approach would allow for a focused way to test the relationship of individual differences in approach motivation after appetitive mood inductions. However, the numbers of cases available for such an analysis were so small in the restricted analyses that they severely lacked power to detect correlations. Earlier we reiterated the importance of the consistent finding of heterogeneity of the pattern induced mood changes across all 3 motivational video studies in this thesis. We found that some participants in each video condition were reporting robust mood changes that were uncorrelated with equally robust patterns of mood changes reported by other participants in the same video condition. The patterns of change we observed were present robustly in only a minority of participants in each video condition. We had hypothesized that extraversion (and neuroticism, more tentatively) would moderate one particular pattern of mood changes. Cleary, as already noted, if that pattern of mood change is occurring in only a minority of participants in an experimental condition, then it becomes very difficult to work out the required sample size to give a desired level of power. This heterogeneity of experimentally induced responses across subjects is *not* something that has previously been explicitly analysed in psychobiological studies of individual differences. The usual implicit model is that all subjects respond via the same mechanism but to greater or lesser extents. Our mood results suggest that unrelated mechanisms may be operating in the same experimental condition. If this finding is reasonably common in psychobiological individual differences work, then the power issues we have encountered might be widespread in the field. This finding could suggest that it is important, in many other kinds of individual differences studies, to assess not just the average effect of a manipulation is as predicted. It is likely to be important to show that other mechanisms are not engaged by the manipulations (especially when these other mechanisms produce effects which are independent of the ones we intended, as in the case of our mood data).

The EEG data is just as problematic, as they are more complex and statistical power is inherently more difficult to quantify for EEG studies. For example, the amount of noise in the data cannot be predicted a priori, neither can deciding whether to prioritise the number of trials recorded versus the number of participants in the study. The EEG studies reported in this thesis are by no means unusual for not reporting power analyses, as this is the norm in EEG research (for a systematic review see Larson & Carbine, 2017). The difficulty in calculating the indices needed to acquire sufficient power, and the lack of a unified effort to do so, is particularly concerning in light of the reproducibility crisis and given reports of the low statistical power, lack of reproducible results and overestimates of effect sizes in neuroscience (Button et al., 2013). Such issues undermine the conclusions of much existent research in neuroscience and psychology and point to a greater need to establish clear guidelines for good practice in EEG and individual differences research (particularly with the use of BMS) and the promotion of open science and collaborative efforts toward the collection and sharing of data (see Cohen, 2017; Larson & Moser, 2017; Smith et al., 2017; Wacker, 2017). If the "heterogeneity of mechanisms" issue, uncovered by our mood data, is widespread then it makes attention to power issues even more important.

7.3.2 Methodological issues in EEG frontal asymmetry

A key issue in EEG asymmetry methodology is the high level of diversity in how frontal EEG asymmetry is quantified and analysed (Smith et al., 2017). Throughout the body of work considering the role of frontal EEG asymmetry in motivation, reward and individual differences, several methodological concerns have been raised with respect to this literature (see, e.g., Davidson, 1988; Hagemann, 2004). These issues are manifold and encompass both sample-specific points, for example the sex and handedness of participants, as well as the heterogeneity of individual differences, and EEG-specific points, like the choice of reference electrode, the subjectivity of data cleaning, the length of the recording and the use of a state manipulation versus trait recording.

Debate exists in the literature as to whether EEG asymmetry reflects state-like or trait-like effects and whether putative trait effects are best assessed during the resting state or during a manipulation of some form (see Harmon-Jones & Gable, 2017 for a recent review). Prior work by Hagemann et al. (2005), assessing resting state stability in healthy participants on three separate occasions, suggest that approximately 60 per cent of the variance of resting state EEG asymmetry is due to stable trait-like effects, whereas the remaining 40 per cent is influenced by sporadic, state-based influences. Thus, while relatively stable trait-like influences may account for most of the variance in frontal EEG asymmetry, future work would do well to clearly contrast how stable trait-like aspects of frontal asymmetry interact with approach and withdrawal motivation, distinct from and under the influence of state-based manipulations.

This thesis examined frontal asymmetry by using a resting-state paradigm to asses changes in FAA as a putative marker of induced approach motivation observed as a function of the motivational video watched between two EEG recording periods (pre and post-test). To emphasise the state-sensitive nature of using EEG measures, fundamental research has explicitly considered the affective context of the EEG testing environment, including mood changes after EEG equipment preparation (e.g., EEG capping), and even gender differences of both the participant and experimenter (Blackhart et al., 2002; Wacker et al., 2013). The previous research highlights that all participants tend to show a shift toward a more negative mood state after undergoing EEG preparation, which in turn is likely to have confounding effects on frontal asymmetry (e.g., Blackhart et al., 2002). The research also highlights that differences in baseline frontal asymmetry and approach motivation may be due to interpersonal interactions during EEG preparation, for example, when a male participant is tested by a female experimenter that they find attractive (e.g., as suggested by Wacker et al., 2013). Such research underlines the confounding nature EEG measures have particularly when the key dependent variable is within the mood realm itself. The most likely interpretation of the current EEG study would be consistent with this work; namely, that the EEG recording procedure itself caused the pre to post-test deactivated mood change that was, on average, reported in the NCV video condition.

7.4 Strengths of this research and recommendations for future work

Work by Rouder and Haaf (2019) emphasises the importance of using the most powerful and appropriate statistical modelling methods in order to more precisely uncover latent effects. This is of particular importance when considering psychometric measures, like measures of core affect. They proposed an alternative hierarchical analysis of task performance that accounts for trial-by-trial variability along with covariation of individuals' performance across tasks, specifically using a Bayes-factor analysis. In chapters 2, 3, and 4 we analyse experimentally induced mood changes using BMS, allowed us to unearth results that would have been entirely missed by the traditional averaging to give “individual by task scores”. As already noted, this raises potentially strong implications for our ability to detect correlations between personality and behavioural measures of mood change derived from a specific model, given that the individuals we studied varied not only in the degree to which a particular experience induced a specific kind of mood change, but also in what type of mood changes were induced by that experience. This shows how individualised fitting methods and model selection methods might offer big advantages over standard fixed effects modelling of behavioural data. Future work should promote such methods to overcome the validity issues in individual differences and behaviour in general.

Moreover, the positive findings from the refined experiments, involving motivational videos as an appetitive mood induction, might confirm such videos are a new and effective form of mood induction (at least for some people). Going further forward, this could help in refining our understanding of individual differences in responses to socially incentivized rewards and positive activated affect. More types of videos testing for the effects of different variables on reinforcer processing, motivational direction, and mood induction should be developed. For example, it would be interesting to see how effective a motivational video that contains personally-directed speech and goal content without any explicit visual representation of social stimuli. This would allow assessment of the extent to which the visual social stimuli usually present in motivational videos (e.g., perceived eye contact and visual examples of modelled behaviour that might trigger vicarious observational learning) account for the mood induction effects, as opposed to the context of the language used. More work could be done to establish the duration of the effects of the motivational videos, which would be of interest to potential viewers who claim that motivational videos have these desired effects (e.g., feeling energised, and alert or attentive). The duration of the effects was a matter that surfaced in chapter 4, where EEG resting-state measure delayed the administering of the mood measure, possibly hindering the measurement of mood effects. Therefore, the duration of the effects will also be of interest from an experimental design perspective as well. The 10-minute delay (and the deactivating experience of having ones EEG re-assessed during this period) seems to have completely removed any activating effect for the group of subjects who watched a motivational video. This suggests that the immediate effects on mood are quite transient. If such videos have such transient effects but are effective in changing real world behaviour, then they must do so either because they cumulate effects by being watched multiple times and/or because watchers can actively retrieve the video content from memory and so reactivate the mood changing experience. A controlled study of the effectiveness of motivational videos could explore these sort of effects (e.g., differences after re-watching the same video, or deliberate recall of the images and messages). A similar point of interest for potential viewers would be the more cognitive effects of motivational videos as well. For example, future work could test the manipulation effects of motivational videos on cognitive performance, such as logical reasoning. There is already some loosely related literature that have found that positive mood inductions can have a positive effect on mathematics-based task in students (Scrimin et al., 2014), for example. If such cognitive effects are found to be present then motivational videos could prove to be more than a mood induction, but also a source of cognitive stimulation.

Furthermore, we were able to develop and replicate the findings of a novel artificial social interaction (ASI) task using social RL properties in a social context that combines traditional methods of associative, probabilistic, reinforcement learning with approaches driven by social perception. We were able to unravel the individual differences in moderating the effect of our social reinforcement manipulation. Most methodological challenges discussed in chapter 5 were resolved with a clear and successful outcome. We determined that this ASI paradigm could provide promising advances for future research, particularly with neural indices of measures involving social reward processing. The ASI paradigm could in theory be adapted and expanded to suit ERP measures of dopaminergic signaling that have been previously associated with probabilistic associative learning, like Reward Positivity in extraverts (Cooper et al., 2004; Smillie et al., 2019) and the P300 component elicited by human facial stimuli (Fishman et al., 2011), and applied to understand the disparity in those with aberrant reward processing. Social perception, a complex feature of human interaction and social behaviour, could possibly be affected by individual differences in empathy and its neural correlates (see Banissy et al., 2012), particular within characteristics of autism (Heerey, 2014).

In particular, the work in this thesis suggests that people will use others' nonverbal cues in the real world and that their ability to do so is moderated by individual differences in personality. This conclusion requires further evaluation under more naturalistic conditions. An innovative way to overcome these ecological validity concerns would be to adapt the ASI paradigm into a virtual reality environment, in future research. This would provide a more naturalistic environment but could do so in an experimentally controlled way. A clear future set of studies after this thesis would be to reproduce the ASI task structure but using virtual reality. Freeman et al. (2017), a pioneer within the field of therapeutic virtual reality, found that using interactive and immersive technology for virtual reality exposure-based treatments can reduce anxiety, and specifically social anxiety, with virtual environments that use social contexts. This highlights the future potential of a paradigm of interpersonal social rewards for use as a diagnostic or therapeutic technological tool when working with those who have aberrant social processing, perhaps as a symptom of any one of many comorbid disorders (e.g., autism spectrum disorders).

7.5 Conclusion

This chapter summarised the main findings from the five experimental chapters of the thesis. We integrated these findings within Berridge's account of the different phases of reward processing (Berridge et al., 2009), in a way that they are specific to social and interpersonal incentives, and rewarding virtual environments. For the first phase and key thesis theme, approach motivation, we utilized a new approach to appetitive mood inductions that involves interpersonal incentives to induce approach motivation and provide the affective activation needed to prepare for the acquisition of a goal. However, no clear effects of individual differences or effects on neural markers were found, challenging the exploration of personality neuroscience within this theme. The second theme concerned the third phase of reward processing, reinforcement learning and how computerised interpersonal interactions with probabilistic socially rewarding feedback can influence learned perceptions of other people. Here, there were clear effects of individual differences that were successfully demonstrated using the paradigm. This doctoral programme of research highlights the importance of adapting the way the effects of virtual and/or technological social rewards are measured, and what the outcome might be for those with aberrant social reward processing in an ever more interactive world. The series of studies utilised innovative methods (including relatively novel statistical analyses) for measuring the effects of social and interpersonal incentives and how these effects are moderated by individual differences. The methods have been extensively piloted and explored here and this has laid the necessary groundwork for future exciting developments.

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Appendices

Appendix A: Outputs of all Bayesian Model Comparisons for activation circumplex model (1) and pleasure circumplex model (2) with the intercept model (0) for video conditions in study 1 (Chapter 2).

Motivational Video Condition - Model 1 vs. Model 0

Dimensions:
- subjects: n=42
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Activation circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98782

Coefficients for target model (=Activation circumplex)
Mean intercept coefficient = -0.093223
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.14992 -0.03653
t-value= -3.3209 df= 41
p-value= 0.0018929
Mean circumplex coefficient = 2.0074
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = 1.275 2.7397
t-value= 5.5358 df= 41
p-value= 1.9743e-06

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.066405
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.12431 -0.0085036
t-value= -2.3161 df= 41
p-value= 0.025628

Number of cases analysed= 42
out of a total number of 55 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.6429

Mean log(Bayes Factor) for target:comparison models= 4.7313
Number of cases where evidence for target model strong by BF= 26
Number of cases where evidence for comparison model strong by BF= 0

Motivational Video Condition - Model 2 vs. Model 0

Dimensions:
- subjects: n=42
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Pleasure circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98768

Coefficients for target model (=Pleasure circumplex)
Mean intercept coefficient = -0.066438
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.12418 -0.0086958
t-value= -2.3237 df= 41
p-value= 0.025179
Mean circumplex coefficient = -0.027821
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.83495 0.7793
t-value= -0.069613 df= 41
p-value= 0.94484

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.066405
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.12431 -0.0085036
t-value= -2.3161 df= 41
p-value= 0.025628

Number of cases analysed= 42
out of a total number of 55 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.6429

Mean log(Bayes Factor) for target:comparison models= 3.7903
Number of cases where evidence for target model strong by BF= 20
Number of cases where evidence for comparison model strong by BF= 0

Control Video Condition - Model 1 vs. Model 0

Dimensions:
- subjects: n=52
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Activation circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98966

Coefficients for target model (=Activation circumplex)
Mean intercept coefficient = -0.15491
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.20819   -0.10164
t-value= -5.8374 df= 51
p-value= 3.6837e-07
Mean circumplex coefficient = 0.41562
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.14582   0.97707
t-value= 1.4862 df= 51
p-value= 0.14339

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.14949
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.20317   -0.095815
t-value= -5.5912 df= 51
p-value= 8.8939e-07

Number of cases analysed= 52
out of a total number of 60 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.8654

Mean log(Bayes Factor) for target:comparison models= 2.7326
Number of cases where evidence for target model strong by BF= 18
Number of cases where evidence for comparison model strong by BF= 0

Control Video Condition - Model 2 vs. Model 0

Dimensions:
- subjects: n=52
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Pleasure circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98957

Coefficients for target model (=Pleasure circumplex)
Mean intercept coefficient = -0.15809
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.2134   -0.10278
t-value= -5.7383 df= 51
p-value= 5.2564e-07
Mean circumplex coefficient = -0.7036
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -1.2781   -0.12913
t-value= -2.4589 df= 51
p-value= 0.017371

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.14949
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.20317   -0.095815
t-value= -5.5912 df= 51
p-value= 8.8939e-07

Number of cases analysed= 52
out of a total number of 60 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.8654

Mean log(Bayes Factor) for target:comparison models= 2.8125
Number of cases where evidence for target model strong by BF= 18
Number of cases where evidence for comparison model strong by BF= 0

Appendix B: Outputs of all Bayesian Model Comparisons for activation circumplex model (1) and pleasure circumplex model (2) with the intercept model (0) for video conditions in study 2 (Chapter 3).

OMV Condition - Model 1 vs. Model 0

Dimensions:
- subjects: n=45
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Activation circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98867

Coefficients for target model (=Activation circumplex)
Mean intercept coefficient = -0.14301
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.22024 -0.065776
t-value= -3.7318 df= 44
p-value= 0.00054196
Mean circumplex coefficient = 1.726
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = 0.76898 2.6831
t-value= 3.6347 df= 44
p-value= 0.00072464

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.12053
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.202 -0.03907
t-value= -2.9819 df= 44
p-value= 0.0046556

Number of cases analysed= 45
out of a total number of 63 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.7111

Mean log(Bayes Factor) for target:comparison models= 5.0715
Number of cases where evidence for target model strong by BF= 26
Number of cases where evidence for comparison model strong by BF= 0

OMV Condition - Model 2 vs. Model 0

Dimensions:
- subjects: n=45
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Pleasure circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98849

Coefficients for target model (=Pleasure circumplex)
Mean intercept coefficient = -0.12142
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.20573   -0.037116
t-value= -2.9026 df= 44
p-value= 0.0057631
Mean circumplex coefficient = -0.11912
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.96264   0.7244
t-value= -0.28461 df= 44
p-value= 0.77728

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.12053
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.202   -0.03907
t-value= -2.9819 df= 44
p-value= 0.0046556

Number of cases analysed= 45
out of a total number of 63 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.7111

Mean log(Bayes Factor) for target:comparison models= 3.0282
Number of cases where evidence for target model strong by BF= 18
Number of cases where evidence for comparison model strong by BF= 0

RMV Condition - Model 1 vs. Model 0

Dimensions:
- subjects: n=43
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Activation circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98765

Coefficients for target model (=Activation circumplex)
Mean intercept coefficient = -0.18862
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.26038 -0.11685
t-value= -5.3042 df= 42
p-value= 3.9453e-06
Mean circumplex coefficient = 0.12817
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.36173 0.61806
t-value= 0.52796 df= 42
p-value= 0.6003

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.18678
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.25836 -0.11521
t-value= -5.2665 df= 42
p-value= 4.4636e-06

Number of cases analysed= 43
out of a total number of 59 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.814

Mean log(Bayes Factor) for target:comparison models= 2.0893
Number of cases where evidence for target model strong by BF= 11
Number of cases where evidence for comparison model strong by BF= 0

RMV Condition - Model 2 vs. Model 0

Dimensions:
- subjects: n=43
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Pleasure circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98804

Coefficients for target model (=Pleasure circumplex)
Mean intercept coefficient = -0.19181
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.26684 -0.11678
t-value= -5.1592 df= 42
p-value= 6.3402e-06
Mean circumplex coefficient = -0.42517
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -1.1575 0.30713
t-value= -1.1717 df= 42
p-value= 0.24793

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.18678
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.25836 -0.11521
t-value= -5.2665 df= 42
p-value= 4.4636e-06

Number of cases analysed= 43
out of a total number of 59 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.814

Mean log(Bayes Factor) for target:comparison models= 3.2869
Number of cases where evidence for target model strong by BF= 22
Number of cases where evidence for comparison model strong by BF= 0

NCV Condition - Model 1 vs. Model 0

Dimensions:
- subjects: n=50
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Activation circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98961

Coefficients for target model (=Activation circumplex)
Mean intercept coefficient = -0.074341
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.18724   0.038554
t-value= -1.3233 df= 49
p-value= 0.19188
Mean circumplex coefficient = 1.4983
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = 0.83639   2.1602
t-value= 4.549 df= 49
p-value= 3.5619e-05

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.055081
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.16713   0.056969
t-value= -0.98785 df= 49
p-value= 0.32808

Number of cases analysed= 50
out of a total number of 62 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.72

Mean log(Bayes Factor) for target:comparison models= 3.5194
Number of cases where evidence for target model strong by BF= 22
Number of cases where evidence for comparison model strong by BF= 0

NCV Condition - Model 2 vs. Model 0

Dimensions:
- subjects: n=50
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Pleasure circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98967

Coefficients for target model (=Pleasure circumplex)
Mean intercept coefficient = -0.058994
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.17306 0.055075
t-value= -1.0393 df= 49
p-value= 0.30376
Mean circumplex coefficient = -0.35933
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -1.3923 0.67369
t-value= -0.69902 df= 49
p-value= 0.48784

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.055081
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.16713 0.056969
t-value= -0.98785 df= 49
p-value= 0.32808

Number of cases analysed= 50
out of a total number of 62 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.72

Mean log(Bayes Factor) for target:comparison models= 5.1495
Number of cases where evidence for target model strong by BF= 26
Number of cases where evidence for comparison model strong by BF= 0

Appendix C: Outputs of all Bayesian Model Comparisons for activation circumplex model (1) and pleasure circumplex model (2) with the intercept model (0) for video conditions in study 3 (Chapter 4).

RMV Condition - Model 1 vs. Model 0

Dimensions:
- subjects: n=41
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Activation circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.9876

Coefficients for target model (=Activation circumplex)
Mean intercept coefficient = -0.16788
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.23549 -0.10027
t-value= -5.0186 df= 40
p-value= 1.116e-05
Mean circumplex coefficient = 0.11629
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.8938 1.1264
t-value= 0.23268 df= 40
p-value= 0.8172

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.16687
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.23402 -0.099724
t-value= -5.0226 df= 40
p-value= 1.1019e-05

Number of cases analysed= 41
out of a total number of 43 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.3171

Mean log(Bayes Factor) for target:comparison models= 4.8144
Number of cases where evidence for target model strong by BF= 27
Number of cases where evidence for comparison model strong by BF= 0

RMV Condition - Model 2 vs. Model 0

Dimensions:
- subjects: n=41
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Pleasure circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98744

Coefficients for target model (=Pleasure circumplex)
Mean intercept coefficient = -0.16673
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.2371 -0.096359
t-value= -4.7886 df= 40
p-value= 2.3168e-05
Mean circumplex coefficient = -0.034072
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.93969 0.87155
t-value= -0.076039 df= 40
p-value= 0.93977

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.16687
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.23402 -0.099724
t-value= -5.0226 df= 40
p-value= 1.1019e-05

Number of cases analysed= 41
out of a total number of 43 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.3171

Mean log(Bayes Factor) for target:comparison models= 3.9861
Number of cases where evidence for target model strong by BF= 19
Number of cases where evidence for comparison model strong by BF= 0

NCV Condition - Model 1 vs. Model 0

Dimensions:
- subjects: n=40
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Activation circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98746

Coefficients for target model (=Activation circumplex)
Mean intercept coefficient = -0.08101
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.16236 0.00033694
t-value= -2.0143 df= 39
p-value= 0.05091
Mean circumplex coefficient = -2.3848
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -3.3453   -1.4242
t-value= -5.0218 df= 39
p-value= 1.169e-05

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.11168
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.19388   -0.029487
t-value= -2.7483 df= 39
p-value= 0.0090261

Number of cases analysed= 40
out of a total number of 42 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.375

Mean log(Bayes Factor) for target:comparison models= 6.5803
Number of cases where evidence for target model strong by BF= 29
Number of cases where evidence for comparison model strong by BF= 0

NCV Condition - Model 2 vs. Model 0

Dimensions:
- subjects: n=40
- models: K=2

Posterior probabilities:
- RFX: p(H1|y)= 1.000
- null: p(H0|y)= 0.000

Compared with the reference model (Intercept only),
the statistics in favour of the hypothesized target model (Pleasure circumplex) were:
protected exceedance probability (pxp) = 1
expected frequency of target model (Ef) = 0.98714

Coefficients for target model (=Pleasure circumplex)
Mean intercept coefficient = -0.12314
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.20731   -0.038964
t-value= -2.959 df= 39
p-value= 0.0052246
Mean circumplex coefficient = -1.0943
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -2.0067   -0.18181
t-value= -2.4257 df= 39
p-value= 0.020006

Coefficients for comparison model (=Intercept only)
Mean intercept coefficient = -0.11168
Testing whether this value differs from zero (via two-tailed t-test):-
95% CIs for coeff. value = -0.19388   -0.029487
t-value= -2.7483 df= 39
p-value= 0.0090261

Number of cases analysed= 40
out of a total number of 42 cases in selected condition in dataset
Mean number of mood items per analysed case= 59.375

Mean log(Bayes Factor) for target:comparison models= 3.3073
Number of cases where evidence for target model strong by BF= 17
Number of cases where evidence for comparison model strong by BF= 0

Appendix D: Speaker rating questions

Questions about the speaker in the videos used in study 2 (Chapter 3), and study 3 (Chapter 4).

1. Do you recognise the speaker in the video you watched?
   __ Yes
   __ Maybe
   __ No

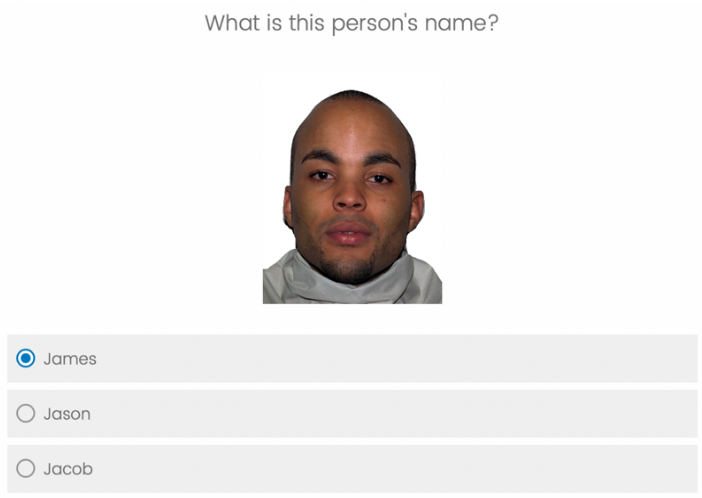
2. Do you know the name of the speaker in the video you watched?
   __ Yes
   __ No

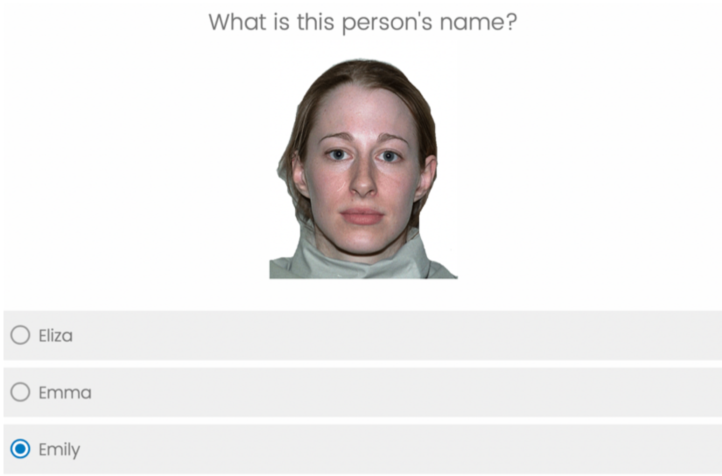
3. If you can remember the name of the speaker, please write it in the box below.

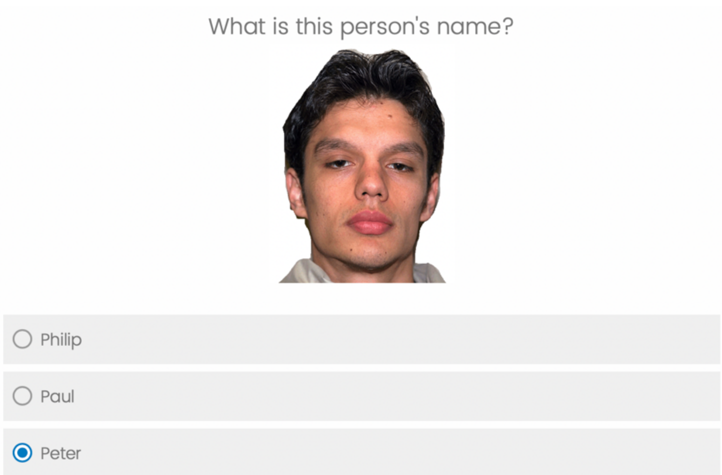
4. Please rate the extent to which you think each of these adjectives describe the speaker in the video you watched. (1: Not at all – 10: Extremely)

   i. Successful
   ii. Uninspiring
   iii. Intelligent
   iv. Unattractive
   v. Hardworking
   vi. Dull
   vii. Healthy
   viii. Poor

Appendix E: The name recognition task as it was presented in the Qualtrics survey for the ASI task (Chapter 5 and 6). Each thumbnail shows the character's face along with their name (marked with a blue circle) and the two distractor names.







What is this person's name?

Laura

Lucy

Lisa

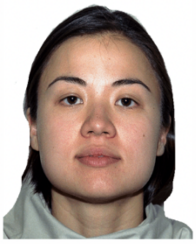
What is this person's name?

Justin

Joseph

Joshua

What is this person's name?



Ella

Eva

Eve

What is this person's name?

- ○ Martin
- ◉ Michael
- ○ Matthew

What is this person's name?

- ○ Sasha
- ○ Sadie
- ◉ Sarah

What is this person's name?

- ○ Daniel
- ◉ David
- ○ Dylan

What is this person's name?

- (selected) Jessica
- Joanna
- Julianna

What is this person's name?

- Alan
- (selected) Adam
- Andy

What is this person's name?

- (selected) Megan
- Molly
- Mary