Goldsmiths Research Online

Goldsmiths Research Online (GRO)
is the institutional research repository for
Goldsmiths, University of London

Citation

Eisenkoeck, Antonia. 2019. Judging the intentionality of ambiguous action. Doctoral thesis, Goldsmiths, University of London [Thesis]

Persistent URL

https://research.gold.ac.uk/id/eprint/28248/

Versions

The version presented here may differ from the published, performed or presented work. Please go to the persistent GRO record above for more information.

If you believe that any material held in the repository infringes copyright law, please contact the Repository Team at Goldsmiths, University of London via the following email address: gro@gold.ac.uk.

The item will be removed from the repository while any claim is being investigated. For more information, please contact the GRO team: gro@gold.ac.uk

Goldsmiths
UNIVERSITY OF LONDON

Judging the intentionality of ambiguous action

PhD Thesis

Antonia Eisenkoeck

Department of Psychology

Goldsmiths, University of London

Declaration of Authorship

I, Antonia Eisenkoeck, hereby declare that this thesis and the work presented in it is my own. Where I have consulted the work of other, this is always clearly stated.

Signed: _ [redacted] , Date: 24 September, 2019

Acknowledgements

First and foremost, I would like to express my sincerest gratitude to my supervisor Dr James Moore for the continuous support throughout my PhD, for his patience, motivation, kindness and vast knowledge. He guided me through my research and the writing of this thesis. Dear James, at all stages of my PhD, your advice was invaluable to me and I could not have wished for a better supervisor and mentor.

I would also like to thank my second supervisor Professor Joydeep Bhattacharya for his insightful comments and encouragement.

Besides my supervisors, I would like to thank Professor Jan de Fockert for his much-appreciated input on some of my work.

My sincere thanks also go to Dr Devin Terhune, Professor Alan Pickering, Dr Marinella Cappelletti and Professor Pamela Heaton for advising me on issues regarding experimental design and data analysis.

I would also like to thank Dr Rachel Slavny and Jack Moore, with whom I worked together on some projects discussed in this thesis, including a study at the London Science Museum.

I gratefully acknowledge the funding received towards my PhD from the Leverhulme Trust.

Heartfelt thanks go to all the people who proof-read my thesis, especially Ben, whose honest feedback was very much appreciated. All your help was very valuable to me.

Lastly, I would like to thank my family and my partner Julien for their support, patience and motivation. Especially, I would like to express my gratitude to my parents. Your love gives me strength and allows me to be brave.

Abstract

Judging the intentionality of others' actions is a key aspect of social cognition; it gives meaning to actions and helps us predict what others will do. The ability to correctly judge intentionality is central to everyday social interactions as well as our justice system, where responsibility rests on the judgement of intentionality. Despite the clear importance of accurately judging other peoples' action, it has been suggested that humans have a bias towards intentional attributions (Rosset, 2008). To explain this, Rosset (2008) introduced a dual-process model of intention attribution which suggests that there is an automatic tendency to judge *all* action as intentional, but that this can be overridden by higher-level controlled cognitive processes, leading to *unintentional* explanations of behaviour. Consequently, the model predicts that factors facilitating controlled processing (e.g., time to engage in processing, cognitive maturity linked to age, cognitive ability and availability of cognitive capacity) play a role in judging intentionality. In this thesis, I tested some of these predictions, however, apart from a replication of Rosset's (2008) study, suggesting time pressure increases individuals' intentionality endorsement, results do not support the dual-process model.

Additionally, I investigated judging intentionality in Autism Spectrum Conditions (ASC) and the role of Theory of Mind (ToM). Individuals with ASC

showed an increased tendency to attribute intent to ambiguous behaviour compared to neurotypicals, which could not be explained by differences in ToM. These results could indicate a difference in intention attribution *style* rather than failing to perceive mental states in ASC, which could help understand one aspect of social difficulties in ASC.

In summary, the empirical evidence gathered in this thesis suggests that judging intentionality cannot be fully captured in a dual-process model. Therefore, at the end of this thesis, other approaches including a revised dual-process model and a single-system framework will be explored.

Table of Contents

List of Tables

List of Figures

CHAPTER ONE

General Introduction

Imagine a man is walking his dog along a sports ground. All of a sudden, he is hit by a ball on the back of his head. He turns around and sees a boy in muddy shorts looking at him. He quickly infers that this was an intentional assault, takes the ball and - as hard as he can - throws it in the other direction, down a hill.

Now imagine a different scenario. The man is struck by a ball on the head, and as he turns around he sees a boy in muddy shorts. However, as he judges from the look in the boy's face, he is concerned and surprised, which makes the man infer that he was hit with the ball by accident. He therefore playfully throws the ball back towards the boy.

Our judgments of intentionality shape our social interactions. Whereas in the first case, judging the boy's action to be intentional led to a hostile reaction in the man, in the second case, judging it to be an accident led to a playful interaction between the two parties. Importantly, at this point, it is of little relevance which interpretation of the boy's action was correct. What is indeed important, however, is that both interpretations had different consequences. This applies to a wide range of social contexts. For example, during a romantic date, intentionally brushing someone's arm might lead to the conclusion of reciprocated sexual interest in the other, and similarly, intentionally failing to greet a colleague in the morning might lead to them feeling ignored and avoiding helping out in the future. Our perception of others' intentions are the building blocks of our social worlds. Sometimes, they are even more important than the actions themselves, as for example in cases in which punishment of an action only occurs when the action was done intentionally (e.g., punishment of handball in a football game; Fédération Internationale de Football Association, 1995).

Perceived intentionality plays a crucial role in how we interpret our surroundings – it provides meaning to the flow of social information and cues we receive. As social beings, the intentional status of other people's actions is of fundamental importance, as we do not simply perceive a chain of unrelated and meaningless movements, but instead, we go beyond the surface features of movements, making inferences about the mental states that might produce them (Baldwin & Baird, 2001). These judgements of intentionality, and how we arrive at them, are the focus of this thesis.

Perceiving intentional action

According to Dennett (1987), there are three stances (i.e., perspectives) in which we can interpret our surroundings: the physical stance, the design stance and the intentional stance. The physical stance predicts an event or behaviour of an object to be controlled by physical laws (e.g., an object falls on the ground because of gravity). The design stance predicts the behaviour of an object to be controlled by its design or function (e.g., when the button is pushed, coffee maker produces coffee because it is designed to do so). The intentional stance can be seen as the highest (i.e., most advanced) level at which to analyse and predict an object's or system's behaviour. It can only be applied to objects or systems with some form of intelligence – here action is interpreted as being controlled by mental states and implies some degree of agency, rationality and goal-directedness (Dennett, 1987).

When interpreting events caused by inanimate objects or systems such as machines, the physical and design stances are suitable to identify the causes for most events. When interpreting human behaviour, though, the first two stances alone are of minimal use. Although some of our actions might be primarily caused by physical laws (e.g., falling off a tree), or some of what we do can be interpreted from a design stance (e.g., watering of the eyes as a self-cleaning function), most people believe a large part of what we humans do is caused by our mental states - one of them being intention. Using the intentional stance, therefore, is often more useful when explaining one's own and others’ behaviour than trying to explain every action as a chain of movement of atoms.

In his Intentional System Theory, Dennett (2009) further argues that perceiving an agent as an intentional system facilitates predicting future events or actions as it decreases the number of possible events, i.e., adopting the intentional stance has more predictive validity. To explain this, Dennett (2009) uses the example of playing chess against a computer. Predicting the computer’s next move assuming its “intention” is to win the game, decreases the number of possible moves substantially (i.e., the prediction is more likely to be accurate) and is also less costly (in time and energy) than considering all possible moves the computer’s code (design stance) or the laws of physics (physical stance) allow it to do (Dennett, 2009). Similarly, when predicting human action, when one perceives another as an intentional agent and has a good idea of what their intention could be, the number of possible events is smaller than, for example, all physically possible events. In other words, our social environment generally becomes more predictable and easier to navigate around when perceiving others as intentional agents who act purposefully (Dennett, 2009).

Implication of perceiving actions as intentional

In our complex social world, we are constantly exposed to the actions of others. A key demand of us as social agents is to judge which actions are intentional and which are accidental (i.e., *not* caused by intention). Identifying and understanding others' intentions is thus a key element of social cognition. It shapes how we interact with each other, as we react differently to behaviour judged to be intentional as opposed to unintentional. Notions of praise and blame only make sense when viewed through the prism of intentional action (Shaver, 1985). Unkind behaviour that is judged to be intentional leads to a stronger emotional response, is condemned more readily and is more likely to evoke a negative reaction (Taylor, Shuntich, & Greenberg, 1979; Gilbert, Lieberman, Morewedge, & Wilson, 2004; Gray & Wegner, 2008; Cushman, 2008), perhaps because an intentional action is conclusive in terms of the agent's motivation and how likely the action is to reoccur. Similarly, intentional helping-behaviour is more likely to be reciprocated than helping-behaviour that is unintentional (e.g., Swap, 1991), maybe because we want to reward and reinforce altruistic behaviour in each other. Additionally, intentionality determines whether, and to what extent, actions are punished. For example, in football, the punishment of a handball depends on whether a ball was intentionally or unintentionally touched (Fédération Internationale de Football Association, 1995), which shows that an agent's intention has sometimes more weight than the actual action. Also, intentionality has judicial implications as, for example, in the United Kingdom it provides the basis for distinguishing between murder and manslaughter ("Homicide; Murder and Manslaughter: Legal Guidance: The Crown Prosecution Service," 2017). In summary, we do not only have one-off interactions with each other but are likely to repeatedly interact with the same people. To predict future action, it is necessary to understand other agents' motivations and desires. This could be why we pay so much attention to each other's intentions and why our judgement of intentionality shape our social interactions.

Why it is important to study how we judge intentionality of *ambiguous* action?

As alluded to above, judgements of intentionality are important because they play a role in the success of interpersonal social interaction (e.g., aggressive reaction to harmful behaviour, reciprocation of helping behaviour etc.) as well as, for example, how individuals are punished in legal or sports settings. What is often overlooked, though, is the fact that the actions we witness are often ambiguous in terms of their intentional status, i.e., there are no strong cues marking intentionality. Although, in everyday life, we seem to be fairly good at judging intentionality of action that surrounds us, when it goes wrong it can lead to negative consequences ranging from simple misunderstandings to, for example, aggressive reactions towards accidental behaviour.

A substantial part of the intention attribution literature focuses on actions of *unambiguous* intent and investigates the accuracy of intention reading in children or individuals with psychiatric or neurological conditions. However, little is known about how individuals deal with incomplete information and how they judge ambiguous action. By studying ambiguous action (i.e., action for which no strong cues marking intentionality lead to normative correct answers), one can detect variability in individuals who would otherwise likely pick up on strong cues overriding default responses and, hence, conform in their judgements. This approach allows us to detect basic attributional styles in judging intentionality, which in turn opens up new possibilities for studying patterns of intention attribution. For example, one can compare groups (e.g., neurotypicals vs. individuals with Autism Spectrum Conditions) or look at changes across the lifespan. Findings from such studies can potentially help explain social difficulties in certain populations. Additionally, as there are no obviously correct answers, judgements of intentionality can be more easily manipulated which enables us to study factors contributing to intentional reasoning.

Also, by studying ambiguous action, we can investigate whether people tend to process observed behaviour in a certain way. In other words, when there are no strong cues marking intentionality, we can test whether there is a default judgement of others' behaviour. As suggested by Rosset (2008), people have an automatic tendency to perceive others' action to be intentional. This tendency could be a feature of human cognition for a number of different reasons, including a general need or desire to detect patterns in our surroundings and the potentially higher predictive value of intentionality compared to accidental action.

Given the importance of detecting and understanding others' intentions, our cognitive system seems to be strongly attuned to cues marking intentionality. We appear to preferentially process and recall intent-relevant information, whilst discounting intent-irrelevant information (Baldwin & Baird, 2001; Blakemore & Decety, 2001; Zadny & Gerard, 1974). As early work from Heider and Simmel (1944) suggests, we do not only have a sensitivity towards perceiving intentional agents but perhaps even a hypersensitivity that leads us to readily perceive intent in inanimate objects such as moving geometrical shapes (a phenomenon also known as animacy). It has been suggested that this tendency to perceive intentional agents is caused by a so-called Hyperactive Agency Detection Device, which yields more false positives (i.e., detecting intentional agent when none is there) than false negatives (failing to detect intentional agent; Barrett, 2000). If a physical object behaves (e.g., moves) in a way that violates one's expectations of physical objects it is perceived as an agent. On this view, one evolutionary advantage could be that we are more likely to detect hidden or disguised agents (e.g., hungry animals; Barrett, 2000; Guthrie, 1993). Therefore, understood in the light of the so-called Error Management Theory (Haselton & Buss, 2000), perceiving intentional agents increases evolutionary fitness. Importantly, as the Error Management Theory suggests, two underlying assumptions that need to be met for a cognitive bias to evolve are i) some uncertainty over a genuine signal and ii) asymmetry of inferential error-cost (Haselton & Buss, 2000; Haselton & Nettle, 2006). In the context of the actions of others, both assumptions seem to be met: a substantial proportion of actions are ambiguous in intentionality (i.e., uncertain signal), and failing to detect intentionality is likely to be more costly (e.g., making communication and interaction difficult as well as failing to predict harmful behaviour).

Similarly, animism (attribution of mental states to inanimate objects) is also a key feature of religion. As Guthrie (2001) explains, it is important to have a low threshold to detect other intentional agents, as their interests are often different to that of the observer and, therefore, in ambiguous situations, failing to detect an intentional agent (e.g., another human, a god, etc.) might be more costly than falsely detecting one, as it can lead to confrontation caused by the conflict of interest. For example, if one sees certain patterns in the environment such as stones arranged in a certain way it would be more beneficial to assume this to be the work of another intentional agent (e.g., god) rather than disregarding it and potentially missing an important sign and the presence of an agent (e.g., Guthrie, 2001).

This overarching predisposition to perceive intentional agents might be involved in what Rosset (2008) coined the *intentionality bias* – an automatic tendency to perceive ambiguous behaviour to be intentional. Being aware of such a tendency and better understanding the underlying cognitive mechanisms (e.g., dual-process model, explained further below) would not only be beneficial in everyday social interactions but also in legal settings, for example, involving eyewitness testimony. The aim of this thesis, therefore, is to investigate how we judge intentionality of ambiguous action and what factors influence our judgements.

A folk concept of intentionality

Importantly, the focus of this thesis is *perceived* intentionality rather than intentionality per se (which could be understood as the quality of mental states that are targeted towards an outcome or state). Therefore, it is not a precise definition of intentionality that is of interest but rather how and why actions are judged to be intentional. An essential consideration, however, is that without a shared understanding of intentionality, making inferences about other people would be fairly inefficient and difficult, and thereby defeat the purpose, as an inference that does not deliver accurate predictions is hardly worth achieving. Therefore, a key point of discussion has been whether there is a common understanding of intentionality shared across individuals and how individuals arrive at a judgement of intentionality.

As discussed by Baldwin and Baird (2001), there are broadly two traditional approaches attempting to explain how humans discern intentional action. One approach understands intentional inferences to be reliant on the sensitivity to certain perceptual cues, for example, intentionality can be inferred from detecting certain kinematic cues (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Premack & Premack, 1995). The other approach views them as constructed through knowledge and past experience (e.g., Baldwin & Baird, 1999; Malle & Knobe, 1997; Malle, Moses, & Baldwin, 2001). Both approaches have in common that they predict the ability to discern intentionality as a skill that develops and matures with age – a notion that was later challenged by Rosset (2008) in her dual-process model. To illustrate how Rosset's model compares to more previous ways of explaining intention attribution, I will now discuss one - Malle and Knobe's (1997) *Folk Concept of Intentionality* - as an example of a traditional approach viewing intentional inferences being based on past experience and knowledge. Subsequently, I will explain Rosset's dual-process model of intention attribution.

Malle and Knobe (1997) see intentionality as a *social* fact rather than an *objective* fact about the mind. This means that although it can be questioned whether intentionality is a genuinely objective attribute of human cognition, it is undeniable that humans infer intentions from each other's behaviour. They argue further that a model aiming to describe intentional action needs to capture a concept that applies to how people experience and judge intentionality (as previously emphasised by Heider, 1958). In contrast to earlier models of intentional action that are largely theoretical accounts of intentionality (e.g., Heider, 1958; Jones & Davis, 1965; Ossorio & Davis, 1968; Shaver, 1985), Malle and Knobe's (1997) model is directly based on empirical evidence. In three studies they investigated people's understanding of intentionality and what components were required for an action to be regarded as intentional. They introduced the so-called *Folk Concept of Intentionality*, which they argue is a concept shared across individuals on what constitutes an *intentional* action. It takes into account the social role of intentionality (i.e, understanding that intentionality is influenced by the social context rather than an objective attribute of the mind) and is based on the premise that intentionality is not a purely theoretical concept but that people have a common understanding of it, which they automatically apply to form judgments of intentionality. In other words, people seem to agree on whether an action is done intentionally or unintentionally. Their empirical model involves five components: The *desire* for an outcome; *beliefs* about an action that leads to an outcome; an *intention* (decision) to perform the action; the *skill* to perform the action; the *awareness* of fulfilling the intention while performing the action (Figure 1.1). As Malle and Knobe argue, all five components have to be present for an action to be judged as intentional. In other words, behaviour that leads to the desired outcome, that involves an understanding of how to achieve that outcome, that was decided to be done, that shows the actor's ability to perform the action and their awareness thereof, is considered to be intentional (Malle & Knobe, 1997).

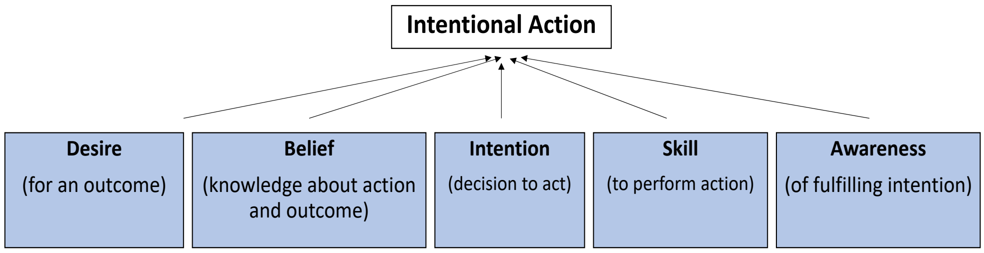


Figure 1.1. Illustration of Malle and Knobe's (1997) Folk Concept of Intentionality.

It is important to note here that, according to this model, judging others' action to be intentional requires the observer to have some information on these five components. This was illustrated in Malle and Knobe's (1997) *Study 3*, in which participants' judgements of intentionality were influenced by explicit manipulation of some components (e.g., *Desire*: "Frank hates/likes George."; *Awareness:* "Frank was (not) aware of bumping into the blue BMW behind him."; *Belief*: "Frank knew/did not know that the blue BMW was George's car"). Such manipulations turned out to drastically change judgements of intentionality. Participants tended to judge actions to be intentional if, a) they led to the desired outcome, b) the agent held beliefs about them and, and c) the agent was skilled at performing them. However, if the agent did not desire an outcome, had no beliefs about an action or was not skilled at performing the action, it was hardly ever judged to be intentional. This demonstrates how what we know about an agent's mental state influences how we judge their intentionality.

While in Knobe and Malle's experiments, participants had explicit information about others' mental states, in real-life situations we usually do not have direct access to an agent's mental state. Because of this, we need to infer the existence of these mental states based on available information. Although we might in theory broadly agree on what criteria make an action intentional, our estimations of whether these criteria are met might vary across individuals and situations. As mentioned above, a premise of Malle and Knobe's (1997) model (as well as other models preceding it) is that the true skill lies in detecting intention in an action. The assumption here is that this skill develops with age and experience. This would entail that the quality of intentionality endorsement increases with age as individuals become more sensitive to, and have established a more in-depth knowledge of, relevant cues. As mentioned above, it is exactly this notion that is challenged by an alternative framework proposed by Rosset (2008). According to her, the true marker for mature intentional reasoning is the ability to judge behaviour to be accidental. At the core of this framework is an *intentional heuristic* that leads to an automatic tendency to judge behaviour to be intentional and it is the inhibition of such tendency that develops with age. This alternative framework will be discussed in the next section.

A dual-process model of intention attribution

Rosset (2008) proposed that we are biased towards attributions of intent when judging other people's actions. To explain this so-called *intentionality bias*, Rosset put forward a dual-process model of intention attribution comprising two streams: an automatic stream that is always active and leads to intentional judgments and a non-automatic, controlled stream involving higher-level processing that can override automatic judgments (Figure 1.2). The higher-level stream involves cognitive capacity to enable reasoning about alternative causes for behaviour, detection of situational and perceptual cues and inhibition of an automatic response. Inherent to this theory is the idea that it is not the concept of intentionality that develops throughout infancy and childhood but the ability to override *intentional heuristics*. This ability can be compromised in situations of increased cognitive load (i.e., decreased availability of cognitive processing capacity) or lack of knowledge of alternative causes or cues (Rosset, 2008).

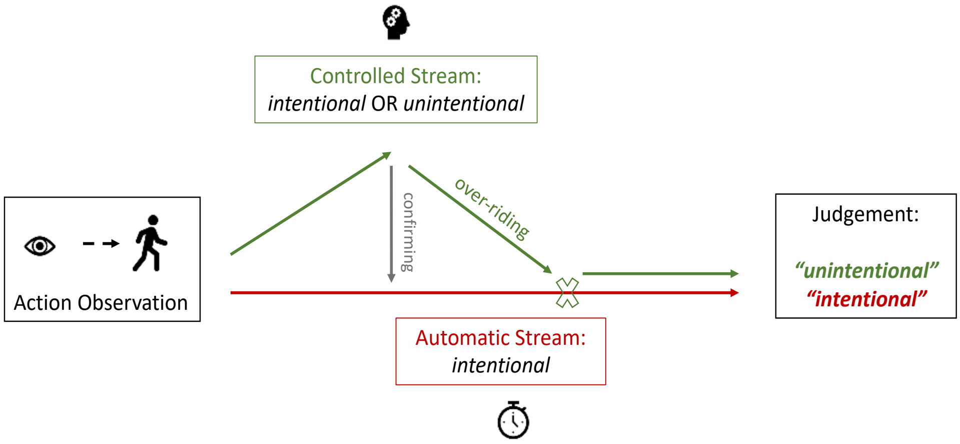


Figure 1.2. A schematic illustration of Rosset's dual-process model of intention attribution. It comprises two streams: A fast automatic stream leading to an intentional explanation for the observed behaviour (shown in red on the figure), and a slower, controlled stream enabling analytical processing of observed behaviour (shown in green on the figure). The controlled stream can inhibit and override the judgement of the automatic stream and lead to an unintentional explanation of behaviour. (Please note, for simplicity, when talking about observed behaviour we do not only refer to visually observed behaviour but all behaviour that is perceived, processed and judged.)

A key element of this framework and a premise of this thesis is that situations of true interest are ones that are ambiguous with respect to their intentionality, i.e. situations in which no easily observable perceptual or situational cues control the judgement of intentionality. Studying ambiguous situations allow us to investigate how individuals deal with incomplete information, what biases they potentially express, and how people differ in their responses.

Empirical evidence for the dual-process model of intention attribution

Rosset (2008)

Rosset's (2008) paper introducing the dual-process model of intention attribution consists of three experiments. In *Experiment 1*, Rosset made use of the *Ambiguous Sentence* Paradigm specifically created for this paper. In this task, participants were presented with sentences describing actions that could either be done intentionally or unintentionally (e.g., *She broke the vase*, *He typed the email*, etc.). Each sentence either belonged to one of two unambiguous control categories (accidental: *Accidental control sentences*; intentional: *Intentional control sentences*) or to one of two ambiguous test categories (ambiguous but prototypically accidental: *Prototypically Accidental test sentences*; ambiguous but prototypically intentional: *Prototypically Intentional test sentences*; Figure 1.3). Participants were asked to judge whether each sentence described an action generally done *on purpose* or *by accident*. They made these judgements in one of two conditions: a speeded condition, where participants were given 2.4 seconds to respond, or an un-speeded condition, where participants were given 5 seconds to respond. This manipulation was introduced to alter the availability of cognitive resources, which was thought to be required for judgments involving the controlled stream.

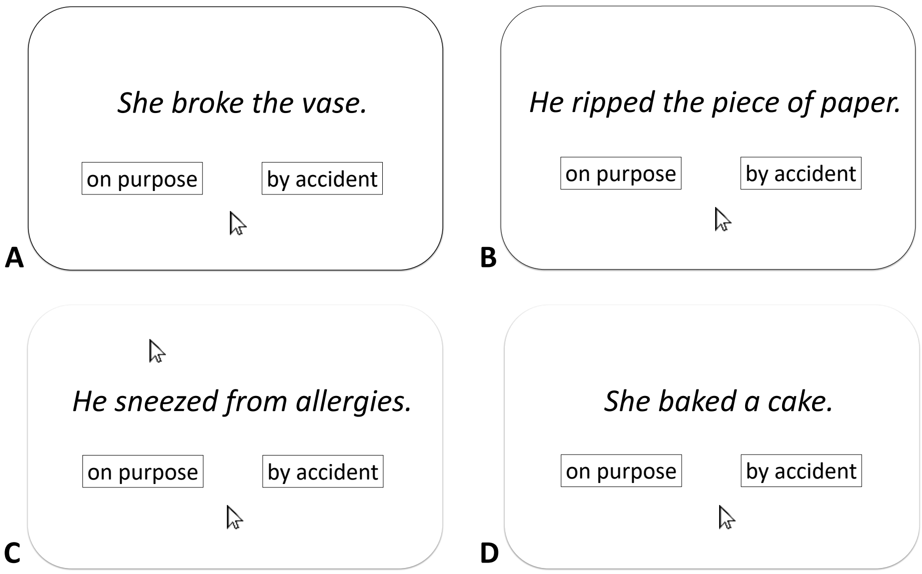


Figure 1.3. Example stimuli for each test- and control category of Rosset's Ambiguous Sentence Paradigm. A) Example for Prototypically Accidental test sentence, B) example for Prototypically Intentional test sentence, C) example for Accidental control sentence and D) example for Intentional control sentence. Participants are presented with one sentence at a time and are asked to judge whether the action depicted in the sentence is generally done on purpose or by accident. Please note that Rosset's original paradigm was conducted using paper and pen, however, studies conducted in this thesis used a computer version of the paradigm in which participants were asked to respond by clicking on the corresponding box.

For all four categories, an intentionality endorsement score was computed by calculating the percentage of *on purpose* judgments in a given category, which was thought to reflect each participant's tendency to judge ambiguous actions to be intentional (Rosset, 2008). Of particular interest are intentionality endorsement scores for Prototypically Accidental test sentences. This is because these depict ambiguous but *prototypically accidental* actions, which are expected to be judged differently depending on whether analytical processing is involved or whether the judgement is driven by a default process. Indeed, results showed that participants were more likely to judge ambiguous but prototypically accidental actions (Prototypically

Accidental test sentences) to be intentional when under time pressure (Table 1.1), which suggests that under conditions that tax the controlled cognitive processing, humans are more likely to judge ambiguous but prototypically accidental actions to be intentional. Additionally, participants in the speeded condition were more likely to judge Accidental control sentence to depict intentional action.

Table 1.1. Mean intentionality endorsement scores for Prototypically Accidental test sentences (PA), Prototypically Intentional test sentences (PI), Accidental control sentences (UA) and Intentional control sentences (UI) taken from Rosset (2008). No standard deviations were given.

	PA**	PI	UA*	UI
Speeded	22	66	2	98
Un-speeded	15	69	5	98

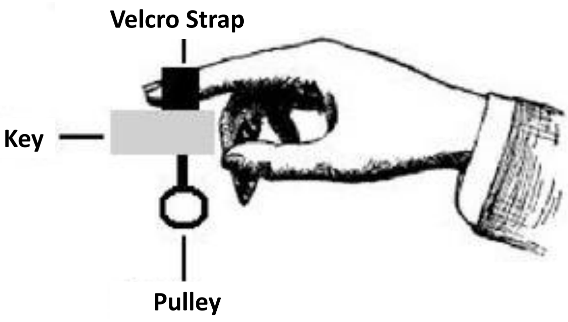
**p<.001
*p<.02

In two follow-up studies, the idea of *intentional* judgments as the automatic response was tested by using an implicit measure (*Experiment 2*) and by assessing recall of test items (*Experiment 3*). Results of Experiment 2 suggest when participants are asked for spontaneous descriptions of events (i.e., not explicitly bringing to mind a possible accidental nature of the event), participants were significantly more likely to give an intentional analysis of events, even for prototypically accidental stimuli (e.g., *She broke the vase.*). To further investigate whether more processing is required to interpret an action as intentional, *Experiment 3* introduced a surprise recall task, based on the idea that more in-depth processing facilitates recall. Participants were asked to judge 12 sentences (unambiguously intentional or unintentional) in one of two aspects: pleasant/unpleasant (control group) or intentional/unintentional (experimental group). Analysis revealed a greater recall of *unintentional* sentences in the experimental compared to the control group. This suggests that judging actions to be unintentional requires more processing than judging them on other aspects. Together, these three studies form the basis for Rosset's formulation of the dual-process theory.

Importantly, a replication attempt has been published by Hughes, Sandy and Trafimow (2012). They found that results from Rosset's (2008) *Experiment 1* could only be partly replicated, in so far as intentionality endorsement scores for Prototypically Accidental test sentences were not significantly higher in the speeded condition. However, when both test sentence categories were combined (Prototypically Accidental and Prototypically Intentional), intentionality endorsement scores were significantly higher in the speeded compared to the un-speeded condition. (Similar to Rosset's (2008) study, participants in the speeded condition also showed significantly higher intentionality endorsement scores for Accidental control sentences.) The absence of a significant difference between the speeded and un-speeded condition for the Prototypically Accidental test sentences in this replication attempt could be due to the comparatively smaller sample size and a different data analysis approach to Rosset's (2008) study. Therefore, in *Chapter 2* the different ways of analysing the Ambiguous Sentence Paradigm will be explored in order to find the optimal approach.

Moore and Pope (2014)

One criticism that has been raised against Rosset's paradigm is that the tendency to judge actions to be intentional could be a linguistic effect arising from the stimuli used to measure it. As Rosset (2008) pointed out herself, an accidental action might be marked by the use of the passive voice, or by explicitly calling it accidental. To deal with these potential linguistic confounds, Moore and Pope (2014) developed a non-linguistic video paradigm (*Ambiguous Movement Paradigm*), in which people are asked to judge the intentionality of a simple hand movement. A hand is shown resting on a keyboard with one finger strapped to a key. In every video, the finger moves down and pushes the key (Figure 1.4). Participants are told that this action can either be an intentional key-press (the actor actively pushes the key down) or an unintentional key-press (the finger is pulled down via a pulley mechanism hidden under the keyboard).



A

B

Figure 1.4. Moore and Pope's Ambiguous Movement Paradigm: A) Illustration of the pulley mechanism: A finger is fixed to a key with a Velcro strap. A pulley hidden under the keyboard can pull the key - and with it the finger - down. B) Screenshot of the video stimulus.

Unknown to the participant, all 24 stimuli show the same movement. This ensures that there is perceptual consistency across all trials so that any behavioural effect cannot be linked to perceptual differences in the video. There are three different movement onset times, so as to encourage participants to believe they are seeing a different video on each trial. Importantly, the movement is unintentional (i.e., the finger is pulled), which is crucial as only a tendency to judge a genuinely unintentional movement to be intentional can function as evidence for a bias. To compute the intentionality endorsement score, the percentage of trials judged as *intentional* is calculated. In Moore and Pope's (2014) study, the mean intentionality endorsement score was 64.2% (statistically significantly higher than 50%), which led the authors to conclude that when observing ambiguous movements people are more likely to judge them to be intentional rather than unintentional (Moore & Pope, 2014).

Moore and Pope's (2014) conclusion is in line with Rosset's (2008) definition of the intentionality bias, although total scores reflecting a bias are understood differently because of the differential nature of the paradigms. Whereas in Moore and Pope's (2014) Ambiguous Movement Paradigm an intentionality endorsement percentage score over 50 is thought to reflect a bias, Rosset (2008) does not specify any precise cut-off points but rather takes increased intentionality endorsement percentage scores under speeded conditions as evidence for an intentionality bias. Considering this, detecting an *intentionality bias* per se is not particularly meaningful. However, meaningful indeed is understanding tendencies of intention attribution, the underlying cognitive processes and the variability across conditions. In this thesis, therefore, the emphasis will be placed on the latter.

Another important difference between the paradigms is that the target actions are of a different level of complexity. Whereas the Ambiguous Movement Paradigm involves low-level actions with no outcome and little context, the Ambiguous Sentence Paradigm provides a bit more context (e.g., *He bumped into a classmate in the hall.* -> school context) and depicts actions that are commonly associated with an outcome (e.g., *He set the house on fire.* -> house burns down). Also, an unintentional action as understood in the Ambiguous Movement Paradigm is inherently passive, whereas in the Ambiguous Sentence Paradigm unintentional actions are still largely active. Additionally, some of the stimuli in the Ambiguous Sentence Paradigm involve or could potentially affect others (e.g., *She woke the baby up*., *She ignored the question*.). These differences have to be kept in mind when comparing results from studies using the different paradigms.

Type 1 and Type 2 processing in Rosset's dual-process model

As discussed above, Rosset's dual-process model of intention attribution assumes two streams within which information can be processed and which can lead to differential judgements (Figure 1.2). Dual-process models are a widely used way of explaining cognition and have been used in different cognitive domains. In essence, most of them propose two distinct information processes (i.e., streams): A *Type 1* process, which is assumed to be automatic, intuitive, quick and to operate in a parallel fashion (also known as heuristic process); and a *Type 2* process, which is assumed to be analytical, reflective, slow and to operate in sequential fashion (Evans, 2003; Evans & Stanovich, 2013). *Type 1* processing leads to responses that involve little reflection, whereas, *Type 2* processing involves hypothetical and abstract thinking, mental simulation and prediction of future events (Evans, 2003). Dual-process models in general - and the Rosset's dual-process model of intention attribution specifically - will be discussed in more detail in *Chapters 2* and *8*. For the purpose of this introduction, the key point is that the automatic stream and controlled stream of Rosset's dual-process model reflect *Type 1* and *Type 2* processes respectively. It is important to note that they are qualitatively distinct cognitive processes, but not necessarily distinct neuroanatomical systems.

Controlled cognitive processes and cognitive load in a healthy population

Following on from this, according to Rosset's dual-process model, controlled cognitive processes (i.e., *Type 2* processes) enable us to form *unintentional* judgments. Healthy adults have a broad knowledge of potential non-intentional causes for events and are thought to usually have the cognitive resources available to access and make use of this knowledge. However, if knowledge or cognitive resources are compromised they seem to over-attribute intent (Rosset, 2008; Rosset & Rottman, 2014).

As has previously been described, Rosset manipulated cognitive control by running a speeded vs. un-speeded condition. In follow-up work, Bègue, Bushman, Giancola, Subra and Rosset (2010) used alcohol to disrupt cognitive control. They asked participants to complete a modified version of Rosset's (2008) Ambiguous Sentence Paradigm under acute alcohol intoxication or when sober. Intoxicated participants were more likely to judge ambiguous behaviour to be intentional. The authors concluded that alcohol consumption disrupts higher-level cognitive processes that are essential for making accurate judgments. The results can potentially explain the link between alcohol intake and aggression. For example, when facing harmful behaviour, people are more likely to react aggressively if they perceive it to be intentional (Taylor et al., 1979). So, if an intoxicated individual is more likely to perceive harmful behaviour as intentional, they are more likely to react aggressively and, therefore, this leads to more aggressive reactions than if the person was sober. Also, the results are evidence for the involvement of frontal lobe processes in intentional attribution. Acute alcohol intoxication has been shown to impair cognitive functioning such as planning, motor control and memory (Peterson, Rothfleisch, Zelazo, & Pihl, 1990), which are all associated with frontal brain areas (Miller, 2000).

Controlled cognitive processes, including inhibitory control, are thought to develop throughout infancy, childhood and adolescence (e.g., Welsh, Pennington, & Groisser, 1991). Based on empirical evidence suggesting an age-related decrease in tendency to judge ambiguous behaviour to be intentional (e.g., Schult & Wellman, 1997; Smith, 1978), Rosset and Rottman (2014) developed a framework which suggests *unintentional* explanations for behaviour are the true marker for intentional reasoning maturity (NICED framework; for more detail see *Chapters 3* and *4*). They argue that this developmental trend of intention attribution is due to the improvement of executive functioning, more precisely inhibitory control, rather than the increased proficiency in identifying intentionality. In *Chapters 3* and *4*, therefore, age-related changes in intentionality endorsement as a marker for the maturation of cognitive control will be explored.

Atypical intention attribution patterns and social dysfunction

As discussed above, our judgements of intentionality have an impact on our social interactions. Some neurological and psychiatric conditions that are associated with social dysfunction show patterns of intention attribution different from those of neurotypical controls. Such conditions are often associated with frontal lobe dysfunction. Controlled cognitive processes and executive functions are reliant on frontal lobe activity. Therefore, the link between psychiatric/neurological conditions and atypical intention attribution patterns strengthens the idea of the involvement of controlled cognitive processes in judging intentionality. In this section, I will discuss two groups of conditions associated with atypical patterns of intention attribution.

Judging intentionality in Schizotypy and Schizophrenia spectrum disorder

It has long been suggested that people suffering from schizophrenia spectrum disorders show reduced inhibitory control (Frith, 1979).

Schizophrenia spectrum disorders are heterogeneous and are associated with a range of symptoms including hallucinations, delusions and disorganised speech (American Psychiatric Association, 2013). However, it is widely assumed that psychotic symptoms lie on a continuum and schizophrenic traits can also be found in individuals of the general population, also known as schizotypy. Highly schizotypal people who are not diagnosed with schizophrenia may still show performance on various cognitive tasks similar to diagnosed individuals (Van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009).

Moore and Pope (2014) investigated the relation between intentionality endorsement of ambiguous action and schizotypy. They found a significant positive correlation between the intentionality endorsement of ambiguous action using the Ambiguous Movement Paradigm and schizotypal traits. They argued that this link could potentially be due to impaired cognitive control in highly schizotypal individuals.

A similar pattern has also been observed in individuals with a diagnosis of schizophrenia. Peyroux, Strickland, Tapiero and Franck (2014) used a verbal paradigm similar to the Ambiguous Sentence Paradigm. A key difference to the Ambiguous Sentence Paradigm was that the set of sentences used in this study consisted of unambiguously intentional and unambiguously unintentional scenarios only, there were no ambiguous sentences. Participants with a schizophrenia diagnosis (subtypes not specified) and healthy controls were asked to judge whether the action described in each sentence was intentional or unintentional. People with a schizophrenia diagnosis judged a significantly higher proportion of sentences to be intentional compared to the control group. This shows a tendency to misinterpret behaviour as intentional in individuals with schizophrenia spectrum disorders. In addition, within the schizophrenia group, they found an association between intentionality endorsement scores and the excitation-dimension of the five-dimensional Positive and Negative Symptoms Scale (Lancon, Aghababian, Llorca, & Auquier, 1998). More precisely, correlations were found between intentionality endorsement scores and the items *poor impulse contro*l and *excitement*. Based on this, the authors suggested the inability to suppress the automatic tendency to judge behaviour to be intentional (i.e. a lack of inhibitory control) as a possible explanation for the increased attribution of intentionality in individuals with schizophrenia (Peyroux et al., 2014).

Judging intentionality in Autism Spectrum Conditions

Another condition associated with impaired executive functioning (see Hill, 2004) and social dysfunction (see Baron-Cohen et al., 1999; Klin, Volkmar, & Sparrow, 1992; Volkmar et al., 1987) is autism. Autism is a spectrum condition that comprises of different subgroups including Asperger's Syndrome, high-, medium- and low functioning autism (see Simon Baron-Cohen, 2006). Although the condition is heterogeneous, there seem to be aspects shared by all affected individuals; namely, deficits in social communication and interaction as well as restricted interest and repetitive behaviour (American Psychiatric Association, 2013). The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) refers to autism as *Autism Spectrum Disorder* (American Psychiatric Association, 2013). As argued by Baron-Cohen (2017) the term 'disorder' implies some malfunctioning in the individual's behaviour and/or cognition and brings with it the risk of stigma. However, in the appropriate environment, an affected individual can function just as well as or sometimes even better than neurotypicals (Baron-Cohen, 2017). Therefore, in line with the concept of neurodiversity, the term *Autism Spectrum Conditions (ASC)* will be used in this thesis. This means that although some aspects of an individual's condition might be a disability, the autism condition per se is not.

An area in which individuals with ASC have repeatedly shown deficits is accurately identifying an agent's intention, as for example in studies involving the comic strip paradigm or faux-pas detection tasks (Baron-Cohen, Leslie, & Frith, 1986; Zalla, Sav, Stopin, Ahade, & Leboyer, 2009). However, for these tasks, participants are usually asked to correctly *identify intentions* of actions and little is known about how individuals with ASC *categorise* ambiguous actions in terms of their intentionality. In other words, they struggle with identifying normative correct solutions, however, there is little research into how they judge the intentionality of actions that are neither clearly intentional nor unintentional. ASC is associated with social difficulties (Klin et al., 1992; Volkmar et al., 1987) and it is likely that appropriate intentionality judgements play a significant role in the success of social interaction. Therefore, the focus of *Chapters 5* to *7* will be how individuals with ASC judge intentionality of ambiguous action. These three studies are potentially informative as they will help us to better understand 1) intention attribution styles in a highly prevalent spectrum of conditions (more than 1 in 100; Brugha et al., 2012), and 2) the cognitive processes underlying intentionality judgements by investigating cases deviating from the neurotypical norm.

General aims and objectives

The overarching aim of this thesis is to gain a better understanding of how humans form judgements of intentionality by testing Rosset's (2008) dual-process model of intention attribution and the assumptions based on it. Due to the reasons discussed above, the focus of this research will be ambiguous action. More specific aims and objectives are outlined below:

1. The aim of *Chapter 2* is to replicate one of Rosset's key findings of increased intentionality endorsement under time constraints. This

will enable me to evaluate some of the empirical evidence the dual-process model is based on.

2. I will explore the role of factors in forming intentionality judgements, as predicted by the model. These include age and cognitive ability (*Chapters 3* and *4*). This will enable me to examine whether assumptions made by the dual-process model are valid and, hence, to indirectly test the model without manipulating any variables.

3. The dual-process model will be directly tested by manipulating working memory load and capacity, which – as the model suggests – might be essential for inhibiting automatic responses (*Chapter 8*).

4. Judgments of intent for ambiguous actions in ASC will be explored (*Chapters 5* to *7*). This will give us a better understanding of intention attribution in general by studying cases deviating from the norm. Also, I hope to shed some light on some potential underlying reasons for social difficulties in ASC.

The thesis concludes with a general discussion, in which key findings and general limitations are discussed. I will critically evaluate whether the evidence gathered supports Rosset's dual-process model of intention attribution and consider possible future directions including the potential need to revise the model.

CHAPTER TWO

Judging intentionality under time pressure: A replication of Rosset (2008).

Abstract

According to Rosset's (2008) dual-process model of intention attribution, humans tend to automatically judge behaviour to be *intentional*, but that this can be overridden, leading to a judgement that the behaviour was unintentional. Rosset found evidence in support of this model by showing that intentionality endorsement is higher in speeded vs. un-speeded conditions. The explanation for this is that in the speeded condition there is insufficient time to engage in controlled processing and, hence, responses are guided by automatic processing. This study tried to replicate Rosset's speeded vs. un-speeded finding. An online version of the task was developed to reach a wider population and to increase the sample size relative to Rosset's study. In support of Rosset's (2008) findings, we found a significantly higher intentionality endorsement for ambiguous but prototypically accidental actions in the speeded compared to un-speeded condition. To fine-tune and optimise the paradigm for future use, we explored alternative data analysis approaches.

Introduction

Dual-process model of intention attribution

Generally speaking, dual-process models assume that the presence of constraints to reasoning, such as time constraints, will lead to an increased tendency to give a default (heuristic) response (Evans, 2007; Evans & Stanovich, 2013; Kahneman, 2003). The reason for this is that the constraints inhibit cognitively demanding analytical processing (*Type 2*), which could override heuristic processing (*Type 1*; Evans, 2007; Evans & Curtis-Holmes, 2005; Evans & Stanovich, 2013). Analytical processing (*Type 2*), in contrast, is sequential and requires more time and cognitive capacity (Evans & Stanovich, 2013). Indeed, some empirical studies have found that individuals are more likely to make biased responses based on heuristic inferences when under time pressure (Evans & Curtis-Holmes, 2005; Forgues & Markovits, 2010; Markovits, Brunet, Thompson, & Brisson, 2013; Roberts & Newton, 2001; Shafto, Coley, & Baldwin, 2007).

In her 2008 study, Rosset asked participants to judge whether actions depicted in a series of sentences were done on purpose or by accident, under speeded (2.4 seconds) or un-speeded (5 seconds) conditions. Participants under time constraints showed significantly higher intentionality endorsement scores for ambiguous but prototypically accidental as well as unambiguously accidental action. However, this was not the case for prototypically intentional or unambiguously intentional actions. Rosset used these findings (in addition to findings from two other experiments of the same study[1]) to support her argument that when cognitive processing is hindered by, for example, time constraints, intentionality judgements are driven by an automatic process that assumes all actions to be intentional. When individuals are allowed time to process intentionality of an action more thoroughly (un-speeded condition), the automatic response can be inhibited. This experiment forms the basis of Rosset's dual-process model, which assumes that two processes govern intention attribution: an automatic process leading to *intentional* judgements, and an analytical and controlled process that can inhibit the automatic response and lead to a judgement that the behaviour was *unintentional*.

To our knowledge, one previous replication attempt of Rosset's key finding has been published (Hughes, Sandry, & Trafimow, 2012). This only partly replicated Rosset's findings, however, results of this previous replication study are somewhat inconclusive because 1) the sample size was significantly lower (i.e., decreased power) and 2) data were analysed in a different way than in Rosset (2008). The aim of the present study was to run a more thorough and conclusive replication attempt. An online version of the task

[1] In Experiment 2, an implicit measure was used asking participants to describe their mental image of the action to assess perceived intentionality. Participants tended to report mental images of intentional action. In Experiment 3, the recall of test items was measured. More unintentional test items were remembered, which Rosset took as evidence for more in-depth processing.

was developed, which enabled us to recruit a more substantial sample size. Also, the task was streamlined by reducing the number of control sentences – these are *irrelevant* to the measure of interest and therefore can be pared down so as to lessen participants' fatigue. Finally, two different analyses on the data were run: a replication of Rosset's analysis separately analysing both control- and test categories, and an alternative analysis treating control categories as screening tools, which might be more appropriate given the task structure.

Hypothesis

Our hypothesis was that participants in the speeded condition would show higher intentionality endorsement scores for Prototypically Accidental test sentences (which is one of two ambiguous test categories of the paradigm). Although Rosset (2008) also found significantly higher intentionality endorsement scores for unambiguously Accidental control sentences, we made no prediction regarding them, because the focus of this thesis is ambiguous action and, as we will argue, control sentences are more appropriately used as screening measures. Furthermore, in line with Rosset (2008), we predicted no group differences for ambiguous but Prototypically Intentional test sentences.

Methods

Participants

The study was approved by Goldsmiths College Department of Psychology Ethics Committee. An a priori sample size calculation based on Rosset's (2008) results using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) revealed a required sample size of 290 participants (d=0.3, α=0.05, Power=0.80). Participants were recruited via *Testable Minds*, an online platform in which participants are monetarily reimbursed for their participation. The study description asked for English native speakers of at least 18 years of age. 340 participants started the study. Data from participants who did not complete the study or who missed ≥ 25% of the trials were excluded. This resulted in a final sample size of 294 participants, 165 in the un-speeded condition and 129 in the speeded condition. The unequal sample sizes are a result of more participants in the speeded condition being excluded as a consequence of missing too many trials.

Measures and Procedure

At the beginning of the study, participants were presented with general information on the study and were asked for their consent. Only if they had given consent to take part in the study and had confirmed they were at least as old as 18 years of age could they proceed with the study.

Participants were randomly allocated to one of the two conditions (speeded, un-speeded). Participants' task was to judge whether an action depicted in a sentence was more likely to be done on purpose or by accident. There were 54 sentences in total; 22 of which were ambiguous but prototypically accidental test sentences (Prototypically Accidental test sentences), 12 were ambiguous but prototypically intentional test sentences (Prototypically Intentional test sentences), 10 were unambiguously accidental control sentences (Accidental control sentences) and another 10 were unambiguously intentional control sentences (Intentional control sentences). Note that Rosset's original paradigm comprises 20 sentences of each control category, however, in this study, the number of control sentences was halved to decrease the total duration of the study and, hence, keep fatigue and drop-out rates to a minimum. Please see below for some examples of the stimuli used (Figure 2.1). A full list of the stimuli used can be found in *Appendix 1*. Sentences were presented in a set-randomised order, one at a time. As in Rosset (2008), in the speeded condition, participants were presented with each sentence for 2.4 seconds and in the un-speeded condition for 5 seconds, during which they had to make their decision by clicking one of two boxes labelled *on purpose* or *by accident*. All sentences are roughly the same length and are, according to Rosset (2008), sufficiently simple to be read in the given time frames. After every eight sentences, participants could take a short break. This ensured that participants who had missed a trial could gather themselves before continuing with the experiment.

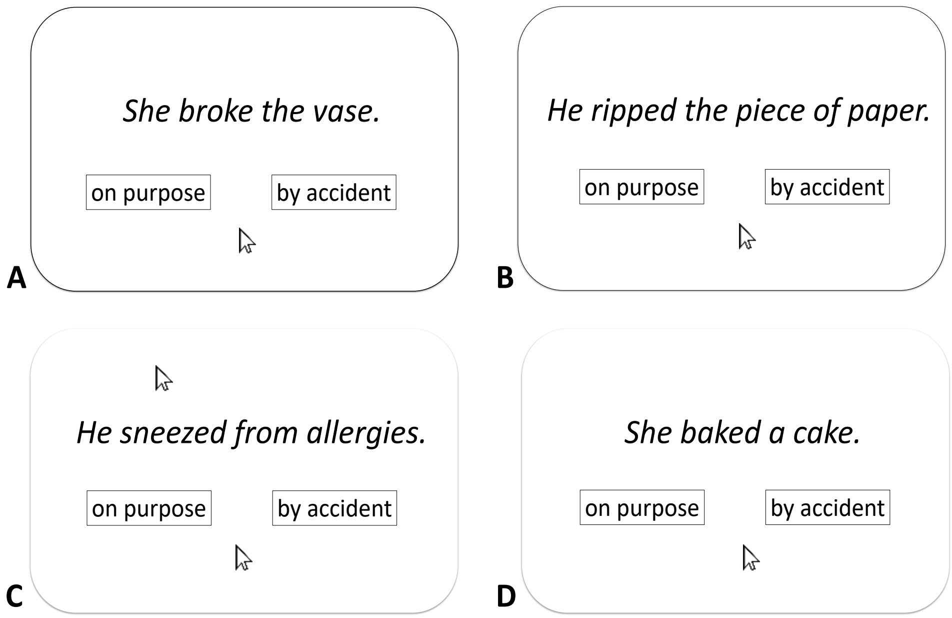


Figure 2.1. Example stimuli for each test- and control category of Rosset's Ambiguous Sentence Paradigm. A) Example for Prototypically Accidental test sentence, B) example for Prototypically Intentional test sentence, C) example for Accidental control sentence and D) example for Intentional control sentence. Participants are presented with one sentence at a time and are asked to judge whether the action depicted in the sentence is generally done on purpose or by accident. Please note that Rosset's original paradigm was conducted using paper and pen, however, studies conducted in this thesis used a computer version of the paradigm in which participants were asked to respond by clicking on the corresponding box.

Analyses

Analysis I

For this analysis, an intentionality endorsement score for each test sentence category and each control sentence category was calculated for every participant. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions. In line with Rosset's (2008) analysis, we first analysed all sentence categories separately. Unsurprisingly, both types of control sentence-categories were heavily skewed. Therefore, non-parametric Mann Whitney-U tests were used to examine whether there were differences in intentionality endorsement scores between the speeded and the un-speeded group. Subsequently, a parametric independent samples t-tests for both types of test sentence-category was conducted. Please note that Rosset (2008) conducted non-parametric Mann Whitney U tests for all sentence categories. In contrast, we chose parametric independent samples t-tests for the test sentence categories as our data do not deviate from normality sufficiently to justify non-parametric tests. For completeness, results of non-parametric Mann Whitney U tests for the test sentence-categories can be found in *Appendix 2*. There is no change in significance of results when conducting non-parametric tests.

Analysis II

The analysis described above is perhaps not the most appropriate analytical approach given that control sentences are treated the same way as test sentences and no participants are excluded on the basis of answering incorrectly to control items. Under normal circumstances, in a neurotypical sample (i.e., without atypical social attribution patterns), multiple incorrect responses to control items are only to be expected when an individual does not attempt to complete or pay attention to the task. In light of this, a second analysis in which the control items functioned as a screening tool was conducted. Hence, for this analysis, only the intentionality endorsement scores for each test sentence category were calculated. Firstly, participants who had responded incorrectly to more than one control item of any test category were removed. This ensured that participants who had not paid attention to or who had misunderstood the task would be excluded. Secondly, similar to *Analysis I*, for the remaining sample, two independent samples t-tests were conducted to investigate whether there were any differences in intentionality endorsement scores between the speeded and un-speeded condition.

Results

As in Rosset (2008), only participants who responded to at least 75% of the test stimuli in either experimental category were included in the analysis.

Analysis I: Replication of Rosset's results

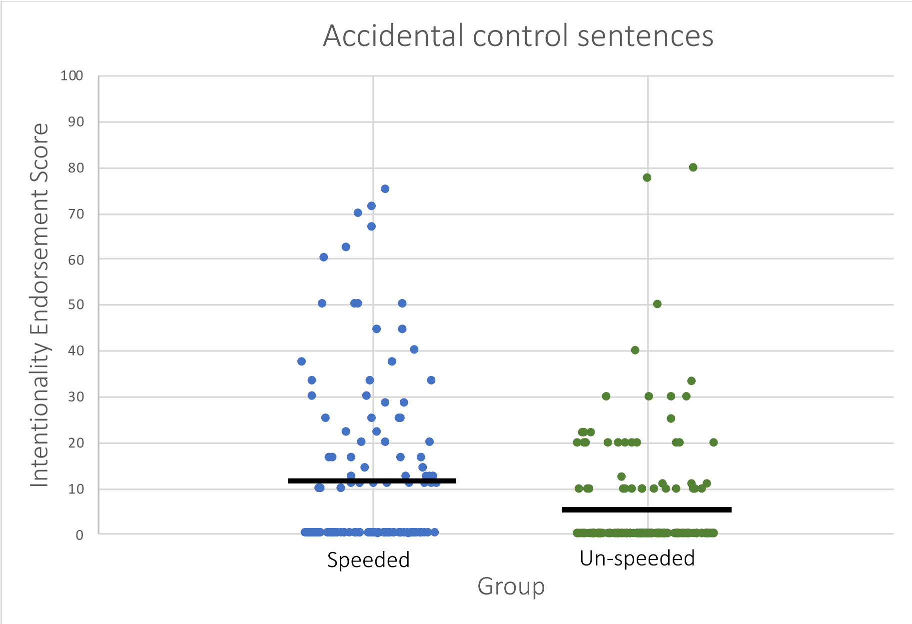
There were no extreme outliers (based on inter-quartile range rule with a multiplier of 3.0; Hoaglin, Iglewicz, & Tukey, 1986), i.e., no participants were excluded from analysis on the basis of being an outlier. Mean results per group for each sentence category are presented in Table 2.1.

Table 2.1. Mean intentionality endorsement scores and standard deviations in brackets for Prototypically Accidental test sentences (PA), Prototypically Intentional test sentences (PI), Accidental control sentences (UA) and Intentional control sentences (UI) for participants of the speeded and the un-speeded condition included in Analysis I.

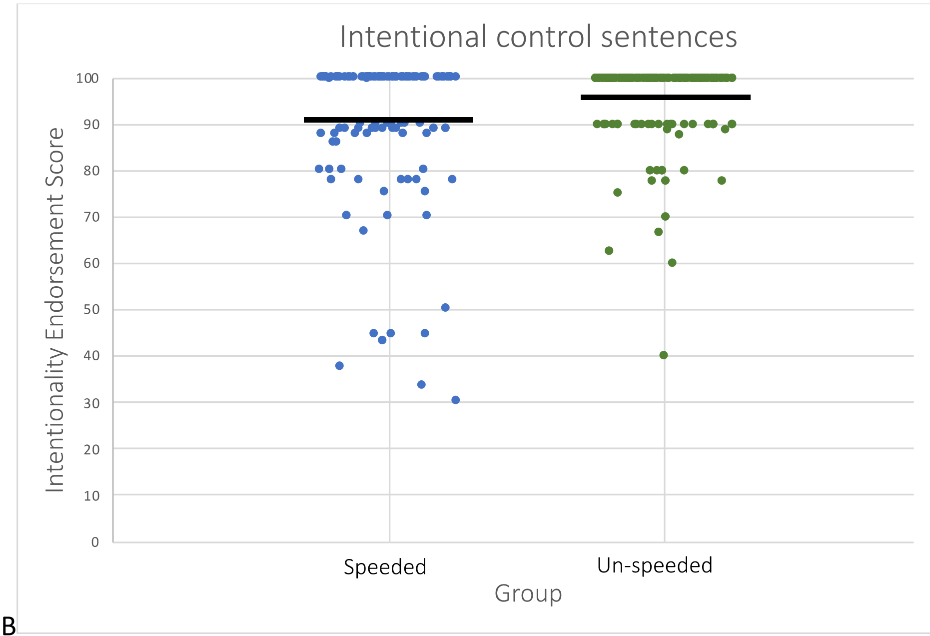
	PA	PI	UA	UI
Speeded (n= 129)	32.27 (*18.66*)	68.41 (*22.07*)	11.9 (*18.35*)	91.04 (*15.55*)
Un-speeded (n=165)	26.81 (*14.69*)	73 (*17.55*)	5.45 (*12.3*)	95.96 (*8.85*)

Control sentences

Pooled across conditions, participants responded correctly to on average 91.72% of Accidental control sentences and 93.80% of Intentional control sentences. This shows that participants generally understood the task instructions and paid attention to the task. Two non-parametric Mann-Whitney U tests revealed significant differences between the speeded and the un-speeded condition. Same as Rosset (2008), the speeded group had higher intentionality endorsement scores for Accidental control sentences (U=8494.5, p<.001, one-tailed, Figure 2.2 A). However, not in line with Rosset (2008) who found no group differences, the speeded condition had significantly lower intentionality endorsement scores for the Intentional control sentences compared to the un-speeded group (U=8755, p=.001, two-tailed; Figure 2.2 B).



A

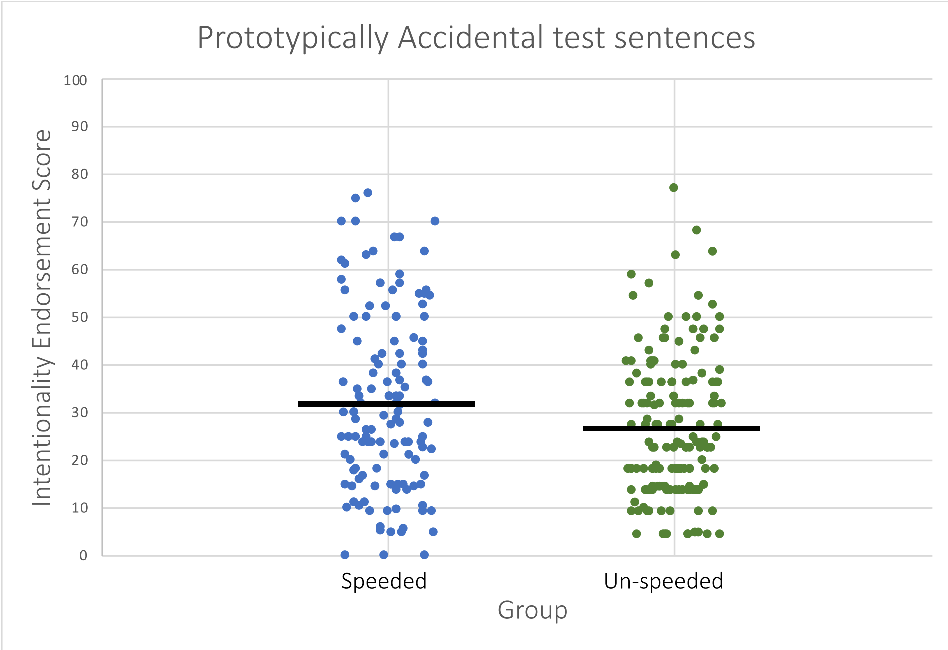


B

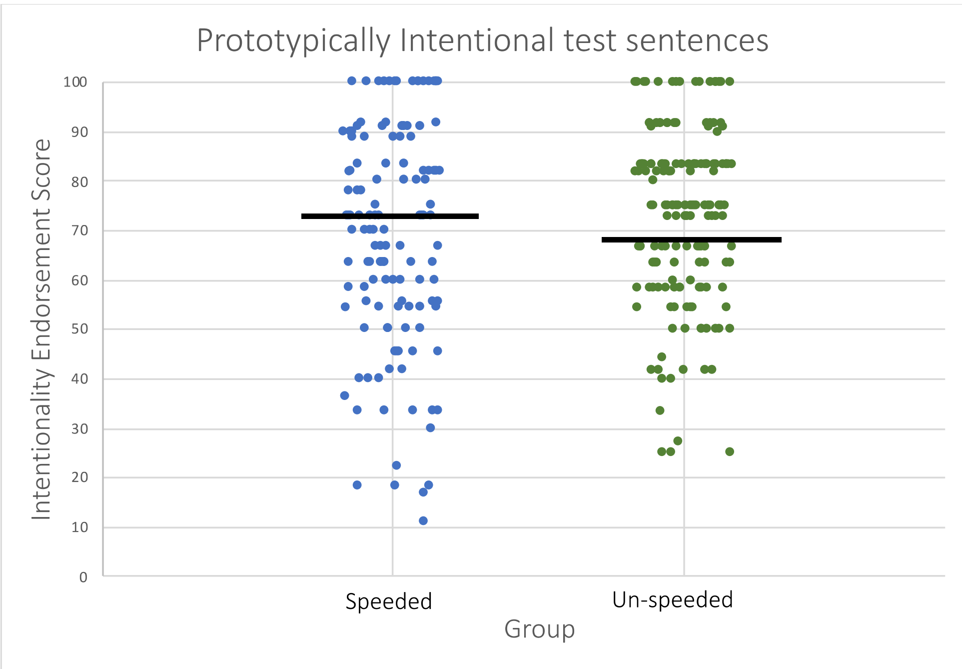
Figure 2.2. Intentionality endorsement scores for the speeded and un-speeded condition for Accidental control sentences (A) and Intentional control sentences (B) for Analysis I. Mean intentionality endorsement scores are marked by horizontal lines.

Test sentences

Two independent samples t-tests revealed a significant difference between intentionality endorsement scores for Accidental test sentences between the speeded and the un-speeded condition, with the speeded condition showing higher intentionality endorsement scores ($t(238.37)=-2.73$, $p=.004$, one-tailed, Figure 2.3 A). There was no significant difference between intentionality endorsement scores of the speeded and un-speeded group for Intentional test sentences ($t(240.07)=1.93$), $p=.055$, two-tailed, Figure 2.3 B).



A



B

Figure 2.2. Intentionality endorsement scores for the speeded and un-speeded condition for Prototypically Accidental test sentences (A) and Prototypically Intentional test sentences (B) for Analysis I. Mean intentionality endorsement scores are marked by horizontal lines.

In summary, results Prototypically Accidental test sentences, Prototypically Intentional test sentences and Accidental control sentences are in line with Rosset (2008). However, in contrast to Rosset (2008), we found decreased intentionality endorsement scores in the speeded condition for Intentional control sentences. This could be driven by factors such as inattentiveness or not understanding the task.

Analysis II:

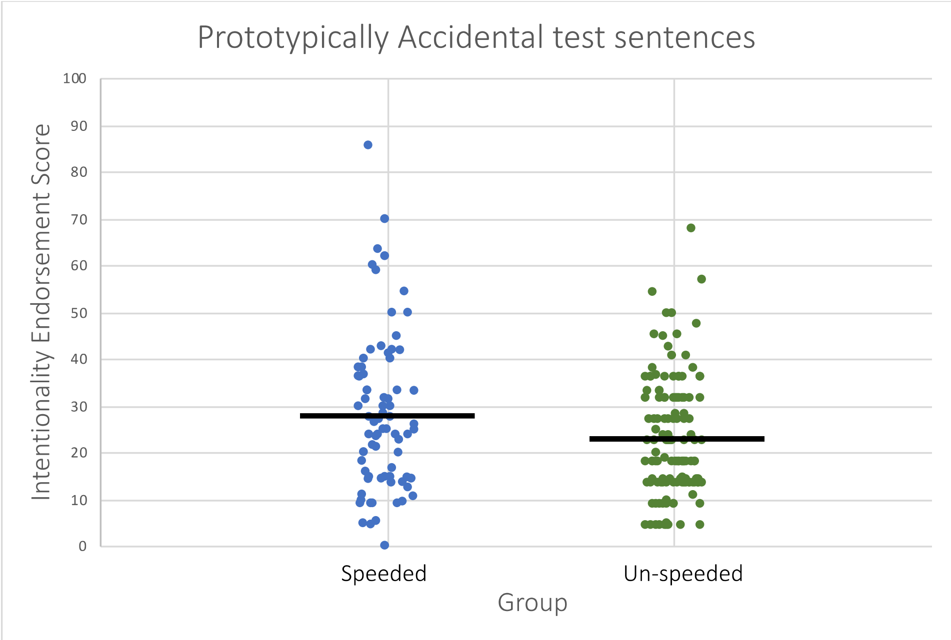
Participants who had responded incorrectly to more than one control item were excluded from this analysis, resulting in a sample size of 207 participants (speeded: 76; un-speeded: 131). This ensured that only data of participants who had understood the task instructions and paid full attention to the task were used. There were no extreme outliers (based on inter-quartile range rule with a multiplier of 3.0; Hoaglin, Iglewicz, & Tukey, 1986). Mean intentionality endorsement scores for both groups can be seen in Table 2.2.

Table 2.2. Mean intentionality endorsement scores and standard deviations in brackets for Prototypically Accidental test sentences (PA) and Prototypically Intentional test sentences (PI) for participants of the speeded and the un-speeded condition with participants who had answered incorrectly to too many control items excluded (Analysis II).

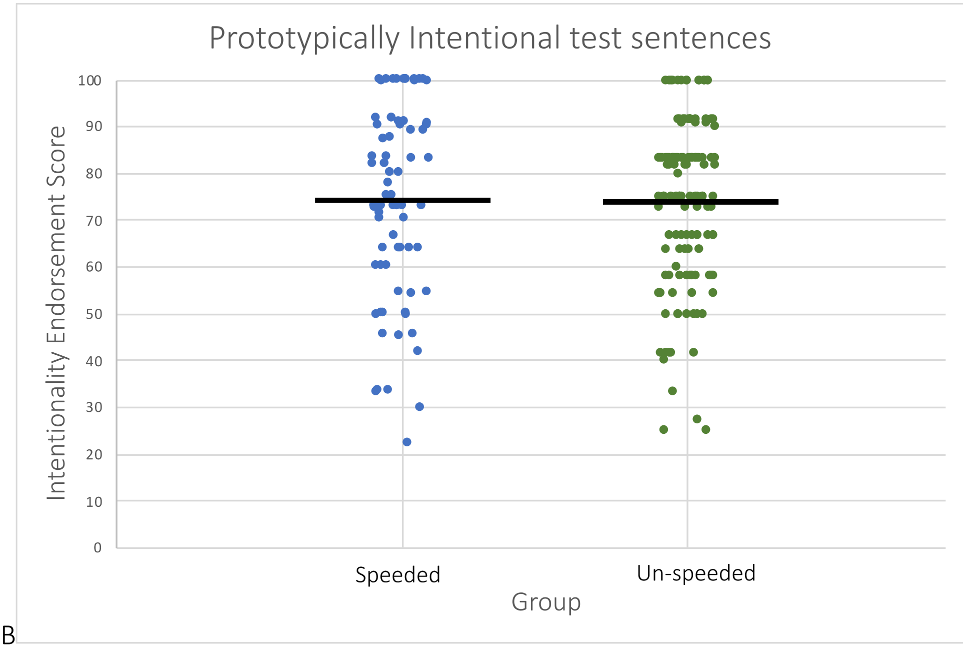
	PA	PI
Speeded (n= 131)	28.2 (*16.74*)	74.32 (*20.65*)
Un-speeded (n=76)	23.13 (*12.6*)	73.83 (*17.82*)

Test sentences

Two independent samples t-test revealed a significant difference between intentionality endorsement scores for Prototypically Accidental test sentences of the speeded and un-speeded group ($t(124.66)= -2.29$, $p=.012$, one-tailed; Figure 2.3 A). This is in line with Rosset's key finding. There was no significant difference between intentionality endorsement scores for Prototypically Intentional test sentences ($t(205)= -.18$, $p=.865$, two-tailed; Figure 2.3 B).



A



B

Figure 2.3. Intentionality endorsement scores for the speeded and un-speeded condition for Prototypically Accidental test sentences (A) and Prototypically Intentional test sentences (B) for Analysis II. Mean intentionality endorsement scores are marked by horizontal lines.

Discussion

The main aim of this study was to investigate whether individuals would show a higher tendency to judge ambiguous but prototypically accidental behaviour to be intentional when under time pressure. We replicated Rosset's findings in so far that individuals who had to judge whether ambiguous but prototypically accidental behaviour was intentional or unintentional within 2.4 seconds judged more actions to be intentional compared to individuals who had more time to respond. Results were significant for both analyses conducted (*Analysis I* and *Analysis II*).

Biased intentionality judgements under time constraints – implication of findings

These findings are in line with predictions of the dual-process model of intention attribution, which suggests that our automatic response is to judge ambiguous behaviour to be intentional (*Type 1* processing), which can only be overridden by an analytical process when sufficient cognitive capacity and time is available (*Type 2* processing). *Type 1* processing is assumed to be rapid, parallel and automatic, i.e., it generates a response quickly and is not greatly affected by time constraints. *Type 2* processing, in contrast, is assumed to be sequential, controlled and to require sufficient time to analytically process information, to take into account stored knowledge and to apply logic (Evans & Stanovich, 2013; Evans, 2007; Evans & Curtis-Holmes, 2005; Shafto et al., 2007). Assuming Rosset's dual-process model is valid, by manipulating available response time, we decreased participants' ability to engage in *Type 2* processing and, hence, their responses were mainly driven by *Type 1* processing.

In *Analysis I* the data were analysed in the same way as Rosset (2008). In line with Rosset's (2008) results, we found significantly higher intentionality endorsement scores for Prototypically Accidental test sentences in the speeded condition. However, contrary to Rosset's (2008) findings, results revealed significantly lower intentionality endorsement scores for Prototypically Intentional test items. A reason for this could be that as for the current study the number of control items was reduced by half, a single item accounts for a larger percentage and therefore a larger proportion of the intentionality endorsement score.

Sentence categories: How to treat control sentences and what analysis to choose

Another aim of the current study was to more closely inspect the usefulness and appropriateness of the sentence categories of the Ambiguous Sentence Paradigm and find a way of how best to treat them.

Rosset (2008) initially analysed all sentences separately. Control categories were treated as test categories (i.e., their label is misleading) and no participants were excluded, which means even inattentive individuals were included in the analysis. Inattentiveness or lack of motivation could be more detrimental in the speeded condition (as participants have to pay more attention to avoid missing trials) and therefore, could potentially explain the significantly worse performance on the control items (*Analysis I*).

Hughes and colleagues (2012), in contrast, conducted an omnibus test, which we judge as unsuitable for two main reasons: 1) Overall, participants tend to respond relatively accurately on control items. This implies scores are generally not normally distributed, i.e., omnibus tests assuming a normal distribution of the dependent variable (e.g., ANOVA) are perhaps not the most appropriate, and 2) Test and control sentences are qualitatively different.

Therefore, we argue that the most appropriate way to analyse data from the Ambiguous Sentence Paradigm is to treat test sentences as a screening measure to filter out the participants who had not fully paid attention to the task and/ or had not fully understood task instructions (see *Analysis II*). The real focus of this field of research are *ambiguous* actions as they give us a handle on attributional biases. As Rosset (2008) argued herself, if cues strongly suggest an action is accidental (e.g., embarrassed facial expression of the agent, verbal cue, etc.), they will override any default *intentional* judgement. Furthermore, the emphasis should be put on Prototypically Accidental test sentences. Items of this category describe actions that are ambiguous in nature but more likely to be accidental. Impairment of analytical processing (e.g., through time constraints) required for judging the action to be accidental would have an effect for these items, as they would by default be judged as intentional. Prototypically Intentional test items, in contrast, incorporate cues indicating that the actions described are more likely to be intentional. Therefore, analytical processing and automatic processing are more likely to lead to similar responses and, therefore, this category is not of great use for this research. Also, the number of items in Prototypically Intentional test sentences is significantly lower than in the Prototypically Accidental test sentences (12 vs 22). As intentionality endorsement scores reflect percentage of items judged to be intentional, in the Prototypically Intentional test category, a single item accounts for a higher percentage (i.e., a higher spread of scores is to be expected).

Limitations of time manipulation

In this study, we attempted to prevent controlled processing by applying time pressure in order to see whether this would lead to an increased tendency to judge ambiguous but prototypically accidental action to be intentional. Although our results are in line with predictions, a problem with such manipulations is that when introducing time pressure, it cannot easily be determined which cognitive functions are affected. Dealing with time pressure has been argued to involve multiple processes, as for example, selective attention, affect control, and parsimony of information processing (Stiensmeier-Pelster & Schürmann, 1993). Therefore, our results could be due to factors other than simply having insufficient time to engage in controlled processing.

Anxiety is another factor that might have contributed to the group differences induced by time pressure. It has been suggested that people are more anxious when required to make decisions under time pressure (Maule, Hockey, & Bdzola, 2000). Increased anxiety could also lead to participants perceiving the actions described in the stimuli as more threatening. Some of the sentences depict actions with negative consequences and a threatening interpretation thereof would be to judge them to be intentional, i.e., the agent intended to cause harm. In the final two experiments of this thesis (see *Chapter 8*) we use a more controlled way of preventing *Type 2* processing, in order to overcome some of these limitations.

General limitations

As Rosset (2008) herself pointed out, it could be that what really becomes apparent with the time manipulation is a linguistic bias rather than an intentionality bias. In the English language, accidental action is frequently marked by the use of passive voice or linguistic cues (e.g., “by mistake”, “by accident”, etc). In the final two experiments of this thesis (see *Chapter 8*) we use a non-linguistic paradigm to investigate whether intentionality endorsement increases when engagement of controlled processes is prevented through increased working memory load.

Another limitation of this study is that a large number of participants had to be excluded because of too many missed trials, which affected the speeded group more than the un-speeded group. This not only resulted in un-equal sample sizes but also could mean that the participants in the speeded condition included in our analysis were a biased sample of "quick responders", i.e. individuals who are quick and efficient in processing information and/or individuals who are more likely to respond intuitively and jump to conclusions. Also, as in Rosset's (2008) as well as Hughes and colleagues' (2012) experiments, no participants were reported to have missed too many trials, the question has to be raised how the authors ensured that participants stuck to the time manipulation with a paper and pen test and whether some participants only wrote down their answer after the trial had passed. This would mean that the time manipulation was not conducted rigorously.

Conclusion

In this study, we replicated Rosset's (2008) findings of individuals showing higher intentionality endorsement scores for ambiguous but prototypically accidental actions when under time pressure. Furthermore, two approaches to analyse responses of the Ambiguous Sentence Paradigm were discussed and a preferable way for subsequent analysis was specified.

CHAPTER THREE

Exploring intentionality judgements across the lifespan

Abstract

Previous research in adults found an automatic tendency to perceive ambiguous behaviour to be intentional. Rosset (2008) proposed a dual-process model to explain this tendency. It suggests that all actions are automatically judged to be intentional until inhibited by higher-level cognitive processes leading to non-intentional explanations. In line with this, Rosset and Rottman (2014) proposed a framework to explain developmental changes in intentional reasoning, arguing it is the ability to identify accidental action that characterises mature intentional reasoning. This study aims to test this hypothesis by investigating whether there are age-related effects in the intention attribution of ambiguous action. Data of 312 participants aged between 12 and 67 years were included in the analysis. Linear regression analysis suggested no significant effects of age on intentionality endorsement scores. Therefore, our findings do not support Rosset and Rottman's framework.

Introduction

In the previous chapter, one core prediction of Rosset's dual-process model (increased intentionality endorsement when under time pressure) was replicated. In this chapter, we will explore another key prediction of the dual-process model, namely the involvement of age in judging intentionality of ambiguous action. Distinguishing intentional from unintentional actions is a cornerstone of social cognition and therefore of relevance to all age groups (Baldwin & Baird, 2001; Feinfield, Lee, Flavell, Green, & Flavell, 1999; Premack, 1990; Tomasello, Carpenter, Call, Behne, & Moll, 2005). Previous research has placed a focus on when and how the *ability to understand intentionality* develops (Baird & Astington, 2005; Meltzoff, 1995; Mull & Evans, 2010; Tomasello et al., 2005). Children were assumed to acquire the understanding of intentionality and the ability to detect intentional actions over time and, thereby, to develop into more mature social agents. However, Rosset and Rottman (2014) put forward an alternative framework that suggests that it is not the ability to identify intentional action *per se* that marks mature intentional reasoning, but rather this maturity is characterised by the ability to understand that an observed *action can be unintentional or accidental*. This ability, Rosset and Rottman (2014) argue, might require knowledge of alternative causation and might be more cognitively demanding than simply attributing intent.

Are unintentional judgements cognitively more demanding?

In line with Rosset and Rottman's (2014) assumption that judging behaviour to be unintentional is more cognitively demanding than simply attributing intent, previous research suggests that adults have an automatic tendency to attribute intent to ambiguous action (i.e., action that can be intentional *or* unintentional), sometimes referred to as the *intentionality bias* (Moore & Pope, 2014; Peyroux, Strickland, Tapiero, & Franck, 2014; Rosset, 2008; Slavny & Moore, 2018). Rosset (2008) proposed a dual-process model to explain this tendency. It states that all action is automatically considered to be intentional and only ever perceived to be unintentional if an automatic judgement is inhibited and overridden by a higher-level cognitive system. This higher-level system is assumed to involve reasoning about alternative causation and to take into account past experience and knowledge of the situation.

Empirical evidence for this dual-process model comes from three lines of research: 1) Findings, suggest that when under time pressure (i.e., when deployment of the higher-level cognitive process is hindered), individuals are more likely to judge ambiguous but prototypically accidental action to be intentional (see Rosset, 2008; and our replication in *Chapter 2*); 2) An increased tendency to perceive action to be intentional has also been associated with schizophrenia (a disorder associated with frontal lobe dysfunction (Peyroux et al., 2014); 3) Acute alcohol intoxication, which is known to temporarily diminish executive functioning has been shown to lead to more *intentional* judgements for behaviour (Bègue, Bushman, Giancola, Subra, & Rosset, 2010). This strengthens the argument that judging behaviour to be unintentional is the more cognitively demanding response.

However, to-date Rosset and Rottman's (2014) framework has not been directly tested. In other words, it has not been investigated whether there are any age-related changes in the expression of the intentionality bias. It is worth noting that ambiguous action is of primary interest here for two reasons: a) biased judgement patterns will only be observable in ambiguous situations (i.e., no strong external cues indicate intentionality of action), and b) a great deal of real-life social situations is ambiguous and actions are not always explicitly intentional or unintentional. The aim of this study, therefore, is to investigate age-related changes in intentionality endorsement of ambiguous action.

Developmental framework

As mentioned above, previously held views assume that understanding intention as a possible cause for behaviour develops with age (Baird & Astington, 2005; Miller & Aloise, 1989; Tomasello et al., 2005). Rosset and Rottman (2014) termed this traditional approach the Intention as Causal Explanation Develops (ICED) framework. According to the ICED framework, at first, children are not capable of understanding that behaviour can be caused by an individual's mental state (e.g., their intention). This ability emerges during the course of development in line with a more mature understanding of human action. A key focus of this framework is on *when and how* children develop an understanding of intention.

In contrast, the Non-Intention as Causal Explanation Develops (NICED) framework put forward by Rosset & Rottman (2014) suggests that it is the continuous increase in *unintentional* judgements of observed behaviour that indicates mature intentional reasoning (Figure 3.1). They argue that once the cognitive system has developed to have a sufficient understanding of intentionality, *intentional* explanations for action will be the default judgement. Furthermore, during childhood and adolescence the expression of this default is attenuated as a) individuals accumulate knowledge of alternative causes (e.g., biological causes such as a reflex for sneezing), b) individuals get better at identifying action cues/triggers (e.g., visual and acoustic cues for sneezing), and c) executive functioning skills mature, resulting in better inhibition of automatic responses.

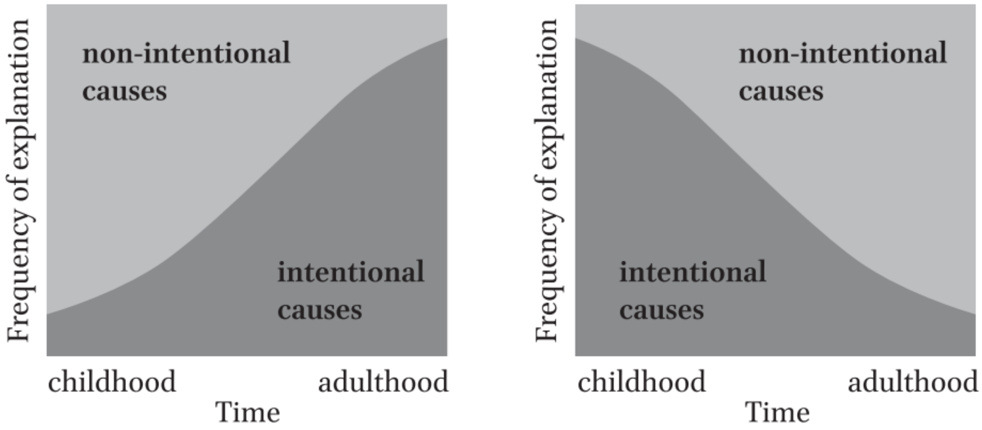


Figure 3.1. An illustration of the contrasting developmental prediction of the traditional approaches (left) and the NICED framework (right) taken from Rosset and Rottman (2014).

Rosset and Rottman's (2014) NICED framework is based on examples from the developmental literature. Considering infant studies, there is evidence demonstrating that intentionality is already perceived at a very early age, i.e. suggesting that it is not slowly and effortfully acquired over time. For example, at three months of age, infants seem to perceive human as well as non-human actions to be goal-directed (Luo, 2011; Sommerville & Woodward, 2005). Later, during language development in the second year of life, children perceive adults' intentions when acquiring new words (e.g., Tomasello, Strosberg, & Akhtar, 1996). Around the same age, perceiving intentional actions directs infants' behaviour, as they are more likely to imitate intentional than accidental actions (Carpenter, Akhtar, & Tomasello, 1998) and do not simply copy an action gone wrong but re-enact the intended action (Meltzoff, 1995). Furthermore, there is evidence suggesting that toddlers use information regarding others' intentions to solve novel problems (Carpenter, Call, & Tomasello, 2002; DiYanni & Kelemen, 2005). Together, this demonstrates that by at least two years of age, children have developed an understanding of intentionality.

Although this alone does not function as evidence for either framework, both make different hypotheses for the subsequent developmental trajectory of intentional reasoning. The ICED framework suggests intentional explanations increasingly dominate reasoning about human action in the course of development, whereas the NICED framework suggests that intentional explanations will become less prominent as development progresses (Rosset & Rottman, 2014).

When considering studies with slightly older children than discussed above, data seem to be more consistent with the NICED framework. For example, Smith (1978) presented 4- to 6-year olds with videos showing four types of actions: voluntary actions with intended side effects, voluntary actions with unintended side effects, involuntary actions, and “object-like” movements (e.g., arm hooked by umbrella). 4-year olds judged all actions to be intentional, whereas 5-year olds on average only judged voluntary actions to be intentional. 6-year olds tended to judge only actions to be intentional that were voluntary and intended, a pattern that was also found in adults. As Rosset and Rottman (2014) argue, this shows a developing ability to identify non-intentional action. Similarly, other research suggests that although children around three to four years of age might acknowledge that the cause for behaviour could be physical or biological, their initial automatic judgement tends to be an intentional explanation for behaviour, especially in younger children of that age group (Schult & Wellman, 1997).

In summary, the developmental literature demonstrates that children have a sensitivity towards perceiving intentions, to the extent that they seem to over-attribute intention to observed behaviour, which gradually reduces with age. This is why Rosset and Rottman developed the NICED framework, which suggests it is not the ability to detect intention but rather the ability to understand that a behaviour is not caused by intent that develops and matures with age.

Most studies investigating the development of intentional explanation have focused on infants and children rather than adolescents or young adults. Although Rosset and Rottman (2014) make no explicit prediction as of when intentional reasoning maturity is typically reached, they suggest that development of intentional reasoning is a gradual process. Importantly, the inhibition of *intentional* explanations is likely to be tied to frontal lobe functions, which are known to continue developing into adolescence and early adulthood (see Blakemore & Choudhury, 2006; Romine & Reynolds, 2005). One can, therefore, assume that the development of mature intentional reasoning, as proposed by the NICED framework, will show developmental changes that continue into adolescence and beyond.

Present study

The NICED framework was based on existing literature but as mentioned above, to date, no study has attempted to empirically test age-related changes of intentionality judgements of ambiguous action. The aim of the current study is to test whether, in line with the predictions from the NICED framework, intentionality judgements gradually decrease with age. Importantly, this decrease is expected to mirror changes in executive functioning skills, so one would also predict that this decrease will plateau after full maturation of the frontal lobes (between early and late 20s; Giedd et al., 1999; Sowell et al., 2003; Sowell, Thompson, Holmes, Jernigan, & Toga, 1999; Sowell, Thompson, Tessner, & Toga, 2001).

Methods

Participants

Visitors to the Science Museum in London aged 12 years and above were invited to take part in the study between June 11 and July 22, 2018. As Goldsmiths Department of Psychology Ethics committee only approved for individuals of 12 years or older to participate, no younger individuals were included. In total, 1083 museum visitors took part in the study. Data from 312 participants were included in the analysis (180 females, 129 males, 3 not specified). The age range was 12 to 67 years (M=25.78, *SD=10.83;* Figure 3.2). Data from 770 participants were excluded on the basis of the following criteria: English not being their first language, responses were incomplete, data for age was missing or they had incorrectly responded to one or more control items of any test category which tested their understanding of the task. Such stringent exclusion criteria needed to be applied as a result of the testing environment being busy and noisy and aimed to keep inattentiveness as a confounding factor to a minimum.

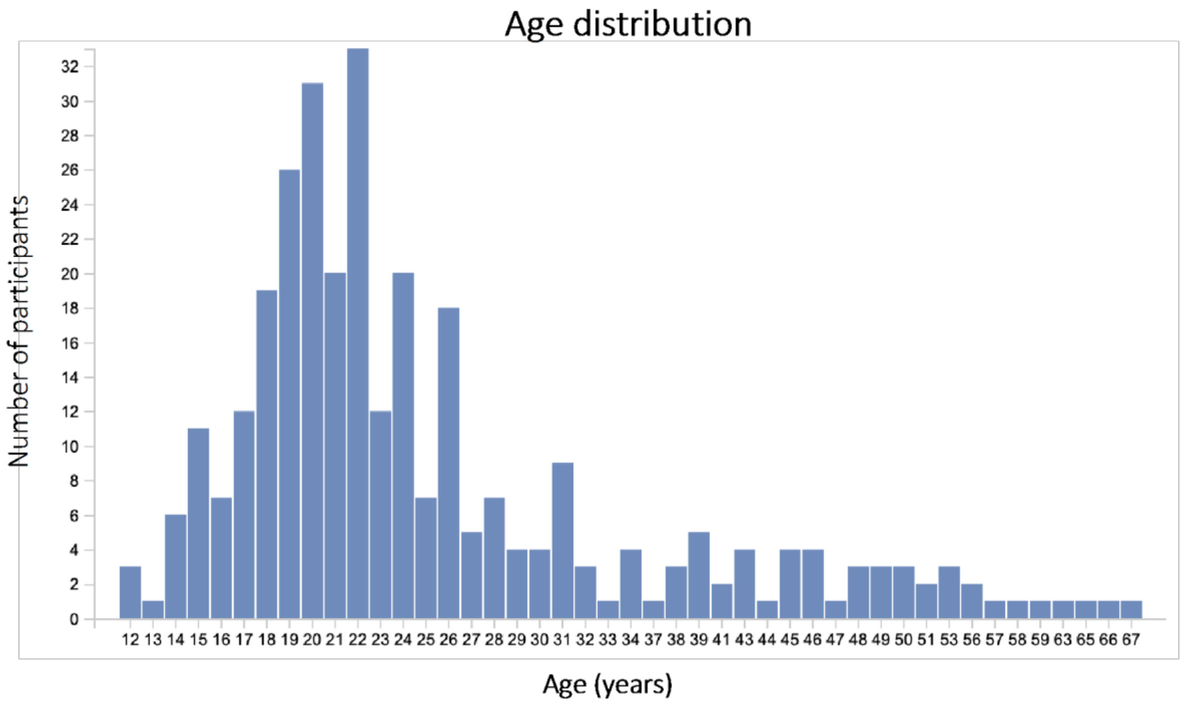


Figure 3.2. Number of participants for each year of age.

Measures

A modified version of Rosset's (2008) Ambiguous Sentence Paradigm was used to measure participants' tendency to judge ambiguous actions to be intentional. Participants were presented with 33 test sentences describing ambiguous actions that could either be intentional or unintentional. 21 of these sentences described ambiguous but prototypically accidental actions (Prototypically Accidental test sentences; e.g., *He stepped in the puddle.*) and 12 described ambiguous but prototypically intentional actions (Prototypically Intentional test sentences; e.g., *She averted her eyes.*). Additionally, participants were presented with 10 unambiguously accidental control sentences (Accidental control sentences; e.g., *He fell down the stairs.*) and 9 unambiguously intentional control sentences (Intentional control sentences; e.g., *She followed the recipe.*). (Because of a technical error the number of Prototypically Accidental test stimuli and Accidental control stimuli deviate by one item each from the number of items usually used in this thesis. We do not assume this to have a confounding effect on the results because intentionality endorsement scores reflect percentage scores of all stimuli respondent to and stimuli are not assumed to differ qualitatively.)

The control sentences were used to assess reading ability and correct understanding of the task. All sentences were presented one at a time in a set-randomised order and participants had to respond by indicating whether the sentence presented was more likely to describe an action done *on* *purpose* or *by accident*. In contrast to Rosset's (2008) original paradigm, participants in this study were given no time constraints to respond to each sentence. This ensured that reading speed would not confound the results. Also, there were no breaks between sentences, but participants were asked to complete the task in one go. For each type of test sentence, an intentionality endorsement score was computed, reflecting the percentage of sentences judged to describe an intentional rather than accidental action.

Procedure

The experiment was completed using the online survey software *Qualtrics*. Participants could either use their smartphone or a tablet provided to complete the experiment. Information, consent form and instructions for the task were presented online. After participants completed the task, they were debriefed and had the opportunity to ask questions. The study was approved by Goldsmiths College Department of Psychology Ethics Committee.

Results

One statistically significant outlier was removed prior to all analyses (based on inter-quartile range rule with a multiplier of 3.0; Hoaglin, Iglewicz, & Tukey, 1986). Mean intentionality endorsement scores for Prototypically Accidental test sentences were 19.24 (*SD*=11.09) and mean intentionality scores for Prototypically Intentional test sentences were 69.20 (*SD*=17.55).

They are similar to previously reported scores in purely adult samples (Rosset, 2008; Slavny & Moore, 2018).

Age effects on judging intentionality of ambiguous action

As Rosset and Rottman (2014) had not specified the shape of the relation between age and intentionality endorsement but simply predicted a gradual decrease in intentionality endorsement, linear effects of age on intentionality endorsement scores were tested. Simple linear regression analyses were conducted to examine whether age would predict intentionality endorsement scores for Prototypically Accidental (Figure 3.3) and for Prototypically Intentional test sentences (Figure 3.4). The results were non-significant for both types of test sentences: Prototypically Accidental: (F(1,310)=.035, p=.852, R^2 <.001, β=.011; Prototypically Intentional: F(1,310)=3.206, p=.074, R^2=.010, β=-.101). Given that age was not normally distributed both the analysis was repeated with a logarithmic transformation of age (base-10; *Appendix 3*), which did not change the significance of the results.

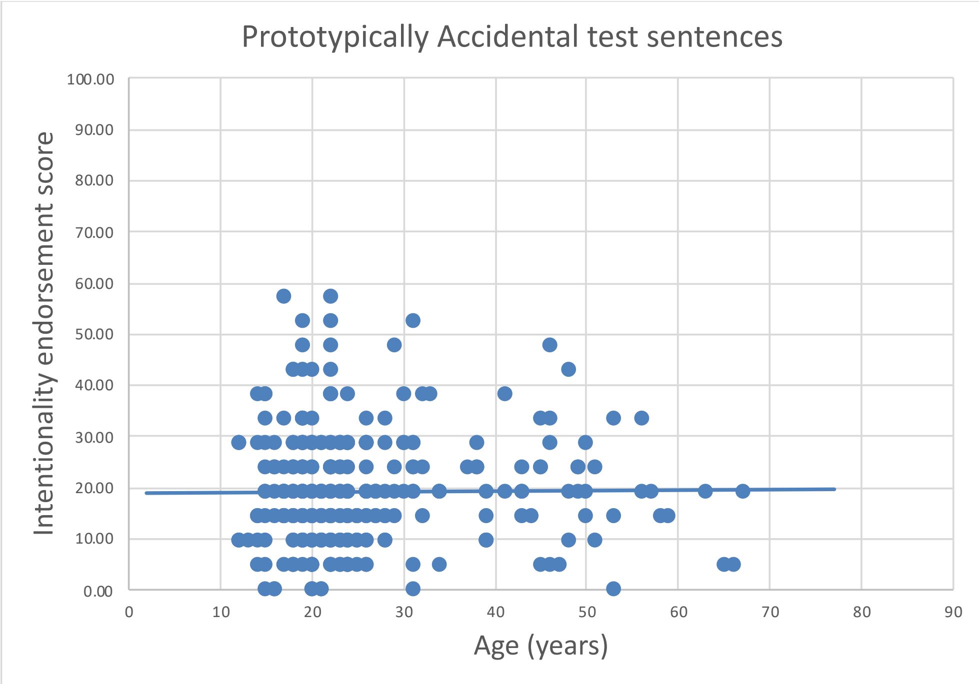


Figure 3.3. Scatterplot showing the association between months of age and intentionality endorsement scores for Prototypically Accidental test sentences with linear trendline. Intentionality endorsement scores reflect the percentage of sentences judged to describe behaviour done on purpose.

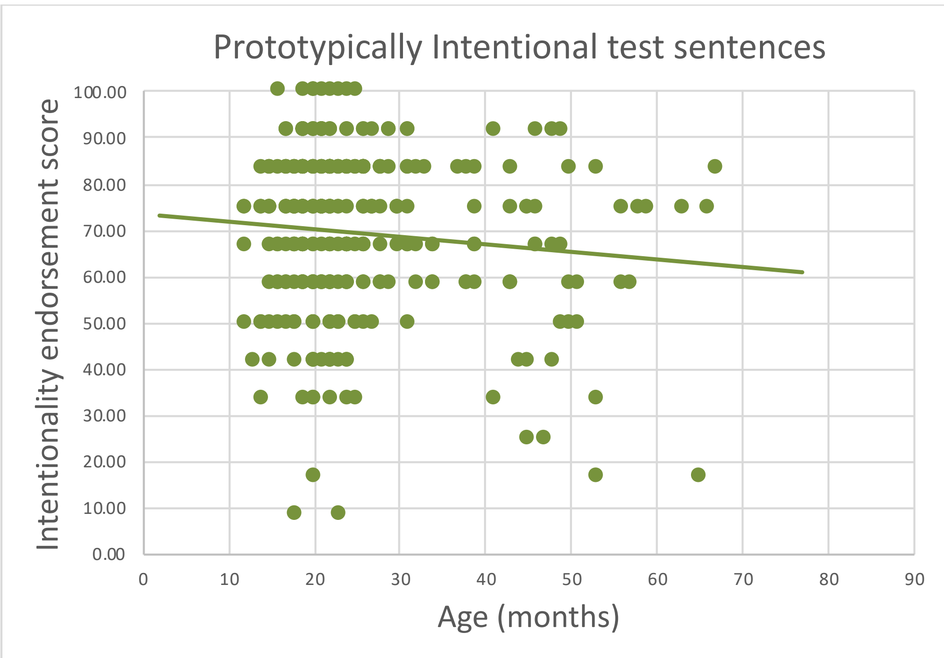


Figure 3.4. Scatterplot showing the association between months of age and intentionality endorsement scores for Prototypically Intentional test sentences with linear trendline. Intentionality endorsement scores reflect the percentage of sentences judged to describe behaviour done on purpose.

Discussion

The NICED framework put forward by Rosset and Rottman (2014) predicts a negative association between age and intentionality endorsement based on the idea that as we get older, we accumulate a greater knowledge of alternative causation for action and the development of our executive control allows us to inhibit and "override" an automatic judgement of intentionality. However, results of the current study did not suggest an association between age and intentionality endorsement of ambiguous action and, hence, our data do not support an intention attribution model as assumed by the NICED framework.

Role of factors other than age

As there was no relation between age and intentionality endorsement, other factors not accounted for in the NICED model are likely to explain individual differences in intentionality endorsement. These could be factors that are not necessarily linked to age, such as personality, psychopathological traits, social background, socioeconomic status or similar. The NICED framework suggests a rather simple model of intentional reasoning that predicts a similar developmental trajectory for all individuals and is influenced only by exposure to alternative action causes and individual differences in executive control (both of which supposedly mediate the relation between intentionality endorsement and age). Other possible contributors are not factored in. However, our data suggest that age alone does not explain variability in intentionality scores and, hence, variability must be caused by other factors.

Range in intentionality endorsement scores

When looking at Figure 3.2, it becomes apparent that the majority of our participants were adolescents and young adults. This age group also shows the highest range in intentionality endorsement scores. This could be simply because with a larger sample size come more extreme scores, or because of variability inherent to these age groups. If the latter is the case, a sample with more older adults would be required to reveal this trend. Factors contributing to a wider range of intentionality endorsement scores could be cognitive ability, working memory, language competence, Theory of Mind skills, which in adolescence/early adulthood have possibly not fully matured yet and, hence, lead to more extreme scores.

Plateau before 12 years

A major limitation of the current study was that only participants of 12 years and above were allowed to participate in the study. Considering previous intentional reasoning literature, substantial changes happen between the ages of four to six years (e.g., Schult & Wellman, 1997; Smith, 1978) and already 6-year olds seem to judge intentionality of action similarly to adults (Smith, 1978). According to Rosset's (2008) dual-process framework, executive functioning skills and knowledge of alternative causes are required for judging behaviour to be accidental. As the stimuli include everyday actions (e.g., *He forgot his homework.*, *He tracked mud inside.*, *He arrived 5 minutes late for class.*), individuals of 12 years and above may have already acquired a good knowledge of alternative causes, i.e., differences would not be expected to greatly influence intentionality endorsement. On the contrary, perhaps children and adolescents are more familiar with some of the scenarios and are more likely to do these accidentally themselves. For example, arriving late for class by accident is a) more likely to happen to an individual still at school and b) younger individuals are less likely to schedule their own commute to school, so they are more reliant on others' punctuality. Therefore, any age-related differences could only stem from differences in executive functioning. However, it is possible that by the age of 12 years and above their executive functions are already developed enough to inhibit automatic responses to the deployed stimuli. In that sense, the lack of age-related effects would be unsurprising.

Role of available cognitive capacity

Following on, if we assume for the used scenarios alternative causes come to mind easily and possibly not a great amount of executive control is required to judge them to be accidental, cognitive capacity would need to be compromised to detect age-related changes specifically related to executive functioning.

As Rosset (2008) argues, even mature intentional reasoners are still likely to demonstrate biased responses when their cognitive resources are compromised (e.g., due to time pressure, see *Chapter 2*). It is possible that executive functioning ability (i.e., ability to inhibit an automatic response) only plays a role under conditions in which it is really needed. Therefore, it is possible that age-related effects are only apparent when availability of cognitive capacity or time to engage in higher-level processing is limited, which presumably was not the case in this study. Future studies should consider a speeded condition similar to Rosset's (2008) Experiment 1 (see *Chapter 2*), to investigate whether younger individuals tend to engage in more biased thinking than adults when engagement in higher-level processing is made more difficult.

Future directions

As discussed above, future studies should include younger participants, ideally including children as young as four years. If including children who cannot read independently, a different paradigm would have to be used. A version of Heider and Simmel's (1944) task could be used, which is an implicit measure of perception of goal-directed behaviour. However, we are unsure whether such a task would capture the same concept that is the focus of our research. In their task, participants are shown moving shapes and they frequently perceive these shapes as having mental states and goals, indicated by how the participants refer to the shapes and their "actions" (Heider &

Simmel, 1944). In other words, the task measures whether participants *perceive an agent* that caused an action per se, however, we are interested in *how* participants perceive an individual's action – to be intentional or unintentional. Therefore, we assume that a novel paradigm would be required to measure the same concept as the Ambiguous Sentence Paradigm but suitable for younger as well as older individuals.

Furthermore, future research could consider including a condition of limited cognitive capacity (e.g., through time pressure) to highlight differences in intentionality endorsement due to the efficiency of executive functions. As discussed above, any age-related effects are more likely to be detected under conditions in which cognitive ability (i.e., efficiency of information processing) and executive functions have to be sufficiently developed to counteract biased reasoning and automatic judgements.

In addition, future research could investigate whether individual differences in executive functioning skills and cognitive ability are associated with intentionality endorsement across development, particularly given the assumptions set out by the dual-process model (Rosset, 2008).

CHAPTER FOUR

Exploring the effects of age and IQ on intentionality judgements in a school sample

Abstract

Previous research suggests that humans have a tendency to judge actions to be intentional. According to Rosset (2008), this tendency is the product of a dual-process system underpinning intention attribution. On this view, action observation triggers automatic attributions of intent, which may then be "overridden" by higher-level cognitive processes if available. More recently, Rosset and Rottman (2014) suggested that this overriding of intentional judgements (and the associated deployment of higher-level cognitive processes) is a marker of mature action understanding; and so it is the ability to detect unintentional, rather than intentional, causation, that is the defining feature of successful cognitive development. In this study, we set out to probe some of the predictions made by Rosset and Rottman's developmental model of intention attribution. More specifically, we investigated the relationship between intention attribution on the one hand, and age and cognitive ability on the other. We tested a sample of eight- to 12-year old children and found that neither age nor cognitive ability could predict intentionality endorsement of ambiguous action. Therefore, our data do not appear to support Rosset and Rottman's framework.

Introduction

Intentionality and maturation of intention attribution system – NICED framework

As discussed in the previous chapter, in line with Rosset and Rottman's (2014) NICED framework, understanding that actions can be unintentional is assumed to be a marker of mature intentional reasoning rather than understanding intentionality per se. The study discussed in the previous chapter set out to measure the effect of age on intentionality judgements of ambiguous action in a large sample of visitors to the London Science Museum aged between 12 and 67 years of age. As discussed in the previous Chapter, 12 years of age might have been too old to detect age-related changes in judging intentionality in ambiguous action. Therefore, in this study, we aimed to further investigate Rosset and Rottman's developmental model of intention reasoning by examining the effect of cognitive ability, as well as age, in a sample of school-aged children (i.e., partially younger participants than in the previous study).

According to Rosset and Rottman (2014), several factors contribute to the ability to judge behaviour to be accidental, including knowledge of alternative causes as well as executive functioning skills necessary to inhibit automatic responses. These are factors that develop and improve with age (e.g., Huizinga, Dolan, & van der Molen, 2006). For example, over time, individuals are repeatedly exposed to and learn differential, non-intentional action causes (e.g., biological causes such as a reflex for sneezing). Simultaneously, children cognitively mature; frontal lobe processes develop throughout childhood and adolescence, allowing for increasingly refined executive functioning skills (Blakemore & Choudhury, 2006; Romine & Reynolds, 2005). Age, therefore, acts as an index for mature intentional reasoning.

However, by studying intentionality endorsement as a function of age only, as in the previous chapter, it is not possible to disentangle whether it is age in general, or cognitive maturity specifically, that underlies the decreased tendency to judge behaviour to be intentional. In other words, it is not possible to tell whether it is greater social experience or greater cognitive ability that enable an individual to judge ambiguous action to be accidental. Therefore, in addition to investigating age-related effects, the aim of this study is to test whether individual differences in cognitive ability (i.e., the efficiency with which information is processed, usually measured with specific cognitive ability tests; see Evans, 2003, 2007; Evans & Stanovich, 2013) have an effect on intentionality endorsement of ambiguous action. According to the dual-process model of intention attribution (Rosset, 2008), Type 2 processing *inhibits an intentional judgement* and *enables an unintentional judgement*. We assume greater cognitive ability to facilitate Type 2 processing and, hence, to be associated with lower intentionality endorsement for ambiguous action. In other words, higher levels of general cognitive ability would enable mature intentional reasoning.

Intentionality endorsement and cognitive ability – Type 1 and 2 processing

Dual-process accounts of reasoning assume that Type 1 processing is independent of cognitive ability whereas Type 2 processing is correlated with it (see Evans, 2003, 2007; Evans & Stanovich, 2013). People with higher cognitive ability are thought to be more able to resolve a conflict between Type 1 and Type 2 processes, to engage in decoupled and analytical reasoning, and in doing so, achieve an answer that is not purely guided by heuristics (e.g., Baron, 1991, 1995; Brenner, Koehler, & Tversky, 1996; Galotti, 1989; Kardash & Scholes, 1996; Klaczynski, 1997; Klaczynski & Gordon, 1996; Kuhn, 1991, 1993; Nickerson, 1987). A vast amount of empirical evidence suggests a positive association of cognitive ability and the ability to find normatively correct solutions to problems (e.g., Capon, Handley, & Dennis, 2003; Klaczynski, 2000; Klaczynski & Daniel, 2005; Klaczynski & Gordon, 1996; Neys, 2006).

In terms of judging intentionality of ambiguous action, if we assume a dual-process model, in which action is judged to be unintentional only if an automatic response is overridden by a Type 2 process, then higher cognitive ability will be associated with lower intentionality endorsement scores.

Indeed, findings from the cognitive bias-literature suggest an association between cognitive ability and decreased susceptibility to biased thinking (Bruine de Bruin, Parker, & Fischhoff, 2007; Klaczynski & Lavallee, 2005; Kokis, Macpherson, Toplak, West, & Stanovich, 2002; Newstead, Handley, Harley, Wright, & Farrelly, 2004; Toplak, Liu, MacPherson, Toneatto, & Stanovich, 2007). This further supports the prediction of a negative association between cognitive ability and intentionality endorsement of ambiguous action.

Verbal and visual paradigm

The study presented in the previous chapter only included Rosset's (2008) Ambiguous Sentence Paradigm. However, criticism has been raised the intentionality bias in Rosset's (2008) studies could have emerged out of a linguistic bias (see Moore & Pope, 2014). As Rosset (2008) pointed out herself, an accidental action, for example, might usually be marked by the use of passive voice or by explicitly calling it accidental. Therefore, an increased tendency to judge behaviour to be intentional under conditions such as time pressure could mark biased responding due to the nature of the paradigm and unrelated to intentional reasoning. If this is the case, a response pattern guided by a more pronounced linguistic bias could potentially be found in children, which could be a potential limitation of the study.

To deal with such potential linguistic bias, Moore and Pope (2014) developed a non-linguistic video paradigm (Ambiguous Movement Paradigm). As described in *Chapter 1*, it involves short video clips of ambiguous finger movements that can either be judged to be intentional or unintentional. We included this measure in this study to ensure that a greater tendency to judge ambiguous behaviour to be intentional (if found) is not paradigm- or domain-specific.

Hypotheses

For both paradigms (Ambiguous Sentence Paradigm, Ambiguous Movement Paradigm), we make the following two hypotheses:

1) Age in months and full-scale IQ as a measure of general cognitive ability will be negatively related to intentionality endorsement scores (for the Ambiguous Sentence Paradigm as well as the Ambiguous Movement Paradigm).
2) If this is the case, the association between age and intentionality endorsement will be mediated by full-scale IQ.

Methods

Participants

The study was approved by Goldsmiths College Department of Psychology Ethics Committee. Neurotypical school students aged between 8 and 15 years (n=62; mean age=10.1 years, *SD*=1.35; 32 females) participated in the study. They were all students from one of two participating schools, one Primary and one Secondary School in East London, United Kingdom.

Testing took place over a period of five weeks in the form of one-to-one and group sessions. Participants completed up to three tasks (WASI-II, Ambiguous Sentence Paradigm, Ambiguous Movement Paradigm; see below), which were not necessarily conducted on the same day or in the same order for each participant. Not all participants completed all tasks. Therefore, participants are described in more detail for each of the two experimental measures (Ambiguous Sentence Paradigm and Ambiguous Movement Paradigm) below.

Measures and Procedure

The study involved three tasks, one standardised IQ measure (WASI-II) and two experimental paradigms investigating participants' tendency to judge ambiguous actions to be intentional. Additionally, all participants' age in months at the time of the IQ testing was recorded. (Note: Although IQ testing and the other tasks were not necessarily conducted on the same day, all experimental sessions per form (year group) would usually be conducted within a week.)

IQ measure

Participants' IQ was measured using the Wechsler Abbreviated Scale of Intelligence II (WASI-II; Wechsler, Zhou, Corporation., & Laboratory, 2011). It involves four sub-tasks, two of them (Vocabulary, Similarities) measuring verbal reasoning ability (VCI) and the other two (Block Design, Matrix Reasoning) measuring non-verbal perceptual reasoning ability (PRI). Each participant received a VCI and a PRI score and a full-scale IQ score (FSIQ4), which is a measure of performance on all sub-tasks taking age into account.

Rosset's Ambiguous Sentence Paradigm

Participants were asked to complete a modified version of Rosset's (2008) Ambiguous Sentence Paradigm to measure their tendency to judge ambiguous actions to be intentional. As in *Chapter 2*, participants were presented with 34 test sentences describing ambiguous actions that could either be intentional or unintentional. 22 of them were ambiguous but prototypically accidental (Prototypically Accidental test sentences) and 12 were ambiguous but prototypically intentional (Prototypically Intentional test sentences). Additionally, participants were presented with 10 unambiguously accidental control sentences (Accidental control sentences; e.g., *The girl had a seizure*.) and 10 unambiguously intentional control sentences (Intentional control sentences; e.g., *He listened attentively.*). Sentences were presented one at a time in a set-randomised order on a computer- or laptop screen. Participants were asked to indicate whether they thought the action described in each sentence was done *on purpose* or *by accident* by clicking on the corresponding answer. As in the previous study, there were no time constraints given to respond to each stimulus, to ensure that reading ability and -speed would not confound the results. Also, there were no breaks between sentences, but participants were asked to complete the task in one go.

Testing took place in classroom settings of four to 27 students. Each student completed the task independently on a laptop or computer. At the beginning of each session, task instructions were given to the whole group. Students were also instructed not to talk to each other and to complete the task in their own time. When participants started the task, they were presented with the first screen which repeated the task instructions to allow participants to read through them in their own time and to ensure all participants understood the task. After completing the task, participants quietly left the room.

Intentionality endorsement scores were calculated for each category of test sentences, comprising of the percentage of items for which actions were judged to be intentional.

Ambiguous Movement Paradigm

In this paradigm, participants were asked to judge the intentionality of a simple hand movement. More precisely, they were asked to judge the intentionality of a finger strapped to a keyboard pressing a key. (For more details of the paradigm, please refer to the *Chapter 1*.) There were 24 trials and to compute the intentionality endorsement score the percentage of trials judged to be intentional was calculated (Video intentionality endorsement score).

Results

Results Ambiguous Sentence Paradigm

Exclusion

Participants who only responded to 75% or less of the test items and participants who incorrectly responded to more than one control item of either category were excluded from further analysis. This resulted in a sample size of 50 participants (mean age=125.36 months (10.45 years), *SD*=14.27). By excluding participants who responded to more than one control item of any test category incorrectly, inattentiveness due to the nature of the in-class testing is not assumed to be a great confounding factor.

There were no statistically significant outliers in intentionality endorsement scores for Prototypically Accidental nor Prototypically Intentional test sentences (based on inter-quartile range rule with a multiplier of 3.0; Hoaglin, Iglewicz, & Tukey, 1986).

Correlations

Pearson's correlation analyses for the following variables were run: age in months, intentionality endorsement scores for Prototypically Intentional test sentences, intentionality endorsement scores for Prototypically Accidental test sentences, spatial reasoning ability (PRI), verbal reasoning ability (VCI), full-scale IQ (FSIQ4).

There were no significant correlations between the variables of interest (intentionality endorsement scores for either type of test sentences) and any of the other variables, however, there was a significant negative correlation between age and verbal reasoning and full-scale IQ (Table 4.1).

Table 4.1. Pearson correlations for n=50 among age in months, spatial reasoning ability (PRI), verbal reasoning ability (VCI), full-scale IQ (FSQ4), intentionality endorsement scores for Ambiguous but Prototypically Accidental test sentences (PA) and for Ambiguous but Prototypically Intentional test sentences (PI). All values in bold are significant either at the level of 0.05 (, two-tailed) or at the level of 0.01 (**, two-tailed).*

n=50	PRI	VCI	FSIQ4	PA	PI
Age months	-.231	**-.326***	**-.300***	-.107	.182
PRI	-	**-.423****	**.821****	-.186	-.051
VCI	-	-	**.843****	-.169	.074
FSIQ4	-	-	-	-.200	.019
PA	-	-	-	-	**.302***

Further inspection of the data revealed that this correlation was driven by the four oldest students of the dataset from one particular school with lower than average IQ. At this particular school, the study was advertised to parents by the school's Special Educational Needs Coordinator. As a result, only parents who were regularly in contact with them (i.e., parents of students who struggled at school) gave consent for their children to participate.

After excluding these four students, age and IQ did not significantly correlate any longer (Table 4.2). As these four students seem to represent a subgroup, they were excluded from subsequent analyses, which resulted in a final sample size of 46 students (mean age=122.5 months (10.21 years), *SD*=9.7; age range: 113-140 months; Table 4.3). (Note, all remaining students were from a single school only.)

Table 4.2. Pearson correlations for n=46 among age in months, spatial reasoning ability (PRI), verbal reasoning ability (VCI), full-scale IQ (FSQ4), PA- and PI intentionality endorsement scores. All values in bold are significant either at the level of 0.05 (, two-tailed) or at the level of 0.01 (**, two-tailed).*

n=46	PRI	VCI	FSIQ4	PA	PI
Age months	-.064	-.014	-.054	-.190	.267
PRI	-	**-.311***	**.809****	-.170	-.049
VCI	-	-	**.797****	-.178	.064
FSIQ4	-	-	-	-.231	-.002
PA	-	-	-	-	**.291***

Table 4.3. Mean age, full-scale IQ (FSIQ4), spatial reasoning ability (PRI), verbal reasoning ability (VCI), intentionality endorsement scores for Prototypically Accidental- (PA) and Prototypically Intentional test sentences (PI) and standard deviations in brackets for n=46. The mean age equivalates to 10.2 years.

n=46	Age (months)	FSIQ4	PRI	VCI	PA	PI
	122.5	102.07	96.41	106.61	24.14	64.76
	(*9.7*)	(*11.32*)	(*12.11*)	(*11.83*)	(*13.4*)	(*16.02*)

Multiple regression analyses

For this part of the analysis, full-scale IQ (FSQ4) was used as a predictor variable rather than both sub-domains separately as no prediction regarding spatial or verbal ability specifically was made and both variables correlate. Two multiple regression analyses with age and full-scale IQ as the predictor variables and intentionality endorsement scores as the dependent variables were run (Figure 4.1 - 4.4).

Age and full-scale IQ did not significantly predict intentionality endorsement scores for Prototypically Accidental test sentences ($F(2, 43)=2.249$, $p=.118$) nor intentionality endorsement scores for Prototypically Intentional test sentences ($F(2, 43)=1.652$, $p=.204$). Because our independent variables did not significantly predict intentionality endorsement scores, no further analysis (i.e., mediation analysis) was conducted.

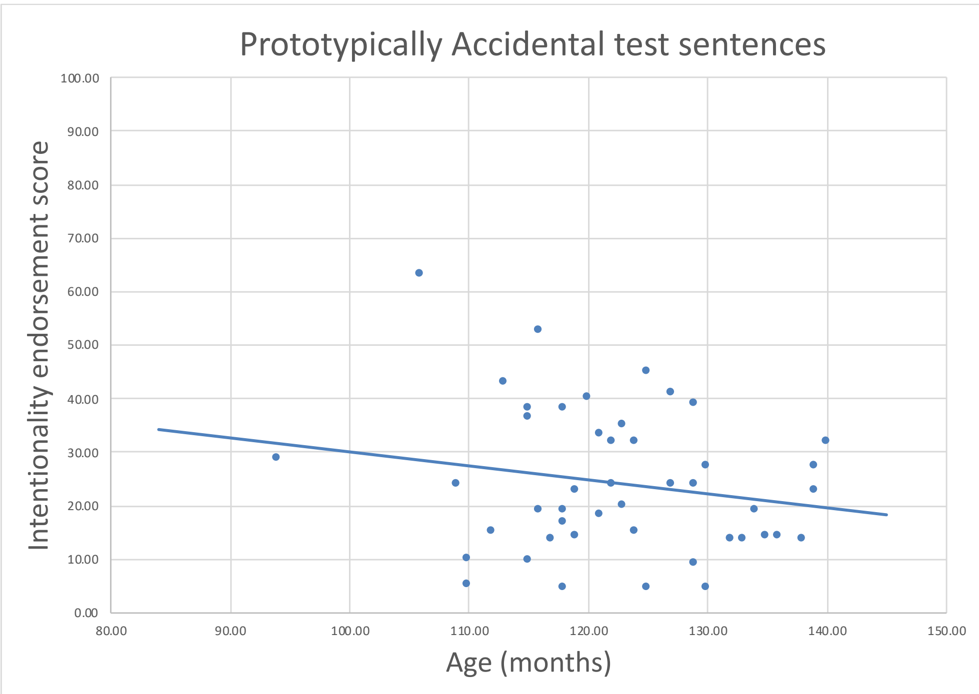


Figure 4.1. Scatterplot of months of age versus intentionality endorsement scores for Ambiguous but Prototypically Accidental test sentences with a linear trendline. Intentionality endorsement scores reflect the percentage of trials judged to be intentional.

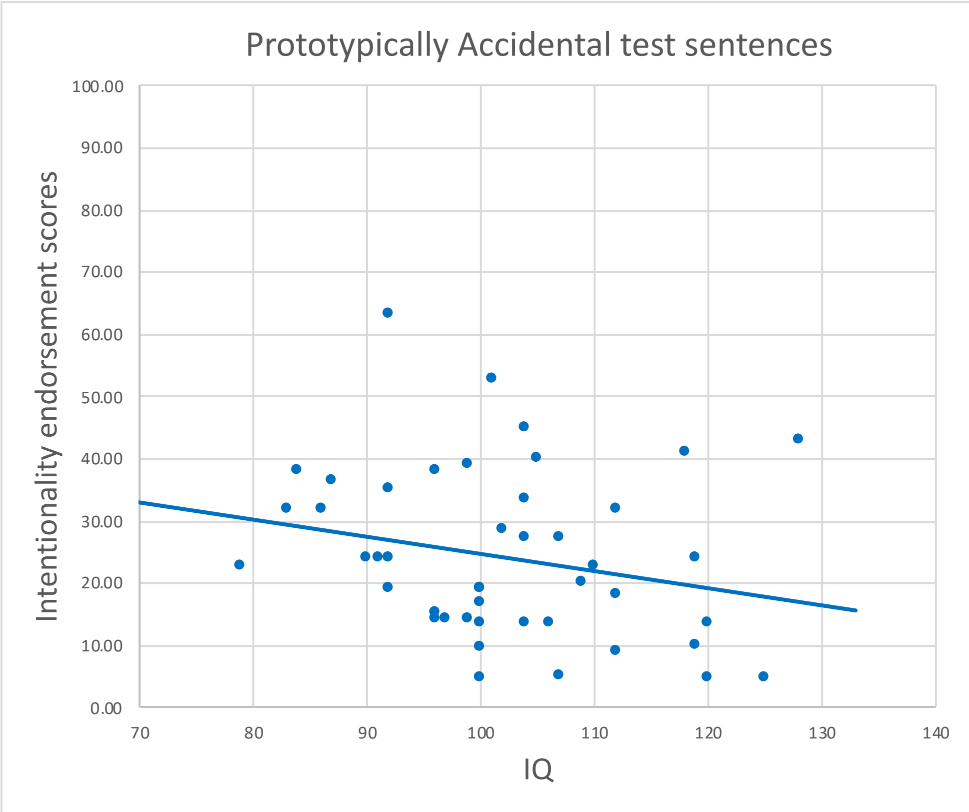


Figure 4.2. Scatterplot of full-scale IQ (FSIQ4) versus intentionality endorsement scores for Ambiguous but Prototypically Accidental test sentences with a linear trendline. Intentionality endorsement scores reflect the percentage of trials judged to be intentional.

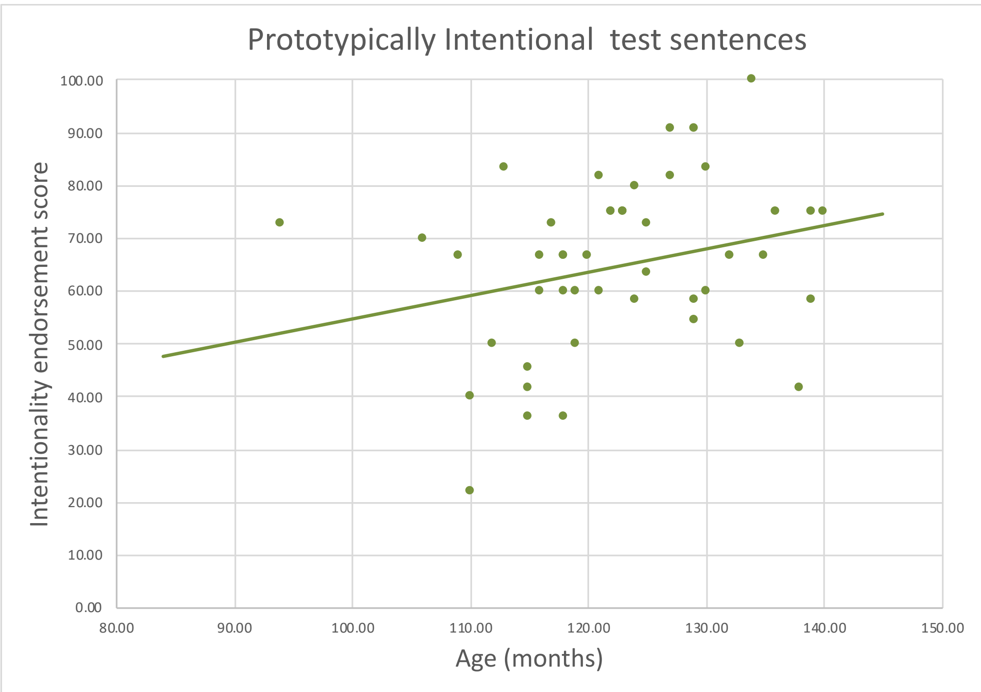


Figure 4.3. Scatterplot of months of age versus intentionality endorsement scores for Ambiguous but Prototypically Intentional test sentences with a linear trendline. Intentionality endorsement scores reflect the percentage of trials judged to be intentional.

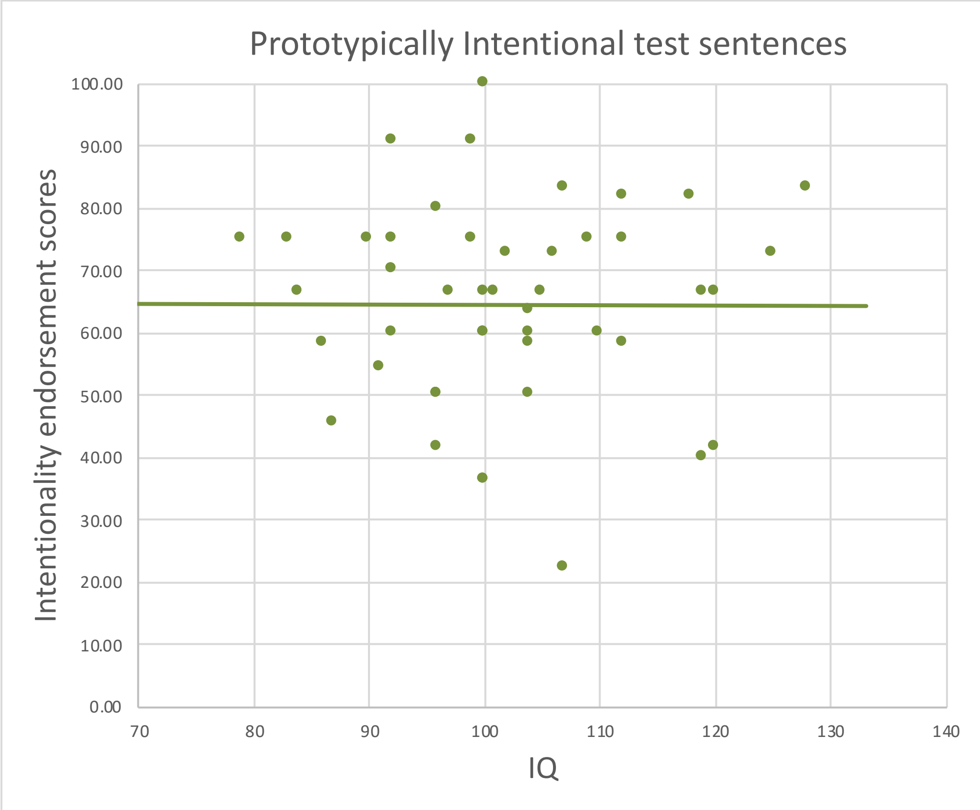


Figure 4.4. Scatterplot of full-scale IQ (FSIQ4) versus intentionality endorsement scores for Ambiguous but Prototypically Intentional test sentences with a linear trendline. Intentionality endorsement scores reflect the percentage of trials judged to be intentional.

Results Ambiguous Movement Paradigm

Exclusion

44 students completed the task. Three statistically significant outliers were removed from the analysis (one scoring significantly lower and two scoring significantly higher), resulting in a new sample size of 41 students.

In line with the analysis of the Ambiguous Sentence Paradigm, the four oldest students from that particular school were removed, resulting in a new sample size of 37 (mean age=123.08 months (10.26 years), *SD*=10.78; age range: 94-139 months; Table 4.4).

Table 4.4. Mean age in months, full-scale IQ (FSIQ4), spatial reasoning ability (PRI), verbal reasoning ability (VCI), intentionality endorsement scores for the Ambiguous Movement Paradigm and standard deviations in brackets.

n=37	Age (months)	FSIQ4	PRI	VCI	i. e. score
	123.08 (*10.78*)	99.62 (*14.15*)	95.00 (*14.23*)	104.62 (*13.37*)	52.93 (*5.09*)

Intentionality bias

A one-sample t-test with a test value of 50 revealed that participants judged significantly more than half of the trials to show intentional movements (M=52.93, *SD*=5.09; $t(36)=3.498$; $p<.001$). This suggests participant did not answer randomly but tended to favour *intentional* explanations. Although this trend is in accordance with Moore and Pope's (2014) findings in an adult sample, mean intentionality endorsement scores of this study are below those reported in Moore and Pope (M=64.2, *SD*=17.6). This is not in line with our prediction of higher intentionality endorsement scores in younger people.

Correlations

Pearson's correlation analyses for the following variables were run: age in months, Ambiguous Movement Paradigm intentionality endorsement score, spatial reasoning ability (PRI), verbal reasoning ability (VCI), full-scale IQ (FSIQ4).

There was no significant correlation between the variables of interest (Video intentionality endorsement score) and any of the other variables (Table 4.5).

Table 4.5. Pearson correlation among age in months, spatial reasoning ability (PRI), verbal ability (VCI), full-scale IQ (FSQ4), intentionality endorsement scores of the Ambiguous Movement Paradigm. All values in bold are significant either at the level of 0.05 (, two-tailed) or at the level of 0.01 (**, two-tailed).*

n=37	PRI	VCI	FSIQ4	i.e. score
Age months	-.297	-.183	-.054	.118
PRI	-	**.452****	**.830****	.101
VCI	-	-	**.834****	.030
FSIQ4	-	-	-	.125
i. e. score	-	-	-	-

Multiple regression

As above, for this part of the analysis full-scale IQ was used rather than both sub-domains separately as no prediction regarding spatial or verbal ability specifically was made and both variables correlate. A multiple regression analysis with age and full-scale IQ as the predictor variables and intentionality endorsement scores as the dependent variable was run. Age and full-scale IQ did not significantly predict intentionality endorsement ($F(2, 34)=.739$, $p=.485$; Figure 4.5). As our independent variables did not significantly predict intentionality endorsement scores, no further analysis (i.e., mediation analysis) was conducted.

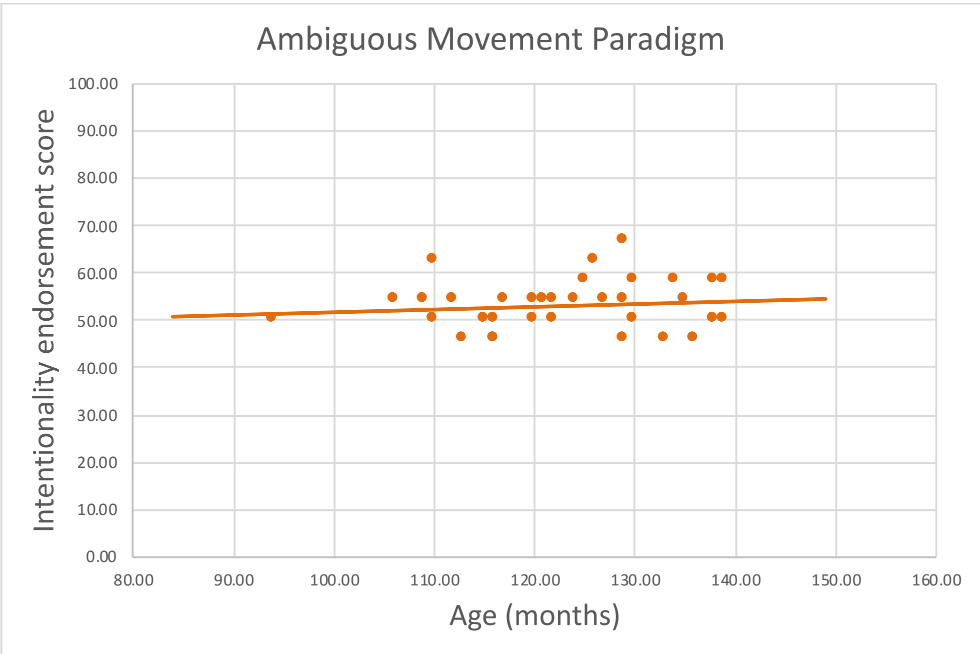


Figure 4.5. Scatterplot of months of age versus intentionality endorsement scores for the Ambiguous Movement Paradigm with a linear trendline. Intentionality endorsement scores reflect the percentage of trials judged to be intentional.

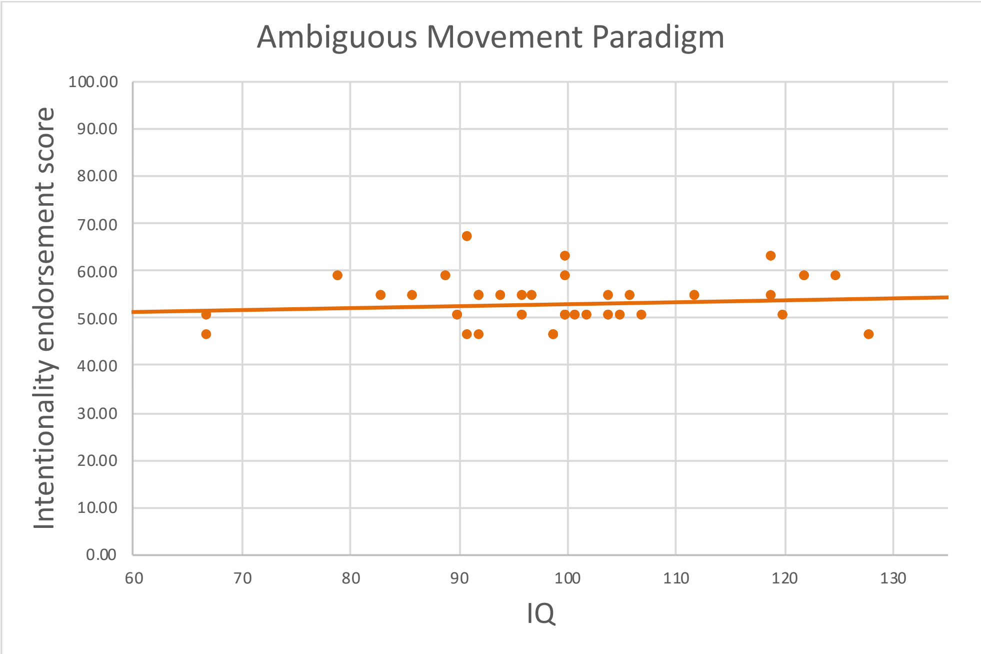


Figure 4.6. Scatterplot of full-scale IQ (FSIQ4) versus intentionality endorsement scores for the Ambiguous Movement Paradigm with a linear trendline. Intentionality endorsement scores reflect the percentage of trials judged to be intentional.

Discussion

According to Rosset and Rottman's (2014) NICED framework, as we get older, our knowledge of action-causation and our executive functioning skills increase, which together allow us to inhibit and "override" an automatic judgement of intentionality. Additionally, in line with this framework, judging ambiguous action to be accidental is thought to involve higher-level cognitive processing and, therefore, it was predicted that individual differences in cognitive ability would explain differences in intentionality endorsement scores. However, results of this study did not suggest an association between age nor cognitive ability and intentionality endorsement of ambiguous action as measured by a verbal and a visual paradigm. Although, the small sample size makes it difficult to draw clear conclusion about the absence of an effect (i.e., the study could have been under-powered), our findings do not seem to support an intention attribution model as assumed by the NICED framework.

In the previous chapter possible explanations for the lack of association between age and intentionality endorsement of ambiguous action were discussed, including the possibility of most significant changes happening at an earlier age than test-age. Although in this study we included slightly younger participants, it is still possible that most relevant changes happen before the study's minimum test age (8 years), i.e., we acknowledge this as a major limitation. However, as this was already discussed in the previous chapter, the focus of this discussion will be on the lack of association between cognitive ability and intentionality endorsement scores.

Role of other individual differences

A possible reason for the apparent lack of association between cognitive ability and intentionality endorsement for ambiguous action could be that the association might be "over-shadowed" by thinking dispositions (tendency for actively open-minded thinking/ need for cognition or lack thereof; West, Toplak, & Stanovich, 2008), which might play a deciding role in whether an intentionality judgement is guided by Type 1 or Type 2 processing.

Stanovich and West (1997), for example, found that individual differences in cognitive ability, *as well as* open-minded thinking, predicted performance on a task requiring participants to question prior beliefs and detaching them from argument evaluation (i.e., engagement of Type 2 processing). Open-minded thinking predicted variance in task performance even when cognitive ability was controlled for. This shows that cognitive ability is not the only factor deciding whether prior beliefs or analytical thinking guide judgements. As Stanovich and West (1997) argue, some individuals might put low emphasis on using computational capacity to assess an argument on its validity, and instead use the capacity to determine whether it violates previously held beliefs. At the same time, equally cognitively able individuals might dedicate most of their cognitive resources to decoupling prior beliefs from assessing the argument. This means that in this study some cognitively able participants might not have used their cognitive resources on overriding an intentional judgement of ambiguous action, whereas others did. This would explain the apparent lack of association between cognitive ability.

According to Anderson (1990), the thinking disposition (or the rational level as Anderson calls it) is concerned with the system's beliefs and goals and puts constraints on how the system acts in the best possible way for the organism. It is more plastic than cognitive ability (the algorithmic level) and can be influenced by, for example, task instructions (e.g., asking participants to disregard prior beliefs). It constantly adapts the behaviour to its environment and tries to optimise it. As will be outlined further below, it is possible that in this study, no specific instructions to inhibit default judgements or any another motivation to engage in analytical thinking was given, i.e. doing so perhaps does not seem like the ideal strategy.

In line with this, evidence suggests that in a lot of cases individual differences in both, cognitive ability as well as thinking disposition predict performance on whether individuals engage in biased processing (Stanovich & West, 1998). Further, Stanovich and West (2008) found that for a number of cognitive bias tasks, performance is sometimes even independent of cognitive ability.

Need to override heuristic response detected?

Stanovich and West (2008) put forward a new framework, which demonstrates *when* cognitive ability will and *when* it will *not* be associated with Type 2 response patterns. For example, when a task requires "overriding" of heuristic responses but overriding is effortlessly done, cognitive ability is not thought to play a big role. Similarly, when detecting the need to override is very difficult, overall performance will be low and no association between performance and cognitive ability will be observed. Following this, when being made aware of the need to override (i.e. thinking disposition is changed), individuals with higher cognitive ability will be less likely to engage in biased thinking. However, without prior warning (i.e., when a cue is absent or not known; see Kahneman, 2000), individuals with higher cognitive ability might not demonstrate difference in performance, as no conflict will have been detected.

Perhaps, the same applies to both paradigms used in the current study. Neither the Ambiguous Sentence Paradigm nor the Ambiguous Movement Paradigm involves clear cues for what is a right or wrong answer. This is because both paradigms are thought to involve truly ambiguous actions. Also, no rule indicating the right response (i.e., a rule-based on logical deduction) can be learnt, i.e. more efficient learning and applying of rules facilitated by higher cognitive ability plays no role in the current paradigms. This could explain the missing link between cognitive ability and intentionality endorsement scores.

Challenging prior beliefs

Alternatively, the missing link could be due to the desire to sustain prior beliefs and the nature of the used scenarios. Decoupling from prior beliefs is more likely to occur when it does not greatly challenge epistemic goals, i.e. when sustaining prior beliefs is not of high importance. For example, if one does not have strong knowledge or opinion on painting, they might find it easier to detach from the prior belief that all actions are done intentionally when judging whether someone inhaled paint fumes on purpose or by accident. In contrast, in highly contextualised situation (e.g., when an individual has a vast knowledge and a strong opinion on something, e.g., inhaling fumes is an efficient way to get high), decontextualizing might not necessarily be or seem like the optimum use of cognitive capacity. Considering the paradigm used in this study, participants are presented with rather contextualised situations (everyday actions in the Ambiguous Sentence Paradigm; finger pressing computer key in Ambiguous Movement Paradigm), which most participants have extensive experience of. Therefore, it is possible that decoupling the evaluation of the action from prior beliefs is unlikely to occur. Future studies could consider developing a paradigm including actions that participants have no or little experience with and are, therefore, not contextualised, as for example, nonsense verbs.

Domain-specific vs domain-general

Another possibility for the lack of age-related or cognitive ability-related effects is that the *domain-general* development of intentional reasoning as proposed by the NICED framework (i.e., applicable to *all* types of actions) does not reflect typical development. The NICED framework suggests a context-independent developmental trajectory that predicts a general decrease of intentional explanations for ambiguous behaviour, rather than a context-dependent increase in accuracy of interpreting specific social situations. For example, judging actions such as sneezing is assumed to show the same developmental trajectory as leaving the window open on a hot day. More precisely, within the framework, intentional reasoning is presented as a skill that an individual acquires over time and can apply to all social situations. An accidental explanation is, therefore, always seen as a cognitively mature judgement. This, however, does not cater for situations in which intentional explanations are more probable (i.e., leaving window open on hot day) and for which an accidental explanation could be seen as the *less cognitively mature* judgement. Considering that a lot of behaviour is indeed intentional, it seems plausible that learning about *all causes* for behaviour (including intentional ones) would play a role.

With age and experience, individuals become better at understanding and identifying causes for behaviour, be it intent, biological (e.g., sneezing or other reflexes), lack of ability (e.g., hitting the ball over the fence) or similar. Considering this, contrary to what Rosset and Rottman (2014) suggest, judging intentionality could be *domain-specific* rather than domain-general development after all. Such a context-dependent development of intentional reasoning would suggest that individuals become more accurate in their interpretations of behaviour but would not necessarily predict a shift towards more accidental explanations with age and maturity. For example, for actions such as sneezing, tripping over curb or breaking objects, one might indeed see more accidental explanations with an increase in age and cognitive maturity. However, for actions such as leaving a window open on a hot day or deleting unimportant emails, the opposite could be the case.

A domain-specific development does not fit the dual-process model as proposed by Rosset but would be supported by unimodal frameworks of learning and development such as for example unsupervised learning models (e.g., Hebbian learning; Cleeremans & Jiménez' (2002) Dynamic Graded Continuum; etc.). Such approaches assume a cognitive system that develops a practical model of its environment by learning correlations of occurrences (Cleeremans & Jiménez, 2002). In other words, a system learns what occurrences are probable to cue other events. Rather than context-independent expertise, over time the cognitive system acquires expertise in situations it has been exposed to. In terms of intentional reasoning, this would suggest that individuals judge intentionality of action based on whether in the past such actions have usually been intentional or unintentional.

A domain-specific development (i.e., improved accuracy), could explain the decrease of range of scores with age as seen in the previous chapter. The idea behind this is that as individuals' judgements improve in accuracy, their responses align and appear to be less random.

However, domain-specific development is arguably impossible to be detected with binary forced-choice tasks such as utilised in the current study. Therefore, future research should consider developing a paradigm that allows for a more nuanced investigation of changes in explanation for action causation and a measure of accuracy. For example, using a Likert scale ranging from *accidental* to *intentional* could give indication over whether more mature participants are more likely to choose either end of the scale than less mature participants. Similarly, one could study whether individuals who have expertise in a particular field, as for example experienced chess players, judge intentionality of another's advantageous move as intentional and whether this judgement pattern is different to that of inexperienced players or specific to the domain of chess.

Limitations and future directions

As already mentioned, the sample size of this study was relatively small, which makes it difficult to establish whether the non-significant findings truly reflect no association between intentionality endorsement and our variables of interest or whether there was not sufficient statistical power to detect an effect.

Furthermore, in addition to a more nuanced investigation of intention attribution patterns, future research could consider including a condition limiting the availability of cognitive capacity to augment differences caused by cognitive ability and executive functioning skills (see previous chapter). Also, as discussed in the previous chapter, it is possible that any age-related changes happen prior to the age of our youngest participants. This is a major limitation and particularly important if we assume a domain-specific development of judging intentionality, as one might see very different judgement patterns for actions with which younger individuals have little experience, as for example, giving the wrong change or violating traffic rules. Therefore, future studies should include younger participants.

Furthermore, future studies should increase the age *range*. In this study, participants' age ranged from roughly eight to 12 years, which could be a too narrow frame to depict an age-trend. Although, we cannot draw any strong conclusions from comparing results between studies, mean intentionality endorsement scores for Prototypically Accidental test sentences were higher than of the sample discussed in the previous chapter (including older individuals). This could mean that eight to 12-year olds judge indeed more actions as intentional than adults, but which can only be detected when a sufficiently wide age range is tested.

In addition, based on the participants' feedback, a potential limitation of the current study is that the "cover story" of a pulley mechanism causing an unintentional movement in the Ambiguous Movement Paradigm might have been too abstract for some children to grasp and as a result, their responses could be somewhat random. Although in total, our sample judged significantly more trials to show intentional movements than unintentional ones, the mean is below what has been previously reported (Moore & Pope, 2014). This could mean that participants did not fully believe or understand the cover story and as a result responded more arbitrarily.

Lastly, future research could consider including a measure of thinking disposition to investigate whether it is the motivation to inhibit an automatic response/ consider alternative causation, and not primarily the capacity to do so, that influences intentionality endorsement.

Conclusion

In line with results of the study discussed in the previous chapter, our data do not support the NICED framework. A number of possible reasons for the lack of association between age, cognitive ability and intentionality endorsement for ambiguous action including the role of thinking disposition and a domain-specific development were discussed. Also, suggestions on how future research could be improved were given, with the one we want to emphasise the most being inclusion of younger participants.

CHAPTER FIVE

Judging Intentionality of Ambiguous Action in an Adult ASC Sample[2]

Abstract

Discerning intentional from unintentional actions is a key aspect of social cognition. Mental state attribution tasks consistently show that people with Autism Spectrum Conditions (ASC) tend to be less accurate in attributing an agent's intention when there is clearly a right answer. However, little is known about how they judge intentionality of ambiguous action, i.e. their intention attribution style. The aim of this study was to find out whether individuals with ASC differ in their interpretation of ambiguous action compared to neurotypical controls. This has great ecological validity, as we often face ambiguous actions in our every-day social life. We found that participants with ASC showed a higher intentionality endorsement score for ambiguous but prototypically accidental action than controls. Theory of Mind (ToM) scores did not correlate with intentionality endorsement scores in either group, therefore, group differences could not be explained by ToM ability. Other potential underlying factors are discussed.

[2] Eisenkoeck, A., Slavny, R., and Moore, J. (Manuscript in preparation).

Introduction

In previous chapters, we studied judging intentionality of ambiguous actions in neurotypical populations. In this study we turn our attention to individuals with ASC, which are associated with atypical patterns of social cognition and social difficulties. By studying cases in which intention attribution might deviate from the norm, we hope to gain better understanding of the underlying process of judging intentionality of ambiguous action in general and potentially help to explain some aspects of social difficulties in ASC.

Intentionality judgements in ASC

A vast body of the literature on social cognition in ASC addresses the question of how and when people with a diagnosis *accurately* attribute intentions to actions. Performance on mental state attribution tasks in which there is clearly a right or wrong answer consistently show deficits in intention attribution accuracy in those with ASC. Even in the case of high functioning autism, when standard behavioural tasks such as theory of Mind (ToM) tasks are passed, long developmental delays to develop mentalising skills have usually been observed and individuals are prone to errors on more advanced tests (e.g., Roeyers, Buysse, Ponnet, & Pichal, 2001; Baron-Cohen et al., 2001; Klin, 2000; Happé, 1994). Hence, there is strong evidence to suggest individuals with ASC tend to be less accurate in their intentionality judgements for actions that have a clear goal or intention (e.g. comic strip paradigm; see Baron-Cohen, Leslie, & Frith, 1986). However, we know relatively little about how individuals with ASC judge ambiguous action (i.e. action where intentionality is not clearly evident). The present study focuses on the interpretation of such actions. This has great ecological validity because many social actions are ambiguous and require some interpretation on part of the viewer.

Some evidence including the work discussed in *Chapter 2* suggests that typically developing individuals have an automatic tendency to judge ambiguous behaviour to be intentional, especially apparent when under conditions of cognitive load or time pressure (e.g., Moore & Pope, 2014; Rosset, 2008). This biased processing style is augmented under alcohol intoxication (Bègue et al., 2010), in schizophrenia (Peyroux et al., 2014) and in Tourette's syndrome (Eddy, Mitchell, Beck, Cavanna, & Rickards, 2010), all of which are associated with social dysfunction.

As discussed in *Chapters 3* and *4*, Rosset and Rottman (2014) put forward a framework that suggests perceiving an action to be *accidental* requires higher cognitive demand and reflects greater maturation of intentional reasoning than simply understanding intentionality. The framework is based on Rosset's (2008) dual-process model of intention attribution, which suggests an automatic tendency to judge all behaviour to be intentional that can only be overridden by a more controlled cognitive pathway when enough cognitive capacity is available. Following this, Rosset and Rottman (2014) argued that it is primarily the controlled pathway, i.e. the one that requires more mature cognitive processing skills and inhibitory control, that develops with age rather than solely the ability to understand intention. (This trend, however, could not be observed in the studies discussed in *Chapters 3* and *4*, which could partly be due to a too old age range.) In line with the notion of *unintentional* judgements being reliant on controlled processing, an underlying reason for the association between over-attribution of intentionality and, for example, alcohol intoxication, schizophrenia and Tourette's syndrome could be the impairment of this mature intentional reasoning process.

In the case of ASC, prior studies report over-attribution of intent in Asperger Syndrome (AS) for Faux-pas tasks, i.e. individuals were less likely to think the person having committed a faux-pas did so out of a false belief but rather out of intention (Zalla et al., 2009). Similarly, it was found that individuals with ASC were more likely than neurotypical controls to judge a clearly accidental agent to have acted out of intent (Buon et al., 2013). (Notably actions in both studies are associated with a negative outcome/harmful effect.) Also, results of a recently published study suggest that autistic traits in a neurotypical sample predict intentionality endorsement of ambiguous actions that lead to negative side effects, in that higher autistic traits are associated with high intentionality endorsement scores (β=.28; Zucchelli, Nori, Gambetti, & Giusberti, 2018). These findings suggest it is not understanding intentionality per se that individuals with ASC or with high autistic traits struggle with (i.e., they are not "blind" to intentions), but rather that their intention attribution *style* differs to that of neurotypicals (i.e., they show different patterns of attributing intent). Because discerning intentional from unintentional behaviour is a key aspect of social cognition and because individuals with ASC often exhibit difficulties in social interaction, it is important to get a better understanding of their intentional reasoning style, of any potential differences to neurotypicals and of the underlying reasons for those differences.

Theory of mind and judging intentionality

Results from Zucchelli et al.'s (2018) study also suggest that the association between autistic traits and attribution of intentionality is partially mediated by a theory of mind (ToM) ability, which is understood as the ability to attribute mental states to oneself and to others (Premack & Woodruff, 1978). More specifically, decreased ToM abilities mediate the positive association between autistic traits and intentionality endorsement. Their findings can be interpreted in a sense that it requires a ToM to understand that overt behaviour does not necessarily correspond to an agent's mental state, i.e., that an action can be done accidentally and can lead to an unintended outcome.

There is broad consensus that ASC is associated with ToM difficulties (for review see Baron-Cohen, 2000). However, affected adults without intellectual disability often pass commonly used ToM tasks, as lab-based experimental measures sometimes cannot pick up subtle deficits, in other words, they do not very well represent real-world social interactions and can even be passed by people with deficits. Hence, in this study, we use a recently developed video task (Strange Stories Film Task [SSFt]), which was designed to test ToM abilities in naturalistic video scenarios (Murray et al., 2017). The SSFt is based on the Strange Stories Task (Happé, 1994), but conversely requires individuals to process social information at a pace corresponding to that of naturalistic social interactions rather than reading the scenarios at one's own pace (see *Methods* for more detail).

Present Study

This study will investigate differences between an ASC and a control group in the perceived intentionality of ambiguous actions. A verbal paradigm will be used, which consists of sentences depicting every-day ambiguous actions and asking participants to make a two-alternative forced-choice judgment on the actions' intentionality (Ambiguous Sentence Paradigm; Rosset, 2008). As discussed in previous chapters, the original paradigm involves two categories of ambiguous action: ambiguous but prototypically accidental, and ambiguous but prototypically intentional. We make no predictions as to whether group differences will only be apparent in one or both categories.

However, as some of the previous work discussed in this thesis suggests that both categories measure different concepts, they will be analysed separately. Furthermore, the SSFt will be used to investigate whether ToM abilities partly explain group differences, if found.

Hypotheses

Considering the evidence discussed above we arrived at the following two hypotheses:

- Individuals with ASC will show a difference in the extent of intentionality endorsement for ambiguous actions (ambiguous but prototypically accidental; ambiguous but prototypically intentional), compared to neurotypical controls. (As the current study differs in some respects to previously published results, a non-directional hypothesis was made.)

- If this is the case, we predict deficits in ToM to partly explain this difference.

Methods

Participants

The study was approved by Goldsmiths University Psychology Department Ethics Committee. 20 individuals with an ASC diagnosis (7 female) and 20 neurotypical controls (11 female) took part in the study. They were recruited via the National Autism Society UK, social media platforms and community platforms, as well as through London-based community organisations. All participants in the ASC group had been diagnosed by a clinician. The ASC group and the control group differed significantly in autism traits measured by the Autism Quotient ($t(38)=9.83$, $p<.001$; Table 5.1). Additionally, they significantly differed in all three sub-measures of the ToM task used (SSFt); namely, ToM accuracy ($t(38)=-2.86$, $p=.007$), interaction based on inferring a ToM ($t(38)=-4.25$, $p=.006$) and the use of mental state language ($t(31.51)=-2.68$, $p=.012$) with the ASC group scoring lower on all three sub-measures (Table 5.1). There were no significant group differences in the control items ($p>.05$). Hence, it was concluded that the two groups differed in our variables of interest; autism traits and ToM ability.

There were no significant group differences in verbal reasoning ability (verbal IQ; VCI) between the ASC group and controls ($t(38)=-1.07$, $p=.292$; Table 5.1). Nor were there group difference in perceptual reasoning ability

(PRI; *t*(38)=.16, *p*=.876; Table 5.1). In light of these non-significant differences, IQ was not controlled for in the main analysis.

Table 5.1. Age in years, AQ scores, verbal reasoning ability (VCI), perceptual reasoning ability and performance on SSFt sub-measures (accuracy, interaction, mental state words, memory) with standard deviations in brackets.

	Age	AQ (max 50)	VCI	PRI	ToM accuracy (max 24)	ToM interaction (max 24)	ToM MS (max 24)	ToM memory (max 12)
ASC	36.05 (*10.32*)	36.05 (*6.37*)	108.75 (*15.53*)	110.10 (*14.99*)	15.40 (*4.67*)	12.25 (*4.49*)	8.95 (*3.20*)	11.40 (*.94*)
Controls	30.00 (*10.32*)	14.25 (*7.60*)	114.15 (*16.40*)	109.35 (*15.30*)	19.05 (*3.30*)	16.50 (*4.70*)	11.20 (*1.96*)	11.90 (*.308*)

Measures and Procedure

At the beginning of each testing session, participants' IQ was measured using the Wechsler Abbreviated Scale of Intelligence II (WASI-II; Wechsler, Zhou, Corporation., & Laboratory, 2011). Every participant received a score for verbal reasoning ability (VCI) and non-verbal perceptual reasoning ability (PRI).

Subsequently, participants were asked to complete a modified version of Rosset's (2008) Ambiguous Sentence Paradigm to measure their tendency to judge ambiguous actions to be intentional. For details of the version used, please refer to *Chapter 4*. There are two ambiguous test categories (Prototypically Accidental test sentences; Prototypically Intentional test sentences) and two unambiguous control categories (Accidental control sentences; Intentional control sentences). Intentionality endorsement scores were calculated for both types of test sentences and both types of control sentences, comprising of the percentage of items for which actions were judged to be intentional.

Next, participants completed the Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), a self-report measure of autistic traits, to ensure both groups were representative samples. It consists of 50 items, made up of ten items measuring five relevant aspects of autistic traits (social skills, attention switching, attention to detail, communication, and imagination). For each item, participants can score 1 point for mild or strong autistic-like behaviour. Hence, participants can reach a total score from 0 to 50, with a score of 32 and above indicative of high autistic traits. Good test-retest reliability and construct validity has been reported (Simon Baron-Cohen, Wheelwright, Skinner, et al., 2001).

Finally, Murray et al.'s (2014) Strange Stories Film Task (SSFt) was conducted to measure participants' ToM abilities using naturalistic scenarios. The SSFt consists of short videos showing acted social interactions. It was designed to detect subtle impairments in mentalising that are observed in high functioning adults with ASC. There are 12 experimental clips that use the following types of scenarios: lie, irony, double-bluff, pretence, joke, appearance/reality, white-lie, persuasion, misunderstanding, forgetting, contrary emotions, and idioms. After each clip participants are asked three questions to evaluate their social understanding; namely, what the actors' intention was (*accuracy*), how they would react to what had been said (*interaction*) and a memory question (*memory*). Responses to the intention question were also scored for the use of mental state language (*mental state language*). Additionally, there were three control items that did not require mentalising to make sure that any group differences would not be due to differences in cognitive reasoning. To assess the consistency of scoring, interrater reliability was calculated with two coders, using two-way random model intraclass correlations (absolute agreement). All scores showed good or excellent agreement (ToM accuracy: r=.930; ToM interaction: r= .774; mental state language: r=.948; memory: r=.914; control accuracy: r=.889, control interaction: r=.907, control mental state language: r=.838, control memory: r=.930).

Results

One statistical outlier (based on inter-quartile range rule with a multiplier of 3.0; Hoaglin, Iglewicz, & Tukey, 1986) in the ASC group with an intentionality endorsement score for Prototypically Accidental test sentences of 77.27 was removed prior to analysis.

Control sentences/ Manipulation check

Scores of the control items revealed that participants were generally attentive and followed task instructions. All control participants responded correctly to all control items. Participants in the ASC group on average responded correctly to 94.7% of the Accidental control items and 97.4% of the Intentional control items. Data were not normally distributed. Results of non-parametric Mann Whitney-U tests revealed no significant difference between the ASC and control group for either control category (Accidental: U=150, p=.270; Intentional: U=170, p=.588; Table 5.2).

Table 5.2. Means and standard deviations for intentionality endorsement scores for Prototypically Accidental test sentences (PA), Prototypically Intentional test sentences (PI), Accidental Control sentences (UA) and Intentional control sentences (UI) for ASC- and control group.

	PA	PI	UA	UI
ASC (n=19)	18.42 (*7.34*)	65.35 (*13.96*)	5.27 (*11.72*)	97.37 (*9.33*)
Controls (n=20)	13.18 (*8.59*)	60.83 (*19.7*)	0 (*0*)	100(*0*)

In the main analysis, we decided *not* to exclude any participants on the basis of unusual control category-scores for the main analysis (unlike in previous chapters). Our reasoning was that we are investigating potentially *atypical* intention attribution patterns in a clinical population. In this way, we felt it was inappropriate to exclude those who may have not responded accurately to the control items. However, we acknowledge that with this approach it is difficult to establish whether group differences are due to differences in intention attribution or to factors such as inattentiveness or reading comprehension. Therefore, the analysis was repeated with a sub-sample consisting of only participants who had not responded incorrectly to more than one item of any control category.

Main analysis: Ambiguous test sentences

As explained, in this part of the analysis we investigated group differences in intentionality endorsement scores without excluding participants on the basis of too many incorrect control items. As can be seen in Figure 5.1, the ASC group showed a higher intentionality endorsement score than controls for both types of test sentences. An independent sample t-test revealed a significant difference in intentionality endorsement scores for Prototypically Accidental test sentences between the two groups ($t(37)=2.04$, $p=.048$). There was no significant group difference in intentionality endorsement scores for Prototypically Intentional test sentences, although there was a trend ($t(37)=.82$, $p=.416$; Figure 5.2).

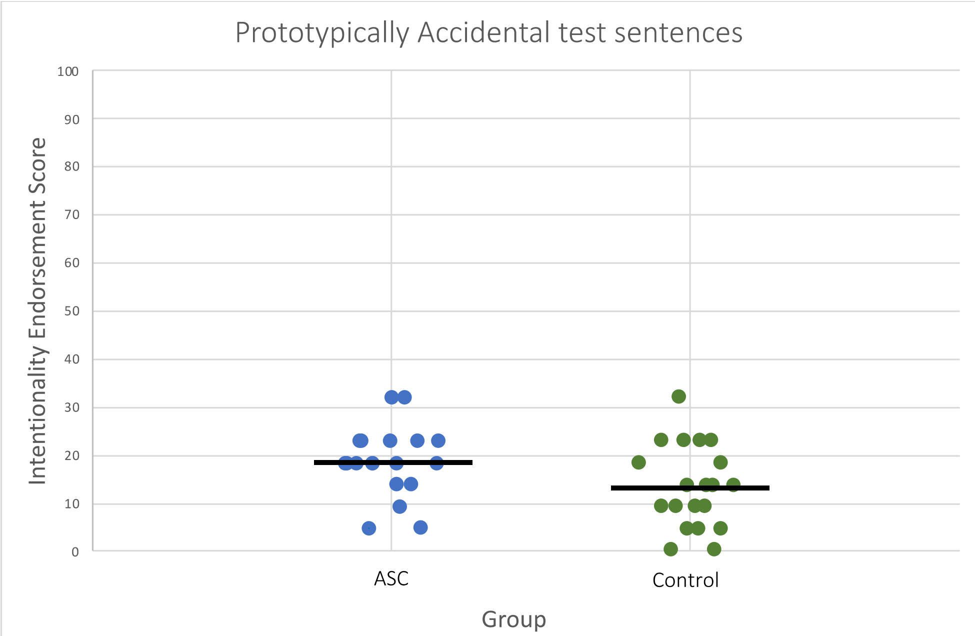


Figure 5.1. Intentionality endorsement scores for Prototypically Accidental (PA) test sentences for ASC- and control group. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

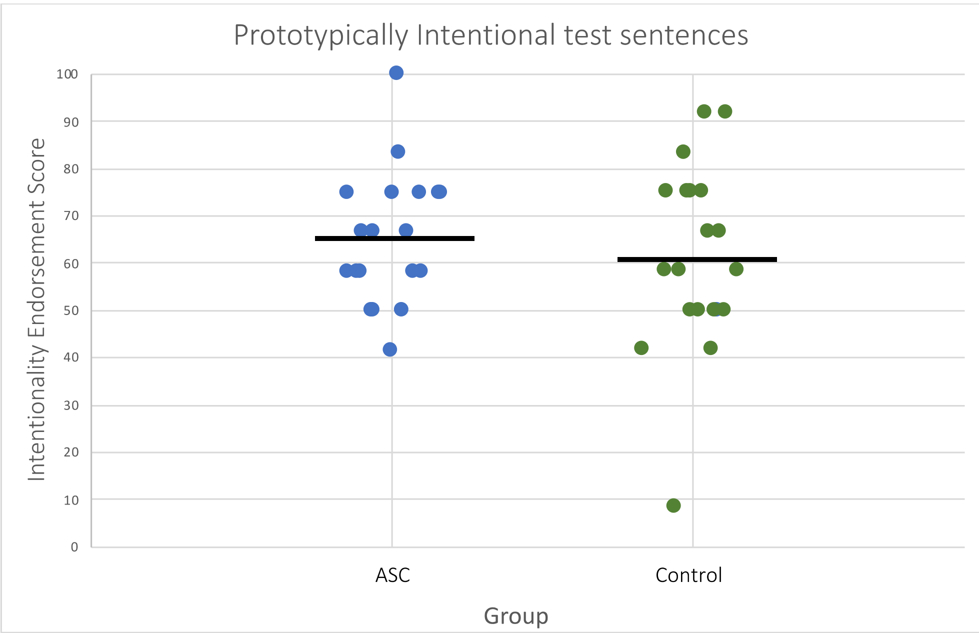


Figure 5.2. Intentionality endorsement scores for Prototypically Intentional (PI) test sentences for ASC- and control group. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

Analysis repeated with sub-sample

After excluding participants who had responded incorrectly to more than one item of any control condition, differences in intentionality endorsement scores between the ASC and the control group were investigated. The ASC group (n=16) showed a higher intentionality endorsement scores than controls (n=20) for Prototypically Accidental test sentences (ASC: M=17.32, *SD*=7.08; Controls: M=13.18, *SD*=8.59) as well as Prototypically Intentional test sentences (ASC: M=67.71, *SD*=8.59; Controls: M=60.83, *SD*=19.70). However, independent sample t-tests revealed this difference not to be significant neither for Prototypically Accidental test sentences ($t(34)=1.55$, $p=.130$; Figure 5.3) nor Prototypically Intentional test sentences ($t(34)=1.2$, $p=.240$; Figure 5.4).

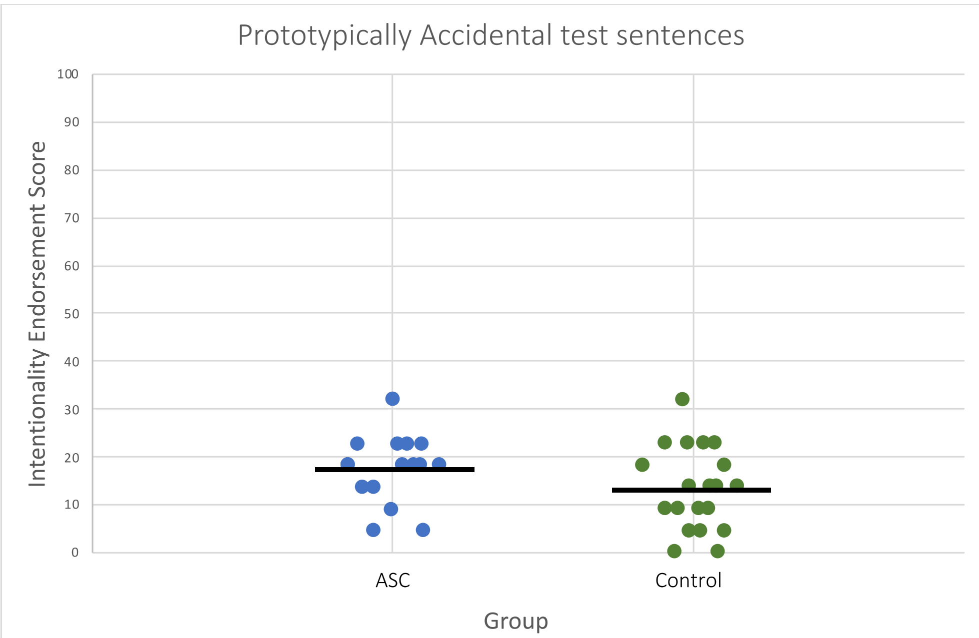


Figure 5.4. Intentionality endorsement scores for Prototypically Accidental (PA) test sentences for ASC- and control group excluding participants who had respondent incorrectly to too many control items. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

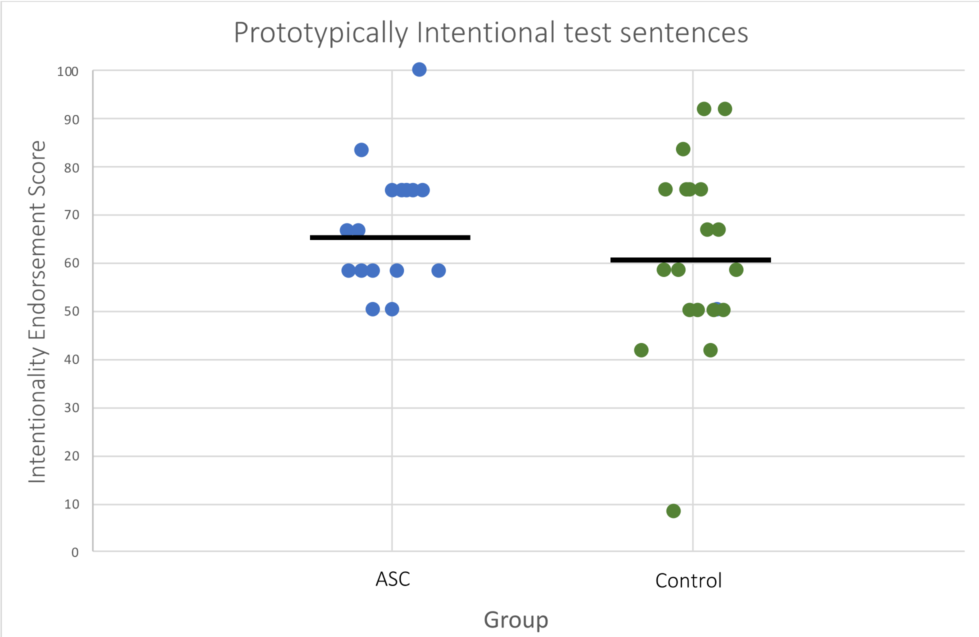


Figure 5.4. Intentionality endorsement scores for Prototypically Intentional (PI) test sentences for ASC- and control group excluding participants who had respondent incorrectly to too many control items. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

ToM accuracy and intention attribution of ambiguous but accidental action

To explore the role of ToM in judging intentionality of ambiguous but prototypically accidental action, the relation of ToM accuracy scores and intentionality endorsement scores for Prototypically Accidental test sentences was investigated. The SSFt sub-measure ToM-accuracy reflects the ability to understand what others are thinking (Murray et al., 2017), which were assumed to be the most relevant of the three sub-measures in relation to intention attribution and, hence, was included in this part of the analysis. Simple linear regression analyses in both groups separately were conducted to examine whether ToM accuracy scores would linearly predict intentionality endorsement scores for the test sentence category of interest.

Results indicated that ToM accuracy did not significantly predict intentionality endorsement scores in either group (ASC: $F(1,17)=3.61$, $p=.074$; Controls: $F(1,18)=.37$, $p=.548$). (Please note that for this and subsequent analyses no participants had been excluded on the basis of too many incorrect control items.)

ToM and verbal reasoning ability

To explore the relationship between ToM scores and verbal reasoning ability (VCI) and to get a better understanding of whether participants would rely on verbal skills when solving the SSFt, Pearson's correlation analyses were run in both groups separately. In the ASC group, VCI significantly positively correlated with all three ToM sub-measures ($p<.05$; Table 5.3). In the control group there was no significant correlation between VCI and either of the ToM sub-measures ($p>.05$, Table 5.3). (Please note that one control participant who had a considerably lower VCI than the rest of the sample was excluded prior to this analysis.)

Table 5.3. Correlation coefficients between verbal reasoning ability (VCI) and ToM sub-measures for ASC- and control group.

	ToM accuracy	ToM interaction	ToM mental state language
ASC (n=19)	**.621****	**.631****	**.499***
Controls (n=19)	-.095	.047	.160

*p<.05
**p<.01

Discussion

General

In this study, we investigated how individuals with ASC judge intentionality of ambiguous actions. The results suggest that when presented with ambiguous but prototypically accidental action, high functioning adults with ASC show an increased *tendency* to perceive ambiguous behaviour to be intentional rather than accidental compared to neurotypical controls. Although this difference is only marginally significant, it is a noteworthy result in a small sample and suggests group differences in intention attribution style.

Individuals with ASC often show poor performance on mental state attribution tasks, which is sometimes understood as an indication for a *deficit* in the ability to perceive intentionality (Ciaramidaro et al., 2014). However, our results suggest that this might not be the only issue. Instead, our results indicate differences in intention attribution *styles* between with ASC and neurotypical controls, in so far as individuals with ASC seem to over-attribute intention for ambiguous action. Similar patterns can be seen in other disorders associated with social dysfunction such as schizophrenia or Tourette's syndrome (Peyroux et al., 2014; Eddy et al., 2010). Hence, atypical intention attribution styles could play a causal role in social difficulties.

For the sake of completeness, the main analysis was repeated excluding participants who had incorrectly responded to too many control items, which showed no significant effect. However, we draw no strong conclusion from this result, firstly because the sample size of the ASC group was reduced by over 15% (resulting in decreased power), and secondly because ASC is a spectrum disorder and by excluding participants "abnormally" responding to control items, participants falling on the end of the spectrum who make atypical social attributions were excluded. Importantly, our results support the argument made in *Chapter 2* that when studying a neurotypical population, control sentences should be used as a screening tool as otherwise effects can be driven by individuals who tend to make such atypical social attributions.

ToM

Notably, in both the control and clinical group, intentionality endorsement scores for ambiguous but prototypically accidental action were not significantly related to ToM scores (results reached marginal significance in the ASC group). However, the small sample size (n_{ASC}=19; $n_{Control}$=20) makes it difficult to establish whether ToM abilities are truly not involved in discerning the intentionality of ambiguous actions or whether our analysis was simply under-powered. According to Klin (2000), it is an oversimplification (or even mistake) to assume that ToM deficits can explain all aspects of social communication impairments in autism. Klin puts forward two lines of evidence. Firstly, he argues that good performance on ToM tasks does not necessarily guarantee good social adaption skills (see Klin, 2000; Klin, Volkmar, Schultz, Pauls, & Cohen, 1997). Secondly, empirical evidence suggests teaching children ToM skills improves their performance on experimental ToM tasks but not necessarily their social- or communicative capabilities (see Ozonoff & Miller, 1995; Hadwin, Baron-Cohen, Howlin, & Hill, 1997).

One of the possible factors that might enable individuals with ASC to pass ToM tasks but does not necessarily lead to good naturalistic social adaption is verbal scaffolding. Previous research suggests that individuals with ASC often use their verbal skills on ToM tasks (e.g., Happé, 1995a), however, these can potentially not be used to the same extent in our spontaneous everyday social interactions, in which situations change quickly, problems are not verbally formulated and learnt scripts are not suitable (Klin, 2000). In our ASC sample, performance on all three ToM sub-measures significantly and positively correlate with verbal IQ, whereas there is no relation between verbal IQ and ToM abilities in the control group (Table 5.3), which could be a result of individuals in the ASC group relying more heavily on their verbal skills when solving the ToM task rather than genuine social skills.

A point worth noting, however, is that Zuccheli and colleagues (2018) found a mediating role of ToM in attributing intent to ambiguous behaviour. One underlying reason for this could be that in their study, ToM could be indexing executive functioning skills. Previous research suggests that ToM abilities are strongly linked to executive functioning (e.g., Carlson, Moses, & Breton, 2002), hence, it is possible executive functioning skills rather than ToM per se are driving their results.

Role of executive functioning

Rosset and Rottman's (2014) framework suggests perceiving behaviour to be accidental is what indicates mature intentional reasoning. Accordingly, understanding that an agent's overt behaviour does not necessarily correspond to its mental state requires more cognitive demand than simply perceiving intentionality. This is because, 1) it entails processing and taking into account additional sources of information such as the observer's past experience, alternative (e.g. environmental) causes for behaviour and the agent's motivation, and 2) it requires inhibition of an automatic response of judging behaviour to be intentional. Both aspects involve executive functioning.

Executive functioning is an umbrella term used to talk about functions including planning, inhibitory control, working memory and cognitive flexibility (see Hill, 2004). In fact, a number of disorders associated with social dysfunction are also associated with frontal lobe or executive functioning deficits (see Alvarez & Emory, 2006; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005; Royall et al., 2002), and the general consensus is that executive functioning skills play a major role in social cognition and interaction. As mentioned above, individuals with ASC have also been found to exhibit executive functioning deficits (see Hill, 2004). These could come into play when judging intentionality of ambiguous action. A special focus here should be put on inhibition and cognitive flexibility: inhibition could be necessary for stopping any automatic responses and allowing for more thorough processing of social information (based Rosset's dual-process theory); and cognitive flexibility could be necessary to shift to an alternative thought or response and may permit the idea that information (agent's overt behaviour and mental state) can be conflicting.

Unfortunately, in this study no measure of executive functioning was employed, but future research could consider including tasks such as the Go/No-Go task (Ozonoff, Strayer, McMahon, & Filloux, 1994) to investigate the role of inhibition, or the Intradimensional-Extradimensional shift (ID/ED shift) task of the CANTAB (Hughes, Russell, & Robbins, 1994) to investigate the role of cognitive flexibility.

Ambiguous but prototypically intentional action

Notably, there was no significant group difference in intentionality endorsement scores for Prototypically Intentional test sentences. We assume that this indicates an unsuitable test category rather than a meaningful finding. Pilot work conducted by our research group consistently fails to detect group differences in intentionality endorsement scores of Prototypically Intentional tests sentences. A contributing factor for this could be the small number of stimuli (12 compared to 22 in the other test category), which means that a single item accounts for a bigger proportion of intentionality endorsement scores and, hence, the variability within each group is inflated. This could make it more difficult to detect any potential differences. Also, as previously mentioned, Prototypically Intentional test sentences involve cues marking the action to be intentional, hence, automatic as well as analytical processing is assumed to lead to similar judgements. This means there would be no difference in response due to executive functioning deficits (as common in ASC). Therefore, in future investigations, we suggest excluding the category of Prototypically Intentional test sentences, as they do not seem to be an appropriate test category.

Limitations

In addition to the lack of an executive functioning measure discussed above, there are a number of limitations to the study that are briefly outlined here.

Firstly, as already mentioned, in the current design, it is impossible to assess whether participants with ASC, who responded incorrectly to any control items, did so because of factors such as reading comprehension or inattentiveness or because of a social information processing style related to their condition. As we assumed the latter, for the main analysis we did not exclude participants on the basis of incorrectly responding to control items. However, future studies should consider including a new control category asking participants to judge a different aspect of the agent's action than its intentionality to assess reading comprehension/attentiveness. This would be conclusive in terms of the nature of incorrect responses.

Secondly, the sample size of this study was low and as a result our analysis is likely underpowered. A follow-up study with a bigger sample should be considered to replicate the group difference in intentionality endorsement scores for ambiguous but prototypically accidental actions and to establish whether ToM can predict intentionality endorsement scores with sufficient power.

Thirdly, our ASC group consists of high functioning adults only. Although this comes with the benefit that the ASC- and control group are matched in IQ, it has to be taken into account that our sample only represents a subgroup and our results cannot necessarily be generalised to the entire ASC population.

Conclusion and future directions

The current study investigated the intention attribution style of individuals with ASC when facing ambiguous action. Individuals with ASC had a tendency to over-attribute intention compared to neurotypical controls. This difference could not be explained by deficits in ToM abilities, which, however, could be due to insufficient power. Therefore, future research should aim to replicate the effect and further explore the role of ToM in a bigger sample. As discussed, a non-intentional control condition for the intention attribution task and an executive functioning measure could be included in future studies. Additionally, future research could explore intention attribution for ambiguous actions in children with ASC to explore whether there can be found similar group differences between children with ASC and controls. Given that ASC is a neurodevelopmental condition, one could assume that there would be delays in maturation of intentional reasoning, which may lead to an augmented difference between children with ASC and controls.

CHAPTER SIX

Differences in Intention Attribution Style between Children with ASC and Neurotypical Controls

Abstract

A study was conducted investigating differences in *intention attribution style* between children with ASC and neurotypicals. 15 children with ASC and 15 neurotypical controls were asked to judge whether actions ambiguous in intentionality were done on purpose or by accident. Our results showed that participants with ASC judged significantly more ambiguous but prototypically accidental actions to be intentional than neurotypical controls. This is the same pattern found in adults with ASC in the experiment presented in *Chapter 5*. The number of actions judged to be done on purpose was not related to verbal ability, i.e. verbal ability could not explain group differences. Possible factors contributing to the group difference are discussed, including anxiety and executive functioning deficits.

Introduction

In a previous study (*Chapter 5*), we investigated differences in intention attribution style between adults with ASC and neurotypical controls. We found that individuals with ASC judged significantly more ambiguous but prototypically accidental actions to be intentional. This difference in intention attribution style could be an underlying factor for social difficulties in ASC. For example, individuals act more aggressively towards harmful behaviour they perceive to be intentional rather than accidental (e.g., Taylor, Shuntich, & Greenberg, 1979). Over-attribution of intent has an impact on social interaction and as a result can lead to predicaments or to rejection by others. Therefore, studying intention attribution style in ASC is of great importance.

As a logical progression of the study with an adult ASC sample, in this study, we will investigated whether differences between individuals with ASC and neurotypicals are already present in childhood and early adolescence, an important developmental period in the context of social cognition (Bukowski, Newcomb, & Hartup, 1998; Parker & Gottman, 1989).

Difficulty accurately inferring intention

A key feature of ASC is delayed or reduced development of communicative understanding and social skills, a crucial aspect of which is attributing mental states and making accurate conclusions based on them (Simon Baron-Cohen, 2001). This ability is also referred to as Theory of Mind (ToM) or mentalising and includes the ability to infer all types of mental states, as for example beliefs, desires, emotions, imagination and intentions. A vast body of literature suggests weaker performance on different ToM tasks of children with ASC compared to neurotypical controls, i.e. the ability to mentalise is compromised or develops at a later stage (for review see Baron-Cohen, 2000).

Of special interest for this study is the apparent difficulty of understanding intentions in ASC. For example, children with ASC have been found to show deficits in understanding figurative speech (for review see Happé, 1995b). Figurative speech (e.g., irony, sarcasm, metaphors, etc.) requires the listener to have an idea of the speaker's intention to move beyond the literal level of what is being said and is considered to be an advanced ToM skill. Evidence suggests that children with ASC have a harder time understanding intentions behind figurative utterances compared to neurotypical controls (e.g., MacKay & Shaw, 2004; Peterson, Wellman, & Slaughter, 2012; Wang, Lee, Sigman, & Dapretto, 2006). According to Happé (1995b), the failure to interpret the speaker's utterance based on their thoughts and mental states is an underlying reason for communication difficulties. Whereas a literal interpretation might work for some cases (e.g., "Can you give me an apple?", "The water is boiling."), it might lead to confusion for others (e.g., "Can you give me a hand?", "It's boiling today."). The evidence suggests that the difficulty lies in understanding that the overt behaviour (i.e., literal meaning of utterance) does not necessarily align with the covert behaviour (i.e., intention). This is of particular interest in this study, as the focus is the perception of ambiguous action, in which the action does not necessarily correspond to an intention.

Similarly, previous literature suggests that children with ASC have difficulties with faux-pas detection, i.e. they have deficits in understanding that a negative outcome was not intended (e.g., Baron-Cohen, O'riordan, Stone, Jones, & Plaisted, 1999). Children's deficits in faux-pas detection are associated with peer-rejection (Banerjee & Watling, 2005; Banerjee, Watling, & Caputi, 2011), which could indicate that a lack of understanding of *accidental* insults fosters negative social interactions. Therefore, it is important to study intention attribution styles in childhood and adolescence – at an age at which social behaviour and cognition is developing and being consolidated through interaction with others (see Forrester, 2013), self-identity develops (Coleman & Hendry, 1990) and positive peer-relationships are crucial for an individual's wellbeing (Asher & Coie, 1990).

Differences in social attribution style

It is widely known that there is a high prevalence of comorbid psychiatric symptoms such as anxiety or depression in ASC (see Simonoff et al., 2008).

Meyer and colleagues (2006) argue that atypical information processing in social situations might be an underlying reason for the high prevalence of such symptoms in children with ASC. This suggests that affected children are indeed socially aware (as opposed to “mind-blind”) and suffer under negative social experiences. Children with Asperger syndrome showed deficits in psychosocial adjustment, which was linked to how they processed social information (hostile vs benign), i.e. their social information processing patterns or -style (Meyer, Mundy, Van Hecke, & Durocher, 2006). Similarly, so-called hostile attribution biases (the tendency to perceive action as having hostile intent) have been found in children diagnosed with conduct disorder, depression and paranoid ideation (Dodge, 1993; Quiggle, Garber, Panak, & Dodge, 1992; Turkat, Keane, & Thompson-Pope, 1990), and are associated with feeling threatened (Dodge & Somberg, 1987) and with impulsivity (Dodge & Newman, 1981).

There are various factors that might shape a child’s social information processing style, one of them being past experience. First, children encode and interpret social information and then they consider an appropriate reaction. Previous experience can influence how information is processed and, hence, reinforce a negative interaction. For example, in the case of judging intentionality of ambiguous action, a child that has previously been bullied might tend to interpret being hit with a ball as an intentional rather than accidental action. As a result, the child might be more likely to react aggressively. This, in turn, would likely make the interaction an unpleasant experience, which would influence how information is processed in the future. This can lead to a self-reinforcing cycle of negative social experiences.

To date, there has been little research on social attribution styles of children with ASC. One underlying reason for this is that ASCs are considered to entail *deficits* in all aspects of socio-cognitive abilities, as for example, executive functions, ToM and emotional decoding (Capps, Yirmiya, & Sigman, 1992; Dahlgren & Trillingsgaard, 1996; Klinger & Renner, 2000; Macdonald et al., 1989; Ozonoff & Griffith, 2000; Ozonoff, Rogers, & Pennington, 1991; Schultz, Romanski, & Tsatsanis, 2000). Because of this assumption, past research has put an emphasis on what they *cannot* do rather than on *how* they do it. However, even though children with ASC might have socio-cognitive deficits, they could still try to interpret and attribute social information. The pattern of how they do it, in other words, their *social information attribution style,* might be conclusive in terms of psychological well-being and interventions (Meyer et al., 2006).

Previous research has found that adults diagnosed with Asperger syndrome (AS; an autism condition associated with relatively spared intellectual ability) performed worse on a ToM task but scored higher on a measure of paranoid attributions compared to controls (Blackshaw, Kinderman, Hare, & Hatton, 2001). According to the authors, the paranoia was caused by confusion about social interactions and was linked to private self-consciousness. Similarly, it has been argued that the diminished ability to consider alternative perspectives when processing social information in AS might contribute to increased suspicion and hostile attributions (Frith, 2004). Hence, atypical socio-cognitive processing may not prevent individuals with ASC from making social interpretations and attributions but rather predispose them to such that might be faulty and/or do not encourage positive social interactions. This might play a role in the high prevalence of comorbid psychiatric symptoms.

Intention attribution style specifically

As mentioned above, in the case of intention attribution style, specifically, adults with ASC show an increased tendency to perceive ambiguous but prototypically accidental action to be intentional compared to neurotypical controls (*Chapter 5*). In contrast to studies on hostile attributions, in which participants either attribute hostile or benign intent to behaviour associated with a negative outcome, the focus of the present research is whether participants attribute intention to ambiguous behaviour. As discussed in previous chapters, ambiguous behaviour is assumed to be of great importance as not only social actions are often ambiguous, but also studying judgements of ambiguous actions allows us to capture differences in processing styles rather than in accuracy. Also, ASC individuals with spared cognitive ability may use coping mechanisms to achieve accuracy, which makes it difficult to detect subtle differences to neurotypical controls (Hull et al., 2017; Livingston & Happé, 2017).

The aim of this study, therefore, is to investigate whether there are differences in intention attribution style between children with ASC and neurotypical controls. As in the previous study with an adult ASC sample, Rosset's (2008) Ambiguous Sentence Paradigm will be used. However, in the current study, the focus will be only on Prototypically Accidental test sentences, as we assume this to be the only suitable test category (for discussion see *Chapter 5*).

Hypothesis

In line with results from the previous chapter, we predict children with ASC to judge significantly more ambiguous but prototypically accidental actions to be intentional (directional hypothesis).

Methods

Participants

The study was approved by Goldsmiths College Department of Psychology Ethics Committee. Participants were recruited in four different schools based in London and other parts of South East England (United Kingdom). Three of them were Primary Schools and one of them a Secondary School. 16 participants with an ASC diagnosis participated in the study, however, one of them had to be excluded due to an insufficient number of trials responded to (<75%), which resulted in a group size of 15 participants (Age in months: M=145 (*SD*=30.02), mean equivalates to 12.08 years; Age range: 101-185 months, equivalates to 8.4-15.4 years; 3 females). The control sample was drawn from the sample of neurotypical children collected for the study investigating the effects of age and cognitive ability on judging intentionality (*Chapter 4*). To match the groups in age as closely as possible, data of the oldest 15 participants who had responded to a sufficient number of trials were used from this sample (Age in months: M=142 (*SD*=13.3), mean equivalates to 11.83 years; Age range: 132-181 months, equivalates to 11-15.08 years; 5 females). Importantly, the control sample was chosen blind to scores on the variables of interest (intentionality endorsement scores). Analysis revealed no significant differences of age ($t(19.3)=-.362$, $p=.721$), verbal reasoning ability (VCI; $t(28)=.977$, $p=.337$) or perceptual reasoning ability (PRI; $t(28)=-.76$, $p=.453$) between the ASC and control group (Table 6.1). All participants could read independently.

Table 6.1. Group means for age in months, verbal reasoning ability (VCI) and perceptual reasoning ability (PRI) with standard deviations in brackets.

	Age (months)	VCI	PRI
ASC	145 (*30.02*)	89.87 (*13.8*)	96.4 (*18.67*)
Controls	142 (*13.30*)	95.33(*16.71*)	91.53 (*16.32*)

Measures

IQ Measure

To measure participants' IQ, the Wechsler Abbreviated Scale of Intelligence II was used (WASI-II; Wechsler, Zhou, Corporation., & Laboratory), 2011). It consists of four sub-tasks, two of them (Vocabulary, Similarities) assessing verbal reasoning ability and the other two (Block Design, Matrix Reasoning) assessing non-verbal perceptual reasoning ability. Each participant received a verbal reasoning ability score (VCI) and a perceptual reasoning score (PRI) score, which reflect performance taking into account age.

Ambiguous Sentence Paradigm

To measure participants' tendency to judge ambiguous behaviour to be intentional, they were asked to complete Rosset's (2008) Ambiguous Sentence Paradigm. Every participant completed the task on a computer or laptop in their own time. For details of the paradigm, please refer to *Chapter 4*. For each participant, an intentionality endorsement score for

Prototypically Accidental test sentences was calculated. Stimuli of the other test condition of Rosset's original paradigm (Prototypically Intentional test sentences) were treated as filler questions, as we believe it not to be a useful test category and have no predictions regarding any group differences or similar.

Results

Control Sentences

A non-parametric Mann-Whitney U test revealed no significant difference between groups for either category of control sentences (Accidental: U=73.50, p=.092; Intentional: U=82.00, p=.161). Based on this, we assume that task comprehension and attention to the task did not differ significantly between groups. For the main analysis, participants were not excluded based on incorrect responses to control trials as atypical response patterns could be inherent to ASC in children. However, for completeness, the analysis was repeated only including participants who had not incorrectly responded to more than one item of any control category.

Main analysis: Judging intentionality of ambiguous action

As discussed above, the focus of the analysis was Prototypically Accidental test sentences. A one-tailed independent samples t-test revealed a significant difference in intentionality endorsement scores for Prototypically Accidental test sentences (*t*(21.31)=-2.01, *p*=.029). Participants with ASC (M=33.58, *SD*=20.21) scored significantly higher than neurotypical controls (M=21.73, *SD*=10.72; Figure 6.1).

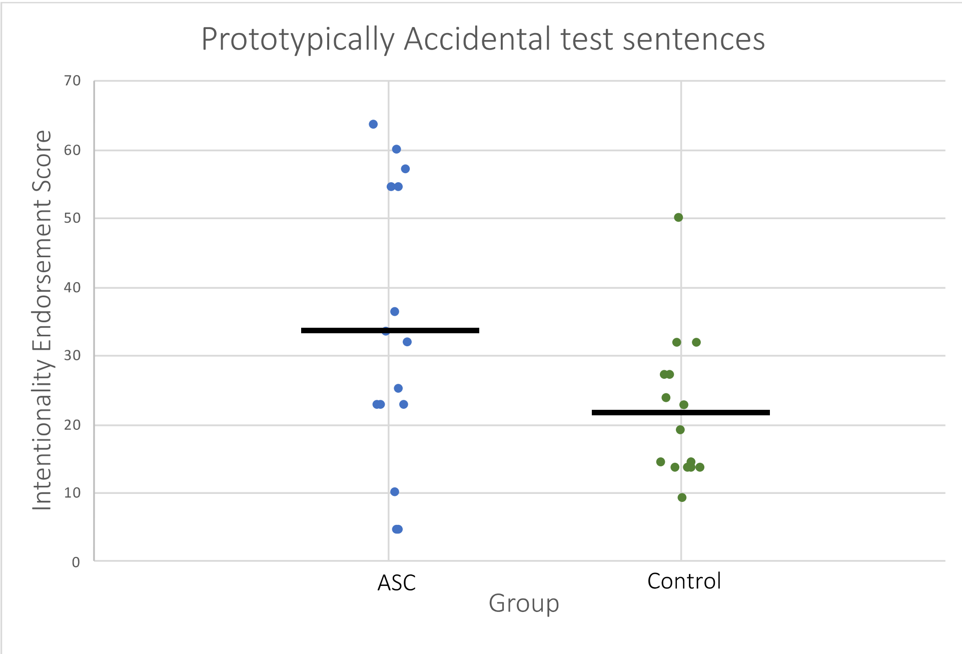


Figure 6.1. Intentionality endorsement scores for Prototypically Accidental (PA) test sentences for ASC- and control group. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

Analysis repeated with sub-sample

Excluding participants who had incorrectly responded to more than one item of any control category reduced the sample size to 16 participants. Although ASC participants (n=7; M=26.48, *SD*=17.55) still showed higher intentionality endorsement scores than controls (n=9; M=18.42, *SD*=7.44), a one-tailed independent samples t-test revealed that this difference was not significant (*t*(14)=-1.249, *p*=.116; Figure 6.2).

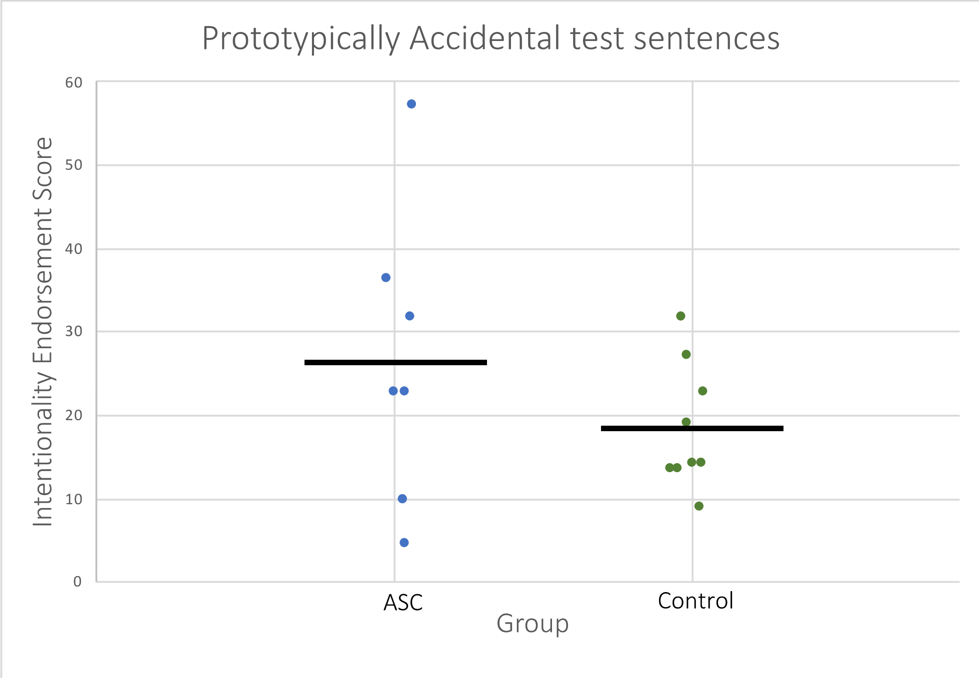


Figure 6.2. Intentionality endorsement scores for Prototypically Accidental (PA) test sentences for ASC- and control group excluding participants with too many incorrect control items. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

Relation to verbal reasoning ability

To investigate the role of verbal ability in judging intentionality of ambiguous action, Pearson's correlation analyses were conducted in each group separately. There was no significant correlation between verbal reasoning ability (VCI) and intentionality endorsement scores for Prototypically Accidental test sentences in either group (ASC: *r*=-.230, p=.411; Control: *r*=-.090, *p*=.749).

Discussion

A study was conducted investigating the differences in intention attribution style of children with ASC and neurotypical controls. In line with our predictions, results indicated that overall children with ASC more readily judge ambiguous but prototypically accidental behaviour to be intentional than controls. Although the Ambiguous Sentence paradigm is a verbal task, we are confident that the group difference is not caused by verbal ability as a) there were no significant differences in verbal ability between ASC and control group, and b) there was no correlation between verbal ability and intentionality endorsement scores in either group. Therefore, we assume our results reflect a genuine cognitive difference in intention attribution style. This is a noteworthy result, as it provides insight into the nature of intention attribution in children with ASC, which might play a role in social- and mental well-being.

Importantly, as in the previous chapter, an analysis with a sub-sample of participants who had not incorrectly responded to more than one item of any control category did not reach significance. As argued previously, reasons for this could be that a) in this analysis, we excluded individuals with atypical social attribution patterns who had been driving the group difference, and b) there was insufficient power to detect group differences due to a too small sample size.

Intention attribution style and anxiety

Previously, it has been suggested that differences in social attribution patterns might be a mediating factor for the high comorbidity of psychiatric symptoms such as anxiety or depression in children with ASC (Meyer et al., 2006). Children with ASC might process social information in a way that does not necessarily promote successful social interaction. Especially for more socially aware individuals, this can have a negative impact on self-confidence and feeling socially connected. Additionally, negative experiences in social interactions could perhaps increase social anxiety and influence how social information is processed in the future. An individual who has had one negative social interaction, therefore, is more likely to experience another one. This highlights the importance of studying intention attribution styles in ASC, as it might give us some insight into diminished social- and mental wellbeing.

Additionally, it suggests that there might be a reciprocal relationship between social anxiety and atypical patterns of intention attribution, in which being anxious promotes over-attributing intent and the other way around. Affected individuals might be confused over how to interpret an ambiguous social situation and feel threatened and as a result err on the side of caution by judging an action to be intentional (i.e., targeted). In line with this, previous findings suggest that socially anxious children are more likely to attribute (hostile) intent to accidental situations associated with negative outcomes (Bell-Dolan, 1995). Perhaps, the increased tendency to attribute intent to ambiguous but prototypically accidental action in the current study could be partly explained by social anxiety. To investigate this, future research should, therefore, consider including a measure of social anxiety to investigate whether it can explain group differences.

Role of executive functioning

Another possible underlying reason for the group differences in intention attribution style are deficits in executive functioning skills. As discussed in previous chapters, according to Rosset's (2008) dual-process model of intention attribution, *unintentional* explanations of behaviour are only possible when an automatic *intentional* explanation is overridden by a cognitively higher-level process. This implies, when executive functioning ability is temporarily compromised or generally diminished, most behaviour will be judged to be intentional. ASC is associated with deficits in executive functioning, including inhibition (Hughes & Russell, 1993; Hughes et al., 1994; McEvoy, Rogers, & Pennington, 1993). Meyer and colleagues (2006) found some measures of executive functioning (including verbal inhibition) to be negatively related to the likelihood of attributions of hostile intent. This strengthens the argument that there could be an association between executive functioning deficits and intention attribution. Future research should, therefore, include a measure of executive functioning skills to investigate whether it can explain group differences in judging intentionality of ambiguous action.

Reduced ability to generate other possible causes for behaviour

Following on, an integral aspect of judging behaviour to be accidental is taking into consideration alternative causes for behaviour (i.e., generating novel potential underlying reasons for an event; Rosset, 2008). It is possible that children with ASC are less able to consider alternative explanations for an event than their neurotypical peers. Frith (2004), for example, argued that the reduced ability to consider alternative perspectives when processing social situations might contribute to more hostile attributions in AS.

Evidence supporting the hypothesis that children with ASC are less likely to consider causes alternative to the overt behaviour comes from studies demonstrating imaginative deficits in ASC (for review see Crespi, Leach, Dinsdale, Mokkonen, & Hurd, 2016). It is possible that these deficits contribute to the decreased likelihood of judging an action to be non-intentional in children with ASC. For example, there are a number of non-intentional reasons an agent can break a vase: the vase could be wet and slip through the agent’s hands; the agent could accidentally push the vase off the table when walking by; the agent could accidentally apply too much pressure when cleaning the vase; etc. Coming up with such explanations requires a participant to imagine a situation or some additional information that is not presented.

The executive dysfunction theory (Ozonoff, Pennington, & Rogers, 1991) states, that individuals with ASC have difficulty withholding or overriding automatic responses to allow for the generation of novel thoughts (Craig & Baron-Cohen, 1999). This directly relates to Rosset's (2008) dual-process model and the role of executive functioning discussed above. Therefore, in addition to a measure of executive functioning, future research could consider including a measure of imaginative fluency (e.g., Craig & Baron-Cohen, 1999).

Wider range of scores in the ASC group

When looking at the distribution of intentionality endorsement scores (Figure 6.1), it becomes apparent that participants in the ASC group showed a wider range of scores than neurotypical controls. In fact, the lowest intentionality endorsement score of the entire sample can be found in the ASC group. A reason for this could be that children with ASC have a decreased understanding of social situations and, therefore, do not conform on similar judgement patterns. It further suggests that it might be a sub-group of children with ASC which is driving the difference in intentionality endorsement to neurotypical controls. In light of this, it would be unsurprising that when those with atypical response patterns are excluded (see Analysis repeated with sub-sample), the group difference does not reach significance anymore.

Limitations

It is important to note that the age range of our sample was eight to 15 years. Practical constraints did not allow us to collect a large enough sample to split the age range into children and young adolescents. We are aware that individuals undergo substantial social, cognitive and socio-cognitive development in this period of their lives, and therefore, it might not be ideal to combine this age range into one group. We acknowledge this limitation, however, we believe our results still demonstrate valid and noteworthy group differences.

Furthermore, due to the nature of the Ambiguous Sentence Paradigm, we were restricted to including only individuals who could read independently. ASC is often associated with deficits in verbal ability and a number of affected children never learn how to read or only at a later stage. Therefore, our sample is only representative of a subgroup of ASC individuals with relatively spared verbal ability.

Conclusion

The aim of this study was to investigate how children with ASC judge the intentionality of ambiguous but prototypically accidental action, in other words, to study their intention attribution style. Against more traditionally hold views of ASC being characterised by overall deficits in responsiveness to others, in this study we took the approach that children with ASC are indeed socially aware in their own way. Our results suggest that they judge more ambiguous behaviour to be intentional than neurotypical controls. This shows that in our sample rather than being socially unresponsive, children with ASC indeed attribute intentional states to others, however, the way they go about it is different to that of neurotypicals. Identifying socio-cognitive *style differences* rather than simply deficits is important, as it allows us to understand how individuals with an ASC handle social situations, what coping mechanisms they apply (see Klin, Jones, Schultz, & Volkmar, 2003) and might be conclusive in terms of comorbidity of psychiatric symptoms (Meyer et al., 2006). In contrast, knowing about deficits in socio-cognitive abilities alone might not reveal how individuals with ASC process social information and try to manage situations.

As discussed above, there are a number of factors that could explain the difference in intention attribution style between children with ASC and neurotypicals, including social anxiety and executive functioning deficits. The aim of future studies should be to include the appropriate measure to investigate contributing factors and, thus, help to gain an even better understanding of intention attribution in ASC.

CHAPTER SEVEN

The role of autistic traits and executive control in judging intentionality of ambiguous action

Abstract

In this experiment we tried to a) replicate the findings of increased intentionality endorsement in adults with ASC, this time in an online study, and b) explore the relationship between intention attribution and certain individual differences variables. We found that the ASC group showed an increased tendency to attribute intent to ambiguous but prototypically accidental behaviour compared to neurotypical controls, thus replicating the findings from *Chapter 5*. In addition, the role of autistic traits, ToM skills, executive functioning deficits and cognitive ability was explored. There was some evidence for autistic traits and executive functioning deficits predicting intentionality endorsement scores, which did not differ as a function of diagnostic group (ASC vs Control). However, the effect of executive functioning deficits seemed to be reliant on including individuals who performed considerably worse on the executive functioning task than the rest of the sample. Nevertheless, the findings highlight a potentially important association between intentionality endorsement and autistic traits as well as executive functioning.

Introduction

Results from the study discussed in *Chapter 5* revealed an increased tendency to judge ambiguous but prototypically accidental behaviour to be intentional in adults with ASC. As argued in *Chapter 5*, these results could indicate a difference in *intention attribution style* between individuals with ASC and neurotypical controls. However, the study was based on a small sample and the effect was only marginally significant. Therefore, the primary aim of the current study is to replicate findings in a bigger sample. The secondary aim is to investigate possible underlying factors for the difference in intention attribution style by exploring the role of autistic traits, ToM skills, executive functioning skills and cognitive ability for a sub-sample of our participants for which test scores from an existing database could be obtained.

Role of autistic traits

Previous findings in a neurotypical population indicate that high autistic traits predict high intentionality endorsement for accidental action with negative side effects (Zucchelli et al., 2018). This suggests that an increased tendency to judge behaviour to be intentional is not necessarily down to belonging to a diagnostic group (ASC vs neurotypical), but rather to having high traits associated with such a group. The idea here is that psychopathology lies on a continuum with individuals on the extreme end of the continuum fulfilling diagnostic criteria. Therefore, in this study scores on the Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) will not only be used to confirm that individuals are representative of the two groups under investigation (neurotypical vs. ASC) but will also be used to investigate the role of autistic traits in judging intentionality *across* individuals, irrespective of group membership.

Furthermore, it will be explored whether autistic traits predict intentionality endorsement differently in the ASC and the control group. In other words, we will investigate whether the relation between autistic traits and intentionality endorsement is dependent on being a member of a diagnostic group. This would give an indication of whether autistic traits affect intention attribution patterns similarly across a continuum, with individuals with an ASC diagnosis being at one end of this continuum, or whether intention attribution patterns are strictly different between both groups.

Role of Theory of Mind (ToM)

In addition to autistic traits, the role of ToM will be explored. In the previous study (*Chapter 5*), ToM deficits did not correlate with intentionality endorsement scores, i.e., they could not explain group differences in intentionality endorsement. However, with a sample size of 20 individuals per group, the study was likely under-powered, therefore, it is difficult to ascertain whether intentionality endorsement of ambiguous action is truly independent of ToM skills. Therefore, in the current study, a measure of ToM skills will be included to explore its role in judging intentionality of ambiguous action.

Previously, ToM skills have been shown to partly mediate the association between autistic traits and intentionality endorsement of ambiguous action (Zucchelli et al., 2018). However, as argued in *Chapter 5*, in Zucchelli and colleagues' (2018) study, ToM skills could be an index for executive functioning skills. ToM abilities have been shown to be strongly linked to executive functioning (e.g., Carlson, Moses, & Breton, 2002), therefore, executive functioning skills rather than ToM per se could be driving Zucchelli and colleagues' (2018) results. One aim of the current study, therefore, is to get a clearer understanding of the role of ToM in judging intentionality of ambiguous action. In contrast to the study discussed in *Chapter 5*, a non-verbal ToM measure will be used (The Reading the Mind in the Eyes Test, RMET). It has previously been used by Zucchelli and colleagues and has the advantage that it does not need to be conducted in a lab-setting.

Role of executive functioning

According to Rosset's (2008) dual-process model, humans have an automatic tendency to judge behaviour to be intentional. This automatic response can be inhibited and overridden by a more controlled process leading to an unintentional explanation for behaviour. Therefore, judging behaviour to be unintentional likely involves executive functioning (Rosset, 2008; Rosset & Rottman, 2014). ASC has been associated with executive functioning deficits (see Hill, 2004), which could be a contributing factor for increased intentionality endorsement of ambiguous action. In previous chapters of this thesis, the role of executive functioning was indirectly explored by studying factors such as age and cognitive ability, which are positively related to executive functioning (see *Chapter 3* and *4*). In the present study, the role of executive functioning will be looked at directly by using a measure of inhibitory control (*Go/No-Go Task; GNG task*), a main aspect of executive functioning (see Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003).

Role of cognitive ability

In addition to impaired executive functioning, ASC is often associated with decreased cognitive ability (or cognitive capacity, i.e., efficiency of information processing; e.g., Ballaban-Gil, Rapin, Tuchman, & Shinnar, 1996; Volkmar, Klin, Marans, & McDougle, 1996). According to Rosset and Rottman's (2014) framework, efficient information processing (as indicated by higher performance on cognitive ability tests) facilitates inhibition and overriding of default responses. In previous studies (e.g., *Chapters 5* and *6*) measures of cognitive ability were included to test for this assumption. Results suggested no relation with intentionality endorsement scores and, hence, cognitive ability could not explain differences in intentionality endorsement scores between individuals with ASC and controls. However, the previous studies only included small samples, therefore, a measure of cognitive ability (Ravens Advanced Progressive Matrices, RAPM) will also be included in this study to once more explore its relation to intentionality endorsement in a bigger sample.

Present study

In line with *Chapter 6*, the present study only focuses on ambiguous but prototypically accidental actions (i.e, Prototypically Accidental test sentences). As previously discussed, this is the only test category of the Ambiguous Sentence Paradigm assumed suitable to detect individual differences in intention attribution style. Therefore, in the present chapter, when speaking of intentionality endorsement scores, intentionality endorsement scores for Prototypically Accidental test sentences are referred to.

Hypotheses

- Firstly, based on previous results, we predict that individuals with ASC will show a greater tendency to judge ambiguous action to be intentional.

- Secondly, we predict that intentionality endorsement scores will be positively related AQ (autistic traits)- and GNG task error (executive functioning deficits) scores and negatively related to scores RMET (ToM)- and RAPM (cognitive ability) scores.

Methods

Participants

The study was approved by Goldsmiths Psychology Department Ethics Committee. Participants were recruited via an email newsletter sent out to members of the Cambridge Autism Research Database (CARD). This is a database containing data and contact details of 30,000 individuals and families with and without an autism spectrum diagnosis. To participate, individuals had to follow a link included in the email. Participants were asked whether they had an ASC diagnosis at the beginning and at the end of the study. Only participants who indicated the same diagnosis status both times were included in the study.

The study was started by 164 individuals (n_{ASC}=92, $n_{Control}$=72). Duplicates, as well as participants who had responded to fewer than 75% of the test sentences of the Ambiguous Sentence Paradigm, were excluded. Participants of the control group who had AQ scores of 32 or above were excluded from analysis, as 32 is commonly used as a cut-off point to exclude individuals with clinically significant levels of autistic traits (Simon Baron-Cohen, Wheelwright, Skinner, et al., 2001). One participant had to be excluded because they indicated being a “basic” English speaker, all remaining participants were either native or fluent English speakers. This resulted in a final sample size of 143 participants (n_{ASC}=87, $n_{Control}$=56; Table 7.1). There was a significant difference in AQ scores between participants with an ASC diagnosis and controls, i.e., the groups are representative (t(99.36)=17.92, p<.001).

Table 7.1. Age in years, performance on AQ with standard deviation in brackets, number of females, number of native speakers and intentionality endorsement scores for Prototypically Ambiguous test sentences (PA), Accidental- (UA) and Intentional control sentences (UI) with standard deviations in brackets for both groups.

	Age	AQ (max 50)	Nr of females	Nr of native speakers	PA	UA	UI
ASC (n=87)	38.01 (*10.8*)	39.47 (*5.86*)	56	79	23.88 (*18.94*)	1.84 (*5.61*)	99.65 (*2.39*)
Controls (n=56)	43.58 (*8.08*)	18.71 (*7.21*)	46	51	17.78 (*9.39*)	2.14 (*6.24*)	99.64 (*1.87*)

Unfortunately, data for some participants were missing for the Raven’s Advanced Progressive Matrices (RAPM), Reading the Mind in the Eyes Test (RMET), and the Go/No-Go (GNG) Task. The reason for this was that participants had either not completed the tasks or they provided no, or incorrect, personal identifiers. This issue was particularly acute in the neurotypical group. To check whether the sub-sample was representative of the whole sample, t-tests comparing AQ scores and intentionality endorsement scores of the sub-sample and the whole sample were conducted. Analysis revealed no significant differences in intentionality endorsement scores nor AQ scores between the sub-sample and the whole sample for neither the ASC (intentionality endorsement: $t(130)=-.325$, $p=.746$; AQ: $t(130)=.189$, $p=.850$) nor the control group (intentionality endorsement: $t(67)=-1.804$, $p=.076$; AQ: $t(67)=-1.730$, $p=.088$). (Please note that results reach marginal significance for the control group and it is, therefore, hard to ascertain whether the control sub-group was representative of the whole control group.)

Group differences for the sub-sample of participants for which all CARD scores could be obtained were explored (Table 7.3). Both groups performed generally well on the RAPM and the. GNG Task, i.e., data were skewed. Non-parametric Mann-Whitney U tests revealed no significant differences in RAPM percentage scores ($U=268$, $p=.647$), nor in the number of GNG errors ($U=279$, $p=.801$) between groups. Therefore, groups were assumed to have similar non-verbal cognitive ability and executive control. Furthermore, there was no significant difference in test scores for the RMET ($t(56)=-1.006$, $p=.319$). However, unsurprisingly, there was a significant difference in AQ scores ($t(56)=8.692$, $p<.001$).

Measures and Procedure

After reading the information sheet and giving consent to taking part in the study, participants were asked to complete a modified version of the Ambiguous Sentence Paradigm (Rosset, 2008) and subsequently the AQ (Simon Baron-Cohen, Wheelwright, Skinner, et al., 2001). For details of the measures, please refer to *Chapters 4* and *5*. As in the previous chapter, Prototypically Intentional test sentences were treated as filler questions.

In addition, participants were asked for permission to link their responses to their data stored on the CARD. For participants who had given permission, scores from the following measurements (collected online between 2007 and 2019) were obtained:

The Raven's Advanced Progressive Matrices (RAPM)

A timed test which functions as a non-verbal index of cognitive ability involving the completion of matrices (Raven, Court, Raven, & Kratzmeier, 1994). It consists of 60 trials. Scores reflect the percentage of trials answered correctly.

The Reading the Mind in the Eyes Test

The Reading the Mind in the Eyes Test (RMET) is a timed test measuring ToM ability in which participants are asked to choose from a set of mental state terms and match them to pictures of people's eyes (Simon Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). It consists of 36 grey-scale photographic images of human eyes. Participants are asked to choose one of four options describing what the person the eyes belong to is thinking or feeling. There is only one correct answer and participants are given 20 seconds to respond. If the participant fails to respond within the given time, the trial is treated as incorrect. The maximum total score is 36.

Go/No-Go Task,

The Go/No-Go (GNG) Task is a timed test measuring the executive function of sustained attention and response control (i.e., inhibitory control). Participants are asked to press buttons in response to pictures as quickly as possible and sometimes withholding a response. More specifically, they are presented an arrow pointing to the left or the right and press the corresponding button. If they are presented with an arrow pointing up, they are not supposed to press any button. The task consists of 300 trials, 220 of which asks for a response (110 arrow pointing right, 110 arrow pointing left); and 80 of which asks for no response. Participants have to respond within 1200 ms. An incorrect response would be pressing the wrong key, failing to withhold a key or failing to press a key within the time given (for details, please see Uzefovsky, Allison, Smith, & Baron-Cohen, 2016). An overall error score consisting of the number of incorrect trials was calculated (GNG error score). (Due to technical reasons it was not possible to differentiate between false-alarms and false-responses, which is why an overall error score was used for analysis).

Results

Control Sentences

As in *Chapter 5* and *6*, for the main analysis, no participants were excluded on the basis of answering incorrectly to too many control items, however, for completeness the analysis was repeated with a sub-sample of participants who did not respond incorrectly to too many control items. Generally, participants responded accurately to control items with a mean accuracy of 99.65% for Intentional control items and a mean accuracy of 98.04% for Accidental control items. Two Mann-Whitney U tests revealed no significant difference between the ASC- and the control group for either control category (Intentional: U=2406, p=.664; Accidental: U=2430.5, p=.968; Table 7.1).

Main analysis: Ambiguous Sentence Paradigm

There were no extreme outliers in intentionality endorsement scores in either group. As predicted, a one-tailed t-test revealed a significant difference between intentionality endorsement scores of individuals with ASC and neurotypical controls ($t(133.72)=2.56$, $p=.006$, Figure 7.1). This replicates findings from *Chapter 5*.

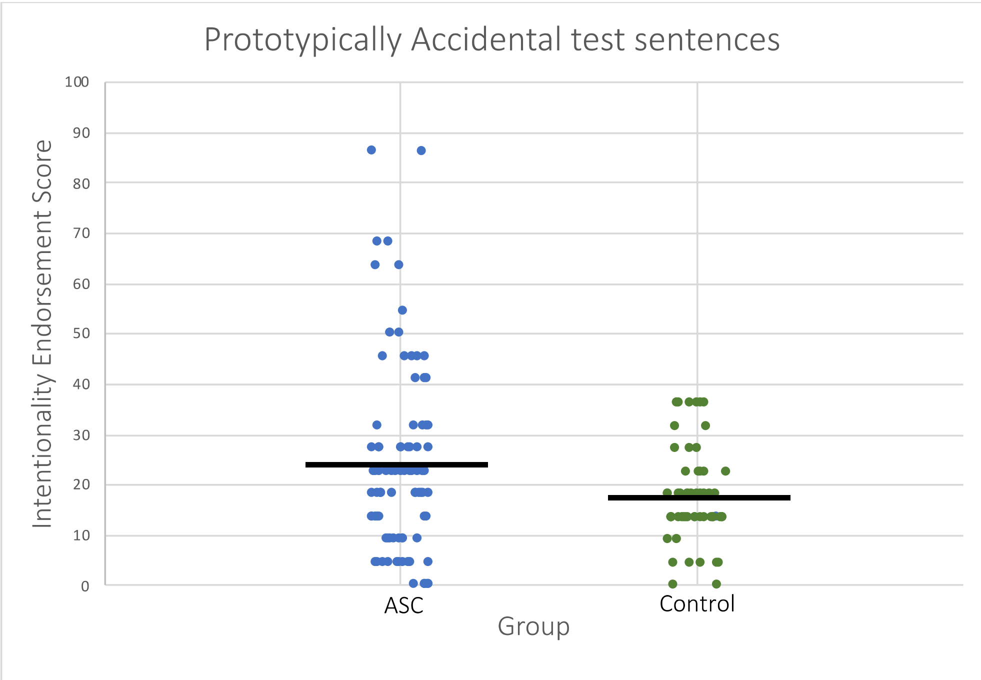


Figure 7.1. Intentionality endorsement scores for Prototypically Accidental test items for ASC- and control group. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of items judged to be intentional.

Analysis with sub-sample

For completeness, the same analysis was also conducted on a sub-sample consisting of participants who did not make more than one incorrect response of any control category. A one-tailed t-test revealed a significant difference between intentionality endorsement scores of individuals with

ASC and controls ($t(115.12)=2.04$, $p=.022$). ASC participants (n=75; M=20.73, *SD*=16.34) judged significantly more ambiguous but prototypically accidental actions to be intentional compared to controls (n=48; M=16.19, *SD*=8.12; Figure 7.2). Therefore, excluding participants based on incorrectly responding to control items did not change the significance of results.

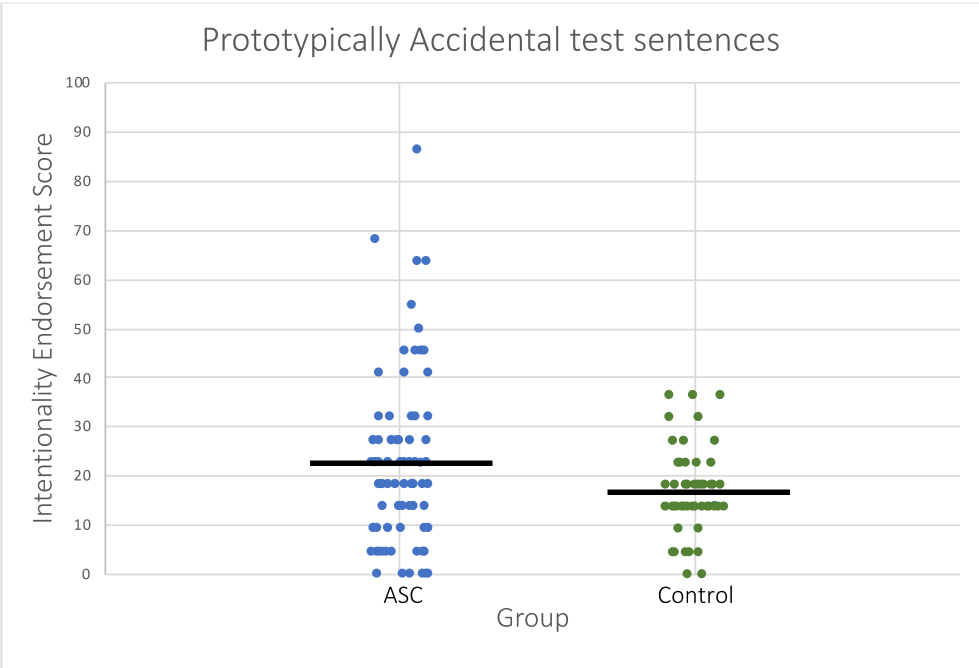


Figure 7.2. Intentionality endorsement scores for Prototypically Accidental test items for ASC- and control group excluding participants with too many incorrect control items. Each group's mean score is marked by a horizontal line. Intentionality endorsement scores reflect the percentage of items judged to be intentional.

Multiple regression analyses

To investigate the role of autistic traits (AQ scores), ToM (RMET scores), cognitive ability (RAPM scores) and executive functioning deficits (GNG error scores), a hierarchical multiple regression analysis using the enter method was conducted combining participants of both groups for whom the relevant scores could be obtained. Scores were standardised prior to analysis (zAQ, zRMET, zRAPM, zGNGerror). An examination of correlations (Table 7.2) prior to conducting the multiple regression revealed that no independent variables were correlated, with the exception of RMET scores and GNG error scores. However, values of the collinearity statistics (i.e., Tolerance & VIF) did not exceed commonly accepted limits (Field, 2013), hence, collinearity was not assumed to pose a problem.

Table 7.2. Pearson's correlation coefficient for standardised AQ scores, standardised GNG error scores, standardise RMET scores and standardised RAPM percentage scores and p-values.

	zAQ	zGNG	zRMET	zRAPM
zAQ	-	.036	-.183	-.002
		p=.787	p=.169	p=.986
zGNG	-	-	**-.323***	-.146
			p=.013	p=.273
zRMET	-	-	-	.120
				p=.369

Data screening revealed some univariate and multivariate outliers. As removing the outliers (especially univariate outliers with significantly higher GNG error scores) would considerably decrease the variance in our variables of interest and, hence, make it difficult to detect associations between variables, first, the analysis with outliers included (*Regression Analysis 1*) and, then, with outliers excluded (*Regression Analysis 2*) was conducted.

Multiple regression - outliers included (Regression Analysis 1)

In this section, no outliers were excluded from analysis. A two-stage hierarchical multiple regression was conducted with intentionality endorsement scores as the dependent variable (n=58; Table 7.3). At stage one, standardised AQ scores, GNG error scores, RMET scores and RAPM percentage scores were entered (*Model 1*). At stage two, the interaction terms of all four standardised independent variables with group (zAQ x zGroup, zGNG x zGroup, zRMET x zGroup, zRAPM x zGroup) were added, to see whether there was an interaction between the independent variables and diagnostic group (*Model 2*).

Table 7.3. Means and standard deviations for variables taken from CARD: RAPM percentage scores, The Reading the Mind in the Eyes test scores, nr of Go/No-Go Task errors, AQ scores and intentionality endorsement scores for Prototypically Accidental test sentences (PA) with standard deviations. Intentionality endorsement scores reflect the percentage of items judged to be intentional. These scores are inclusive of all participants for which all CARD scores could be obtained, no outliers had been removed.

	RAPM %	RMET (max 36)	GNG errors (max 300)	AQ (max 50)	PA
ASC (n=45)	91.11 (*8.66*)	23.73 (*6.35*)	11.38 (*13.74*)	39.27 (*5.94*)	25.05 (*21.07*)
Controls (n=13)	93.36 (*4.07*)	25.62 (*4,.09*)	11.62 (*13.9*)	22.54 (*6.69*)	23.08 (*10.24*)

Results revealed that *Model 1* was statistically significant (F(4, 53)=4.547, p=.003; R^2=.255; $R^2_{adjusted}$=.199). ZAQ scores (β=.344, p=.006; Figure 7.3) and zGNG errors (β= .310, p=.017; Figure 7.4) significantly predicted intentionality endorsement scores, however, neither zRMET scores (β= .038, p=.766) nor zRAPM percentage scores (β=-.173, p=.155) significantly contributed to the model.

When the interaction terms were added to the model, the model was still significant, however, $R^2_{adjusted}$ of *Model 2* decreased in comparison to *Model 1* (F(8, 49)=2.612, p=.018; R^2=.299; $R^2_{adjusted}$=.185), with R^2_{change} being non-significant (R^2_{change}=.043; p=.556). As in *Model 1*, zAQ scores (β=.388, p=.004) and zGNG errors (β =.341, p=.012) significantly predicted intentionality endorsement scores. No other independent variables nor interactions were significant (p>.05). Therefore, adding the interaction terms did not improve the model (Table 7.4).

Table 7.4. Regression table for the hierarchical regression analysis with all participants for whom CARD scores could be obtained.

Predictor variable	*B*	*SE B*	β	*t* value	*p* value	$R^2_{adjusted}$	*F*
Model 1						**.199**	**4.547**
zAQ	**6.489**	**2.274**	**.344**	**2.854**	**.006**		
zGNG error	**5.839**	**2.378**	**.310**	**2.455**	**.017**		
zREMT	.725	2.426	.038	.299	.766		
zRAPM	-3.474	2.409	-.173	-1.442	.155		
Model 2						.185	2.612
zAQ	**7.310**	**2.416**	**.388**	**3.026**	**.004**		
zGNG	**6.424**	**2.464**	**.341**	**2.608**	**.012**		
zRMET	1.141	2.469	.060	.462	.646		
zRAPM	-3.819	2.769	-.191	-1.379	.174		
zAQ x zGroup	-2.217	2.649	-.115	-.837	.407		
zGNG x zGroup	-2.210	2.553	-.118	-.866	.391		
zRMET x zGroup	-.720	2.499	-.037	-.288	.774		
zRAPM x zGroup	-2.841	3.772	-.109	-.753	.455		

Note: Unstandardised beta (B); Standard error of unstandardized beta (SE B); Standardised beta (β)

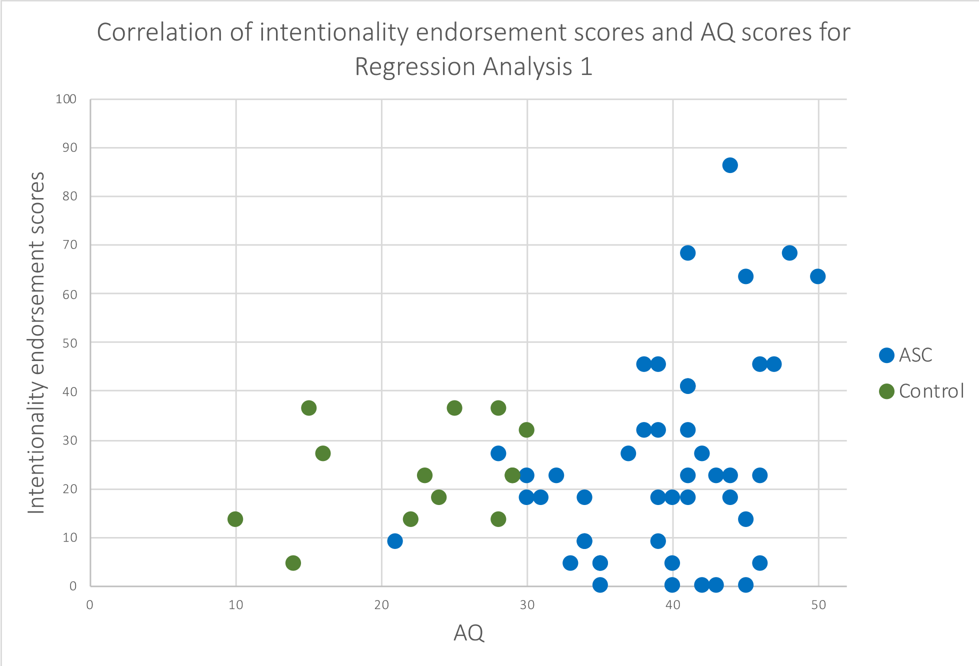


Figure 7.3. A scatterplot showing the relation between of Autism Quotient (AQ) scores (max. 50) and intentionality endorsement scores for Prototypically Accidental test sentences (PA) for Regression Analysis 1. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

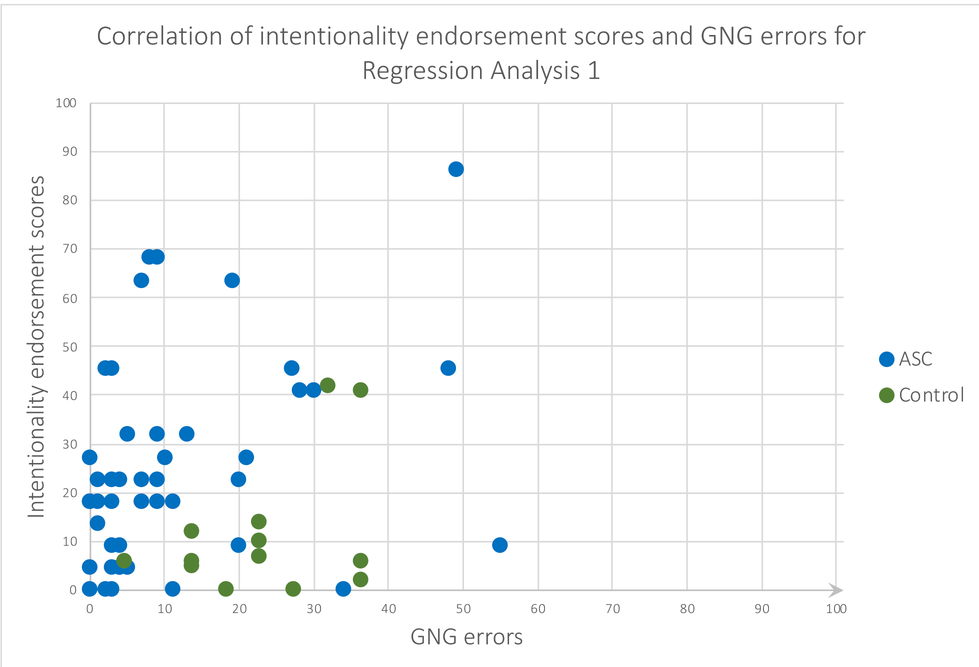


Figure 7.4. A scatterplot showing the association of number of GNG errors (max. 300) and intentionality endorsement scores for Prototypically Accidental (PA) test sentences for Regression Analysis 1. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

Multiple regression - outliers excluded (Regression Analysis 2)

As mentioned above, four univariate and four multivariate outliers were detected. In this section, outliers were excluded form analysis (Table 7.5).

Table 7.5. Means and standard deviations for variables taken from CARD: RAPM percentage scores, The Reading the Mind in the Eyes test scores, number of Go/No-Go Task errors, AQ scores and intentionality endorsement scores for Prototypically Accidental test sentences (PA) with standard deviations and sample sizes in brackets. Intentionality endorsement scores reflect the percentage of items judged to be intentional. 13 outliers had been removed prior to analysis.

	RAPM	RMET (max 36)	GNG (max 300)	AQ (max 50)	PA
ASC (n=38)	93.36 (*4.41*)	23.82 (*6.41*)	7.39 (*8.37*)	39.58 (*5.22*)	22.85 (*19.9*)
Controls (n=7)	92.77 (*4.68*)	27.57 (*1.72*)	6.57 (*4.99*)	20.86 (*5.96*)	22.08 (*12.15*)

A two-stage hierarchical multiple regression was conducted with intentionality endorsement scores as the dependent variable. At stage one, standardised AQ scores, GNG error scores, RMET scores and RAPM percentage scores were entered (*Model 1*). At stage two, the interaction terms of all four standardised independent variables with group (zAQ x zGroup, zGNG x zGroup, zRMET x zGroup, zRAPM x zGroup) were added, to see whether there was an interaction between the independent variables and diagnostic group (*Model 2*).

Results revealed that *Model 1* was statistically non-significant ($F(4, 40)=2.364$, $p=.069$; $R^2=.191$; $R^2_{adjusted}=.110$). However, closer inspection revealed that the zAQ score's coefficient was significant ($\beta=.310$, $p=.039$; Figure 7.5). No other coefficients were significantly contributed to the model (zGNG: $\beta=.065$, $p=.718$, Figure 7.5; zRMET: $\beta=-.079$, $p=.659$; zRAPM: $\beta=-.237$, $p=.106$; Table 7.6; Figure 7.6).

When the interaction terms were added, the model remained non-significant, again with $R^2_{adjusted}$ of *Model 2* decreasing in comparison to *Model 1* ($F(8, 36)=1.219$, $p=.316$; $R^2=.213$; $R^2_{adjusted}=.038$). Same as before, R^2_{change} was non-significant ($R^2_{change}=.252$; $p=.907$). No coefficient significantly contributed to the model ($p>.05$). In sum, adding the interaction terms did not improve the model (Table 7.6).

Table 7.6. Regression table for the hierarchical regression analysis excluding outliers.

Predictor variable	*B*	*SE B*	β	*t* value	*p* value	$R^2_{adjusted}$	*F*
Model 1						.110	2.364
zAQ	**6.636**	**3.115**	**.310**	**2.130**	**.039**		
zGNG	2.085	5.729	.065	.364	.718		
zRMET	-1.526	3.435	-.079	-.444	.659		
zRAPM	-8.343	5.042	-.237	-1.655	.106		
Model 2						.038	1.219
zAQ	8.270	4.107	.386	2.014	.052		
zGNG	1.018	6.375	.032	.160	.874		
zRMET	-.794	4.520	-.041	-.176	.862		
zRAPM	-9.850	6.233	-.279	-1.580	.123		
zAQ x zGroup	2.412	5.877	.094	.410	.684		
zGNG x zGroup	-4.388	7.065	-.123	-.621	.538		
zRMET x zGroup	.305	7.039	.011	.043	.966		
zRAPM x zGroup	-6.706	8.427	-.201	-.796	.431		

Note: Unstandardised beta (B); Standard error of unstandardized beta (SE B); Standardised beta (β)

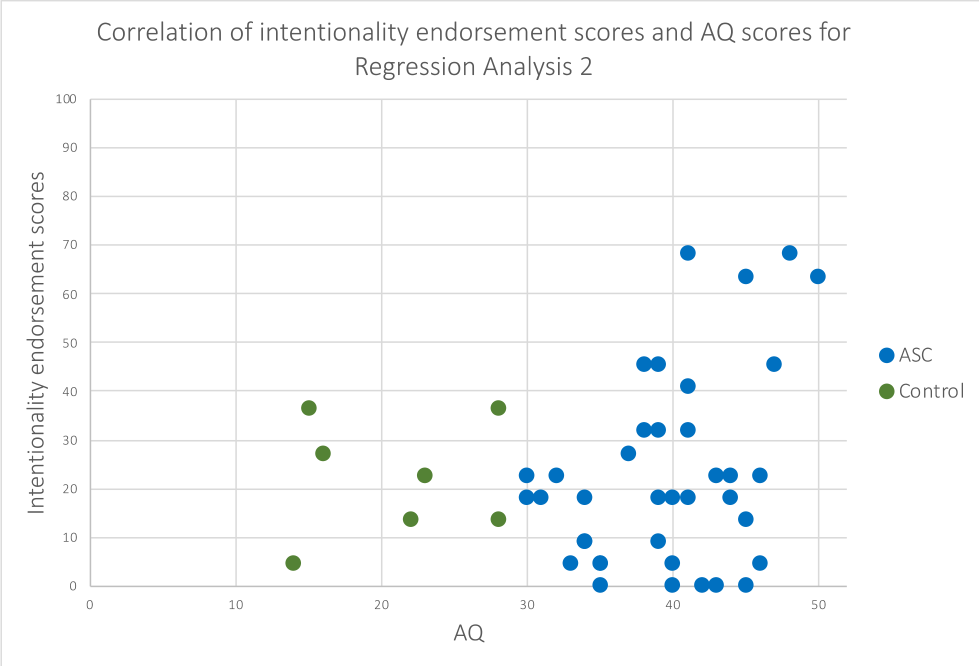


Figure 7.5. A scatterplot showing the association of Autism Quotient (AQ) scores (max. 50) and intentionality endorsement scores for Regression Analysis 2. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

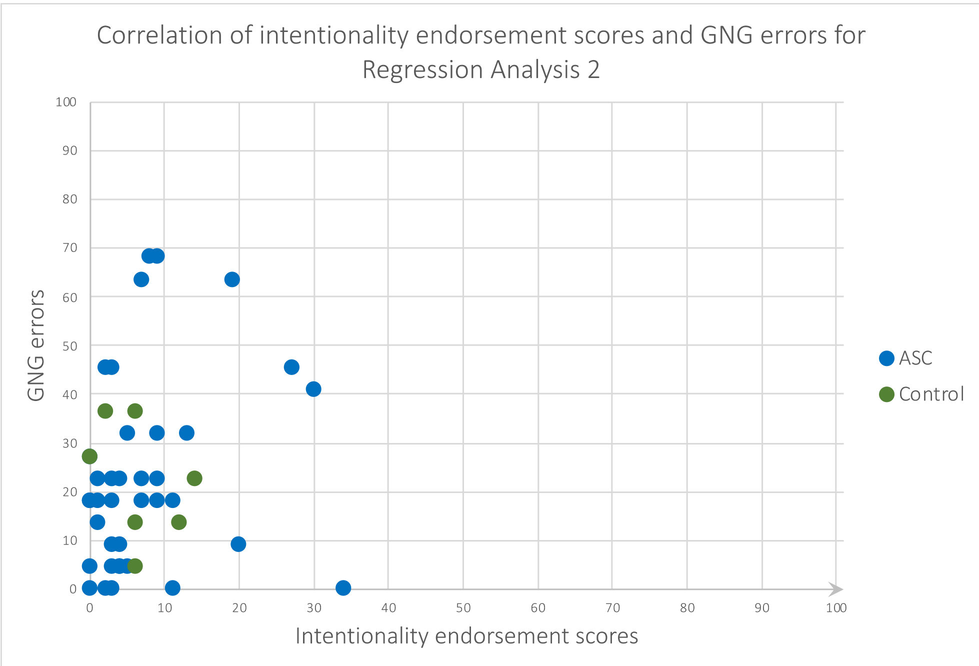


Figure 7.6. A scatterplot showing the association of number of GNG errors (max. 300) and intentionality endorsement scores for Regression Analysis 2. Intentionality endorsement scores reflect the percentage of trials judged to depict intentional actions.

Discussion

In this study, we investigated differences in intentionality endorsement between individuals with ASC and neurotypical controls. The study was conducted online which allowed us to reach a bigger sample size than in our previous study (*Chapter 5*) and to include participants who would not have been comfortable with travelling to our campus and face-to-face interactions. In line with previous findings, participants with ASC judged significantly more ambiguous but prototypically accidental actions to be intentional.

In addition, the role of autistic traits, executive functioning skills, ToM skills and cognitive ability was investigated. An analysis with the entire sample revealed that autistic traits and executive functioning significantly predicted intentionality endorsement scores. There was no interaction with diagnostic group, i.e., the relation between the independent variables and intentionality endorsement scores appears to be similar in individuals with an autism diagnosis and neurotypical controls.

Furthermore, the same analysis was conducted on the sample excluding statistical outliers. Neither *Model 1* (AQ, ToM, executive functioning and cognitive ability only) nor *Model 2* (added interactions) was significant. However, the β coefficient of AQ scores was significant and of similar value as in *Regression Analysis 1*, which could suggest there is indeed a relation between autistic traits and intentionality endorsement, however, with the reduced sample there was not enough power to detect it. Executive functioning, on the other hand, could not significantly predict intentionality endorsement, which is unsurprising given that removing outliers substantially decreased the variance in GNG error scores. Therefore, studying only individuals whose executive functioning skills allow them to perform well on tasks such as the GNG Task, makes it difficult to detect relations between executive functioning and intentionality endorsement.

Implications of findings of group differences

The findings of the current study are in line with findings from *Chapter 5* and *6,* in which individuals with ASC judged significantly more ambiguous but prototypically accidental actions to be intentional. This suggests differences in *intention attribution style* in individuals with ASC. As discussed in the previous chapters, the premise is that individuals with ASC are indeed socially aware and have an understanding of intentionality, however, their social information processing *style* is different to that of neurotypicals. This difference in style becomes apparent when judging *ambiguous* action as no strong situational or perceptual cues regulate responses. In this study, factors contributing to differences in intention attribution style were explored, which are discussed below.

Role of autistic traits

Results of *Regression Analysis 1* revealed that autistic traits could predict intentionality endorsement scores. This means individuals with higher autistic traits showed higher intentionality endorsement scores. The same trend was found in *Regression Analysis 2*, although effects were non-significant.

The relation between autistic traits and intentionality endorsement scores goes in hand with the detected group differences in intentionality endorsement scores between the ASC- and control group. Individuals with high autistic traits (i.e., participants from the ASC group) were more likely to judge ambiguous but prototypically accidental sentences to be intentional than individuals with low autistic traits.

Importantly, results indicate that this relationship did not interact with group, which could suggest that social attribution patterns (e.g., tendency to attribute intent to behaviour) lie on a continuum with individuals with an ASC diagnosis lying on the extreme end and that autistic traits affect intention attribution patterns similarly across the continuum. This would mean that there are not two *distinct* groups of intention attribution style but rather that patterns of intention attribution vary as a function of autistic traits. It has to be noted, though, that at this point such conclusions are somewhat speculative as the present study could have been underpowered due to relatively small and unequal sample sizes.

Role of executive functioning

Another focus of this study, which has direct implications to Rosset's (2008) dual-process model, was the role of executive functioning. The dual-process model suggests that one can only ever arrive at an accidental judgement if an automatic response judging all action to be intentional is inhibited and overridden by a higher-level cognitive process. Individuals, who have better executive functioning skills are predicted to have an easier time inhibiting such automatic responses and, consequently, to show lower intentionality endorsement scores. As results from *Regression Analysis 1* suggest, individuals who commit more errors in the GNG task (i.e., have lower executive functioning skills) show higher intentionality endorsement scores. These findings support Rosset's dual-process model of intention attribution and also potentially explain differences in intentionality endorsement between individuals with ASC and neurotypical controls. Although it is hard to ascertain whether this was the case in the present study (as GNG error scores could not be obtained for all participants), ASC is generally associated with diminished executive functioning skills (see Hill, 2004). This alludes to executive functioning deficits potentially explaining some socio-communicative difficulties in ASC related to attributing intention. If, for example, individuals with ASC find it more difficult to inhibit default judgements of intentionality because of executive functioning deficits, they are more likely to over-attribute intent – even for accidental action. This could be detrimental for harmful accidental action, for which misattributing intent could lead to inappropriate and/or aggressive reactions in the observer.

Importantly, in *Regression Analysis 2*, when outliers – of which some had significantly higher GNG error scores – were removed, GNG errors could no longer predict intentionality endorsement scores. As mentioned above, this is unsurprising given that by removing the outliers the variance in GNG errors was substantially decreased. When only including individuals who performed well on the GNG Task, no relation could be detected.

The advantage of studying atypical populations such as individuals with ASC is that it allows for exploring attribution patterns in individuals with 'extreme' cognitive profiles (e.g., executive functioning deficits), who are less likely to be included in a purely neurotypical sample. Therefore, results from *Regression Analysis 1*, in which outliers were not excluded, highlight some potentially important relation between executive functioning and intentionality endorsement. With an increased sample size more individuals with executive functioning deficits could be targeted (i.e., they would not count as outliers) and in that way, a better understanding of the role of executive functioning in judging intentionality could be gained.

Role of ToM

Notably, in neither *Regression Analysis 1* nor *Regression Analysis 2*, ToM could predict intentionality endorsement. In comparison, in *Chapter 5*, a correlation analysis of ToM scores and intentionality endorsement scores reached marginal significance in the ASC group, i.e., power could have been too low and no strong conclusions could be drawn from the results. Although a different ToM measure was used in the present study, findings in the comparatively larger sample provide more concrete evidence that ToM skills are not related to intentionality endorsement of ambiguous action. This finding is of potential importance, as it suggests it is not the ability to mentalise per se that enables individuals to understand that action was not necessarily driven by the agent's intention. Rather, arriving at *unintentional* explanations of behaviour seems to be reliant on factors different to ToM.

It is worth noting that contrary to results of the current study in which ToM and autistic traits did not correlate, previously ToM skills have been shown to partly mediate the association between autistic traits and intentionality endorsement of ambiguous action (Zucchelli et al., 2018). As argued in the introduction of this chapter, ToM skills could index executive functioning skills in Zucchelli and colleagues' study, which would be in line with the current results.

Furthermore, it has been argued that attributing all deficits or differences in social cognition to ToM deficits is likely to be an over-simplification (Klin, 2000). For example, some individuals with ASC who perform well on ToM tasks, still show social deficits in social adaption in the real world (see Klin, 2000; Klin, Volkmar, Schultz, Pauls, & Cohen, 1997). A possible explanation for this could be that individuals use verbal scaffolding to pass ToM tasks (e.g., Happé, 1995a), which is potentially harder to do in everyday social interactions, in which problems are not verbally formulated and learnt scripts are unlikely to be fitting for specific situations (Klin, 2000). In sum, the results of this study suggest that ToM skills are not related to intentionality endorsement of ambiguous action and, hence, cannot explain higher intentionality endorsement in ASC.

Social anxiety as a potential contributing factor to intentionality endorsement

Another possible underlying reason for differences in intentionality endorsement between individuals with ASC and neurotypical controls, which was not explored in this study, is that individuals with ASC might be more likely to judge ambiguous behaviour to be intentional because of increased social anxiety. There is a higher prevalence of social anxiety in ASC compared to neurotypicals (Bejerot, Eriksson, & Mörtberg, 2014; Maddox & White, 2015). As discussed in *Chapter 6*, previously, increased social anxiety in ASC has been linked to hostile attributions of intent (Meyer et al., 2006; White, Kreiser, Pugliese, & Scarpa, 2012) and potentially, increased social anxiety is also a reason for why individuals with ASC attribute more intent in general. Affected individuals might perceive it as 'safer' to assume an action is intentional as it is more conclusive in terms of an agent's aims and subsequent behaviour. Future research, therefore, should consider including a measure of social anxiety to explore its role in attributing intent to ambiguous action.

Less exposure to social situations and 'over-correction' as a potential contributing factor to intentionality endorsement

Because of associated symptoms such as social difficulties, anxiety and increased threat perception, individuals with ASC tend to have fewer friends, frequently show avoidance of social situations and have a preference for solitary activities (Howlin, 2000; Jennes-Coussens, Magill-Evans, & Koning, 2006; Orsmond, Krauss, & Seltzer, 2004; Richer, 1976). This results in them generally having less exposure to social situations. As has been suggested (Rosset, 2008; Rosset & Rottman, 2014), detecting cues for accidental behaviour and having a broad knowledge of causes alternative to intention is key in judging behaviour to be accidental. The ability to interpret cues and the understanding of alternative causes is assumed to develop over time, in line with increased exposure to social situations. If there is an avoidance of social situations in ASC, this could result in increased intentionality endorsement owing to deficits in social knowledge and cue-understanding. In the current design, this hypothesis cannot be tested, however, future research could consider including a suitable measure to explore it further.

Limitations

There were two main limitations in the current study. Firstly, a limitation exclusive to the regression analyses is that CARD scores could only be obtained for a sub-sample of the participants included in this study, most of them being ASC participants. This not only resulted in a small sample size but also decreased the power of detecting an interaction between the role of relevant scores and diagnostic group. This essentially means that although none of the independent variables appears to predict intentionality endorsement differently in both groups, this might be due to a lack of statistical power rather than a genuine lack of difference. Furthermore, the sub-sample of control participants included in the regression analyses is potentially not representable for the entire control group. Although not significantly, AQ scores and intentionality endorsement scores are slightly higher in the sub-sample compared to the entire control sample.

Secondly, because of the nature of the tasks and procedure, only participants who could independently sign up for online research and complete the tasks were included in this study. This implies that our sample is not representative of the entire autism spectrum.

Conclusion

In a large-scale online study, findings from previous studies were replicated: Individuals with ASC judged significantly more ambiguous actions to be intentional than neurotypical controls. Furthermore, for ASC individuals as well as neurotypicals, there was some evidence of autistic traits as well as deficits in executive functioning predicting intentionality endorsement of ambiguous action. This evidence, however, was somewhat inconclusive as it could only be reliably established prior to excluding outliers from the sample. Nevertheless, results of the current study are important as they highlight the role of autistic traits and executive functioning in intentionality endorsement of ambiguous action independent of diagnostic group.

CHAPTER EIGHT

The effect of cognitive load on intentionality endorsement of ambiguous actions[3]

Abstract

According to Rosset's dual-process model of intention attribution, our judgements of intentionality can be guided either by an automatic process leading to *intentional* explanations of behaviour or by a higher-level and cognitively more demanding process enabling *unintentional* explanations of behaviour. Based on this model, under conditions of compromised cognitive capacity, individuals should judge more behaviour to be intentional rather than unintentional. This prediction was tested in one lab-based experiment and one online experiment. Specifically, we investigated whether increased working memory load would lead to higher intentionality endorsement of ambiguous action when controlling for individual differences in working memory. Results of both experiments indicated no effect of working memory load on intentionality endorsement. The implications of these results for the dual-process model of intention attribution are discussed.

[3] Eisenkoeck, A, De Fockert, J.W., and Moore, J.W. (Manuscript submitted for publication).

Introduction

In the studies presented in previous chapters, assumptions based on Rosset's (2008) dual-process model of intention attribution, such as the role of age, cognitive ability, executive functioning skills and time pressure were investigated. So far, our findings do not consistently support the dual-process model (no effect of age and cognitive ability, inconclusive evidence for the involvement of executive functioning). In these final two experiments, we set out to test the dual-process model more directly by manipulating the availability of cognitive capacity and hence interfering with processing of the controlled pathway (i.e., Type 2 processing; see *Chapter 1*). To do so, we used the Ambiguous Movement Paradigm, a visual paradigm involving judging of low-level action (Moore & Pope, 2014).

Dual-process theory of intention attribution

As discussed in the Introduction of this thesis, dual-process models generally assume two types of information processing: a fast, parallel and automatic *Type 1* process and a slower, sequential and analytical *Type 2* process (Evans & Stanovich, 2013; Evans, 2003). As already explained in previous chapters, Rosset's (2008) dual-process model of intention attribution suggests that humans' automatic response to others' behaviour is to judge it to be intentional (Figure 8.1). This automatic (Type 1) response can be inhibited by a more controlled pathway (Type 2) deploying higher-level cognitive processes. However, this can only occur when enough cognitive capacity is available and circumstances allow for the involvement of higher-level cognitive processing. Consequently, when availability of cognitive capacity is reduced or deployment of higher-level cognitive processes is prevented otherwise, more behaviour should be judged to be intentional. Indeed, empirical data discussed in Rosset (2008) and *Chapter 2* seem to confirm this prediction: when participants had to judge the intentionality of others' behaviour under time constraints (i.e. decreased possibility to deploy higher-level processes) intentionality endorsement scores were higher than under no time constraints. Also, in another study, intentionality endorsement scores were found to be increased when Type 2 processing was disrupted by acute alcohol intoxication (Bègue et al., 2010).

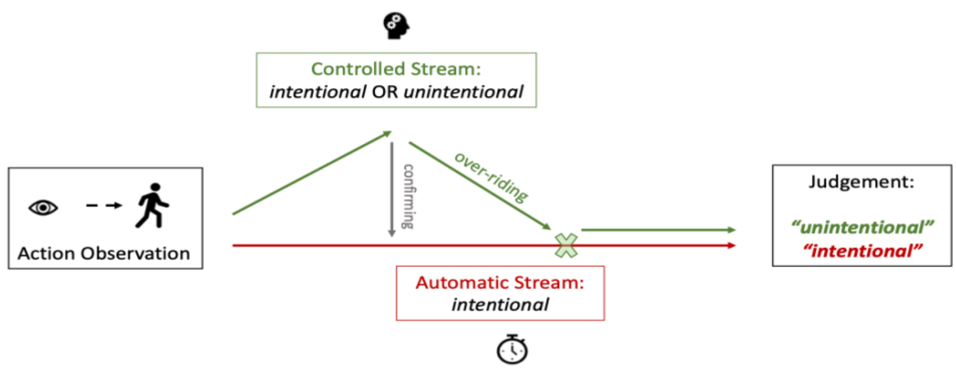


Figure 8.1. Schematic illustration of Rosset's (2008) dual-process model of intention attribution. An automatic process leads to intentional explanations of behaviour, which can either be confirmed or inhibited and overridden by a controlled process leading to unintentional explanations of behaviour.

Despite this apparent support for the dual-process model, there are some key limitations in these previous studies. For example, when employing time pressure, it is hard to ascertain which cognitive functions are affected. It has been suggested that dealing with time pressure involves several processes, such as selective attention, affect control, and parsimony of information processing (Stiensmeier-Pelster & Schürmann, 1993). Also, previous findings suggest that when individuals have to make decisions under time pressure they experience increased anxiety (Maule et al., 2000). Therefore, a possible reason for higher intentionality endorsement scores could be due to changes in affect rather than having insufficient time to engage in controlled processing. Furthermore, an issue with alcohol manipulations is that such interventions are not well-controlled, in the sense that alcohol intoxication affects a number of cognitive functions (e.g., Field, Wiers, Christiansen, Fillmore, & Verster, 2010; Peterson, Rothfleisch, Zelazo, & Pihl, 1990).

Therefore, although results from Rosset (2008) and the study discussed in *Chapter 2* show increased intentionality endorsement under time constraints, they are inconclusive in regard to which cognitive processes are affected. The aim of the current study was to focus on and manipulate *WM load* (i.e., availability of WM capacity) specifically, and to study its role in intention attribution to ambiguous behaviour. According to Evans and Stanovich (2013), the requirement of WM is a defining feature of Type 2 processing, hence, we have reason to believe it is involved in the higher-level process of intentional reasoning.

Dual-task design

To manipulate working memory (WM) load a dual-task approach was chosen. It is based on the assumption that available WM capacity is limited and can be flexibly distributed (see Baddeley, 1986; Miyake & Shah, 1999). When two tasks have to be completed simultaneously and both require cognitive resources, available capacity has to be split between both of them. As a result, the availability of cognitive resources for each individual task decreases compared to a single-task condition (see Brünken, Steinbacher, Plass, & Leutner, 2002). If response patterns are contingent on available capacity then a dual-task condition should alter these. Baddeley and colleagues (Baddeley, 1986; Baddeley & Hitch, 1974; Baddeley & Logie, 1999) have employed different versions of this paradigm to empirically test their model of WM, which assumes that working memory is divided into multiple components and when two tasks rely on the same component, performance decreases.

In the current study, the role of WM in judging intentionality of ambiguous action was investigated by asking participants to complete a WM task while simultaneously being asked to judge intentionality of ambiguous action. More precisely, participants in the experimental conditions were presented with digit strings of varying lengths and were asked to retain these digits until the end of the trial, at which point participants had to indicate whether a probe given digit had been previously present (for previous studies using similar manipulation of WM load see De Fockert & Bremner, 2011; Lavie, Hirst, De Fockert, & Viding, 2004).

Whilst maintaining the digits in their memory, they were asked to complete a version of Moore and Pope's (2014) Ambiguous Movement Paradigm. This paradigm involves video stimuli of ambiguous finger movements, i.e. movements that can be done either intentionally or unintentionally. Participants are asked to judge the intentionality of the observed movement. The advantage of using non-linguistic stimuli is that they do not draw on cognitive resources as heavily as linguistic stimuli (Moore & Pope, 2014), making them more suitable for a dual-task design. Additionally, as Rosset (2008) highlighted, intentional causation could have been inadvertently implied as a result of a linguistic bias rather than an intentionality bias (see *Chapter 1*), which was another incentive for using a non-linguistic paradigm.

To ensure individual differences in WM capacity[4] do not confound the results, a version of Johnson et al.'s (2013) Change Localisation task to measure participants' visual WM capacity was included. It is assumed to provide a pure measure of visual WM capacity (i.e., amount of information

[4] Note, when talking about *WM capacity* we are referring to an individual's WM capacity, which is assumed to be stable over time, as opposed to *available WM capacity*, which is dependent on conditions.

that individuals can retain in short-term storage) that is not heavily influenced by non-storage-specific processing strategies such as chunking or verbal rehearsal (Cowan, 2010). In the version used in the current research, a sample array of four stimuli is presented for a brief period. After a short delay, a test array is shown and participants are asked to indicate which of the four stimuli has changed colour (see Methods section for details).

Hypothesis

When participants' WM capacity is controlled for, we predict there will be a significant effect of WM load on intentionality endorsement scores, in that increased WM load will be associated with increased intentionality endorsement scores.

Experiment 1:

Methods Experiment 1

Participants

In total 46 participants took part in the experiment, but two had to be excluded because of technical issues and another two were excluded because they had indicated that they had noticed that the videos always showed the same movement. Hence, data of 42 participants were included in the analysis (mean age in years=20.43, *SD*=4.06; 37 females). Participants were recruited through a combination of opportunity sampling and a course credit system (n=35). Participants were randomly allocated to one of the three conditions (no WM load, low WM load, high WM load). The experiment was approved by the Goldsmiths Psychology Department Research Ethics Committee.

Measures and Procedure

Participants completed two tasks. All stimuli were presented on a 24-inch computer screen.

Change Localisation Task

All participants first completed a version of Johnson et al.'s Change Localisation Task (Johnson et al., 2013). The task consists of 12 practice trials and two experimental blocks of 32 trials. For each trial, participants were first presented with a fixation cross for 1000 ms, subsequently they were presented with four coloured dots on random locations around the fixation cross, followed by a screen with the fixation cross only for 900 ms, and finally the fixation cross and four coloured dots on the same spatial locations as before but one of them being in a different colour. There was an inter-trial interval of 500 ms (Figure 8.2; for more details on this version of the Change Localisation Task please refer to Ortells, De Fockert, Romera Álvarez, & Fernández García, 2018). Participants were asked to click on the circle they think has changed colour. For the practice trials, participants were given feedback on whether they have correctly responded to ensure they had understood the task instructions, however, no feedback was given for the experimental trials. The researcher stayed in the room for the practice trials to answer any questions but left the room thereafter.

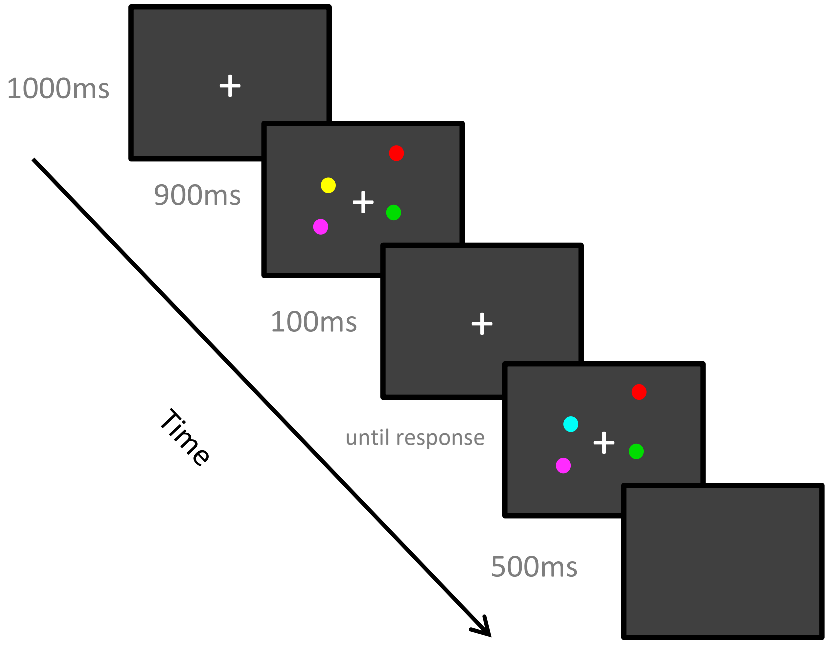


Figure 8.2. Sequence of events for one trial of the Change Localisation Task.

Ambiguous Movement Paradigm

After the Change Localisation Task, participants were asked to complete a version of Moore and Pope's (2014) Ambiguous Movement Paradigm either under the condition of no -, low- or high WM load. In the no WM load (NL) condition participants were presented with a fixation cross for two seconds, followed by a blank screen for two seconds, followed by the video stimulus showing the ambiguous finger movement (three seconds), after which they had to indicate their response by saying *unintentional* or *intentional* out loud. In the load conditions, a simultaneous WM task had to be completed: Participants were shown a fixation cross for two seconds, followed either by one digit (one second; LL condition) or six digits (three seconds; HL condition) and then the video stimulus. They then had to verbally indicate first whether the movement was intentional or unintentional and then whether a single probe digit had been previously present (Figure 8.3).

Before the start of the experiment, all participants were informed that the finger movement would either be intentional, with the person pressing the key, or unintentional, with a mechanism under the key pulling the finger down. In reality, the same video was shown in all trials, however, with three different movement onset delays (100ms, 400ms, 700ms) randomised across trials. It showed an unintentional movement, in which the finger was pulled down. As the same movement was shown every trial, we ensured that perceptual cues would not confound intention attribution judgements.

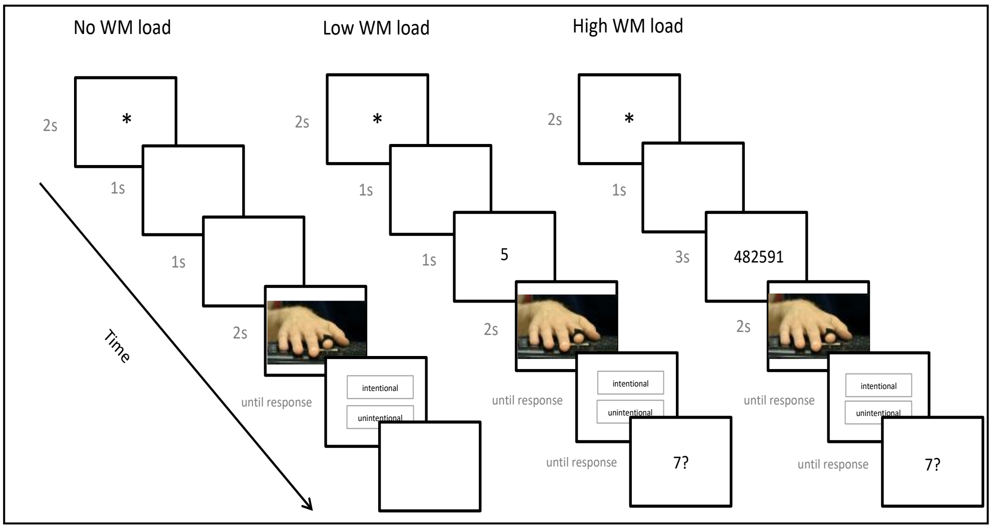


Figure 8.3. Sequence of events for one trial of each condition (NL, LL, HL) of the Ambiguous Movement Paradigm.

The researcher, who stayed in the room for this task, wrote down each participant's responses. There were two practice trials and 24 experimental trials. After the task was completed, the participant was debriefed and thanked for their participation.

Results Experiment 1

For each participant, we calculated an intentionality endorsement score (percentage of trials judged *intentional*) for the Ambiguous Movement Paradigm. We also calculated their *K* score for the Change Localisation Task, which was computed by dividing the hit rate by the number of trials and multiplying it by the set size of the visual displays (K=hit rate/nr of trials*set size). Consequently, each participant's K score ranged from 0 and 4 (Table 8.1). Additionally, participants of the load conditions received a WM-task performance score (i.e., number of correct trials; 0-24). There were two outliers in the LL conditions, however, as they were no extreme outliers (based on inter-quartile range rule with a multiplier of 3.0; Hoaglin, Iglewicz, & Tukey, 1986), they were not excluded from analysis.

Table 8.1. Experiment 1. Intentionality endorsement scores, K scores and WM-task performance scores with standard deviations in brackets for no WM load- (NL), low WM load- (LL) and high WM load (HL) condition. Possible intentionality endorsement scores range from 0 to 100, possible K scores from 0 to 4 and possible WM-task performance scores from 0 to 24.

Condition	Intentionality endorsement score	K score	WM-task performance score
NL (n=14)	61.61 (*10.98*)	2.87 (*.3*)	-
LL (n=14)	64.88 (*15.48*)	2.71 (*.49*)	20.93 (*4.34*)
HL (n=14)	61.94 (*20.90*)	2.96 (*.39*)	14.71 (*1.49*)

Working memory capacity

A one-way ANOVA was conducted to test whether groups differed in WM capacity. Results revealed no significant differences between groups in WM capacity ($F(2, 39)=1.42$, $p=.254$).

Manipulation check – Working memory task

A non-parametric Mann-Whitney U test revealed a significant difference in number of correct trials between the low- and the high WM load condition for the working memory task (U=28, p<.001; Table 8.1). Based on this, we assume the WM load manipulation was successful.

Intentionality bias

In Moore and Pope's (2014) study, participants were significantly more likely to judge ambiguous movements to be intentional than unintentional (i.e., intentionality bias). To examine whether participants in the current study showed a similar biased processing style (i.e., whether they would be significantly more likely to judge over 50% of the trials to be intentional) a one-tailed one-sample t-test on intentionality endorsement scores with a test value of 50 was conducted. Results suggested that participants judged significantly more than half of the trials to be intentional (M=62.5 (SD=16); t(41)=5.065, p<.001).

Main analysis- the effect of cognitive load on intentionality endorsement

A one-way ANCOVA was conducted to determine the effect of WM load (no load, low load, high load) on intentionality endorsement scores controlling for WM capacity (K). It revealed no significant difference between groups (F(2, 38)=.114, p=.892; Figure 8.4). One underlying reason for incorrect responses for the cognitive load task could be failing to attempt to remember the digit(s), i.e. no increased cognitive load. As such, the analysis was also performed including only trials with a correct working memory task response, which can be found in *Appendix 4*. It did not change significance of results.

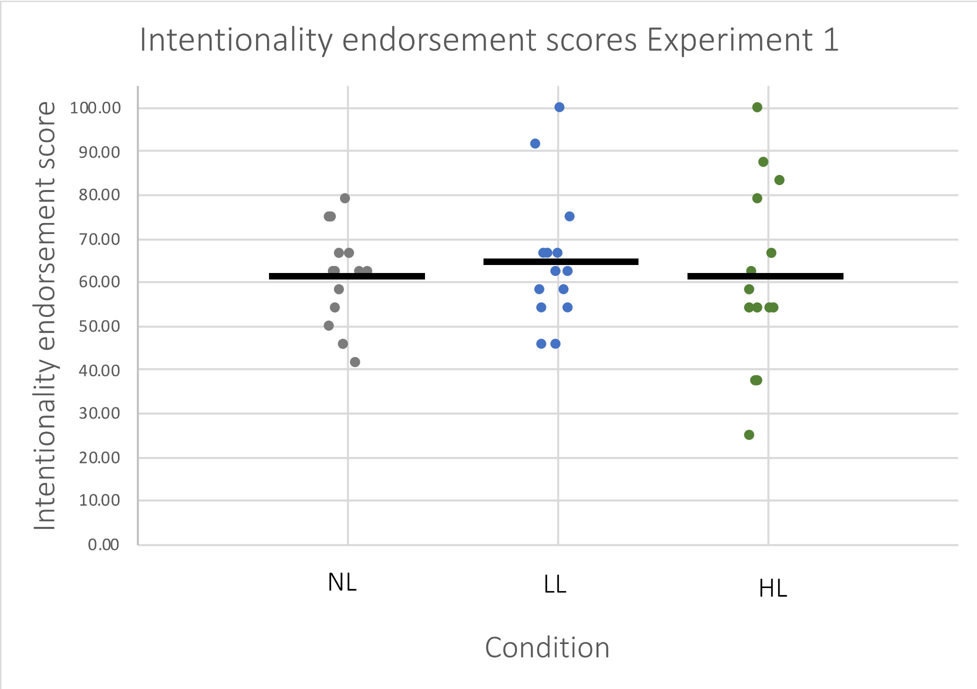


Figure 8.4. Intentionality endorsement scores for each WM load condition (no WM load, low WM load, high WM load) in Experiment 1. Intentionality endorsement scores reflect the percentage of trials judged to show intentional movements. Each mean is marked by a horizontal line.

Exploratory analysis: correlation working memory capacity

Involvement of WM is an essential feature of Type 2 processing (Evans & Stanovich, 2013), which is associated with making unintentional attributions. To establish whether there was a negative association between WM capacity (as a possible index for participants' capability to engage in Type 2 processing) and intentionality endorsement, one-tailed Pearson's correlation analyses were conducted. Analyses were conducted for each condition separately (n=14) as well as pooled across groups (n=42) in order to increase the sample size. Results suggested no association between working memory capacity and intentionality endorsement for each group separately (NL: r=.275, p=.171; LL: r=-.293, p=.155; HL: r=-.099, p=.369) nor for all three groups combined (r=-.131, p=.204; Figure 8.5).

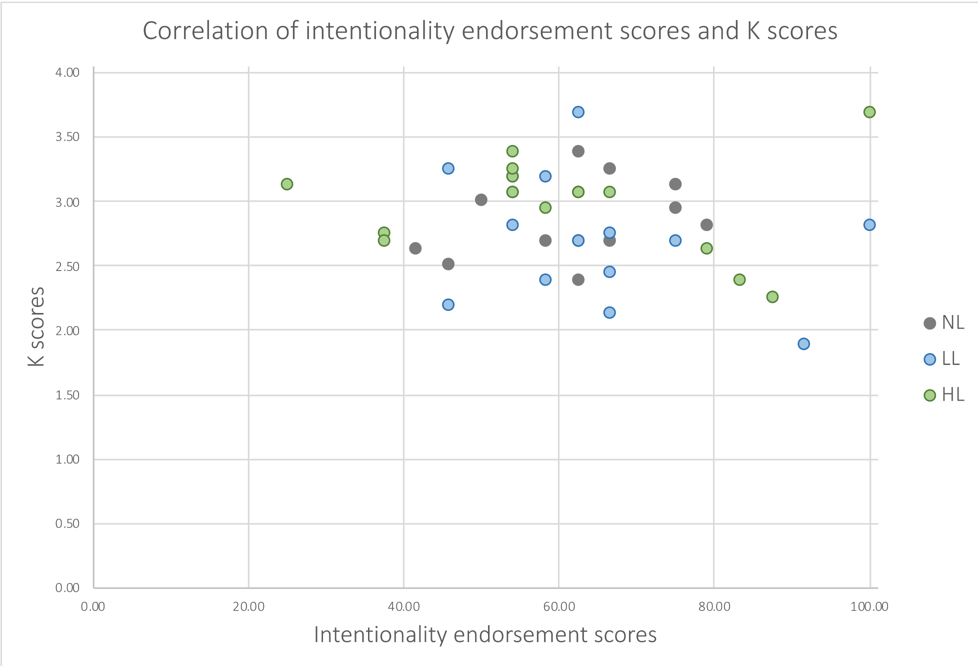


Figure 8.5. A scatterplot showing the association of K scores and intentionality endorsement scores for all three conditions for Experiment 1. K scores reflect individuals' WM capacity (ranging from 0 to 4) and intentionality endorsement scores reflect the percentage of trials judged to show intentional movements.

Preliminary Discussion

In *Experiment 1* we investigated the effect of increased WM load on intentionality endorsement scores for ambiguous action. It was predicted that WM load would lead to increased intentionality endorsement scores. In a between-participants design with three groups that did not differ in terms of WM capacity, we compared intentionality endorsement scores under conditions of no WM load, low WM load and high WM load. All groups showed a bias towards judging the movement to be intentional. Results of the effect of WM load on intentionality judgements are not in line with our predictions. It is possible that the parameters used for the a priori sample size calculations were inaccurate and, hence, our sample size was too low. Therefore, in *Experiment 2*, we decided to re-test our hypothesis.

Our sample size calculations for the second experiment were based on detection of a correlation between WM capacity and intentionality endorsement. As argued by Evans and Stanovich (2013) the involvement of WM is essential for Type 2 processing. According to Rosset's dual-process unintentional explanations for behaviour are based on Type 2 processing. In light of this, we had formed a second hypothesis: Individuals with higher WM capacity (i.e. individuals who find easier to engage in Type 2 processing) will show overall lower intentionality endorsement scores. Results from *Experiment 1* do not show a significant correlation, though, this could be due to the small sample size (N=42), which is why we decided to investigate the association in a larger sample.

Experiment 2

Methods Experiment 2

Participants

Based on the results from *Experiment 1*, the sample size required to detect a significant negative correlation between WM capacity (*K*) and intentionality endorsement scores pooled across all three conditions (for simplicity and feasibility) was calculated using G*Power 3.1 (r=0.131, Power=0.8; one-tailed hypothesis; Faul, Erdfelder, Buchner, & Lang, 2009), which resulted in a required sample of 358 participants. Participants were recruited via *Testable Subject Pool*, an online platform on which participants get reimbursed monetarily for their participation. The study was online for 20 days during which a sample size of 329 participants (Mean age in years=34.96; *SD*=11.83; 143 female) was reached, which is slightly below the a priori calculated sample size. Participants were randomly allocated to one of three conditions: no WM load condition (NL; n=107), low WM load condition (LL; n=108), or high WM load condition (HL; n=114). The study was approved by the Goldsmiths Psychology Department Research Ethics Committee.

Measures and Procedure

Experiment 2 was an online replication of *Experiment 1*, i.e. online versions of the same tasks were conducted: After reading the online information sheet and consent form, participants completed an online version of the Change

Localisation Task. Thereafter, they were asked to complete the Ambiguous Movement Paradigm under the condition of no WM load (NL), low WM load (LL) or high WM load (HL).

For details of both paradigms, please refer to *Experiment 1*. As this was an online experiment and, hence, screen size could not be controlled, an average screen size and distance from the screen was estimated. Based on this estimate, a window with a fixed size (pixels) was created on which stimuli were displayed. This ensured that, for the Change Localisation Task, the angles of the circle-positionings relative to the fixation cross would not differ greatly between participants. Because of a technical error, only one of two experimental blocks of the Change Localisation was presented, i.e. the number of trials was 32 in total. (As can be seen from the Results section, performance on this shorter version of the task was similar to the full task run in *Experiment 1*.)

Results Experiment 2

As in *Experiment 1*, for each participant, a K score (WM capacity) and an intentionality endorsement score (percentage of trials judged *intentional*) were calculated. Participants from the two WM load conditions additionally received a WM-task performance score. Six extreme outliers who had significantly poorer WM-task performance scores than the other participants in their group (based on inter-quartile range rule with a multiplier of 3.0; Hoaglin, Iglewicz, & Tukey, 1986), were excluded from the analysis, as such scores could be a sign of inattentiveness or misunderstanding of the task instructions. All of them were from the LL group. Excluding them resulted in a new sample of 323 participants.

Table 8.2. Experiment 2. Intentionality endorsement scores, K scores and WM-task performance scores with standard deviations in brackets for no WM load- (NL), low WM load- (LL) and high WM load (HL) condition. Possible intentionality endorsement scores range from 0 to 100, possible K scores from 0 to 4 and possible WM-task performance scores from 0 to 24.

Condition	Intentionality endorsement score	K score	WM-task performance score
NL (n=107)	59.07 (*17.23*)	2.79 (.*73*)	-
LL (n=102)	60.74 (*20.96*)	2.94 (.*52*)	22.03 (*3.19*)
HL (n=114)	63.38 (*20.75*)	2.88 (.*55*)	*21.41 (3.15*)

Working memory capacity

A one-way ANOVA was conducted to test whether groups differed in WM capacity. Results revealed no significant differences between groups in WM capacity ($F(2, 320)=1.57$, $p=.209$).

Manipulation check – Working memory task

Participants in the LL- as well as the HL condition, responded correctly to a large proportion of trials of the WM task, with the LL group scoring slightly higher (Table 8.2). A one-tailed Mann-Whitney U test revealed that this difference was statistically significant (U=4639.5, p=.008). Based on this, we assume that the WM load manipulation was successful.

Intentionality bias

To examine whether participants in this experiment showed a bias in their intentionality judgements (i.e., whether they would be significantly more likely to judge over 50% of the trials to be intentional) we conducted a one-tailed one-sample t-tests on intentionality endorsement scores with a test value of 50. Results suggested that participants judged significantly more than half of the trials to be intentional (M=61.12 (SD=19.75); t(322)=10.12, p<.001).

Main analysis- the effect of cognitive load on intentionality endorsement

A one-way ANCOVA was conducted to determine the effect of WM load (no WM load, low WM load, high WM load) on intentionality endorsement scores controlling for working memory capacity (K). Although the trend pointed in the right direction, analysis revealed no significant difference between groups (F(2)=1.49, p=.227; Figure 8.6). As can be seen in *Appendix 5*, the significance of the results was the same when outliers were included. (As participants responded correctly to most trials and therefore a lack of engagement to the task could not explain results, no analysis on correct WM-task trials only was conducted.)

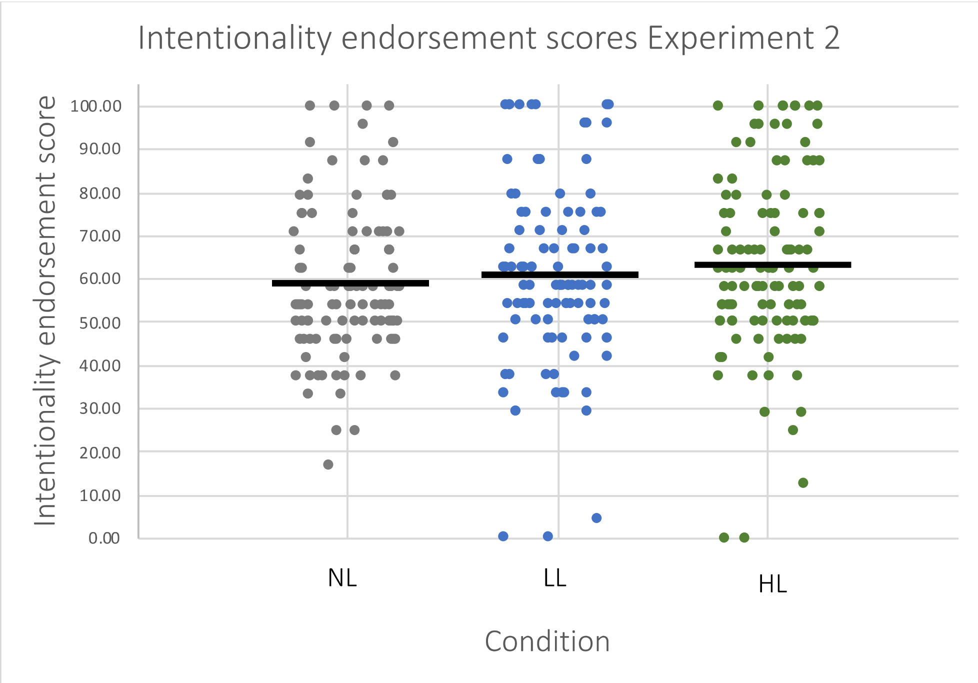


Figure 8.6. Intentionality endorsement scores for each WM load condition (no WM load/NL, low WM load/LL, high WM load/HL) in Experiment 2. Intentionality endorsement scores reflect the percentage of trials judged to show intentional movements. Each mean is marked by a horizontal line.

Correlation WM capacity and intentionality endorsement

To investigate the relation between WM capacity (*K*) and intentionality endorsement scores, a one-tailed Pearson's correlational analysis was conducted. It revealed no significant correlation between K scores and intentionality endorsement scores, however, results indicated a trend in the predicted direction (r=-.088, p=.057; Figure 8.7).

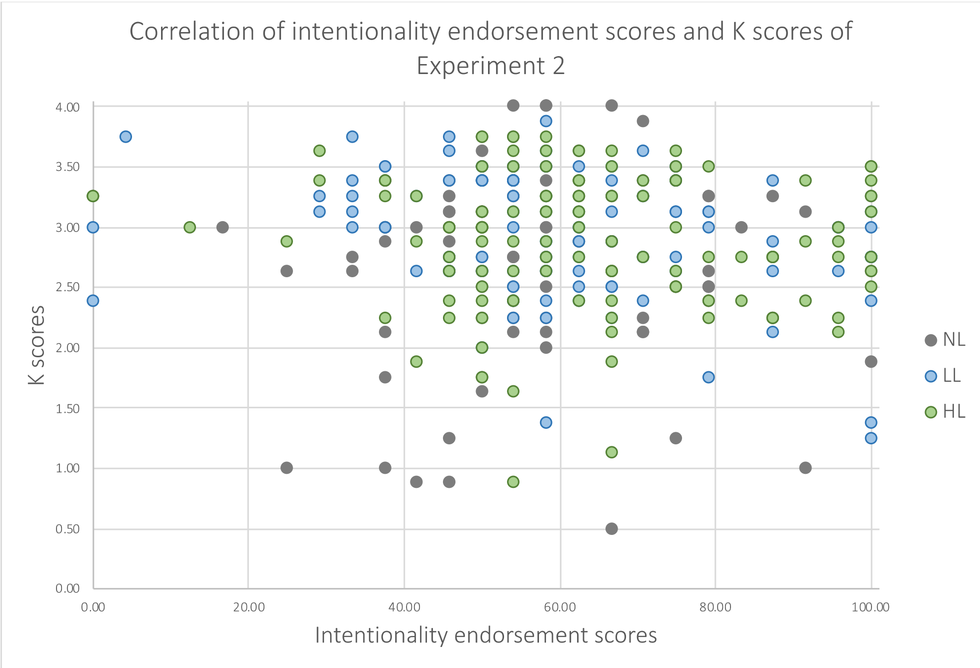


Figure 8.7. A scatterplot showing the association of K scores and intentionality endorsement scores for all three conditions for Experiment 2. K scores reflect individuals' WM capacity (ranging from 0 to 4) and intentionality endorsement scores reflect the percentage of trials judged to show intentional movements.

Exploratory analysis: Correlation WM capacity and intentionality endorsement for each condition separately

As individual differences in WM capacity might play a role only under certain conditions (e.g., under NL when participants can make full use of their WM capacity, *or* under conditions of increased WM load, as only then individual differences in WM capacity become apparent), in this part of the analysis we looked at the relation between WM capacity and intentionality endorsement in each group separately (one-tailed).

i) No Load Condition

There was no significant correlation between intentionality endorsement scores and WM capacity (K) in the NL condition (*r*=.046, *p*=.319; Figure 8.8).

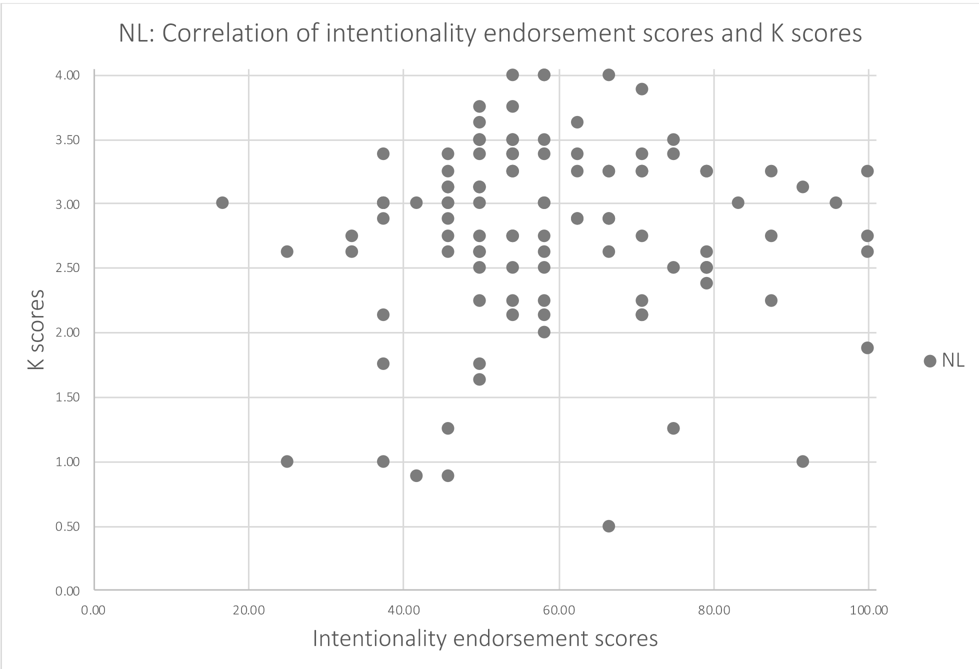


Figure 8.8. A scatterplot showing the association of K scores and intentionality endorsement scores in Experiment 2 for the no WM load condition only. K scores reflect individuals' WM capacity (ranging from 0 to 4) and intentionality endorsement scores reflect the percentage of trials judged to show intentional movements.

ii) Low Load Condition

There was a significant negative correlation between intentionality endorsement scores and WM capacity (K) in the LL condition (r=-.291, p<.001; Figure 8.9)[5].

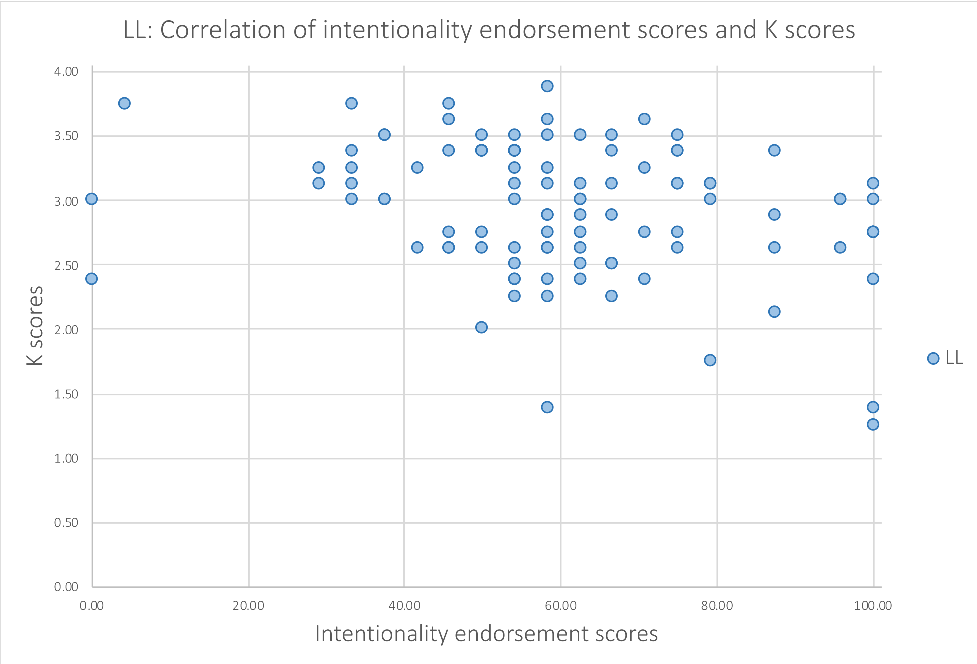


Figure 8.9. A scatterplot showing the association of K scores and intentionality endorsement scores in Experiment 2 for the low WM condition only. K scores reflect individuals' WM capacity (ranging from 0 to 4) and intentionality endorsement scores reflect the percentage of trials judged to show intentional movements.

[5] This effect was not dependent on exclusion of outliers.

iii) *High Load Condition*

There was no significant correlation between intentionality endorsement scores and WM capacity (K) in the HL condition (r=-.078, p=.201; Figure 8.10).

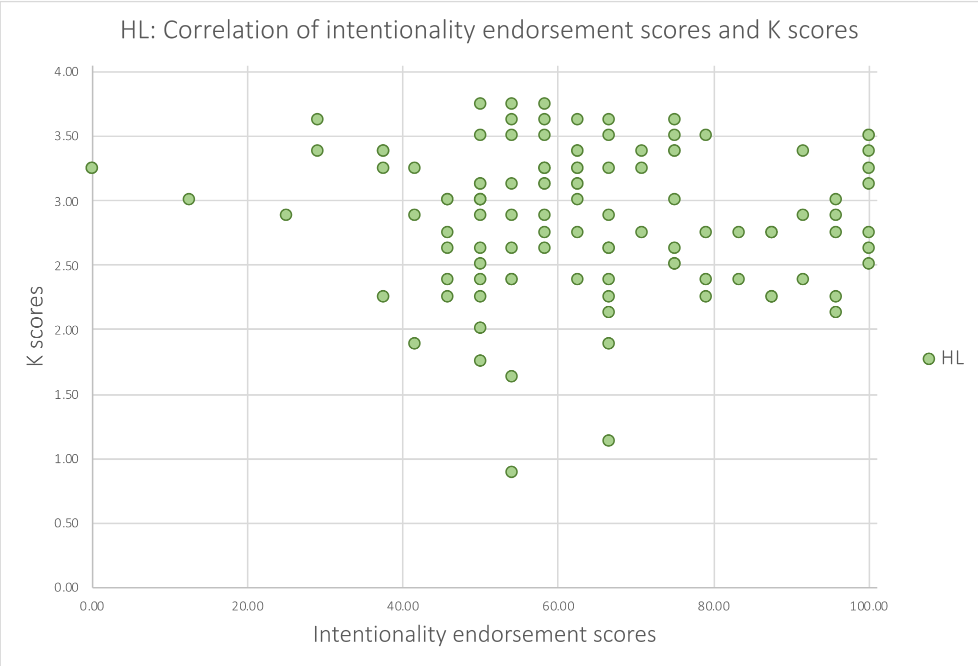


Figure 8.10. A scatterplot showing the association of K scores and intentionality endorsement scores in Experiment 2 for the high WM load condition only. K scores reflect individuals' WM capacity (ranging from 0 to 4) and intentionality endorsement scores reflect the percentage of trials judged to show intentional movements.

Preliminary Discussion

In *Experiment 2* we set out to re-test our hypothesis from *Experiment 1*. Participants showed a bias towards judging the movement to be intentional. Although our results of the between-group analysis go in the predicted directions and intentionality endorsement scores are higher under conditions of increased WM load, differences are not significant.

In addition, we tested whether WM capacity was negatively correlated with intentionality endorsement. Whereas there is no significant correlation when pooled across groups, an exploratory analysis revealed a significant negative correlation between WM capacity and intentionality endorsement scores in LL condition only. One possible explanation is that only under a condition in which WM capacity is compromised (i.e., an individual's entire WM capacity cannot be dedicated to the task) but not compromised enough to demand most WM capacity of all participants including high WM-capacity individuals, individual differences in WM capacity play a role.

In addition, on average, participants in the HL condition of *Experiment 2* scored relatively high on the WM task (compared to *Experiment 1* and previous pilot results), which suggests that these participants dedicated a large part of their WM capacity to the WM-task. This alludes to the possible role of thinking disposition, as it influences which task the available cognitive capacity is allocated to (see *Chapter 4*). However, it has to be emphasised here that at this stage such possibilities remain speculative, as we did not specifically test for the involvement of thinking disposition.

Discussion

Rosset (2008) proposed a dual-process model for intention attribution which suggests that when observing an ambiguous action, humans automatically attribute intent. This attribution can, however, be inhibited and overridden by a higher-level process, given enough cognitive resources are available. A prediction from this model is that decreasing the availability of such cognitive resources would lead to increased intentionality endorsement. Rosset gave no clear indication as of which cognitive resources were likely to be involved in judging intentionality of ambiguous action, however, according to Evans and Stanovich (2013) a defining feature of Type 2 processing is the dependency on WM. Therefore, in two experiments, the role of WM load on judging intentionality of ambiguous action was investigated. In line with Moore and Pope's (2014) results, in both experiments, participants of all three conditions were more likely to judge the ambiguous finger movements to be intentional than unintentional, which suggests an automatic tendency to perceive ambiguous behaviour to be intentional. However, the null hypothesis was not rejected: Participants did not show higher intentionality endorsement under conditions of increased WM load.

Apart from potential design-limitations (discussed at the end of this chapter), we identify three explanations for the lack of effect of WM load on intentionality endorsement:1) Rosset's dual-process model is incomplete or inaccurate, 2) WM is not the main cognitive function involved in controlled processing of intentionality and 3) individual differences such as thinking disposition play a bigger role in judging intentionality of ambiguous action and, hence, "over-shadow" any relation between WM and intentionality endorsement.

Dual-process model - too simplistic a model?

A possible explanation for why manipulating WM capacity did not have an effect on intentionality endorsement could be that Rosset's (2008) dual-process model is a too simplistic or is even an incomplete model of intention attribution. The model implies two predictions: 1) An *unintentional* response always requires the involvement of Type 2 processing, and 2) the default heuristic response is always *intentional*.

Regarding the first point, according to Rosset's dual-process model, an *unintentional* judgment always needs to be preceded by and is caused by mental simulation and cognitive decoupling (i.e., Type 2 processing). Essentially, this means that an *unintentional* judgement can never be made automatically and independent of analytical thought. The question arises whether it is plausible that for all the accidental behaviour we observe, we always "stop and think" about it before judging it to be an accident.

Regarding the second point, this inevitably means that neither varying prior beliefs and experience nor other individual differences play a big role in identifying intentional action. The heuristic (default) response is always *intentional* and does not change as a function of what an observer knows or thinks about a certain action. However, traditional approaches to dual-process models assume processing based on beliefs to be the essence of Type 1 processing (see Evans, 2007; Evans, Barston, & Pollard, 1983; Evans & Stanovich, 2013). Taking the paradigm used in the current studies as an example, there are two options of prior beliefs: key-presses are intentional versus key-presses are unintentional. Even if it were the case that most people's prior belief was that such movements were intentional, the dual-process model put forward by Rosset (2008) seems to be incomplete as it does not allow for a single participant having the prior belief of key-presses – or any other actions for that matter - being unintentional. As participants receive a description of the set-up that explains how and why the movement could be unintentional, it is likely, however, that for at least some of them prior beliefs are altered in a way that favours unintentional explanations. We, therefore, argue that the dual-process model of intention attribution as it stands now needs to be reviewed. In the discussion chapter of this thesis, a revised model dual-process model of intention attribution, as well as an alternative approach to model intention attribution, will be discussed.

WM capacity – successful obstruction of Type 2 processing?

Availability of WM was manipulated through a working memory task completed simultaneously to the intention attribution task. In both experiments, participants' performance on the WM task in the HL condition was significantly lower than in the LL condition, so we can assume that task difficulty – and therefore WM capacity demand - was increased with the number of digits participants were asked to remain in their memory. However, we do not know whether i) available WM capacity was sufficiently impaired to interfere with the controlled processing of intentionality of others' action, and ii) whether our manipulation targeted a cognitive resource required for such controlled processing.

In other words, firstly, it is possible that task demands might still have been insufficient to interfere with analytical processing for the intentionality task. The paradigm used in the current study involves a very low-level action. Perhaps it requires little WM capacity to engage in analytical processing in response to such simple actions, which could be why our WM load manipulation had no effect.

And secondly, it is possible that our manipulation did not tap into the type of cognitive resource or function required for analytical and controlled processing of intentionality of others' action. For example, it is possible that instead of manipulation of WM load, interfering with inhibitory control or selective attention would have had a more pronounced effect on intentionality endorsement.

Other individual differences: thinking disposition

Furthermore, as already mentioned above, it is possible that other individual differences, such as for example thinking disposition “over-shadow” the role of availability of WM capacity in judging intentionality of ambiguous action. For example, the participants’ ‘felt need’ to override an automatic response (i.e., detection of possible violation of normative correct response) might have differed between groups. Perhaps, although participants in the NL condition had capacity available to detect a heuristic response and to give an analytical one instead, they might have not felt the need to do so (Stanovich & West, 1997, 1998a, 2008).

Similarly, groups might have differed in their preferred target for the allocation of cognitive resources. Our exploratory analysis in *Experiment 2* revealed a significant correlation between individuals’ WM capacity and intentionality endorsement scores in the LL condition only. This could potentially suggest that only participants of this condition dedicated a large enough proportion of their WM capacity towards the intentionality judgement task for individual differences in WM capacity to make a difference. Furthermore, the difference between WM-task performance scores of participants of the LL- and HL condition was not as big as in *Experiment 1* and previous experiments, which could indicate that in *Experiment 2* participants of the HL condition dedicated a large part of their WM capacity to the WM-task.

Limitations

One limitation of the current research is that the WM task involves number stimuli which potentially did not strain visual working memory but rather verbal working memory. Future research involving visual intentionality attribution tasks should consider using a visual WM task, for example, involving shapes instead of numbers.

Another limitation, specific to *Experiment 2*, is that it was an online experiment and therefore, it was impossible to control participants' environment. Judging from the high mean WM-task performance scores and K scores, we assume participants paid attention to the tasks. However, we cannot know whether they used additional aids such as taking notes for the WM-task.

Additionally, we did not explicitly ask participants whether they had noticed that the videos always show the same movement as this would pose a leading question. However, apart from the two participants in *Experiment 1*, who made us aware of having noticed that the same movement was presented repeatedly, we do not know whether other participants noticed too.

Conclusion

In two experiments we investigated the effect of WM load on intentionality endorsement of ambiguous action. In neither of the experiments, WM had an effect on intentionality endorsement. This undermines Rosset's (2008) dual-process model of intention attribution, which we argue is incomplete and needs to be revised. In the discussion chapter of this thesis possible revised models are proposed.

CHAPTER NINE

General Discussion

Judgements of intentionality are a crucial aspect of social cognition and social interaction. We react differently to behaviour that we judge to be intentional rather than accidental (Cushman, 2008; Gilbert et al., 2004; Gray & Wegner, 2008; Shaver, 1985; Swap, 1991; Taylor et al., 1979), and decisions about criminal responsibility rest on attributions of intent ("Homicide; Murder and Manslaughter: Legal Guidance: The Crown Prosecution Service," 2017). In this thesis, I investigated the psychological processes that underpin these attributions, and in doing so, I hope to have shed light on this key aspect of our social lives.

The theoretical framework for this thesis was provided by Rosset's (2008) dual-process model of intention attribution. By testing predictions based on this model, I investigated different factors that might come into play when interpreting behaviour. More specifically, I investigated the role of age, cognitive ability, WM load and -capacity, time constraints, executive functioning skills and social information processing in individuals with ASC. Results of my empirical work suggest no effect of age, cognitive ability, WM load or capacity on judging intentionality of ambiguous action. However, individuals with ASC showed a bias towards intentional explanations of ambiguous but prototypically accidental behaviour.

Overall, my results suggest that intention attribution is not fully captured by Rosset's dual-process model. These are informative and important findings because they tell us that a different model or approach is required to describe human intentional reasoning. Additionally, the observed difference in intentionality endorsement in the context of ambiguous action between neurotypicals and individuals with ASC gives us a better understanding of intention attribution in ASC and could be useful in explaining social difficulties. In this Discussion chapter, I will summarise key findings and subsequently, I will consider alternatives to Rosset's dual-process model as well as additional contributing factors to judgments of intentionality. I will then highlight similarities between the so-called intentionality bias and other attributional biases and briefly discuss some general limitations.

Differences in intention attribution style between individuals with ASC and neurotypicals

Previous research suggests, individuals with ASC tend to be less accurate in discerning agents' intentions when actions are unambiguous (e.g., Roeyers, Buysse, Ponnet, & Pichal, 2001; Baron-Cohen et al., 2001; Klin, 2000; Happé, 1994). However, little is known about how they attribute intentions when making judgements about ambiguous actions. In *Chapters 5* and *7*, differences in intentionality endorsement of ambiguous actions between adults with ASC and neurotypicals were investigated. In two studies, adults with ASC showed higher intentionality endorsement scores for ambiguous but prototypically accidental actions than controls. In neither study could group differences be explained by cognitive ability or ToM skills. As argued in the relevant chapters, the results suggest that differences in intention attribution between individuals with ASC and neurotypicals are not only or always a question of *deficit* but rather a question of *style* (i.e., difference in tendencies to judge ambiguous action).

The same pattern could also be found in children with ASC (*Chapter 6*), which suggests a bias towards intentional explanations of behaviour to either be inherent to ASC or acquired at an early stage. Our findings are important, as they highlight that adults as well as children with ASC do not necessarily lack the ability to process and respond to social action, but that this can differ from neurotypicals. It is possible that social behaviour elicited by an over-attribution of intent could be a contributing reason to social difficulties in individuals with ASC. As discussed in previous chapters, social difficulties could be impairing and distressing in ASC, hence, it is important to gain a better understanding of why and how social difficulties arise and how they can be counteracted. With the work presented in this thesis, I hope to have shed some light on a possible contributing factor and paved the way for further investigations.

Proposing a revised dual-process model

Another aim of this thesis was to investigate whether human intentional reasoning is well described by Rosset's dual-process model. This was done by testing predictions made by the dual-process model, as for example, the involvement of age, cognitive ability, availability of WM capacity and time pressure. However, apart from increased time pressure leading to increased intentionality endorsement and some evidence of the involvement of executive functioning, my findings do not support the dual-process model of intention attribution as described by Rosset (2008).

As discussed in *Chapter 8*, Rosset's dual-process model makes two predictions: 1) *Unintentional* judgements always involve analytical (*Type 2*) processing, and 2) an automatic (*Type 1*) process always leads to *intentional* explanations of behaviour as a default response (Figure 9.1). Considering the first prediction, this means an *unintentional* judgment always needs to be preceded and achieved by mental simulation and cognitive decoupling (i.e., *Type 2* processing), which implies an *unintentional* judgement can never be formed automatically and independent of analytical thought. However, a lot of behaviour we observe is accidental, and, moreover, there are certain behaviours that are only ever performed unintentionally. In this way, the plausibility of Rosset's model is questionable. The advantage of *Type 1* processing is that it is computationally less demanding. Information processing "short-cuts" can be used to arrive at conclusions and to choose appropriate responses. In fact, *Type 1* processing can be a sign of proficiency and skill when complex cognitive processes become automatic and do not require analytical thought any longer (Kahneman & Frederick, 2002). Considering the amount of social information we have to process every day, it is important that we process this information in the most efficient way. Given that some actions are almost always accidental, it is plausible one should *automatically* judge them to be so, in order to save cognitive resources. Therefore, *unintentional* snap-judgements seem to be necessary. This directly contradicts one of the key tenets of Rosset's model.

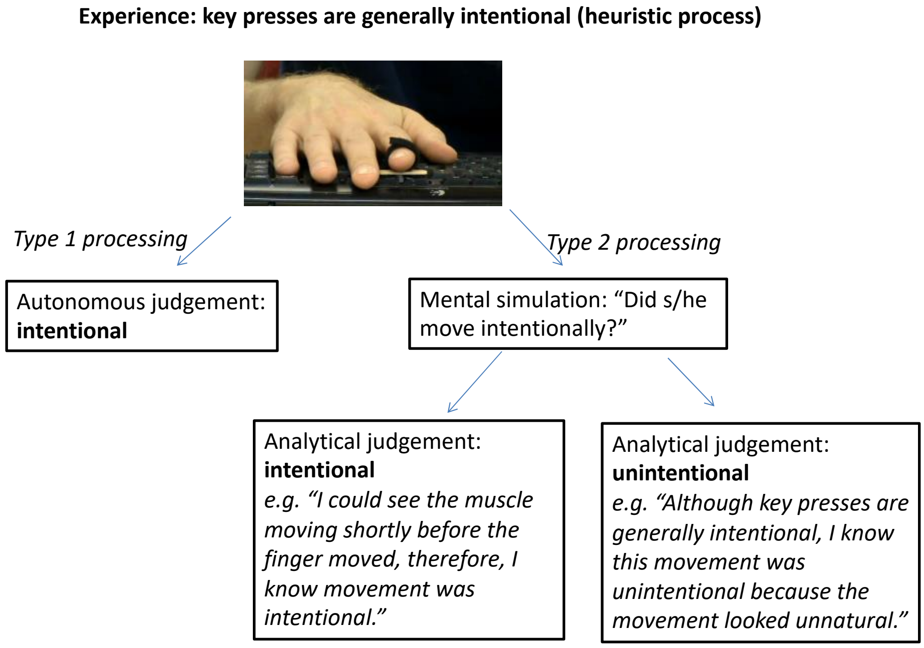


Figure 9.1. An illustration of the dual-process model put forward by Rosset. Automatic (Type 1) processing leads to intentional judgments of behaviour. Controlled (Type 2) processing leads to intentional or unintentional explanations of behaviour.

Leading on, considering the second prediction (that an automatic (*Type 1*) process always leads to *intentional* explanations of behaviour as a default response), this means that prior beliefs and past experience play no role in judging intentionality. As the heuristic (default) judgment is always *intentional*, what an observer knows about a certain action or what their past experience is, has little impact. However, belief-based (rather than logic-based) processing is generally assumed to be the essence of *Type 1* processing (see Evans, Barston, & Pollard, 1983; Evans, 2007; Evans & Stanovich, 2013). As mentioned above, with proficiency and skill often comes increased engagement of *Type 1* processing. This means that complex cognitive processes are migrated from *Type 2* to *Type 1* processing as one becomes more experienced. Kahneman and Frederick (2002) give the example of a highly skilled chess player, who perceives the strength of a chess position instantly without serial processing. As social beings, throughout our lives, we acquire a great amount of knowledge about behaviour, and it seems plausible that the experiences we have shape how we process information. For example, if someone has grown up in an environment in which harmful behaviour towards others is commonly not intentional, that person is perhaps more likely to perceive someone bumping into them as accidental, compared to another individual who has grown up in an intentionally harmful environment.

As illustrated in Figure 9.1, according to Rosset's dual-process model the only route to an unintentional judgement is via mental simulation during which alternative causes for behaviour are considered. Although this might be appropriate for some actions (e.g., pressing a key) which are generally more likely to be intentional, for others it appears less plausible. Now, let us consider the opposite case, in which the heuristic judgement is *unintentional* (Figure 9.2). For example, an observer might have the prior belief that strapped fingers generally are not moved intentionally. Their default would be to judge such finger movements to be unintentional. Only if mental simulation gets involved and the automatic judgement is inhibited and overridden by a controlled process evaluating the information at hand (e.g., visual cue signalling intentional movement), the action would be judged to be intentional.

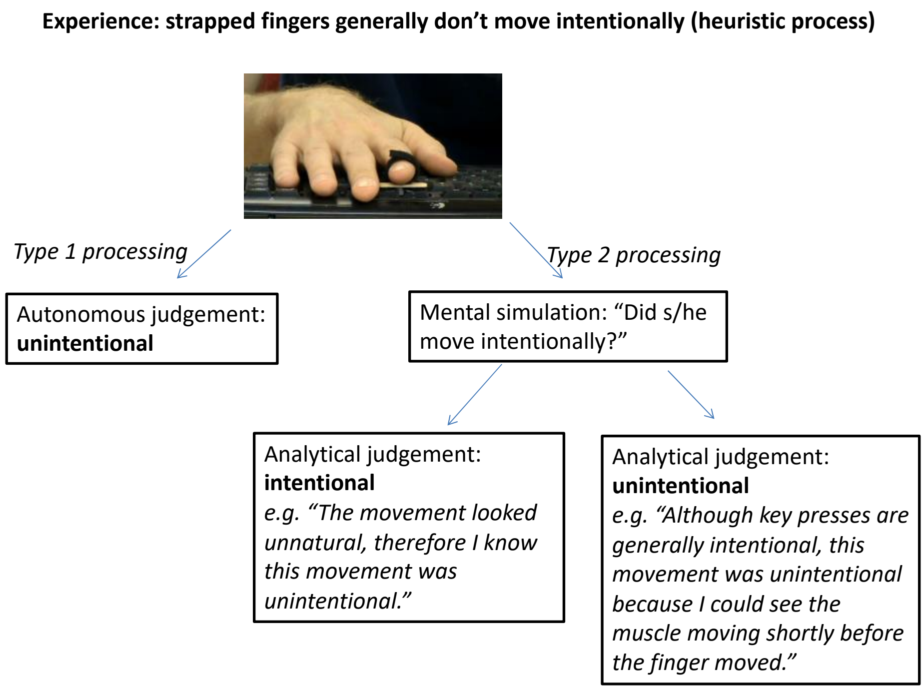


Figure 9.2. An illustration of an alternative dual-process model, in which automatic (Type 1) processing leads to unintentional judgments of behaviour and controlled (Type 2) processing leads to intentional or unintentional explanations of behaviour.

It becomes apparent that an observer's prior belief and experience likely influences or determines what the default explanation for behaviour is. Although a lot of our experience with certain actions might be similar (e.g., most of us have experienced tripping over a curb as an accidental action), for some of us our prior beliefs might be different (e.g., stuntmen often experience falling as intentional action). Therefore, neither Rosset's dual-process model nor the alternative outlined in Figure 9.2 seem to be complete as they do not allow for differences between actions nor individuals.

In light of this, I propose a revised dual-process model for intention attribution, which is a further development of Rosset's (2008) model in that it allows for two default options - *unintentional* or *intentional*, which are based on past experience, beliefs, contextual cues etc. (Figure 9.3). The new model is similar to Rosset's (2008) in a sense that heuristic processes are assumed to lead to a default judgement, which guides the response unless there is an intervention by analytical processes.

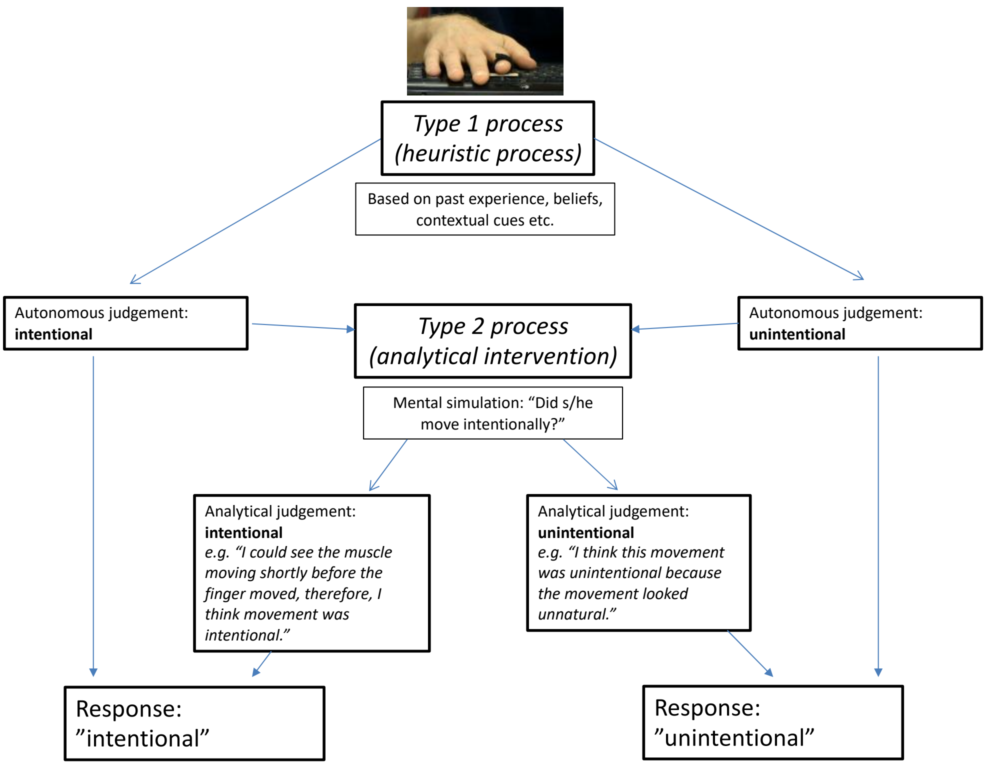
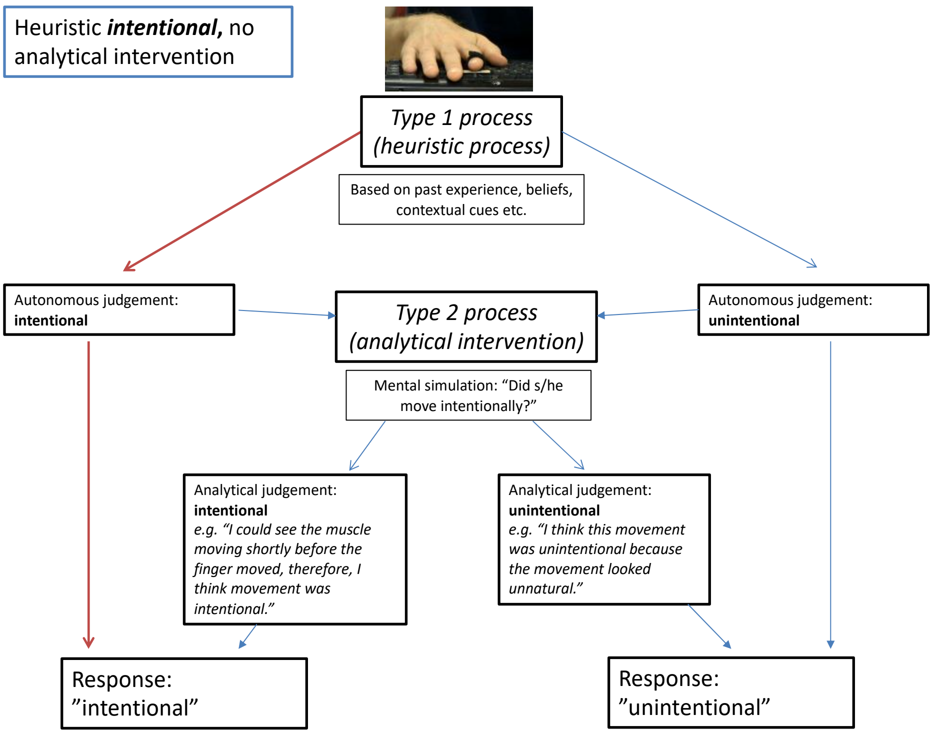


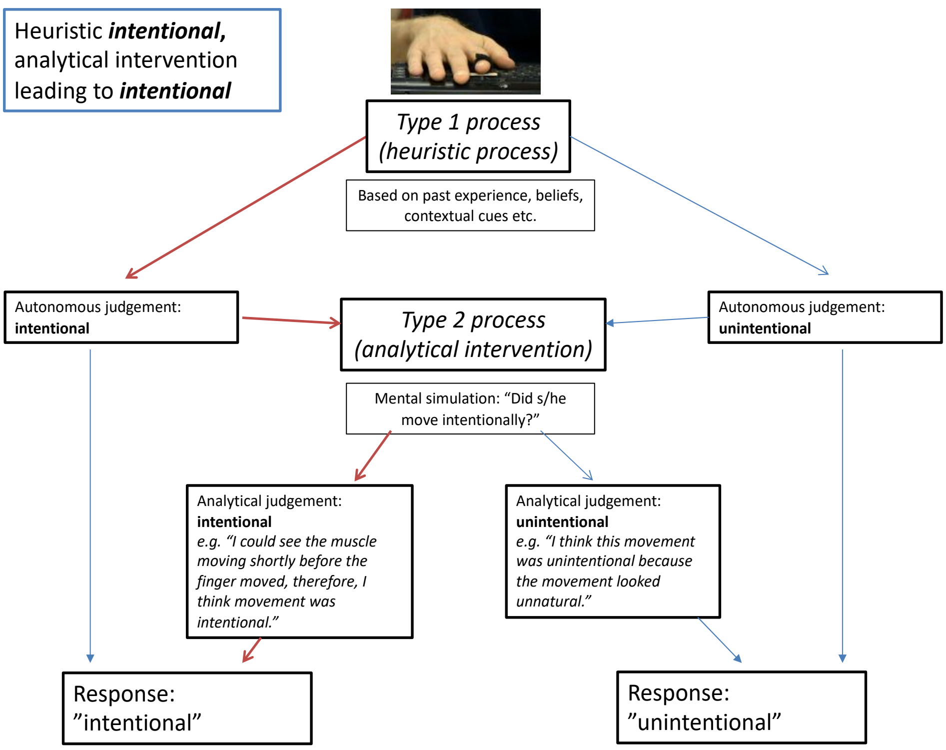
Figure 9.3. Illustration of a revised dual-process model. There are two possible autonomous judgements: intentional OR unintentional. An analytical intervention can inhibit and override and autonomous judgement.

Considering both experiments of *Chapter 8*, with added WM load, we observed increased variability in intentionality endorsement scores, i.e., "more extreme" scores in either direction could be found in the load conditions. This could mean that increasing WM revealed a default *intentional* judgement in some individuals and a default *unintentional* judgement in others. This would support a revised dual-process model of intention attribution allowing for two alternative default options and suggests that when there are fewer cognitive resources available participants engage in more heuristic (biased) processing that could either mean they perceive most movements to be intentional or most movements to be unintentional.

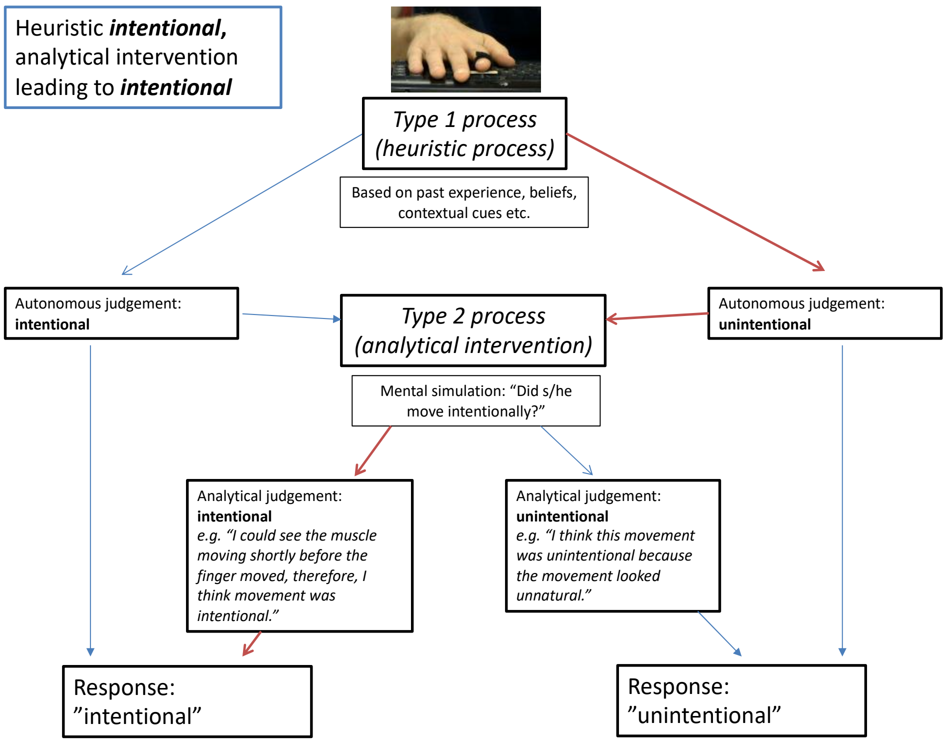
Contrary to Rosset's model, in the model proposed here, there are three routes to an intentional judgement: *intentional* as the heuristic response with no analytical intervention (Figure 9.4a), *intentional* as the heuristic response with analytical intervention confirming the heuristic response (Figure 9.4b), *unintentional* as the heuristic response with analytical intervention changing the response to *intentional* (Figure 9.4c). Notably, only one of them (Figure 9.4a) involves purely Type 1 processing. This implies that intentional judgements would not necessarily be free of analytical processing or independent of cognitive ability, which could explain the apparent lack of effect of availability of WM capacity, cognitive ability and age.


Heuristic ***intentional***, no analytical intervention
Type 1 process (heuristic process)
Based on past experience, beliefs, contextual cues etc.
Autonomous judgement: **intentional**
Type 2 process (analytical intervention)
Autonomous judgement: **unintentional**
Mental simulation: "Did s/he move intentionally?"
Analytical judgement: **intentional** *e.g. "I could see the muscle moving shortly before the finger moved, therefore, I think movement was intentional."*
Analytical judgement: **unintentional** *e.g. "I think this movement was unintentional because the movement looked unnatural."*
Response: "intentional"
Response: "unintentional"

A


Heuristic ***intentional***, analytical intervention leading to ***intentional***
Type 1 process (heuristic process)
Based on past experience, beliefs, contextual cues etc.
Autonomous judgement: **intentional**
Type 2 process (analytical intervention)
Autonomous judgement: **unintentional**
Mental simulation: "Did s/he move intentionally?"
Analytical judgement: **intentional** *e.g. "I could see the muscle moving shortly before the finger moved, therefore, I think movement was intentional."*
Analytical judgement: **unintentional** *e.g. "I think this movement was unintentional because the movement looked unnatural."*
Response: "intentional"
Response: "unintentional"

B



C

Figure 9.4. Illustration of three possible routes to arrive at an intentional judgement in a revised dual-process model: A) Response is driven by a heuristic intentional judgement with no analytical intervention; B) Response is driven by an analytical intervention confirming the heuristic judgement; C) Response is driven by analytical intervention overriding an analytical judgement.

Single-system approach

Another possibility worth considering is that intention attribution does not fit a dual-process model at all, but rather that it is better accommodated by a single-system framework. In fact, dual-process theories of cognition have been critically assessed by a number of authors (Gigerenzer & Regier, 1996; Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011; Melnikoff & Bargh, 2018; Osman, 2004, 2013).

The main line of argument here is that the dichotomy proposed by dual-process theories does not reflect the nature and variety of human reasoning but that the two processes might be unified within a single-system (Osman, 2004). In other words, single-system accounts question two distinct qualitatively different processes and attempt to capture human reasoning within a single dynamic model.

One point of evidence against dual-process accounts of reasoning is the misalignment of processing features. As argued by Melnikoff and Bargh (2018), there is empirical evidence for processing that contains features of both *Type 1* and *Type 2* processing, such as for example uncontrollability and inefficiency. The question, therefore, arises whether the dual-process distinction truly reflects human reasoning if their features are not stable but rather can be applied to both types of processing.

An example of a single-system model of human cognition is the connectionist framework. This framework understands human cognition as a dynamic and adaptive system that learns and develops through its experience (Feldman, 1981; Feldman & Ballard, 1982). A premise of connectionist models in the context of social cognition is that a substantial part of social judgements results from basic associative learning processes (Van Overwalle, Schachtman, & Reilly, 2011). Connectionism, therefore, views social cognition as learning and adapting to a constantly shifting environment, which shapes our attributions and judgements. Information about the social environment is thought to be represented by interconnected units and social attributions are understood as the output of their distributing activation (Van Overwalle et al., 2011).

Connectionist networks characteristically comprise at least two layers (input layer and output layer) of these units. Inherent to such models is that the storage of social information is dependent on the strength of connections, which can increase with repeated paired activation of units. Importantly, connections between units can change, which allows for the network to update and learn. In other words, internal representations of the environment (internal activations) are gradually approximating towards the environment (external activations) (for more detailed account of the components of social connectionist models please refer to Van Overwalle et al., 2011).

This would imply that, in contrast to what Rosset (2008) proposed, there is no default judgement for actions in general, but rather that each action specifically is either associated with being done intentionally or unintentionally. For example, actions such as described in Rosset's Accidental control category as well as Prototypically Accidental test category are largely associated with not being caused by intention. In comparison, actions such as described in the Intentional control category as well as Prototypically Intentional test category are largely associated with an intentional cause. Such an association would be reflected in the participants' judgements. Similarly, most individuals frequently experience a key-press being an intentional action. Therefore, from a connectionist perspective, the observed tendency to judge the key-press in the Ambiguous Movement Paradigm to be intentional could be explained by a strong association between key-presses and intentional causation. This would question whether there is a general intentionality bias or whether this bias only applies to certain actions that are associated with intentional causations.

Importantly, although a system might have strong associations, this does not imply the association truly represent the environment. For reasons, as for example generalising information about one concept to other concepts or ignoring new information that would call for updating of a connection, a representation of the environment can be inaccurate and lead to incorrect judgements. Establishing cause-effect relations and predicting similar events in the future is key in human survival (Van Overwalle & Van Rooy, 1998), however, some of these established relations and predictions can simply be wrong or inappropriate.

Importantly, using a connectionist approach one could potentially explain the difference in judging intentionality of ambiguous action between neurotypicals and individuals with ASC. ASCs have been associated with atypical pattern of perceptual generalisation and learning (e.g., Church et al., 2015; Dovgopoly & Mercado, 2013). This implies that individuals with ASC are likely to have different representations of their social world compared to neurotypicals. For example, if an affected individual is less likely to generalise the accidental action of falling to other accidental actions such as tripping, they could be prone to judge the latter to be intentional.

A single-system approach such as a connectionist approach or similar allows for an intentional reasoning system that is dynamic and constantly updates as one's representations of the world change. In contrast, the dual-system model initially proposed by Rosset (2008) is relatively rigid. The only variables that can change are an individual's capacity and the possibility to engage in *Type 2* processing enabling an *unintentional* judgement. As discussed in previous chapters, no strong evidence for an involvement of cognitive ability, nor WM capacity or load was found, therefore, variability in responses must be affected by other factors (some of which are discussed below). Perhaps a single-system approach can better account for such additional components than a dual-process approach as it allows for the incorporation of many connected concepts (e.g., type of action, nature of agent, etc.). Unfortunately, it is not in the scope of this thesis to develop a detailed account of a single-system model of intention attribution, however, in this section I offered a possible alternative approach and highlighted some advantages it could bring.

Potential other components that should be included in the model

In this thesis, not only the plausibility of theoretical models was explored but, importantly, the role of several factors in judging intentionality of ambiguous action was investigated, including age, cognitive ability, WM load and capacity, executive functioning, ToM, etc. However, as discussed in previous chapters, there are some factors which were not covered in the empirical part of this thesis but that might influence how individuals judge each other's behaviour. In this section, I will briefly outline some of them.

Social anxiety

A factor worth exploring is social anxiety. As previously discussed, higher levels of social anxiety in ASC could be an underlying factor for differences in intention attribution style compared to neurotypical controls (Meyer et al., 2006). However, this is not exclusive to ASC, but social anxiety might also influence how individuals without ASC process ambiguous behaviour.

The prediction here is that socially anxious individuals process information in a way that favours intentional over unintentional explanations for behaviour. For example, it might appear “safer” to judge every action to be targeted and to have a purpose. This would make it easier to predict whether it is safe to interact with another person and what they are trying to achieve and are going to do next. Previous research has shown that socially anxious children are more likely to attribute (hostile) intent to unintentional harmful behaviour (Bell-Dolan, 1995). This supports the argument of an association between social anxiety and intentionality endorsement. This could also explain the link between high intentionality endorsement and schizotypy (Moore & Pope, 2014) and schizophrenia (Peyroux et al., 2014). Social anxiety is a common feature of schizotypy (e.g., Brown, Silvia, Myin–Germeys, Lewandowski, & Kwapil, 2008) and schizophrenia (e.g., Penn, Hope, Spaulding, & Kucera, 1994), which could be a driving factor for perceiving ambiguous behaviour to be intentional.

A point worth reiterating here, is that there might be a reciprocal relationship between social anxiety and judging ambiguous behaviour to be intentional, in that a tendency to judge accidental harmful behaviour to be intentional might lead to negative appraisal of social situations and unsuccessful social interaction, both of which can promote social anxiety (Meyer et al., 2006).

Thinking disposition

Another factor that might influence judging intentionality of ambiguous action, especially when assuming a dual-process model, is thinking disposition. The possible role of thinking disposition in a dual-process framework is discussed in more detail in *Chapter 3*, therefore, it will only be briefly outlined here. The main premise is that differences in thinking disposition might over-shadow the role of other factors such as cognitive ability and WM capacity. This is because individuals might differentially choose whether to dedicate processing capacity towards the task of judging intentionality and engaging in *Type 2* processing. Even highly cognitively able individuals might not detect or feel the need to decouple and to analytically assess prior beliefs and, hence, still engage in biased processing. Therefore, the missing effect of cognitive ability on intentionality endorsement (as found in *Chapter 3*) alone, is insufficient to reject a dual-process model of intention attribution and future research should consider exploring the role of thinking disposition.

Belief in free will

Another component that possibly contributes to perceiving intentionality is a belief in free will. It has been suggested that whether individuals believe in free will shapes their judgements of intentionality, in that individuals with a stronger belief in free will are more likely to judge behaviour to be intentional

(Genschow, Rigoni, & Brass, 2019). This highlights that it might not only be purely cognitive aspects and ability that play a role but factors such as beliefs about human action in general that play a role, which vary greatly across individuals, cultures and societies.

Nature of agent

In the empirical work of this thesis, I exclusively looked at factors relating to the individuals who form the judgements. More specifically, I investigated traits and states that would influence judgement making. However, there might be factors within the *agent* that play a role in whether their actions are perceived to be intentional. For example, the agent's perceived ability or skill could influence whether their actions are judged to be intentional. For example, when an agent has never kicked a ball in their life before (i.e., they have no ability kicking a ball) but coincidentally strikes a goal, an observer is unlikely to perceive the action of kicking the ball into the goal to be intentional (Malle & Knobe, 1997).

In both of the paradigms used in the empirical part of this thesis, there is a lack of information on the nature of the agents. This is because the focus of this research is ambiguous action and giving information about the agents could prime participants to respond in a certain way. However, it is worth highlighting that certain aspects of the agent, such as ability, age, gender and whether the agent is perceived as an in-group or out-group member, likely will have an effect on how their actions are judged. Additionally, it is possible that certain factors within an agent might interact with an observer's conditions, as for example, biased judging of out-group members' actions might become primarily apparent under time constraints. Future research, therefore, could consider the role of the nature of the agent in judging intentionality of ambiguous action.

Social context

Leading on, another aspect worth mentioning is social context. With both paradigms used in the empirical part of this thesis, actions are assumingly studied in isolation with limited social context. In other words, there is neither any information about the agent nor the relationship between agent and observer and what situation they are in. However, when, for example considering, the sentence *She broke the vase,* perceived intentionality might vary as a function of whether *She* is a friend or a foe, or socially superior or inferior to the observer. Also, the type of situation might play a role. Whereas intentionally breaking a vase might be more likely during a row, the same action might be less likely to be intentional during birthday celebrations. In other words, the meaning of an action is derived from its context, it is, therefore, context-sensitive (Read & Miller, 1998). This poses the challenge for future research to incorporate social context into a model of intention attribution. From a theoretical view, social context could perhaps be incorporated more easily into a connectionist model of intention attribution, in which several cues (about the action, the agent, the situation etc.) can be interconnected in various ways, rather than a dual-process approach which assumes a rather fixed model for all kinds of action.

Other attributional biases

A point worth noting is that there are some other attributional biases which overlap with the tendency to attribute intent to ambiguous behaviour as studied in this thesis. In this section, I will briefly discuss them and raise the question whether the so-called *intentionality bias* as observed by Rosset (2008) and Moore and Pope (2014) could be explained by other attributional biases.

One potentially relevant bias is the fundamental attribution error; the failure to consider contextual (i.e., situational) factors when judging others' actions (Ross, 1977). In other words, individuals are inclined to overemphasise personal aspects and ignore external ones that might cause an action. One main personal aspect that drives action is intent. And overemphasising of intent could, therefore, be explained by the fundamental attribution error.

Similarly, it has been shown that people have a tendency to attribute motives to behaviour that are in line with the consequence of the behaviour (Pepitone & Sherberg, 1957). In other words, overt behaviour is assumed to be in accord with covert behaviour. For example, when an action leads to a negative consequence for another person, that person is more likely to attribute a hostile rather than a benign intent (Kelley & Stahelski, 1970). Any outcome is perceived to reflect the agent's intention. There is an obvious link to the intentionality bias here, in that a behaviour leading to a consequence is perceived to be intended, in that its consequence is perceived to be intended.

Additionally, it has been suggested that individuals are biased towards accepting the first cause for behaviour that sufficiently explains an event, rather than continue looking for an alternative cause that might better explain the event (Kanouse, 1971; Simon, 1967). Hence, in situations where there is little context and no other obvious reasons for behaviour is apparent, intentionality might be the first and therefore also preferred explanation. For example, in the Ambiguous Sentence Paradigm, all actions are described within one sentence (e.g., *She kicked her dog*.), and causes for behaviour other than intent might not come to mind as easily.

Together this shows that there is some association between the tendency to judge ambiguous behaviour to be intentional (i.e., *intentionality bias*) and other attributional biases. Possibly, the tendency to judge ambiguous behaviour to be intentional could also be explained by these attributional biases. However, perhaps the importance does not lie in the terminology but rather in what these tendencies, patterns and styles can tell us about social information processing in general, and the effects they might have on social interaction.

Other general limitations

At the end of each chapter, I discussed limitations of the paradigms in context of each study and issues with the study designs. Here, I will outline and briefly discuss some more general limitations.

For example, some of my studies only comprised small sample sizes and were, therefore, likely under-powered. In some instances, this prevents me from drawing clear conclusions from the non-signifcant effects.

Moreover, a large part of the empirical work of this thesis involved online data collection. Although this allowed us to reach large sample sizes, there was limited control over what participants were doing when participating. Although we had some control over excluding inattentive participants by using control sentences as a screening tool, we do not know whether all participants, for example, completed the tasks alone or in what environment.

Furthermore, our sample largely comprised of English native speakers (with some exceptions of fluent but non-native speakers). This entails that our participants were ethnically and culturally similar. As mentioned previously, beliefs about intentionality and free will might differ across cultures. Therefore, our findings are perhaps not representative of other cultures or societies.

Another major limitation concerns the nature of the Ambiguous Sentence Paradigm. Increased mean intentionality endorsement scores for Prototypically Accidental test sentences (our variable of interest) under time constraints (*Chapter 2*) as well as in ASC samples (*Chapter 5* to *7*) are closer to 50 than scores of the control groups. A score of 50 would be expected if individuals answer arbitrarily. Therefore, we do not know for certain whether increased intentionality scores for Prototypically Accidental test sentences in these samples reflect genuine increased intentionality endorsement or more arbitrary responding. An indicator for the latter could be that individuals under time constraints as well as the ASC groups generally performed worse on control items (i.e., closer to an endorsement score of 50) than control participants, although differences were largely non-significant. As outlined in

Chapter 2, we decided not to conduct an omnibus test including test- as well as control items, as both categories are qualitatively different. However, this means that we do not know for certain whether genuinely increased intentionality endorsement or more arbitrary responding when under time pressure/ specific to ASC are driving the results.

Related to this is the issue that the Ambiguous Sentence Paradigm, as well as the Ambiguous Movement Paradigm, comprise no true control categories. For example, as discussed in *Chapter 5*, with the Ambiguous Sentence Paradigm it is impossible to detect whether increased intentionality endorsement scores in ASC are specific to intention attribution or reflect a more general tendency to attribute a cause to an event. As outlined in *Chapter 2*, the categories labelled *control* categories would not reveal whether increased attributions are specific to intention attribution and are better used as screening measures. However, future research should consider developing a paradigm including an appropriate control category. For example, participants could be asked to judge whether an event occurred by chance or was caused by external, non-intentional factors (e.g., weather conditions, computer code, etc.).

Concluding remarks

As Dennett (2009) argued in his Intentional System Theory, perceiving others as intentional agents facilitates making sense of our social surroundings, choosing appropriate reactions to behaviour and predicting others' actions. However, not all actions that we are exposed to are intentional. We have to distinguish between actions that are intentional and actions that are accidental. These judgements play an important role in how we interact with each other. Although in some situations there might be a clear indication of whether an action was intentional or unintentional, in a lot of situations intentionality is ambiguous. In this thesis, I investigated how individuals judge intentionality of ambiguous actions and what factors influence our judgements. In every chapter, I discussed the findings of each specific study and their relevance. In this final section, my aim is to reflect on the overall implications of this work.

Previously, a dual-process model to explain intention attribution has been suggested. In this thesis I directly and indirectly tested assumptions of the dual-process model by investigating factors including age, cognitive ability, WM load and -capacity, having ASC, ToM and executive functioning. Apart from a replication of Rosset's (2008) findings and an indication of the involvement of executive functioning, largely, the empirical evidence gathered in this thesis does not support the dual-process model of intention attribution. This suggests the model is either incomplete or that it is not an appropriate model of intention attribution. Although in general it may be beneficial to perceive action to be intentional (as for example because it has higher predictive validity and enables us to use cognitive “short-cuts” when interpreting events), and under some circumstances we might show a tendency to judge ambiguous action to be intentional, this seems to be only one aspect of intentional reasoning. As complex social beings living in multifaceted social environments, a dual-process model does not seem to be able to fully capture how we judge the intentionality of others’ actions.

The work in this thesis shows that judgements of intentionality differ between individuals and certain conditions, i.e., they are not set. In fact, atypical intention attribution styles might be a contributing factor to social difficulties, as for example in ASC. Therefore, achieving a better conceptual understanding of intentional reasoning is of importance. In the Discussion chapter of this thesis, I proposed a revised model of the dual-process model and an alternative approach, which could form the starting point for further exploration into how we judge intentionality of ambiguous action.

References

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: a meta-analytic review. *Neuropsychology Review*, *16*(1), 17–42.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)* (5th ed.). Arlington, VA: Author.

Asher, S. R., & Coie, J. D. (1990). *Peer Rejection in Childhood.* (Vol. 20). New York: Cambridge University Press. https://doi.org/10.2307/2071877

Baddeley, A. (1986). Modularity, mass-action and memory. *The Quarterly Journal of Experimental Psychology*, *38*(4), 527–533.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In *Psychology of learning and motivation* (Vol. 8, pp. 47–89). New York: Academic Press.

Baddeley, A. D., & Logie, R. H. (1999). Working memory: The multiple-component model. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 28–61). New York: Cambridge University Press. https://doi.org/http://dx.doi.org/10.1017/CBO9781139174909.005

Baird, J. A., & Astington, J. W. (2005). The development of the intention concept: From the observable world to the unobservable mind. In R. R. Hassin, J. S. Uleman, & J. A. Bargh (Eds.), *The new unconscious* (pp. 256–276). New York: Oxford University Press New York, NY.

Baldwin, D. A., & Baird, J. A. (1999). Action analysis: A gateway to intentional inference. In P. Rochat (Ed.), *Early social cognition: Understanding others in the first months of life* (pp. 215–240). Mahwah, NJ, US: Lawrence Erlbaum Associates, Publishers.

Baldwin, D. A., & Baird, J. A. (2001). Discerning intentions in dynamic human action. *Trends in Cognitive Sciences*, *5*(4), 171–178.

Ballaban-Gil, K., Rapin, I., Tuchman, R., & Shinnar, S. (1996). Longitudinal examination of the behavioral, language, and social changes in a population of adolescents and young adults with autistic disorder. *Pediatric Neurology*, *15*(3), 217–223.

Banerjee, R., & Watling, D. (2005). Children's understanding of faux pas: Associations with peer relations. *Hellenic Journal of Psychology*, *2*(1), 27–45.

Banerjee, R., Watling, D., & Caputi, M. (2011). Peer relations and the understanding of faux pas: Longitudinal evidence for bidirectional associations. *Child Development*, *82*(6), 1887–1905.

Baron-Cohen, S., Baron-Cohen, S., Ring, H. A., Ring, H. A., Wheelright, S., Wheelright, S., … Williams, S. C. (1999). Social intelligence in the normal and autisitic brain: an fMRI study. *European Journal of Neuroscience*, *11*(6), 1891–1898. https://doi.org/10.1046/j.1460-9568.1999.00621.x

Baron-Cohen, Simon. (2000). Theory of mind and autism: A review. In L. M. Glidden (Ed.), *International review of research in mental retardation* (Vol. 23, pp. 169–184). San Diego: Academic Press.

Baron-Cohen, Simon. (2001). Theory of mind in normal development and autism. *Prisme*, *34*(1), 74–183.

Baron-Cohen, Simon. (2006). Two new theories of autism: hyper-systemising and assortative mating. *Archives of Disease in Childhood*, *91*(1), 2–5.

Baron-Cohen, Simon, O'riordan, M., Stone, V., Jones, R., & Plaisted, K. (1999). Recognition of faux pas by normally developing children and children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental Disorders*, *29*(5), 407–418.

Baron-Cohen, Simon, Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" Test revised version: a study with normal adults, and adults with Asperger syndrome or high-functioning autism. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*(2), 241–251.

Baron-Cohen, Simon, Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, malesand females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, *31*(1), 5–17.

Baron-Cohen, S. (2017). Editorial Perspective: Neurodiversity–a revolutionary concept for autism and psychiatry. *Journal of Child Psychology and Psychiatry*, *58*(6), 744–747.

Baron-Cohen, S., Campbell, R., Karmiloff-Smith, A., Grant, J., & Walker, J. (1995). Are children with autism blind to the mentalistic significance of the eyes? *British Journal of Developmental Psychology*, *13*(4), 379–398.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1986). Mechanical, behavioural and intentional understanding of picture stories in autistic children. *British Journal* *of Developmental Psychology*, *4*(2), 113–125.

Baron, Jonathan. (1991). Beliefs about thinking. *Informal Reasoning and Education*, 169–186.

Baron, Jonathan. (1995). Myside bias in thinking about abortion. *Thinking & Reasoning*, *1*(3), 221–235.

Barrett, J. L. (2000). Exploring the natural foundations of religion. *Trends in Cognitive Sciences*, *4*(1), 29–34.

Bègue, L., Bushman, B. J., Giancola, P. R., Subra, B., & Rosset, E. (2010). "There Is No Such Thing as an Accident," Especially When People Are Drunk. *Personality and Social Psychology Bulletin*, *36*(10), 1301–1304. https://doi.org/10.1177/0146167210383044

Bejerot, S., Eriksson, J. M., & Mörtberg, E. (2014). Social anxiety in adult autism spectrum disorder. *Psychiatry Research*, *220*(1–2), 705–707.

Bell-Dolan, D. J. (1995). Social cue interpretation of anxious children. *Journal of Clinical Child Psychology*, *24*(1), 2–10.

Blackshaw, A. J., Kinderman, P., Hare, D. J., & Hatton, C. (2001). Theory of mind, causal attribution and paranoia in Asperger syndrome. *Autism*, *5*(2), 147–163.

Blakemore, S.-J., & Choudhury, S. (2006). Development of the adolescent brain: implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry*, *47*(3-4), 296–312.

Blakemore, S.-J., & Decety, J. (2001). From the Perception of Action to the Understanding of Intention. *Nature Reviews Neuroscience*, *2*(August), 561–

567. https://doi.org/10.1038/35086023

Brenner, L. A., Koehler, D. J., & Tversky, A. (1996). On the evaluation of one-sided evidence. *Journal of Behavioral Decision Making*, *9*(1), 59–70.

Brown, L. H., Silvia, P. J., Myin–Germeys, I., Lewandowski, K. E., & Kwapil, T. R. (2008). The relationship of social anxiety and social anhedonia to psychometrically identified schizotypy. *Journal of Social and Clinical Psychology*, *27*(2), 127–149.

Brugha, T., Cooper, S. A., McManus, S., Purdon, S., Smith, J., Scott, F. J., … Tyrer, F. (2012). Estimating the Prevalence of Autism Spectrum Conditions in Adults: Extending the 2007 Adult Psychiatric Morbidity Survey. London: The Health and Social Care Information Centre.

Bruine de Bruin, W., Parker, A. M., & Fischhoff, B. (2007). Individual differences in adult decision-making competence. *Journal of Personality and Social Psychology*, *92*(5), 938-956.

Brünken, R., Steinbacher, S., Plass, J. L., & Leutner, D. (2002). Assessment of cognitive load in multimedia learning using dual-task methodology. *Experimental Psychology*, *49*(2), 109-119.

Bukowski, W. M., Newcomb, A. F., & Hartup, W. W. (1998). *The company they keep: Friendships in childhood and adolescence*. New York: Cambridge University Press.

Buon, M., Dupoux, E., Jacob, P., Chaste, P., Leboyer, M., & Zalla, T. (2013). The role of causal and intentional judgments in moral reasoning in individuals with high functioning autism. *Journal of Autism and Developmental Disorders*, *43*(2), 458–470.

Capon, A., Handley, S., & Dennis, I. (2003). Working memory and reasoning: An individual differences perspective. *Thinking & Reasoning*, *9*(3), 203–244.

Capps, L., Yirmiya, N., & Sigman, M. (1992). Understanding of simple and complex emotions in non-retarded children with autism. *Journal of Child Psychology and Psychiatry*, *33*(7), 1169–1182.

Carlson, S. M., Moses, L. J., & Breton, C. (2002). How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development: An International Journal of Research and Practice*, *11*(2), 73–92.

Carpenter, M., Akhtar, N., & Tomasello, M. (1998). Fourteen-through 18-month-old infants differentially imitate intentional and accidental actions. *Infant Behavior and Development*, *21*(2), 315–330.

Carpenter, M., Call, J., & Tomasello, M. (2002). Understanding "prior intentions" enables two–year–olds to imitatively learn a complex task. *Child Development*, *73*(5), 1431–1441.

Church, B. A., Rice, C. L., Dovgopoly, A., Lopata, C. J., Thomeer, M. L., Nelson, A., & Mercado, E. (2015). Learning, plasticity, and atypical generalization in children with autism. *Psychonomic Bulletin & Review*, *22*(5), 1342–1348.

Ciaramidaro, A., Bölte, S., Schlitt, S., Hainz, D., Poustka, F., Weber, B., … Walter, H. (2014). Schizophrenia and Autism as Contrasting Minds: Neural Evidence for the Hypo-Hyper-Intentionality Hypothesis. https://doi.org/10.1093/schbul/sbu124

Cleeremans, A., & Jiménez, L. (2002). Implicit learning and consciousness: A graded, dynamic perspective. In R. M. French & A. Cleeremans (Eds.), *Implicit learning and consciousness* (pp. 1–40). Hove, UK: Psychology Press.

Coleman, J. C., & Hendry, L. (1990). The nature of adolescence. New York: Routlege.

Cowan, N. (2010). The magical mystery four: How is working memory capacity limited, and why? *Current Directions in Psychological Science*, *19*(1), 51–57.

Craig, J., & Baron-Cohen, S. (1999). Creativity and imagination in autism and Asperger syndrome. *Journal of Autism and Developmental Disorders*, *29*(4), 319–326.

Crespi, B., Leach, E., Dinsdale, N., Mokkonen, M., & Hurd, P. (2016). Imagination in human social cognition, autism, and psychotic-affective conditions. *Cognition*, *150*, 181–199.

Cushman, F. (2008). Crime and punishment: Distinguishing the roles of causal and intentional analyses in moral judgment. *Cognition*, *108*(2), 353–380. https://doi.org/10.1016/j.cognition.2008.03.006

Dahlgren, S. O., & Trillingsgaard, A. (1996). Theory of mind in non-retarded children with autism and Asperger's syndrome. A research note. *Journal of Child Psychology and Psychiatry*, *37*(6), 759–763.

De Fockert, J. W., & Bremner, A. J. (2011). Release of inattentional blindness by high working memory load: Elucidating the relationship between working memory and selective attention. *Cognition*, *121*(3), 400–408.

Dennett, D. (2009). Intentional systems theory. In B. McLaughlin, A. Beckermann, & S. Walter (Eds.), *The Oxford handbook of philosophy of mind* (pp. 339–350). Oxford: Oxford University Press Oxford, UK.

Dennett, D. C. (1987). *The Intentional Stance*. Cambridge, MA: MIT Press.

DiYanni, C., & Kelemen, D. (2005). Time to get a new mountain? The role of function in children's conceptions of natural kinds. *Cognition*, *97*(3), 327–335.

Dodge, K. A. (1993). Social-cognitive mechanisms in the development of conduct disorder and depression. *Annual Review of Psychology*, *44*(1), 559–584.

Dodge, K. A., & Newman, J. P. (1981). Biased decision-making processes in aggressive boys. *Journal of Abnormal Psychology*, *90*(4), 375-379.

Dodge, K. A., & Somberg, D. R. (1987). Hostile attributional biases among aggressive boys are exacerbated under conditions of threats to the self. *Child Development*, 213–224.

Dovgopoly, A., & Mercado, E. (2013). A connectionist model of category learning by individuals with high-functioning autism spectrum disorder. *Cognitive, Affective, & Behavioral Neuroscience*, *13*(2), 371–389.

Eddy, C. M., Mitchell D Phil, I. J., Beck, S. R., Cavanna, A. E., & Rickards, H. E. (2010). Altered attribution of intention in Tourette's syndrome. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *22*(3), 348–351.

Evans, J. S. B. T. (2003). In two minds: dual-process accounts of reasoning. *Trends in Cognitive Sciences*, *7*(10), 454–459.

Evans, J. S. B. T. (2007). On the resolution of conflict in dual process theories of reasoning. *Thinking & Reasoning*, *13*(4), 321–339. https://doi.org/10.1080/13546780601008825

Evans, J. S. B. T., Barston, J. L., & Pollard, P. (1983). On the conflict between logic and belief in syllogistic reasoning. *Memory & Cognition*, *11*(3), 295–306.

Evans, J. S. B. T., & Curtis-Holmes, J. (2005). Rapid responding increases belief bias: Evidence for the dual-process theory of reasoning. *Thinking & Reasoning*, *11*(4), 382–389.

Evans, J. S. B. T., & Stanovich, K. E. (2013). Dual-Process Theories of Higher Cognition: Advancing the Debate. *Perspectives on Psychological Science*, *8*(3), 223–241. https://doi.org/10.1177/1745691612460685

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191.

Fédération Internationale de Football Association. (1995). *Laws of the game*. FIFA.

Feinfield, K. A., Lee, P. P., Flavell, E. R., Green, F. L., & Flavell, J. H. (1999). Young children's understanding of intention. *Cognitive Development*, *14*(3), 463–486.

Feldman, J A. (1981). A Connectionist Model of Visual Memory. Parallel Models of Associative Memory. In G. E. Hinton & J. A. Anderson (Eds.), *Parallel Models* *of Associative Memory*. Hillsdale, New Jersey: Lawrence Erlbaum Associates, Publishers.

Feldman, Jerome A, & Ballard, D. H. (1982). Connectionist models and their properties. *Cognitive Science*, *6*(3), 205–254.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. London: Sage Publications Ltd.

Field, M., Wiers, R. W., Christiansen, P., Fillmore, M. T., & Verster, J. C. (2010). Acute alcohol effects on inhibitory control and implicit cognition: implications for loss of control over drinking. *Alcoholism: Clinical and Experimental Research*, *34*(8), 1346–1352.

Forgues, H. L., & Markovits, H. (2010). Conditional reasoning under time constraint: Information retrieval and inhibition. *Thinking & Reasoning*, *16*(3), 221–232.

Forrester, M. A. (2013). *The development of young children's social-cognitive skills*. London: Psychology Press.

Frith, C. D. (1979). Consciousness, information processing and schizophrenia. *The British Journal of Psychiatry*, *134*(3), 225–235.

Frith, U. (2004). Emanuel Miller lecture: Confusions and controversies about Asperger syndrome. *Journal of Child Psychology and Psychiatry*, *45*(4), 672–686.

Galotti, K. M. (1989). Approaches to studying formal and everyday reasoning. *Psychological Bulletin*, *105*(3), 331-351.

Genschow, O., Rigoni, D., & Brass, M. (2019). The hand of god or the hand of

Maradona? Believing in free will increases perceived intentionality of others' behavior. *Consciousness and Cognition*, *70*, 80–87.

Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A., … Rapoport, J. L. (1999). Brain development during childhood and adolescence: a longitudinal MRI study. *Nature Neuroscience*, *2*(10), 861–863. https://doi.org/10.1038/13158

Gigerenzer, G., & Regier, T. (1996). How do we tell an association from a rule? Comment on Sloman (1996). *Psychological Bulletin*, *119*(1), 23–26.

Gilbert, D. T., Lieberman, M. D., Morewedge, C. K., & Wilson, T. D. (2004). The peculiar longevity of things not so bad. *Psychological Science*, *15*(1), 14–19.

Gray, K., & Wegner, D. M. (2008). The sting of intentional pain. *Psychological Science*, *19*(12), 1260–1262. https://doi.org/10.1111/j.1467-9280.2008.02208.x

Guthrie, S. (2001). Why God? A cognitive theory. In J. Andresen (Ed.), *Religion in mind: Cognitive perspectives on religious belief, ritual, and experience* (pp. 94–112). Cambridge, United Kingdom: Cambridge University Press.

Guthrie, Stewart. (1993). *Faces in the Clouds: A New Theory of Religion*. New York: Oxford University Press.

Hadwin, J., Baron-Cohen, S., Howlin, P., & Hill, K. (1997). Does teaching theory of mind have an effect on the ability to develop conversation in children with autism? *Journal of Autism and Developmental Disorders*, *27*(5), 519–537.

Happé, F. G. E. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. *Journal of Autism and Developmental Disorders*, *24*(2), 129–154.

Happé, F. G. E. (1995a). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child Development*, *66*(3), 843–855.

Happé, F. G. E. (1995b). Understanding minds and metaphors: Insights from the study of figurative language in autism. *Metaphor and Symbol*, *10*(4), 275–295.

Haselton, M., & Buss, D. M. (2000). Error management theory: A new perspective in cross-sex mind reading. *Journal of Personality and Social Psychology*, *78*(1), 81–91.

Haselton, M., & Nettle, D. (2006). The paranoind optimist: an integrative evolutionary model of cognitive biases. *Personality and Social Psychology Review*, *10*(1), 47–66. https://doi.org/10.1207/s15327957pspr1001_3

Heider, F. (1958). *The Psychology of Interpersonal Relations*. New York: Wiley.

Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. *The American Journal of Psychology*, *57*(2), 243–259.

Hill, E. L. (2004). Executive dysfunction in autism. *Trends in Cognitive Sciences*, *8*(1), 26–32.

Hoaglin, D. C., Iglewicz, B., & Tukey, J. W. (1986). Performance of some resistant rules for outlier labeling. *Journal of the American Statistical Association*, *81*(396), 991–999.

Homicide; Murder and Manslaughter: Legal Guidance: The Crown Prosecution

Service. (2017). Retrieved October 4, 2017, from http://www.cps.gov.uk/legal/h_to_k/homicide_murder_and_manslaughter/#manslaughter

Howlin, P. (2000). Outcome in adult life for more able individuals with autism or Asperger syndrome. *Autism*, *4*(1), 63–83.

Hughes, C., & Russell, J. (1993). Autistic children's difficulty with mental disengagement from an object: Its implications for theories of autism. *Developmental Psychology*, *29*(3), 498-510.

Hughes, C., Russell, J., & Robbins, T. W. (1994). Evidence for executive dysfunction in autism. *Neuropsychologia*, *32*(4), 477–492.

Hughes, J. S., Sandry, J., & Trafimow, D. (2012). Intentional inferences are not more likely than unintentional ones: some evidence against the intentionality bias hypothesis. *The Journal of Social Psychology*, *152*(1), 1–4. https://doi.org/10.1080/00224545.2011.565383

Huizinga, M., Dolan, C. V, & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia*, *44*(11), 2017–2036.

Hull, L., Petrides, K. V, Allison, C., Smith, P., Baron-Cohen, S., Lai, M.-C., & Mandy, W. (2017). "Putting on My Best Normal": Social Camouflaging in Adults with Autism Spectrum Conditions. *Journal of Autism and Developmental Disorders*, *47*(8), 2519–2534. https://doi.org/10.1007/s10803-017-3166-5

Jennes-Coussens, M., Magill-Evans, J., & Koning, C. (2006). The quality of life of young men with Asperger syndrome: A brief report. *Autism*, *10*(4), 403–414.

Johnson, M. K., McMahon, R. P., Robinson, B. M., Harvey, A. N., Hahn, B., Leonard, C. J., … Gold, J. M. (2013). The relationship between working memory capacity and broad measures of cognitive ability in healthy adults and people with schizophrenia. *Neuropsychology*, *27*(2), 220-229.

Jones, E. E., & Davis, K. E. (1965). From acts to dispositions the attribution process in person perception. In *Advances in experimental social psychology* (Vol. 2, pp. 219–266). Elsevier.

Kahneman, D. (2000). A psychological point of view: Violations of rational rules as a diagnostic of mental processes. *Behavioral and Brain Sciences*, *23*(5), 681–683.

Kahneman, D. (2003). A perspective on judgment and choice: mapping bounded rationality. *American Psychologist*, *58*(9), 697-720.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 49-81). New York: Cambridge University Press.

Kanouse, D. E. (1971). *Language, labeling, and attribution*. Morristown, NJ: General Learning Press.

Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisiting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, *88*(2), 260–271.

Kelley, H. H., & Stahelski, A. J. (1970). Errors in perception of intentions in a mixed-motive game. *Journal of Experimental Social Psychology*, *6*(4), 379–400.

Keren, G., & Schul, Y. (2009). Two is not always better than one: A critical evaluation of two-system theories. *Perspectives on Psychological Science*, *4*(6), 533–550.

Klaczynski, P. A. (1997). Bias in adolescents' everyday reasoning and its relationship with intellectual ability, personal theories, and self-serving motivation. *Developmental Psychology*, *33*(2), 273–283.

Klaczynski, P. A. (2000). Motivated scientific reasoning biases, epistemological beliefs, and theory polarization: A two-process approach to adolescent cognition. *Child Development*, *71*(5), 1347–1366.

Klaczynski, P. A., & Daniel, D. B. (2005). Individual differences in conditional reasoning: A dual-process account. *Thinking & Reasoning*, *11*(4), 305–325.

Klaczynski, P. A., & Gordon, D. H. (1996). Everyday statistical reasoning during adolescence and young adulthood: Motivational, general ability, and developmental influences. *Child Development*, *67*(6), 2873–2891.

Klaczynski, P. A., & Lavallee, K. L. (2005). Domain-specific identity, epistemic regulation, and intellectual ability as predictors of belief-biased reasoning: A dual-process perspective. *Journal of Experimental Child Psychology*, *92*(1), 1–24.

Klin, A, Volkmar, F. R., Schultz, R., Pauls, D., & Cohen, D. (1997). Asperger syndrome: Nosology and phenomenology. In *44th Annual Meeting of the American Academy of Child and Adolescent Psychiatry, Toronto, Canada, October* (Vol. 16).

Klin, Ami. (2000). Attributing social meaning to ambiguous visual stimuli in higher-functioning autism and Asperger syndrome: The social attribution task. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *41*(7), 831–846.

Klin, Ami, Jones, W., Schultz, R., & Volkmar, F. (2003). The enactive mind, or from actions to cognition: lessons from autism. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *358*(1430), 345–360.

Klin, Ami, Volkmar, F. R., & Sparrow, S. S. (1992). Autistic social dysfunction: Some limitations of the theory of mind hypothesis. *Journal of Child Psychology and Psychiatry*, *33*(5), 861–876.

Klinger, L. G., & Renner, P. (2000). Performance-based measures in autism: Implications for diagnosis, early detection, and identification of cognitive profiles. *Journal of Clinical Child Psychology*, *29*(4), 479–492.

Kokis, J. V, Macpherson, R., Toplak, M. E., West, R. F., & Stanovich, K. E. (2002). Heuristic and analytic processing: Age trends and associations with cognitive ability and cognitive styles. *Journal of Experimental Child Psychology*, *83*(1), 26–52.

Kruglanski, A. W., & Gigerenzer, G. (2011). Intuitive and deliberate judgments are based on common principles. *Psychological Review*, *118*(1), 97–109.

Kuhn, D. (1991). *The skills of argument*. New York: Cambridge University Press.

Kuhn, D. (1993). Connecting scientific and informal reasoning. *Merrill-Palmer Quarterly (1982-)*, 74–103.

Lancon, C., Aghababian, V., Llorca, P. M., & Auquier, P. (1998). Factorial structure of the Positive and Negative Syndrome Scale (PANSS): a forced five-dimensional factor analysis. *Acta Psychiatrica Scandinavica*, *98*(5), 369–376.

Lavie, N., Hirst, A., De Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General*, *133*(3), 339–354.

Lehto, J. E., Juujärvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive functioning: Evidence from children. *British Journal of Developmental Psychology*, *21*(1), 59–80.

Livingston, L. A., & Happé, F. (2017). Conceptualising compensation in neurodevelopmental disorders: Reflections from autism spectrum disorder. *Neuroscience & Biobehavioral Reviews*, *80*, 729–742.

Luo, Y. (2011). Three-month-old infants attribute goals to a non-human agent. *Developmental Science*, *14*(2), 453–460.

Macdonald, H., Rutter, M., Howlin, P., Rios, P., Conteur, A. Le, Evered, C., & Folstein, S. (1989). Recognition and expression of emotional cues by autistic and normal adults. *Journal of Child Psychology and Psychiatry*, *30*(6), 865–877.

MacKay, G., & Shaw, A. (2004). A comparative study of figurative language in children with autistic spectrum disorders. *Child Language Teaching and Therapy*, *20*(1), 13–32.

Maddox, B. B., & White, S. W. (2015). Comorbid social anxiety disorder in adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(12), 3949–3960.

Malle, B. F., & Knobe, J. (1997). The Folk Concept of Intentionality. *Journal of Experimental Psychology*, *121*(33), 101–121.

Malle, B. F., Moses, L. J., & Baldwin, D. A. (2001). *Intentions and intentionality: Foundations of social cognition*. Cambridge, MA: MIT press.

Markovits, H., Brunet, M.-L., Thompson, V., & Brisson, J. (2013). Direct evidence for a dual process model of deductive inference. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(4), 1213-1222.

Maule, A. J., Hockey, G. R. J., & Bdzola, L. (2000). Effects of time-pressure on decision-making under uncertainty: changes in affective state and information processing strategy. *Acta Psychologica*, *104*(3), 283–301.

McEvoy, R. E., Rogers, S. J., & Pennington, B. F. (1993). Executive function and social communication deficits in young autistic children. *Journal of Child Psychology and Psychiatry*, *34*(4), 563–578.

Melnikoff, D. E., & Bargh, J. A. (2018). The mythical number two. *Trends in Cognitive Sciences*, *22*(4), 280–293.

Meltzoff, A. N. (1995). Understanding the intentions of others: re-enactment of intended acts by 18-month-old children. *Developmental Psychology*, *31*(5), 838–850.

Meyer, J. A., Mundy, P. C., Van Hecke, A. V., & Durocher, J. S. (2006). Social attribution processes and comorbid psychiatric symptoms in children with Asperger syndrome. *Autism*, *10*(4), 383–402.

Miller, E. K. (2000). The prefrontal cortex and cognitive control. T*Nature Reviews*

Neuroscience, *1*(1), 59–67.

Miller, P. H., & Aloise, P. A. (1989). Young children's understanding of the psychological causes of behavior: A review. *Child Development*, 257–285.

Miyake, A., & Shah, P. (1999). *Models of working memory: Mechanisms of active maintenance and executive control*. Cambridge University Press.

Moore, J. W., & Pope, A. (2014). The intentionality bias and schizotypy. *Quarterly Journal of Experimental Psychology*, *67*(11), 2218–2224. https://doi.org/10.1080/17470218.2014.911332

Mull, M. S., & Evans, E. M. (2010). Did she mean to do it? Acquiring a folk theory of intentionality. *Journal of Experimental Child Psychology*, *107*(3), 207–228.

Murray, K., Johnston, K., Cunnane, H., Kerr, C., Spain, D., Gillan, N., … Happé, F. (2017). A new test of advanced theory of mind: The "Strange Stories Film Task" captures social processing differences in adults with autism spectrum disorders. *Autism Research*, *10*(6), 1120–1132.

Newstead, S. E., Handley, S. J., Harley, C., Wright, H., & Farrelly, D. (2004). Individual differences in deductive reasoning. *The Quarterly Journal of Experimental Psychology Section A*, *57*(1), 33–60.

Neys, W. De. (2006). Dual processing in reasoning: Two systems but one reasoner. *Psychological Science*, *17*(5), 428–433.

Nickerson, R. S. (1987). Why teach thinking? In J. Baron & R. Sternberg (Eds.), *Teaching thinkings kills: Theory and practice* (pp. 27–40). New York: Freeman.

Orsmond, G. I., Krauss, M. W., & Seltzer, M. M. (2004). Peer relationships and social and recreational activities among adolescents and adults with autism. *Journal of Autism and Developmental Disorders*, *34*(3), 245–256.

Ortells, J. J., De Fockert, J. W., Romera Álvarez, N., & Fernández García, S. (2018). Expectancy-based strategic processes are influenced by spatial working memory load and individual differences in working memory capacity. *Frontiers in Psychology*, *9*, 1239.

Osman, M. (2004). An evaluation of dual-process theories of reasoning. *Psychonomic Bulletin & Review*, *11*(6), 988–1010. https://doi.org/10.3758/BF03196730

Osman, M. (2013). A case study: Dual-process theories of higher cognition—Commentary on Evans & Stanovich (2013). *Perspectives on Psychological Science*, *8*(3), 248–252.

Ossorio, P. G., & Davis, K. E. (1968). The self, intentionality, and reactions to evaluations of the self. In C. Gordon & K. J. Gergen (Eds.), *The self in social interaction* (pp. 355-369). New York: Wiley.

Ozonoff, S., & Griffith, E. M. (2000). Neuropsychological function and the external validity of Asperger syndrome. In A. Klin, F. R. Volkmar, & S. S. Sparrow (Eds.), *Asperger syndrome* (pp. 72–96). New York.

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. *Journal of Child Psychology and Psychiatry*, *32*(7), 1081–1105.

Ozonoff, S., Rogers, S. J., & Pennington, B. F. (1991). Asperger's syndrome: Evidence of an empirical distinction from high-functioning autism. *Journal of*

Child Psychology and Psychiatry, *32*(7), 1107–1122.

Ozonoff, S., Strayer, D. L., McMahon, W. M., & Filloux, F. (1994). Executive function abilities in autism and Tourette syndrome: An information processing approach. *Journal of Child Psychology and Psychiatry*, *35*(6), 1015–1032.

Parker, J. G., & Gottman, J. M. (1989). Social and emotional development in a relational context: Friendship interaction from early childhood to adolescence. In T. J. Bernt & G. W. Ladd (Eds.), *Peer relationships in child development* (pp. 95–131). New York: Wiley.

Penn, D. L., Hope, D. A., Spaulding, W., & Kucera, J. (1994). Social anxiety in schizophrenia. *Schizophrenia Research*, *11*(3), 277–284.

Pepitone, A., & Sherberg, J. (1957). Intentionality, responsibility, and interpersonal attraction. *Journal of Personality*, *25*(6), 757–766.

Peterson, C. C., Wellman, H. M., & Slaughter, V. (2012). The mind behind the message: Advancing theory-of-mind scales for typically developing children, and those with deafness, autism, or Asperger syndrome. *Child Development*, *83*(2), 469–485.

Peterson, J. B., Rothfleisch, J., Zelazo, P. D., & Pihl, R. O. (1990). Acute alcohol intoxication and cognitive functioning. *Journal of Studies on Alcohol*, *51*(2), 114–122.

Peyroux, E., Strickland, B., Tapiero, I., & Franck, N. (2014). The intentionality bias in schizophrenia. *Psychiatry Research*, *219*(3), 426–430. https://doi.org/10.1016/j.psychres.2014.06.034

Premack, D. (1990). The infant's theory of self-propelled objects. *Cognition*, *36*(1), 1–16.

Premack, D., & Premack, A. J. (1995). Intention as psychological cause. In D. Sperber, D. Premack, & A. J. Premack (Eds.), *Causal Cognition: A multidisciplinary debate* (pp. 185–199). Oxford: Clarendon Press.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*(4), 515–526.

Quiggle, N. L., Garber, J., Panak, W. F., & Dodge, K. A. (1992). Social information processing in aggressive and depressed children. *Child Development*, *63*(6), 1305–1320.

Raven, J. C., Court, J. H., Raven, J., & Kratzmeier, H. (1994). *Advanced progressive matrices: [APM; RAVEN-Matrizen-Test]*. *Advanced progressive matrices: Raven-matrizen-test*. Weinheim: Beltz.

Read, S. J., & Miller, L. C. (1998). *Connectionist Models of Social Reasoning and Social Behavior*. Mahwah, NJ: Lawrence Erlbaum.

Richer, J. (1976). The social-avoidance behaviour of autistic children. *Animal Behaviour*, *24*(4), 898–906.

Roberts, M. J., & Newton, E. J. (2001). Inspection times, the change task, and the rapid-response selection task. *The Quarterly Journal of Experimental Psychology*, *54*(4), 1031–1048.

Roeyers, H., Buysse, A., Ponnet, K., & Pichal, B. (2001). Advancing advanced mind-reading tests: Empathic accuracy in adults with a pervasive developmental disorder. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*(2), 271–278.

Romine, C. B., & Reynolds, C. R. (2005). A model of the development of frontal lobe functioning: Findings from a meta-analysis. *Applied Neuropsychology*, *12*(4), 190–201.

Ross, L. (1977). The intuitive psychologist and his shortcomings: Distortions in the attribution process. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 10, pp. 173–220). New York: Academic Press.

Rosset, E. (2008). It's no accident: Our bias for intentional explanations. *Cognition*, *108*(3), 771–780. https://doi.org/10.1016/j.cognition.2008.07.001

Rosset, E., & Rottman, J. (2014). The Big ' Whoops !' in the Study of Intentional Behavior : An Appeal for a New Framework in Understanding Human Actions. *Journal of Cognition and Culture*, *14*, 27–39. https://doi.org/10.1163/15685373-12342108

Royall, D. R., Lauterbach, E. C., Cummings, J. L., Reeve, A., Rummans, T. A., Kaufer, D. I., … Coffey, C. E. (2002). Executive control function: a review of its promise and challenges for clinical research. A report from the Committee on Research of the American Neuropsychiatric Association. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *14*(4), 377–405.

Schult, C. A., & Wellman, H. M. (1997). Explaining human movements and actions: Children's understanding of the limits of psychological explanation. *Cognition*, *62*(3), 291–324.

Schultz, R. T., Romanski, L. M., & Tsatsanis, K. D. (2000). Neurofunctional models of autistic disorder and Asperger syndrome: clues from neuroimaging. In A. Klin, F. R. Volkmar, & S. S. Sparrow (Eds.), *Asperger syndrome* (Vol. 1, pp. 179–209). New York: Plenum Press.

Shafto, P., Coley, J. D., & Baldwin, D. (2007). Effects of time pressure on context-sensitive property induction. *Psychonomic Bulletin & Review*, *14*(5), 890–894.

Shaver, K. (1985). *The Attribution of Blame : Causality, Responsibility, and Blameworthiness*. New York: Springer.

Simon, H. A. (1967). Motivational and emotional controls of cognition. *Psychological Review*, *74*(1), 29-39.

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*(8), 921–929.

Slavny, R. J. M., & Moore, J. W. (2018). Individual differences in the intentionality bias and its association with cognitive empathy. *Personality and Individual Differences*, *122*, 104–108.

Smith, M. C. (1978). Cognizing the behavior stream: The recognition of intentional action. *Child Development*, 736–743.

Sommerville, J. A., & Woodward, A. L. (2005). Pulling out the intentional structure of action : the relation between action processing and action production in infancy. *Cognition*, *95*(1), 1–30. https://doi.org/10.1016/j.cognition.2003.12.004

Sowell, E. R., Peterson, B. S., Thompson, P. M., Welcome, S. E., Henkenius, A. L., & Toga, A. W. (2003). Mapping cortical change across the human life span. *Nature Neuroscience*, *6*(3), 309-316.

Sowell, E. R., Thompson, P. M., Holmes, C. J., Jernigan, T. L., & Toga, A. W. (1999). In vivo evidence for post-adolescent brain maturation in frontal and striatal regions. *Nature Neuroscience*, *2*(10), 859-861.

Sowell, E. R., Thompson, P. M., Tessner, K. D., & Toga, A. W. (2001). Mapping continued brain growth and gray matter density reduction in dorsal frontal cortex: Inverse relationships during postadolescent brain maturation. *Journal of Neuroscience*, *21*(22), 8819–8829.

Stanovich, K. E., & West, R. F. (1997). Reasoning independently of prior belief and individual differences in actively open-minded thinking. *Journal of Educational Psychology*, *89*(2), 342-357.

Stanovich, K. E., & West, R. F. (1998). Individual Differences in Rational Thought. *Journal of Experimental Psychology: General*, *127*(2), 161–188.

Stanovich, K. E., & West, R. F. (2008). On the Relative Independence of Thinking Biases and Cognitive Ability, *94*(4), 672–695. https://doi.org/10.1037/0022-3514.94.4.672

Stiensmeier-Pelster, J., & Schürmann, M. (1993). Information processing in decision making under time pressure. In O. Svenson & A. J. Maule (Eds.), *Time pressure and stress in human judgment and decision making* (pp. 241–253). New York: Plenum Press.

Swap, W. C. (1991). When prosocial behavior becomes altruistic: An attributional analysis. *Current Psychology*, *10*(1–2), 49–64.

Taylor, S. P., Shuntich, R. J., & Greenberg, A. (1979). The effects of repeated aggressive encounters on subsequent aggressive behavior. *The Journal of Social Psychology*, *107*(2), 199–208.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, *28*(5), 675–691.

Tomasello, M., Strosberg, R., & Akhtar, N. (1996). Eighteen-month-old children learn words in non-ostensive contexts. *Journal of Child Language*, *23*(1), 157–176.

Toplak, M. E., Liu, E., MacPherson, R., Toneatto, T., & Stanovich, K. E. (2007). The reasoning skills and thinking dispositions of problem gamblers: A dual-process taxonomy. *Journal of Behavioral Decision Making*, *20*(2), 103–124.

Turkat, I. D., Keane, S. P., & Thompson-Pope, S. K. (1990). Social processing errors among paranoid personalities. *Journal of Psychopathology and Behavioral Assessment*, *12*(3), 263–269.

Uzefovsky, F., Allison, C., Smith, P., & Baron-Cohen, S. (2016). Brief report: the go/no-go task online: inhibitory control deficits in autism in a large sample. *Journal of Autism and Developmental Disorders*, *46*(8), 2774–2779.

Van Os, J., Linscott, R. J., Myin-Germeys, I., Delespaul, P., & Krabbendam, L. (2009). A systematic review and meta-analysis of the psychosis continuum: evidence for a psychosis proneness–persistence–impairment model of psychotic disorder. *Psychological Medicine*, *39*(02), 179-195.

https://doi.org/10.1017/S0033291708003814

Van Overwalle, F., Schachtman, T. R., & Reilly, S. S. (2011). Social learning and connectionism. In T. R. Schacthman & S. S. Reilly (Eds.), *Associative Learning and Conditioning Theory: Human and Non-Human Applications* (345-375). New York: Oxford University Press.

Van Overwalle, F., & Van Rooy, D. (1998). A connectionist approach to causal attribution. *Connectionist Models of Social Reasoning and Social Behavior*, 143–171.

Volkmar, F. R., Klin, A., Marans, W. D., & McDougle, C. J. (1996). Autistic disorder. In F. R. Volkmar (Ed.), *Psychoses and pervasive developmental disorders in childhood and asolescence* (pp. 129–190). Arlington, VA: American Psychiatric Association.

Volkmar, F. R., Sparrow, S. S., Goudreau, D., Cicchetti, D. V, Paul, R., & Cohen, D. J. (1987). Social deficits in autism: An operational approach using the Vineland Adaptive Behavior Scales. *Journal of the American Academy of Child & Adolescent Psychiatry*, *26*(2), 156–161.

Wang, A. T., Lee, S. S., Sigman, M., & Dapretto, M. (2006). Neural basis of irony comprehension in children with autism: the role of prosody and context. *Brain*, *129*(4), 932–943.

Wechsler, D. (2011). *Wechsler abbreviated scale of intelligence - Second Edition (WASI-II)*. San Antonio, TX: NCS Pearson.

Welsh, M. C., Pennington, B. F., & Groisser, D. B. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology*, *7*(2), 131–149.

West, R. F., Toplak, M. E., & Stanovich, K. E. (2008). Heuristics and biases as measures of critical thinking: Associations with cognitive ability and thinking dispositions. *Journal of Educational Psychology*, *100*(4), 930-941.

White, S. W., Kreiser, N. L., Pugliese, C., & Scarpa, A. (2012). Social anxiety mediates the effect of autism spectrum disorder characteristics on hostility in young adults. *Autism*, *16*(5), 453–464.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V, & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. *Biological Psychiatry*, *57*(11), 1336–1346.

Zadny, J., & Gerard, H. B. (1974). Attributed intentions and informational selectivity. *Journal of Experimental Social Psychology*, *10*(1), 34–52.

Zalla, T., Sav, A.-M., Stopin, A., Ahade, S., & Leboyer, M. (2009). Faux pas detection and intentional action in Asperger Syndrome. A replication on a French sample. *Journal of Autism and Developmental Disorders*, *39*(2), 373–382.

Zucchelli, M. M., Nori, R., Gambetti, E., & Giusberti, F. (2018). The influence of high autistic personality traits on the attribution of intentionality in typically developing individuals. *Journal of Cognitive Psychology*, 1–14.

Appendices

Appendix 1: List of stimuli of the Ambiguous Sentence Paradigm

This list comprises a full list of stimuli as used in this thesis: 34 ambiguous test sentences (22 Prototypically Accidental test sentences; 12 Prototypically Intentional test sentences) and 20 unambiguous control sentences (10 Accidental control sentences; 10 Intentional control sentences). Please note that Rosset's (2008) original paradigm comprises 20 items of each control category.

Prototypically Accidental test sentences

He hit the man with his car.
He gave her the wrong change.
She burnt the meal.
She broke the vase
He tracked mud inside.
He forgot his homework.
He arrived 5 min late for class.
He bumped into a classmate in the hall.
He broke the window.
The painter inhaled the fumes.
He drank the spoiled milk.
She woke the baby up.
He stepped in the puddle.
He set off the alarm.
He jumped when the bell rang.
He dripped paint on the canvas.
She kicked her dog.
She left the water running.
He set the house on fire.
He ate the bruised part of the apple.

She told the same joke twice.
The girl popped the balloon.

Prototypically Intentional test sentences

She cut him off driving.
The boy knocked over the sand castle.
She walked by without saying hello.
He took an illegal left turn.
He ripped the piece of paper.
She sprayed him with water.
The man left without leaving a tip.
She made a mark on the paper.
She drove over the speed limit.
He deleted the email.
She ignored the question.
She averted her eyes.

Accidental control sentences

She lost her keys.
The girl had a seizure.
She tripped on the jump rope.
The boy hiccupped.
He poked himself in the eye.
She broke her cell phone.
He fell off the skateboard.
He fell down the stairs.
He sneezed from allergies.
He broke his tooth playing hockey.

Intentional control sentences

He threw the football.
He vacuumed the carpet.
She threaded the needle.
The boy smiled for the picture.
She proofread her paper.

He shaved in front of the mirror.
She followed the recipe.
He listened attentively.
She changed the flat tire.
He drew a picture of the beach.

Appendix 2: Results of non-parametric Mann-Whitney U tests for test categories, Chapter 2

As a supplementary analysis for *Analysis I* in *Chapter 2* a Mann-Whitney U test was run to investigate whether group differences between the speeded and un-speeded condition would be significant if a non-parametric test was chosen. Results revealed a significant effect of time constraints on intentionality endorsement scores for Prototypically Accidental test sentences, with participants in the speeded condition scoring higher (U=8835, p=.006, one-tailed). There was no significant difference between intentionality endorsement scores of the speeded compared to un-speeded group (U=9296.5, p=.062, two-tailed).

Appendix 3: Results of regression analysis with logarithmic transformation of the predictor variable, Chapter 3

Given that the distribution of age was positively skewed, as supplementary analyses, linear regression analyses were run after conducting a logarithmic transformation (log10) of the predictor variable age. Results revealed that the transformed predictor variables could not predict intentionality endorsement scores for either type of test sentence: *F*(1, 310)=.118, p=.731, R^2=.00, β=.02, Figure A3.1; Prototypically Intentional: *F*(1, 310)=1.737, *p*=.188, R^2=.006, β=-.075, Figure A3.2.

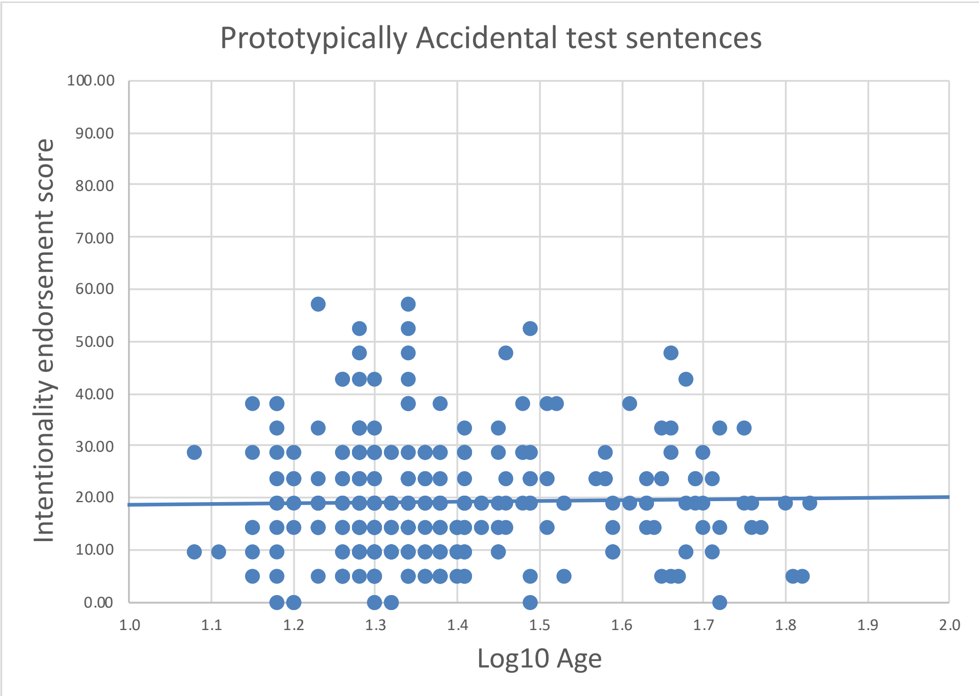


Figure A3.1. Scatterplot showing the association between the log-transformed predictor variable (age) and intentionality endorsement scores for Prototypically Accidental test sentences with a linear trendline. Intentionality endorsement scores reflect the percentage of sentences judged to describe behaviour done on purpose.

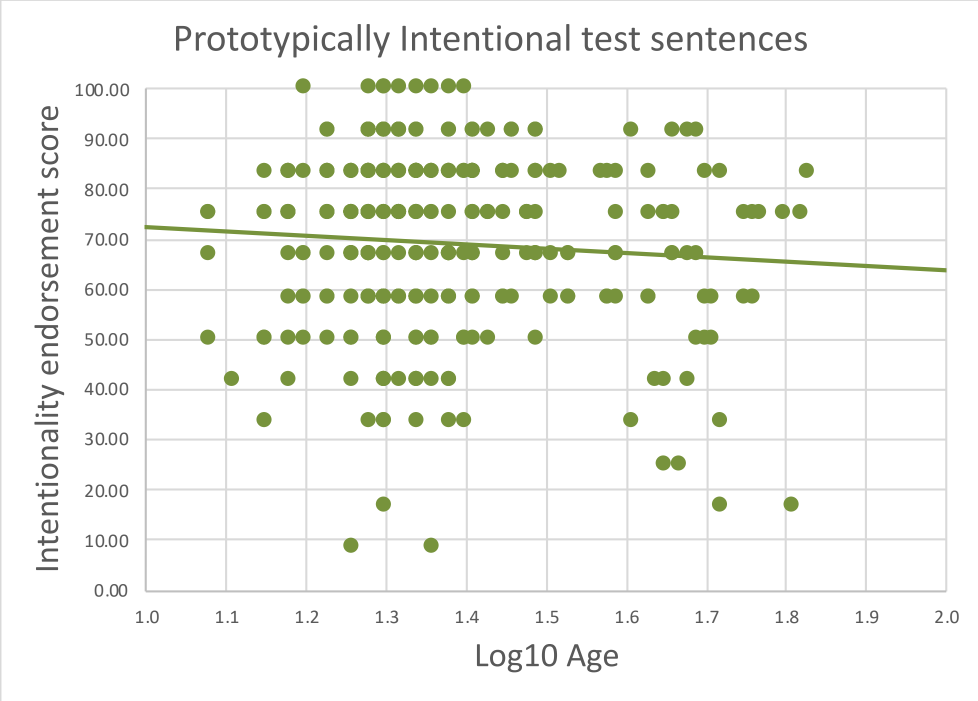


Figure A3.2. Scatterplot showing the association between the log-transformed predictor variable (age) and intentionality endorsement scores for Prototypically Accidental test sentences with a linear trendline. Intentionality endorsement scores reflect the percentage of sentences judged to describe behaviour done on purpose.

Appendix 4: Analysis with correct trials only, Chapter 8

An underlying reason for incorrect responses for the cognitive load task could be the failure to attempt to remember the digit(s), i.e. no increased cognitive load. Therefore, for *Experiment 1* an additional analysis was performed including only trials with a correct working memory task response. A one-way ANCOVA was conducted to determine the effect of cognitive load (no load, low load, high load) on intentionality endorsement scores controlling for working memory capacity (K). It revealed no significant difference between groups, $F(2, 38)=.069$, $p=.934$.

Table A.7. Intentionality endorsement scores for correct WM-trials only with standard deviations in brackets for the no WM load (NL)-, low WM load (LL)- and high WM load (HL) condition. Intentionality endorsement scores reflect the percentage of items judged to be intentional.

Condition	Intentionality endorsement score
NL	61.61 (*10.98*)
LL	64.58 (*16.86*)
HL	61.94 (*17.42*)

Appendix 5: Analysis with outliers included, Chapter 8

As a supplementary analysis for *Experiment 2*, a one-way ANCOVA was conducted to determine the effect of WM load (no WM load, low WM load, high WM load) on intentionality endorsement scores controlling for working memory capacity (K) with no outliers excluded (n=329). Although the trend pointed in the right direction, analysis revealed no significant difference between groups ($F(2)=1.497$, $p=.225$; Table A.9).

Table A.9. Intentionality endorsement scores for each condition with standard deviations in brackets for the no WM load (NL)-, low WM load (LL)- and high WM load (HL) condition. Intentionality endorsement scores reflect the percentage of items judged to be intentional.

Condition	Intentionality endorsement score
NL	59.07 (*17.22*)
LL	60.53 (*20.75*)
HL	63.38 (20.75)