Trait impulsivity, cigarette smoking and e-cigarette use

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DECLARATION

I declare that the work presented in this thesis is my own. All studies and work detailed in the text of this thesis is novel and has not been previously submitted as part of the requirements of a higher degree.

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Abstract

Although there is considerable evidence of an association between impulsivity and cigarette smoking, the magnitude of this association varies greatly across studies. On the other hand, research on the relationship between trait impulsivity and e-cigarette use is limited, and the available results also provide mixed findings. This thesis aimed to understand the relationship between trait impulsivity, cigarette smoking, and e-cigarette use. It also examines the role of e-cigarettes in smoking cessation as there is great controversy over the efficacy of e-cigarette use as a smoking cessation tool. A systematic review of the literature identified that cigarette smokers are more impulsive than non smokers, while emotion-based impulsivity is the impulsivity-related trait most associated with nicotine dependence. A study of 720 mainly European adults found different relationships between specific impulsivity-related traits and different classes of smoking status, suggesting that lack of perseverance differentiated e-cigarette users from cigarette smokers, and emotion-based impulsivity differentiated e-cigarette users from dual users (those who smoke a cigarette and use an e-cigarette). Additionally, it was found that trait impulsivity is related to e-cigarette use through positive e-cigarette attitudes. An Ecological Momentary Assessment study further showed that emotion-based impulsivity is a significant predictor of real-time cravings and real-time moods in cigarette smokers, e-cigarette users and dual users. The final study of the thesis assessed the role of e-cigarettes and trait impulsivity in smoking cessation. Findings suggest that e-cigarette use could potential be a useful tool in helping cigarette smokers to quit smoking. These findings help to further understand the role of trait impulsivity in cigarette smoking and e-cigarette use, and the relationship between cigarette smoking and e-cigarette use.

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Chapter 1

Introduction

Overview

The following introductory chapter aims to present key areas of the existing literature that have informed the work presented in this thesis. First, cigarette smoking will be discussed, along with reasons associated with initiation, maintenance and cessation of cigarette smoking in adults. Second, a description of electronic cigarettes (e-cigarettes) will be provided, with a discussion about the efficacy of e-cigarette use on smoking cessation and the health impacts associated with e-cigarette use. Third, trait impulsivity will be defined, and an overview of the literature regarding cigarette smoking and trait impulsivity will be given. Finally, the programme of research conducted for the purposes of this thesis will be presented by outlining specific aims and research questions. This chapter does not aim to give a comprehensive review of literature on cigarette smoking, e-cigarette use and trait impulsivity. Its purpose is to give an overview of existing knowledge in each of these topics to show why further research, conducted for the purposes of this thesis, is needed.

Cigarette smoking

Cigarette smoking is a substantial global public health concern, and it is the single largest preventable cause of morbidity and mortality in western countries. There is a gradual decline in cigarette smoking in adults in most western countries; however, the prevalence of smoking is still high. The World Health Organization (WHO) calculated that 22.7% of the global population above the age of 15 smokes tobacco cigarettes, which represents 1.1 billion people, of whom 36% are male and 7% are female (WHO, 2018). Europe has the highest prevalence of cigarette smoking among adults (28%), and the highest rate of cigarette smoking in females (18%) (WHO, 2018). In UK, the smoking prevalence in adults is 15.1%; 17% in males and 13.3% in females, and the highest proportion of current smokers are people aged 25 to 34 years old (19.7%), while the largest reduction in smoking prevalence has been among 18 to 24 years old (Office for National statistics, 2019). It is also documented that cigarette smoking is more common in people with lower socioeconomic status; the percentage of smokers in routine and manual occupations is 25.9%, while it is only 10.2% in managerial and professional occupations (Office for National statistics, 2019).

Reducing the prevalence of cigarette smoking is one of the major public health goals worldwide. Intensive tobacco control efforts to reduce uptake and convince current smokers to quit have been undertaken over the past decades (WHO, 2018). Likewise, the UK and many other western countries have introduced a collection of policies aiming to reduce smoking, such as the establishment of non-smoking indoor environments, the ban on tobacco advertising, plain packaging of cigarettes, and the steady increase on taxation of tobacco products (NHS, 2019). All these regulations aim to denormalize smoking behaviour and make cigarettes less

desirable and less accessible. Additionally, smoking cessation services and nicotine replacement therapies are widely available in most western countries to help established smokers to quit smoking. Although these efforts have substantially reduced smoking prevalence, the decline in smoking is considered to be slow, as smoking remains the most important preventable risk factor for morbidity and premature mortality.

Cigarette smoking is recognized to be an independent risk factor for various diseases, such as cardiovascular disease, cancers of any form, stroke and chronic lung disease. Most importantly, smoking kills up to half of its users. According to WHO, there are six million deaths annually due to smoking, and it is predicted that one billion people will die prematurely from smoking related diseases during the 21st century (WHO, 2018). In the United States alone, cigarette smoking causes about one in every five deaths, with the death toll estimated at 300,000 for men and 180,000 for women yearly (WHO, 2018). In Europe, the number of annual smoking-related deaths is estimated at 700,000; in addition, an estimated 443,000 people die prematurely from exposure to second-hand smoking every year (WHO, 2018). Cigarette smoking is also a substantial economic and social burden worldwide. It has been calculated that smoking costs about £2billion a year in medical expenses related to smoking in the UK health care system, while its cost to British businesses accounted for about £8.5billion in lost productivity (ASH, 2019).

Cigarette smoking is a complex behaviour that over time becomes powerfully compulsive. It is highly addictive and the main reason for its addictive nature is nicotine. Tobacco cigarettes contain nicotine which stimulates the central nervous system as it releases the hormone epinephrine when entering the bloodstream, which speed up the heart and raise blood pressure (NIDA, n.d.). During cigarette

smoking nicotine enters the bloodstream via the lungs and reaches the brain within 10 seconds of inhalation, causing the release of various neurotransmitters including dopamine (Benowitz, 2009). In response, the release of dopamine results in the signalling of a pleasurable experience such as feelings of arousal, relaxation and improved concentration, which reinforces the effect of nicotine consumption (Benowitz, 2009).. Repeated exposure to nicotine desensitizes receptors in the brain, with increased amounts of nicotine needed to get the same desired effect (Benowitz, 2009), while nicotine withdrawal results in negative symptoms such as nervousness, restlessness, irritability, anxiety symptoms and impaired concentration (Hughes, 2007).

It has also been suggested that individuals habitually smoke cigarettes in certain situations such as when drinking alcohol or coffee, after a meal or in the presence of other smokers. The repeated association between cigarette smoking and specific events causes particular situations to become powerful smoking cues (Benowitz, 2009). Similarly, aspects of cigarette smoking experience, such as the smell of burnt cigarette, the taste of tobacco, or the feeling of it in the throat, become associated with the pleasurable effects of smoking. Unpleasant moods such as nervousness, stress or frustration can also developed into conditioned cues for smoking. For example, a smoker may learn that not smoking a cigarette causes irritability (a common symptom associated with nicotine withdrawal), whereas having a cigarette provides relief. After such repeated experiences, a smoker may come to regard irritability from any source as an indicator to smoke (Benowitz, 2009).

Cigarette smoking can be conceptualized as a variety of behaviours ranging from initiation to maintenance, cessation, and among people who quit, relapse. Two thirds of people who try cigarettes become daily smokers, and then nicotine

dependent (Birge, Duffy, Miler, & Hajek, 2018). Relapse is very common as a large number of ex smokers begin smoking again within one year (Fiore, 2000). It is acknowledged that there is no single factor that adequately explains smoking behaviour and several explanations of, and causes for, cigarette smoking have been identified in the literature. To a large extent, smoking is driven by neurobiological processes and genetics, but the behaviour is also shaped by social conditions and personality characteristics (Ford, 2001).

Factors associated with cigarette smoking

The role of genetics has been implicated as a key component in adult smoking behaviour. Twin studies support genetic influence as a factor for initiation and maintenance of smoking (Distel et al., 2012; Sullivan & Kendler, 1999; McCaffery, Lloyd-Ricardson, Niaura, Papandonatos, & Stanton, 2008). Preliminary evidence also suggests that genetic variants in the DNA may influence smoking initiation and nicotine dependence (Thorgeisson et al., 2010). While genetic factors may be a substantial reason for cigarette smoking in a portion of the population, there are individuals who have a low heritable risk for smoking, but who smoke nonetheless. Thus, other factors are also implicated in the initiation and the continuation of smoking behaviour.

Regarding the social aspects, it has been found that certain demographic factors such as male gender, young age, low socioeconomic status and low educational level are positively related to cigarette smoking (e.g., Peters, Huxley & Woodward, 2014; Hiscock, Bauld, Amos, Fidler & Munafo, 2012; Gilman et al., 2008; Centers for Disease Control and Prevention, 2017). Social context variables, such as having friends or family members who smoke and view smoking as

attractive, also significantly increase an individual's risk of cigarette smoking (Laverty et al., 2019). In particular, studies with adolescents have shown that the influence of peers appears to be the single most important factor in determining experimentation with cigarette smoking (Liu, Zhao, Chen, Falk & Albarracin, 2017; Fletcher, 2010).

Positive and negative mood have also been suggested to play a pivotal role in smoking motivation, while they have been implicated in the success or failure of smoking cessation. Positive affect is defined as the subjective experience of positive mood states that reflect feelings such as joy, interest, enthusiasm and alertness. On the other hand negative affect is defined as the subjective experience of negative mood states such as sadness, anger, irritability, and anxiety (Watson & Tellegen, 1985). Although correlated, positive and negative affect are distinct constructs (Watson & Tellegen, 1985), associated with different neural underpinnings (Lindquist, Saptute, Wager, Weber & Barrett, 2015; Roy, Shohamy & Wager, 2012), and have different patterns of relationships with other dimensions of mental health symptoms (e.g. Hofmann, Sawyer, Fang & Asnaani, 2012; Trofimova & Sulis, 2018). Consequently, it is reasonable to hypothesize that negative and positive affect would also have distinct relationships with cigarette smoking.

Negative affect demonstrates strong relations with cessation outcomes (McCarthy, Piasecki, Fiore & Baker, 2006; Piasecki et al., 2000; Piper, Cook, Schlam, Jorenby, Baker, 2011), with negative affect states (particularly anxiety-related symptoms), often cited as common antecedents to smoking lapse and relapse (Gilbert, Meliska, Williams & Jensen, 1992; Shiffman & Waters, 2004). In particular, a rapid rise in negative mood a few hours after a quit attempt has been found to be a significant risk factor of smoking relapse, while a gradual increase in negative mood over days is not (Shiffman & Waters, 2004). There is also some

evidence suggesting that smokers reporting more negative affect symptoms are more likely to smoke in order to reduce negative affect, and they actually perceived improved negative mood states following cigarette smoking (Beckham et al., 2007; Perkins, Karelitz, Giedgowd, Concklin, Sayette, 2010) due to the perceived anxiolytic and sedative properties of nicotine (Leventhal & Cleary, 1980). For example Carter et al. (2007) found negative affect ratings to be the lowest immediately after smoking compared with immediately before smoking and at random times during the day, in a sample of non treatment seeking smokers.

Evidence also suggests that positive affect has a strong relation with smoking and plays an important role in smoking cessation. Data has shown that individuals with lower levels of positive affect experience increased temptation to smoke than those with higher levels of positive affect (Rabois & Haaga, 2003), while studies from laboratory cue presentations report that exposure to positive affect cues significantly reduce cravings in adult smokers (Shiffman et al., 2013). Low positive affect also predicts lower likelihood of quitting. Specifically, the occurrence of low positive affect (Leventhal, Piper, Japuntich, Baker, & Cook, 2014), during a smoking cessation attempt (Doran et al., 2006; Leventhal, Ramsey, Brown, LaChance, & Kahler, 2008), or just after quitting (Cook et al., 2015), has been found to predict poorer smoking cessation outcomes, including failure to initiate smoking abstinence and greater risk for smoking relapse (Strong et al., 2011; Cook, Spring, McChargue, Hedeker, 2004).

A large body of research has examined the association of cigarette use with individual differences in the major dimensions of personality. Such research includes cross-sectional surveys that evaluate group differences between smokers and non-smokers and/or ex-smokers on widely used trait measures of broad dimensions of personality such as extraversion, neuroticism, and psychoticism. A review of this

literature suggests that the evidence is mixed with respect to the associations of cigarette smoking with these personality traits.

Earlier studies have shown a significant positive association between extraversion, the personality trait describing how outgoing and social an individual is, and cigarette smoking (Malouff, Thorsteinsson & Schutte 2006; Munafo and Black, 2007). However, in more recent studies, this association was not confirmed (Choi, Payne, Ma & Li, 2017). One possibility for such recent findings may be that cigarette smoking has been denormalized in many countries. Smokers might have been isolated in social situations as smoking restrictions exist in indoor places, and thus changing the relationship between cigarette smoking and extraversion.

Similarly, research on the relationship between neuroticisim, a personality trait defined as a tendency towards anxiety, self-doubt, depression and shyness, and cigarette smoking is also inconsistent. Some studies indicate a significant positive association between cigarette smoking and neuroticism (Hakulinen et al., 2015; Munafo, Zetteler & Clark, 2007), while this relationship was not found in some other studies (Buczkowski et al., 2017**;** Hampson, Goldberg, Vogt & Dubanoski, 2006). Nevertheless, contrary to extraversion, the association between neuroticism and cigarette smoking seems to have grown significantly during the last decades. Neurotic smokers seem to be less willing to quit smoking, since the negative affect caused by abstinence is stronger for them, even when confronted with the recent social pressure (Munafo & Black, 2007; Piasecki et al., 1997). They also feel greater reinforcing effects of nicotine compared with less neurotic individuals as cigarette smoking can help them to relieve feelings of sadness and negative mood (Gonzalez, Zvolensky, Vujanovic, Leyro & Marshall 2008). Additionally, the association between depression and cigarette smoking is well documented in the literature. A number of

studies have shown that depressed individuals are more likely to initiate cigarette smoking in order to relieve negative feeling, while data also suggest that depressed smokers experienced more difficulties in quitting since the negative affection caused by abstinence is stronger for them (Fluharty, Taylor, Grabski & Munafò, 2017).

The personality trait of psychoticism, which encompasses facets of character such as impulsivity, antisocial tendencies, disinhition, sensation seeking and low conscientiousness, has shown a more consistent positive relationship with cigarette smoking (Bickel, Odum & Madden, 1999; Doran, Spring, McChargue, Pergadia & Richmond, 2004; Mitchell 2004). In particular, it has been suggested that trait impulsivity is significantly positively associated with cigarette smoking. However, identifying the role of trait impulsivity in all stages of cigarette smoking (initiation, maintenance, cessation, and relapse) has been challenging mainly because of variation among studies in how trait impulsivity is defined. The present research will focus on the dimensions of personality characteristics related to trait impulsivity and their association with cigarette smoking in adults in an attempt to increase our understanding of continued smoking in a non-smoking environment.

Electronic cigarettes

Electronic cigarettes, also known as e-cigarettes, e-cigs or Electronic Nicotine Delivery Systems (ENDS) are battery-powered or accumulator devices, that contain an inhalation activated mechanism that heats a cartridge to form an aerosol (vapor) which is inhaled into the lungs. The use of e-cigarettes is often termed ‘vaping’, due to the inhalation of vapourised matter. The cartridge contains e-cigarette liquid (e-liquid) which is typically a mixture of propylene glycol, glycerol, distilled water, nicotine and flavourings in differing relative amounts (Hon, 2005). E-cigarettes do not

contain tobacco and consumers may choose between several nicotine strengths, including non-nicotine liquids, and a countless list of flavours (Caponnetto, Russo et al., 2013).

The first attempt to develop a nicotine-delivery device that provides stimulus similar to that of a tobacco cigarette without inhaling tobacco smoke was documented in 1963. However, it was not until 1979 that a non-combustible cigarette, named ‘Favor’, was manufactured and distributed. This device was a failure due to a short shelf life caused by rapid degradation of nicotine into a bitter tasting metabolite. The invention of the modern e-cigarette has been attributed to Chinese pharmacist Hon Lik, who created an electronically powered device that vaporizes a mixture containing, among other things, nicotine, glycerol, propylene glycol, and water with an electro-thermal vaporization nozzle in 2004. In 2007 e-cigarettes became widely commercially available and since then many variations of e-cigarettes exist. As of January 2014, it was estimated that there were at least 466 different brands of electronic cigarettes and 7,764 different flavours (Zhu et al., 2014). Amidst this large variety of options 4 types of e-cigarettes have emerged; disposable, first generation, second generation, and third generation e-cigarettes. Disposable e-cigarettes are similar to conventional cigarettes in appearance, and the entire device is discarded once the battery has been depleted or the e-liquid is finished. First generation e-cigarettes are rechargeable cigarette shaped devices, also known as “cig-a-likes”. They have relatively low-capacity batteries, non-refillable liquid cartridges, few (if any) variable settings, and operate at lower wattages. Second-generation devices, also known as “eGo”, are pen-styled devices which are larger than a cigarette. They typically have large rechargeable batteries, refillable cartridge, and some user adjustable parameters (e.g. variable voltage). Third-

generation devices, also called “mods”, are typically comprised of separate battery, reservoir and atomiser components. They are large devices, rechargeable with manual switches and they typically have many user-customizable parameters (e.g. voltage or wattage) and configurations (e.g. different types of tanks or batteries) (Jankowski, Brożek, Lawson, Skoczyński & Zejda, 2017).

E-cigarette awareness is now widespread and e-cigarette use among adults and adolescents has increased rapidly during the past few years (Pepper & Brewer, 2014). It has been suggested that more than 20 million people use e-cigarettes worldwide and in 2014, the past 30 day use of the e-cigarette surpassed cigarette usage among adolescents in US for the first time in history (Zare, Nemati, Zheng, 2018). The largest market for e-cigarettes is in the United States, where the percentage of individuals who currently use an e-cigarette increased from 3.7% in 2014 to 5.5% in 2017 (Center for disease and Control Prevention, 2018). In the UK, it has been documented that 94% of tobacco smokers and 93% of the general population had heard of e-cigarettes in 2018. This contrasts with data from 2012, when 49% of adults responding to the same question said they had never heard of e-cigarettes (ASH, 2019). Regarding e-cigarette use, there were around 700,000 e-cigarette users in the UK (1.7% of the population) in 2012. This has increased to 3.2 million e-cigarette users (6.2% of the population) in 2018. The rate of uptake of e-cigarettes was much greater earlier on; between 2012 and 2013 there was an 86% increase in the number of adult vapers. However, numbers are still rising, and e-cigarette users have increased from 2.9 million in 2017 to 3.2 million in 2018, which suggests a 10% rise (ASH, 2019).

With the growing use of e-cigarettes in recent years there has been intense debate on their health impact. Initial evidence indicated that e-cigarettes are less

harmful compared to conventional cigarettes as they do not expose vapers to many cancer-related chemical toxicants produced by tobacco and its combustion (Farsalinos & Polosa, 2014). Additionally, no issue of passive smoking has been identified by e-cigarette use as the emission of toxic substances of vaping is minimal (Public Health England, 2019). However, studies assessing the short-term health effects of e-cigarette use suggest that users self-report symptoms such as mouth and throat irritation, dry cough, headache, nausea and dyspnea from vaping, while experimental studies showed genotoxic and carcinogenic effects on white blood cells of e-cigarette users (Callahan-Lyon, 2014). It was also found that the risk of cardiovascular disease may be increased in vapers, as e-cigarettes expose users to high levels of particulates (Siasos et al. 2012). Emerging evidence also suggests e-cigarette use to be linked with six deaths in US and a number of lung illnesses (Centers for Disease Control and Prevention, 2019). Moreover, due to the fact that e-cigarettes have only been in the market for a decade, studies on the long term effects of e-cigarette use on health are not available.

Although the health effects of e-cigarettes have not been fully characterized, leaving questions about the degree of danger posed by e-cigarette vaping on users' health, it has been argued that e-cigarettes could serve as a smoking cessation tool for current cigarette smokers. E-cigarettes provide nicotine in both a manner and quantity that closely mimics cigarette smoking, thus satisfying smoker's habitual needs and nicotine addiction. Consequently, e-cigarettes might be able to diminish cigarette smoking withdrawal symptoms and reduce relapse rates among current cigarette smokers. Indeed, cross-sectional data from a large UK study have suggested that e-cigarette users were more likely to report continued abstinence than those who used a licensed nicotine replacement therapy product bought over-

the-counter (Brown et al., 2014). Such findings were also supported by more recent data from France (Pasquereau, Guignard, Andler & Nguyen-Thanh., 2017) and from the USA (Zhu, Zhuang, Wong, Cummins, & Tedeschi, 2017). Additionally, it has been documented that the proportion of current e-cigarette users that are ex-smokers has increased in the UK in the last few years. In 2014, 35% of current e-cigarette users were ex-smokers and 63% were smokers, while since 2017 the proportion of current e-cigarette users that are ex-smokers has been higher than the proportion that are smokers (ASH, 2019). On the other hand, a systematic review on e-cigarettes and smoking cessation in real-world and clinical settings found that e-cigarette use was associated with 28% reduced chances of quitting (Kalkhoran & Glantz, 2016), while a more recent review found limited evidence for a positive or negative effect of e-cigarettes on smoking cessation and quit attempts (El Dib et al., 2017). Based on such findings, public opinion is divided on whether e-cigarettes could serve as a useful smoking cessation tool for cigarette smokers, or whether they pose an additional risk to public health by maintaining smoking behaviour in many health-concerned individuals who perceive e-cigarettes as healthier than conventional cigarettes and who would have otherwise quit smoking.

Public health advocates are also concerned that e-cigarette use may result in a potential return to the social acceptability of smoking-like behaviour, which could make tobacco consumption in indoor workplaces and public spaces acceptable again, and increase smoking or vaping initiation in young adults and adolescents. Emerging evidence from longitudinal studies examining e-cigarette use among young adults and adolescents suggest that young people who experiment with e-cigarettes are more likely than those who have never tried an e-cigarette to subsequently initiate cigarette smoking. For example, longitudinal studies conducted

in US adolescents reported baseline e-cigarette use to be positively associated with the initiation of cigarette use a year later among 14 and 15 year old students, and sixteen months later among 17 year olds (Barrington-Trimis et al., 2016; Primack, Soneji, Stoolmiller, Fine, Sargent, 2015; Wills et al., 2016). Additionally, a UK based study of 13 and 14 years old students reported similar patterns of results (Conner et al., 2018), while a meta-analytic review estimates a threefold increase in the risk of subsequent cigarette smoking initiation among adolescents who use e-cigarettes (Soneji et al., 2017). On the other hand, a large scale survey study using data from 11-16 year olds across UK suggests that most e-cigarette experimentation does not result into regular e-cigarette use, while e-cigarette use in young people who have never smoked is very rare (Bauld et al., 2017).

Given the rapidly increasing rates of e-cigarette use, mixed findings to date regarding the health impacts associated with e-cigarette use, and concerns of cigarette smoking initiation among e-cigarette users, there is a real need to better understand individual risk factors for e-cigarette use. A number of studies have been published recently exploring the factors associated with e-cigarette use. The majority of these studies have focused on socio-demographic and smoking related characteristics, and showed that being a current cigarette smoker, male, younger, of White ethnicity and more highly educated, was associated with higher likelihood of e-cigarette use (King, Patel, Nguyen & Dube, 2015; McMillen, Maduka & Winickoff, 2012; Richardson, Williams, Rath, Villanti & Vallone, 2014). Less is known regarding personality traits and e-cigarette use. Trait impulsivity could be a potential risk factor for e-cigarette use, given the association of this trait with cigarette smoking (Kale, Stautz & Cooper, 2018). To date, there is a limited amount of studies examining the association between trait impulsivity and e-cigarette use and their results provide

mixed findings with some studies providing support for a positive relationship between trait impulsivity and e-cigarette use (Cohn et al., 2015; Doran & Tuly, 2018; Spindle et al., 2017), while some others do not (Chivers, Hand, Priest & Higgins, 2016). The present thesis will focus on the relationship between e-cigarette use and impulsivity, as well as reasons for e-cigarette use, among cigarette smokers and non-smokers in pursuit of developing a well-grounded model of e-cigarette use. Additionally, the relationship between e-cigarette use and cigarette smoking will be investigated in order to potentially inform cessation treatment plans and decisions. It is hoped that the work presented in this thesis can significantly contribute to e-cigarette research.

Impulsivity

Impulsivity is a broad construct associated with an inability to focus on tasks, a tendency to act on the spur of the moment without planning, and a preference for immediate over delayed gratification (Evenden, 1999). It is highly heterogeneous and it has been the subject of a great deal of terminological and conceptual confusion. It seems that the term impulsivity is used to describe several related but distinct phenomena that may have different biological bases (Evenden, 1999). For example the terms impulsivity, disinhibition, difficulty delaying gratification, lack of forethought, restlessness, lack of persistence, preference for immediate rewards, and sensation seeking have been used in different models to describe impulsive behaviour. Nevertheless, the very use of the term “impulsivity” implies that this concept refers to a single entity. Yet what we commonly call impulsivity may be an overarching construct that can be split into several conceptually and empirically separable traits.

In this section, I will discuss the link between trait impulsivity and cigarette smoking, while I will also describe how impulsivity is conceptualised and operationalised.

Impulsivity and cigarette smoking

Trait impulsivity is widely recognized as a personality trait that is associated with substance use problems, including cigarette smoking. Comparisons between smokers and non smokers consistently reveal that the former are more impulsive. Additionally, research suggests that trait impulsivity is a personality based risk factor that influences all aspects of smoking behaviour, including current smoking status (Mitchell, 1999), smoking initiation (e.g. Perkins et al., 2008), smoking cessation (e.g. Doran, Cook, McChargue & Spring, 2009) and level of nicotine dependence (e.g. Spillane, Smith & Kahler, 2010).

It is hypothesized that higher levels of impulsivity in nicotine-naive individuals increases the likelihood of cigarette experimentation and smoking initiation. Self-report measures, particularly those related most closely to the risk taking and sensation seeking dimension of impulsivity, have been shown to predict cigarette smoking initiation among adolescents and young adults/college students (Burt, Dinh, Peterson, & Sarason, 2000; Doran et al., 2013; Kvaavik & Rise, 2012), including transitions from never smoker to experimentation with cigarettes (Simon, Sussman, Dent, Burton, & Flay, 1995) and from experimentation to more regular smoking (Skara, Sussman, & Dent, 2001). Prospective studies have also supported the hypothesis that differences in impulsivity observed between smokers and non smokers predate smoking initiation both in adolescents and adults. For example, a longitudinal study of Finnish twins showed that children with high rates of inattentiveness, an impulsive characteristic, at age 12 were more likely to have

experimented with cigarettes at age 14, while children with the highest rates of inattentiveness were more likely to be current cigarette smokers at age 14 (Barman, Pulkkinen, Kaprio, & Rose, 2004). Additionally, a study conducted by Elkins, King, McGue, and Iacono (2006) suggested that lower levels of constraint, a personality trait that is the opposite of impulsivity, in 17 year old adolescents was associated with the onset of cigarette smoking from age 17 to 20.

Research has shown that heightened trait impulsivity is associated with greater expectancies for reinforcement from smoking, therefore posing a higher risk for cigarette smoking (Doran et al., 2013). Impulsive individuals seem to expect, and may actually derive, greater positive and/or negative reinforcement from cigarette smoking compared to less impulsive individuals. Indeed, a large cross-sectional study indicated that more impulsive and neurotic adolescents were disproportionately more likely to use cigarette smoking as a means of coping with negative affect. Additionally, a study conducted by Doran, McChargue and Cohen (2007) showed that, among college student smokers, high levels of impulsivity were associated with heightened expectations regarding the positive and negative reinforcement value of cigarette smoking, a relationship that has previously been documented for other substance use (Coskunpinar, Dir & Cyders, 2013; Stautz & Cooper, 2013).

A number of studies have also examined how and why trait impulsivity may influence the maintenance of regular smoking behaviour. They have addressed whether impulsivity is associated with indices of smoking behaviour, such as frequency of cigarette smoking and severity of nicotine dependence. Results suggest that heightened impulsivity is positively linked with frequency of tobacco use (Dom, Hulstijn, & Sabbe, 2006; Fossati, Barratt, Acquarini, & Di Ceglie, 2002; Litvin &

Brandon, 2010), as well as measures of nicotine dependence (Chase & Hogarth, 2011; Litvin & Brandon, 2010; Ryan, Mackillop, & Carpenter, 2013) in both adolescent and adult smokers. In particular, a study conducted by Spillane, Smith and Kahler (2010) suggests that higher levels of trait impulsivity are associated with greater smoking frequency and higher levels of nicotine dependence. Another study also showed that higher disinhibition was positively related with nicotine dependence (Flory & Manuck, 2009). Additionally, it has been found that impulsive individuals who are experimenting with cigarette smoking, and who expect smoking to be more reinforcing, are more likely to engage in more frequent cigarette smoking and therefore be more prone to becoming regular, dependent smokers (Doran, McChargue & Cohen, 2007).

Trait impulsivity has also been associated with difficulty quitting smoking in both adolescents and adults (Doran, Spring, McChargue, Pergadia, & Richmond, 2004; Krishnan-Sarin et al., 2007; Sheffer et al., 2012; VanderVeen, Cohen, Cukrowicz, & Trotter, 2008; Wegmann, Buhler, Strunk, Lang, & Nowak, 2012). It seems that impulsive smokers perceive smoking as more valuable than non impulsive individuals, and thus they are less motivated to quit smoking and less likely to succeed in their efforts to smoking cessation.

Additionally, it has been suggested that impulsive individuals experience more severe withdrawal symptoms, including craving and negative affect, during smoking cessation that leads them to relapse. Indeed, a number of studies using a smoking cue reactivity paradigm have confirmed a positive association between impulsivity and cigarette cravings (Doran, Cook, McChargue, & Spring, 2009; Doran, McChargue, & Spring, 2008; Doran, Spring, & McChargue, 2007; Litvin & Brandon, 2010). These studies suggest that impulsive smokers seems to hold a stronger belief

that smoking could provide a pleasurable experience and alleviate aversive ones, thus they experience stronger urges to smoke in the presence of both external (e.g., other smokers, ashtrays, lighters and smoking advertisements) and internal (e.g., withdrawal and negative affect) smoking cues. It has been also proposed that increased cue reactivity may be an important factor for smoking maintenance (Doran et al., 2004). Research also suggests that impulsive cigarette smokers may be reactive to smoking cues when they think that there is an opportunity to smoke. However, smokers with higher levels of trait impulsivity have not always shown higher reactivity to smoking cues independent of opportunity to smoke (Doran, Cook, McChargue, & Spring, 2009; Doran, McChargue, & Spring, 2008; Doran, Spring, & McChargue, 2007; Litvin & Brandon, 2010).

In abstinent smokers, impulsivity has been shown to be a significant predictor of smoking relapse. This is confirmed by a study conducted by Sheffer et al. (2012), who examined demographic characteristics, nicotine dependence, motivation and confidence to quit, and trait impulsivity as predictors of smoking cessation in a sample of adult smokers receiving treatment for smoking cessation. Their findings suggest that only trait impulsivity was a significant predictor of smoking cessation. Additionally, Doran, Spring, McChargue, Pergadia and Richmond (2004) reported that impulsive smokers were more likely to relapse within one month after one day smoking cessation workshop followed by 48-hour abstinence than non impulsive individuals.

From the research discussed above, it is evident there is an association between trait impulsivity and cigarette smoking behaviour. However, identifying the role of impulsivity in all stages of tobacco use has been challenging. This is largely

due to variation in how impulsivity is defined and measured. The following section introduces trait impulsivity in detail.

Conceptualisation and operationalisation of impulsivity

There are many ways to conceptualise trait impulsivity and the concept of trait impulsivity has been incorporated in most major personality theories that seek to understand an individual's behaviour. Eysenck (1956) originally considered impulsivity to be part of trait extraversion, along with sociability. In a revised version of his theory, impulsivity was related to the personality traits of psychoticism, the tendency for tough-mindedness and anti-social behaviour, and extraversion, the tendency for sociability and outgoing behaviour. Eysencks' model reflects a multidimensional model of impulsivity, as it suggests a two factor model of impulsivity, distinguishing between impulsiveness, which encompasses items relevant to rash action and acting without consideration, and venturesomeness, which is related to sensation seeking and risk taking.

Gray's (1970; 1987) classic Reinforcement Sensitivity Theory (RST) refers to impulsivity as a trait that describes individual differences in the sensitivity to signals of reward. This theory proposes two systems that influence personality, the Behavioural Approach System (BAS) and the Behavioural Inhibition System (BIS). The BIS inhibits behaviours in the presence of punishing stimuli, while the BAS is related to approach motivation in response to rewards, and active avoidance in response to punishment. More recent research on the Reinforcement Sensitivity Theory identified three systems that influence an individual's behaviour; the behavioural approach system (BAS) which is activated by all forms appetitive stimuli, the fight-flight-freeze system (FFFS), which is activated in response to aversive

stimuli, and the behavioural inhibition system (BIS), which is activated by conflicting stimuli (Corr & McNaughton, 2012; Corr & McNaughton, 2008; Gray & McNaughton, 2000). Individuals with higher levels of impulsivity are considered to be sensitive to conditioned signals of reward, and thus show a greater tendency to approach potentially rewarding stimuli.

In Buss and Plomin's (1975) four factor model of temperament impulsivity is defined as a three facet construct that includes; the tendency to become bored and seek novel stimuli , the tendency to consider alternatives and consequences before making decisions, and the ability to remain with a task despite temptation.

Zuckerman's (1971, 1994) personality model refers to sensation seeking as a tendency to pursue stimuli and experiences that are novel, exciting, and intense. In this theory, sensation seeking is a multi-faceted construct, which encompasses four different dimensions: thrill and adventure seeking, experience seeking, boredom susceptibility and disinhibition. Zuckerman (1994) has suggested that the trait cluster of psychoticism, impulsivity, and un-socialised sensation seeking forms a core dimension of human personality.

A similar construct to Zuckerman's sensation seeking is novelty seeking proposed by Cloninger (Cloninger, 1987; Cloninger, Svrakic, & Przybeck, 1993). In this model, novelty seeking is conceptualized as a trait associated with exploratory activity in response to novel stimulation, impulsive decision, excessiveness in approach to reward cues, avoidance of frustration, and quick loss of temper. Novelty seeking shows high correlations with sensation seeking and psychoticism (Zuckerman & Cloninger, 1996), while its suggested biological basis links closely with Gray's BAS (Cloninger, 1987).

In Tellegen's (1982, 1985) three-factor model of personality, impulsivity is conceptualized as one of the three factors that determines the manner and intensity in which individuals respond to emotional stimuli. The other two factors are positive and negative emotionality, and are directly related to mood. The impulsivity-related factor is labelled constraint and it is in fact the opposite of impulsivity as it captures an individual's level of caution, restraint, harm avoidance, and traditionalism. Low constraint and high negative emotionality are prospectively associated with addictive behaviours, while low constraint has also been shown to distinguish between individuals with and without a substance use disorder (McGue, Slutske, & Iacono, 1999).

Dickman's (1990) two-factor model refers to functional and dysfunctional impulsivity. This model suggests that impulsivity can have both positive, as well as negative consequences. It defines functional impulsivity as the tendency to act rashly when such behaviour causes optimal results, and dysfunctional impulsivity as the tendency to act rashly in situations in which it is not beneficial.

Barratt also conceptualised impulsivity as a multifaceted construct in the development of a self-report measure labelled Barratt Impulsiveness Scale (BIS; Patton, Stanford, & Barratt, 1995). He identified three high order factors that measure different aspects of impulsivity, namely attentional impulsiveness, which reflects an inability to concentrate on a task at hand, motor impulsiveness, which reflects a tendency to act with little or no forethought, and non-planning impulsiveness, which refers to reduced capacity for careful thinking and planning.

Neo-PI-R (Neuroticism Extraversion Openness-Personality Inventory-Revised) model of personality (Costa & McCrae, 1992) is based on the Five Factor Model (FFM; McCrae & Costa 1990), which is one of the leading personality

theories. The FFM describes individuals in terms of five fundamental personality domains; neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness, each of which is composed of six facets. In the FFM, three different domains, Neuroticism, Extraversion and Openness, have been shown to capture some aspects of impulsivity (Whiteside & Lynam, 2001). Specifically it has been proposed that the impulsiveness facet of neuroticism and the self-discipline facet of conscientiousness measure self-control. The authors described individuals high on the impulsiveness facet as excitable, moody and irritable, while those who were low on self-control facet were described as disorganised, lazy and not thorough. Additionally, it has been proposed that the excitement seeking facet of extraversion is similar to the sensation seeking of Zuckerman's personality model (1994) and the venturesomeness factor of Eysenck and Eysenck (1977), while the deliberation facet of conscientiousness is similar to Tellegen's constraint factor and to Barratt's non-planning impulsiveness facet. Individuals who score high on the excitement seeking facet are described as pleasure seeking, daring, and adventurous, while those who score low on deliberation facet are described as hasty, impulsive, careless, and impatient.

From all the theories and models described in this section, it is apparent that there is no single construct which we can point to as impulsive personality, but rather we should discuss impulsivity as a multidimensional construct comprising of separate, though related, factors. Additionally, many of the factors appear across many theories and models, while use of alternate labels for equivalent constructs, such as disinhibition or constraint, has further complicated the definition of trait impulsivity. Identifying this confusion and overlap, several researchers have made efforts to integrate current theories and constructs of trait impulsivity. Two of these

approaches have received considerable empirical support: a model based on the theory proposed by Dawe, Gullo, and Loxton (2004), and a model derived by Whiteside and Lynam (2001).

Dawe, Gullo and Loxton (2004) theorised that impulsivity is not a unitary construct and it is best described as a dual component model, with one component called reward sensitivity, or reward drive, and the other rash impulsiveness (Dawe, Gullo & Loxton, 2004; Dawe & Loxton, 2004). Reward sensitivity refers to an elevated sensitivity to conditioned and unconditioned rewarding stimuli. Rash impulsiveness is a tendency to act rashly and spontaneously without consideration of the risks or future consequences involved (Dawe, Gullo & Loxton, 2004; Dawe & Loxton, 2004). Although seemingly interlinked, evidence suggests that these two components represent separate systems based on different neurobiological processes (Dawe, Gullo & Loxton, 2004). Reward sensitivity is considered to involve activity in the mesolimbic dopamine system, a brain region responsible for natural reinforcement responses to nutrients and reproduction (Gullo & Dawe, 2008). In contrast, rash impulsiveness is thought to involve the orbitofrontal cortex and the anterior cingulated cortex, areas associated with impulse control and cognitive processes of decision making (Dawe, Gullo & Loxton, 2004).

Based on this conceptualization of impulsivity, a two-step model of addiction has been proposed which states that individual differences in reward sensitivity mediate initial use, whereas differences in rash impulsiveness mediate persistent abuse of substances (Dawe, Gullo & Loxton, 2004). Research has shown that rash impulsiveness is associated with tobacco dependence and a younger age of initiation of tobacco use, while reward seeking is not. It was also found that both

factors of impulsivity are related to smoking initiation (Flory & Manuck, 2009). Such results are consistent with the proposed two-step model of addiction.

Reward sensitivity and rash impulsiveness have been measured at the trait level using a diverse range of scales, and there is no agreement over a single measure of these two components. Reward sensitivity definition bears robust similarity to Gray's (1991) BAS and factor analysis revealed that both BAS drive and BAS reward responsiveness of the BIS/BAS scales (Carver & White, 1994) load on one factor, that of reward sensitivity. On the other hand, rash impulsiveness is reflected in many different self-report measures such as Eysenck's I7 scale (Eysenck, Pearson, Easting & Allsopp, 1985), Cloninger's (1989) measure of novelty seeking, and Zuckerman's (1994) sensation seeking scale (Gullo et al., 2011). It seems that rash impulsiveness encompasses more than one construct, as the above mentioned scales measure different concepts, such as rash unplanned behaviour, novelty seeking and risk taking. So in relation to two component model, it seems that this is not sufficient to cover the variation in impulsive behaviour.

In an attempt to address the previously discussed confusion regarding the dimensions of impulsivity, and to provide consensus on which domains of impulsive personality are being assessed across measures, Whiteside and Lynam (2001) developed a new instrument to combine existing measures and models of impulsivity. Their approach was data-driven, however their analysis examined the various conceptions of impulsivity within the framework provided by the Five Factor Model (FFM; McCrae & Costa 1990).

Whiteside and Lynam (2001) conducted a study with 437 undergraduate students in the United States. They carried out an exploratory factor analysis using 20 scales drawn from nine well-validated self-report measures, including omnibus

personality measures, as well as measures developed specifically to assess trait impulsivity. The results suggest a four factor scale of impulsivity, namely the UPPS (Urgency, Premeditation (lack of), Perseverance (lack of), Sensation seeking) Impulsive Behaviour Scale, which includes 45 items. The first factor is labelled Urgency, which refers to the tendency to act rashly in response to strong negative emotion (example item: When I am upset I often act without thinking), and seems to be associated with the impulsiveness facet of the FFM. The second factor is lack of Premeditation, which is described as the tendency to act without thinking (example item: My thinking is usually careful and purposeful, reversed), and is associated with the deliberation facet of the FFM. The third factor is lack of Perseverance, which refers to the inability to remain focused on a task (example item: I finish what I start, reversed), and this factor is found to be associated with the self-discipline facet of the FFM. The fourth factor is Sensation seeking, which refers to the tendency to seek out novel experiences (example item: I'll try anything once), and is associated with the excitement seeking facet of the FFM.

Urgency in the UPPS model initially focused only on impulsive responses to negative emotions; it was subsequently revised to add a component of Positive urgency, that is a tendency to act rashly in response to strong positive emotions (example item: When I am very happy, I can't seem to stop myself from doing things that can have bad consequences) (Cyders, Smith, Spillane, Fishwe, Annus & Peterson, 2007). Although newer to the model, the positive urgency scale was reported to be content valid, unidimensional and to represent a distinct factor from the other four facets (Cyders & Smith, 2008). The revised model and measure is referred to as the UPPS-P. In contrast to instruments that examine subtypes of impulsivity, the five facets of the UPPS-P model are intended to capture separable

processes that lead to impulsive-related behaviour, and in this model impulsivity is conceptualized as a latent variable that encompasses these five discrete psychological processes.

Convergent validity of the UPPS model was tested by semi-structured interviews confirming the distinct function of each facet of the scale (Smith et al., 2007). Although the UPPS was initially developed with an undergraduate sample (Whiteside & Lynam, 2001), it has been since replicated in several studies and in different populations, both community and clinical (e.g., Magid & Colder, 2007; Smith et al., 2007; Whiteside, Lynam, Miller, & Reynolds, 2005). It is a reliable measure that appears to exhibit satisfactory construct validity. Examining measurement invariance of the scale across gender (male versus female), the scales structural invariance across gender, and whether the five traits differentially relate to risk outcomes as a function of gender, it was concluded that the scale function comparably across both genders (Cyders, 2013). Additionally, it was found that scores on the UPPS-P subscales also correlate with other instruments designed to assess impulsivity, including other self-report measures (e.g., BIS/BAS, BIS-11, Disinhibition Inventory, NEO-PI-R; Duckworth & Kern, 2011; Seibert, Miller, Pryor, Reidy, & Zeichner, 2010; Sharma, Kohl, Morgan, & Clark, 2013; Whiteside & Lynam, 2001). The UPPS-P scale therefore provides a potentially unique perspective on the development and trajectories of both the personality trait of impulsivity, as well as the disorders in which impulsive behaviour is implicated.

UPPS-P impulsivity scale and cigarette smoking

Since its development, the UPPS-P model has been used to examine the association between self-reported trait impulsivity and cigarette smoking. Findings

suggest that different dimensions of the trait may influence different aspects of smoking behaviour. The sensation seeking facet of impulsivity has been found to predict initiation of smoking (Lipkus, Barefoot, Williams & Siegler 1994; Perkins et al., 2008) and smoking levels (Flory & Manuck, 2009; Spillane, Smith & Kahler, 2010) in adolescents and young adults. For example, Doran et al. (2013) examined the association between the impulsivity-related traits of sensation seeking and negative urgency and cigarette smoking among college students. Their findings suggest that increased levels of sensation seeking directly predict initiation of smoking, while negative urgency does not. Additionally, they found that negative urgency predicts smoking initiation when this relationship is mediated by negative reinforcement expectancies.

The impulsivity-related trait of lack of premeditation was found to be associated with cigarette consumption (Miller, Flory, Lynam & Leukefeld, 2003), but not with nicotine craving (Billieux, Van der Linden & Ceschi, 2007). It has been suggested that individuals with higher levels of lack of premeditation may be more prone to smoke or to engage in more frequent cigarette smoking because they are less likely to consider the potential negative effects of smoking. For the same reason, smokers who lack premeditation may be particularly likely to respond to cigarette craving by smoking.

Positive and negative urgency have been associated with smoking frequency and the development of nicotine dependence in adult smokers (Billieux, Van der Linden & Ceschi, 2007; Doran, Cook, McChargue & Spring, 2009; Tapper, Baker, Jiga-Boy, Haddock & Maio, 2015). For example, Billieux, Van der Linden and Censchi (2007) examined the relationship between different dimensions of trait impulsivity and nicotine cravings and consumption. Their findings suggest that higher

urgency is significantly associated with cigarette cravings (Billieux, Van der Linden and Censchi, 2007). Additionally, Spillane, Smith & Kahler (2010) examined which of UPPS-P impulsivity-related traits predicts being a current smoker among college students. Their results suggest that higher levels of sensation seeking predict smoking status, while positive urgency is the only impulsivity-related trait to be significantly associated with higher nicotine dependence.

The use of more comprehensive instruments, such as the UPPS-P, to assess impulsivity is important for clarification of the relationship between impulsivity and substance use including cigarette smoking and e-cigarette use. Thus, the UPPS-P model will be used as the primary framework for considering impulsivity in this thesis.

The theory and research outlined thus far clearly indicate many issues in the field of individual differences in trait impulsivity and cigarette smoking and e-cigarette use. It is also clear that research on e-cigarettes is in the very early stages and more studies are needed to identify risk factors of e-cigarette use and the relationship between e-cigarette use and cigarette smoking. Better understanding of these issues will help to inform regulations, campaigns and interventions to reduce cigarette smoking and e-cigarette use among adults. Thus, the research presented here aims to contribute to the resolution of these issues and to help reduce rates of smoking prevalence. The next section summarises the individual study aims, and the broad plan of investigation for each study in this thesis. Further rationale for each study will be provided in the introduction sections of the individual empirical chapters.

Aims and research questions

The overall aim of this thesis is to understand the relationship between trait impulsivity, cigarette smoking, and e-cigarette use.

To this end, four broad aims will be pursued:

1. To establish whether the various impulsivity-related personality traits differ from one another in their relationship with cigarette smoking in adults
2. To examine the relationship between impulsivity-related traits and e-cigarette use in adults
3. To examine the relationship between impulsivity-related traits, cravings and mood in cigarette smokers, e-cigarette users and dual users (those who currently smoke cigarettes and use e-cigarettes).
4. To examine the relationship between e-cigarette use, trait impulsivity and smoking cessation

The programme of research will begin with an attempt to delineate the relative roles of impulsivity-related traits in adult cigarette smoking using the existing literature. It is well established that impulsivity is associated with cigarette smoking; what is not yet clear is which aspects of impulsivity show the largest relationships with cigarette smoking, and severity of nicotine dependence. Chapter 2 addresses these issues, investigating the following research questions:

i) Do separate impulsivity-related personality traits show different relationships with cigarette smoking in adults?

ii) Do separate impulsivity-related personality traits show different relationships with severity of nicotine dependence in adults?

iii) Do demographic factors moderate these relationships?

The first empirical study of the thesis is reported in Chapter 3. This chapter addresses the second overall aim of the thesis as it aims to investigate the relationship between impulsivity-related personality traits based on the UPPS-P and e-cigarette use. Additionally in replication of research conducted in chapter 2 we will

examine the relationship between impulsivity-related traits and cigarette smoking and nicotine dependence in adults. Finally, this study will investigate differences between dual users and cigarette smokers in order to advance our understanding of e-cigarette use among current cigarette smokers.

The following research questions are addressed:

i) Do impulsivity-related traits differentiate e-cigarette users from non-smokers, smokers and dual users in adults?
ii) Is there any relationship between impulsivity-related traits and frequency and intensity of e-cigarette use?
iii) What are the main reasons for e-cigarette use?
iv) Do separate impulsivity-related personality traits show different relationships with cigarette smoking in adults?
v) Do separate impulsivity-related personality traits show different relationships with severity of nicotine dependence in adults?
vi) Do cigarette smokers differ from dual users in smoking behaviour, motivation to quit, impulsivity-related traits and attitudes towards e-cigarettes?
vii) Is there any association between reasons for e-cigarette use and intention to quit in dual users?

Chapter 4 uses data collected for the purposes of chapter 3 in order to examine the psychometric properties of the Comparing E-cigarette And Cigarette questionnaire (CEAC) by testing its purported factor structure, reliability and its measurement invariance across e-cigarette use groups. This chapter also aims to examine whether the relationship between impulsivity-related traits and e-cigarette use would be mediated by positive attitudes towards e-cigarettes.

The following questions are addressed:

i) What is the factor structure of the CEAC questionnaire?

ii) What are the psychometric properties of CEAC questionnaire?

iii) Do positive attitudes towards e-cigarettes mediate the relationship between impulsivity-related personality traits and e-cigarette use?

Chapter 5 addresses the third overall aim of the thesis. This study will use Ecological Momentary Assessment (EMA) method, a validated and reliable method to measure one's behaviour and experience in real times, to assess real world e-cigarette use in cigarette smokers and non-smokers and investigate their association with trait impulsivity. It will also evaluate the impact of e-cigarette use in real-time cravings and positive and negative mood.

The following questions are addressed:

i) Do e-cigarette users differ in e-cigarette use from dual users?

ii) Do e-cigarette users differ in their real-time cravings, and negative and positive moods from cigarette smokers and dual users?

iii) What is the relationship between separate impulsivity-related traits and real-time cravings?

iv) What is the relationship between separate impulsivity-related traits and real-time positive and negative moods?

Chapter 6 addresses the fourth overall aim of the thesis as it uses a longitudinal design to examine the association between e-cigarette use, trait impulsivity, and motivation to quit with smoking cessation among adult smokers. Additionally, the effect of e-cigarette use on motivation to quit, as well as the main reasons associated with e-cigarette use in cigarette smokers will be examined.

The following questions are addressed:

i) Does e-cigarette use increase smoking cessation?

ii) Are different levels of e-cigarette use related to smoking cessation?

iii) Is there an association between e-cigarette use and motivation to quit?

iv) What is the role of separate impulsivity-related traits in smoking cessation in cigarette smokers and dual users?

v) Are nicotine dependence, motivation to quit and previous quit attempts associated with smoking cessation in cigarette smokers and dual users?

vi) What are the main reasons associated with e-cigarette use among cigarette smokers?

Chapter 2

Impulsivity related personality traits and cigarette smoking in adults: a meta-analysis using the UPPS-P model of impulsivity and reward sensitivity

Overview

This chapter presents a meta-analysis that aims to examine the direction and magnitude of relationships between specific impulsivity-related traits, namely lack of premeditation, lack of perseverance, sensation seeking, negative urgency, positive urgency and reward sensitivity and both smoking status and severity of nicotine dependence in adults across studies, and to delineate differences in effects across these relationships. Smoking status and severity of nicotine dependence were significantly associated with all impulsivity-related traits except reward sensitivity. Lack of premeditation and positive urgency showed the largest associations with smoking status, while positive urgency showed the largest association with severity of nicotine dependence. Study design moderated associations between lack of premeditation and lack of perseverance and smoking status, with larger effects found in cross-sectional compared to prospective studies.

Introduction

There are currently over a billion smokers worldwide and it is estimated that 80,000 to 100,000 people become addicted to smoking every day (WHO, 2018). Half of all life-long smokers die prematurely and, on average, cigarette smokers lose fifteen years of their life, making smoking the leading cause of premature mortality (WHO, 2018). As such, reducing the prevalence of smoking is one of the major public health goals worldwide.

However, the reinforcing effects of nicotine present a major problem to effective smoking cessation (Hughes, 2001). Current smoking cessation interventions often show limited effectiveness, possibly due to individual differences in the biological and behavioural mechanisms involved in the susceptibility to smoking initiation and maintenance (Sutherland, 2002). Interest in the role played by personality characteristics, and in particular of impulsivity, in all aspects of smoking behaviour is growing (Bloom et al., 2014). A greater understanding of the influence that impulsivity has on cigarette smoking may result in the improvement of interventions to reduce smoking prevalence, and also aid the development of screening and prevention methods for non-users and escalating smokers.

Impulsivity and smoking

Impulsivity can be defined as a tendency to engage rapidly in behaviour without adequate consideration of the potential consequences (Evenden, 1999). It seems that individuals with heightened impulsivity are often either unable or unwilling to consider long-term consequences. Unable, because they have difficulty controlling their impulses and resulting actions, and react to immediate environmental stimuli;

unwilling, because they get more pleasure from immediately available rewards (Evenden, 1999).

Impulsivity has been assessed in various ways; as a stable personality trait through self-report questionnaires, as a behaviour measured with laboratory based behavioural tests, or as a neurobiological process using tools such as functional magnetic resonance imaging to analyse brain structure and function. The typically modest correlations found in previous research between behavioural and self-report measures of impulsivity suggest that the laboratory-based behavioural tasks are measuring different constructs from self-report personality traits (Cyders & Coskunpinar, 2011). Behavioural tasks usually capture what participants do in a given situation, while self-report questionnaires assess what participants tend to do over time and across situations (Cyders & Coskunpinar, 2011). Laboratory tasks of impulsivity and self-reported impulsivity assessments are weakly correlated or uncorrelated, but both aspects of impulsivity have been related to specific brain activity (Cyders & Coskunpinar, 2012). The focus of the present study is on the self-report assessment of impulsivity, which is more appropriate for assessing more stable (trait-dependent) aspects of impulsivity.

Research on trait impulsivity and cigarette smoking has found that smokers are typically more impulsive than non-smokers, and that impulsivity is associated with smoking initiation, maintenance, cessation, and nicotine addiction (e.g. Mitchell, 1999; Reynolds et al., 2007; Doran et al., 2009; Perkins et al., 2008). Studies with adolescents suggest that differences between smokers and non-smokers in self-reported impulsivity appear to pre-date smoking initiation (Bloom et al., 2014). Conversely, chronic exposure to nicotine and acute nicotine deprivation may increase impulsivity (Bloom et al., 2014). It has also been suggested that impulsive

smokers are less likely to quit because they perceive more benefits from smoking and experience more severe withdrawal symptoms (Doran et al., 2007). However, identifying the role of impulsivity in all stages of tobacco use has been challenging because of variation among studies in how trait impulsivity is defined. Consequently, more integrated research is needed in this area.

Over the last few years, researchers have made considerable progress in deconstructing trait impulsivity into its component constructs through the development of the UPPS-P model of impulsivity (Whiteside & Lynam, 2001; Cyders & Smith, 2008). They have identified five different personality dispositions to engage in rash or impulsive action: negative urgency, which refers to the tendency to act rashly in response to negative mood; positive urgency, the tendency to act rashly when experiencing intensely positive mood; lack of premeditation, the tendency to act without thinking; lack of perseverance, the inability to remain focused on a task; and sensation seeking, which refers to the tendency to seek out exciting, novel experiences (Whiteside & Lynam, 2001; Cyders & Smith, 2008). Studies have shown that these traits share between 6% and 27% of their variance, with negative and positive urgency sharing the largest proportion of variance (Cyders & Smith, 2007). Measurement of separate aspects of impulsivity using the UPPS-P framework can clarify the variation observed when using more general measures of trait impulsivity. However, one limitation of the UPPS-P framework is that it does not include a measure of reward sensitivity, which refers to an elevated sensitivity to conditioned and unconditioned rewarding stimuli, and has been highlighted as a key component of impulsivity by some authors in the field (Dawe & Loxton, 2004; Dawe et al., 2004; Gullo & Dawe, 2008). Measures of reward sensitivity were not included in the original factor analysis that generated the UPPS framework (Whiteside & Lynam,

2001).Reward sensitivity is related to the sensation seeking scale from the UPPS-P model, but research has shown that it is distinct from it (Dawe & Loxton, 2004). Reward sensitivity partly reflects individual differences in the functioning of a theorised Behavioural Approach System (BAS; Gray, 1991), and can be measured with personality questionnaires such as the BAS scales (Carver & White, 1994). It is purported by a number of researchers to be a key component of trait impulsivity, and a variable that explains variance in indices of substance use above and beyond other measures of impulsivity (Dawe et al., 2004).

Research using the UPPS-P traits and reward sensitivity has shown that separate traits show different patterns of association and prediction with smoking-related outcomes. For example, whereas sensation seeking predicts initiation of smoking (Lipkus et al., 1994; Perkins et al., 2008) and smoking levels (Flory & Manuck, 2009; Spillane et al., 2010), lack of premeditation and lack of perseverance often do not, yet, the latter are associated with symptoms of tobacco dependence (Chase & Hogarth, 2011; Flory & Manuck, 2009). Additionally, urgency and reward sensitivity have shown to be related to the development of nicotine dependence and smoking frequency (Spillane et al., 2010; Billieux et al., 2007; Doran et al., 2009; Tapper et al., 2015). However, the relationship between impulsivity-related traits and cigarette smoking varies greatly between studies. Synthesizing the findings from multiple studies to produce summary effect sizes of these associations is therefore a useful research endeavour. Additionally, it would be helpful to understand whether sample characteristics such as age, gender, and ethnicity affect these associations. Since it has been documented that impulsivity-related traits decrease with age (Steinberg et al., 2008), are typically observed to be higher in males than females

(Weinstein & Dannon, 2015), and differs between different races (e.g. Hoyle, Stephenson, Palmgreen, Lorch & Donohew, 2002).

Present study

There are a number of meta-analytic reviews assessing the relationship between trait impulsivity and different substances such as alcohol (Stautz & Cooper, 2013; Coskunpinar et al., 2013) and marijuana (VanderVeen et al., 2016). However, to our knowledge, there has been no quantitative review focused on impulsivity-related traits and their relationship with cigarette smoking. Therefore, the aim of the present study is to review research in order to examine the direction and magnitude of relationships between specific impulsivity-related traits and both smoking status and severity of nicotine dependence in adults across studies, and to delineate differences in effects across these relationships. In addition to the primary analyses, the present study will also test whether age, gender, ethnicity, sample type and study type moderate any relationships. Finally the present meta-analysis aims to highlight gaps in the existing research that future studies could address.

Method

Literature search

A literature search was conducted using PubMed, PsychINFO, Medline, EBSCO Academic Search Complete, Elsevier Science Direct and Google Scholar covering articles published up to November 2016. Key words included all possible combinations of two word categories: i) impulsiv*, disinhibition, premeditation, lack of planning, perseverance, boredom proneness, boredom susceptibility, sensation seeking, novelty seeking, urgency, negative urgency, positive urgency, BAS, reward

sensitivity, reward drive, behavioural approach, behavioural activation, and ii) smok*, nicotine, cigarette, tobacco. Ten authors with extensive publications on impulsivity and cigarette smoking were also contacted via email with requests for any unpublished data suitable for this meta-analysis which they might have been able to share. No such data were obtained. The reference sections of all eligible articles were also examined to identify further studies that could be included.

Inclusion and exclusion criteria

Studies were included in the analysis if they met all of the following criteria: 1) contained empirical measurement of both self-report impulsivity and current smoking status and/or severity of nicotine dependence, 2) used measures of impulsivity that mapped onto the UPPS-P model and reward sensitivity, 3) referred to cigarette use and not any other forms of tobacco use (e.g. cigars, e-cigarettes, hookah etc), 4) used a measure of cigarette smoking that was not combined with alcohol and other drug use, 5) the sample were adults (aged 18 or over), although studies that reported results on college students of 17 years old and older, and where the mean age of the sample was over 18 years old were also retained in the analysis, 6) the sample comprised smokers (dependent, nondependent, chippers) and non-smokers (never-smokers, ex-smokers) for the smoking status analysis or just smokers for the nicotine dependence analysis, 7) were available in English.

Studies were excluded if they reported results on the same population with another study. In such cases, the study with the largest amount of usable data was retained in the analysis. In addition two studies were excluded as they presented non-normally distributed data, possibly indicating a biased sample. There were a number of studies that did not include sufficient data to calculate effect sizes. If the

studies had been published within the last ten years (2006 and later), first authors were contacted via email to obtain the necessary information. Figure 2.1 shows a flowchart of the study selection process including numbers of excluded studies.

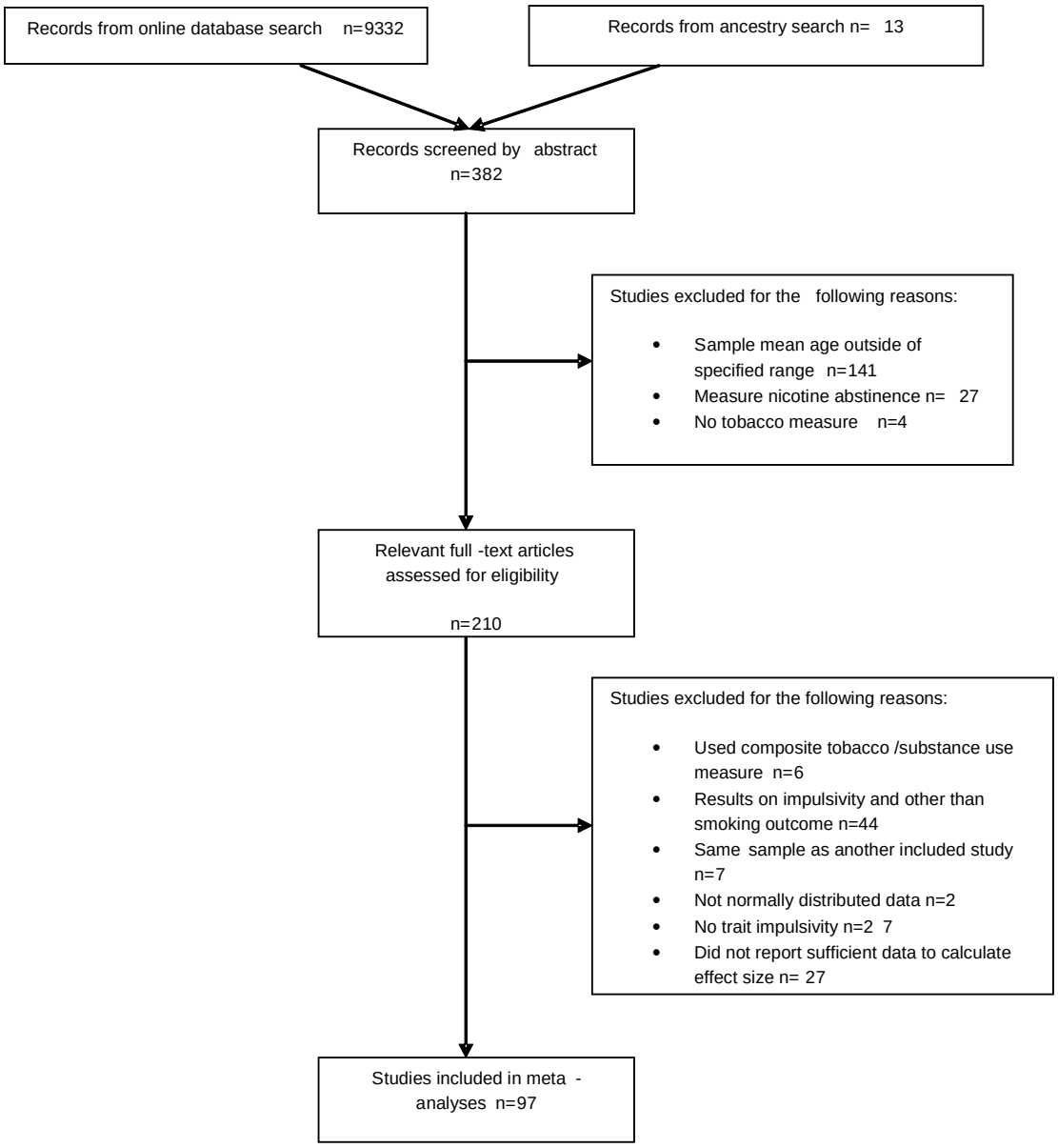

Figure 2.1: Flowchart for study selection

Data extraction

For each study the following data were extracted: Author(s) and year of publication, study design (cross-sectional or prospective), type of sample (normative, such as general population, and college student samples; or non-normative, such as

clinical patients), number of smokers (dependent, non dependent smokers, daily, non daily smokers and chippers) and non-smokers (never smokers and ex-smokers), mean age of the sample (in cases where the age range was reported, median value of the range), percentage of the sample that was male, percentage of the sample that was of white ethnicity (as the majority of studies reported samples of white ethnicity), impulsivity trait scale used, nicotine dependence measure used, and the means and standard deviations, *F*, standardised β values or odds ratio for group comparison studies, and correlation for correlational studies.

Each impulsivity measure used was categorised into trait domains according to each UPPS-P sub-scale and reward sensitivity following previous organisation of existing impulsivity scales (see Stautz & Cooper, 2013). There were eleven studies that used measures that had not previously been categorized in one of the five UPPS-P impulsivity facets or reward sensitivity; these measures were analysed for content and categorised accordingly (Table 2.1). Two of the authors independently reviewed these scales and classified each on to a specific UPPS-P trait (there was agreement of rating in all cases). In the present study the Drive and Reward Responsiveness subscales of the BAS measure (Carver & White, 1994) were considered together as a measure of reward sensitivity, as the effect sizes for both subscales were similar for most of the studies that reported results on both subscales. Most of these self-report impulsivity measures showed good reliability as reported in the original studies (Sharma et al., 2014).

Measures of nicotine dependence included: The Fagerström Test for Nicotine Dependence (Heatherton et al., 1991), The Fagerström Tolerance Questionnaire (Fagerström, 1978), number of cigarettes smoked per day/per week and one study that compared daily versus occasional smokers. Even though the last measure is

categorical and so differs from the continuous measures of nicotine dependence it was included in the analyses as occasional smokers smoke significantly less cigarettes than daily smokers and they vary greatly in their nicotine dependence compared to daily smokers (Gilpin et al., 1997). All data was coded so that higher values on the measures indicated higher levels of impulsivity.

Table 2.1. Impulsivity-related trait categories and measures.

Lack of premeditation	Barratt Impulsivity Scale – Nonplanning and Motor Impulsivity (Patton et al., 1995)
	[b]Barratt Impulsivity Scale –Total score (Patton et al., 1995)
	I-7 Impulsiveness (Eysenck et al., 1985)
	Impulsivity Control Scale (Plutchik & Van Praag, 1978)
	Karolinska Scales of Personality – Impulsiveness (Schalling, 1978)
	Substance Use Risk Profile Scale – Impulsivity (Woicik et al., 2009)
	UPPS – Lack of Premeditation (Whiteside & Lynam, 2001)
	Zuckerman-Kuhlman Personality Questionnaire – Impulsivity (Zuckerman et al., 1993)
	[a] The Personality Inventory (BUPI)- Impetuousness (Hathaway & McKinlet, 1951)
	[a] Dickman Impulsiveness Inventory- Dysfunctional Impulsivity (Dickman, 1990)
	[a] 10 item Impulsivity scale (Littlefield, Sher & Wood, 2009)
	[a] Impulsive Behaviour scale (Morean et al., 2014)
	[a] Eysenck Personality Inventory (EPI)- Extraversion-Impulsivity Subscale (Eysenck and Eysenck 1968)
	[a] EPQ- Eysenck Personality Questionnaire (Eysenck and Eysenck 1978)
Lack of perseverance	Sensation Seeking Scale – Boredom susceptibility, Disinhibition (Zuckerman, 1994)
	UPPS – Lack of perseverance (Whiteside & Lynam, 2001)
	[a] Emotionality, Activity, Sociability and Impulsivity Temperament Survey III- Inhibitory Control Subscale (Buss & Plommin, 1975)
	[a] Frontal Systems Behavior Scale -scale Disinhibition (Grace & Malloy, 2001)
Sensation seeking	BIS/BAS Scales – Fun Seeking (Carver & White, 1994)
	Brief Sensation Seeking Scale (Hoyle et al., 2002)
	I-7 Venturesomeness (Eysenck et al., 1984)
	TCI – Novelty Seeking (Cloninger et al., 1994)
	TPQ – Novelty Seeking (Cloninger, 1989)
	Sensation Seeking Scale – Thrill and adventure seeking (Zuckerman, 1994)
	[b]Sensation Seeking Scale – Total score (Zuckerman, 1994)
	Substance Use Risk Profile Scale – Sensation seeking (Woicik et al., 2009)
	UPPS- Sensation Seeking (Whiteside & Lynam, 2001)
	Zuckerman – Kuhlman Personality Questionnaire – Sensation Seeking (Zuckerman et al., 1993)
	[a] Values, Attitudes and Lifestyles- Novelty seeking (Strategic insight, 2005)
	[a] Domain-specific Risk attitude scale (Weber, Blais & Betz, 2002)
	[a] The Personality Inventory (BUPI)- Thrill and danger seeking (Hathaway & McKinlet, 1951
	[a] Two item risk taking scale (Peltzer, Malaka & Phaswana, 2001)
Negative urgency	Barratt Impulsivity Scale – Attentional Impulsivity (Patton et al., 1995)
	NEO-PI-R Impulsiveness (Costa & McCrae, 1992)
	UPPS – Urgency (Whiteside & Lynam, 2001)
Positive Urgency	UPPS-P Positive Urgency (Cyders et al., 2007)
Reward Sensitivity	BIS/BAS Scales – Drive and Reward Responsiveness (Carver & White, 1994)
	SPSRQ – Sensitivity to Reward (Torrubia et al., 2001)

[a] Scales categorised by authors for the meta-analyses reported in this study; all other scales used the same mapping reported in Stautz and Cooper (2013)

[b] Used only if subscale scores unavailable

Analytic procedure

The meta-analysis used Pearson's *r* as the effect size for relationships between personality and smoking status and severity of nicotine dependence as we were interested in differences in patterns of association and wanted to compare the results with previous reviews that have also reported *r* as the effect size (e.g. Stautz & Cooper, 2013; Coskunpinar et al., 2013; VanderVeen et al., 2016). In the cases that *r* was not reported, it was calculated from descriptive statistics (mean and standard deviation), *F*, odds ratio or standardised *β* values using traditional formulae (DeCoster, 2004; Lipsey & Wilson, 2001; Peterson & Brown, 2005).

A random effects model was employed for all analyses. The random effects model, as opposed to a fixed effects model, assumes a different underlying effect for each study and takes this into account as an additional source of variation. The random effects model gives more conservative results with wider confidence intervals and the results can be generalised to wider populations. This model was preferred in the present analyses as studies were from different populations and there was substantial variation in the measures used across studies.

All *r* values were converted to *Zrs* using Fisher's (1928) *r-to-Zr* transformation. Resulting effect sizes were weighted by sample size across studies. After performing the meta-analytic calculations, Fisher's *Zr* values were converted back to Pearson's *r* using the inverse *Zr* transformation.

Several articles contributed more than one effect size for the relationship between impulsivity-related traits and smoking status. In these cases the average effect size across all measures of the same outcome was calculated to ensure that every study contributed only one effect size to any one meta-analysis. Multiple effect sizes reported on the same sample from longitudinal studies were also averaged.

There were two cases of longitudinal studies (Kvaavik & Rise, 2012; Littlefield & Sher, 2012) that reported results of the same population at two different time points, however the samples size at these two different points was not the same. In this case, only data from the larger sample was retained in the analysis.

Following the recommendations of Tabachnick and Fidell (2001), the effect sizes within each analysis group were examined for univariate outliers by converting to *Z* scores and assessing whether any values were greater than *Z*=3.30.

The *Q* and I^2 statistics were calculated for each analysis. The *Q* statistic reveals how much of the overall heterogeneity can be attributed to true between-studies variation. A statistically significant *Q* statistic indicates the presence of heterogeneity (Borenstein et al., 2009), while the I^2 statistic is a percentage that indicates the proportion of observed variation that can be attributed to the actual difference between studies rather than within-study variance. Its value ranges from 0-100, with higher values representing higher true heterogeneity (Higgins et al., 2003).

Forest plots were also calculated to illustrate the heterogeneity of the included studies for each analysis (i.e. Figure 2.2: forest plot of lack of premeditation and smoking status; Figure 2.3: forest plot of lack of premeditation and severity of nicotine dependence; Figure 2.4: forest plot of sensation seeking and smoking status; Figure 2.5: forest plot of sensation seeking and severity of nicotine dependence).

A fail-safe N (FSN) statistic was estimated on statistically significant mean effects to examine potential publication bias (Orwin, 1983). The FSN estimates the number of unpublished studies with an average effect size of 0 that would be necessary to reduce the observed effect size to non significant levels (Lipsey and

Wilson, 2001; Orwin, 1983). Effect sizes of 0.05 were considered very small and this criterion was used in the FSN analysis.

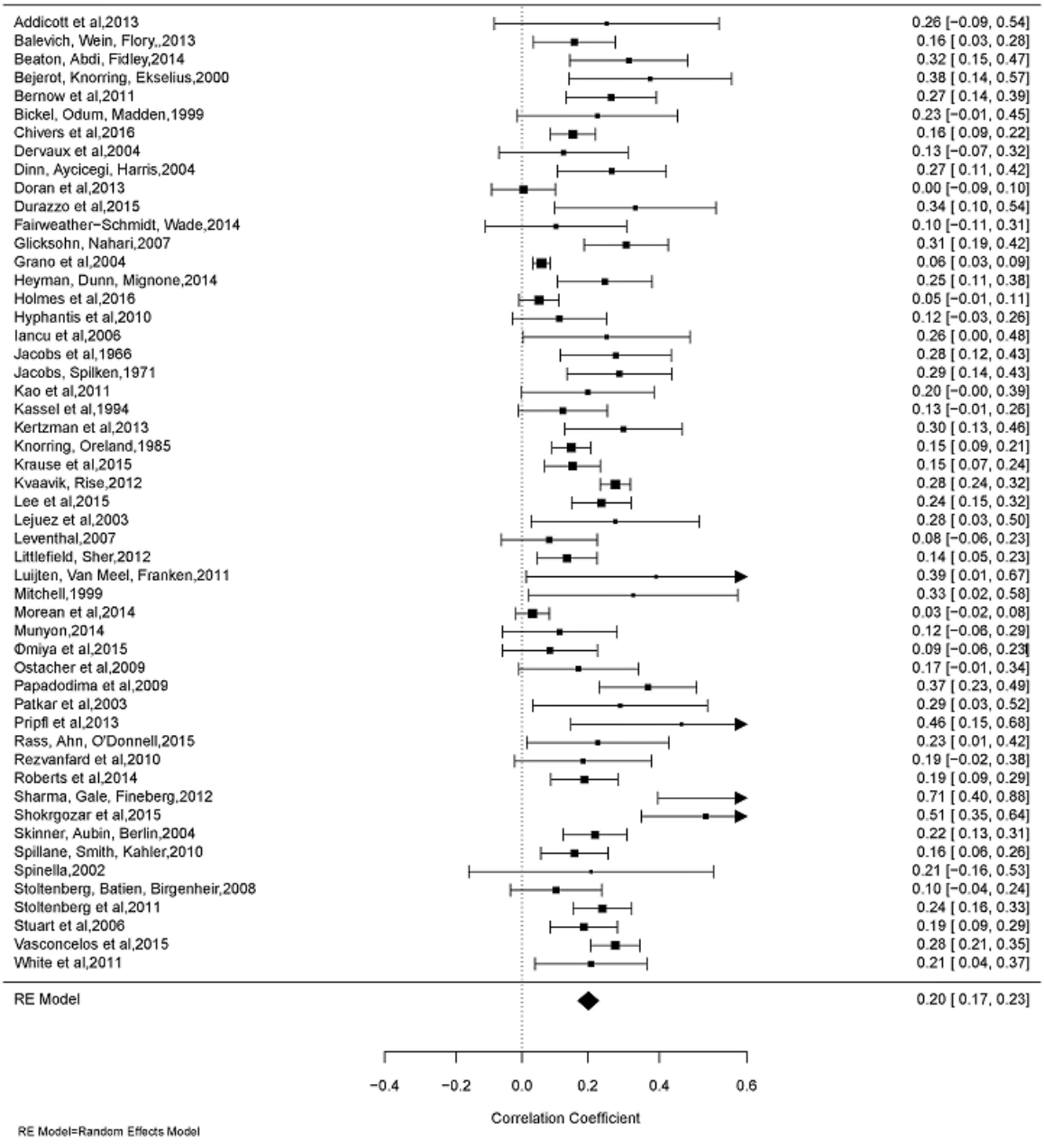

Figure 2.2: Forest plot lack of premeditation and smoking status showing risk ratio and 95%CI for each study

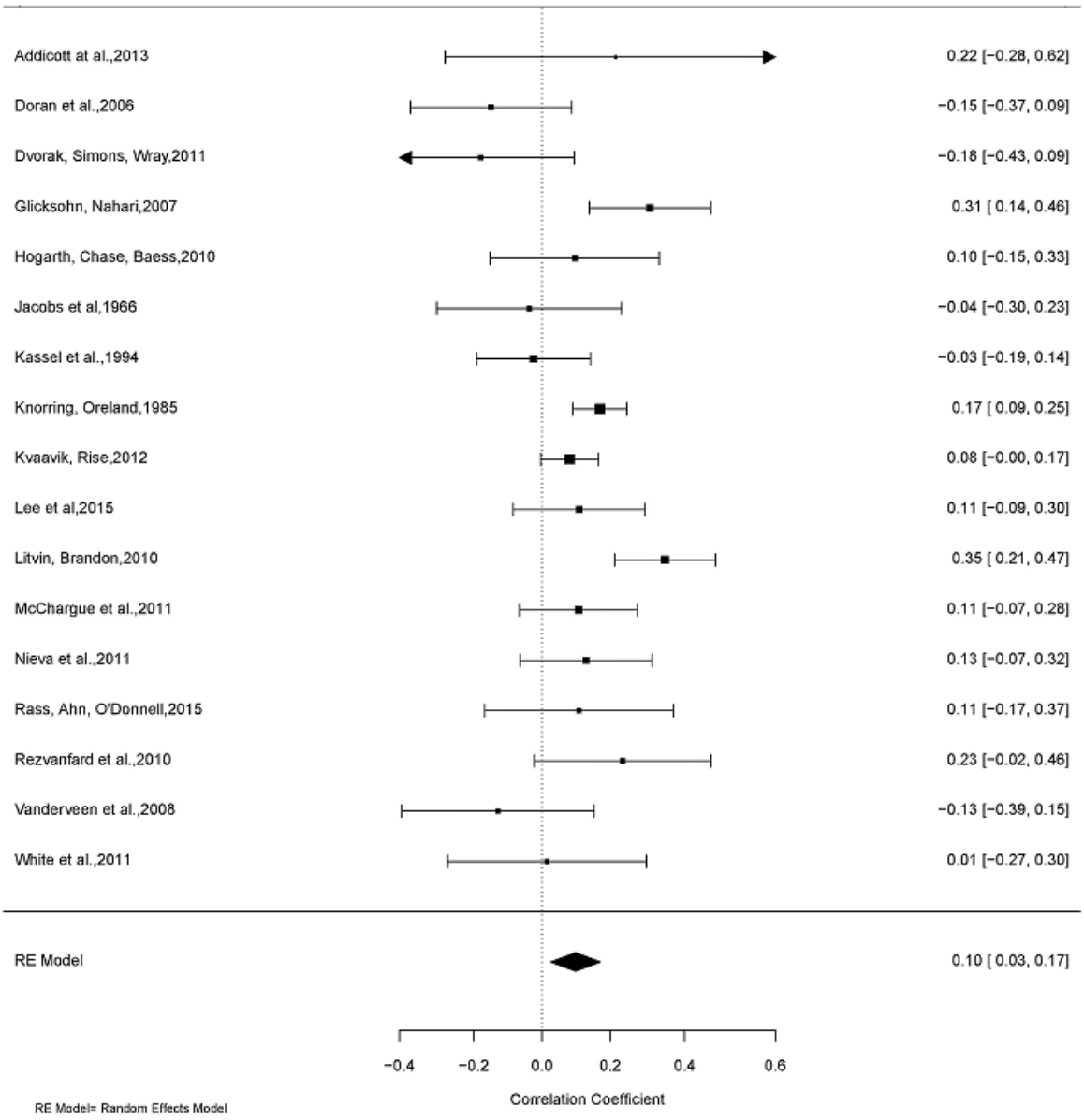

Figure2.3: Forest plot lack of premeditation and severity of nicotine dependence showing risk ratio and 95% CI of each study

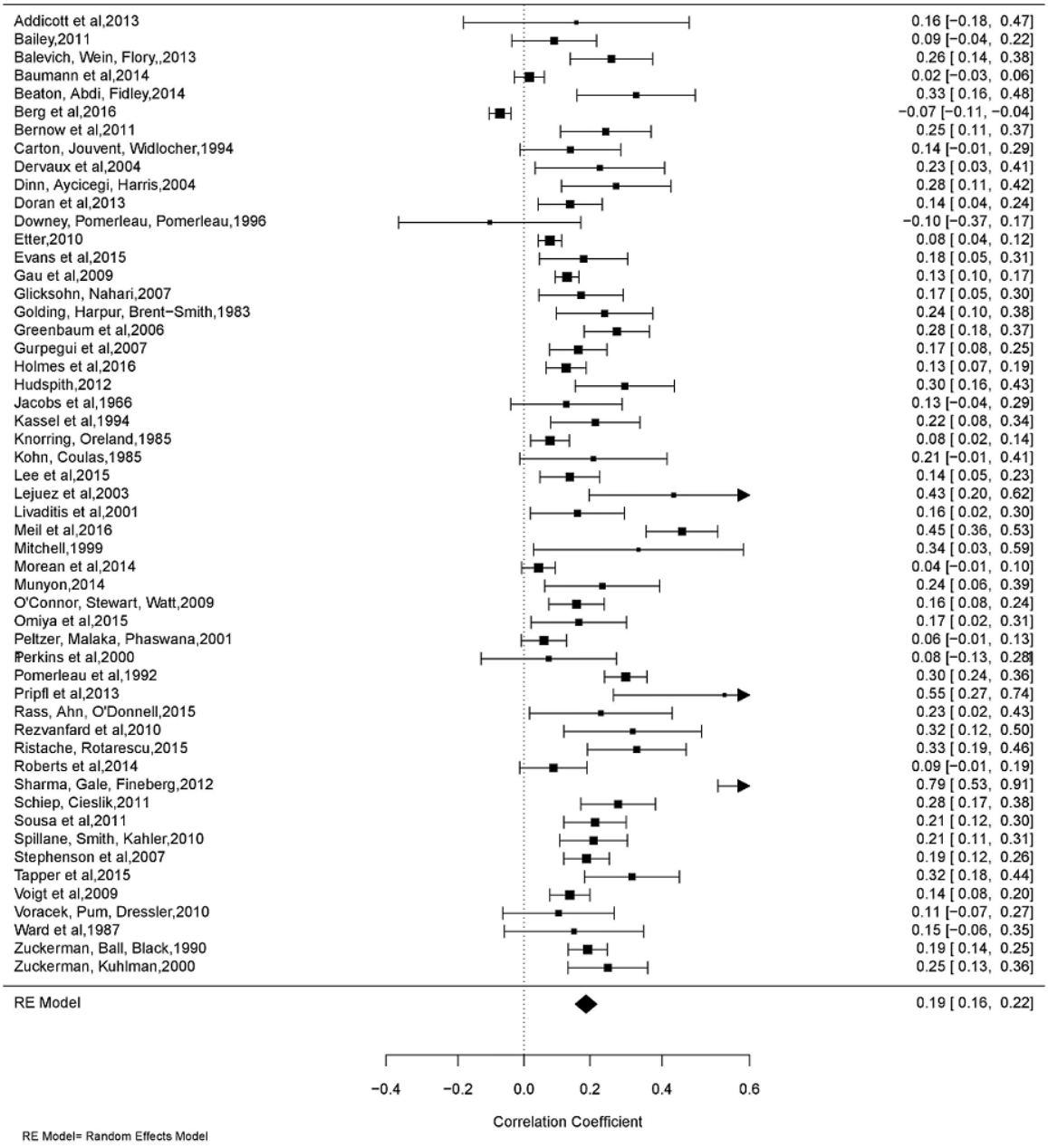

Figure 2.4: Forest plot sensation seeking and smoking status showing risk ratio and 95% CI for each study

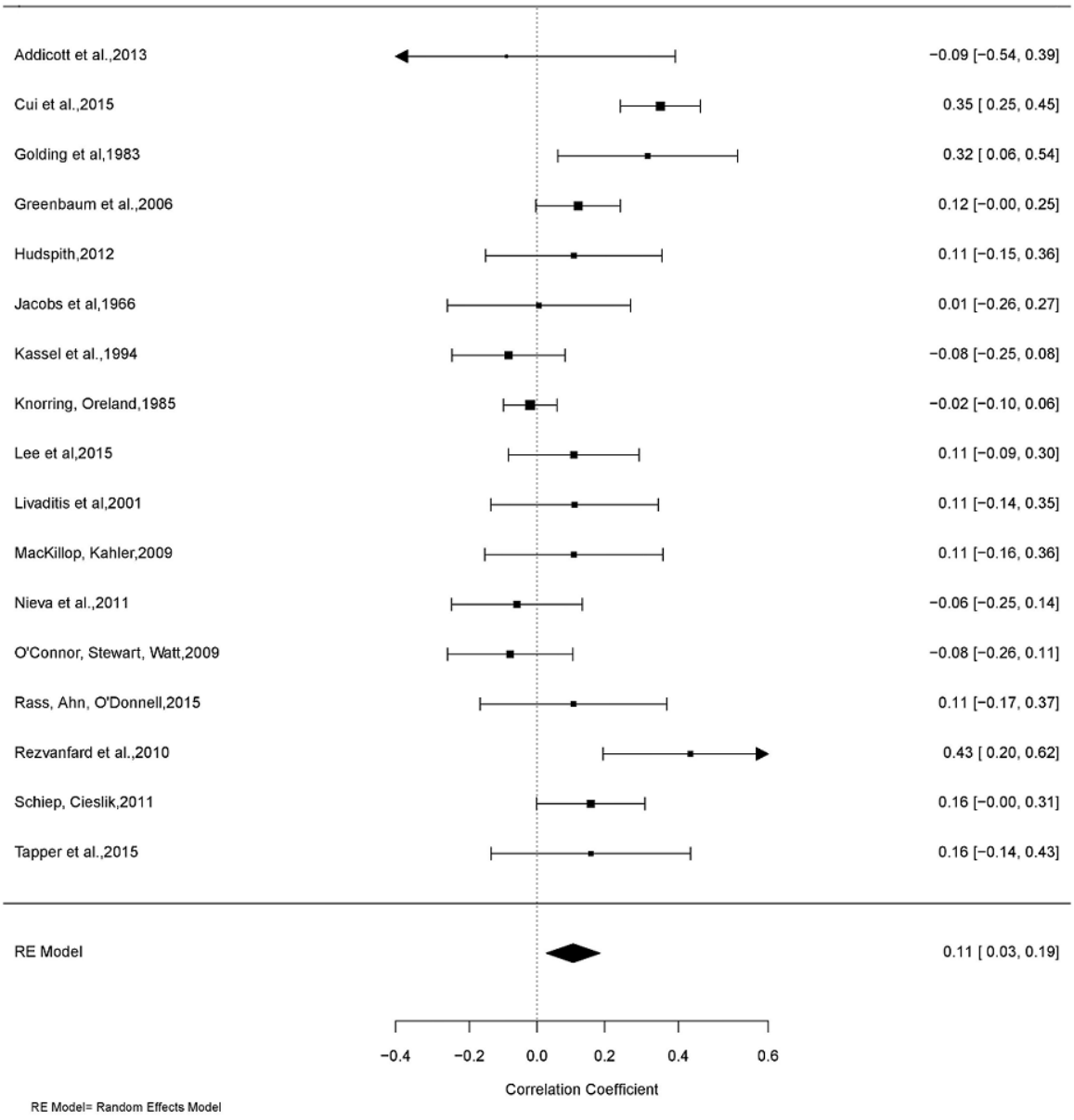

Figure2.5: Forest plot sensation seeking and severity of nicotine dependence showing risk ratio and 95% CI for each study

Potential moderating effects of three categorical variables were tested: sample type (normative or non-normative), study type (cross-sectional or

prospective) and college sample (yes or no). Potential moderating effects of three continuous variables were also tested: the mean age of sample, percentage of male participants in the sample, and percentage of sample that was of white ethnicity.

Sensitivity analysis was conducted to account for any variation in the self-reported impulsivity scales included in the present meta-analyses and the categorization of smokers and non smokers.

Meta-analyses were conducted in the R statistical environment using 'metafor' (Viechtbauer, 2010) and 'robumenta' (Fisher & Tipton, 2015) packages for R (R Development Core Team, 2015).

Due to the large number of analyses conducted, an arbitrary alpha level of p=0.01 was used for significance testing to reduce the likelihood of Type I errors. Any p values less than 0.05 are noted in the tables. Effect sizes were interpreted in accordance with Cohen's (1988) guidelines for small (r=0.10), medium (r=0.30), and large (r=0.50) effects.

Results

Study characteristics

A total of 97 studies were eligible for inclusion, 18 studies were included for both the smoking status and nicotine dependence analysis, 67 studies were included for only the smoking status analysis and 12 studies were included for only the nicotine dependence analysis. These studies comprised 93 peer-reviewed journal articles and four doctoral dissertations. Studies reported a total of 198 effect sizes, ranging from r=-0.10 to r=0.79 (Table 2.2). The majority of these effect sizes related to sensation seeking (n=70, 35.4%) and lack of premeditation (n=69, 34.8%). The mean sample size was 466.46 (SD=798.54; range 20-5433) and the mean sample

age was 30.95 years (SD=11.00; range 18-65.30). Samples were, on average, 50.9% male (SD=23.9; range 0-100; k=10 male only studies), and 77.2% of white ethnicity in 50 studies that reported ethnicity (SD=24.5; range 0-100 white, k=13 white only ethnicity participants). The majority of samples were normative (k=40 general population, k=40 college students, k=4 schizophrenic patients, k=2 adults with ADHD, k=2 OCD patients, k=2 prisoners, k=2 drug dependents, k=1 bipolar disorder patients, k=1 ulcerative colitis and Crohn's disease patients, k=1 traumatic spinal injury patients, k=1 Parkinson's disease patients, k=1 patients with major depression). Most of the studies were cross-sectional (k=93), and the majority (k=56) were conducted in the US. Included studies were published between 1966 and 2016, with most of the studies having been published in the last decade (k=69). Studies included, on average, 47.8% current smokers (SD=27.3**%**; range 1.05-100%).

Table 2.2.Studies included in the meta-analyses

Author(s) (year)	**N**	**Age**	**% male**	**% white**	**sample**	**Design**	**Scale used**	**Trait**	**Smoking measure**	**r**
Addicott et al. (2013)	18 S 17 NS	34	42.86	45.71	Community	CS	SSS-TAS BIS-NP/MI SSS-BS, DI	SS Prem Pers	ST	0.16 0.26 0.13
Addicott et al. (2013)	18S	36	44.44	38.9	Community	CS	SSS-TAS BIS-NP/MI SSS-BS, DI	SS Prem Pers	ND	-0.09 0.22 -0.0005
Bailey (2011)	229	18-20	52	81	College	PR	UPPS	SS NU	ST	0.09 0.13
Balevich, Wein & Flory (2013)	141 S 102 NS	19.4	46.5	62.55	College	CS	SSS-TAS BIS-NP, MI SSS-BS, DI	SS Prem Pers	ST	0.26 0.16 0.30
Baumann et al. (2014)	950 S 891 NS		44.67	80.92	College	CS	BIS/BAS FS BIS/BAS D, R	SS RS	ST	0.02 -0.03
Beaton, Abdi & Fidley (2014)	82 S 37 NS	30.19	49.58		Community	CS	ZKPQ-SS BIS-T	SS Prem	ST	0.33 0.32
Bejerot, Knorring & Ekselius (2000)	13 S 51 NS	42	46.88		OCD patients	CS	KSP-I	Prem	ST	0.38
Berg et al. (2016)	455 S 2963 NS	20.55	35.55	62.4	College	CS	VAL-NS	SS	ST	-0.07
Bernow et al. (2011)	82 S 119 NS	43.21	25.37		Community	CS	I-7 Vert I-7 Imp	SS Prem	ST	0.25 0.27
Bickel, Odum & Madden (1999)	23 S 43 NS	33.97	39.3		Community	CS	EPQ	Prem	ST	0.23
Carton,	96 S	35.11	64		Community	CS	SSS-TAS	SS	ST	0.14

Jouvent & Widlocher (1994)	68 NS						SSS-BS,DI	Pers		0.21
Chives et al. (2016)	400 S 400 NS	31.24	0	76.8	Community	CS	BIS-NP,MI	Prem	ST	0.16
Cui et al. (2015)	272 S	44.4	59.9	75.7	Community	CS	BIS/BAS FS BIS/BAS D, R	SS RD	ND	0.35 -0.014
Dervaux et al. (2004)	67S 33 NS	34.72	68		Schizophrenic patients	CS	SSS-TAS BIS-NP,MI SSS-BS,DI	SS Prem Pers	ST	0.23 0.13 0.27
Dinn, Aycicegi & Harris (2004)	23 S 116 NS	18.6	29.85		College	CS	TPQ-NS, I-7 Vert I-7 Imp	SS Prem	ST	0.28 0.27
Doran et al. (2006)	70 S	29.9	49		Community	CS	BIS-T	Prem	ND	-0.15
Doran et al. (2013)	73 S 327NS	18.3	45	40	College	PR	UPPS	SS Prem Pers NU	ST	0.14 0.01 0.03 0.12
Downey, Pomerleau & Pomerleau (1996)	35 S 17 NS	30.2	100	100	Adults with ADHD	CS	TCI-NS	SS	ST	-0.11
Durazzo et al. (2015)	35 S 30 NS	48.83	88	67	Community	CS	BIS-T	Prem	ST	0.34
Dvorak, Simons & Wray (2011)	53 S	20.26	20.75	90.57	College	CS	I-7 Imp	Prem	ND	-0.18
Etter (2010)	1593 S 1388 NS	33.1	36.2		Community	CS	TCI-NS	SS	ST	0.08
Evans et al. (2015)	97 S 115 NS	65.3	61.32	100	Parkinson's patients/ Community	CS	BSSS	SS	ST	0.18
Fairweather-Schmidt & Wade (2014)	21 S 63 NS	33.5	0		Community	CS	BIS-T	Prem	ST	0.10
Gau et al. (2009)	263 S 2655 NS	19.3	45.5		College	CS	TCI-NS	SS	ST	0.13
Glicksohn & Nahari (2007)	121 S 111 NS	20-34	45.26		Community	CS	I-7 Vert I-7 Imp, BIS-T SSS-BS, DI	SS Prem Pers	ST	0.17 0.31 0.28
Glicksohn & Nahari (2007)	121 S	20-34	50.4		Community	CS	I-7 Imp, BIS-T	Prem	ND	0.31
Golding, Harpur & Brent-Smith (1983)	56 S 122 NS	18-22	61.8		College	CS	SSS	SS	ST	0.24
Golding, Harpur & Brent-Smith (1983)	56 S	18-22			College	CS	SSS	SS	ND	0.32
Grano et al. (2004)	57 S 5376 NS	43.3	11.06		Community	PR	KSP-I	Prem	ST	0.06
Greenbaum et al. (2006)	242 S 142 NS	23.89	0	100	College	CS	TCI-NS	SS	ST	0.28
Greenbaum et al. (2006)	242 S	24.3	0	100	College	CS	TCI-NS	SS	ND	0.12
Guillot, Pang & Leventhal (2014)	205 S	44.4	66.3	37.1	Community	CS	UPPS	NU	ND	0.14
Gurpegui et al. (2007)	174 S 324 NS	45.1	42		Community	CS	TCI-NS	SS	ST	0.17

Heyman, Dunn & Mignone (2014)	184	40.7	43	73	Drug users/ Community	CS	BIS-T	Prem	ST	0.25
Hogarth, Chase & Baess (2010)	64 S	21.15	50		College	CS	BIS-T	Prem	ND	0.10
Holmes et al. (2016)	1015	21.38	47.1	100	College	CS	TCI-NS, BIS/BAS FS, RAS BIS-MI	SS Prem	ST	0.13 0.05
Hudspith (2012)	58 S 111 NS	19.44	50.3	88.2	College	CS	SSS	SS	ST	0.30
Hudspith (2012)	58 S				College	CS	SSS	SS	ND	0.11
Hyphantis et al. (2010)	56 S 129 NS	47.9	63.2		Ulcerative Colitis and Crohn's disease patiens	CS	ZKPQ-Imp	Prem	ST	0.115
Iancu et al. (2006)	24 S 37 NS	41.19	57.5		Schizophrenic patients	CS	ICS	Prem	ST	0.26
Jacobs et al. (1966)	54 S 80 NS	26	100		Community	CS	BUPI-TDS BUPI-I	SS Prem	ST	0.13 0.28
Jacobs et al. (1966)	54 S		100		Community	CS	BUPI-TDS BUPI-I	SS Prem	ND	0.06 -0.04
Jacobs & Spilken (1971)	42 S 108 NS	19	100		College	CS	BUPI-I	Prem	ST	0.29
Kao et al. (2011)	62 S 33 NS	35.87	47.4		Schizophrenic patients	CS	BIS-NP, MI	Prem	ST	0.20
Kassel et al. (1994)	137 S 70 NS	39.99	28.6	100	Community	CS	SSS EPI SSS-BS/DI, EASIT-Inh.C	SS Prem Pers	ST	0.22 0.13 0.12
Kassel et al. (1994)	137 S	39.32	30.66	100	Community	CS	SSS EPI EASIT-Inh.C	SS Prem Pers	ND	-0.09 -0.03 -0.12
Kertzman et al. (2013)	39 S 81 NS	28.41	0		Community	CS	BIS-T	Prem	ST	0.30
Knorring & Oreland (1985)	601 S 481 NS	18	100	100	Community	CS	SSS-TAS EPI SSS-BS	SS Prem Pers	ST	0.08 0.15 0.15
Knorring & Oreland (1985)	601 S	18	100	100	Community	CS	SSS-TAS EPI SSS-BS	SS Prem Pers	ND	-0.02 0.17 0.05
Kohn & Coulas (1985)	78	18.5	23.08		College	CS	SSS SSS-DI	SS Pers	ST	0.21 0.22
Krause et al. (2015)	198 S 326 NS	33.5	79.4	69.5	Traumatic spinal cord patients	CS	ZKPQ-Imp	Prem	ST	0.16
Kvaavik & Rise (2012)	523 S 1253 NS	22.3	41.8	100	Community	CS	EPQ BIS-T	Prem	ST	0.28
Kvaavik & Rise (2012)	523 S	22.1	36.3	100	Community	CS	EPQ BIS-T	Prem	ND	0.08
Lee et al. (2015)	41 S 399 NS	18.49	48	82.8	College	CS	UPPS-P	SS Prem Pers NU PU	ST	0.14 0.24 0.15 0.28 0.25
Lee et al. (2015)	41 S				College	CS	UPPS-P	SS Prem Pers NU PU	ND	0.11 0.11 0.11 0.26 0.24
Lejuez et al. (2003)	26 S 34 NS	20.1	50	68	College	CS	SSS I-7 Imp	SS Prem	ST	0.43 0.28

Leventhal (2007)	120 S 59 NS	24.02	32	64.5	College	CS	DII-DS	Prem	ST	0.08
Littlefield & Sher (2012)	86 S 316 NS	18.2	46		College	PR	10-ITEM	Prem	ST	0.14
Litvin & Brandon (2010)	175 S	39.26	52	71.3	Community	CS	BIS-T	Prem	ND	0.35
Livaditis et al. (2001)	86 S 101 NS		54.01	89.8	College	CS	TPQ-NS	SS	ST	0.16
Livaditis et al. (2001)	86 S		56.25	84.36	College	CS	TPS-NS	SS	ND	0.11
Luijten, Van Meel & Franken (2011)	13 S 14 NS	21.06	70.37		College	CS	I-7 Imp	Prem	ST	0.39
MacKillop & Kahler (2009)	57 S	41.38	61	90	Community	CS	BSSS	SS	ND	0.11
McChargue et al. (2011)	128 S	40.81	56	40.6	Patients with major depression	CS	BIS-T	Prem	ND	0.11
Meil et al. (2016)	138 S 183 NS	18-19	41.4	78.2	College	CS	SSS	SS	ST	0.45
Mitchell (1999)	20 S 20 NS	21.55	50		College	CS	TCI-NS SSS-TAS BIS-NP, MI, EPQ SSS-BS/DI BIS-AI	SS Prem Pers NU	ST	0.34 0.33 0.29 0
Morean et al. (2014)	779 S 658 NS	33.56	51.08	70.84	Community	CS	BIS/BAS FS IBS BIS/BAS D, R	SS Prem RS	ST	0.05 0.03 0.01
Munyon (2014)	63 S 63 NS				College	CS	UPPS-P	SS Prem Pers NU PU	ST	0.24 0.12 0.16 0.21 0.29
Nieva et al. (2011)	103 S	47.1	53.4		Community	CS	ZKPQ-SS ZKPQ-Imp	SS Prem	ND	-0.06 0.13
O'Connor, Stewart & Watt (2009)	112 S 421 NS	18.9	32.27	58	College	CS	BIS/BAS FS BIS/BAS D, R	SS RS	ST	0.16 0.08
O'Connor, Stewart & Watt (2009)	112 S				College	CS	BIS/BAS FS BIS/BAS D, R	SS RS	ND	-0.08 0.005
Omiya et al. (2015)	182	19.99	28.57	0	College	CS	BIS/BAS FS SURPS-Imp	SS Prem	ST	0.17 0.09
Ostacher et al. (2009)	31 S 85 NS	45	40	95	Bipolar Disorder patients	CS	BIS-T	Prem	ST	0.17
Pang et al. (2014)	207 S	44.54	66.7		Community	CS	UPPS-P	NU PU	ND	0.15 0.16
Papadodima et al. (2009)	116 S 57 NS	41.7	100	95	Prisoners	CS	BIS-T	Prem	ST	0.37
Park et al. (2016)	180 S	44.5	68.3	37.4	Community	CS	UPPS-P	NU	ND	0.13
Patkar et al. (2003)	26 S 30 NS	31.32	61.55	0	Community	CS	BIS-NP, MI	Prem	ST	0.29
Peltzer, Malaka & Phaswana (2001)	104 S 695 NS	20.12	55.2		College	CS	RTS	SS	ST	0.06
Perkins et al. (2000)	55 S 37 NS	31.13	48		Community	CS	SSS-TAS SSS-BS, DI	SS Pers	ST	0.08 0.22
Pomerleau et al. (1992)	240 S 676 NS	42.12	48.8		Community	CS	TCI-NS	SS	ST	0.30
Pripfl et al.	18 S	21.7	30.56		College	CS	SURPS-SS	SS	ST	0.55

(2013)	18 NS						SURPS-Imp, BIS-T	Prem		0.46
Rass, Ahn & O' Donnell (2015)	53 S 30 NS	25.25	47	74.7	Community	CS	SS-TAS BIS-NP, MI SSS-BS, DI BIS-AI	SS Prem Pers NU	ST	0.23 0.23 0.20 0.12
Rass, Ahn & O' Donnell (2015)	53 S	25.25	48.01	80.77	Community	CS	SS-TAS BIS-NP, MI SSS-BS, DI BIS-AI	SS Prem Pers NU	ND	0.11 0.19 0.10 0.03
Rezvanfard et al. (2010)	59 S 30 NS	24.36	100		College	CS	I-7 V SS-TAS TCI-NS BIS-NP, MI I-7 Imp SSS-BS, DI	SS Prem Pers	ST	0.32 0.19 -0.02
Rezvanfard et al. (2010)	59 S	24.12	100		College	CS	I-7 V SS-TAS TCI-NS BIS-NP, MI I-7 Imp SSS-BS, DI	SS Prem Pers	ND	0.43 0.24 0.25
Ristache & Rotarescu (2015)	55 S 115 NS	25.76	10.1		College	CS	TPQ-NS	SS	ST	0.33
Roberts et al. (2014)	74 S 287 NS	21.4	49.2	82.8	College	CS	UPPS-P	SS Prem Pers NU PU	ST	0.09 0.19 0.14 0.3 0.22
Schiep & Cieslik (2011)	149 S 146 NS	42.84	55.25		Community	CS	TCI-NS	SS	ST	0.28
Schiep & Cieslik (2011)	149 S	42.1	57		Community	CS	TCI-NS	SS	ND	0.16
Sharma, Gale & Fineberg (2012)	10 S 10 NS		50		Adults with OCD	CS	TCI-NS BIS-T	SS Prem	ST	0.79 0.71
Shokrgozar et al. (2015)	50 S 50 NS	33.67	79		Schizophrenic patients	CS	BIS-NP, MI	Prem	ST	0.51
Skinner, Aubin & Berlin (2004)	326 S 74 NS	43.33	66.75	90	Alcohol dependents	CS	BIS-NP, MI	Prem	ST	0.22
Sousa et al. (2011)	181 S 241 NS	34.12	51.66	100	Adults with ADHD	CS	TCI-NS	SS	ST	0.22
Spielberger et al. (2004)	225 S 490 NS	41.5	100	100	Community	CS	NEO-PI-R	NU	ST	0.09
Spillane, Smith & Kahler (2010)	139 S 87 NS	18.97	41.5		College	CS	UPPS-P	SS Prem Pers NU PU	ST	0.21 0.16 0.16 0.21 0.21
Spillane, Smith & Kahler (2010)	139 S				College	CS	UPPS-P	PU	ND	0.32
Spinella (2002)	30	31.17	36.67		Community	CS	BIS-NP, MI	Prem	ST	0.21
Spinella (2003)	26 S 64 NS	29.92	40		Community-dwelling adults	CS	FSBS-DI	Pers	ST	0.46
Stephenson et al. (2007)	789	24.4	39.5	100	Community	CS	BSSS	SS	ST	0.19
Stoltenberg, Batien & Birgenheir (2008)	31 S 169 NS	22.67	37.06	95.9	College	CS	BIS-NP, MI	Prem	ST	0.11
Stoltenberg et	101 S	22.49	35.3	100	College	CS	BIS-NP, MI	Prem	ST	0.24

al. (2011)	373 NS									
Stuart et al. (2006)	212 S 148 NS	33.1	100	79	Prisoners	CS	I-7 Imp	Prem	ST	0.19
Tapper et al. (2015)	46 S 138 NS	33	0	92	Community	CS	BIS/BAS FS BIS/BAS D, R	SS RS	ST	0.32 0.0005
Tapper et al. (2015)	46 S		0		Community	CS	BIS/BAS FS BIS/BAS D, R	SS RD	ND	0.16 0.30
Terracciano & Costa (2004)	116 S 1638 NS	60.3	50		Community	CS	NEO-PI-R	NU	ST	0.12
Terracciano et al. (2008)	318 S 770 NS	56.64	38	63	Community	CS	NEO-PI-R	NU	ST	0.31
Vanderveen et al. (2008)	50 S	22.72	68	88	College	CS	BIS-T	Prem	ND	-0.13
Vasconcelos et al. (2015)	235 S 435 NS	39.5	43.9		Community	CS	BIS-T	Prem	ST	0.28
Voigt et al. (2009)	976	20.85	41.6		College	CS	BIS/BAS FS BIS/BAS R	SS RS	ST	0.13 -0.01
Voracek, Pum & Dressler (2010)	49 S 85 NS	36.3	100	100	Community	CS	SS-TAS SSS-BS, DI	SS Pers	ST	0.11 0.21
Ward et al. (1987)	18 S 69 NS	19.6	65.52		College	CS	SS-TAS SSS-BS, DI	SS Pers	ST	0.15 0.17
White et al. (2011)	47 S 85 NS	19.44	53.03	100	College	CS	BIS-T	Prem RS	ST	0.21 0.11
White et al. (2011)	47 S		57.5	100	College	CS	BIS-T SPSRQ	Prem RS	ND	0.02 0.07
Zuckerman, Ball & Black (1990)	150 S 921 NS	17-21	39.4		College	CS	SSS	SS	ST	0.19
Zuckerman & Kuhlman (2000)	260		38.85		College	CS	ZKPQ-SS	SS	ST	0.25

Age=mean unless otherwise noted; r=r value before transformations; S=smokers; NS=non-smokers; CS=cross-sectional; PR=prospective; BIS-NP, MI=Barratt Impulsivity Scale – Nonplanning and Motor Impulsivity; BIS-T=Barratt Impulsivity Scale –Total score; I-7 Imp=I-7 Impulsiveness; ICS=Impulsivity Control Scale; KSP-I=Karolinska Scales of Personality–Impulsiveness; SURPS-Imp=Substance Use Risk Profile Scale–Impulsivity; ZKPQ-Imp=Zuckerman-Kuhlman Personality Questionnaire – Impulsivity; BUPI-I=The Personality Inventory–Impetuousness; DII-DS=Dickman Impulsiveness Inventory- Dysfunctional Impulsivity; 10-ITEM=10 item Impulsivity scale; IBS=Impulsive Behaviour scale; EPI=Eysenck Personality Inventory-Extraversion-Impulsivity Subscale; EPQ= Eysenck Personality Questionnaire; SSS-BS, DI=Sensation Seeking Scale – Boredom susceptibility, Disinhibition; EASIT-Inh.C=Emotionality, Activity, Sociability and Impulsivity Temperament Survey III- Inhibitory Control Subscale; FSBS-DI=Frontal Systems Behavior Scale -scale Disinhibition; BIS/BAS FS=BIS/BAS Scales–Fun Seeking; BSSS=Brief Sensation Seeking Scale; I-7 Vert=I-7 Venturesomeness; TCI-NS=TCI–Novelty Seeking; TPQ-NS= TPQ–Novelty Seeking; SSS-TAS=Sensation Seeking Scale–Thrill and adventure seeking; SSS=Sensation Seeking Scale–Total score; SURPS-SS= Substance Use Risk Profile Scale–Sensation seeking; ZKPQ-SS=Zuckerman – Kuhlman Personality Questionnaire – Sensation Seeking; VAL-NS=Values, Attitudes and Lifestyles- Novelty seeking; RAS=Domain-specific Risk attitude scale; BUPI-TDS=The Personality Inventory (BUPI)- Thrill and danger seeking; RTS=Two item risk taking scale; BIS-AI=Barratt Impulsivity Scale – Attentional Impulsivity; NEO-PI-R= NEO-PI-R Impulsiveness; BIS/BAS D, R=BIS/BAS Scales–Drive and Reward Responsiveness; SPSRQ= SPSRQ–Sensitivity to Reward Scale; Prem=lack of premeditation; Pers=lack of perseverance; SS=sensation seeking; NU=negative urgency; PU=positive urgency; RS=reward sensitivity; ST=smoking status, ND=nicotine dependence

Univariate Outliers

Two univariate outliers were identified in the meta-analysis of impulsivity traits and smoking status; one for sensation seeking (Z=4.09) and one for lack of premeditation (Z=3.77). Both came from a single study (Sharma et al., 2012), which

reported results in 20 individuals with Obsessive Compulsive Disorder (10 smokers matched on demographic characteristics with 10 non-smokers). Results were very similar with and without this study; therefore, the effect sizes from this study were retained in the analyses.

Meta-analytic findings

Impulsivity traits and smoking status

Table 2.3.Meta-analyses

	K	N	R	CI	Z	SE	Q	I^2	FSN
Smoking Status									
Lack of premeditation	52	20,129	0.20	0.17-0.24	12.65***	0.02	224.17***	72.03	163
Lack of perseverance	20	4443	0.18	0.14-0.22	8.29***	0.02	30.47*	40.29	51
Sensation Seeking	53	27,566	0.19	0.16-0.22	11.34***	0.02	377.93***	83.30	149
Negative Urgency	11	5498	0.19	0.13-0.25	6.17***	0.03	48.07***	75.41	28
Positive Urgency	4	1305	0.24	0.18-0.29	8.62***	0.03	0.89	0	16
Reward Sensitivity	6	5140	0.01	-0.04-0.06	0.24	0.03	13.06*	60.18	0
Nicotine Dependence									
Lack of Premeditation	17	2358	0.10	0.03-0.17	2.65**	0.04	35.52**	60.30	18
Lack of perseverance	6	970	0.05	-0.05-0.15	1.03	0.05	6.78	32.73	0
Sensation Seeking	17	2183	0.11	0.03-0.19	2.65**	0.04	50.80***	67.24	20
Negative Urgency	5	747	0.15	0.08-0.22	4.08***	0.04	2.18	0	11
Positive Urgency	3	449	0.23	0.13-0.33	4.29***	0.06	2.38	23.24	12
Reward Sensitivity	4	477	0.03	-0.06-0.12	0.58	0.05	3.71	0.02	0

K=no. of studies; N=aggregate sample size; r=mean weighted size; CI=95% confidence interval; Z=Z-test of the mean effect size; SE=standard error; Q=heterogeneity statistic; I^2=true heterogeneity percentage; FSN=no. Of studies with average effect size of 0 required to reduce the observed mean effect size to r=0.05. * p<0.05, ** p<0.01, ***p<0.001

We conducted six meta-analyses to examine how specific UPPS-P traits and reward sensitivity differentially related to smoking status. The weighted mean effect

sizes between smoking status and specific impulsivity traits were all small, but positive, and significantly different from zero, with the exception of reward sensitivity. This relationship was also positive but did not differ from zero (r=0.01, z=0.24, p=0.80). Lack of premeditation and positive urgency showed the largest associations with smoking status, with weighted mean effect sizes of r=0.20 and r=0.24, respectively. However, it should be noted that the confidence intervals of these impulsivity-related traits overlap with those of all others except reward sensitivity, suggesting that the difference between traits is not that large and possibly spurious. A FSN analysis for each specific impulsivity trait and smoking status relationship indicated that for the majority of traits, it would take a similar or larger amount of additional studies for each trait with null effects to reduce the mean effect size to r=0.05 (Table 2.3). These findings suggest that the present results are unlikely to be substantially impacted by unpublished data.

Impulsivity traits and severity of nicotine dependence

In respect to specific UPPS-P traits and reward sensitivity, effects sizes for severity of nicotine dependence ranged from r=0.03 (for reward sensitivity) to r=0.23 (for positive urgency). Most of these effect sizes were not significantly different from zero and did not vary significantly across studies (Table 2.3). These effect sizes are based on 30 studies and 4145 smokers.

Moderation

Regarding the meta-analytic findings of impulsivity traits and smoking status, Q values were significant for five out of six meta-analyses that were conducted, indicating the presence of heterogeneity. For five of these, I^2 values were above 75% suggesting that most of the variation between effect sizes was systematic. Although

significant heterogeneity was not a condition for conducting moderator analyses, these statistics suggested possible moderation effects. Age, gender (%male) and ethnicity (%white) of the sample were first examined as continuous moderators. No significant moderating effects were found for gender, ethnicity and mean age on the relationship between each impulsivity related trait and smoking status. Study type, sample type (normative, non-normative) and whether the samples were college students were then considered as categorical moderators. Similar moderation analyses were conducted for each separate impulsivity trait of the UPPS-P model and reward sensitivity. Sample type was tested as a potential moderator of effect size variation for lack of premeditation, lack of perseverance and sensation seeking only. This was due to limited data for the other traits. Subgroups for non-normative samples included a small number of effect sizes (k<5). However no significant effects were found. Study type was only tested as potential moderator for lack of premeditation, lack of perseverance, sensation seeking and negative urgency. There were only four prospective studies in the analyses, therefore power was low in these analyses and results should be interpreted with caution. For lack of premeditation, cross-sectional studies showed larger weighted mean effect sizes, r=0.21 (0.18-0.24) than the prospective studies, r=0.07 (0.01-0.12), and the difference was significant, Q(1)=8.33, p=0.004. Additionally, for lack of perseverance, cross-sectional studies showed larger weighted mean effect sizes, r=0.17 (0.13-0.20) than the one prospective study, which was included in this analysis, with an effect size of r=0.02 and the difference was significant, Q(1)=7.79, p=0.005. No significant moderation effects of study type were found for sensation seeking and negative urgency and smoking status. Lastly, whether the sample was college students or not was tested as a potential moderator of effect size variation for

all the separate impulsivity traits, apart from positive urgency due to lack of related studies; again the results showed no significant effect (Table 2.4).

We did not conduct any moderation analysis for impulsivity traits and severity of nicotine dependence as the number of studies reported was small and the effect size magnitude did not vary significantly across studies.

Table 2.4.Moderator subgroup analyses (Impulsivity traits and smoking)

	K	Q	P
Lack of premeditation			
Age	50	0.73	0.39
Ethnicity	26	1.52	0.22
Gender	51	2.70	0.10
Sample type	52	2.60	0.11
College students	52	2.51	0.11
Study type	**52**	**8.33**	**0.004**
Lack of perseverance			
Age	18	0.62	0.43
Ethnicity	9	0.60	0.44
Gender	19	0.14	0.70
Sample type	20	0.69	0.41
College students	20	2.26	0.13
Study type	**20**	**7.79**	**0.005**
Sensation Seeking			
Age	48	0.15	0.69
Ethnicity	26	0.08	0.77
Gender	52	3.59	0.06
Sample type	53	0.20	0.65
College students	53	0.02	0.88
Study type	53	0.79	0.37
Negative Urgency			
Age	10	0.002	0.97
Ethnicity	7	0.02	0.87
Gender	10	2.27	0.10
Sample type		No results	
College students	11	0.31	0.58
Study type	11	0.97	0.32
Positive Urgency			
Age	3	0.09	0.76
Ethnicity		No results	
Gender	3	0.13	0.72
Sample type		No results	
College students		No results	
Study type		No results	
Reward Sensitivity			
Age	5	2.05	0.15
Ethnicity	5	0.01	0.93
Gender	6	0.01	0.93
Sample type		No results	
College students	6	0.04	0.83
Study type		No results	

K=no. of studies; Q=heterogeneity statistic; p=alpha level

Sensitivity analyses

We conducted a number of sensitivity analyses. There were a number of cases where the mapping of a specific scale on to the UPPS-P framework may be somewhat arbitrary or ambiguous. To address this issue, we conducted the analysis removing the scales in which the mapping on to the UPPS-P model was made by the authors. Then, we conducted the analyses only with the studies that used the same scales to measure the impulsivity-related traits. For example, we ran the analyses only with studies that used the UPPS-P scale, then with studies that used only the Sensation Seeking Scale, the BIS and so on. In all these cases the results found were very similar to those when all the studies were included in the analyses.

There were eight cases where the reliability of a scale was not provided in the original study. We performed the analysis excluding these scales. The results found were very similar to those when they were included, so in the analyses reported above we retain these scales.

There was one study that compared daily versus occasional smokers. This measure is categorical and different from the rest of the measures of nicotine dependence. We conducted the analyses with and without this study and the results were similar. So, this study was retained in the analyses.

We combined ex-smokers with non-smokers and heavy smokers with non daily smokers in order to categorize groups as either smokers or non-smokers. We took this approach in fourteen studies. When we conducted the analyses excluding these fourteen studies, the results did not change. So these studies were also retained in the present meta-analysis.

Discussion

The aim of this review was to quantify the direction and magnitude of association between impulsivity-related personality traits and two aspects of cigarette smoking - smoking status and severity of nicotine dependence. Meta-analyses of six distinct impulsivity-related traits found that all traits in the UPPS-P model were positively associated both with smoking status and severity of nicotine dependence, while reward sensitivity was not associated with either outcome.

The majority of included studies examined the relationship between sensation seeking and lack of premeditation with smoking status; very few studies have examined the urgency traits and reward sensitivity in this context. Positive urgency and lack of premeditation showed the largest mean associations with smoking status, even though these effect sizes were still small in magnitude, and confidence intervals overlapped with those for all other UPPS-P traits. There appears to be an inconsistency with previous research which suggests that, among impulsivity-related personality traits, sensation seeking best predicts the frequency of engaging in risky behaviours including cigarette smoking (e.g. Zuckerman et al., 1990; O' Connor et al., 2009; Spillane et al., 2010). However the majority of this research is based on adolescents. The present meta-analysis examined studies sampling adults only, with a mean sample age of 31 years old. The discrepancy might therefore be explained by the difference in the age of the samples examined. Younger individuals high in sensation seeking could smoke because of the novelty of the smoking experience and the positive reinforcement they receive from smoking (Clayton et al., 2007). For older smokers, who are likely to have been smoking for a longer time, there is no element of novelty in smoking and therefore sensation seeking may be less relevant, and other impulsivity traits might be more important in predicting their smoking

behaviour. Indeed, the findings of the present study suggest that positive emotion-based impulsivity and lack of planning are better at differentiating smokers from non-smokers. In support of these findings, there is some evidence from previous research suggesting that, among those who try cigarettes, those who become regular smokers are more likely to report higher levels of positive urgency (Cyders & Smith, 2008), and positive affect plays a significant role in the desire to smoke during the course of becoming a regular smoker (Zinser et al., 1992). Nicotine use is also a powerful mood regulator (Brody, 2006; Pomerleau & Pomerleau, 1984), which helps to decrease the intensity and frequency of negative feelings (McGovern et al., 2006). Smokers with high levels of urgency may be prone to smoke impulsively in situations of intense emotion, with smoking becoming conditioned as a negative reinforcer as a result.

Regarding severity of nicotine dependence and its association with specific UPPS-P traits and reward sensitivity, the majority of studies have looked, again, at lack of premeditation and sensation seeking. Based on a small number of eligible studies, positive urgency had the largest association with severity of nicotine dependence, though the effect size was of a small magnitude. This finding is consistent with previous research that suggests that positive urgency is more relevant for predicting the level of nicotine dependence (Spillane et al., 2015). It may be that smokers high in positive urgency, who experience reinforcement from smoking and are more prone than others to react towards their immediate urges, are more likely to smoke more in response to an intense positive mood state (Cyders & Smith, 2008). This preference to smoke when in a heightened emotional state could, in turn, increase the likelihood of nicotine dependence (Baker et al., 2004). Previous studies have also posited a significant role of negative urgency in predicting the level

of nicotine dependence, as it was found that smoking to alleviate negative mood states is a common motivation for smokers (Doran et al., 2009). Indeed, the relationship between negative urgency and severity of nicotine dependence was the second highest in this meta-analysis.

Reward sensitivity was the only impulsivity-related personality trait that showed no association either with smoking status or severity of nicotine dependence. One possible explanation might be that prolonged nicotine use reduces reward sensitivity (Versace et al., 2011; Paelecke-Habermann et al., 2013). It could be the case that the adult smokers in the present analysis had high reward sensitivity when they started smoking, but after a period of smoking, they showed lower levels of reward sensitivity due to inhibitory effects of their nicotine use. Such an explanation would further suggest that reward sensitivity is more relevant to the initiation of smoking than to differentiating smokers from non-smokers. That said, neuroscientific evidence points to a complex pattern of differences between smokers and non-smokers in brain areas related to reward processing (e.g. Martin et al., 2014). It is possible that the self-report scales focused on in this review are not sensitive enough to detect these differences. It should also be noted that reward sensitivity has only been examined in a limited number of studies with small sample sizes. As such, our analysis including this trait was underpowered. However, our results are similar to that found in a previous meta-analysis assessing the relationship between adolescent alcohol use and impulsivity, which showed that reward sensitivity as measured by the BAS scales had weaker associations with adolescent alcohol use than most other impulsivity-related traits (Stautz & Cooper, 2013). Clearly, reward responsiveness's association to smoking status and severity of nicotine dependence warrants further investigation.

We found no evidence of moderation of the association between impulsivity and smoking status by gender, or by age and ethnicity. This finding is consistent with previous research, which has also failed to find any moderation effect of gender on the relationship between specific impulsivity related traits and risk outcomes (Cyders, 2013, Coskunpinar et al., 2013). In the current study, the only moderation effect found was that of study type and lack of premeditation and lack of perseverance. Samples from cross-sectional studies showed significantly larger associations between lack of premeditation, lack of perseverance and smoking status, although these were related to only four and one prospective studies, respectively. These results suggest that the relationship between these traits and smoking might change over time, such that they are stronger correlates than predictors. However, more prospective studies are required in order to verify this idea.

Implications

Results from this review suggest that impulsivity-related traits are more strongly associated with smoking status than severity of nicotine dependence. This pattern of findings suggests a non-linear relationship between impulsivity-related traits and smoking behaviour, such that these traits better help to explain differences between non-smokers and smokers than differences between lighter smokers and heavier (i.e. more dependent) smokers. Attempts to reduce cigarette smoking by targeting impulsivity-related traits may therefore be best aimed at individuals at risk of smoking. Moreover, given that differential patterns of relationships between impulsivity-related personality traits and smoking status and severity of nicotine dependence were found, it could be suggested that different factors should be targeted for preventing initiation of cigarette smoking and for interventions of quitting

smoking. If different traits relate to different aspects of the risk process, it is useful for both researchers and clinicians to understand the role of specific traits and their associated patterns of affect, behaviour, and cognition in relation to smoking. This understanding could help to identify individuals at greater risk of becoming smokers and nicotine dependents, and by extension has the potential to inform individualised treatment plans and decisions.

This study also highlights where further research is needed in examining the relationship between discrete impulsivity-related traits and smoking status and severity of nicotine dependence. Specifically, there is a lack of research examining smoking status and severity of nicotine dependence with positive urgency and reward sensitivity. Generally, more research is needed that include multiple impulsivity-related traits in the same study, to account for shared variance between traits. We recommend that researchers interested in the relationship between impulsivity and smoking behaviour use a multidimensional approach to measuring impulsivity-related traits, based on current understanding of the structure of the impulsivity construct (see Sharma et al., 2014; Sperry et al., 2017; Stautz et al., 2017).

The present review found patterns of small effects for lack of premeditation and positive and negative urgency on smoking status and severity of nicotine dependence. Even though data on positive and negative urgency on both smoking status and severity of nicotine dependence were limited, these results may offer one reason why many smokers are relatively unaffected by campaigns that focus on the health consequences of smoking and the benefits of quitting (NHS, 2019). In addition to present prevention campaigns, smokers high in urgency could benefit from interventions that involve learning to identify behavioural patterns that lead to acting

rashly in response to intense emotions, for example relaxation training and distress tolerance (Zapolski et al., 2010). Smokers high in lack of premeditation could benefit from organization and cognitive remediation training, and learning how to break tasks down into manageable steps along with sticking to long-term goals. In addition to these individualised approaches, interventions that focus on changing or removing environmental cues that promote smoking, such as switching to standardised cigarette packaging or legislating that vendors must place cigarettes behind opaque covers, could be particularly helpful for smokers high in impulsivity-related traits.

Strengths and limitations

To the best of our knowledge this is the first empirical review and quantitative synthesis to focus on trait impulsivity and smoking. Our analysis considered six distinct impulsivity-related personality traits and two smoking outcomes – smoking status and severity of nicotine dependence. We also considered a number of demographic and study-level factors that might moderate any associations.

Despite these strengths, several limitations might affect the generalizability of the findings. First, there were limited data for a number of traits analysed. With regards to positive urgency, only three studies assessed this trait with smoking status and severity of nicotine dependence, and there were only four studies assessing reward sensitivity and severity of nicotine dependence. Our analysis is therefore likely underpowered to detect the true associations of these traits with smoking status and severity of nicotine dependence, if any. Also, in these meta-analyses we have examined bivariate relationships between the impulsivity traits and smoking status and severity of nicotine dependence. It is possible effect sizes will

differ from those reported here for the specific impulsivity traits when controlling for their overlap with the other impulsivity traits

Second, a wide range of impulsivity measures were included. It is likely that this introduced substantial heterogeneity between effect sizes. However, we tried to ensure that all the measures included were categorised according to the relevant impulsivity-related trait and followed the categorization reported in previous research (Stautz & Cooper, 2013; Coskunpinar, et al., 2013). Additionally we employed a random effects model to deal with the differences in effect sizes across studies.

Third, there was variation in the categorization of smoking status used across the studies included in the meta-analysis. In some studies, we had to combine ex-smokers with non-smokers as there is some evidence that ex-smokers do not differ significantly from non-smokers in self-report measures of impulsivity (Bickel et al., 1999), and heavy smokers with non daily smokers, in order to categorize groups as either smokers or non-smokers. This approach may have lead to some inconsistencies across studies. However, we took this approach only in fourteen studies and we also examined differences in impulsivity and differences in severity of nicotine dependence within the smoking group. Moreover, the sensitivity analysis showed no substance difference in results when excluding these fourteen studies from the meta-analysis.

Fourth, the majority of studies reviewed were cross-sectional. Research suggests that heightened impulsivity seems to precede smoking initiation and be a consequence of greater smoking (Bloom et al., 2014). The current analysis does not allow us to delineate these relationships, but prospective studies suggest that two of the impulsivity-related traits (lack of premeditation and lack of perseverance) are weaker predictors than correlates. More prospective studies are needed to shed light

on the changes of impulsivity-related traits and smoking status and severity of nicotine dependence over time.

Most of the included studies sampled from non-clinical populations, limiting the generalizability of findings to clinical populations. Additionally data included in the present meta-analysis was self-reported. Self-reported measures of cigarette use underestimate the true smoking prevalence compared to measures of biological samples (Gorber et al., 2009). In the present analysis there were only eighteen studies that reported biological samples of nicotine use to validate self-report measures.

Another limitation is that there was no second person for screening the articles or for data extraction.

Conclusion

The present review is the first to synthesise data on separable impulsivity-related traits and smoking status and severity of nicotine dependence in adults. It suggests that smokers are more impulsive than non-smokers, impulsivity is positively associated with severity of nicotine dependence, and that unique impulsivity-related traits show modest differences in patterns of association with smoking status and severity of nicotine dependence in adults. Smoking status is most associated with positive urgency and lack of planning. Severity of nicotine dependence appears also to be most associated with positive urgency. Reward sensitivity was the only trait that was not related to either smoking status or severity of nicotine dependence, though was examined in very few studies.

Understanding the complexity of impulsivity-related traits in relation to smoking status and severity of nicotine dependence will help to inform screening and prevention efforts aimed at reducing the number of adult smokers.

Chapter 3

Examining the relationship between impulsivity-related personality traits and e-cigarette use in adults

Overview

This chapter begins by examining motivational factors for e-cigarette use, and summarising the studies that have investigated the role of trait impulsivity and e-cigarette use in adult samples. It then reports a study of 720 mainly European adults, who were either e-cigarette users, non-smokers, cigarette smokers or dual users (those who currently smoke cigarettes and use an e-cigarette). These participants completed online questionnaires regarding sociodemographics, smoking/e-cigarette use behaviour and trait impulsivity (UPPS-P scale). Analysis revealed that trait impulsivity differentiated e-cigarette users from cigarette smokers and dual users, and cigarette smokers from non-smokers and dual users, but did not differentiate e-cigarette users from non-smokers. E-cigarette users showed lower levels of lack of perseverance than cigarette smokers, and they exhibited lower levels of negative and positive urgency than dual users. Results also suggest that smokers had higher levels of negative urgency than non-smokers, and they scored lower on positive and negative urgency than dual users. No significant results were found examining the relationship between the impulsivity-related traits and e-cigarette behaviour among e-cigarette users (number of days vaping per month, number of times vaping per day, and millilitres of e-liquid used per day), while higher nicotine dependence in cigarette smokers was associated with higher levels of negative and positive

urgency. The main reason given for e-cigarette use was the perception that it is less harmful than conventional cigarettes.

Introduction

In contrast to the literature focusing on cigarette smoking reviewed in the previous chapter, the amount of studies examining impulsivity-related traits and e-cigarette use in adults is very small. To the best of our knowledge there have been only five studies examining this relationship, and as such meta-analysis is not appropriate to summarize this literature. However, existing evidence in this area will be informative for the study reported in this chapter and for the thesis more generally. The first part of this chapter presents an overview of perceived reasons for e-cigarette use among smokers and non smokers, and then gives a narrative summary of all five available studies that examines the relationship between trait impulsivity and e-cigarette use.

Perceived reasons for e-cigarette use

E-cigarette users can be divided in two groups, namely those who are using regular tobacco cigarettes in combination with e-cigarettes (dual users), and those who use e-cigarettes exclusively. Since e-cigarettes are currently advertised as a tool to help cigarette smokers to switch from cigarettes, the intended population group target is cigarette smokers, and as such the majority of e-cigarette users should be dual users or ex-smokers. Indeed, population studies have shown that most adult e-cigarette users are either current cigarette smokers or former cigarette smokers who quit smoking using an e-cigarette, while the proportion of e-cigarette

use among never smokers is very small (ASH, 2019; Centers for Disease Control and Prevention, 2019).

Research examining reasons for e-cigarette use among adult cigarette smokers indicates that dual users mainly use e-cigarettes either as a means of reducing or quitting smoking, as e-cigarettes appear to reduce cravings and withdrawal symptoms associated with abstinence from smoking, or as an alternative in settings where cigarettes are banned (Caponnetto, Campagna et al., 2013; Dawkins, Turner, Roberts & Soar, 2013; Patel et al., 2016). However, studies examining the relationship between e-cigarette use and quit attempts found no significant association (Sutfin, McCoy, Morrell, Hoeppner & Wolfson, 2013; Dawkins, Turner, Roberts & Soar 2013), and the majority of dual users remain dual users one year after beginning e-cigarette use (Giovenco & Delnevo, 2018).

Another common motivation factor for e-cigarette use is the belief that e-cigarettes are a healthier alternative to cigarette smoking (Caponnetto, Campagna et al., 2013; Patel et al., 2016). Additionally, several studies documented that some smokers, especially the non-daily, appear to be using e-cigarettes for recreation and affect regulation (Brikmanis, Petersen & Doran, 2017; Lee, Hebert, Nonnemaker & Kim, 2014; Dautzenberg et al., 2013).

Additionally research examining reasons for initiation of JUUL, a new e-cigarette pod device, which uses disposable e-liquid pods containing nicotine salts to deliver high concentration of nicotine (around 60mg/ml), suggests that young adult cigarette smokers in USA initiate JUUL mainly for recreational reasons and not for an intention to quit or reduce cigarette smoking (Patel et al., 2019). This emerging evidence might indicate that the reasons for e-cigarette use, especially for the new e-cigarette pod devices are changing, thus more research is needed to understand

better reasons for vaping among dual users. On the other hand, the reasons for e-cigarette use among never smokers are not very well documented. A study by Sussan et al. (2017) found that the primary motivation for e-cigarette use among never smokers in USA was enjoyment and popularity of e-cigarettes, and was accompanied by lower expectation to eventually discontinue e-cigarette use. Such findings might suggest that daily e-cigarette use among never smokers is an emerging public health concern. Moreover, longitudinal studies have shown that e-cigarette use is predictive of increased cigarette consumption (Dunbar et al., 2018) and the uptake of cigarette use in young adults and adolescents (Wills et al., 2016; Spindle et al., 2017). Therefore, there is a need to explore further the reasons why individuals use e-cigarettes since newer devices are introduced constantly to the market, to help address potential progress into smoking early on.

Trait impulsivity and e-cigarette use

Trait impulsivity could be considered a factor for e-cigarette use given its association with cigarette smoking and nicotine dependence as discussed in the previous two chapters. However, less is known regarding the relationship between trait impulsivity and e-cigarette use, and the available research has shown mixed findings. A study by Chivers, Hand, Priest & Higgins (2016) collected data from 800 women, ages 24-44 years, from the US and examined whether trait impulsivity was a risk factor for e-cigarette use, by comparing current daily cigarette smokers to never cigarette smokers. Their results suggest that trait impulsivity as measured by the Barratt Impulsiveness Scale-11 (Patton et al., 1995) did not predict e-cigarette use among current cigarette smokers, but only among never smokers.

Additionally, Cohn et al. (2015) investigated the relationship between the impulsivity-related trait of sensation seeking as measured by the Brief Sensation Seeking Scale (Hoyle, Stephenson, Palmgreen, Lorch & Donohew, 2002) and e-cigarette use among a representative sample of 4288 US young adults, aged between 18-24 year olds. They found that past 30-day e-cigarette use was positively associated with higher levels of sensation seeking.

Similarly, Doran and Tuly (2018) recruited 335 US young adults (18-24 years old), intermittent cigarette smokers to investigate the relationship between the impulsivity-related traits as measured by the short UPPS-P scale (Cyders, Littlefield, Coffey, & Karyadi, 2014) and patterns of e-cigarette use over a period of two years. Their findings suggest that only higher levels of the impulsivity-related trait of sensation seeking was associated with more frequent e-cigarette use throughout the study period, while a higher level of lack of premeditation was associated with an escalation in e-cigarette use during the second year of follow-up (Doran & Tuly, 2018).

Another longitudinal study by Spindle et al. (2017) used a sample of US college students (n=3757) to examine the predictive value of trait impulsivity, among other factors, on the onset of e-cigarette use among initial never users of either cigarettes or e-cigarettes. Their results indicate that higher levels of lack of perseverance, as measured by the UPPS-S scale in the baseline, increased significantly initial never users' chances of trying both cigarettes and e-cigarettes at one year follow-up. Finally, a study by Hershberger, Connors, Um, and Cyders (2017) in a sample of 714 US adults provides initial support for a model in which trait impulsivity, as measured by the short UPPS-P scale, is related to e-cigarette use through positive e-cigarettes attitudes. In particular, their findings suggest that higher

levels of urgency and higher levels of conscientiousness, as measured by the two facets of the UPPS-P scale (lack of premeditation and lack of perseverance), are related to more positive e-cigarette use attitudes, and that the endorsement of these attitudes is related to greater likelihood of e-cigarette use.

In sum, these findings indicate that sensation seeking and lack of perseverance could be linked with e-cigarette use in young adults, while lack of premeditation could be associated with e-cigarette use among women non-smokers, and with an increase of e-cigarette use among current e-cigarette users. The urgency traits seem to be related to e-cigarette use through positive attitudes towards e-cigarettes. However, such conclusions are only based on a limited amount of studies and it is clear that the relationship between e-cigarette use and impulsivity warrants further investigation.

It is also evident from the research described thus far, that the available studies on impulsivity and e-cigarette use have been conducted in specific populations, such as young adults, who generally show elevated impulsive behaviour (Green et al., 1999), and in the USA, where e-cigarettes are regulated as tobacco products (US Food and Drug Administration, 2016). Other countries though, such as the UK, have relatively liberal regulations around e-cigarettes and allow the prescription of e-cigarettes for patients trying to quit smoking (Public Health England, 2015). Additionally, e-cigarette pod devices, such as JUUL, which use disposable e-liquid pods containing high concentration of nicotine (around 60mg/ml), capture 70% of the USA vaping market (Spindle & Eissenberg, 2018). These devices are very popular especially among young adults in USA, and emerging evidence indicates that they may contribute to higher rates of e-cigarette use among smokers, and non-smokers, and eventual dependence (Spindle & Eissenberg, 2018). On the other

hand such devices have only recently become available in some European countries and their nicotine content is capped at 20mg/ml in line with European Union regulations (McNeill, Brose, Calder, Bauld & Robson, 2019). Thus, they may not become as popular in Europe as in the USA since their nicotine content is the same as the other e-cigarette devices.

To the best of our knowledge, there is no study looking at trait impulsivity and e-cigarette use in a sample that is both primarily recruited from outside of the USA, and from the general adult population, rather than purely from a university student population or young adults.

Aims and hypotheses

The present study seeks to contribute to the literature by giving an insight into the relationship between the multi-faceted personality trait of impulsivity and e-cigarette use in a sample of mainly European adults. It also examines the relationships between impulsivity-related traits and frequency and intensity of e-cigarette behaviour, as such relationships have not been examined elsewhere. Additionally, the present study investigates differences among cigarette smokers and dual users. The meta-analysis presented in the previous chapter indicates unique relationships between different impulsivity-related traits and smoking status and severity of nicotine dependence. In this chapter, we also seek to replicate these findings. Specifically we aim a) to examine how impulsivity-related traits differentiate e-cigarette users from non-smokers, smokers, and dual users; b) to investigate the relationship between impulsivity-related traits and frequency and intensity of e-cigarette behaviour; c) to assess the main reasons for e-cigarette use; d) to replicate previous research by examining the relationship between impulsivity-related traits

and cigarette smoking and nicotine dependence; e) to investigate differences between cigarette smokers and dual users in cigarette smoking behaviour, intention and motivation to quit, and impulsivity-related personality traits; f) to examine the association between reasons for e-cigarette use and intentions to quit among dual users.

First, we hypothesize that higher levels of trait impulsivity will predict membership of the e-cigarette use group compared to the non-smoking group, and lower levels of trait impulsivity will predict membership of the e-cigarette use group compared to the smoking and dual use groups as smokers exhibit higher levels of impulsivity than non smokers (e.g. Mitchell, 1999; Flory & Manuck, 2009; Bloom et al., 2014), and impulsivity confers a risk for heavier use of multiple tobacco products (Doran & Tully, 2018). Secondly, that higher levels of trait impulsivity will be positively associated with higher frequency and intensity of e-cigarette use among e-cigarette users. For both of these hypotheses, there has not been enough research in this area to predict which of the facets of impulsivity will be most important in the specific context of e-cigarette use. Thirdly, given the previous research linking impulsivity with cigarette smoking, we hypothesize that higher levels of the impulsivity-related traits of negative and positive urgency will be associated with cigarette smoking status and higher levels of nicotine dependence. Fourth, we hypothesize that dual users will exhibit higher levels of nicotine addiction, motivation and intention to quit and positive urgency than cigarette smokers.

Methods

Participants and Procedure

Participants for this study were recruited online through three different methods; first year psychology students at Goldsmiths, University of London, took part in exchange for course credits via Psychology Department's research participation scheme; via notice boards on social media (Facebook, e-cigarette users groups); and via Prolific, which is an online web service that connects researchers with individuals willing to complete tasks for a wage (www.prolific.ac). The latter were paid £0.90 in return for 10-minutes participation. We recruited 743 participants in total, however only 720 participants were retained for analysis as 23 people reported currently using other tobacco products. Participation was voluntary and anonymous. After reading the description of the study and signing an informed consent document online, participants completed the study questionnaires using the Qualtrics website (http://www.qualtrics.com). The study was approved by the Goldsmiths, University of London, Psychology Department Ethics Committee. Data collection occurred between November 2017 and May 2018.

Measures

Demographics

Participants reported age, gender (male/female), country of residence (living in Europe or not), employment status (students, employed and unemployed), and ethnicity (white/black/Asian/mixed-race/other). The majority of participants were of white ethnicity, thus we categorized participants as white or others.

General smoking/e-cigarette use behaviour

Respondents' general smoking/e-cigarette behaviour was assessed by four questions: "1.Which, if any, of the following tobacco/nicotine products have you ever used or tried? (cigarettes, e-cigarettes, cigars, hookah, other, none)."; "2.Do you currently use any of the following products? (select all that apply)." (cigarettes, e-cigarettes, cigars, hookah, other, none)."; "3. If you have ever smoked cigarettes. How long is it since you smoked your last cigarette? (within the last 24 hours, 1-6 days, 1-4 weeks, longer than a month)."; "4. If you have ever smoked e-cigarettes. How long is it since you used it? (within the last 24 hours, 1-6 days, 1-4 weeks, longer than a month)."

Four current usage groups were derived from these questions and based on previous research (Cooper, Case, Loukas, Creamer & Perry, 2016): *e-cigarette users* (currently use only e-cigarettes and haven't smoked a cigarette in the last month), *cigarette smokers* (currently smoke cigarettes and haven't used an e-cigarette in the last month), *dual users* (currently smoke cigarettes and use e-cigarettes (In the last 1-4 weeks)), and *non-smokers* (not currently using any product and haven't used any product in the last month).

Current tobacco use, smoking history, intention to quit and cravings

Nicotine dependence of cigarette smokers and dual users was measured with the Fagerstrom test for Nicotine dependence (FTND), a widely used six-item questionnaire (range: 0-10), that predicts biochemical exposure (CO), withdrawal symptoms, and smoking relapse (Heatherton et al., 1991). There are three 'no (0)/yes (1)' questions, two questions are scored 0-3, and one more question is scored 0-1. Scores range from 0 to 10, with higher scored indicating higher levels of

nicotine dependence. The FTND has demonstrated good construct validity and internal consistency (Heatherton et al., 1991), and the alpha reliability was 0.72 in the present sample.

Smoking history included, the age smokers and dual users started smoking and their previous quit attempts. Motivation to quit was assessed with two questions based on the Transtheoretical Model (TTM) of behaviour change (Prochaska & DiClemente, 1983); “Are you seriously thinking of quitting?” (Answers: within the next 2 weeks; within the next 6 months; not within the next 6 months) and “If you are planning to quit have you set a quit date?” (yes /no). Smokers were classified, based on their answers, as being in precontemplation stage (not planning to quit within the next 6 months), contemplation stage (planning to quit within the next 6 months, but no quit date set), and preparation stage (planning to quit within the next 2 weeks and set a quit date). Additionally, motivation to quit was assessed with three more questions: “How much do you want to quit?”, “How determined are you to quit for good?’’, “How confident are you that you can quit for good?”. The last three items were rated on a five-point Likert-type scale (1=none at all to 5= a great deal). We also assessed smoking cravings through the brief version of the Questionnaire of Smoking Urges (QSU-brief; (Cox, Tiffany & Christen, 2001)). The QSU-Brief is a 10-item self-report measure which assesses two different dimensions of cigarette craving. The first dimension primarily reflects intention and desire to smoke and anticipation of pleasure from smoking. Example items include “I have a desire for a cigarette right now” and “A cigarette would taste good now”. The second dimension comprises anticipation of relief from negative affect and nicotine withdrawal, and an urgent and overwhelming desire to smoke. Example items include “I could control things better right now if I could smoke” and “Smoking would make me less

depressed". All items are rated on a 1-7 scale (1=strongly disagree to 7=strongly agree) and subscale scores are calculated by averaging item ratings. Higher ratings indicate stronger cravings to cigarette smoking. Previous research indicates the QSU-Brief has good construct validity and internal consistency (Cox, Tiffany & Christen, 2001). The alpha reliabilities for each dimension were a=0.95 and a=0.93 respectively in the present sample.

Current e-cigarette use and reasons for e-cigarette use

E-cigarette users and dual users reported their current e-cigarette use similarly to previous studies (Bold et al., 2018; number of days in the last month using e-cigarette, average number of vapes per day, average millilitres of e-liquid used per day, type of cartridge used) and the main reasons for using e-cigarettes (perception that they are less harmful than cigarettes, can be used indoors, cheaper than tobacco products, novelty, aid to stop smoking, range of different flavours available, other), with the option to select more than one reason.

Impulsivity

Impulsivity was measured with the UPPS-P Impulsive Behaviour Scale (Cyders et al., 2007; Whiteside & Lynam, 2001), a widely used 59-item, four point Likert type scale assessing five dimensions of impulsivity: negative urgency (12 items), positive urgency (14 items), lack of premeditation (11 items), lack of perseverance (10 items), and sensation seeking (12 items). The majority of items are reversed coded such that a high score reveals an impulsive personality trait. For the present study, the mean score for each scale was calculated, giving a score between 1 and 4, where 4 indicates higher trait expression. The scales have been shown to

display good convergent and discriminant validity (Smith et al., 2007). The Cronbach's alpha reliabilities in the present sample were: lack of premeditation=0.87, lack of perseverance=0.84, sensation seeking=0.86, negative urgency=0.91, positive urgency=0.96.

Analytic procedure

General descriptive analyses were performed to describe the whole sample and the four groups; non-smokers, cigarette smokers, e-cigarette users and dual users. Group differences in all measures apart from impulsivity-related traits were identified by performing Chi-square tests or analysis of variance tests as appropriate.

We used multinomial logistic regressions, controlling for age and gender, to assess the predictive value of each impulsivity-related trait separately in differentiating the 4 groups of participants in this study. Ability of impulsivity traits to discriminate between pairs of levels of the categorical Outcome Variable was tested via planned contrasts. Three contrasts looked at the ability to discriminate e-cigarette from each of the other 3 groups. Additionally, two contrasts tested the ability to discriminate cigarette smokers from non-smokers and from dual users.

Further logistic regressions were used to examine the relationship between impulsivity-related traits, when entered into the equation simultaneously, and smoking status, while controlling for age and gender. Given the strong correlation between negative and positive urgency, we tested positive and negative urgency in separate models with the other three traits in each case, however the results were similar to the models tested with all five traits.

Before conducting the analyses outlined above, the data used was checked for normality, homoscedasticity, linearity and multicollinearity. No problem was observed with these assumptions.

To ascertain the reasons for use of e-cigarettes, additional analyses were limited to e-cigarette users and dual users, while to examine reasons for e-cigarette use and intention to quit cigarette smoking analyses were limited to dual users group only.

All data were analysed using IBM SPSS version 23.0.

Results

Participant characteristics

Overall, the mean age of participants was 32.4 (SD=11.4), ranging from 18 years to 68 years, the majority were female (59.1%), of white ethnicity (92.1%), living in Europe (85.8%), and in full-time employment (56.7%). The results showed that most participants (695, 96.5%) had heard of, or seen, an e-cigarette, while a total of 20.8% (150) of respondents were e-cigarette users, 22.8% (164) were cigarette smokers, 23.9% (172) were dual users and 32.5% (234) were non-smokers.

Omnibus tests for the four groups overall comparisons (Table 3.1) showed that e-cigarette users compared to non-smokers and cigarette smokers were more likely to be older, male, in employment, and not European. Dual users differed significantly from e-cigarette users in their occupation only, with more dual users reporting an employed status. Cigarette smokers compared to dual users were more likely to be younger, female, students and European.

Table 3.1. Demographic characteristics by smoking status

Variable	Non-smokers n= 234(32.5%)		Smokers n= 164(22.8%)		E-cig users n= 150(20.8%)		Dual users n=172(23.9%)			
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**F-Statistic (dfs)**	***p-value***
Age	27.76[1]	10.85	32.02[2,4]	10.92	35.09	11.28	36.63	10.48	26.36 (3, 716)	<0.001
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**Chi^2 statistic (df)**	***p-value***
Gender										
Male	50[1]	21.4	66[2,4]	40.2	84	56.4	94	54.7	65.17 (3)	<0.001
Female	184	78.6	98	59.8	65	43.6	78	45.3		
Ethnicity										
White	222	94.9	147	89.6	135	90.6	156	91.8	4.299 (3)	0.231
Other	12	5.1	17	10.4	14	9.4	14	8.2		
Country of residence										
Europe	219[1]	94.4	152[2]	93.3	115	76.7	128	74.9	48.46 (3)	<0.001
Other[a]	13	5.6	11	6.7	35	23.3	43	25.1		
Occupation										
Student	148[1]	63.2	55[2,4]	33.5	24	16.1	13[3]	7.6	168.26 (6)	<0.001
Employed	76	32.5	89	54.3	104	69.8	139	80.8		
Unemployed	10	4.3	20	12.2	21	14.1	20	11.6		
Ever seen e-cig										
Yes	222[1]	94.9	154[2]	93.9	150	100	172	100	18.50 (3)	<0.001
No	12	5.1	10	6.1	0	0	0	0		
Ever use										
Cigarettes	134[1]	57.3	164[2,4]	100	135	90.0	172[3]	100	192.73 (3)	<0.001
E-cigarettes	63[1]	26.9	107[2,4]	65.2	150	100	172	100	335.38 (3)	<0.001
Cigars	47[1]	20.1	80[4]	48.8	83	55.3	83	48.3	63.02 (3)	<0.001
Hookah	51	21.8	46	28.0	41	27.3	38	22.1	3.24 (3)	0.321
Other	20	8.5	33[4]	20.1	20	13.3	45[3]	26.2	25.18 (3)	0.001
None	83[1]	35.5	0[4]	0	0	0	0	0	194.85 (3)	<0.001

n= number of participants, e-cig=e-cigarette, S.D.=Standard Deviation, p=alpha level

[a] The category 'other' includes 89 participants from the US, 8 from Canada, 6 from Australia and 1 from Turkey

[1]denotes that non-smokers differ significantly from e-cigarette users; [2]denotes that smokers differ significantly from e-cigarette users; [3]denotes that dual users differ significantly from e-cig users; [4]denotes that smokers differ significantly from non-smokers

Comparison of the four groups in their smoking history showed that most of the participants had tried both cigarettes and e-cigarettes in their lifetime.

Discriminating the 4 participant groups using impulsivity-related traits

The 5 multinomial logistic regression analyses for each impulsivity trait were each assessed against a Bonferroni-corrected alpha value of 0.01 (0.05/5). The analysis for positive urgency revealed that this impulsivity trait made a significant contribution to discriminating between the 4 groups (likelihood ratio [LR] test for removing positive urgency from the model: chi-square LR test =38.8, df=3, p<0.001).

A similar result was found for negative urgency (LR test =32.4, df=3, p<0.001). Lack of premeditation ((LR test =4.6, df=3, p=0.2), lack of perseverance (LR test =8.1, df=3, p=0.044) and sensation-seeking showed no ability to significantly differentiate the 4 groups (LR test =6.5, df=3, p=0.09).

Discriminating e-cigarette users from non-smokers, cigarette smokers and dual users using impulsivity-related traits **(see Table 3.2)**

We conducted 25 logistic regressions, controlling for age and gender, to assess the predictive value of each impulsivity-related trait separately to differentiate e-cigarette users from each of the other three groups, and cigarette smokers from non-smokers and dual users. The Bonferroni-adjusted critical alpha for these analyses would be 0.002.

The planned contrast analyses focussing on the discrimination of pairs of user groups (and corrected for multiple comparisons) showed that impulsivity-related traits did not differentiate e-cigarette users from non smokers.

Lack of perseverance (OR=1.82, 95% CI 1.14-2.92) was the only impulsivity related trait which differentiated e-cigarette users from cigarette smokers after correcting for multiple comparisons. However, negative urgency (OR=1.48, 95% CI 1.02-2.15) was able to differentiate cigarette smokers from e-cigarette users to a lesser extent; the effect did not reach significance after correcting for multiple comparisons. No significant predictors were found when all the impulsivity-related traits were entered as predictors simultaneously.

Negative (OR=2.02, 95% CI 1.40-2.92) and positive (OR=2.14, 95% CI 1.54-2.97) urgency differentiated dual smokers from e-cigarette users significantly, when used as single predictors. Analyses with all the impulsivity-related traits entered as

predictors simultaneously showed that only positive urgency continued to differentiate dual users from e-cigarette users (OR=2.01, 95% CI 1.16-3.49).

Table 3.2. Impulsivity-related characteristics by smoking status and contrasts (logistic regression for each impulsivity-related trait separately)

Variable	1.Non-smokers n=234		2. Smokers n=164		3. E-cig users n=150		4. Dual users n=172		
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Lack of Premeditation	1.94	0.49	2.04	0.43	1.98	0.46	2.00	0.49	
Lack of Perseverance	2.08	0.46	2.17	0.52	2.01	0.52	2.05	0.46	
Sensation Seeking	2.53	0.59	2.55	0.61	2.57	0.61	2.66	0.61	
Negative Urgency	2.34	0.58	2.55	0.53	2.40	0.59	2.64	0.63	
Positive Urgency	1.93	0.65	2.14	0.70	2.02	0.65	2.36	0.75	
Contrasts (logistic regression for each impulsivity-related trait separately)									
	E-cig users vs non smokers		E-cig users vs smokers		E-cig users vs dual users		Smokers vs non smokers		Smokers vs dual users
Variable	Odd ratio (95% CI)		Odd ratio (95% CI)		Odd ratio (95% CI)		Odd ratio (95% CI)		Odd ratio (95% CI)
Lack of Premeditation	0.80 (0.50-1.27)		1.26 (0.78-2.04)		1.09 (0.68-1.75)		0.63 (0.41-0.97)*		0.86 (0.55-1.37)
Lack of Perseverance	1.09 (0.69-1.73)		**1.82 (1.14-2.92)****		1.28 (0.80-2.03)		0.60 (0.39-0.92)*		0.70 (0.45-1.10)
Sensation Seeking	0.93 (0.63-1.37)		0.97 (0.65-1.44)		1.45 (0.98-2.15)		0.96 (0.67-1.38)		1.50 (1.01-2.21)*
Negative Urgency	0.79 (0.54-1.13)		1.48 (1.02-2.15)*		**2.02 (1.40-2.92)*****		**0.53 (0.37-0.75)*****		1.36 (0.95-1.95)
Positive Urgency	0.84 (0.60-1.18)		1.35 (0.97-1.89)		**2.14 (1.54-2.97)*****		0.62 (0.45-0.85)**		1.58 (1.15-2.17)**

n=number of participants, e-cig=e-cigarette, S.D.=Standard Deviation

*p<0.05, **p<0.01, ***p<0.001 unadjusted for multiple comparisons

We conducted 25 logistic regressions, controlling for age and gender, to assess the predictive value of each impulsivity-related trait separately to differentiate e-cigarette users from each of the other three groups, and cigarette smokers from non-smokers and dual users. The Bonferroni-adjusted critical alpha for these analyses would be 0.002. Bold cells indicate which comparisons survive this conservative correction.

E-cig users versus non smokers: contrast between e-cigarette users and non-smokers (reference category= e-cigarette users); E-cig users versus smokers: contrast between e-cigarette users and smokers (reference category= e-cigarette users); E-cig users versus dual users: contrast between e-cigarette users and dual users (reference category= e-cigarette users); Smokers versus non smokers: contrast between smokers and non-smokers and smokers (reference category=smokers); Smokers versus dual users: contrast between smokers and dual users (reference category=smokers)

Discriminating smokers from non-smokers and dual users using impulsivity-related traits (see Table 3.2)

Separate analyses using each impulsivity scale as a predictor showed that negative urgency (OR=1.89, 95% CI 1.33-2.69) was the only impulsivity trait which differentiated smokers from non-smokers after correcting for multiple comparisons. However, positive urgency (OR=1.61, 95% CI 1.17-2.91), lack of premeditation (OR=1.59, 95%CI 1.03-2.45) and lack of perseverance (OR=1.67, 95% CI 1.09-2.55) were able to differentiate cigarette smokers from non-smokers to a lesser extent; the effects did not reach significance after correcting for multiple comparisons. When all five traits were entered as predictors into a logistic regression equation simultaneously, no significant predictors were found.

Positive urgency (OR=1.58, 95% CI 1.15-2.17) and sensation seeking (OR=1.50, 95%CI 1.01-2.21) differentiated cigarette smokers from dual users to a lesser extent as the effects did not reach significance after correcting for multiple comparisons. When all five traits were entered as predictors into a logistic regression equation simultaneously, no significant predictors were found.

Current tobacco use, smoking history, intention to quit and cravings

Smoking behaviour of cigarette smokers and dual users groups, their motivation to quit, and their cigarette cravings are summarized in Table 3.3. Most participants of both groups started smoking over the age of 16 and they smoked daily, while almost half of the participants indicated that they had quit in the past for longer than a month. Compared to cigarette smokers, dual users showed higher levels of nicotine dependence (FTND score), $F(1, 331)=34.12$, $p<0.001$, more motivation, $F(1, 330)=12.65$, $p=0.001$, and determination to quit, $F(1, 328)=16.63$, $p<0.001$. Based on the TTM stages, most dual users were in the contemplation stage (53.9%), while most cigarette smokers were in the pre-contemplation stage

(52.3%) (χ^2=24.36, p<0.001). The two groups did not differ in their confidence in quitting. Regarding cigarette cravings, dual users scored significantly higher in positive desire to smoke for reward scale (F(1,331)=23.05, p<0.001) and in need to smoke for relief scale (F(1, 331)=44.72, p<0.001) than cigarette smokers.

The mean FTND score for cigarette smokers only group was 2.68 (SD=2.40), showing a low nicotine dependence group. Linear regression analysis with smokers group alone, controlling for age and gender, showed that higher nicotine dependence was associated with significantly higher levels of negative (β=0.257, p<0.001) and positive urgency (β=0.220, p=0.003) when each of these traits was entered as the sole impulsivity predictor variable. No significant results were found when all the five traits were entered as predictors simultaneously in the regression.

Table 3.3. Current tobacco use, cessation history, intention to quit and cravings

Variable	Smokers n= 164		Dual users n=170			
	No	**%**	**No**	**%**	**Chi^2 statistic (df)**	***p*-value**
Days per month of cigarette smoking						
6-9 days	6	4.1	7	4.4	6.346 (3)	0.096
10-19 days	13	8.8	27	17.0		
20-29 days	29	19.7	20	12.6		
30 days	99	67.3	105	66.0		
Age started smoking						
<14	13	8.2	19	11.2	0.866 (2)	0.649
14-16	50	31.4	53	31.2		
>16	96	60.4	98	57.6		
Quit for longer than a month						
no	78	48.4	99	58.2	3.184 (1)	0.074
yes	83	51.6	71	41.8		
Motivation to quit (TTM)						
Pre-contemplation	80	52.3	54	32.3	24.361 (2)	**<0.001**
Contemplation	71	46.4	90	53.9		
Preparation	2	1.3	23	13.8		
	Mean	**SD**	**Mean**	**SD**	**F-Statistic (dfs)**	***p*-value**
Nicotine Dependence						
FTND	2.68	2.40	4.26	2.51	34.12 (1, 331)	**<0.001**
Mean score 'How much do you want to quit' (scale1-5)	3.13	1.18	3.60	1.20	12.65 (1, 330)	**0.001**
Mean score 'How determined are you to quit for good' (scale1-5)	2.89	1.21	3.44	1.24	16.63 (1, 328)	**<0.001**
Mean score 'How confident are you to quit for good' (scale1-5)	2.98	1.26	3.21	1.24	2.81 (1, 329)	0.095
Cravings						
Positive desire to smoke for reward	3.74	1.73	4.62	1.61	23.05 (1, 331)	**<0.001**
Need to smoke for relief	2.79	1.50	3.96	1.67	44.72 (1, 331)	**<0.001**

Current e-cigarette use and reasons for e-cigarette use

Regarding e-cigarette usage, most e-cigarette users reported using their e-cigarette every day (79.8%), while dual users reported using it some days (39.9%; Table 3.4). The two groups differed significantly in the number of times of vaping per day, but they did not differ in the millilitres of e-liquid they used per day, and the type of cartridge they used showed only a trend (p=0.051) of a difference between the groups.

Table 3.4. E-cigarette use behaviour and reasons for e-cigarette use among e-cigarette users and dual users

Variable	**E-cig users n=150**		**Dual users n=172**			
	No	**%**	**No**	**%**	**Chi^2 statistic (df)**	***p-value***
Reason for e-cigarette use						
Less harmful	105	70.0	97	56.4	6.34 (1)	0.012
Used indoors	69	46.0	95	55.2	2.73 (1)	0.098
Cheaper	77	51.3	74	43.0	2.22 (1)	0.136
Novelty	13	8.7	12	7.0	0.32 (1)	0.572
Smoking cessation	102	68.0	88	51.2	9.39 (1)	0.002
Flavour availability	63	42.0	47	27.3	7.67 (1)	0.006
other	10	6.7	12	7.0	0.01 (1)	0.912
Number of reasons endorsed per participant						
1	32	21.5	38	24.5	6.49 (6)	0.370
2	29	19.5	34	21.9		
3	30	20.1	39	25.2		
4	34	22.8	30	19.4		
5	22	14.8	12	7.7		
6	2	1.3	1	0.6		
7	0	0	1	0.6		
E-cigarette use						
Days of vape/month						
1-2 days	0	0	0	0	76.22 (3)	**<0.001**
3-5 days	0	0	0	0		
6-9 days	1	0.8	20	13.1		
10-19 days	12	9.3	61	39.9		
20-29 days	13	10.1	27	17.6		
All 30 days	103	79.8	45	29.4		
Cartridge						
Nicotine free	29	19.3	41	24.3	5.94 (2)	0.051
Nicotine containing	101	67.3	92	54.4		
both	20	13.3	36	21.3		
	Mean	**S.D.**	**Mean**	**S.D.**	**F-Statistic (dfs)**	***p-value***
Times of vape/ day	26.77	32.24	12.25	28.53	16.66 (1, 291)	**<0.001**
Mls e-liquid/ day	5.94	6.08	4.93	5.47	2.22(1, 290)	0.137

e-cig=e-cigarette, S.D.=Standard Deviation, dfs=degrees of freedom, p=alpha value, Mls=millilitres

The most important reason for e-cigarette use for both groups was 'the perception that it is less harmful than cigarettes' (70% of e-cigarette users, 56.4% of dual users). Smoking cessation was the second most important reason for e-cigarette users (68%), while dual users chose 'can be used indoors' as their second most important reason (55.2%).

Using a linear regression within the e-cigarette user group alone, controlling for age and gender, no significant results were found examining the relationship between the impulsivity-related traits and frequency and intensity of e-cigarette behaviour (number of days vaping per month, number of times vaping per day, millilitres of e-liquid used per day) when each of these traits was entered as the sole impulsivity predictor variable, or when all the five traits were entered as predictors simultaneously in the regression.

We also assessed bivariate association between reasons for e-cigarette use and reported intentions to quit regular cigarettes in dual users only group. Dual users who intended to quit smoking within 6 months more frequently endorsed the reason 'aid to stop smoking' than those who were not intending to quit (χ^2=11.95, p=0.001). The two groups, dual smokers who intended to quit smoking in the next 6 months and those who did not, did not differ significantly in any e-cigarette use characteristic.

Discussion

The primary aim of the study was to investigate the relationship between impulsivity-related traits based on the UPPS-P model and e-cigarette use, by examining if these traits were able to differentiate e-cigarette users from non-smokers, cigarette smokers and dual users. Results showed that only the two urgency traits were able significantly to differentiate the 4 groups in our study. E-

cigarette users did not differ in any impulsivity-related trait from non-smokers. E-cigarette users showed lower levels of lack of perseverance and negative urgency than cigarette smokers, although the negative urgency finding did not survive a correction for multiple comparisons. E-cigarette users exhibited lower levels of negative and positive urgency compared to dual users.

Research on the role of trait impulsivity and e-cigarette use has shown mixed findings, with some studies indicating that trait impulsivity positively predicts e-cigarette use (Cohn et al. 2015; Spindle et al., 2017; Doran & Tully, 2018), while others have not (Chivers et al., 2016). We did not find a significant relationship for impulsive personality traits in discriminating e-cigarette users from non-smokers. The discrepancy between the results of the present study and other studies might be the result of differences in samples. Studies that found a relationship between impulsivity and e-cigarette use had drawn their data from the USA from both the general community and college students (Cohn et al. 2015; Spindle et al., 2017; Doran & Tully, 2018). The present study, however, mainly used a sample of European older adults in full-time employment. It has been suggested that impulsivity is generally elevated in adolescence, but decreases as the life span progresses (Green et al., 1999), and so the relationship may be found only where impulsivity levels are relatively higher (as in younger people).

Another finding from the present study was that negative urgency was able to discriminate both cigarette smokers and dual users from e-cigarette users. It is well documented in the literature that negative urgency is one of the most consistent impulsivity-related predictors of cigarette smoking behaviours (e.g. Spillane at al., 2010; Doran et al., 2013). Moreover, findings are consistent with studies examining the longitudinal association between impulsivity and cigarette smoking, in that they

suggest that impulsivity confers a risk for heavier use of multiple tobacco products over time (Doran & Tully, 2018). Indeed, in the present study, dual users exhibited the highest levels of the impulsivity-related traits.

Lack of perseverance significantly differentiated e-cigarette users from cigarette smokers; with cigarette smokers exhibiting higher scores on this trait. In contrast, there was no significant ability for lack of perseverance to differentiate between e-cigarette users and dual users. It can be argued that lack of perseverance, the inability to remain focused on the goal of stopping a behaviour, is higher in cigarette smokers than e-cigarette users and dual users because individuals who lack perseverance may be less able to resist cigarette smoking urges that result from high levels of distress and negative affect (Bresin, Carter & Gordon, 2013), and may be less able to use an alternative such as an e-cigarette to replace cigarette smoking.

Most e-cigarette users were using their e-cigarette every day and their puff frequency was higher than dual users, although the liquid used per day for both groups was almost the same. One possible explanation for this observation might be that e-cigarette users take shorter puffs and/or vape at lower power settings, thus using less liquid than dual users. Previous studies have documented an opposite finding, that dual users were using significantly less liquid per week than e-cigarette users, although their puff frequency was the same (Farsalinos et al., 2015; Adriaens et al., 2018). The discrepancy in the results may be accounted for by the way e-cigarette use was measured, as there is no standard way to accurately measure e-cigarette use. Additionally, users may be confused with the way puffs are measured, as some may assume that usage period of their e-cigarette constitutes a puff, while others report every single puff. Moreover, the questions administered in this survey

did not differentiate between different e-cigarette models and e-liquids, of which there are thousands available on the market currently. Different device and e-liquid characteristics can have a profound influence on users' nicotine delivery and, presumably, on a user's level of dependence (Farsalinos & Polosa, 2014). However, in line with our results, there is some previous research suggesting that college students who reported dual use in the past month generally reported higher levels of e-cigarette use compared to students who only used e-cigarettes (Littlefield et al., 2015).

Examining the relationships between frequency (number of days vaping per month, number of times vaping per day) and intensity (millilitres of e-liquid used per day) of e-cigarette use with impulsivity-related traits in the e-cigarette user only group, no significant relationships were found, which could also be accounted for in terms of the way frequency and intensity were measured. Quantifying frequency and intensity of e-cigarette use is difficult as e-cigarette users report that e-cigarette use typically occurs in short, frequent sessions that are often difficult to count (Baweja et al., 2016; Cooper, Harrell & Perry, 2016). Additionally, to date, there is only one e-cigarette dependence measure; the Penn State Electronic Cigarette Dependence Index (Foulds et al., 2015), which captures some, but not all, of the constructs that are essential to accurately measure e-cigarette dependence (Bold et al., 2018). However, the present study did not measure e-cigarette dependence, while assessed e-cigarette use was based on questions used in previous studies. In accordance with previous research (Farsalinos et al., 2015; Adriaens et al., 2018), both e-cigarette users and dual users showed a low risk perception concerning e-cigarette use, and perceived e-cigarettes as less harmful than cigarettes. E-cigarette users also agreed more than dual users with the statement that they vape as an aid

for smoking cessation, suggesting that most of the e-cigarette users were ex-cigarette smokers, although the present survey did not assess smoking history of e-cigarette users. On the other hand, dual users endorsed the statement that they vape because they can use their e-cigarette indoors more than e-cigarette users, and did so less for the statement about vaping to help with quitting smoking. Previous research regarding the situations where traditional cigarettes or e-cigarettes are preferred has shown that dual users mostly smoke cigarettes in stressful situations, while they use their e-cigarettes indoors and in situations with a higher risk of exposing others to second-hand smoke (Rass et al., 2015; Pokhrel et al., 2015).

The present study adds support to previous evidence consistently showing that cigarette smoking, and severity of nicotine dependence, are associated with higher levels of negative and positive urgency (Doran et al., 2009; Kale, Stautz & Cooper, 2018), as smoking to alleviate negative and positive mood states is a common motivation for smokers (Doran et al., 2009; Spillane at al., 2010).

An examination of smoking behaviour characteristics of cigarette smokers and dual users showed that dual users reported higher levels of nicotine dependence as measured by FTND, and higher levels of nicotine withdrawal symptoms. Additionally, dual users were more likely to report an intention to quit smoking in the next 6 months (being categorised in contemplation stage of TTM) than smokers, while dual users who intended to quit smoking within 6 months were more likely to report smoking cessation as a reason for e-cigarette use. It is possible that these findings indicate that this group of highly addicted smokers may have just initiated e-cigarette use to help them to attain smoking cessation, thus becoming dual users for a period while trying to stop smoking. Another possible explanation is that smokers initiate e-

cigarette use, especially the most addicted ones, in order to deal with nicotine withdrawal symptoms in settings where smoking may be restricted. On the other hand, another possible explanation of e-cigarette use among dual users may be that e-cigarettes are not helping smokers to quit. Research on their efficacy as a smoking cessation aid has shown inconsistent findings. A recent meta-analysis found that odds of quitting smoking were 28% lower in smokers who used e-cigarettes compared with those who did not use e-cigarettes (Kalkhoran & Glantz, 2016), while a systematic review reported that most reviewed studies showed a positive association between e-cigarette use and smoking cessation, even though the quality of studies was assessed as low (Malas et al., 2016).

Implications

Should the current findings suggesting that different impulsivity related traits relate to different classes of smoking status be replicated, this would be important in not only helping identify factors associated with e-cigarette use, but also to help researchers and clinicians understand the role of specific traits and their associated patterns of affect, behaviour, and cognition in relation to cigarette smoking and e-cigarette use.

Available evidence does seem to indicate that e-cigarettes are likely less harmful than traditional cigarettes, and that e-cigarette use may serve as a useful smoking cessation aid (Public Health England, 2015). Indeed, our findings suggest that a number of dual users possibly use e-cigarette as a means to stop cigarette smoking, which reflects an important opportunity to help these smokers quit. Such findings highlight the potential utility for interventions where e-cigarettes could be used as an opportunity to discuss cessation and to recognize e-cigarette as a

smoking cessation tool, especially among smokers motivated to quit. However, e-cigarettes might function best as a valuable harm reduction tool for addicted smokers, if this results in complete cigarette smoking cessation (Public Health England, 2015). Sustained dual use of cigarettes and e-cigarettes may confer substantial disease risk, in that even low levels of cigarette smoking increases one's risk for cardiovascular disease and lung cancer (Public Health England, 2015). Moreover, it is possible that using both products would help to sustain nicotine addiction, which might deter complete quitting and sustain the cigarette smoking, despite users' intentions to quit.

Additionally, if, as the present study suggests, compared to e-cigarette use, dual use is associated with increased levels of urgency, while cigarette smoking is associated with higher levels of lack of perseverance, prevention strategies and interventions to reduce dual use may need to differ systematically from interventions to encourage smokers to switch from cigarette smoking to e-cigarette use; there are different interventions associated with negative urgency, positive urgency and lack of perseverance (Zapolski, Settles, Cyders, & Smith, 2010).

Limitations and future directions

A potential limitation of the current study is that the recruitment method is likely to have led to selection bias. The study recruited from university students, from social media, and from a platform that consisted of individuals who were interested in participating in research surveys in exchange for money. As a result, certain socio-demographic groups are likely to have been under-represented; for example, both older individuals and those with lower incomes typically have fewer online utility skills and more limited internet access (Dutton & Blank, 2011). This self-selection bias

implies that conclusions cannot be generalized to the overall population. However, previous research suggests that adults aged 18-49 years represent the subgroup with the highest prevalence of e-cigarette use (Pericot-Valverde et al., 2017). Additionally, it should be noted that the groups differed significantly across most of their demographic variables, with non-smokers being younger, including more females and more students, than the other groups. Another limitation of the study is that participants self-reported their data online, which could be affected by self-report bias, although in-person survey measures suffer from similar challenges that rely on the openness of the participants (Kraut et al., 2004). The present study assessed a number of potential reasons for e-cigarette use based on previous literature (Schore, Hummel & de Vries, 2017). However, it did not include an explicit positive reinforcement option, which has been recently found to be an important factor for e-cigarette use (Brandon et al., 2019). Lastly, the study design was cross-sectional, so is not a test of a risk model. Future longitudinal work could evaluate the causal relationships between impulsivity-related traits and e-cigarette use. Moreover, in depth, qualitative studies and longitudinal research are needed to fully investigate the reasons of e-cigarette use and if these reasons influence cigarette smoking reduction or smoking cessation.

Conclusions

The present study did not find any association between trait impulsivity and e-cigarette use when differentiating e-cigarette users from non-smokers. This contrasts with the strong association between trait impulsivity and cigarette smoking in the literature and in this study. However, results showed that impulsivity-related traits differentiated e-cigarette users from cigarette smokers and dual smokers. If, as

suggested here, different traits relate to different classes of smoking status, it is important not only to help us to distinguish among likely non-smokers, potential smokers, e-cigarette users and dual users, but also has the potential to inform treatment plans and decisions.

Chapter 4

Examining the psychometric properties of the CEAC (Comparing E-cigarette And Cigarette) questionnaire and its usefulness as a predictor of e-cigarette use

Overview

The study outlined in this chapter sought to examine attitudes towards e-cigarettes and their association with e-cigarette use. The first aim of the study is to examine the psychometric properties of the Comparing E-cigarette And Cigarette questionnaire (CEAC), a newly developed scale that assesses attitudes towards e-cigarettes as compared to cigarettes. Second aim is to replicate a structural model of the relationship between impulsive-related personality traits as described by the UPPS-P and e-cigarette use mediated by positive attitudes towards e-cigarettes. A total of 525 adults (mean age=33.42, SD=11.27) from Europe, non-smokers, smokers, e-cigarette users and dual users completed the CEAC and UPPS-P questionnaires online. Confirmatory factor analysis of the CEAC replicated the *a priori* factor structure of the questionnaire. Additionally, structural path analysis showed that deficits in conscientiousness, as measured by lack of premeditation and lack of perseverance, were significantly negatively related to e-cigarette attitudes, while urgency showed a significant positive relationship to e-cigarette attitudes. E-cigarette users showed significantly more positive attitudes towards e-cigarettes than non-users. No significant direct effects were found between impulsivity-related traits and e-cigarette use. The present study suggests that impulsivity-related traits and attitudes towards e-cigarettes are likely to be important risk factors for e-cigarette

use, and the model described in this study could be potentially used to guide strategies for reducing risk for e-cigarette use.

Introduction

In the previous chapter we examined the role of trait impulsivity in e-cigarette use among adults, while we also assessed factors associated with e-cigarette use. This chapter will examine attitudes towards e-cigarettes as a risk factor of e-cigarette use in adults in order to further enhance our understanding of what motivates e-cigarette use in adults.

Attitudes towards e-cigarettes

Research on smoking and other addictive behaviours suggest that attitudes are one set of forces that influence behaviour (West & Brown, 2013; Borland, 2014). It was found that individuals who hold more positive attitudes and fewer negative beliefs about cigarette smoking are more likely to initiate cigarette smoking (Larsen & Cohen, 2008), while smokers who hold positive attitudes towards cigarettes are less likely to quit successfully (Yong & Borland, 2008).

Regarding e-cigarette use, emerging evidence indicates that holding favourable attitudes towards e-cigarettes, especially compared to traditional cigarettes, is associated with e-cigarette use among adult cigarette smokers and non smokers. E-cigarettes are marketed as alternatives to conventional cigarettes, thus the comparison between e-cigarettes and cigarettes is inevitable. This comparison is significant because the more that individuals perceive e-cigarettes as being more beneficial than cigarettes, the more likely they may be to transition from cigarettes to e-cigarettes, or even transition from non use to e-cigarette use. Cross-sectional

studies also indicate that holding favourable attitudes towards e-cigarettes is associated with e-cigarette use among adult smokers. For example, a cross-sectional study conducted by Pokhrel, Little, Fagan, Muranaka & Herzog (2014) assessed attitudes regarding the perceived harm of e-cigarette relative to cigarettes in sample of multiethnic US college students, current, never or former cigarette smokers. They also assessed participants' current e-cigarette use. Their findings suggest that positive beliefs about e-cigarettes were associated with past 30-day e-cigarette use and intentions to use e-cigarettes in the future.

Similarly, Wackowski & Delnevo (2016) found that more favourable attitudes towards e-cigarettes among US young adults, tobacco and non-tobacco users, were associated with ever trying and current use of e-cigarettes. Such findings were also supported by a study conducted among adults seeking substance use treatment in US, where it was found that participants who perceived e-cigarettes to be less harmful than other substances were more likely to use an e-cigarette (Peters et al., 2015). Additionally, a study examining attitudes towards the effectiveness of e-cigarette use in smoking cessation among young adults, cigarette smokers from the US, found that smokers who believed that e-cigarettes could help them quit smoking were more likely to experiment and actually use an e-cigarette, even though they did not want to quit (Choi & Forster, 2013). These findings were also confirmed in a longitudinal study in the UK of smokers and former smokers, who were more likely to use e-cigarettes one year later if they perceived them to be less harmful and more socially acceptable than cigarettes at baseline (Brose, Brown, Hitchman, & McNeill, 2015). Based on the evidence cited above, it can be concluded that favourable attitudes towards e-cigarettes could be considered a potential risk factor for e-cigarette use.

Comparing E-cigarette and Cigarette (CEAC) Questionnaire

Hershberger, Karyadi, VanderVeen, and Cyders (2017) adopted a more structured approach to assess e-cigarette attitudes by directly comparing them to cigarette attitudes. They developed and tested in a US population a 17-item questionnaire empirically derived from the existing e-cigarette belief literature: the Comparing E-cigarette And Cigarette (CEAC) questionnaire (Hershberger, Karyadi, et al., 2017). The 17 items of the CEAC questionnaire covered areas that were previously found to be associated with intent to use e-cigarettes and actual e-cigarette use (Pokhrel, Little, Fagan, Muranaka & Herzog, 2014; Hendricks et al., 2014), they also assessed beliefs that influence intent and e-cigarette use and these beliefs are targeted in advertisements that promote e-cigarette use (Grana & Ling, 2014), they could be used both in smokers and non smokers and in university and community samples (Grana & Ling, 2014), and they were phrased to compare e-cigarettes to traditional cigarettes. Hershberger, Karyadi, et al. (2017) conducted exploratory factor analysis on these 17 items, eventually retaining 10 items and identifying three factors: General benefits entailing general benefits perceived from e-cigarette use compared to cigarette smoking; general effects, entailing perceived positive effects e-cigarette use has compared to cigarette smoking; and health benefits entailing perceived health benefits of e-cigarette use compared to traditional cigarettes. The original sample included 451 college students, while these factors were subsequently replicated via confirmatory factor analysis in an independent sample of 699 from US community adult population. The present study is utilizing this recently developed measure in order to assess participants' attitudes towards e-cigarette use. Prior to this, it aims to replicate the factor structure of the CEAC and assess its psychometric properties in a different population. If we can do so, this will

help establish the CEAC as a robust and reliable measure of attitudes towards e-cigarettes to help and uncover why individuals across different populations might be more likely to use e-cigarettes.

Trait impulsivity, attitudes towards e-cigarettes and e-cigarette use

In the previous chapter we found that different impulsivity-related traits as measured by the UPPS-P model relate to different classes of smoking status. In particular it was found that e-cigarette users exhibited lower levels of lack of perseverance than cigarette smokers, and they scored lower on negative and positive urgency scales than dual users, while they did not differ in trait impulsivity from non smokers. Such results contradict previous research that suggests a positive relation between the impulsivity-related traits of sensation seeking and lack of perseverance and e-cigarette use (Cohn et al. 2015; Doran & Tully, 2018; Spindle et al., 2017). However, such differences may be accounted to the sample of the studies, as has been already discussed in Chapter 3.

A recent study conducted by Hershberger, Connors et al. (2017) provides initial support for a model in which impulsivity is related to e-cigarette use through positive e-cigarette attitudes. Hershberger, Connors, et al. (2017) used a theory based approach to examine the relationship between trait impulsivity, attitudes towards e-cigarettes and e-cigarette use. They applied the Theory of Planned Behavior (TPB; Ajzen, 1991) to examine a causal model in which impulsivity contributes to e-cigarette attitude endorsement and use. The TPB posits that a certain behaviour is influenced by an individual's intention to perform that behaviour, which in turn is determined by three cognitive factors: attitudes, perceived behavioural control and the subjective norm (Ajzen, 1991). It further suggests that

attitudes towards behaviours are a function of a person's accessible beliefs about the behaviour (Fishbein & Ajzen, 1975), meaning that an individual's belief that e-cigarette use is healthier than smoking cigarettes may contribute to an increase in intentions to use an e-cigarette and, subsequently, may present greater risk for engaging with e-cigarette use. To examine this model, they utilised the impulsivity-related traits based on UPPS-P and created three latent variables based on previous research (Cyders and Smith, 2007; Cyders, Littlefield, Coffey, & Karyadi, 2014); urgency (composed of negative and positive urgency), deficits in conscientiousness (composed of lack of premeditation and lack of perseverance), and sensation seeking. Their findings suggest that higher levels of urgency are related to more positive e-cigarette use attitudes, and that the endorsement of these attitudes is related to greater likelihood of e-cigarette use. Individuals reporting higher levels of deficits in conscientiousness held less positive attitudes towards e-cigarettes. The data for the Hershberger, Connors, et al. study was obtained from a US population, where e-cigarettes are regulated as tobacco products (US Food and Drug Administration, 2016), and there is no regulation for e-cigarette nicotine content. Moreover, they measured e-cigarette use with a single question about current use, without assessing participants' other smoking behaviour.

In the current study, we seek to replicate and extend the work by Hershberger, Connors et al. by utilising a sample from a different population, based in Europe, where e-cigarette regulations are more liberal and e-cigarettes can be described as a Nicotine Replacement aid for cigarette smokers trying to quit. Additionally, e-cigarette nicotine content is capped at 20 mg/ml (McNeil, Brose, Calder, Bauld & Robson, 2019). On that basis, the structure of attitudes towards e-

cigarettes in Europe might be different from that in a US population, and subsequently the relationship between attitudes and e-cigarette use.

Aims and hypotheses

The aims of the present study are, firstly, to examine the psychometric properties of the CEAC by testing its purported factor structure, reliability and its measurement invariance across e-cigarette use groups in a European sample. Secondly, we sought to examine whether the relationship between impulsivity-related personality traits and e-cigarette use would be mediated by positive attitudes towards e-cigarettes.

Hypothesis one is that e-cigarette users will hold more positive attitudes towards e-cigarette use, and will exhibit higher levels of impulsivity-related traits, than non e-cigarette users. Hypothesis two is that the relationship between impulsivity-related traits and e-cigarette use will be mediated by positive attitudes towards e-cigarettes. It is important to understand the relationship between attitudes, trait impulsivity and e-cigarette use in order to design effective prevention and intervention strategies that can be generalized to any target population.

Methods

Participants

Participants were a sub-set of the sample recruited as part of the research study described in Chapter 3. For the purposes of the present study we included only participants who stated that their country of residence was in Europe. We recruited 529 participants living in Europe; however, four participants were removed from the

study prior to data analysis for not completing any items from the CEAC questionnaire, resulting in a final sample size of 525.

The study received ethical approval from the Goldsmiths, University of London, Department of Psychology Ethics Committee. Data collection occurred between November 2017 and May 2018.

Measures

Demographics and product use status

Participants reported their age, gender, ethnicity, and employment status. For the purposes of the present study, e-cigarette use was assessed with the following question: “Do you currently use any of the following products (select all that apply).” (cigarettes, e-cigarettes, cigars, hookah, smokeless tobacco, other tobacco product ‘even 1 puff’, none of these).”

We first conducted analyses using all participants split in to two groups, defined as follows: those choosing e-cigarettes, including those who used any other product on the above list, were designated as ‘e-cigarette users’, while those choosing any other response apart from e-cigarettes were designated as ‘non e-cigarette users’. We then conducted two other sets of similar analyses with a subset of the total number of participants. One set including those participants who use e-cigarettes only and none of the other products (exclusive e-cigarette users), and those who replied ‘none of these’ (non users), and another set including exclusive e-cigarette users, and exclusive cigarette smokers. All sets of analyses showed similar results, so we present here only the first set of analyses referred to above as conducted using all participants.

Attitudes towards e-cigarettes

The 10-item CEAC questionnaire (Hershberger, Karyadi et al. 2017) was used to assess attitudes towards e-cigarettes compared to cigarettes. It measures three factors, general benefits (5 items), health benefits (2 items), and general effects (3 items), using a 5-point likert scale (1=strongly disagree to 5 strongly agree). Less than 0.01% of CEAC data was missing, and it appeared to be missing at random. Missing data were imputed using multiple imputation. The CEAC has been shown to be positively related to e-cigarette use and has demonstrated good psychometric properties, albeit it only appears to have been used in two published studies thus far (Hershberger, Karyadi et al., 2017; Hershberger, Connors et al., 2017).

Impulsivity

Impulsivity was measured using the 59-item UPPS-P Impulsive Behavior Scale (Cyders et al., 2007; Whiteside & Lynam, 2001). The alpha reliabilities in the present sample were: lack of premeditation=0.88, lack of perseverance=0.84, sensation seeking=0.85, negative urgency=0.90, positive urgency=0.96, which are similar to past published studies. Correlations between the UPPS-P subscales showed modest correlations between the subscales, range 0.02 to 0.75 with the highest correlation between negative urgency and positive urgency. Less than 0.01% of UPPS-P data was missing, and it appeared to be missing at random. Missing data were imputed using multiple imputation.

Analytic procedure

General descriptive analyses were performed to describe the whole sample and the two groups of participants; e-cigarette users and non e-cigarette users.

Group differences were identified by performing Chi-square tests or independent sample t-tests as appropriate.

Confirmatory factor analysis was performed to examine the structure of the CEAC questionnaire. Additionally, we assessed between-group e-cigarette use invariance for this questionnaire by testing configural, metric (constraining loadings to be equal across groups), and scalar (constraining loadings and intercepts to be equal across groups) invariance (Widaman & Reise, 1997).

Finally, a structural path analysis was conducted to replicate the model identified by Hershberger, Connors et al. (2017). In order to replicate this model, each item from the UPPS-P was left free to load on its respective *a priori* facet only. Two higher order impulsive personality latent variables were then further defined: urgency, with loadings from positive and negative urgency, and deficits in conscientiousness, with loadings from lack of premeditation and lack of perseverance. The sensation-seeking latent factor was simply defined by its constituent items from the UPPS-P. Similarly, the ten items from the CEAC were left free to load on their respective *a priori* factor only. These three factors, general benefits, health benefits, and general effects, then loaded on a higher order e-cigarette attitudes latent factor. E-cigarette use was modelled as a measured dichotomous variable (e-cigarette use or no e-cigarette use). We included pathways from each of the three higher order latent impulsivity variables to 2) the latent variable of e-cigarette attitudes based on the three scales of CEAC questionnaire to 3) the measured variable of e-cigarette use (See Figure 4.1).

We used maximum likelihood estimation of the covariance matrix to ascertain statistical fit and we report the following fit indices for each analysis (Bentler, 1990; Hu & Bentler, 1999): model χ^2, the comparative fit index (CFI), the Tucker-Lewis

index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Rules of thumb for CFI and TLI values suggest that values between 0.90 and 0.95 indicate acceptable fit, and values above 0.95 indicate good fit (Hu & Bentler, 1999). RMSEA values of <0.05 are taken as good fit, 0.05-0.08 as moderate fit, 0.08-0.10 as marginal fit, and >0.10 as poor fit (Hu & Bentler, 1999), and SRMR values of less than 0.08 indicate acceptable fit, while a value of zero indicates perfect fit (Hu & Bentler, 1999). However, it has been argued that the cut off values of these indices are arbitrary and lower values do not necessarily indicate that the data did not fit the model well. In particular, it has been suggested that inconsistencies in the results of the RMSEA and CFI indices can occur because these two indices are designed to evaluate fit of the model from different perspectives (Lai & Green, 2016).

Confirmatory factor analyses and path analysis were conducted using the lavaan package in R3.0.1 (Rosseel, 2012), the remaining analyses were conducted using IBM SPSS version 23.

Results

Preliminary analysis and participant characteristics

Overall the mean age of participants was 33.42 (SD=11.27), ranging from 18 years to 68 years, the majority were female (59.45%), of white ethnicity (92.2%), and in full-time employment (61.6%). The participants comprised of 244 (46.5%) e-cigarette users and 281 (53.5%) non e-cigarette users. Table 4.1 provides descriptive statistics by e-cigarette use status.

Table 4.1. Descriptive statistics, and mean and standard deviations for the UPPS-P Impulsive Behaviour Scale by e-cigarette use status

Variable	Non e-cigarette users n= 281		E-cigarette users n= 244			
	Mean	**SD**	**Mean**	**SD**	**t(df)**	***p*-value**
Age	31.33	10.87	35.83	11.26	-4.65 (523)	<0.001
UPPS-P						
Negative Urgency	2.48	0.62	2.47	0.60	0.23 (523)	0.815
Positive Urgency	2.05	0.70	2.19	0.60	-2.50 (523)	0.013
Lack of Premeditation	2.03	0.48	2.00	0.45	0.88 (523)	0.378
Lack of Perseverance	2.14	0.50	2.05	0.50	2.07 (523)	0.039
Sensation Seeking	2.52	0.59	2.56	0.61	-0.66 (523)	0.510
	No	**%**	**No**	**%**	**Chi^2(df)**	***p*-value**
Gender						
Male	95	33.8	118	48.6	11.75 (1)	0.001
Female	186	66.2	125	51.4		
Ethnicity						
White	258	91.8	224	92.6	0.100 (1)	0.751
Other	23	8.2	18	7.4		
Occupation						
Student	116	41.3	22	9.1	69.77 (2)	<0.001
Employed	138	49.1	185	76.1		
Unemployed	27	9.6	36	14.8		

n=number of participants, SD=standard deviation, df=degrees of freedom

Average scores on the UPPS-P scales ranged from 1 to 4, where 4 indicates higher trait expression. E-cigarette users differed significantly only on positive urgency and lack of perseverance than non e-cigarette users, with e-cigarette users scoring higher on positive urgency (t(523)=-2.50, p=0.013), but lower on lack of perseverance, than non users (t(523)=2.07, p=0.039). There was no difference between the two groups in sensation seeking (t(523)=-0.66, p=0.51), lack of premeditation (t(523)=0.88, p=0.378), and negative urgency (t(523)=0.23, p=0.815).

Confirmatory Factor analysis and measurement invariance for the CEAC

Confirmatory factor analysis (Table 4.2) of the *a priori* structure for the CEAC questionnaire on the whole sample showed an adequate fit for the model:

χ^2(df=32)=172.85, CFI=0.94, TLI=0.91, RMSEA=0.09 (0.08-0.11, 90% Confidence Interval), SRMR= 0.06.

Table 4.2. Factor loadings for confirmatory factor analyses of CEAC questionnaire

Thematic Facets	1. General benefits	2. Health benefits	3.General effects
1. General benefits			
1.Electronic cigarettes can be used to quit or cut down on smoking traditional cigarettes	0.81	0[a]	0
2. Electronic cigarettes are less expensive than traditional cigarettes	0.59	0	0
3. Electronic cigarettes are more convenient or easier to use than traditional cigarettes	0.41	0	0
4. Electronic cigarettes are more enjoyable to use than traditional cigarettes	0.45	0	0
5. Electronic cigarettes are more socially acceptable to use than smoking traditional cigarettes	0.40	0	0
2. Health benefits			
6. Electronic cigarettes are less harmful to the user's health than traditional cigarettes	0	0.88	0
7. Electronic cigarettes are less harmful to the health of those in close proximity to the user than traditional cigarettes	0	0.87	0
3. General effects			
8. Compared to traditional cigarettes, electronic cigarettes can improve health	0	0	0.64
9. Using electronic cigarettes, compared to traditional cigarettes, can improve my general sense of smell	0	0	0.91
10. Using electronic cigarettes, compared to traditional cigarettes, can improve my sense of taste	0	0	0.90
Factor Correlations			
1. General benefits	-		
2. Health benefits	0.79*	-	
3. General effects	0.65*	0.60*	-

*p<0.001, [a] Confirmatory Factor Analysis: each item is restricted to load only on its corresponding scale, while its loadings to the other scales are constrained to be 0.

All items had robust factor loadings on their respective factor, and the three factors correlated positively and strongly with each other (range r=0.60 to r=0.79). The alpha reliabilities of the three factors of the CEAC questionnaire in the present sample were: general benefits=0.70, general effects=0.86 and health benefits=0.85 (The alpha reliabilities in Hershberger, Karyadi et al. (2017) study were: general benefits=0.80, general effects=0.86, and health benefits= 0.88).

Table 4.3 shows the results of the analyses for testing measurement invariance across e-cigarette users and non e-cigarette users. Fit indices for the configural (1) model were: χ^2(df=64)=192.04, RMSE= 0.09(0.07-0.10, 90% Confidence Interval), SRMR=0.06, CFI=0.926, while for the metric (2) model were: χ^2(df=71)=213.59, RMSE=0.09 (0.07-0.10, 90% Confidence Interval), SRMR=0.08, CFI=0.918. These results shows that for the configural (1) and metric (2) models, CFI, and SRMR values indicated moderately good model fit, while RMSEA values indicated marginal model fit. The difference in CFI values between the full metric invariance model (2) and configural model (1) was less than 0.01, suggesting that invariance can be assumed based on recommendations by Cheung and Rensvold (2002). They suggest that the ΔCFI is a robust statistic for testing the between-group invariance of CFA models, and invariance can be assumed when this value is 0.01or less.

The fit indices for the model (3) assessing scalar invariance were: χ^2(df=78)=266.79, RMSEA= 0.10(0.08-0.11, 90% Confidence Interval), SRMR=0.08, CFI=0.892. Such values indicate that the model (3) assessing scalar invariance met the SRMR criteria for acceptable fit, the RMSEA criteria for marginal fit, while the CFI value indicated a less than ideal model fit. CFI difference of model (3) and model (2) indicates that full scalar invariance cannot be assumed. Modification indices were then used to identify which item intercepts were non-invariant. Results showed that item 8 (Compared to traditional cigarettes, electronic cigarettes can improve health), had an intercept that was non-invariant across groups. We then identified a model (3a), where partial invariance was allowed by freeing the intercept of item 8. Results indicated a better fitting model (χ^2(df=77)=237.55, RMSEA= 0.09(0.08-0.10, 90% Confidence Interval), SRMR=0.08, CFI=0.909), where the CFI difference between

model (3a) and model (2) was 0.009. We then assumed partial scalar invariance and the latent mean differences were estimated. After allowing for partial invariance, e-cigarette users scored higher on all three factors compared to non e-cigarette users (p<0.001).

Table 4.3. Measurement invariance by e-cigarette use

Model	**χ^2**	**df**	**CFI**	**RMSEA (90%CI)**	**SRMR**	**ΔCFI**	**$\Delta\chi^2$**	**Δdf**	**$\Delta\chi^2 p$**
1. Configural	192.04	64	0.926	0.09(0.07-0.10)	0.06				
2. Metric	213.59	71	0.918	0.09(0.07-0.10)	0.08	0.008	21.55	7	0.001
3.Scalar	266.79	78	0.892	0.10(0.08-0.11)	0.08	0.026	53.20	7	<0.001
3a. Scalar with partial invariance (item 8)	237.55	77	0.909	0.09(0.08-0.10)	0.08	0.009	23.96	6	<0.001

df=degrees of freedom; CFI=comparative fit index; RMSEA=root mean square error of approximation; CI=confidence interval; Δ = difference.

The average scores of each CEAC subscale were then calculated for e-cigarette users and non e-cigarette users (Table 4.4). These scores ranged from 1 to 5, where 5 indicates more favourable attitudes towards e-cigarettes. Comparison of e-cigarette users with non e-cigarette users in CEAC subscales showed that e-cigarette users scored significantly higher in all CEAC subscales than non e-cigarette users (general benefits: $t(523)=-13.47$, $p<0.001$; health benefits: $t(523)=-10.03$, $p=<0.001$; general effects: $t(523)=-11.32$, $p<0.001$).

Table4.4. Mean and standard deviations for the Comparing E-cigarettes and Cigarette questionnaire (CEAC) by e-cigarette use status

Subscale	Non e-cigarette users n= 281		E-cigarette users n= 244			
	Mean	**SD**	**Mean**	**SD**	**t(df)**	***p*-value**
General benefits	3.16	0.62	3.89	0.61	-13.47 (523)	<0.001
Health benefits	3.37	0.98	4.16	0.78	-10.03 (523)	<0.001
General effects	2.83	0.93	3.70	0.81	-11.32 (523)	<0.001

n=number of participants, SD=standard deviation, df=degrees of freedom

Structural Path analysis

Fit indices for the model (Figure 4.1) examining the relationship between impulsive personality traits, e-cigarette attitudes and e-cigarette use were as follows: χ^2(df=2325)=5516.97, RMSEA=0.051 (0.049-0.053, 90% Confidence Interval), SRMR=0.075, CFI=0.84, TLI=0.83. These results shows that the model met the RMSEA criteria for good fit, and also met the SRMR criteria for an adequate fit, but CFI and TLI values indicated a less than ideal model fit. However, as mentioned earlier in the methods, the latter values do not necessarily indicate that the data did not fit the model well, as it has been suggested that inconsistencies in the results of the RMSEA and CFI indices can occur because these two indices are designed to evaluate fit of the model from different perspectives. Additionally, as mentioned earlier, the cut off values for these indices are arbitrary, and the meaning of 'good fit' and its relationship with fit indices are not well understood in the current literature (Lai & Green, 2016).

Urgency was significantly and positively related to e-cigarette attitudes (β=0.19, p=0.018). Deficits in conscientiousness were significantly and negatively related to e-cigarette attitudes (β=-0.20, p=0.01). Sensation seeking did not show any significant relationship to e-cigarette attitudes (β=0.06, p=0.27). E-cigarette attitudes scores were significantly higher for e-cigarette users than non-users (β=0.59, p<0.001). There were no significant direct paths from impulsivity traits to e-cigarette use (urgency: β=0.08, p=0.18; deficits in conscientiousness: β=-0.05, p=0.41; sensation seeking: β=-0.06, p=0.17).

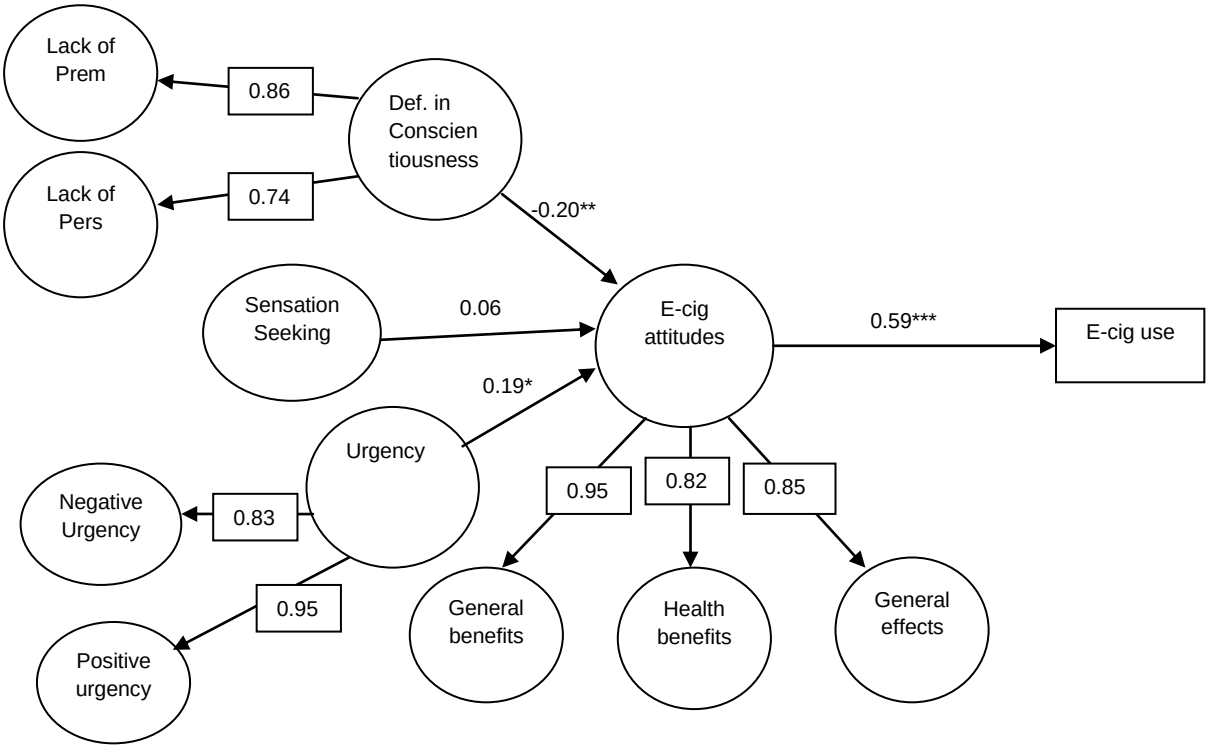

Figure 4.1. Structural path analysis examining the relationship between impulsive personality traits, e-cigarette attitudes and e-cigarette use, χ^2 (df=2325) =5516.97, CFI=0.84, TLI=0.83, RMSE=0.051 (0.049-0.053, 90% Confidence Interval), SRMR=0.075
*p<0.05, **p<0.01, ***p<0.001
There were no significant direct paths from impulsivity traits to e-cigarette use.

Discussion

Results of the present study confirmed the factor structure of the CEAC questionnaire and showed full configural and metric measurement invariance, and partial scalar measurement invariance across e-cigarette use groups. Additional analysis identified one item (8. Compared to traditional cigarettes, e-cigarettes can improve health) that is potentially affected by product status use. E-cigarette users had higher latent means for this questionnaire item than non e-cigarette users.

The present study also examined a model based on the TPB to investigate the relationship between impulsivity-related traits, as described by the UPPS-P, attitudes towards e-cigarettes and e-cigarette use. Our findings are comparable to the Hershberger, Connors et al. (2017) study and suggest that higher levels of

conscientiousness, as measured by two facets from the UPPS-P (lack of premeditation and lack of perseverance), are related to more positive attitudes towards e-cigarettes, and subsequent e-cigarette use. Urgency, which is a tendency to engage in risky and disinhibited behaviour when in a heightened emotional state, was positively related to e-cigarette attitudes and subsequently to e-cigarette use, while no significant relationship was found between sensation seeking and e-cigarette use. Moreover, the results of the present study showed that there was no significant direct effect of impulsivity-related traits on e-cigarette use.

The fit of the structural model tested, as judged by standard fit indices, was not as good as the one described by Hershberger, Connors et al. (2017). The discrepancies found could be the result of the model definition. The present study used the individual item scores to compute the five latent variables of UPPS-P scale and subsequently the higher order variables of impulsivity-related traits, and the three latent factors of e-cigarette attitudes. Hershberger, Connors et al. used the mean score across all items of each sub-scale to construct their latent variables. It has been suggested that the optimal way of computing latent variables is to use individual item level indicators, rather than parcels or aggregates of items (Marsh, Ludtke, Nagengast, Morin, & VonDavierrtf, 2013), so the present study is likely to give a better indication of model fit.

The data presented here suggest that the CEAC questionnaire could be used as a valid and reliable questionnaire to measure attitudes towards e-cigarettes across different populations. One advantage of CEAC is that it does not only assess health and general benefits of e-cigarettes compared to cigarettes, but it also measures factors that are not widely investigated by research such as cost effectiveness, enjoyment, and social enhancement of e-cigarettes. These beliefs

could potentially help to understand better why individual might be more prone to use e-cigarettes compared to cigarettes, or why some smokers switch from cigarettes to e-cigarettes. It was also found that e-cigarette users scored significantly higher than non users in all CEAC scales, though both groups had average mean scores for each of the subscales above the scale midpoint (>2.5). Such findings suggest that participants regardless of their product use statuses hold very positive attitudes towards e-cigarettes compared to cigarettes, and confirm empirical data that found e-cigarette use to be associated with less harmful health consequences than cigarette smoking (Farsalinos & Polosa, 2014; Harrell, Simmons, Correa, Padhya & Brandon, 2014).

The results of the present study support previous work that reported an association between e-cigarette use and trait impulsivity, similar with other addictive substances. A significant indirect path from urgency to e-cigarette use via attitudes towards e-cigarettes was found, providing preliminary evidence that urgency is related to the development of positive e-cigarette use expectancies, which subsequently may contribute to elevated risk of e-cigarette use. Negative and positive urgency have been previously linked to positive substance use expectancies, and subsequently to problematic substance use (Settles, Cyders & Smith, 2010). Theoretically, urgency combines two facets of behaviour considered to be more prominent in those at greater risk for substance use disorders: the inability to control one's actions and the inability to regulate one's emotions (Tarter et al., 2003). It is suggested that high-urgency individuals are particularly vulnerable to engaging in risky behaviours, especially under conditions of high emotional intensity (Dinc & Cooper, 2015; Cyders & Smith, 2008). One possible explanation for such behaviour is that individuals high in positive urgency have increased expectations

that substance use has positive, arousing effects, and these expectations lead to actual substance use. Additionally, negative urgency leads individuals to hold increased motives to use addictive substances to cope with subjective distress (Settles, Cyders, & Smith, 2010).

Our findings also suggest that higher levels of conscientiousness, as measured by two facets from the UPPS-P (lack of premeditation and lack of perseverance), are related to more favourable attitudes towards e-cigarettes compared to cigarettes. Conscientiousness involves strong will, determination, responsibility and the observance of rules, and has been linked to healthier lifestyles; regarding cigarette smoking, high conscientious individuals tend to be non-smokers (Terracciano & Costa, 2004). Available evidence does seem to indicate that e-cigarettes are likely less harmful than traditional cigarettes (Public Health England, 2015). Thus, it might be the case that people high in conscientiousness hold more favourable attitudes towards e-cigarettes compared to cigarettes based on such evidence.

The pattern of differential links between UPPS-P factors and e-cigarette use found in the present study is similar to the Hershberger, Connors et al. study. Such findings might suggest that trait impulsivity affect e-cigarette attitudes via two distinct pathways; cigarette smokers higher in conscientiousness engage with e-cigarette use because of the perceived health benefits of e-cigarette use compared to cigarette smoking, whereas those higher in urgency engage with e-cigarettes because of positive expectancies of e-cigarette use.

Limitations

There are some limitations to the current study which mean that the conclusions above need to be treated with some caution. The data were self-reported and relied on participants' ability and willingness to report accurately about their behaviour. However previous studies have shown that self-reported smoking was validated strongly by biological markers (Wong, Shields, Leatherdale, Malaison, & Hammond, 2012). Additionally, the cross-sectional nature of this study does not allow one to draw causal interpretations with confidence. Though we hypothesized that the direction of the mediational pathway runs from impulsivity-related personality traits to e-cigarette attitudes to e-cigarette use, it could be the case that e-cigarette use may influence the attitudes towards e-cigarettes. Another limitation when modelling the mediation of the association between trait impulsivity and e-cigarette use by attitudes is that trait impulsivity is not clearly associated with e-cigaretre use, based on the results presented in Chapter 3. However, the present study sought to test the specific model outlined in Hershberger, Connors et al. (2017).

Conclusions and future directions

Findings of the present study support our hypotheses as they showed that e-cigarette users hold more positive attitudes towards e-cigarettes, while they exhibit higher levels of positive urgency. It was also found that positive attitudes towards e-cigarettes mediate the relationship between impulsivity-related traits and e-cigarette use. Additionally, the present study showed that the CEAC questionnaire could be considered a valid and reliable questionnaire to measure attitudes towards e-cigarettes use across different populations. It also suggests that impulsivity-related traits as measured by the UPPS-P scale, and attitudes towards e-cigarettes, as

measured through the CEAC questionnaire, are likely important risk factors for e-cigarette use. Future prospective and experimental studies should test if the causal model described in this study predicts risk for e-cigarette use, and whether this model could therefore be used to guide strategies for reducing risk for e-cigarette use among those who are non-smokers, and especially young adults and adolescents, as recent surveys have shown that e-cigarette experimentation and use has risen the last few years in this group of people (Wang, King, Corey, Arrazola, Johnson, 2014; Bauld et al., 2017). It has also been suggested that e-cigarettes have become the most popular tobacco product, which has suppressed use of traditional cigarettes among young people who have never smoked (Jamal et al., 2017). Consideration should also be given to the prevention strategies which might prove effective, such as focusing on changing overly positive views of e-cigarettes by communicating the risks associated with e-cigarette use both to non smokers and smokers. Reducing cigarette consumption, but sustained dual use of cigarettes and e-cigarettes may still confer substantial disease risk and could increase one's risk for cardiovascular disease and lung cancer. E-cigarettes might function best as a valuable harm reduction tool for addicted smokers, if this results in complete smoking cessation.

Chapter 5

Real time cravings and mood assessments of cigarette smokers, e-cigarette users and dual users and their relationship with trait impulsivity

Overview

The study outlined in this chapter uses the Ecological Momentary Assessment (EMA) method to examine the relationship between cravings, positive and negative moods and trait impulsivity in cigarette smokers, e-cigarette users and dual users. It also evaluates the impact of e-cigarette use in real-time cravings and explores the role of trait impulsivity in e-cigarette use and cravings. Results suggest that cigarette smokers, e-cigarette users and dual users exhibited higher levels of real-time cravings during mornings, while e-cigarette use for e-cigarette users and dual users was significantly higher in evenings. It also showed that dual users differed in their cravings and in their negative moods from e-cigarette users, while no significant difference was detected between cigarette smokers and e-cigarette users, and between cigarette smokers and dual users. In support of previous research, the present study also suggests a significant positive interaction between negative mood and smoking status. Regarding trait impulsivity as measured by the UPPS-P scale and its association with cravings and moods results suggest that only urgency was a significant predictor of real-time cravings and real-time moods.

Introduction

Cravings and negative mood have long been associated with day-to-day cigarette smoking as two of the primary motivational forces behind the maintenance of the behaviour, as well as significant barriers to smokers' attempts to quit (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Hughes, Higgins, & Hatsukami, 1990; Shiffman et al., 1997). This chapter will focus on the relationship between cravings, positive and negative moods and trait impulsivity in cigarette smokers, e-cigarette users and dual users.

Cigarette Cravings

Cigarette cravings can be defined as a subjective, unwanted desire or urge to smoke a cigarette, while attempting to abstain. Classical conditioning models suggest that cigarette cravings are triggered by specific situations that have been previously associated with cigarette smoking and may be reinstated years after abstinence (Robinson & Berridge, 1993). Tiffany and Conklin (2000) have additionally suggested that cravings involve a variety of cognitive processes, including memory of past cigarette smoking and the anticipation of the consequences of subsequent use. Cravings can be divided into tonic or abstinence-induced, which are the cravings that smokers experience irrespective of situational cues, and phasic or cue-provoked, which are cravings that occur quickly in response to situational cues, both of which have been associated with smoking relapse (Ferguson & Shiffman, 2009).

Cravings tend to onset typically between the first 60 and 180 minutes of abstinence just like other withdrawal symptoms (Brown et al., 2013; Hendricks, Ditre, Drobes & Brandon, 2006). It has been also suggested that cigarette cravings tend to

decrease in strength and frequency with a longer abstinence period, however a small number of ex-smokers still report strong urges to smoke after six months of quitting (Ussher, Beard, Abikoye, Hajek & West, 2013). Additionally, research has shown that cravings are one of the most frequent predictors of relapse in ex-smokers (Killen & Fortmann, 1997), and consequently their reduction is a primary objective of smoking cessation interventions.

Cigarette Cravings and trait impulsivity

Cigarette cravings are experienced differently by every smoker; specifically it has been suggested that impulsive individuals may experience greater urges to smoke during periods of abstinence (e.g. Doran, Cook, McChargue & Spring, 2009). For example, a study utilising a composite measure of impulsivity, the BIS-11 (Patton et al. 1995), and a single item to measure cigarette cravings that was averaged over 48h of nicotine deprivation, reported a positive relationship between trait impulsivity and cravings (VanderVeen, Cohen, Cukrowicz & Trotter, 2008), while a similar study found that the BIS-11 was not associated with cravings (Doran, Spring, McChargue, Pergadia & Richmond, 2004). Additionally, a survey study of college students suggested that urgency was positively correlated with cigarette cravings, while lack of premeditation, lack of perseverance, and sensation seeking were not (Billieux, Van der Linden & Ceschi, 2007). On the other hand, a study by Doran, Cook, McChargue & Spring (2009) examining the effect of different aspects of the UPPS model of impulsivity on cigarette cravings following exposure to a smoking cue suggested that sensation seeking was positively associated with a greater appetitive craving response to a smoking cue, while negative urgency and lack of perseverance were positively associated with a greater negative affect craving

response. Lack of premeditation did not show any significant relationship with any craving response to cue exposure, whereas positive urgency was not measured. It is clear from the studies discussed above that the relationship between impulsivity and cigarette cravings is not very clear, as not all studies document a significant relationship. However, it has been suggested that the discrepancies found between studies may be due to inconsistencies in the measurement of both trait impulsivity and cigarette cravings. Some studies conceptualized impulsivity and cravings as unidimensional constructs, while others as multidimensional, or studies did not assess craving in response to a smoking cue.

Cigarette cravings and e-cigarette use

There is increasing evidence from randomized controlled trials and observational studies that e-cigarettes significantly reduce cigarette cravings and withdrawal symptoms, and that dealing with cravings is one of the most significant reasons why former cigarette smokers use e-cigarettes (Etter and Bullen, 2011). Additionally, laboratory research suggests that short-term exposure to e-cigarettes may reduce withdrawal symptoms and cravings both during temporary abstinence in non-quitting smokers, as well as during 24hr or more abstinence in smokers planning to quit permanently, at least in the minutes after e-cigarette use and in some smokers (Malas et al., 2016; Perkins, Karelitz & Michael, 2017). Experimental studies have also shown that e-cigarettes containing nicotine had a stronger effect on urges to smoke than e-cigarettes without nicotine (Dawkins, Turner, Hasna & Soar, 2012), and that being told that an e-cigarette contains nicotine (even though it actually contains no nicotine) alleviates craving for tobacco (Copp et al., 2014). A study conducted by Farsalinos et al. (2014) also suggested that new e-cigarette

models with refillable tanks were more effective at relieving craving for tobacco than older models (“cig-alike”); however, another study found no difference (Dawkins, Kimber, Puwanesarasa & Soar, 2015). Research has also shown that e-cigarettes that visually resemble a tobacco cigarette were associated with lower tobacco craving and withdrawal symptoms in e-cigarette naive abstinent smokers. Though, similar effects were not observed in those with previous e-cigarette experience, suggesting that the effect may be short lived (Dawkins, Munafò, Christoforou, Olumegbon & Soar, 2016).

Smokers who reported stronger effects of e-cigarettes on tobacco cravings also reported using the e-cigarette more intensively (more puffs, more e-liquid), higher satisfaction levels of e-cigarette use, stronger perceived effects of e-cigarette use on tobacco smoking and on withdrawal symptoms, and they were the most likely to use e-cigarettes as a smoking cessation tool (Etter, 2015).

Mood and cigarette smoking

As discussed in Chapter 1, there is a strong association between mood and smoking behaviour. Most of the available research focuses on the relationship between negative mood and cigarette smoking and suggests that individuals consistently endorse smoking in response to self-reported negative affect and stress, and that high levels of negative affect often precede smoking lapses and relapse among smokers attempting to quit (Kassel et al. 2003). In addition to self-reported expectations regarding the effects of cigarette smoking, several experimental studies have shown a causal relationship between induced negative mood and smoking behaviour (e.g., Heckman et al., 2013; Kotlyar et al., 2011). Exposing deprived smokers to nicotine has been shown to reduce negative affect (Gentry, Hammersley,

Hale, Nuwer, & Meliska, 2000), while smokers subjected to negative mood inductions consistently showed shorter latencies to cigarette smoking (Weinberger & McKee, 2012), increased number of cigarette puffs (Heckman et al., 2016; Perkins, Giedgowd, Karelitz, Conklin, & Lerman, 2012), and increased cravings (Perkins, Karelitz, Giedgowd, & Conklin, 2013). Some studies of non-deprived smokers have shown that smoking reduces negative mood (Perkins & Grobe, 1992; Warburton & Mancuso, 1998), while others have shown no effects (Conklin & Perkins, 2005; Herbert, Foulds, & Fife-Schaw, 2001). For example, a laboratory study by Conklin and Perkins (2005) examining the potential reinforcing effects of smoking while in a negative mood, showed that smoking did not reduce negative mood. However, their results suggested that greater levels of negative mood shortened latency to smoke and increased smoking behaviour. Additionally, relief from negative mood due to smoking was shown to depend on the situation rather than nicotine intake, as it was found that smoking modestly improves negative mood due to other sources of stress, such as preparing for a public presentation, engaging in a challenging computer task, and watching negative affect slides (Perkins, Karelitz, Conklin, Sayette, & Giedgowd, 2010). Experimental studies have also showed that nicotine administration mildly increased pleasurable emotions among non-deprived and deprived smokers in several studies (Malpass & Higgs, 2007; Spring et al., 2008), but did not impact positive mood in another (Parrott & Gamham, 1998).

Various theoretical models of addiction also suggest that mood regulation is an important determinant of smoking behaviour. For example, the self-medication hypothesis (Khantzian, 1997) posits that smokers learn that smoking cigarettes may alleviate or change non pleasurable affective states, provide a feeling of relief, and a perception of emotional control, thus making cigarette smoking a negatively

reinforcement over time. Additionally, social-cognitive models highlight the importance of outcome expectancies on smoking behaviours. Outcome expectancy theory suggests that individuals engage in behaviours based on their expectations of the behaviour's reinforcing effects (Bandura, 1977) and that such expectancies are important in understanding the motivational antecedents of substance use (Abrams & Niaura, 1987). Indeed, positive cigarette outcome expectancies (e.g., stress reduction, weight control) are associated with nicotine dependence and smoking motivation (Copeland, Brandon, & Quinn, 1995), and current smokers with stronger positive expectancies from smoking report higher levels of nicotine dependence and cigarette consumption (Brandon & Baker, 1991).

In sum, the relationship between mood and smoking is complex, may be reciprocal, and may involve both bio-behavioural factors and individual differences (Carmody, Vieten & Astin, 2007; Kassel, Stroud & Paronis, 2003).

Ecological Momentary Assessments

Research discussed so far has evaluated the relationship between cigarette cravings and e-cigarette use, mood, and smoking behaviour based on survey and laboratory studies. Such research methods have been criticized for the validity of their results. For example, self-report studies ask individuals to recall mood and behaviours over time, and to aggregate or summarize such information (Shiffman, Stone & Hufford, 2008). Many of our daily experiences are not preserved in memory, so we do not necessarily have the information that we are being asked to remember (Shiffman, Stone, & Hufford, 2008). It is also common that people are more likely to retrieve and summarize their most recent experiences (recency effects) or evaluate emotionally prominent experiences more heavily (saliency effects), which may bias

and affect the validity of the results of self-report measures (Shiffman, Stone, & Hufford, 2008). Similarly, experimental studies have been criticized for poor external validity, that is, whether or not their results can be generalized to a larger population or across a variety of settings (Calder, Phillips, & Tybout, 1982). It has been also argued that it is very difficult in the laboratory to simulate the actual conditions of the environment or behaviour under investigation. Thus, laboratory research findings cannot be generalized to different population, settings, and times (Shiffman & Stone, 1998; Winer, 1999).

Ecological momentary assessment (EMA) methods, which involve repeated assessments of states and behaviours, in real time (or nearly real-time), in participants' real world environments, are able to overcome many of the limitations of survey and experimental studies. In EMA studies data is collected in real-time and within participant's natural environments, thus minimizing recall bias, maximizing ecological validity and considers all the factors that influence behaviour in real world contexts (Shiffman, Stone, & Hufford, 2008). EMA studies are frequently implemented via smartphone technology nowadays, and there are three documented types of data collection: signal-contingent, where participants have to complete a questionnaire when they receive a notification; interval-contingent, where participants complete a questionnaire in a fixed period of time; and event-contingent, where participants complete a short questionnaire when a specific event occurs.

EMA studies allow researchers to study phenomena more thoroughly than in traditional studies, as EMA gathers longitudinal data through repeated observations for each individual. Thus, these methods allow researchers to study both between-person and within-person variability of a behaviour (i.e., variability from occasion to

occasion within a person) and to study a behaviour both within and across days (Shiffman, Stone & Hufford, 2008).

The use of EMA research designs is growing in behavioural research, as this methodology is well-suited to study cigarette smoking, e-cigarette use, emotion regulation, cravings and withdrawal symptoms as a function of a wide range of environmental determinants. Repeated within-day assessments capture the rapid fluctuations of these variables (Shiyko & Ram, 2011) and inform researchers about prospective and potentially causal relationships.

EMA studies on mood and cigarette cravings

Several naturalistic studies have used EMA to investigate the relationship between negative and positive mood and smoking. These studies, in contrast with conventional self-report data, which clearly shows an association between negative mood and smoking, have yielded mixed results depending on the phase of smoking behaviour (maintenance phase or quit attempt). For example, Todd (2004) found that perceived stress among community residing smokers was a significant trigger to smoking urges and actual smoking behaviour in a two-week period EMA study. Similarly, Carter et al.'s (2008) naturalistic 10-day study in a sample of non-treatment seeking smokers showed that cigarette craving and negative mood ratings were lowest immediately after smoking compared with immediately before smoking and at random times-of day. On the other hand, Shiffman, Patty, Gwaltney and Dang (2004) found that craving to smoke was the strongest predictor of subsequent smoking in a study of non-treatment seeking smokers, while a weak association was reported between mood and smoking. Similarly, another study suggested that smoking increased with higher craving, but level of negative mood was unrelated to the

initiation of smoking. However, participants in this study reported a significant decrease in negative mood immediately after smoking, suggesting that smokers may not smoke in response to increased levels of negative mood, but may be motivated to smoke in order to reduce baseline levels of negative mood (Shiffman et al., 2002). In another study comparing light, non-addicted smokers to heavy smokers, it was found that smoking was predicted by negative affect only in the light, not addicted group of smokers (Shiffman & Paty, 2006). Moreover, available EMA research suggests no significant relationship between positive mood and cigarette smoking (Shiffman et al., 2002; Shiffman, Patty, Gwaltney & Dang, 2004).

To our knowledge, a limited number of EMA studies have examined the relationship between cigarette cravings and e-cigarette use (Carpenter et al., 2017; Jorenby, Smith, Fiore & Baker, 2017), while there is no study examining mood and e-cigarette use. Results from these studies suggest that e-cigarette use is positively associated with reductions in cigarette cravings (Carpenter et al., 2017; Jorenby, Smith, Fiore & Baker, 2017).

Given some of the inconsistent results in EMA studies in negative mood and cigarette smoking, the lack of EMA research on positive affect and cigarette smoking, the mood-smoking relationship needs to be further examined in future EMA studies including e-cigarette users.

Present study

The present study will use EMA method to assess real-world e-cigarette use and/or cigarette smoking in cigarette smokers, e-cigarette users and dual users. It will also evaluate the impact of e-cigarette use on real-time cravings and explore the role of trait impulsivity in e-cigarette use and cravings. In particular, the aims of the

present study are: (a) to measure and compare real-time cravings and moods of cigarette smokers, e-cigarette users, and dual users, (b) to assess real world e-cigarette use in e-cigarette users and dual users, (c) to assess real world cigarette smoking in cigarette smokers and dual users, (d) to examine the relationship between trait impulsivity and real-time cravings, and (e) to examine the relationship between trait impulsivity and real-time negative and positive mood.

It is predicted that cravings and negative mood will be higher in cigarette smokers compared to dual users and e-cigarette users. On the other hand, the available literature does not allow us to make any prediction with confidence for the relationship between positive mood and smoking status. We also hypothesize that cigarette smokers will smoke more cigarettes than dual users, and e-cigarette users will use their e-cigarette more frequently than dual users. Finally, we hypothesize that some of the impulsivity-related traits, as measured by the UPPS-P scale, will be associated with higher levels of cravings, though the available literature does not allow us to predict which with any confidence, while the impulsivity-related traits of negative and positive urgency will be associated with real-time negative and positive moods as measured by the app questionnaire.

Knowledge of features (cravings, moods) associated with real-time e-cigarette use would contribute to a better understanding of e-cigarette use. Additionally, if e-cigarettes can suppress cigarette cravings, they may be a significant tool for smoking cessation interventions, and they can potentially produce public health benefits. Furthermore, an understanding of how impulsivity is related to real-time e-cigarette use and cravings would potentially suggest strategies for intervening in cigarette smoking.

Methods

Participants

One hundred and three participants with an age range of 18-62 (M=32.13, SD=10.62) were recruited from Prolific, and were paid £5 in return for one hour participation.

The present study consisted of two parts. First, participants had to complete a baseline questionnaire, which included questions about themselves, e-cigarette use and cigarette smoking. The baseline questionnaire was completed online through the Qualtrics survey tool (www.qualtrics.com). Then, they had to download an app to their smartphone, and complete a short questionnaire (approximately one minute) three times per day for seven consecutive days. The app questionnaire was designed and administered through Instant Survey app (https://instantsurveyapp.com; Richardson, 2015a; Richardson, 2015b), which is a free Android and iOS app suitable for collecting intensive longitudinal data. Participants were also asked to enable notifications in their smartphone in order to get the study notifications properly.

The study was conducted between March 2018 and June 2018. All participants provided written consent, and the study received approval from Goldsmiths University of London, Psychology Department Ethics Committee. Eligibility criteria for study participation included: being a minimum of 18 years old; being able to read and write English; being a cigarette smoker and/ or an e-cigarette user; owning a smartphone and being willing to download the study's app to the smartphone. Participants who completed the baseline questionnaire, but did not download the app were not included in the study.

Procedure

Once informed consent was obtained by interested individuals, participants were directed to a URL, which provided them with instructions on how to download the study app (Instant Survey) via iTunes AppStore (Richardson, 2015a) or Google Play (Richardson, 2015b). Participants had to find and enrol in the study with ID: 8MF3PK and titled 'Real time cravings and emotions of e-cigarette users, cigarette smokers and dual users'. The app was downloaded prior to commencement of the baseline questionnaire as the app generated a random alphanumeric code that allowed the researcher to link baseline Qualtrics data (Part 1) to app-based, experience sampling data (Part 2). Part 2 of the study commenced the morning after downloading the app, and all participants completed the baseline assessments (Part 1) prior to generating app data.

Part 2 consisted of three audible alerts on participants' phone per day at fixed scheduling intervals between 10 am and 10 pm, which divide the day in three epochs, roughly corresponding to morning, afternoon, and evening, for seven consecutive days. The first notification was sent between 10.00 and 11.00, the second notification between 15.00 and 16.00 and the last one between 20.00 and 21.00. During the last time, participants had also to complete the end of day survey, a brief assessment of their overall mood during the day, the amount of smoking (and/or e-cigarette use) during the day and their predictions of smoking/e-cigarette use for the following day. Upon completion of the study, participants were offered the opportunity to receive a personalized report on their smoking habits and/or e-cigarette use and emotions.

The instant survey app did not have the feature to send reminders to participants who had not completed the app questionnaire, thus participants'

compliance to prompts was monitored very closely. For this purpose, participants were sent a reminder email every day to complete the app questionnaire when they would receive a notification. Moreover, there were five participants who failed to complete the app questionnaire for either one or two whole days. These five participants agreed to prolong their study participation for either one or two extra days in order to have data for seven days.

Debrief information was given to each participant at the end of the baseline questionnaire, along with relevant websites to get more information about stopping smoking, and they were given the opportunity to email the researcher with any questions about the study.

Baseline questionnaire

Demographic measures

Participants reported their age, gender, ethnicity, country of residence and employment status, similar to Chapter 3.

General smoking/e-cigarette use behaviour

Respondents' general smoking/e-cigarette behaviour was assessed with the same four items reported in Chapter 3. Participants were defined as smokers if they replied that they currently smoke cigarettes and haven't used an e-cigarette in the last month, or as e-cigarette users, if they currently use only e-cigarettes and haven't smoked a cigarette in the last month, and as dual users if they replied that they currently both smoke cigarettes and use an e-cigarette (in the last 1-4 weeks).

Current tobacco use, cessation history and intention to quit (cigarette smokers and dual users only)

Nicotine dependence of cigarette smokers and dual users was measured with The Fagerstrom test for Nicotine dependence (FTND; Heatherton, Kozlowski & Frecker, 1991), a widely used six-item questionnaire, which demonstrated acceptable internal consistency in this study, α=0.72. Participants were also asked the age they started smoking, and we also assessed if they have quit smoking for longer than a month in the past. Motivation, determination and confidence to quit were assessed with the same items reported in Chapter 3.

Smoking cravings were assessed through the 10-item brief version of the Questionnaire of Smoking Urges (QSU-Brief; Cox, Tiffany & Christen, 2001). The Cronbach's alpha reliabilities in the present sample were: positive desire for reward subscale =0.90 and need to smoke for relief subscale =0.89.

Current e-cigarette use and reasons for use (e-cigarette users and dual users only)

Current e-cigarette use for e-cigarette users and dual users only was assessed with questions regarding participants' number of days on the last month of e-cigarette use, average number of vapes per day, average millilitres (mls) of e-liquid used per day and type of cartridge used. Reasons for e-cigarette use were assessed with the same items reported in Chapter 3.

Impulsivity

The UPPS-P Impulsive Behaviour Scale was used to measure the five facets of impulsivity. The Cronbach's alpha reliabilities in the present sample were: lack of premeditation=0.80, lack of perseverance=0.83, sensation seeking=0.90, negative

urgency=0.89, positive urgency=0.94. Correlations between the UPPS-P subscales showed modest correlations between the subscales, range 0.72 to 0.03 with the highest correlation between negative urgency and positive urgency, suggesting that the subscales index distinct components of impulsivity.

App questionnaire

The app questionnaire included questions about participants' cigarette smoking/e-cigarette use, their cravings and their negative and positive mood.

Participants were asked the following questions about cigarette smoking: "Have you smoked any cigarettes since the last time you logged in the app?" If participants replied yes, then they were additionally asked: "How many cigarettes have you smoked since the last time you logged in the app?"

For e-cigarette use participants were asked: "Have you used your e-cigarette since the last time you logged in the app?" If participants replied yes then they were additionally asked: "How many times have you used your e-cigarette since the last time you logged in the app?"

Craving self-report was assessed through five questions derived from the QSU-Brief questionnaire (Cox, Tiffany & Christen, 2001), and were used in previous EMA studies (Carter et al., 2008; Shiffman et al., 1997). Two items were obtained from the positive desire for reward subscale ("I have a desire for cigarette/e-cigarette", "I have an urge for a cigarette/e-cigarette") and three items from the need to smoke for relief subscale ("I could control things better right now if I could smoke/use the e-cigarette", "I would do almost anything for a cigarette/to use the e-cigarette", and "Smoking/Vaping would make me less depressed"). All assessments used a 7-point scale with anchor points of "Strongly Disagree" (1), to "Strongly

Agree" (7). The Cronbach's alpha reliabilities for each of the two craving dimension for each assessment time ranged from 0.73 to 0.95.

Mood was assessed with seven questions based on the 12-point circumplex structure of core affect (Yik, Russell & Steiger, 2011), and were used in similar EMA studies (Carter et al., 2008). In particular, negative mood was assessed as a mean score of four questions, "How anxious/tense do you feel?", "How upset/distressed do you feel?", "How sad/depressed do you feel?", "How bored do you feel?". Positive mood was assessed as a mean score of three questions, "How happy do you feel?", "How relaxed do you feel?", "How enthusiastic do you feel?". All assessments used a 5-point scale with anchor points of "Not at all" (1), to "Extremely" (5). When the negative and positive mood scales were evaluated for reliability using Cronbach's alpha, for each time point, the alphas ranged from 0.91 to 0.93 for negative mood, and 0.88 to 0.90 for positive mood. Additionally, a correlational analysis was conducted with negative and positive mood scores. Mean negative mood scores measured at three different time points during the day (morning, afternoon, evening), were highly correlated with each other (r=0.94 for morning and afternoon negative mood scores; r=0.88 for morning and evening negative mood scores, and r=0.94 for afternoon and evening negative mood scores). Likewise, positive mood scores were also highly correlated with each other (r=0.86 for morning and afternoon positive mood scores, and morning and evening positive mood scores; r=0.89 for afternoon and evening positive mood scores). However, positive and negative mood scores at the same time point were only modestly negatively correlated (range r=−0.56 to r=−0.57). This suggests that positive and negative self-report moods are not simply mirror images of each other, and should be considered different scales (Watson, Clark, & Tellegen, 1988).

Participants were also asked at the end of the questionnaire if it was after 8.00pm. If they answered no, then the questionnaire was ended. If they answered yes, then they were subsequently presented with the end of day questionnaire. The end of the day questionnaire included questions about the overall number of cigarettes participants smoked during the day, and/or the overall times they used an e-cigarette and the millilitres of e-liquid they used during the day. Moreover, we assessed participants' overall mood of the day by asking them to indicate to what extent they felt each of the emotions described earlier during the day. Finally, we asked participants to estimate how many cigarettes they anticipated they would smoke the next day, how many times they anticipated using their e-cigarette the next day and how many millilitres they anticipated consuming the next day.

Results

Data screening

The data files of the app questionnaire were first converted from Microsoft Excel to SPSS. Data were analysed using IBM SPSS version 23.

Group differences in all baseline measures apart from impulsivity-related traits were identified by performing Pearson's chi-square tests (categorical variables) or analysis of variance (ANOVA) tests (continuous variables assuming equal variance across groups) as appropriate. Regarding impulsivity-related traits, e-cigarette users were contrasted with the other two groups (cigarette smokers and dual users), and cigarette smokers were contrasted with dual users.

Overview of participants' characteristics (baseline questionnaire)

Sociodemographic characteristics of this sample are presented in Table 5.1. Of the 103 participants, 59 were females (57.3%), 91 were of White ethnicity (88.3%), and 71 were in full-time employment (68.9%), while 35 (34%) were classified as cigarette smokers, 35 (34%) as e-cigarette users and 33 (32%) as dual users. Comparison of the three groups in their demographic characteristics showed no significant difference between them.

Table 5.1. Sociodemographic characteristics per group

Variable	Smokers n= 35(34%)		E-cig users n= 35(34%)		Dual users n= 33(32%)			
Demographic Variables								
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**F-Statistic (dfs)**	***p* value**
Age	33.69	11.35	30.37	10.43	32.33	10.05	0.859 (2,100)	0.427
	No	**%**	**No**	**%**	**No**	**%**	**Chi^2 statistic (df)**	***p* value**
Gender								
Male	14	40.0	15	42.9	15	45.5		
Female	21	60.0	20	57.1	18	54.5	0.207 (2)	0.902
Ethnicity								
White	33	94.3	29	82.9	29	87.9		
Other	2	5.7	6	17.1	4	12.1	2.231 (2)	0.328
Occupation								
Student	5	14.3	9	25.7	4	12.1		
Employed	24	68.6	22	62.9	25	75.8		
Unemployed	6	17.1	4	11.4	4	12.1	3.013 (4)	0.556

Smoking-related characteristics of the cigarette smokers group and dual users group are summarized in Table 5.2. Most participants of both groups started smoking over the age of 16 years and they were daily cigarette smokers. The two groups did not differ in their levels of nicotine dependence as measured by FTND score, and could be characterized as low nicotine dependent groups as the mean FTND scores for cigarette smokers was 3.23 (SD=2.29) and for dual users 3.88 (SD=2.72). The two groups did not differ in their motivation, determination and confidence in quitting cigarette smoking. Most of the participants of both groups were in the contemplation stage of motivation to quit, meaning that they were thinking to quit in the next six months, but they have not set a quit date. Regarding cigarette

cravings the groups did not differ significantly in any of the two cigarette craving scales and their scores indicate medium levels of cravings. The two groups differed significantly only in their past quit attempts, as more cigarette smokers had quit smoking for longer than a month in the past compared to dual users ($\chi^2(1)=7.944$, $p=0.005$).

Table 5.2. Current tobacco use, cessation history, intention to quit and cravings

Variable	Smokers (n= 35)		Dual users (n=33)			
	No	**%**	**No**	**%**	**Chi^2 statistic (df)**	***p*-value**
Age started smoking						
<14	1	2.9	1	3.0		
14-16	15	42.9	11	33.3		
>16	19	54.3	21	63.6	0.657 (2)	0.720
Quit for longer than a month						
no	12	35.3	23	69.7		
yes	22	64.7	10	30.3	7.944 (1)	**0.005**
Motivation to quit (TTM)						
Pre-contemplation	12	34.3	10	30.3		
Contemplation	22	62.9	21	63.6		
Preparation	1	2.9	2	6.1	0.480 (2)	0.787
	Mean	**SD**	**Mean**	**SD**	**F-Statistic (dfs)**	***p*-value**
Nicotine dependence index (FTND)	3.23	2.29	3.88	2.72	1.140	0.290
Number of cigarettes	9.60	6.63	9.03	7.62	0.108 (1,67)	0.743
Mean score 'How much do you want to quit' (scale1-5)	3.56	1.13	3.33	1.14	0.661 (1,65)	0.419
Mean score 'How determined are you to quit for good' (scale1-5)	3.26	1.22	3.36	1.27	0.124 (1,67)	0.726
Mean score 'How confident are you to quit for good' (scale1-5)	3.14	1.40	3.21	1.29	0.045 (1,67)	0.833
Cravings for cigarette						
Positive desire to smoke for reward	4.55	1.26	4.64	1.35	0.078 (1,67)	0.781
Need to smoke for relief	3.35	1.28	4.02	1.62	3.677 (1,67)	0.059

E-cigarette use characteristics of e-cigarette users and dual users are summarized in Table 5.3. Regarding e-cigarette usage, most e-cigarette users reported using their e-cigarette every day (71.4%), while dual users reported using it some days (22.7%), $\chi^2(2)=13.88$, $p=0.001$. The two groups differed significantly in the number of times of vaping per day, but they did not differ in the millilitres of e-liquid they used per day, and the type of cartridge they used.

The most important reason for e-cigarette use for both groups was 'the perception that it is less harmful than cigarettes' (64.7% of e-cigarette users, 76.7%

of dual users), while indoors use of e-cigarette was the second most cited reason (60.0% of e-cigarette users, 62.5% of dual users).

Table 5.3. E-cigarette use behaviour and reasons for e-cigarette use

Variable	E-cig users (n=35)		Dual users (n=33)			
	No	**%**	**No**	**%**	**Chi² statistic (df)**	***p-value***
Reason for e-cigarette use						
Less harmful	22	64.7	23	76.7	1.092 (1)	0.296
Used indoors	21	60	20	62.5	0.044 (1)	0.834
Cheaper	13	37.1	9	29	0.487 (1)	0.485
Novelty	2	5.7	3	9.7	0.369 (1)	0.544
Smoking cessation	19	54.3	15	46.9	2.42 (1)	0.324
Flavour availability	15	42.9	9	30.0	1.147 (1)	0.284
other	3	8.6	0	0	2.784 (1)	0.095
Number of reasons endorsed per participant						
1	7	20	9	28.1		
2	6	17.1	10	31.3		
3	12	34.3	7	21.9		
4	6	17.1	3	9.4		
5	4	11.4	2	6.3		
6	0	0	1	3.1	5.108 (5)	0.403
E-cigarette use						
Days of vape/month						
10-19 days	6	17.1	18	54.5		
20-29 days	4	11.4	6	18.2		
All 30 days	25	71.4	9	27.3	13.883 (2)	**0.001**
Cartridge						
Nicotine free	7	20	9	27.3		
Nicotine containing	25	71.4	16	48.5		
both	3	8.6	8	24.2	4.443 (2)	0.108
	Mean	**SD**	**Mean**	**SD**	**F-Statistic (dfs)**	***p-value***
Times of vape/ day	17.29	18.86	9.39	9.59	4.644 (1,67)	**0.035**
Mls e-liquid/ day	5.94	6.21	8.39	11.44	1.212 (1,64)	0.275

Table 5.4 summarizes the scores of three groups on impulsivity-related traits. Comparison of the three groups on trait impulsivity showed that dual users scored significantly higher on positive urgency than cigarette smokers (t(100)=-2.61, p=0.01) and e-cigarette users (t(100)=-3.64, p<0.001). No other significant difference was found.

Table 5.4. Impulsivity-related characteristics and attitudes towards e-cigarettes by smoking status

Variable	1. Smokers n= 35		2. E-cig users n= 35		3. Dual users n= 33		Contrasts		
	Mean	SD	Mean	SD	Mean	SD	1 vs 2	1 vs 3	2 vs 3
Impulsivity									
Lack of Premeditation	1.86	0.37	1.96	0.33	1.93	0.39	-1.14	-0.78	0.33
Lack of Perseverance	1.91	0.42	2.07	0.40	2.05	0.53	-1.40	-1.22	0.16
Sensation Seeking	2.60	0.69	2.69	0.70	2.82	0.59	-0.51	-1.36	-0.85
Negative Urgency	2.46	0.63	2.43	0.50	2.65	0.54	0.24	-1.37	-1.61
Positive Urgency	2.05	0.66	1.90	0.58	2.44	0.60	1.04	**-2.61****	**-3.64*****

**p≤0.01, ***p≤0.001, 1 versus 2: contrast between smokers and e-cigarette users, 1 vs 3: contrast between smokers and dual users, 2 vs 3: contrast between e-cigarette users and dual users

EMA data

Over the course of seven days, participants responded to 2122 prompts and completed all app questionnaire items, resulting in 98.10% compliance rate.

Inspection of app data suggested a similar pattern of number of cigarettes smoked, times of e-cigarette use, cravings and moods across the seven days as shown in the graphical representations presented in figures 5.1-5.16. Thus, the app data was aggregated over the seven days for each time point. We additionally aggregated participants' scores across weekends and week days, and the analyses showed similar results. Therefore, we present only results from aggregated data across the three time points in this Chapter.

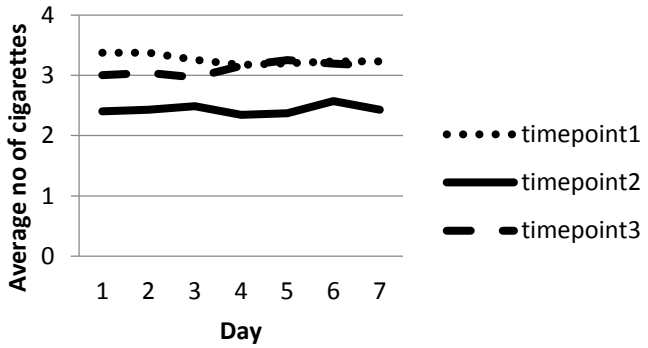

Figure 5.1. Average number of cigarette per day across the 3 time points for cigarette smokers

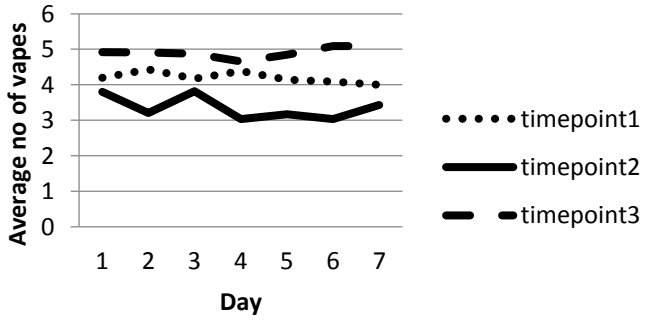

Figure 5.2. Average number of vapes per day across the 3 time points for e-cigarette users

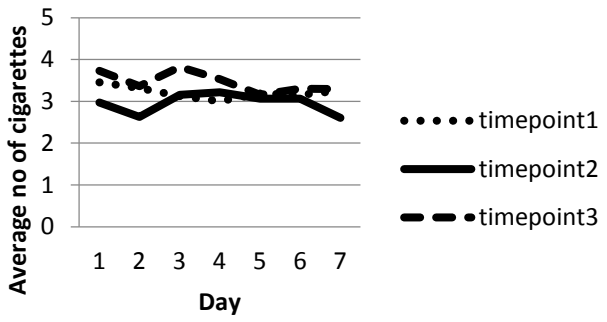

Figure 5.3. Average number of cigarettes per day across the 3 timepoints for dual users

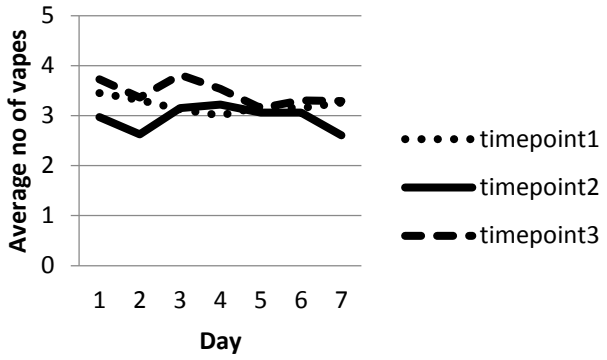

Figure 5.4. Average number of vapes per day across the 3 timepoints for dual users

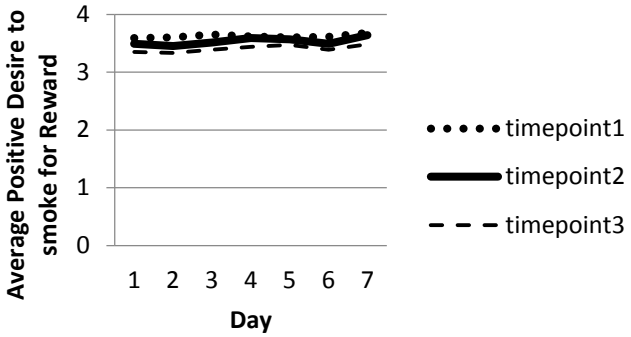

Figure 5.5. Average score on positive desire to smoke for reward subscale of cravings for cigarette per day for each time point for cigarette smokers

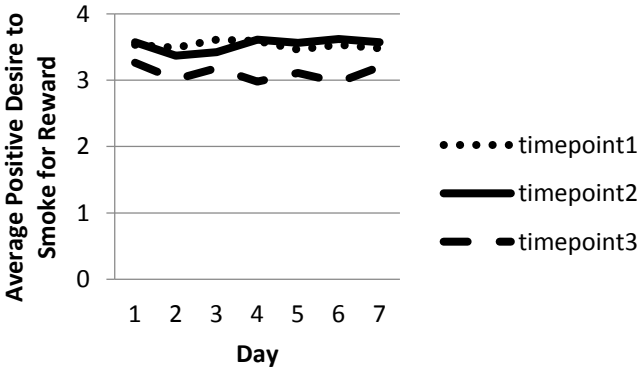

Figure 5.6. Average score on positive desire to smoke for reward subscale of cravings for e-cigarette per day for each time point for e-cigarette users

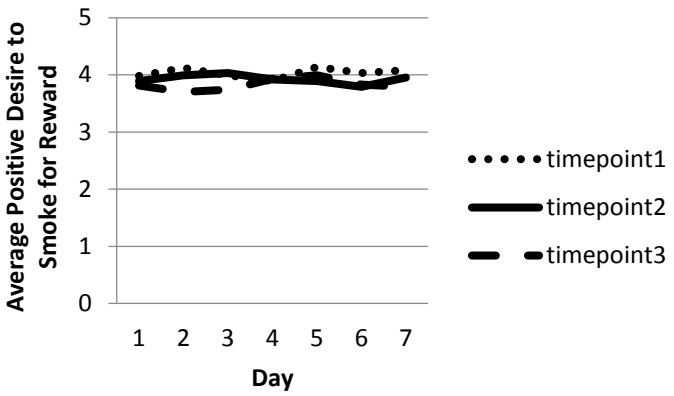

Figure 5.7. Average score on positive desire to smoke for reward subscale of cravings of cigarette/e-cigarette per day for each time point for dual users

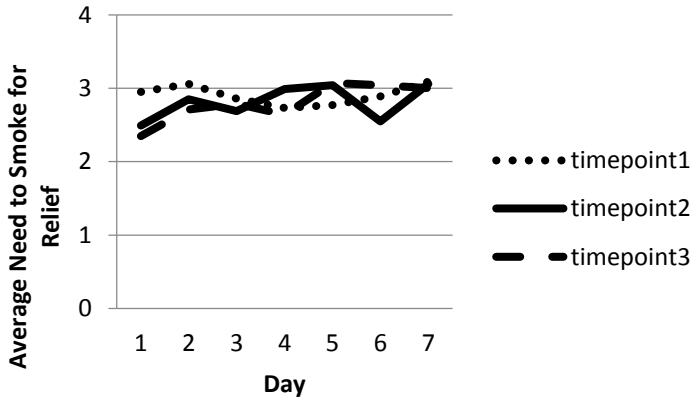

Figure 5.8. Average score on need to smoke for relief subscale of cravings for cigarette per day for each time point for cigarette smokers

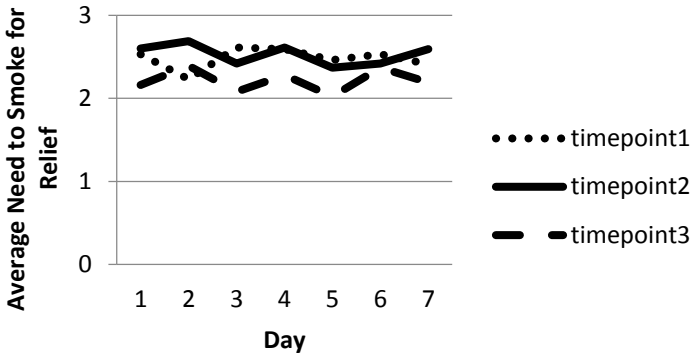

Figure 5.9. Average score on need to smoke for relief subscale of cravings for e-cigarette per day for each time point for e-cigarette users

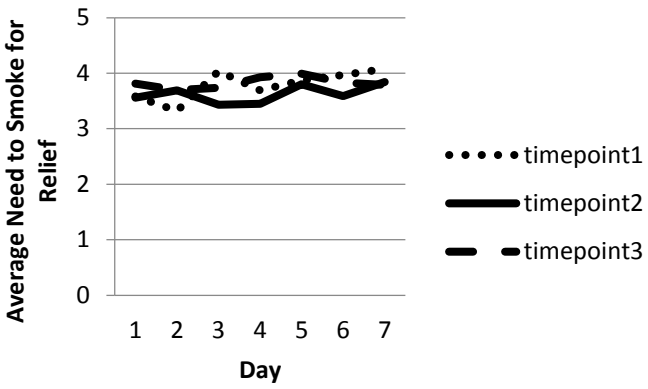

Figure 5.10. Average score on need to smoke for relief subscale of cravings for cigarette/e-cigarette per day for each time point for dual users

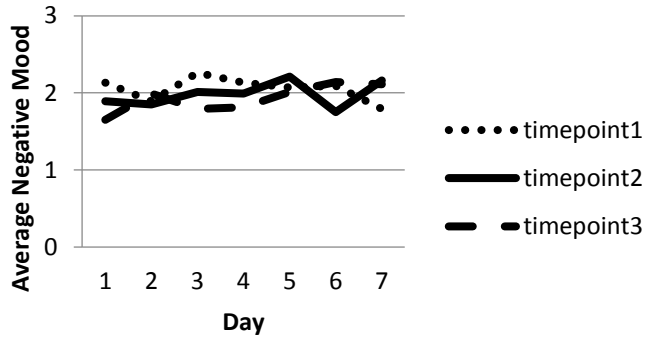

Figure 5.11. Average score of negative mood per day for each time point for cigarette smokers

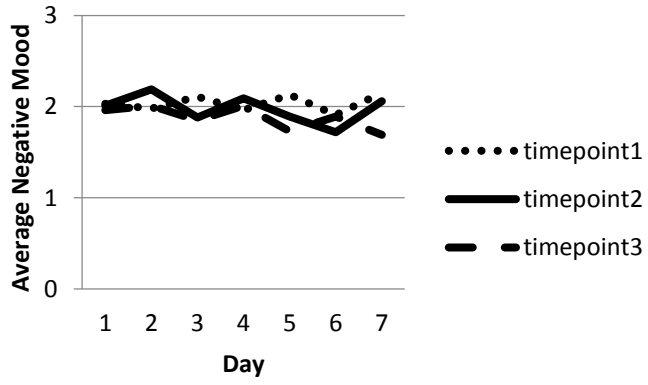

Figure 5.12. Average score of negative mood per day for each time point for e-cigarette users

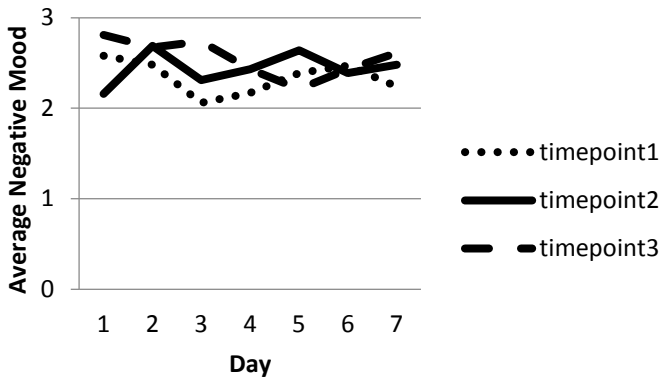

Figure 5.13. Average score of negative mood per day for each time point for dual users

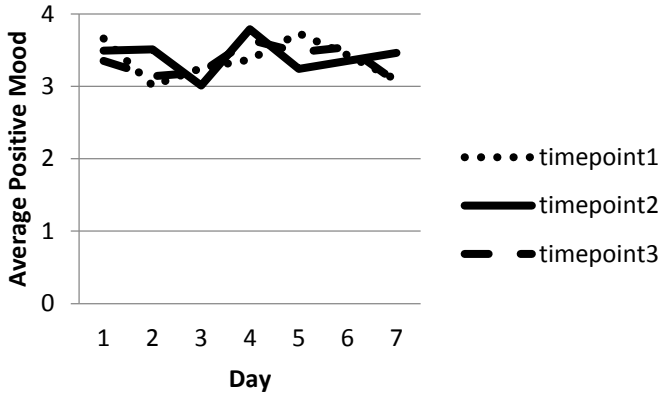

Figure 5.14. Average score of positive mood per day for each time point for cigarette smokers

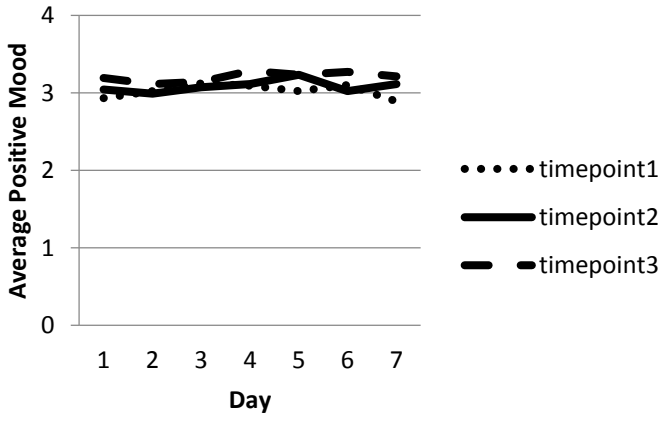

Figure 5.15. Average score of positive mood per day for each time point for e-cigarette users

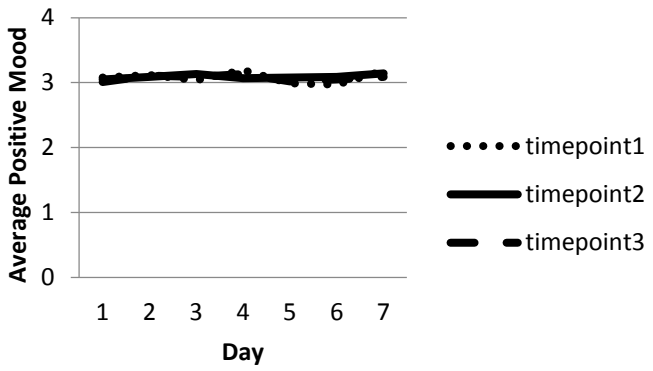

Figure 5.16. Average score of positive mood per day for each time point for dual users

Correlation analysis

Correlation analyses were conducted to identify the relation between the two subscales of cravings and positive and negative mood. Bivariate correlations were interpreted in accordance with Cohen's (1988) guidelines for small (r=0.10), medium (r=0.30), and large (r=0.50) correlations. We conducted 66 correlations, thus the Bonferroni-adjusted critical alpha for these analyses was 0.0007.

Bivariate correlations between cravings and positive and negative moods at each of the three time points of the aggregated measures of the app questionnaire were analysed for the whole sample (Table 5.5), as well as for each group separately (Table 5.6, 5.7, 5.8). The analysis for all the participants revealed significant positive correlations between the two subscales of cravings and negative mood at each of the three time points. There were also significant negative correlations between the two subscales of cravings and positive mood at each of the three time points.

Table 5.5. Correlations between cravings for cigarette/e-cigarette and mood across the 3 different time points (app data/ aggregated measures) all participants

Measure	1	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Cr1_1		.65***	0.26**	-0.27**	0.81***	0.59***	0.27*	-0.14	0.76***	0.56***	0.22*	-0.15
2. Cr2_1			0.38***	-0.26**	0.53***	0.93***	0.41***	-0.23*	0.63***	0.91***	0.42***	-0.27**
3. Neg1				-0.61***	0.24*	0.40***	0.92***	-0.50***	0.34***	0.45***	0.87***	-0.54***
4. Pos1					-0.28**	-0.25*	-0.55***	0.87***	-0.33**	-0.25**	-0.49***	0.84***
5. Cr1_2						0.61***	0.28**	-0.26**	0.71***	0.47***	0.20*	-0.20*
6. Cr2_2							0.44***	-0.24**	0.60***	0.89***	0.44***	-0.51**
7. Neg2								-0.54***	0.35***	0.47**	0.91***	-0.50***
8. Pos2									-0.24*	-0.21*	-0.45***	0.84***
9. Cr1_3										0.73***	0.38***	-0.37***
10. Cr2_3											0.53***	-0.34***
11. Neg3												-0.53***
12. Pos3												

Cr1_1= Positive desire to smoke for reward, time point1; Cr2_1= Need to smoke for relief, time point1; Neg1= Negative affect, time point1; Pos1= Positive affect, time point1; Cr1_2= Positive desire to smoke for reward, time point2; Cr2_2= Need to smoke for relief, time point2; Neg2= Negative affect, time point2; Pos2= Positive affect, time point2; Cr1_3= Positive desire to smoke for reward, time point3; Cr2_3= Need to smoke for relief, time point3; Neg3= Negative affect, time point3; Pos3= Positive affect, time point3

*p≤0.05, **p≤0.01, ***p≤0.001, uncorrected for multiple comparisons

Shaded cells indicate which correlations survived the correction.

The analysis for cigarette smokers only showed significant positive correlations of medium magnitude between the two subscales of cravings and negative mood only during evenings. There were also significant negative correlations of medium magnitude between the two subscales of cravings and positive mood during the evenings.

The analysis for e-cigarette users only showed a significant positive correlation between the ‘positive desire to smoke for reward’ subscale of cravings and negative mood during afternoons and evening, r=0.46 and r=0.54 respectively. No significant correlations were found between the ‘need to smoke for relief’ subscale and negative mood in any time point. Similarly, no significant correlations were observed between the two subscales of cravings and positive mood.

Bivariate correlation analysis for dual users only revealed a significant positive correlation between the ‘need to smoke for relief’ subscale and negative mood during evenings (r=0.45). No significant correlations were observed between the ‘positive desire to smoke for reward’ subscale and negative mood in any time point.

There was not also any significant correlation between the two subscales of cravings and positive mood.

Table 5.6. Correlations between cravings for cigarette and mood across the 3 different time points (app data/ aggregated measures) cigarette smokers

Measure	1	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Cr1_1		0.61***	0.28	-0.27	0.82***	0.62***	0.23	-0.22	0.76***	0.55**	0.15	-0.27
2. Cr2_1			0.38*	-0.40*	0.50**	0.96***	0.34*	-0.39*	0.60***	0.92***	0.33	-0.49**
3. Neg1				-0.76***	0.19	0.38*	0.95***	-0.72***	0.39*	0.44**	0.90***	-0.76***
4. Pos1					-0.28	-0.40*	-0.76***	0.92***	-0.44**	-0.39*	-0.71***	0.91***
5. Cr1_2						0.60***	0.18	-0.32	0.70***	0.46**	0.09	-0.32
6. Cr2_2							0.35*	-0.43*	0.57***	0.90***	0.342*	-0.51**
7. Neg2								-0.77***	0.40*	0.44**	0.94***	-0.77***
8. Pos2									-0.39*	-0.40*	-0.71***	0.92***
9. Cr1_3										0.73***	0.34**	-0.49**
10. Cr2_3											0.45**	-0.54**
11. Neg3												-0.77***
12. Pos3												

Table 5.7. Correlations between cravings for e-cigarette and mood across the 3 different time points (app data/ aggregated measures) e-cigarette users

Measure	1	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Cr1_1		0.56***	0.09	-0.25	0.85***	0.37*	0.18	-0.13	0.73***	0.33*	0.05	0.01
2. Cr2_1			0.37*	-0.14	0.56**	0.87***	0.45**	-0.11	0.46**	0.83***	0.37*	0.01
3. Neg1				-0.60***	-0.02	0.31	0.86***	-0.50**	0.02	0.39*	0.86***	-0.49**
4. Pos1					-0.15	-0.02	-0.47**	0.87***	-0.08	-0.02	-0.45**	0.81***
5. Cr1_2						0.53**	0.17	-0.19	0.60***	0.28	-0.06	0.07
6. Cr2_2							0.46**	-0.04	0.33	0.80***	0.35*	0.08
7. Neg2								-0.55**	0.10	0.46**	0.85***	-0.34*
8. Pos2									0.00	0.04	-0.42*	0.73***
9. Cr1_3										0.55**	0.15	-0.15
10. Cr2_3											0.54**	-0.05
11. Neg3												-0.48**
12. Pos3												

Table 5.8. Correlations between cravings for cigarette/e-cigarette and mood across the 3 different time points (app data/ aggregated measures) dual users

Measure	1	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Cr1_1		0.81***	0.33	-0.33	0.72***	0.77***	0.28	0.03	0.80***	0.80***	0.30	-0.07
2. Cr2_1			0.27	-0.31	0.55**	0.91***	0.26	-0.14	0.69***	0.90***	0.26	-0.11
3. Neg1				-0.46**	0.48**	0.37*	0.92***	-0.15	0.45**	0.43*	0.87***	-0.19
4. Pos1					-0.50**	-0.36*	-0.43*	0.72***	-0.58***	-0.42*	-0.38*	0.75***
5. Cr1_2						0.69***	0.43*	-0.23	0.84***	0.64***	0.43*	-0.33
6. Cr2_2							0.34	-0.19	0.76***	0.92***	0.33	-0.11
7. Neg2								-0.22	0.38*	0.38*	0.93***	-0.23
8. Pos2									-0.33	-0.19	-0.19	0.82***
9. Cr1_3										0.86***	0.45**	-0.41*
10. Cr2_3											0.42*	-0.20
11. Neg3												-0.28
12. Pos3												

*p≤0.05, **p≤0.01, ***p≤0.001, uncorrected for multiple comparisons
Shaded cells indicate which correlations survived the correction.

Comparison of average product use, cravings for cigarette/e-cigarette and moods in three time points between and within groups

To compare groups in their average product use, cravings and moods over the three time points, mixed methods ANOVAs were conducted. Mauchly's test of sphericity showed $p<0.05$ in each case, suggesting that sphericity was violated. For this reason, the F-values reported with a Greenhouse-Geisser correction (Field, 2013). Inspection of Levene's test indicated that variances were homogeneous for all levels of the repeated measures variables as all significance *p* values were greater than 0.05 in each case. The Bonferroni-adjusted critical alpha for these analyses was 0.008, as we conducted 6 mixed methods ANOVAs (Dependent variables: average number vapes, average number of cigarettes, positive desire to smoke for reward, need to smoke for relief, negative mood, positive mood; Table 5.9).

Product use

Mixed methods ANOVA with a Greenhouse-Geisser correction showed that there was a significant main effect of time of day on average e-cigarette use ($F(1.63, 107.31)=7.79$, $p=0.002$). Post hoc tests using Bonferroni correction revealed that e-cigarette use (vapes) during afternoons was significantly less than evenings ($p<0.001$; M=3.20, SE=0.63 versus M=4.45, SE=0.83). The main effect of smoking status showed that the effect was not significant ($F(1,66)=0.489$, $p=0.487$) suggesting that there was not any significant difference in the number of average e-cigarette use at each of the three time points between e-cigarette users and dual users (M=4.15, SE=0.96, M=3.19, SE=0.99 respectively). Additionally, it was found there was no significant interaction between time of day and smoking status on average number of e-cigarette uses ($F(1.63, 107.31)=1.93$, $p=0.158$; figure 5.17).

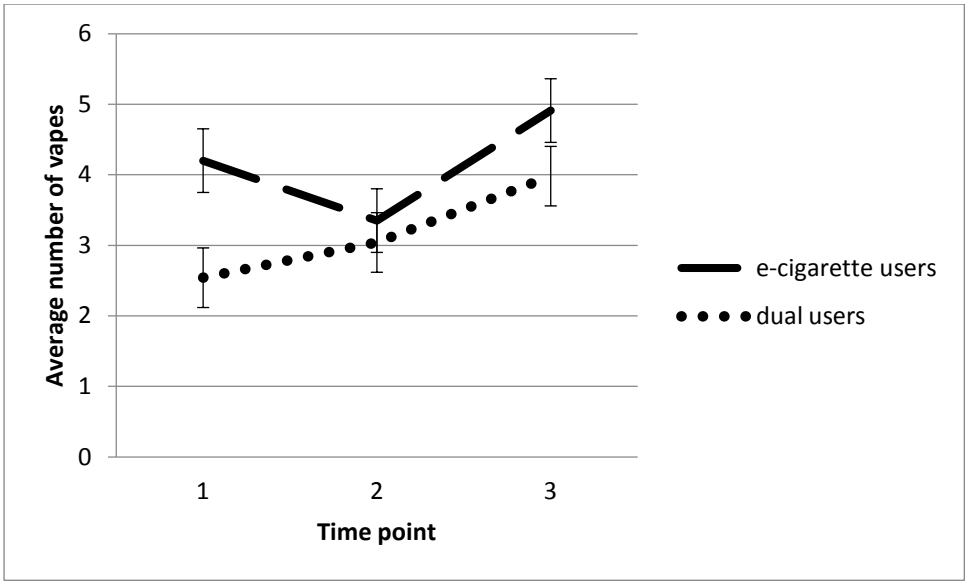

Figure 5.17. Comparison of average number of vapes reported at each time point

Similar analysis showed that there was not a significant difference in the average number of cigarettes smoked across the three time points when judged against the adjusted critical alpha value (0.008; F[1.76, 115.82]=4.79, *p*=0.013) ; M=3.24, SE=0.29, timepoint1; M=2.70, SE=0.25, timepoint2; M=3.29, SE=0.32). The main effect of smoking status showed that the effect was not significant (F(1,66)=0.285, *p*=0.595), suggesting that there was not any significant difference in the average number of cigarettes smoked across the three time points between cigarette smokers and dual users (M=2.93, SE=0.36, M=3.21, SE=0.38 respectively). The analysis also showed that there was not a significant interaction between time of day and smoking status on average number of cigarette smoked (F(1.76, 115.82)=0.98, *p*=0.37; figure 5.18).

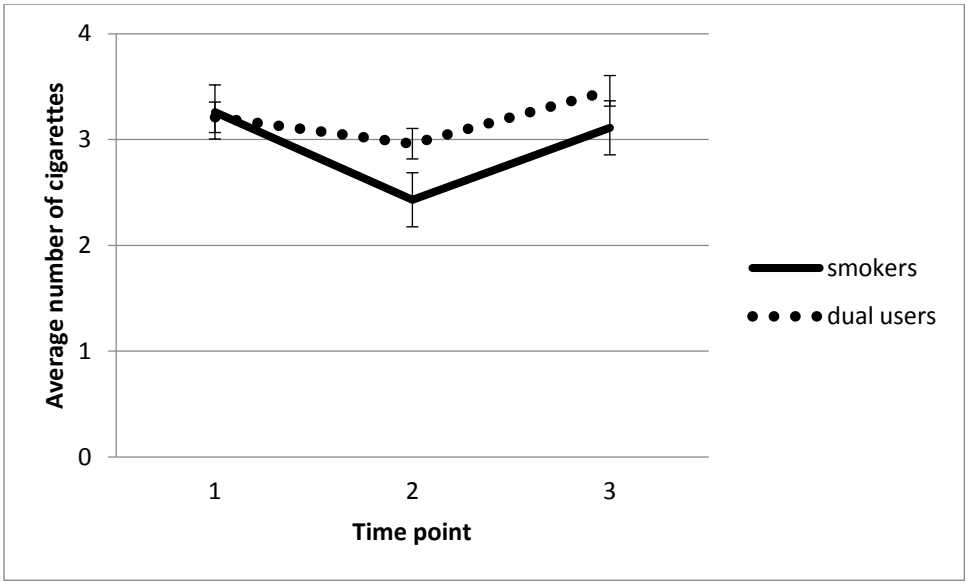

Figure 5.18. Comparison of average number of cigarettes reported at each time point

Cravings for cigarette/e-cigarette

Mixed methods ANOVA with Greenhouse-Geisser correction revealed that there was a significant main effect of time of day on positive desire to smoke for reward subscale of cravings at each of the three time points ($F(1.85, 185.02)=6.66$, $p=0.002$). Post hoc tests using Bonferroni correction revealed that there was a significant difference in the positive desire to smoke for reward subscale of cravings between mornings and evenings ($p=0.002$; M=3.73, SE=0.11 versus M=3.44, SE=0.12). The main effect of smoking status was not significant ($F(2,100)=2.32$, $p=0.103$) suggesting that there was not any significant difference in the positive desire to smoke for reward subscale of cravings averaged across the three time points, between cigarette smokers, e-cigarette users and dual users (M=3.52, SE=0.18; M=3.39, SE=0.18; M=3.93, SE=0.19 respectively). Additionally, no significant interaction was found between smoking status and time of day for the positive desire to smoke for reward subscale of cravings ($F(3.7, 185.02)=0.898$, $p=0.460$; figure 5.19).

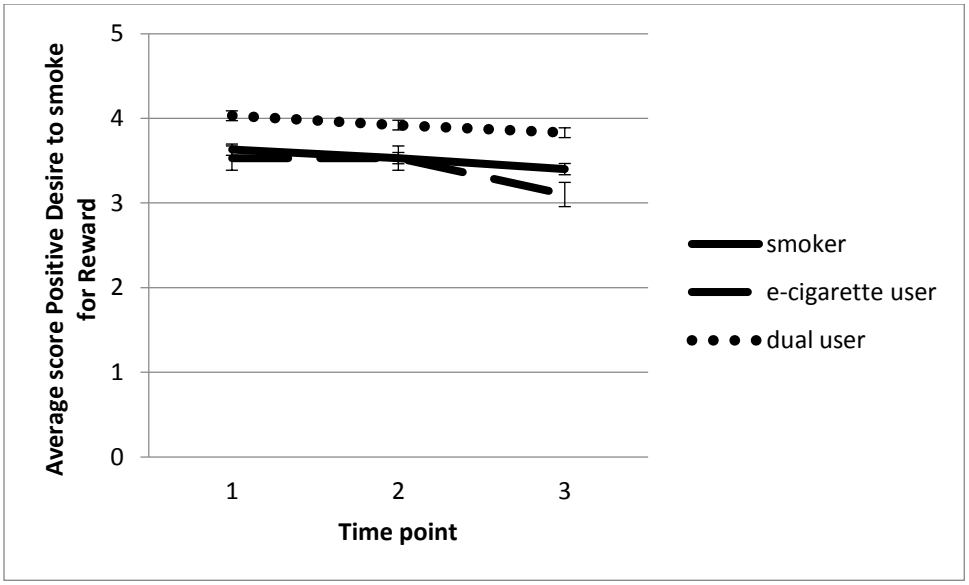

Figure 5.19. Comparison of average score of positive desire to smoke for reward subscale of cravings (for cigarette/ e-cigarette) across 3 time points in 3 different user groups

Mixed methods ANOVA with Greenhouse-Geisser correction also showed a significant main effect of time of day on need to smoke for relief subscale of cravings ($F(1.85, 184.83)=6.73$, $p=0.001$). Post hoc tests using Bonferroni correction revealed that there was a significant difference in the need to smoke for relief subscale of cravings between mornings and evenings ($p=0.002$; M=3.06, SE=0.12 versus M=2.87, SE=0.12). The main effect of smoking status was also significant ($F(2,100)=10.25$, $p<0.001$). Post hoc tests using Bonferroni correction revealed that there was a significant difference in the need to smoke for relief subscale of cravings, averaged across the three time points, between e-cigarette users and dual users (M=2.41, SE=0.20; M=3.67, SE=0.20 respectively). The analysis also showed that there was no significant interaction between time of day and smoking status on the need to smoke for relief subscale of cravings ($F(3.67, 184.83)=1.74$, $p=0.143$; figure 5.20).

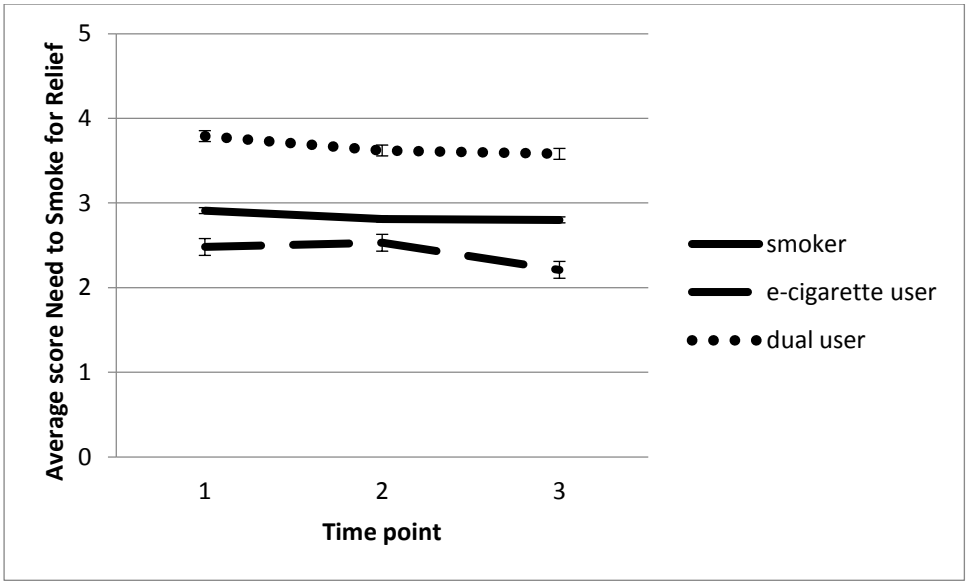

Figure 5.20. Comparison of average score of Need to smoke for relief subscale of cravings (for cigarette/e-cigarette) across 3 time points in 3 different groups

Moods

Mixed methods ANOVA with Greenhouse-Geisser correction showed that there was not a significant difference of negative mood across the three time points F(1.89, 188.55)=0.26, *p*=0.769 ; M=2.15, SE=0.07, timepoint1; M=2.13, SE=0.07, timepoint2; M=2.12, SE=0.073). The main effect of smoking status was significant (F(2,100)=7.39, *p*=0.006). Post hoc test using Bonferroni correction revealed that there was a difference in negative moods, averaged across the three time points, between cigarette smokers and dual users (*p*=0.017; M=1.99, SE=0.11; M=2.45, SE=0.12 respectively) and a difference between e-cigarette users and dual users (*p*=0.013, M=1.97, SE=0.11; M=2.45, SE=0.12 respectively), with duals users exhibiting higher levels of negative mood than the other two groups. However, neither of these differences reached significance after correcting for multiple comparisons. The analysis also showed that there was a significant interaction between negative mood at each of the three time point and smoking status (F(3.77, 188.55)=7.82, *p*<0.001; figure 5.21). This interaction arose because the negative

mood of dual users increased across the three time points whereas it decreased for the other two groups.

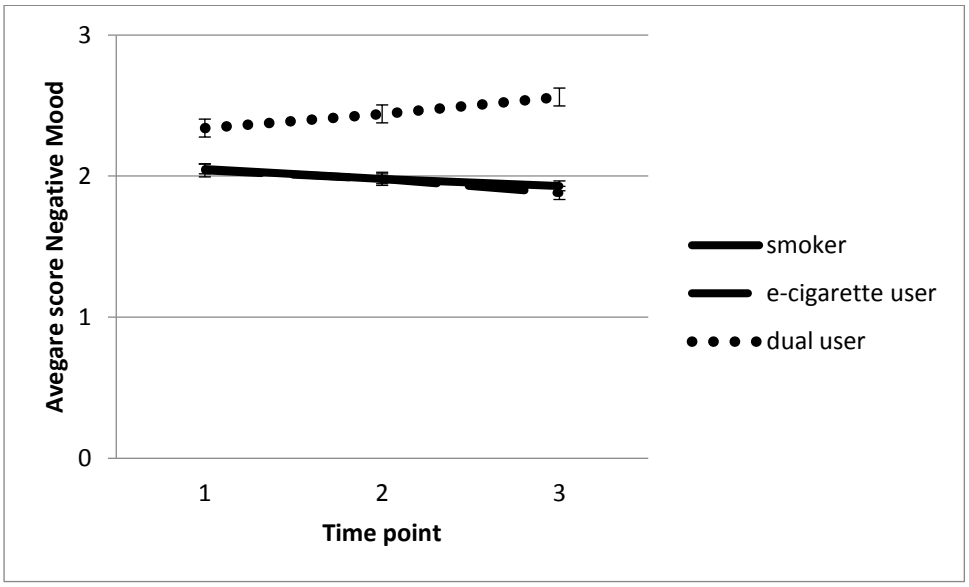

Figure 5.21. Comparison of average score of negative mood across 3 time points in 3 different groups

Similarly, mixed methods ANOVA with Greenhouse-Geisser correction showed that there was no significant main effect of time of day on positive mood F(1.98, 197.52)=0.99, *p*=0.375; M=3.16, SE=0.06, timepoint1; M=3.19, SE=0.06, timepoint2; M=3.20, SE=0.06). The main effect of smoking status was not significant (F(2,100)=2.32, *p*=0.104) suggesting that there was not any significant difference in positive mood, averaged across the three time points, between cigarette smokers, e-cigarette users and dual users (M=3.37, SE=0.10; M=3.11, SE=0.10; M=3.08, SE=0.11 respectively). The analysis also showed that there was no significant interaction between time of day and smoking status on positive mood (F(3.95, 184.83)=1.93, *p*=0.107; figure 5.22).

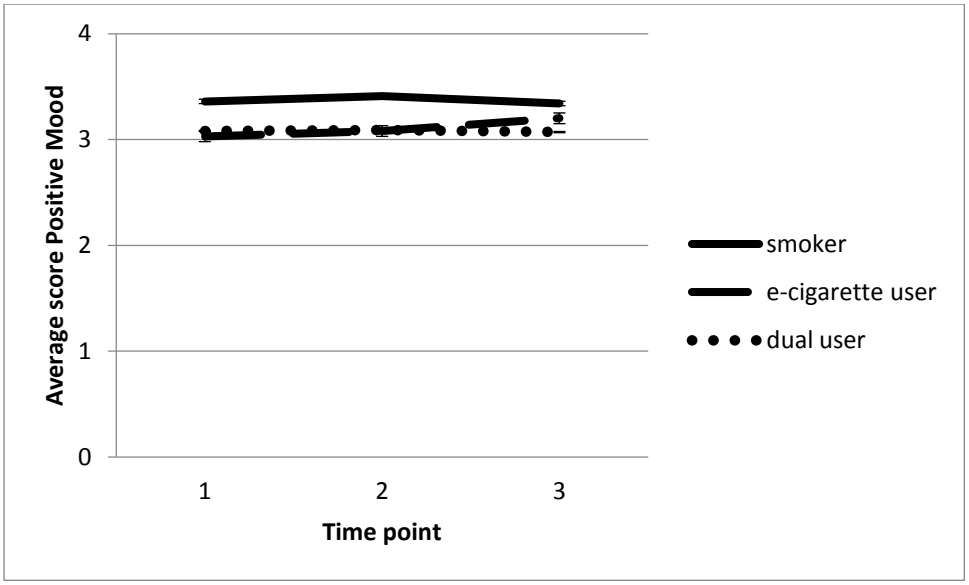

Figure5.22. Comparison of average score of positive mood across 3 time points in 3 different groups

Table 5.9: Summary of ANOVAs

Variable	Main effect of time of day	Main effect of smoking status	Interaction
	F-Statistic (dfs)	**F-Statistic (dfs)**	**F-Statistic (dfs)**
Product use			
No of average vapes	7.79 (1.63,107.31)**	0.489 (1,66)	1.93 (1.63,107.31)
No of average cigarettes	4.79 (1.76,115.82)*	0.285 (1,66)	0.98 (1.76,115.82)
Cravings for cigarette/e-cigarette			
Positive desire to smoke for reward	6.66 (1.85,185.02)**	2.32 (2,100)	0.898 (3.7,185.02)
Need to smoke for relief	6,73 (1.85,184.83)***	10.25 (2,100)***	1.74 (3.67,184.83)
Moods			
Negative mood	0.26 (1.89,188.55)	7.39 (2,100)**	7.82 (3.77,188.55)***
Positive mood	0.99 (1.98,197.52)	2.32 (2,100)	1.93 (3.95,184.83)

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$, uncorrected for multiple comparisons

Discrepancy scores

Analysis on the predictions of tobacco product use showed that most participants overestimated their next day usage. In particular, 23 cigarette smokers overestimated their next day number of cigarettes, 3 were accurate and 9 underestimated their next day cigarette consumption. The actual average number of cigarettes smoked by smokers was 8.43 cigarettes, while the estimated number was 9.41 cigarettes, showing a 0.98 (11.63%) discrepancy.

Dual users showed similar results with 19 overestimating both their next day cigarette consumption and e-cigarette use, 3 were accurate for cigarette consumption and 2 for e-cigarette use, while 11 and 12 respectively underestimated their next day cigarette consumption and e-cigarette use. The actual average number of cigarettes smoked by dual users was 9.44 cigarettes, while the estimated was 9.82 cigarettes showing a 0.38 (4.02%) discrepancy. As far as it concerns e-cigarette use for dual users, the actual average number of occasions of e-cigarette use was 9.56 and the estimated was 11.01 showing a discrepancy of 1.45 (15.17%) average number of occasions of e-cigarette use.

Regarding e-cigarette users, 30 overestimated their next day e-cigarette use, while 5 underestimated it. No one was accurate. The actual average number of occasions of e-cigarette use for e-cigarette users was 13.13, while the estimated was 16.11 showing a discrepancy of an average 2.98 (22.7%) number of occasions of e-cigarette use.

The end of day data was also used to examine if participants were accurate in their responses during the day. Data revealed that participants were 100% accurate as there were no discrepancies between responses collected during the day and at the end of day questionnaire.

Trait impulsivity, cravings for cigarette/e-cigarette and moods

Linear regression analyses were performed in order to find out which dimension of trait impulsivity best predicted cravings and moods in all three groups. A regression analysis allows one to highlight the relative importance of each predictor and determine the specific effect of each one because it takes into account the relations between the various predictors entered in the regression. Before

conducting such analysis, the data used was checked for normality, homoscedasticity, linearity and multicollinearity. No problem was observed with these assumptions. Absolute t-values were used to determine the relative importance of each variable (Howell, 1998). We conducted 12 linear regressions (4 dependent variables at each of three separate time points), thus the Bonferroni-adjusted critical alpha for these analyses would be 0.004. Any p values less than 0.05 are noted in the tables.

Given the strong correlation between negative and positive urgency, we combined positive and negative urgency in a single variable called urgency and conducted the linear regression analyses again. Results with urgency as a single variable revealed more effects and are presented below, while results with distinct positive and negative urgency variables are presented in Appendix I.

Cravings

Three linear regressions were conducted using the dimension of positive desire to smoke for reward subscale of cravings as the criterion variable and smoking status, urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point. As shown in Table 5.10, analysis indicated that only urgency was a significant predictor of the positive desire to smoke for reward subscale of cravings during evenings (t=3.166, p=0.002).

Table 5.10. Linear Regressions examining the relationship between trait impulsivity and positive desire to smoke for reward subscale of cravings at each of 3 time points

	Cravings1_T1			Cravings1_T2			Cravings1_T3		
Predictor variables	B	SE B	β	B	SE B	B	B	SE B	β
Smokers	0.040	0.278	0.017	0.020	0.282	0.008	0.141	0.287	0.054
Dual users	0.337	0.291	0.138	0.276	0.295	0.112	0.408	0.300	0.153
Urgency	0.343	0.242	0.168	0.235	0.246	0.114	0.791	0.250	0.355**
Lack of Premeditation	-0.415	0.355	-0.131	-0.341	0.360	-0.107	-0.643	0.366	-0.186
Lack of Perseverance	-0.034	0.319	-0.013	0.377	0.323	0.147	-0.136	0.329	-0.049
Sensation seeking	0.139	0.174	0.081	0.154	0.177	0.088	0.026	0.180	0.014

Cravings1_T1: $F(6,96)=1.336$, $p=0.249$, $R^2=0.077$, Cravings1_T2: $F(6,96)=1.247$, $p=0.289$, $R^2=0.072$ Cravings1_T3: $F(6,96)=3.396$, $p=0.004$, $R^2=0.175$, *$p\leq0.05$, **$p\leq0.01$, ***$p\leq0.001$ uncorrected for multiple comparisons. Reference variable e-cigarette users coded 0

Similarly, three linear regressions were conducted using the dimension of need to smoke for relief subscale of cravings as the criterion variable and smoking status, urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point (Table 5.11). Being a dual user, and urgency showed a positive relation with the need to smoke for relief subscale of cravings during evenings (t=3.34, p=0.001 dual use; t=3.32, p=0.001 urgency), while only dual use remained significantly positively related to this subscale of cravings during mornings and afternoons (t=3.49, p=0.001; t=3.01, p=0.003 respectively).

Table 5.11. Linear Regressions examining the relationship between trait impulsivity and need to smoke for relief subscale of cravings at each of 3 time points

	Cravings2_T1			Cravings2_T2			Cravings2_T3		
Predictor variables	B	SE B	B	B	SE B	B	B	SE B	β
Smokers	0.280	0.278	0.103	0.178	0.278	0.068	0.425	0.290	0.148
Dual users	1.011	0.290	0.365**	0.872	0.290	0.329**	1.011	0.303	0.347**
Urgency	0.683	0.242	0.295**	0.511	0.242	0.231*	0.837	0.252	0.343**
Lack of Premeditation	-0.830	0.354	-0.232*	-0.801	0.354	-0.234*	-0.843	0.370	-0.224*
Lack of Perseverance	-0.069	0.318	-0.024	0.109	0.318	0.040	-0.072	0.332	-0.024
Sensation seeking	0.115	0.174	0.059	0.062	0.174	0.033	0.097	0.181	0.047

Cravings2_T1: $F(6,96)=6.379$, $p<0.001$, $R^2=0.285$, Cravings2_T2: $F(6,96)=4.542$, $p<0.001$, $R^2=0.221$ Cravings2_T3: $F(6,96)=6.714$, $p<0.001$, $R^2=0.296$, *$p\leq0.05$, **$p\leq0.01$, ***$p\leq0.001$ uncorrected for multiple comparisons. Reference variable e-cigarette users coded 0

Moods

Three linear regressions were conducted using negative mood as the criterion variable and smoking status, urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point. As shown in Table 5.12, analysis indicated that only urgency showed a positive relation with negative mood at each of the three time points (t=4.18, p<0.001, mornings; t=4.38, p<0.001, afternoons; t=4.73, p<0.001, evenings).

Table 5.12. Linear Regressions examining the relationship between trait impulsivity and negative mood at each of 3 time points

	Negative_mood_T1			Negative_mood_T2			Negative_mood_T3		
Predictor variables	B	SE B	β	B	SE B	B	B	SE B	β
Smokers	-0.029	0.147	-0.020	-0.055	0.149	-0.037	-0.009	0.147	-0.005
Dual users	0.089	0.153	0.060	0.226	0.155	0.147	0.435	0.153	0.268**
Urgency	0.533	0.128	0.431***	0.566	0.129	0.440***	0.605	0.128	0.444***
Lack of Premeditation	-0.437	0.187	-0.228*	-0.391	0.190	-0.196*	-0.463	0.187	-0.220*
Lack of Perseverance	0.325	0.168	0.212	0.268	0.170	0.168	0.305	0.168	0.181
Sensation seeking	0.018	0.092	0.018	0.043	0.093	0.040	0.026	0.092	0.023

Negative_mood_T1: F(6.96)=2.458, p<0.001, R^2=0.301, Negative_mood_T2: F(6,96)=8.063, p<0.001, R^2=0.335, Negative_mood_T3: F(6,96)=11.519, p<0.001, R^2=0.419, *p≤0.05, **p≤0.01, ***p≤0.001 uncorrected for multiple comparisons. Reference variable e-cigarette users coded 0

Similarly, three linear regressions were conducted using positive mood as the criterion variable and smoking status, urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point (Table 5.13). Analysis revealed that only urgency showed a negative relation with positive mood during mornings and evenings (t=-3.07, p=0.003; t=-3.15, p=0.002, respectively).

Table 5.13. Linear Regressions examining the relationship between trait impulsivity and positive mood at each of 3 time points

	Positive_mood_T1			Positive_mood_T2			Positive_mood_T3		
Predictor variables	B	SE B	β	B	SE B	B	B	SE B	β
Smokers	0.353	0.143	0.259*	0.314	0.150	0.226*	0.161	0.147	0.116
Dual users	0.185	0.149	0.134	0.087	0.156	0.061	0.022	0.153	0.016
Urgency	-0.381	0.124	-0.330**	-0.237	0.130	-0.200	-0.403	0.128	-0.343**
Lack of Premeditation	0.333	0.182	0.187	0.282	0.191	0.154	0.353	0.187	0.194
Lack of Perseverance	-0.329	0.163	-0.230	-0.436	0.171	-0.298*	-0.335	0.168	-0.230
Sensation seeking	0.107	0.089	0.110	0.066	0.094	0.066	0.041	0.092	0.041

Positive_mood_T1: F(6,96)=5.131, $p<0.001$, $R^2=0.243$, Positive_mood_T2: F(6,96)=4.047, $p=0.001$, $R^2=0.202$, Positive_mood_T3: F(6,96)=4.593, $p<0.001$, $R^2=0.223$, *$p=0.05$, **$p=0.01$, ***$p<0.001$, uncorrected for multiple comparisons. Reference variable e-cigarette users coded 0

Discussion

The purpose of this study was to investigate differences in cravings, positive and negative moods, and product use among cigarette smokers, e-cigarette users and dual users using an EMA study. Additionally, the present study examined the relationships between trait impulsivity, real-time cravings, and real-time positive and negative moods.

Results suggest that participants exhibited higher levels of cravings in mornings than in afternoons. Dual users reported higher levels of need to smoke for relief cravings than e-cigarette users, but did not differ from cigarette smokers in this subscale of cravings. No significant difference was also detected for the positive desire for reward subscale of cravings among dual users and e-cigarette users and cigarette smokers. There was also no significant difference in any of the two subscales of cravings between cigarette smokers and e-cigarette users. Additionally, no significant interaction was detected for either of the subscales of cravings, between time of day and smoking status.

Regarding positive and negative moods, findings suggest that there was no significant difference in positive and negative moods as measured by the app

questionnaire across each of the three time points. Cigarette smokers, e-cigarette users and dual users did not differ in their positive moods, while dual users exhibited higher levels of negative mood than cigarette smokers and e-cigarette users, although these differences did not survive a correction for multiple comparisons. There was also no significant difference in negative mood between cigarette smokers and e-cigarette users. The results also suggest a significant interaction for negative mood between smoking status and time of day.

Product use as measured by the app study was not different between cigarette smokers and dual users, and between e-cigarette users and dual users. There was also no difference in the average number of cigarette smoked at each of the three time points, while it was found that e-cigarette use among e-cigarette users and dual users was significantly less in afternoons than evenings.

Regarding trait impulsivity as measured by the UPPS-P scale and its association with cravings and moods, the results suggested that only urgency was a significant predictor of real-time cravings and real-time moods. In particular, a positive association was found between higher levels of urgency and cravings during mornings, and negative moods at each of the three time points, while a negative association was detected between higher levels of urgency and positive mood during mornings and evenings.

Our findings suggest that the dimension of tobacco cravings related to the relief of negative affect and nicotine withdrawal was the only dimension that was significantly associated with dual use. Such results contradict previous findings from cross-sectional and experimental studies indicating that e-cigarette use among cigarette smokers is associated with reduced cigarette cravings and withdrawal symptoms (Etter & Bullen, 2011; Copp, Collins, Dar & Barrett, 2015). However, it has

been suggested that frequency and intensity of e-cigarette use, experience in using the e-cigarette, as well as e-cigarette device effect the efficacy of e-cigarette use in alleviating tobacco cravings (Dawkins, Kimber, Puwanesarasa & Soar, 2015; Etter, 2015; Farsalinos et al., 2014). Our group of dual users vaped less than 10 times per day on average and they consumed less than 4 mls of e-liquid per day. This pattern of e-cigarette use is similar to patterns observed in previous studies and characterizes not particularly intensive e-cigarette users (Etter, 2010; Farsalinos, Romagna, Tsiapras, Kyrzopoulos & Voudris, 2013), while smokers who reported stronger effects of e-cigarette use on tobacco cravings in previous studies, also reported using the e-cigarette more frequently and intensively (Etter, 2015). Additionally, the discrepancy in findings of our study and previous research may relate to study design. The present study used an EMA method, which, compared to survey and experimental studies, collects data in real-time and within participant's natural environments, thus minimizing recall bias, maximizing ecological validity and considers all the factors that influence behaviour in real world contexts.

Regarding the experience of e-cigarette use, it has been suggested that vapers who use their e-cigarette for longer get better satisfaction from their e-cigarette than more recent vapers (Etter, 2015). Moreover, new second and third generation e-cigarette devices are associated with lower tobacco cravings compared to first generation cig-alike devices (Farsalinos et al., 2014). The questions administered in the baseline questionnaire did not assess e-cigarette use history orthe model of e-cigarette device. It might be that our sample of non-intensive dual users was new vapers who were not using third generation e-cigarette devices, and thus e-cigarettes did not help them to alleviate cravings related to nicotine withdrawal. In line with our results though, a recent randomized controlled trial found

that cravings among overnight abstinent smokers were reduced significantly more after cigarette smoking than after e-cigarette use (Adriaens, Van Gucht & Baeyens, 2018).

Findings of the present study suggest a significant positive interaction on negative mood between time of day and smoking status. Correlation analyses also suggest a significant positive relationship between negative mood and tobacco cravings for the whole group. Additionally, it was found that dual users, who also showed the highest levels of cravings, exhibited higher levels of negative mood compared to cigarette smokers and e-cigarette users during afternoons and evenings. Such findings support previous research that indicates a strong association between higher levels of negative mood and increased cravings (e.g., Gentry et al., 2000; Perkins, Karelitz, Giedwong & Conklin, 2013). In addition to differences in cravings, there might be unmeasured variables that might have affected the interaction on negative mood between time of day and smoking status. For example, dual users are not ingesting as much nicotine as smokers, despite using the same number of cigarettes. Regarding positive mood, the app data suggests that there was no significant difference among the three groups. Available research has shown mixed results for the relationship between positive mood and smoking status with some experimental studies suggesting a negative relationship between positive mood and withdrawal symptoms of cigarette abstinence (e.g. Shiffman, Dunbar, Kirchner et al., 2013; Spring et al., 2008; Malpass & Higgs, 2007), while others suggest no impact of positive mood on cigarette smoking (Parrott & Gamham, 1998).

Comparison of real world e-cigarette use among cigarette smokers and non-smokers showed no significant difference. However, we noted a difference in e-

cigarette use patterns of e-cigarettes users and dual users. It seems that participants used their e-cigarette significantly more during evenings than afternoons. Research on daily cigarette smoking patterns suggests that within-subject variability in smoking behaviour is highly related to situational factors such as switching from working to socializing and environmental restrictions (Hatsukami et al., 1990). It has been further suggested that people who mostly smoke at the end of the day may do so in order to preload with nicotine before going to sleep to prevent nicotine withdrawal from occurring while they sleep (Chandra, Shiffman, Scharf, Dang & Shadel, 2007). Alternatively, cigarette smokers might smoke heavily in the evenings as part of a relaxation process that also may include alcohol consumption, which is also associated with smoking (Shiffman et al., 2002). Similarly, it might be argued that e-cigarette users vape mostly during evenings for the same reasons. On the other hand dual users might use their e-cigarette more during evenings because of indoor cigarette restrictions in public places during the day. However, the present study did not assess any situational factors associated with e-cigarette use in order to confirm such assumptions.

In the present study positive urgency was significantly higher in dual users than e-cigarette users and cigarette smokers, confirming results from Chapter 3. Results from this study also indicate that the intensity of both dimensions of cravings were significantly associated with higher levels of urgency, as measured by the positive and negative urgency scales of the UPPS-P model, during the evenings, but not in the earlier periods of the day. Previous research also indicates that higher levels of urgency are positively associated with increased levels of cravings among cigarette smokers (Billieux et al., 2007; Doran, Cook, McChargue & Spring, 2009), and those higher in trait impulsivity have more difficulty finding cigarette substitutes

during a quit attempt (Kreudelbach, McCormick, Schulz, & Grueneich, 1993). In the same manner, our findings might suggest that dual users exhibited higher levels of positive urgency, the tendency to act rashly in response to positive affect, and may have more difficulty finding appropriate substitutes when experiencing a positive situation during a quit attempt. Such findings may also imply that these individuals are more likely to relapse, because they find cigarette smoking more rewarding during positive experiences compared to their peers with lower levels of positive urgency.

The present study also found a significant relation between urgency, the emotion based dimension of trait impulsivity and positive, and negative moods in all three time points. Such findings confirm laboratory studies that have reported a significant positive association between negative mood and trait impulsivity (Doran et al., 2006). They also suggest that impulsive individuals may experience negative and positive affect more frequently than others and may be susceptible to cigarette smoking and e-cigarette use as a way of coping with their emotions. Indeed, previous research indicates that individuals with heightened levels of trait impulsivity expect substances to alleviate their negative moods to a greater extent than non-impulsive individuals (Cooper, Agocha & Sheldon, 2000; Doran et al., 2006).

Should the current findings be replicated, this would be important not only in helping identify patterns of cravings and positive and negative emotions among cigarette smokers, e-cigarette users and dual users, and how these are influenced by trait impulsivity, but also in helping researchers and clinicians understand how to help individuals deal with cravings and emotions. Our findings suggest that dual users experience the highest levels of cravings, negative moods, and urgency compared to the other two groups, while their product use (number of cigarettes

smoked and frequency of e-cigarette use) was the same as cigarette smokers and e-cigarette users. Such results may suggest that dual users are the most addicted group and trying to substitute cigarettes with e-cigarette use may not be enough to deal with their cravings and emotions. It may also suggest that dual users are in need of more intensive stop smoking interventions to help them overcome their cravings and become smoke free.

Strength, Limitations and future directions

The present study benefited from its EMA methods as we used near-real time assessments in participants' natural environments to assess cigarette smoking and e-cigarette use habits, cravings, and positive and negative moods. Naturalistic data collection eliminates situational effects on smoking that occur when smoking is monitored in a laboratory. Additionally, such data eliminates some of the problems associated with other forms of data collection related to smoking behaviour, such as retrospective recall. Despite these methodological advances, results of this study must be interpreted with a number of limitations. The validity of the present study depends greatly on participant compliance. The study achieved very high compliance as participants responded to 98.1% to issued notifications. However, the features of the app used did not allow us to record the exact time that the data was collected. On the other hand comparison of real-time data with end of the day data and baseline measures suggest that participants recorded most of their cigarettes, although we cannot objectively confirm that they did so in a timely way. Regarding e-cigarette use, app data collected throughout the day and end of the day data provide similar e-cigarette use rates for both e-cigarette users and dual users. In contrast, e-cigarette use for e-cigarette users observed in the study was lower than rates

reported by participants during baseline assessment. However, this discrepancy might not be related to participants' non-compliance, but the way frequency and intensity of e-cigarette use is defined. As already mentioned in Chapter 3, there is no standard way to accurately measure e-cigarette use, and users may be confused with the way puffs are measured, as some may assume that usage period of their e-cigarette constitutes a puff, while others report every single puff. Future research should focus on creating valid and reliable measures of e-cigarette use.

The study relied exclusively on self-report data, while other measures of cravings and moods and/or objective observations of smoking could possibly result in different findings. It is also not possible to assess what reactive impact the notifications that participants received throughout the day may have had on cigarette smoking and e-cigarette use patterns, and cravings. Finally, the findings are based on a small convenience sample of non-highly cigarette dependent smokers and intermittent e-cigarette users. It is possible that the results of the present study may be less relevant to other populations of cigarette smokers and e-cigarette users. Further research with larger samples is needed both to verify the findings of the present study, and examine real-time cravings and moods in highly addicted cigarette smokers and dual users.

Additionally, even though the pattern of participants' responses allowed us to aggregate the data for analysis, the optimal way to analyze EMA data is the use of multi-level modelling. Such approach could be considered in future research along with an attempt to model the relationship between recent use of nicotine and cravings.

Conclusion

The present EMA study suggests that cigarette smokers, e-cigarette users and dual users exhibited higher levels of real-time cravings during mornings, while e-cigarette use for e-cigarette users and dual users was significantly higher in evenings. It also showed that dual users differed from e-cigarette users in their cravings related to the relief of negative affect and nicotine withdrawal, and in their negative moods, while no significant differences were detected between cigarette smokers and e-cigarette users, and between cigarette smokers and dual users. In support of previous research, the present study also suggests a significant positive relationship between negative mood and smoking status. Results from this study also support findings from Chapter 3 which indicate that the impulsivity-related trait of positive urgency significantly differentiates e-cigarette users from dual users, while also showing a significant association between urgency and real-time positive and negative moods. Such findings could potentially inform interventions to help cigarette smokers and dual users to deal with their cravings and emotions in their effort to quit smoking.

Chapter 6

A longitudinal study of electronic cigarette use among adult smokers: association with smoking cessation, motivation to quit and trait impulsivity

Overview

This chapter describes a three month prospective study to assess the association between e-cigarette use and smoking cessation, motivation to quit and trait impulsivity among adult smokers. It aims to replicate and extend findings from cross-sectional study reported in Chapter 3 suggesting that greater intention to quit cigarette smoking was associated with e-cigarette use. It was found that dual users were more likely to report an intention to quit smoking in the next 6 months than cigarette smokers, while dual users who intended to quit smoking within 6 months were more likely to report smoking cessation as a reason for e-cigarette use. It also extends the research described thus far on trait impulsivity and cigarette smoking by examining the role of the impulsivity-related traits in smoking cessation. Results of the present study suggest that the use of e-cigarettes in non-treatment seeking smokers is associated with a higher rate of quitting smoking three months later, relative to smokers who did not use e-cigarettes. The present study failed to find links between any impulsivity-related trait and smoking cessation. We also did not find any significant association between different levels of e-cigarette use, and smoking related characteristics such as nicotine dependence, motivation to quit, past quit attempts and smoking cessation.

Introduction

Stopping cigarette smoking is associated with large health benefits and many smokers want to quit. However, cigarette smoking is a very difficult habit to break and many smokers find it hard to remain abstinent in the long term. It has been shown that approximately 80% of smokers who try to quit without support relapse within the first month of abstinence, and fewer than 5% remain smoke-free at six months after quitting (Hughes, Keely & Naud, 2004).

Evidence based recommendations indicate that behavioural support and nicotine replacement therapy (NRT) products such as nicotine patches or gum increase the chances of smoking abstinence, but even with this additional support long-term quit rates remain low (Cahill, Lindson-Hawley, Thomas, Fanshawe & Lancaster, 2016; Hughes, Stead, Hartmann-Boyce, Cahill & Lancaster, 2014; Stead et al., 2012). NRT therapies have a success rate of less than 7% when assessing smoking status at one year (Moore et al., 2009). The limited success of current treatments can be attributed to the low speed of nicotine delivery, and none of the available treatments adequately addresses the sensory and behavioural aspects of smoking.

As discussed in the introductory chapter, smokers become dependent on tobacco, and find it difficult to quit smoking mainly because of nicotine and its actions on the brain's reward system (Balfour, 2004). However, other factors such as the sensory and behavioural aspects of smoking also contribute to cigarette dependence (Rose, 2006). Thus, developing smoking cessation products that would not only help relieve the unpleasant nicotine withdrawal symptoms, but would also address the rituals and sensations that accompany smoking may help more cigarette smokers to remain abstinent long term. The only available NRT product that has some of these

characteristics is the nicotine inhalator. However, research indicates that the inhalator does not result in greater abstinence rates compared to other NRT products (Hajek et al., 1999; Stead, 2012). This may be due to the fact that about 20 minutes of continuous puffing is needed to provide nicotine blood concentrations similar to other smoking cessation products (Schneider, Olmstead, Franzon & Lanell, 2001). Additionally, it has been observed that adherence to correct use of the inhalator is lower than other NRT products (Hajek et al., 1999). It is therefore possible that even if the inhalator addresses the behavioural aspect of cigarette smoking, it may not adequately relieve nicotine withdrawal symptoms and may not provide the sensations of smoking, thus not improving the chances of long term abstinence (Bullen, 2010).

In contrast e-cigarettes have been designed to mimic conventional cigarettes in nicotine delivery, sensations and behavioural rituals. Thus, e-cigarette use may help smokers quit smoking as it may offer a way to overcome some of the limitations of other NRT products. Indeed, examination of the reasons for e-cigarette use in chapters three and five, and the impact of stated reasons on current tobacco use and intentions to quit, showed that the majority of dual users endorsed reasons for e-cigarette use related to quitting and reduction in health risks. However, evidence on the efficacy of e-cigarettes as smoking cessation aids remains limited and inconclusive (see following section).

Overview of studies examining e-cigarette use as smoking cessation aid

To date, four randomized controlled trials (RCTs) have been published assessing the effectiveness of e-cigarette use in smoking cessation. Bullen et al. (2013) conducted one of these in New Zealand among 657 regular cigarette

smokers interested in quitting. Participants were randomly assigned to receive low intensity behavioural support for 6 months, along with either placebo (0.0mg) e-cigarette, 16 mg cartridges e-cigarette, or 21 mg nicotine patches. Their findings suggest that there was no significant difference in quit rates among groups. However, they observed that smokers in the nicotine e-cigarette group were significantly more likely to have reduced tobacco cigarette consumption compared to those in the nicotine patches group.

Another study by Caponnetto, Campagna et al. (2013) randomized 300 Italian non-treatment seeking participants to receive either 7.2 mg e-cigarette for 12 weeks, or 7.2 mg e-cigarette for 6 weeks followed by 5.4 mg e-cigarette for 6 weeks, or placebo (0.0mg) e-cigarette for 12 weeks. After 12 weeks, participants were advised to continue using their e-cigarette if they wished, but no additional cartridges were provided by the investigators. Participants were subsequently followed for additional 40 weeks. At 52 weeks, no significant difference was found among study groups in terms of reduction or quitting rates, while the groups did not also differ in the numbers of cartridge used. Additionally, a study conducted by Adriaens, Van Gucht, Declerck and Baeyens (2014) randomly allocated 48 non-treatment seeking smokers living in Belgium to either a control group with no intervention or to one of two different brands of 18 mg second generation e-cigarettes for 8 weeks. Their findings suggest that after 8 weeks, significantly more smokers from the e-cigarette groups had stopped cigarette smoking compared to the control group.

The fourth available RCT was conducted by Tseng et al. (2016) in New York among 99 non-treatment seeking young adults. Participants were offered a brief counselling session and then they were asked to reduce their cigarette consumption by 50%. At this point, participants were randomly allocated to use either a placebo e-

cigarette or a nicotine containing e-cigarette for 3 weeks. After three weeks, participants from both groups had significantly reduced their cigarette consumptions, though no participants reported complete cessation. Findings from these RCT studies, which represent the gold-standard in assessing the efficacy of any medical intervention, suggest at best a modest effect of e-cigarette use in smoking cessation compared to placebo or NRT.

In contrast a number of observational studies have provided some support for the effectiveness of e-cigarette use as a smoking cessation aid. For example, findings from two UK cohort studies suggest a significant positive association between e-cigarette use and smoking cessation. Brown et al. (2014) in a retrospective cohort study recruited 5863 adult smokers from England who had made at least one quit attempt in the last 12 months with either an e-cigarette, NRT, or no aid at all. The primary outcome of the study was self-report abstinence up to the time of survey. Their findings suggest that e-cigarette users were more likely to report abstinence compared to those who used NRT or no aid. Similarly, a cross-sectional population based survey of smokers ofn the UK Smoking Toolkit Study, which assesses data of approximately 1200 smokers each quarter since November 2006 (Beard, West, Michie & Brown, 2016), reported that the increase in e-cigarette use in England has been positively associated with self-reported success rates of quit attempts. Recent evidence from a US population survey also suggests that the substantial increase in e-cigarette use among US adult smokers is associated with a statistically significant increase in the smoking abstinence rate at the population level (Zhu, Zhuang, Wong, Cummins & Tedeschi, 2017). Support for an association between e-cigarette use and smoking cessation was also provided by a non-randomized trial with 100 smokers seeking help from UK's Stop Smoking Services

(Hajek, Corbin, Ladmore & Spearing, 2015). In this study, researchers offered to participants use of an e-cigarette, in addition to the standard behavioural and medication treatment of the services. Their results suggest that smokers who used an e-cigarette had a higher validated quit rate at four weeks follow-up than those who had not used an e-cigarette, though the difference did not reach statistical significance. Interestingly, the participants who used an e-cigarette along with varenicline, a form of NRT, reported significantly higher abstinent rates than those who used only an e-cigarette.

Findings from longitudinal studies suggest that only intensive daily use of e-cigarettes is significantly associated with higher rates of quit attempts and successful smoking abstinence. Biener and Hargraves (2015) conducted a three year longitudinal study among 1374 adult smokers in US. Self-reported one month abstinence was not significantly different among daily users, non-daily e-cigarette users, and non users. However, in adjusted analyses for demographic and smoking related characteristics, compared to non-users, daily e-cigarette users were six times more likely to quit smoking, while no association was observed between non-daily e-cigarette use and smoking cessation. Similarly, Brose, Hitchman, Brown, West and McNeil (2015) surveyed 4064 adult smokers in the UK at baseline and one-year later with a retention rate of 43% at follow up. The authors found a significant positive association between e-cigarette use and increased quit attempts, but no significant association between e-cigarette use and smoking abstinence.

From what has been discussed so far, it is clear that the evidence remains inconclusive regarding the effectiveness of e-cigarette use in smoking cessation. Similar conclusions can be drawn from the published systematic reviews examining the effectiveness of e-cigarette use in smoking cessation. For example, Franck,

Budlovsky, Windle, Filion and Eisenberg (2014) reviewed seven experimental studies, two of which have been discussed earlier in this section (Bullen et al., 2013; Caponnetto, Campagna et al., 2013), and they concluded that there remains significant uncertainty about the efficacy of e-cigarettes for cigarette abstinence mainly due to methodological weaknesses of the reviewed studies. Similarly McRobbie, Bullen, Hartmann-Boyce and Hajek (2014) reviewed 13 studies, again two of them have been discussed earlier in this section (Bullen et al., 2013; Caponnetto, Campagna et al., 2013), and they concluded that it is difficult to be that confident about e-cigarettes' efficacy for smoking cessation as the number of well conducted studies is small. A meta-analysis of six studies, three of which have been discussed earlier (Bullen et al., 2013; Caponnetto, Campagna et al., 2013; Brown et al., 2014), conducted by Rahman, Hann, Wilson, Mnatzaganian and Worrall-Carter (2015) suggested that nicotine-containing e-cigarettes are more effective for smoking cessation and cigarette reduction compared to nicotine-free ones, while their results could not provide adequate evidence that e-cigarette use is more effective than other smoking cessation methods, such as other NRT products. Malas et al. (2016) conducted a systematic review on 62 studies published until February 2016. The number of the articles that they reviewed was higher than the reviews discussed ealier in this section, as they included not only experimental and randomized controlled trials, but also longitudinal studies independently of their follow-up time, and cross-sectional studies. Their results showed very modest evidence in support of the effectiveness of e-cigarette use in helping smokers quit and reduce their cigarette consumption. However, their results suggest that e-cigarette use could alleviate smoking withdrawal symptoms and cravings in laboratory settings. Conversely, Kalkhoran and Glantz (2016) examined the effects of e-cigarettes use

on quitting and reducing smoking in 38 peer-reviewed studies, they included cohort studies, longitudinal studies and randomized controlled trials, and their results suggest that the odds of quitting smoking were 28% lower in those who used e-cigarettes compared with those who did not use e-cigarettes. Notably, a significant amount of variability was present in the reviewed studies, though the authors concluded that differences in the study designs did not affect their results.

The discrepancies in results of the meta-analyses, experimental and observational studies may relate to how e-cigarette use is measured and differences in how e-cigarettes are used in experimental study settings versus in the real world. Additionally, it seems that many studies fail to account for important variables related to e-cigarette characteristics such as e-cigarette devices, fluid, nicotine delivery, as well as those related to the characteristics of users such as quitting history, motivation to quit, personality characteristics, and variables related to patterns of use (intensity, frequency). The study of the efficacy of e-cigarette use in smoking cessation is still in the early stages and more studies are needed to establish a strong body of evidence. Moreover, to the best of our knowledge none of the existing studies examine if impulsivity-related traits predict cigarette smoking cessation among e-cigarette users.

Trait impulsivity and smoking cessation

Individual differences in trait impulsivity are increasingly recognized as a significant determinant of smoking cessation outcomes. It has been suggested that smokers with higher levels of trait impulsivity have greater difficulty maintaining abstinence than their less impulsive peers. For example, a study that examined the influence of trait impulsivity on the ability to maintain abstinence following a 1-day

smoking cessation found that trait impulsivity accounted for approximately 14.7% of the variance in time to relapse following the workshop; more impulsive participants relapsed more quickly (Doran, Spring, McChargue, Pergalia & Richmond, 2014). Littlewood et al. (2017), in a study examining moderators of smoking cessation, found that participants who achieved continuous abstinence had significantly lower scores of motor impulsivity and non-planning impulsivity as measured by BIS-11. It has also been suggested that non-planning impulsivity is significantly associated with poorer adherence to cognitive-behavioural intervention for smoking cessation (Celma-Merola, Abella-Pons, Mata, Pedra-Pages & Verdejo-Garcia, 2017).

Similarly, Lopez-Torrecillas, Perales, Nieto-Ruiz, and Verdejo-Garcia (2014) found that higher scores on novelty seeking and on BIS non-planning impulsivity were significantly associated with smoking cessation treatment dropout, while non-planning impulsivity predicted greater smoking relapse during the later stages of smoking cessation. Evidence from a study examining the association between sensation seeking and smoking cessation in heavy social drinkers suggests that higher sensation seeking was significantly negatively associated with compliance with NRT and reduced odds of abstinence from smoking over 26 weeks of follow-up (Kahler, Spillane, Metrik, Leventhal, Monti, 2009). These findings clearly suggest that trait impulsivity is a significant predictor of smoking abstinence.

The present study

The present study will use a longitudinal design to assess the associations between e-cigarette use and smoking cessation, motivation to quit and trait impulsivity among adult smokers. In particular the aims of the present study are: (a) to investigate whether e-cigarette use increases smoking cessation; (b) to assess

different levels of intensity and frequency of e-cigarette use and their relationship with smoking cessation; (c) to examine the association between e-cigarette use and motivation to quit; (d) to assess the role of trait impulsivity in smoking cessation; (e) to examine if nicotine dependence, motivation to quit and previous quit attempts are associated with smoking cessation; and finally (f) to assess the reasons and characteristics associated with smokers using e-cigarettes. First, it is hypothesised that e-cigarette use among cigarette smokers will be positively associated with smoking cessation and motivation to quit. Secondly, that higher levels of intensity and frequency of e-cigarette use will be associated with higher levels of smoking cessation. Thirdly, that higher motivation to quit will be associated with e-cigarette use. Fourth, that higher levels of some impulsivity-related traits as measured by the UPPS-P scale will be associated with lower levels of smoking cessation, though the available literature does not allow us to predict which with any confidence. Finally, it is hypothesized that lower nicotine dependence, higher motivation to quit and previous quit attempts will be associated with higher levels of smoking cessation.

Methods

Participants

One hundred and fifty three individuals (84 females) with an age range of 18-47 years (M=23.73, SD=5.00) completed the first wave of the study. Ninety one of these participants (59.5%; 54 females) were successfully followed up after three months. Participants were recruited using online message forums, through emails sent via the Psychology department office and Graduate School office of Goldsmiths, University of London, and through Prolific. Participants recruited through Prolific (n=67, 43.8%) were paid £0.85 for completing the 10 minute baseline questionnaire

and another £0.85 for completing the 5 minute follow-up questionnaire three months later. Self-reported inclusion criteria for participants were: age 18 years old or above, being either a cigarette smoker or dual user (i.e., both smoke cigarettes and use an e-cigarette), having an active email address account and being able to read and understand English.

Measures

Baseline questionnaire

Demographic measures

Participants reported their age, gender, ethnicity, country of residence and employment status, using the same questions as in the study reported in Chapter 3.

General smoking/e-cigarette use behaviour

Respondents' general smoking/e-cigarette behaviour was assessed with the same four items reported in Chapter 3. Participants were defined as smokers if they replied that they currently smoke cigarettes and haven't used an e-cigarette in the last month, and as dual users if they replied that they currently both smoke cigarettes and use an e-cigarette (in the last 1-4 weeks).

Current tobacco use, cessation history and intention to quit

Nicotine dependence of cigarette smokers and dual users was measured with The Fagerstrom test for Nicotine dependence (FTND; Heatherton, Kozlowski & Frecker, 1991), which demonstrated acceptable internal consistency in this study, α=0.72. Smoking history also included the age at which participants started smoking, while we also asked if they have ever quit smoking for longer than a month in the

past. Motivation, determination and confidence to quit were assessed with the same items reported in Chapter 3.

Current e-cigarette use and reasons for e-cigarette use (dual users only)

Current e-cigarette use for dual users only was assessed with questions regarding participants' number of days of e-cigarette use in the last month, average millilitre of e-liquid used per day, type of cartridge used, and times of e-cigarette use per day. Regarding the last question, participants had to select between '1-4 times', '5-9 times', '10-14 times', '15-19 times', '20-29 times', and '30+ times'. They were also instructed that one "time" consists of around 15 puffs or lasts around 10 minutes (Foulds et al., 2014). Reasons for e-cigarette use were assessed with the same items reported in Chapter 3. Additionally, dual users were asked to what extent they use their e-cigarette to help them quit smoking. This item was rated on a five-point Likert-type scale (1=never to 5=almost always).

E-cigarette dependence was assessed with the Penn State Electronic Cigarette Dependence Index (PS-ECDI; Foulds et al., 2014), a recently developed 10 item brief questionnaire that covers the main components of dependence such as consumption, drive, craving, withdrawal, and difficulty quitting. The PS-ECDI was created from a review of existing questionnaires assessing nicotine dependence. Two of the 10 items were adapted from the FTND scale (Heatherton, Kozlowski & Frecker, 1991), however, in the PS-ECDI questionnaire participants are required to write the actual numbers, rather than select from a pre-defined list choice. Five items are from the Hooked On Nicotine Checklist (HONC; DiFranza et al., 2002) and cover difficulty in quitting, experience of craving, and withdrawal symptoms. Two items assess waking at night to use an e-cigarette (adapted from Bover, Foulds, Steinberg,

Richardson, & Marcella, 2008), and one item assesses recent strength of urges to use an e-cigarette (adapted from Fidler, Shahab, & West, 2011). Questionnaire scores of 0-3 indicate non dependence, scores of 4-8 indicate low dependence, scores of 9-12 indicate medium dependence and scores above 13 indicate high dependence. The mean score of e-cigarette use dependence in the present sample was 7.21 (SD=4.56) indicating a low dependence group. The internal consistency of the PS-ECDI questionnaire for the present study was α=0.71.

Attitudes towards e-cigarettes

The Comparing e-cigarettes and cigarettes questionnaire (CEAC, Hershberger et al. 2017) was used to assess attitudes towards e-cigarettes compared to cigarettes. The Cronbach's alpha reliabilities in the present sample were: general benefits=0.75, general effects=0.71 and health benefits=0.83.

Impulsivity

The UPPS-P Impulsive Behaviour Scale was used to measure the five facets of impulsivity. Cronbach's alpha values in the present sample were: lack of premeditation=0.85, lack of perseverance=0.84, sensation seeking=0.86, negative urgency=0.88, positive urgency=0.96. Correlations between the UPPS-P subscales showed modest correlation between the subscales, range 0.04 - 0.66, with the highest correlation between negative urgency and positive urgency, suggesting that the subscales index distinct components of impulsivity.

Follow-up questionnaire

Smoking status at the follow-up questionnaire was assessed with the same 4 items used in the baseline questionnaire. Change from being a cigarette smoker at baseline to being an ex-smoker at follow-up was coded as successful smoking cessation. In particular, participants were classified as ex-smokers if they had not smoked any cigarette in the last month, cigarette smokers if they continued to smoke only cigarettes, dual users if they both smoked a cigarette and used an e-cigarette, and e-cigarette users if they only used an e-cigarette.

Participants were also asked about the number of attempts they had made to stop smoking in the last three months.

Procedure

The study was approved by the Goldsmiths, University of London, Psychology Department Ethics Committee. Initial recruitment took place between May and September 2018. Measures were completed online through Qualtrics survey website (www.qualtrics.com). Participants completed a consent form prior to beginning the questionnaires confirming that they were 18 years old or above, and were given the opportunity to email the researcher with any questions about the study. Participants were informed that they had the option to exclude themselves from participation at any stage of the study if they wished to do so. Three months after completing the baseline (T1) measures, participants were emailed a link to complete the follow-up (T2) questionnaire. Those who did not complete the follow-up questionnaire on first request were emailed with reminders each week for three weeks. Debrief information was given to participants at the end of both questionnaires, along with relevant websites to get more information about quitting smoking.

Results

Data were analysed using IBM SPSS version 23. All baseline variables had less than 5% of missing values. Missing trait scores were imputed using expectation maximisation.

Owing to the large number of analyses conducted, an alpha level of p=0.01 was used for significance testing to reduce the likelihood of Type I errors. Accordingly we will report 99% confidence intervals in this chapter as well.

Attrition

Independent t-tests and chi-squared tests were conducted to assess differences in demographics, smoking status, impulsivity-related traits, attitudes towards e-cigarettes, nicotine dependence, motivation to quit, and e-cigarette use between participants that were followed up and those that were not.

More dual users (53, 58.2%) than smokers (38, 41.8%) completed the follow-up questionnaire ($\chi^2(1)=8.77$, $p=0.003$). Additionally, participants who completed the follow-up measures showed significantly lower lack of perseverance scores (M=2.04, SD=0.51 versus M=2.25, SD=0.54, $t(151)=2.43$, $p=0.01$), while they scored higher in the general benefits subscale of attitudes towards e-cigarettes than participants who did not complete the follow-up questionnaire (M=3.46, SD=0.80 versus M=3.12, SD=0.76, $t(150)=-2.61$, $p=0.01$).

No other significant differences were found.

Descriptive statistics

Sociodemographic characteristics of the participants for the present study are presented in Table 6.1. Of the 153 participants recruited in this study, 79 (51.6%)

were cigarette smokers and 74 (48.4%) were dual users at baseline (T1). Most of the participants were of white ethnicity 88.9% (n=136), were European residents 97.4% (n=148) and were students 77.8% (n=119). Cigarette smokers did not differ from dual users in any demographic characteristics.

Table 6.1. Demographic characteristics

Variable	Total n=153		Smokers n= 79 (51.6%)		Dual users n=74 (48.46%)			
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**t-test (dfs)**	***p*-value**
Age	23.73	5.00	23.59	4.26	23.86	5.71	-0.33 (151)	0.740
	No	**%**	**No**	**%**	**No**	**%**	**Chi^2 (df)**	
Gender								
Male	69	45.1	33	41.8	36	48.6	0.73 (1)	0.393
Female	84	54.9	46	58.2	38	51.4		
Ethnicity								
White	136	88.9	71	89.9	65	87.8	0.16 (1)	0.689
Other	17	11.1	8	10.1	9	12.2		
Country of residence								
European	148	97.4	77	97.5	71	97.3	0.006 (1)	0.936
Other	4	2.6	2	2.5	2	2.7		
Occupation								
Student	119	77.8	66	83.2	53	71.6	3.46 (2)	0.177
Employed	30	19.6	12	15.2	18	24.3		
Unemployed	4	2.6	1	1.3	3	4.1		

SD=Standard Deviation, df=degrees of freedom, n=number of participants, p=alpha value

Table 6.2 summarizes the smoking behaviour of the two groups, their motivation to quit, and their attitudes towards e-cigarettes at baseline. Most of the participants of both groups started smoking over the age of 16 years old and they were daily smokers, while almost half of the participants indicated that they had quit in the past for longer than a month. Compared to cigarette smokers, dual users showed higher levels of nicotine dependence (FTND score), $t(149)=-3.56$, $p<0.001$ and more motivation to quit cigarette smoking, $t(151)=-2.48$, $p=0.01$. Based on the TTM stages, most dual users were in the contemplation stage (52.7%), while most cigarette smokers were in the pre-contemplation stage (55.7%), however the difference was a modest one ($\chi^2(2)=6.13$, $p=0.05$). With respect to participants'

attitudes towards e-cigarette use, dual users scored significantly higher in the general attitudes and health benefits, t(150)=-9.44, p<0.001 and t(149)=-4.51, p<0.001 respectively.

Table 6.2. Baseline tobacco use, cessation history, and intention to quit

Variable	Smokers n= 79 (51.6%)		Dual users n=74 (48.4%)			
	No	**%**	**No**	**%**	**Chi^2 (df)**	***p*-value**
Days per month of cigarette smoking						
6-9 days	7	8.9	9	12.2	4.809 (3)	0.186
10-19 days	19	24.1	10	13.5		
20-29 days	20	25.3	14	18.9		
30 days	33	41.8	41	55.4		
Age started smoking						
<14	6	7.6	6	8.2	4.035 (2)	0.219
14-16	28	35.4	36	48.6		
>16	45	57.0	32	43.2		
Quit for longer than a month						
no	38	48.1	41	55.4	0.816 (1)	0.366
yes	41	51.9	33	44.6		
Motivation to quit (TTM)						
Pre-contemplation	44	55.7	29	39.2	6.125 (2)	0.047
Contemplation	26	32.9	39	52.7		
Preparation	9	11.4	6	8.1		
	Mean	**SD**	**Mean**	**SD**	**t-test (dfs)**	***p*-value**
Nicotine dependence index (FTND)	2.30	2.23	3.64	2.38	-3.560(149)	**<0.001**
Mean score 'How much do you want to quit' (scale1-5)	3.09	1.27	3.58	1.18	-2.475(151)	0.014
Mean score 'How determined are you to quit for good' (scale1-5)	3.05	1.28	3.41	1.22	-1.756 (151)	0.081
Mean score 'How confident are you to quit for good' (scale1-5)	3.32	1.20	2.92	1.13	2.101 (151)	0.037
Attitudes towards e-cigarettes						
General benefits	2.85	0.64	3.83	0.64	-9.439 (150)	**<0.001**
Health benefits	3.36	0.74	3.91	0.76	-4.511 (149)	**<0.001**
General effect	3.02	0.79	3.33	0.90	-2.304 (150)	0.023

A comparison of the two groups in trait impulsivity (Table 6.3) showed that dual users and smokers scored very similarly in all impulsivity-related traits. None of the differences between the two groups were statistically significant.

Table 6.3. Mean and standard deviations for the UPPS-P Impulsive Behaviour Scale

	All sample	Smokers	Dual users	UPPS-P Pearson's r			
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	2.	3.	4.	5.
1. Negative Urgency	2.57 (0.58)	2.54 (0.60)	2.60 (0.55)	0.658***	0.341***	0.301***	0.259**
2. Positive Urgency	2.16 (0.71)	2.11 (0.67)	2.22 (0.75)		0.408***	0.254**	0.298***
3. Lack of Premeditation	2.03 (0.47)	2.09 (0.49)	1.97 (0.46)			0.495***	0.424***
4. Lack of Perseverance	2.12 (0.53)	2.20 (0.54)	2.04 (0.51)				0.037
5. Sensation Seeking	2.66 (0.62)	2.74 (0.59)	2.57 (0.64)				

SD=standard deviation. Means reflect mean item scores for each subscale. Pearson's r correlations are presented between mean sub-scale of the UPPS-P. **p<0.01; ***p<0.001
1. t(151)=-0.676, p=0.500; 2. t(151)=-0.980, p=0.329; 3. t(151)=1.481, p=0.141; 4. t(151)=1.781, p=0.077; 5. t(151)=1.640, p=0.103

Baseline e-cigarette use characteristics are summarized in Table 6.4. Most dual users (67.6%) reported using their e-cigarette 1-4 times per day, they consumed on average 5.17 millilitres of e-liquid per day (SD=6.56), and they mostly used a nicotine-containing cartridge (73.0%). Their main reason for e-cigarette use was as an aid to stop smoking, while the second most important reason was that e-cigarettes are less harmful than cigarettes.

We also assessed the bivariate association between reasons for e-cigarette use and reported intentions to quit regular cigarettes. Dual users who intended to quit smoking within the next 3 months more frequently endorsed the reason 'aid to stop smoking' than those who did not intend to quit ($\chi^2(1)=8.76$, p=0.003). Additionally, their mean score on the question to what extent they use their e-cigarette to help them quit smoking was 3.55 (SD=1.11) compared to 2.45 (SD=0.87) for dual users who did not intend to quit within 3 months (t(71)=4.49, p<0.001). Dual users who intended to quit smoking in the next 3 months and those who did not, did not differ significantly on any other e-cigarette use characteristic (Table 6.4).

Table 6.4. Baseline e-cigarette use and reasons for use (dual users only)

Variable	Dual users=74		Considered quitting the next 3 months (n=45)		Not consider quitting the next 3 months (n=29)			
	No	**%**	**No**	**%**	**No**	**%**	**Chi2 (df)**	***p*-value**
Reason for e-cigarette use								
Perception that they are less harmful than cigarettes								
Yes	45	60.8	31	68.9	14	48.3	3.144 (1)	0.076
No	29	39.2	14	31.1	15	51.7		
Can be used indoors								
Yes	41	55.4	25	55.6	16	55.2	0.001 (1)	0.974
No	33	44.6	20	44.4	13	44.8		
Cheaper than tobacco products								
Yes	29	39.2	21	46.7	8	27.6	2.694 (1)	0.101
No	45	60.8	24	53.3	21	72.4		
Novelty								
Yes	3	4.1	2	4.4	1	3.4	0.045 (1)	0.832
No	71	95.9	43	95.6	28	96.6		
Aid to stop smoking								
Yes	46	62.2	34	75.6	12	41.4	8.757 (1)	**0.003**
No	28	37.8	11	24.4	17	58.6		
Range of different flavours available								
Yes	26	35.1	16	35.6	10	34.5	0.009 (1)	0.925
No	48	64.9	29	64.4	19	65.5		
E-cigarette use								
Days of vape/month								
6-9 days	18	24.3	7	15.6	11	37.9	7.591 (3)	0.055
10-19 days	19	25.7	11	24.4	8	27.6		
20-29 days	12	16.2	7	15.6	5	17.2		
All 30 days	25	33.8	20	44.4	5	17.2		
Times of vape/day								
1-4	50	67.6	27	60.0	23	79.3	3.65 (4)	0.455
5-9	12	16.2	9	20.0	3	10.3		
10-14	3	4.1	2	4.4	1	3.4		
15-19	2	2.7	2	4.4	0	0		
20-29	7	9.5	5	11.2	2	2		
E-cigarette dependence								
Not dependent	21	36.2	13	35.1	8	38.1	7.730 (3)	0.052
Low	15	25.9	6	16.2	9	42.9		
Medium	17	29.3	13	35.1	4	19.0		
High	5	8.6	5	13.5	0	0		
Cartridge								
Nicotine free	7	9.5	5	11.1	2	6.9	0.389 (2)	0.823
Nicotine containing	54	73.0	32	71.1	22	75.9		
Both	13	17.5	8	17.8	5	17.2		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**t-test (dfs)**	***p*-value**
use e-cigarette to quit	3.11	1.15	3.55	1.11	2.45	0.87	4.491 (71)	**<0.001**
e-cigarette dependence	6.52	4.33	7.11	4.62	5.48	3.63	1.39 (56)	0.170
Mls e-liquid/ day	5.17	6.56	6.65	7.76	2.65	2.20	2.409 (60)	0.019

Smoking status at follow-up

Of the 38 cigarette smokers who completed the follow-up questionnaire, 3 (7.9%) had quit cigarette smoking at the 3 month follow-up, 2 (5.3%) of them were not using any tobacco product, while 1 (2.6%) had switched to e-cigarette use. Of the remaining 35, 2 (5.3%) indicated that they were dual users at follow-up, while 33 (86.6%) continued to smoke only traditional cigarettes. In contrast, of the 53 dual users who completed the follow-up questionnaire, 15 (28.3%) indicated that they had quit smoking at the 3 month follow-up, 4 (7.5%) of them were not using any tobacco product and 11 (20.8%) were e-cigarette users only. Of the remaining 38, 29 (54.7%) were still dual users at the 3 month follow-up, while 9 (17.0%) were cigarette smokers only. Analysis showed that smokers who were using an e-cigarette at baseline were more successful at quitting smoking at 3 month follow-up compared to cigarette smokers only, and the difference almost reached our adjusted criterion for statistical significance ($\chi^2(1)=5.81$, p=0.016). Additionally, more smokers who were using an e-cigarette at baseline had made a quit attempt during the last three months compared to cigarette smokers only (52.8% versus 36.5%), however the difference was not significant ($\chi^2(1)=3.10$, p=0.078).

Table 6.5. Smoking status at follow-up

	Smokers (n=38)		Dual users (n=53)			
	No	**%**	**No**	**%**	**Chi^2 (df)**	***p*-value**
Quit cigarette smoking						
Yes	3	7.9	15	28.3	5.809 (1)	0.016
No	35	92.1	38	83.3		
Smoking status at T2						
Non-smokers	2	5.3	4	7.5	44.980 (3)	**<0.001**
Smokers	33	86.6	9	17.0		
Dual users	2	5.3	29	54.7		
E-cigarette users	1	2.6	11	20.8		
Any quit attempt the last 3 months						
Yes	14	36.8	28	52.8	3.099 (1)	0.078
No	24	63.2	25	47.2		
No smoking for 7 days the last 3 months						
Yes	10	26.3	23	43.4	2.794 (1)	0.095
No	28	73.7	30	56.6		

Predictors of smoking cessation

Univariate regression analyses, controlling for age and gender, were used to examine if e-cigarette use, motivation to quit, nicotine dependence, and previous quit attempts for longer than a month at baseline were each significant predictors of smoking cessation. Analyses showed that e-cigarette use at baseline increased the odds of quitting at 3 month follow-up, however this was not statistically significant based on our adjusted criterion for statistical significance (OR=4.54, 99%CI=0.80-25.87, p=0.025). Nicotine dependence at baseline and previous quit attempts for longer than a month did not predict smoking cessation (OR=1.15, 99%CI=0.86-1.53, p=0.22; OR=1.20, 99%CI=0.61-2.36, p=0.49 respectively). Baseline motivation to quit, as measured both by the statement 'How much do you want to quit?' and the TTM, were higher in participants that quit smoking at 3 months than participants who did not quit, however the difference was not statistically significant based on our adjusted criterion for statistical significance (OR=0.50, 99%CI=0.24-1.04, p=0.015; OR=2.27, 99%CI=0.76-6.77, p=0.05 respectively). In contrast, determination to quit, as measured by the statement 'How determined are you to quit for good?', was a significant predictor of smoking cessation at 3 months follow-up (OR=0.49, 99%CI=0.25-0.96, p=0.006).

Examining the association between impulsivity-related traits and smoking cessation, univariate regression analyses, controlling for age and gender, showed no significant association (negative urgency: OR=0.74, 99%CI=0.22-2.51, p=0.52; positive urgency: OR=0.80, 99%CI=0.29-2.20, p=0.57; sensation seeking: OR=1.14, 99%CI=0.35-3.66, p=0.78; lack of premeditation: OR=0.81, 99%CI=0.20-3.37, p=0.71; lack of perseverance: OR=1.55, 99%CI=0.39-6.12, p=0.41).

Factors associated with smoking cessation among dual users

Univariate logistic regression analyses, controlling for age and gender, were also conducted for the baseline dual users only to examine if intensity of e-cigarette use, reasons of e-cigarette use and motivation to quit at baseline each predicted smoking cessation. Analyses showed that dual users who claimed at baseline that they use their e-cigarette to help them quit smoking were more likely to quit smoking at 3 months follow-up than those who did not (OR=2.20, 99%CI=0.99-4.89, p=0.01). However, participants who selected 'aid to stop smoking' as one of their main reasons for e-cigarette use were not more likely to quit smoking at 3 months follow-up (OR=0.40, 99%CI=0.08-2.13, p=0.16). Baseline e-cigarette dependence was found not to be a significant predictor of smoking cessation among dual users at 3 month follow-up (OR=1.15, 99%CI=0.90-1.46, p=0.15). Similarly, days of e-cigarette use (OR=2.08, 99%CI=0.93-4.64, p=0.02), times of e-cigarette use per day (OR=1.35, 99%CI=0.76-2.42, p=0.18), cartridge used (OR=2.10, 99%CI=0.27-16.33, p=0.35) and millilitres of e-liquid used per day (OR=0.97, 99%CI=0.82-1.13, p=0.58) also did not significantly predict smoking cessation. Examining motivation to quit in the dual users group only, it was found that motivation was not a significant predictor of smoking cessation (TTM: OR=2.27, 99%CI=0.60-8.60, p=0.11; want to quit: OR=0.55, 99%CI=0.23-1.31, p=0.08), however determination to quit for good was a significant predictor (OR=0.38, 99%CI=0.15-0.97, p=0.008).

Furthermore, univariate regression analyses were conducted to examine if impulsivity-related traits were significant predictors of smoking cessation in dual users. Again, the results showed no significant association (negative urgency: OR=0.53, 99%CI=0.11-2.51, p=0.30; positive urgency: OR=0.80, 99%CI=0.29-2.37, p=0.59; sensation seeking: OR=2.03, 99%CI=0.52-7.99, p=0.18; lack of

premeditation: OR=1.25, 99%CI=0.25-6.13, p=0.72; lack of perseverance: OR=3.06, 99%CI=0.54-17.43, p=0.10).

Discussion

The main purpose of this longitudinal study was to examine whether e-cigarette use among adult cigarette smokers increased smoking cessation at three months follow-up. Secondary aims of this study were to examine whether a number of variables such as different levels of e-cigarette use, motivation to quit, previous quit attempts, nicotine dependence and trait impulsivity affected smoking cessation, and whether e-cigarette use increased motivation to quit. Finally, the study examined smokers' reasons and characteristics associated with e-cigarette use.

Results of the present study suggest that the use of e-cigarettes in non-treatment seeking smokers is associated with a higher rate of quitting smoking three months later, relative to smokers who did not use e-cigarettes, and this association was close to significant judged against a more stringent type 1 error rate (0.01). This finding is in keeping with recent research that indicates e-cigarettes are a useful smoking cessation aid (i.e. Adriaens et al. 2014; Biener & Hargraves, 2015; Beard et al., 2016). It should be also noted that the association between e-cigarette use and smoking cessation might have been stronger if the design of the study was different. The design of this study analyzed results from smokers based on e-cigarette use at baseline, and might have excluded any ex-smokers who have already successfully quit using e-cigarettes. Thus potentially this study might have included mainly participants who would be 'treatment failures'.

The results of the present study differ from previous studies that compared cigarette smokers with dual users and found no association (i.e. Bullen et al., 2013;

Biener & Hargraves, 2015), or even a negative correlation, between e-cigarette use and smoking abstinence (Kalkhoran & Glantz, 2016). It could be argued that the main difference between the present study and the earlier ones might be the time of data collection. E-cigarette devices have evolved a lot since they were first introduced to the market, and nowadays second and third generation open system devices have become more popular than first generation “cig-alike” devices. Open system devices generally provide increased control over vapour production and greater concentration of nicotine, and there is some preliminary research suggesting that in a sample of ex-smokers who had quit using e-cigarettes all had used more recently developed products (Chen, Zhuang & Zhu, 2016; Hitchman, Brose, Brown, Robson & McNeil, 2015). Hence, if the proportion of smokers who use open system devices increases, this may result in higher quit rates due to e-cigarette use and might explain the slightly more promising results in the present study compared with the previous studies where first generation devices were being used. Additionally, the popularity of e-cigarette use grows constantly and more people, especially smokers, use them intensively. The present study found that 33.8% of baseline e-cigarette users were using their e-cigarette every day, and this percentage is similar to another report that found an association between e-cigarettes and smoking abstinence (Biener & Hargraves, 2015). In contrast, studies that found no association between smoking cessation and e-cigarette use did not report intensity of e-cigarette use, or report just their participants “ever use” of e-cigarettes and not their current use. It has been suggested that intensive use of e-cigarettes is very important in order to help smokers quit smoking. For example, Biener and Hargraves (2015) found that among smokers, intermittent non-daily e-cigarette use was not significantly related to smoking cessation one year later, but their findings suggest

that smokers who had used an e-cigarette daily for at least one month were significantly more likely to quit cigarette smoking than non e-cigarette users. Similarly, Hitchman et al. (2015) found that all first generation e-cigarette users and non-daily tank system users had lower odds of quitting cigarettes, while daily tank system users were significantly more likely to report smoking cessation.

Examining the relationship between different levels of e-cigarette use (e-cigarette dependence, days of e-cigarette use in the last month, times of e-cigarette use per day, mls used per day, and cartridge used) and smoking cessation in the present sample, it was found that only the number of days of e-cigarette use in the last month variable was associated with smoking cessation, however this association was not significant judged against the more stringent type 1 error employed in the present analysis. The null results between the other variables of frequency and intensity of e-cigarette use and smoking cessation can be attributed to the way frequency and intensity were measured. As discussed in Chapter 3 quantifying frequency and intensity of e-cigarette use is difficult as e-cigarette users report that e-cigarette use typically occurs in short, frequent sessions that are often difficult to count (Baweja et al., 2016; Cooper, Harrell &Perry, 2016). Moreover, the present sample included smokers with low levels of e-cigarette addiction, as measured with the newly developed scale PS-ECDI (Foulds et al., 2014). This was also confirmed by the times of day that dual users used their e-cigarette, as they mostly indicated that they vaped one to four times per day. Additionally, it should be noted that the sample size of baseline dual users who quit smoking at three months follow-up was small (n=15), which may have limited the statistical power to detect any significant association between frequency and severity of e-cigarette use and smoking cessation.

Findings from the present data also failed to find any association between smoking related characteristics such as nicotine dependence, motivation to quit, past quit attempts and smoking cessation. It has been suggested that higher levels of nicotine dependence are negatively associated with successful smoking cessation (Kale, Gilbert, & Sutton, 2015; Vangeli, Stapleton, Smit, Borland & West, 2011). The discrepancy of our results from previous studies may be attributed to the fact that the present sample was a low nicotine addicted group of smokers. Previous research also indicates that motivation to quit is positively associated with quit attempts and use of treatment, and not with success in stopping smoking (Kale, Gilbert, & Sutton, 2015; Vangeli et al., 2011). In the present study smokers who were using an e-cigarette were more motivated to quit than non e-cigarette using smokers, but motivation was not a significant predictor of smoking cessation. Previous quit attempts in general have also been found to be associated with future quit attempts and not smoking cessation (West, McEwen, Bolling & Owen, 2001; Zhou et al., 2009), whereas previous prolonged abstinence of 6 months or more has been found to positively predict smoking abstinence (Li et al., 2010; Feng, Jiang, Yong, Borland & Fong, 2011). The present study assessed if participants had previously quit smoking for one month or longer, and the results indicate that the two groups, smokers and dual users, did not differ significantly in their previous quit attempts.

The present study did not find any link between any impulsivity-related trait and e-cigarette use. Results from Chapters 3 and 5 suggest that higher levels of positive urgency, a tendency to act rashly when experiencing extremely positive moods, are associated with e-cigarette use among current smokers. The pattern of mean scores of the impulsivity-related traits of cigarette smokers and dual users were similar in all three studies, however the present study did not find any

statistically significant differences. The discrepancy in the findings may be accounted for by levels of nicotine dependence, as positive urgency has been linked with the severity of nicotine dependence (Kale, Stautz & Cooper, 2018). Dual users from the present study exhibited lower levels of nicotine dependence compared to participants from Chapters 3 and 5. Moreover, the present sample showed low e-cigarette dependence. However, we cannot compare e-cigarette dependence of the present sample with the samples of studies 3 and 5, as it was not measured in the earlier studies.

Our results also indicate that there is not a significant relationship between impulsivity-related traits as measured by the UPPS-P scale and smoking cessation, as previous studies suggest. This may also be accounted for by the low numbers of participants who quit smoking at three months follow-up, which may have limited the statistical power to find any association. Additionally, the discrepancy of the present results from previous research may be attributed to the study design, as most of the previous studies were clinical trials (Doran et al., 2004; Kahler et al., 2009; Littlewood et al., 2016). Another difference is in the way trait impulsivity was measured. Previous studies used the BIS-11 scale (Patton, Stanford, & Barratt, 1995) or measures of sensation seeking (Temperament and Character Inventory; Cloninger, Svrakic & Przybeck, 1993), while the present study used the UPPS-P scale.

Examining participants' characteristics associated with e-cigarette use, data suggest that e-cigarette use among smokers was associated with higher levels of nicotine dependence as measured by FTND, more positive attitudes towards e-cigarettes, and higher motivation to quit. Additionally, dual users' most common reason for e-cigarette use was as an aid for smoking cessation, particularly among

dual users who intended to quit smoking within three months. These results are similar to the findings reported in Chapter 3. It has also been suggested that interest in quitting smoking is a common reason for e-cigarette use, possibly because e-cigarette use is promoted as an effective smoking cessation aid by e-cigarette advertisements in many countries (de Andrade Hastings & Angus, 2013; Grana & Ling, 2014), even though such claims have not been accepted by regulatory authorities in every country. For example, only e-cigarettes that make smoking cessation claims are regulated as medicines in the UK (Public Health England, 2015), while all e-cigarettes are regulated as tobacco products in the US (US Food and Drug Administration, 2016). E-cigarettes are also marketed as a way to substitute for cigarettes in smoke-free environments (de Andrade Hastings & Angus, 2013; Grana & Ling, 2014), and could be used as such by highly nicotine-addicted smokers who have lower motivation and intention to quit cigarette smoking. In the present study, half of the participants chose, as one of their reasons for e-cigarette use, the fact that it can be used indoors, and the percentage was similar between dual users who considered quitting in the next three months and those who did not. With respect to perceptions of relative harm, dual users in the present study reported that they perceived e-cigarettes to be safer than traditional cigarettes, a finding consistent with results in Chapter 3 and previous reports (Public Health England, 2015).

Limitations and future directions

A number of limitations should be noted which may have affected the results of the present study. First, the online recruitment method is likely to have led to some selection bias. The study recruited from university students, from online forums, and

from a platform that consisted of individuals who were interested in participating in research surveys in exchange for money. As a result, certain socio-demographic groups are likely to have been under-represented, similar to the studies in Chapters 3, 4 and 5. Another limitation of the study is the small sample size which affects the statistical power of the study. However, the sample size achieved at this study was the maximum that was practical within the limited time and financial resources available during the latter stages of the current PhD. Additionally, the follow-up rate was relatively modest (59.5%), which may lead to selection bias and loss of more statistical power in tests involving T2 measures. Loss for follow-up is inevitable in longitudinal studies and many authors have proposed that a 50% retention rate is adequate, 60% is good and 70% is very good (Babbie, 1998), while others suggest that 80% should be the acceptable follow-up rate (Nemes, Wish, Wraight & Messina, 2000). The retention rate in this study was 59.5%, and it may be attributed to data being collected online and follow-up requests being made by emails that could have been easily dismissed. It is also noteworthy that significantly more cigarette smokers were not retained in the study compared to dual users. The convention in smoking cessation studies is that participants who are lost to follow-up are still smokers (Intention to treat analysis; Gupta, 2011). So if we had data from all participants at the follow-up, the results might have indicated a stronger relationship between e-cigarette use and smoking cessation.

The present study explored a number of characteristics that might influence the association between e-cigarette use and smoking cessation, such as frequency and duration of e-cigarette use, motivation to quit, nicotine dependence, and previous quit attempts. However, it did not assess characteristics of the e-cigarette device, which may play a role in cigarette cessation. Previous research suggests that

users of second-generation and third-generation e-cigarettes are more likely to quit smoking than users of cigalike first-generation devices, possibly because later generation models are more effective at delivering nicotine (Chen, 2016; Hitchman et al., 2015). The current study may have also missed important factors associated with quit attempts or cessation, such as the use of other aids to stop smoking, or the mental health status of respondents. Additionally, the analysis may have been stronger if it included adjustement for baseline differences, even though smokers differed from dual smokers only in attitudes towards e-cigarettes, or if we have used stratified sampling.

A further limitation is that smoking status in this study was exclusively self-reported and retrospective, so while prior validation studies have shown self-reported cigarette smoking behaviours among adults are consistent and reliable (Patrick et al., 1994) especially in large trials of general population (Benowitz et al., 2019), they may be subject to errors. The conclusions of the present study may also be limited by the relatively short follow-up time to assess successful long term cigarette abstinence. The Russell Standard has suggested 6 or 12 months as the standard length for assessing abstinence (West, Hajek, Stead & Stapleton, 2005). However, others have argued that most relapses happen within the first 3 months of quitting (Anderson, Jorenby, Scott & Fiore, 2002). Additionally, the constraints of a time-limited PhD meant that 3 months was the longest follow-up period available for this study.It should be also noted that both e-cigarette devices and the marketing and regulatory environment are continuously changing, all of which could influence the role of e-cigarette use in smoking cessation.

Future research using a larger sample and including longer-term quitters over six months to a year, with greater follow-up retention, that will account for e-cigarette

device characteristics and other important factors associated with smoking abstinence, may provide a greater insight in to the relationship between e-cigarette use and smoking cessation among smokers.

Conclusion

The data from the present longitudinal study adds to current evidence that e-cigarettes may increase rates of smoking cessation among cigarette smokers (i.e. Adriaens et al. 2014; Biener & Hargraves, 2015; Beard et al., 2016), most likely because they provide nicotine replacement, as well as behavioural and sensory replacement for cigarettes (Barbeau, Burda & Siegel, 2013). Electronic cigarettes may therefore serve as a source of nicotine replacement for smokers who do not like other NRT products and could help more smokers to attempt quit smoking and remain smoke-free.

Chapter 7

General discussion

Overview

This chapter will review the key findings of the thesis and consider their implications for current theory and for the development of prevention and intervention campaigns. Broad limitations of the research will be acknowledged with a focus on issues relating to sampling and measures. Finally, ideas for further research will be discussed.

Key Findings

The research programme documented in this thesis set out to enhance understanding regarding how trait impulsivity, as measured by the UPPS-P model, relates to cigarette smoking and e-cigarette use in adults, and to identify possible effects of e-cigarette use on cigarette smoking. There is considerable evidence of an association between trait impulsivity and cigarette smoking (e.g. Doran et al., 2009; Mitchell, 1999; Perkins et al., 2008; Reynolds et al., 2007). However, identifying the magnitude of this association in all stages of cigarette smoking varies greatly among studies mainly because of how trait impulsivity is defined. Regarding the relationship between trait impulsivity and e-cigarette use, to date, there is a limited number of studies examining this relationship, and their results provide mixed findings. There have also been a few studies recently examining the effectiveness of e-cigarette use in smoking cessation; however, evidence on the efficacy of e-cigarettes as a

smoking cessation aid remains inconclusive. The research presented herein employed systematic review, and studies with cross-sectional, ecological momentary assessment (EMA) and prospective designs to address these issues. The main findings of the thesis are presented below with reference to the four overall aims of the thesis outlined in Chapter 1.

Aim 1: To establish whether the various impulsivity-related personality traits differ from one another in their relationship with cigarette smoking in adults

This first broad aim of the thesis sought to reframe the existing literature regarding impulsivity and cigarette smoking in terms of a multi-trait conceptualisation of impulsivity. Separating the broad trait of impulsivity into a number of narrower facets has helped to further understanding of the role of impulsive behaviour in many addictive substances (Stautz & Cooper, 2013; VanderVeen et al., 2016), but has not been widely employed to understand cigarette smoking in adults. It was proposed that understanding the complexity of impulsivity-related traits in relation to cigarette smoking could help the development of screening and prevention methods for non-cigarette smokers and escalating smokers, and could also inform cessation treatment. The UPPS-P model (Whiteside & Lynam, 2001; Cyders & Smith, 2008) was selected as a method of operationalisation for trait impulsivity due to its growing acceptance in the literature, and evidence from other substances (alcohol, marijuana) indicating that the separable impulsivity-related traits of the UPPS-P model may be associated with different aspects of substance use through distinct pathways (Stautz & Cooper, 2013; VanderVeen et al., 2016).

The meta-analysis presented in Chapter 2 was the first to synthesize data on separable impulsivity-related traits and two aspects of cigarette smoking (smoking

status and severity of nicotine dependence) and showed that separate impulsivity-related traits do show differences in patterns of association with cigarette smoking and severity of nicotine dependence in adults. Lack of premeditation and positive urgency showed the largest associations with smoking status, indicating that cigarette smoking in adults is related to a reduced ability to consider the potential negative consequences of cigarette smoking prior to engaging in it, and a difficulty to regulate impulsive behaviour when in a positive emotional state. Positive urgency showed the largest association with severity of nicotine dependence, while negative urgency showed the second highest association, indicating that individual differences in regulating impulsive behaviour when experiencing an intense emotion is associated with an increase in the numbers of cigarette smoked. These results were replicated in the cross-sectional study reported in Chapter 3, where comparison between smokers and non-smokers in impulsivity-related traits showed that positive and negative urgency were associated with smoking status and severity of nicotine dependence. Such findings indicate that separate impulsivity-related traits differentially relate to smoking status and severity of nicotine dependence, and could potentially inform smoking cessation treatment plans. Thus, the first aim was achieved, and a novel contribution to the literature was made.

Aim 2: To examine the relationship between impulsivity-related traits and e-cigarette use in adults

The literature on impulsivity-related personality traits and e-cigarette use was shown to be limited compared to cigarette smoking. The few available studies have been conducted in specific populations (i.e., college students from USA), while most of these studies did not assess the multi-component nature of trait impulsivity. The

shortage of studies assessing trait impulsivity and e-cigarette use meant that no firm conclusion could be made regarding differential associations between impulsivity-relared traits and e-cigarette use.

The cross-sectional study reported in Chapter 3 was the first to investigate the relationship between the different facets of trait impulsivity based on the UPPS-P model, and was the first to do so in a more general sample of adult population mainly recruited from Europe. In this study we examined the predictive value of each impulsivity-related trait to differentiate e-cigarette users from non-smokers, cigarette smokers, and dual users. Findings from this chapter suggest that separate impulsivity-related traits significantly differentiate e-cigarette users from cigarette smokers and dual users, while e-cigarette users did not differ in any impulsivity-related trait from non-smokers. E-cigarette users reported lower levels of lack of perseverance and negative urgency compared to cigarette smokers, while they exhibited lower levels of positive and negative urgency compared to dual users. Findings from Chapter 5 also suggest that e-cigarette users exhibited lower levels of positive urgency compared to dual users. Chapter 3 also examined the relationships between impulsivity-related traits and frequency and intensity of e-cigarette behaviour, because such relationships have not been examined elsewhere. However, no significant relationships were found.

Regarding the role of trait impulsivity in e-cigarette use, a recent study conducted in the US suggests that trait impulsivity is related to e-cigarette use through positive e-cigarette attitudes as measured by a recently developed questionnaire: the Comparing E-cigarette and Cigarette questionnaire (CEAC; Hershberger, Karyadi et al. 2017). In Chapter 4, we tried to replicate and extend such findings by utilising a sample from a different population, based in Europe. Prior

to this we examined the psychometric properties of the CEAC questionnaire by testing its purported factor structure, reliability and its measurement invariance across e-cigarette use groups in a European sample. Replication is very important, especially for the reliability of a new measure. Our findings suggest that the CEAC questionnaire could be considered a reliable measure to assess attitudes towards e-cigarettes use across different populations. Our findings also supported previous research and suggest that the relationship between impulsivity-related traits and e-cigarette use is mediated through positive attitudes towards e-cigarette use in an adult population drawn from Europe only. Additionally, it was found that lower levels of lack of premeditation and lack of perseverance, and higher levels of negative and positive urgency, were related to more positive attitudes towards e-cigarettes and subsequent e-cigarette use.

To fulfil the second overall aim of the thesis we also examined the relationship between impulsivity-related personality traits and e-cigarette use among adult cigarette smokers. To this end, we compared cigarette smokers and dual users in impulsivity-related traits in Chapters 3, 5, and 6. Our findings consistently suggested that dual users exhibited higher positive urgency compared to cigarette smokers.

To summarize the evidence presented, our findings indicate that impulsivity-related traits as measured through the UPPS-P model, are risk factors for e-cigarette use in adults. Moreover, our findings suggest that impulsivity-related traits differentiate e-cigarette users from cigarette smokers and dual users. Such findings contribute to the existing literature by underlining that trait impulsivity is a risk factor for e-cigarette use among adults, an area that has not been widely researched yet. Additionally, our findings support these results in a more general sample of adults mainly recruited from Europe, and contribute to the literature of individual differences

and addictive behaviours. Our results also suggest that different impulsivity traits within the UPPS-P model seem to be associated with different classes of smoking status in adults. The integration of such findings to the existing literature on cigarette smoking and e-cigarette use is important, not only to help us to distinguish among likely non-smokers, potential smokers, e-cigarette users and dual users, but also in the future to inform treatment plans and decisions.

Aim 3: To examine the relationship between impulsivity-related traits, cravings and mood in cigarette smokers, e-cigarette users and dual users.

Past research has shown that trait impulsivity is associated with every aspect of cigarette smoking, including cravings from nicotine withdrawal. It has been suggested that cigarette smokers with higher levels of trait impulsivity experience stronger cravings from nicotine withdrawal. Additionally, e-cigarettes have been promoted as an effective way to deal with nicotine cravings. A number of cigarette smokers actually use an e-cigarette to deal with nicotine cravings in places where cigarette smoking is not permitted (Dawkins et al., 2013; Etter and Bullen, 2011). This claim is supported from findings in Chapter 3, where dual users cited that the second most important reason for their e-cigarette use was that it can be used indoors. Comparison of cravings among cigarette smokers and dual users showed that dual users exhibited higher levels than cigarette smokers for both the positive desire to smoke for reward scale, and the need to smoke for relief scale of cigarette cravings.

Another important factor linked with cigarette smoking and cravings is positive and negative mood. Once again, however, research investigating the link between positive and negative mood and e-cigarette use is limited.

Building on findings from Chapter 3, that dual users exhibited higher levels of cravings than cigarette smokers, the limited previous research, and gaps in the existing literature, the EMA study in Chapter 5 was designed to investigate differences in real-time cravings and real-time negative and positive mood among cigarette smokers, e-cigarette users and dual users. We also sought to examine the association between different facets of the UPPS-P model, cravings and moods among adult cigarette smokers, e-cigarette users and dual users.

The analysis of the EMA data from Chapter 5 indicated that dual users exhibited higher levels of need to smoke for relief scale of cravings and higher levels of negative mood than the other two groups. On the other hand, no significant difference in real-time cravings was found between cigarette smokers and e-cigarette users, while the three groups did not differ in their positive mood. Our findings also suggest a positive association between higher levels of urgency and cravings and moods. Such findings add to existing literature that suggest a significant positive association between negative mood and smoking status (Heckman et al., 2013; Kassel et al. 2003), and extends the existing literature by adding support of such results for real-time cravings. Additionally, it examines the relationship between cravings, moods and e-cigarette use. Results from Chapter 5 also add tentative support to findings from Chapter 3, which indicated that the impulsivity-related trait of positive urgency significantly differentiated e-cigarette users from dual users.

Aim 4: To examine the relationship between e-cigarette use, trait impulsivity and smoking cessation

There has been a great controversy over the potential effectiveness of e-cigarette use as a smoking cessation tool (i.e Beard et al., 2016; Kalkhoran & Glantz, 2016; Zhu, Zhuang, Wong, Cummins & Tedeschi, 2017). Findings from the cross-sectional study in Chapter 3 suggest that one of the main reasons for e-cigarette use was as an aid for smoking cessation. The majority of e-cigarette users chose this as their sole reason for e-cigarette use, suggesting that most e-cigarette users were ex-cigarette smokers, although the study did not assess smoking history of e-cigarette users. Among dual users, smoking cessation was also a main reason for e-cigarette use, while further analysis showed that dual users who intended to quit smoking within 6 months were more likely to report smoking cessation as a reason for e-cigarette use. However, it should be noted that these findings are based on cross-sectional data, while no data on cessation outcomes was collected. Thus, caution should be taken in the interpretation of these findings. In order to address these limitations of Chapter 3, we conducted a longitudinal, prospective study described in Chapter 6.

This longitudinal study examined whether e-cigarette use among adult cigarette smokers increased both probability of making a quit attempt and success of smoking cessation at three months follow-up. Our findings suggest that use of e-cigarettes in non-treatment seeking adult smokers is associated with a higher rate of quitting smoking three months later relative to smokers who did not use e-cigarettes. Such findings add evidence to recent research that indicates e-cigarettes are a useful smoking cessation aid (i.e. Adriaens et al. 2014; Biener & Hargraves, 2015; Beard et al., 2016). Results from Chapter 6 also suggest that dual users who claimed at baseline that they use their e-cigarette to help them quit smoking were more likely to stop cigarette smoking at 3 months follow-up than those who did not,

confirming the findings of Chapter 3 that one of the main reasons users give for e-cigarette use is as an aid for smoking cessation. We also examined the association of trait impulsivity as measured through the UPPS-P model and smoking cessation, but no significant findings were reported. As discussed in Chapter 6, previous studies have linked trait impulsivity with difficulties in quitting cigarette smoking. The discrepancy of our results from previous studies may be accounted for by the study design, as most of the previous studies were clinical trials (Kahler et al., 2009; Doran et al., 2014; Littlewood et al., 2017), or the discrepancy might result from differences in the way trait impulsivity was measured. Moreover, our low numbers of participants who quit smoking at three months follow-up may have limited the statistical power of finding any significant association.

Implications

Intensive tobacco control efforts to reduce the uptake of cigarette smoking and to convince current smokers to quit have been undertaken over the past decades in most western countries (WHO, 2018). However, interventions to reduce smoking prevalence often show limited effectiveness (e.g. Cahill, Lindson-Hawley, Thomas, Fanshawe & Lancaster, 2016; Hughes, Stead, Hartmann-Boyce, Cahill & Lancaster, 2014; Moore et al., 2009; Stead et al., 2012), so that cigarette smoking still remains the leading preventable cause of morbidity and premature mortality (WHO, 2018). Our findings provide evidence that trait impulsivity is associated with being a cigarette smoker. Thus, in addition to present smoking cessation programmes, attempts to reduce cigarette smoking should also target specific impulsivity-related traits as suggested in Chapter 2. For example interventions that focus on changing or removing environmental cues that promote smoking, such as

switching to standardised cigarette packaging or legislating that vendors must place cigarettes behind opaque covers, could be particularly helpful for smokers high in impulsivity-related traits. Additionally, smokers with higher levels of lack of premeditation could benefit from organization and cognitive remediation training, and learning how to break tasks down into manageable steps along with sticking to long-term goals.

The urgency traits showed the highest association, amongst impulsivity-related traits, with nicotine dependence. Such information may be useful for the planning of programmes to help impulsive smokers to quit. It has been suggested that individuals high in negative and/or positive urgency could benefit especially from cognitive behavioural therapies that focus on changing smokers' reactions to their urges to smoke (Zapolski, Settles, Cyders, & Smith, 2010). For example, learning to identify behavioural patterns that lead to acting rashly in response to distress or intense emotions, and learning how to stop and adjust an emotional reaction have proved helpful (Dimeff & Linehan, 2008; Linehan, 1993). Additionally, addressing the influence of positive urgency in smoking cessation interventions could include therapies to train smokers to identify alternative ways of acting when experiencing positive emotions, or to help them identify signs that they are at risk of having a cigarette and develop reminder cues to help smokers remain focused on their long-term goal of abstinence. Such techniques have been proven effective to overcome addictive behaviours (Zapolski, Settles, Cyders, & Smith, 2010).

The findings regarding e-cigarette use presented in this thesis may also have relevance to smoking cessation interventions. If, as suggested here, e-cigarettes can suppress cravings and they can actually help cigarette smokers to quit smoking they can serve as an effective smoking cessation tool. Indeed, it has been recognized

from the stop smoking services in England that the best possible option for smokers to quit cigarette smoking is by combining stop smoking services support with e-cigarette use (McNeill, Brose, Calder, Bauld & Robson, 2019). Our findings also showed that distinct impulsivity-related personality differentiate e-cigarette use from dual use and from cigarette smoking. As such, it could be recommended that different factors should be targeted to reduce dual use and to encourage smokers to switch from cigarette smoking to e-cigarette use. Different interventions have been identified for addressing the distinct impulsivity-related factors, as described by the UPPS-P model (Zapolski, Settles, Cyders, & Smith, 2010). Additionally, our findings from Chapter 4 suggest people high in conscientiousness as measured by two facets from the UPPS-P (lack of premeditation and lack of perseverance) hold more favourable attitudes towards e-cigarettes compared to cigarettes and subsequently are more likely to use an e-cigarette. Thus, strategies to prevent e-cigarette use among high conscientiousness non cigarette smoker individuals should focus on changing overly positive views of e-cigarette use by communicating the risks associated with e-cigarette use compared to non-smoking. On the other hand, these strategies should also communicate that e-cigarettes are likely less harmful compared to cigarette smoking and could serve as an effective smoking cessation tool to cigarette smokers. Such strategies should be also considered to prevent e-cigarette use in young adults and adolescents, as recent findings show a sharp increase in youth usage of e-cigarette use in the USA (Jenssen & Boykan, 2019).

Limitations

Specific limitations of each study have been underlined in the respective chapters. Here, some weaknesses and limitations of the overall thesis will be discussed, focusing mainly on the samples used and the measures employed.

Samples

One limitation faced in all empirical studies reported in this thesis was the recruitment method. Participants were recruited online from university students, from social media, and from a platform that consisted of individuals who were interested in participating in research surveys in exchange for money. Online recruitment offers an easy way to quickly recruit a large sample (Lane, Armin & Gordon, 2015). However, there are a number of potential limitations in the use of online recruitment when compared with in-person recruitment. For example, racial and ethnic differences exist in the accessibility and use of internet (Dutton & Blank, 2011), while those who participate in online studies tend to be younger adults and more familiar with web-based technology (Moore & Tarnai, 2002). Thus, certain socio-demographic groups are likely to have been under-represented in our studies; for example, both older individuals and those with lower incomes. Indeed the mean average age of our participants was 31 years across studies. However, previous research suggests that adults aged between 18-49 years represent the subgroup with the highest prevalence of e-cigarette use (Pericot-Valverde et al., 2017), while the highest proportion of current smokers in UK are people aged 25 to 34 years old (Office for National statistics, 2019).

Additionally, the samples from empirical studies were from non-clinical population, while the meta-analysis reported in Chapter 2 included a very small number of studies sampled from clinical populations. Thus, there is a limitation of generalizability of findings to clinical populations.

Another limitation of the samples used in our studies was that the majority of participants were not highly cigarette dependent smokers and were intermittent e-cigarette users. Thus, it is possible that our findings may not be relevant to other populations, i.e. smokers with high nicotine dependence or heavier e-cigarette users.

Measures

As with nearly all online studies, all our empirical data relied on self-reported information. This presents the possibility that participants do not provide answers that reflect their actual beliefs and behaviours, and thus not all responses are valid and accurate. Previous research has concluded that in-person survey measures also suffer from similar challenges that rely on the openness of the participants (Kraut et al., 2004). We also acknowledge the fact that we cannot verify smoking status via online studies. Current smoking status was exclusively self-reported and retrospective in all studies. However, we attempted to design quality screens by asking a number of questions related to smoking status (i.e. number of cigarette smoked, last time of cigarette/ e-cigarette use); of course this is not a proven method of objectively verifying smoking status. Biochemical validation, such as urine cotinine tests, is the optimal way to validate the smoking status of a sample. However, such method has its own disadvantages including cost and time of administration. Moreover, prior validation studies have shown self-reported cigarette smoking behaviours among adults are consistent and reliable (Patrick et al., 1994), while

some studies have shown that self-reported smoking was validated strongly by biological markers (Wong, Shields, Leatherdale, Malaison, & Hammond, 2012).

Another limitation of our empirical studies was the way e-cigarette use was measured. The questions administered to measure quantity and frequency of e-cigarette use were based on questions used in previous research (Bold et al., 2018). However, it is widely acknowledged that quantifying frequency and intensity of e-cigarette use is difficult as e-cigarette users report that e-cigarette use typically occurs in short, frequent sessions that are often difficult to count (Baweja et al., 2016; Cooper, Harrell & Perry, 2016). Additionally, there is not a valid and reliable measure to date to accurately measure e-cigarette use, while there is only one recently developed e-cigarette dependence measure (The Penn State Electronic Cigarette Dependence Index; Foulds et al., 2015), which captures some, but not all, of the constructs that are essential to accurately measure e-cigarette dependence (Bold et al., 2018).

A further limitation of our empirical studies is that we did not assess the characteristics of the e-cigarette device used by participants, as well as the type of e-liquid used. Previous research suggests that different devices and e-liquid characteristics can have a profound influence on users' nicotine delivery, and presumably on a user's frequency and intensity of e-cigarette use (Farsalinos & Polosa, 2014). Second and third generation devices are more effective at delivering nicotine and are more effective as a smoking cessation tool than first generation cigalike devices (Chen, Zhuang, & Zhu, 2016; Hitchman et al., 2015).

Additionally, it should be acknowledged that the studies reported in Chapter 3 and 5 did not assess the smoking history of e-cigarette users. We assessed only whether participants had ever smoked cigarettes in their lives, and their current

reasons for e-cigarette use. The results of these questions suggest that most e-cigarette users were ex-cigarette smokers. If the fact that most e-cigarette users were former cigarette smokers was validated from our questionnaires, more support would have been provided to our findings aiming to evaluate the effectiveness of e-cigarette use as a smoking cessation tool.

Finally, it should be noted that the e-cigarette devices, as well as the marketing and regulatory environment of e-cigarette use, are continuously changing. All of these factors could influence e-cigarette use, attitudes towards e-cigarettes and the role of e-cigarette use in smoking cessation. It is then hard to say whether our results will be able to be translated into widely-applicable, real world recommendations regarding e-cigarette use.

Future directions

This section will discuss suggestions for future research based on the main findings and limitation of the thesis. It will focus on the broader research themes, as possible future directions of each study have been discussed in respective chapters.

The UPPS-P framework used in the present thesis to examine individual differences in trait impulsivity and smoking status is considered a reliable and valid self-report measure (Smith et al., 2007). However, the causality of the relationship between the impulsivity-related traits and addictive behaviours is not well established. For example, it is not clear if positive urgency leads to increased cigarette smoking or increased smoking may result in higher levels of positive urgency. There is some evidence suggesting that higher levels of impulsivity can be either a consequence or a determinant of an addictive behaviour (de Wit, 2009). On the other hand, it has been also suggested that personality traits are relatively

consistent over a person's lifespan (Roberts & DelVecchio, 2000). The studies presented in this thesis did not assess how the impulsivity-related traits might be influenced by previous smoking behaviour. Thus, future longitudinal studies are needed to strengthen our understanding of the causal sequence between traits and smoking status.

Further research is also needed to determine whether the impulsivity-related traits linked to cigarette smoking are useful in the context of designing campaigns and interventions to discourage people from starting smoking, and to help current smokers to quit. We also need to establish if the available stop smoking therapies are effective in helping impulsive smokers to quit smoking, and whether interventions targeting the specific impulsivity-related traits that are most closely associated with cigarette smoking, such as positive and negative urgency, are effective in helping impulsive smokers to quit. For example, future studies may examine if Cognitive Behavioural Therapy focusing on controlling responses to affective stimuli is effective for those smokers who score higher on urgency.

One of the main issues of our studies examining e-cigarette use was how to accurately measure frequency, intensity, and dependency of e-cigarette use. Thus, future research needs to focus on creating valid and reliable measures of e-cigarette use. This will not only help to accurately measure e-cigarette use, but also to compare findings between studies. Alternatively, if newer e-cigarette devices that could log users' usage were introduced to the market, this could potentially help future longitudinal studies on e-cigarette use.

There is a huge concern about the use of e-cigarettes in young adults and adolescents and the possible addictive nature of such products (i.e. Conner et al., 2018; Soneji et al., 2017), while the long–term effects of e-cigarettes on young

bodies and brains remain unknown. Additionally a number of studies have shown that young adults who use an e-cigarette are likely to smoke cigarettes in the future, but none has established a causal link (Glasser, Abudayyeh, Cantrell & Niaura, 2019). Thus, well conducted and well-powered longitudinal studies are needed to give a better insight in to these issues.

Changes in the e-cigarette devices, marketplace and policies are creating even more areas for research. E-cigarette devices are changing quickly. Initially e-cigarettes mimicked the look and feel of cigarettes, while nowadays the devices are more complex; they can be customized, while their nicotine concentration has been also increased. It has been suggested that Juuls, one of the newest e-cigarette device, contain as much nicotine as a pack of 20 cigarettes (Spindle & Eissenberg, 2018). E-cigarette marketing has also evolved by becoming more sophisticated, while reaching more consumers through the widely available social media. E-cigarette regulations have been only introduced in the last couple of years, while they vary from country to country, and now customers and retailers are adapting to these regulations. Thus, understanding factors associated with e-cigarette use among adult and adolescents smokers and non smokers, as in the present thesis, is important. But this information must be combined with work on how e-cigarettes affect health, how the use of e-cigarettes may affect use of other tobacco products, and whether e-cigarettes help people to quit cigarette smoking or increase health risks. Integrated programmes of research will be needed that can rapidly respond to the changing landscape of findings in all these areas.

Conclusion

The present programme of research has given a better insight into the role of distinct facets of trait impulsivity in cigarette smoking, nicotine dependence and e-cigarette use among adults. It has consistently showed that cigarette smokers are more impulsive than non smokers, while emotion-based impulsivity, or urgency, is the impulsivity-related trait most associated with nicotine dependence. It has also identified different relationships between specific impulsivity-related traits and different classes of smokers and e-cigarette users, suggesting that lack of perseverance differentiated e-cigarette users from cigarette smokers, and negative and positive urgency differentiated e-cigarette users from dual users. The thesis has also provided support for a model in which trait impulsivity is related to e-cigarette use through positive e-cigarette attitudes, while it also suggest that urgency is a significant predictor of cravings and moods in cigarette smokers, e-cigarette users and dual users. Finally, the research has considered the role of e-cigarette use in smoking cessation, suggesting that e-cigarette use could potentially be a useful tool in helping cigarette smokers to quit smoking. It is hoped that the research outlined in the present thesis will contribute to theoretical development of models of nicotine addiction, will help to inform screening and prevention efforts to reduce the number of adult smokers, and will encourage more research in personality traits and cigarette smoking and e-cigarette use.

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Appendix I

Trai impulsivity, cravings and moods

Linear regression analyses to examine which dimension of the five impulsivity-related traits based on the UPPS-P scale best describes cravings and moods in cigarette smokers, e-cigarette users (reference group), and dual users.

The Bonferroni-adjusted critical alpha for these analyses is 0.004. Any p values less than 0.05 are noted in the tables.

Cravings

Three linear regressions were conducted using the dimension of positive desire to smoke for reward subscale of cravings as the criterion variable and smoking status, negative urgency, positive urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point. As shown in Table 10, analysis indicated that none of the impulsivity-related traits of the UPPS-P model was a significant predictor of the positive desire to smoke for reward subscale of cravings in any time point after correcting for multiple comparisons.

Table 10. Linear Regressions examining the relationship between trait impulsivity and positive desire to smoke for reward subscale of cravings at each of 3 time points

	Cravings1_T1			Cravings1_T2			Cravings1_T3		
Predictor variables	B	SE B	β	B	SE B	B	B	SE B	β
Smokers	0.051	0.279	0.021	0.035	0.283	0.014	0.140	0.289	0.053
Dual users	0.384	0.297	0.157	0.338	0.301	0.137	0.404	0.308	0.152
Negative Urgency	0.412	0.335	0.201	0.438	0.339	0.212	0.376	0.346	0.168
Positive Urgency	-0.018	0.274	-0.010	-0.136	0.277	-0.076	0.411	0.284	0.213
Lack of Premeditation	-0.408	0.356	-0.129	-0.331	0.360	-0.104	-0.643	0.368	-0.187
Lack of Perseverance	-0.115	0.336	-0.045	0.269	0.340	0.105	-0.129	0.348	-0.047
Sensation seeking	0.159	0.177	0.092	0.180	0.179	0.103	0.025	0.183	0.013

Cravings1_T1: $F(7,95)=1.225$, $p=0.297$, $R^2=0.083$; Cravings1_T2: $F(7,95)=1.217$, $p=0.301$, $R^2=0.082$; Cravings1_T3: $F(7,95)=2.881$, $p=0.009$, $R^2=0.175$

*$p\leq0.05$, **$p\leq0.01$, ***$p\leq0.001$ uncorrected for multiple comparisons

Similarly, three linear regressions were conducted using the dimension of need to smoke for relief subscale of cravings as the criterion variable and smoking status, negative urgency, positive urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point (Table 11). Being a dual user, and positive urgency showed a positive relation with the need to smoke for relief subscale of cravings during morning (t=3.08, *p*=0.003 dual use; t=2.97, *p*=0.004 positive urgency), while only positive urgency remained significantly positively related to this subscale of cravings during afternoons and evenings (t=3.11, *p*=0.002; t=3.86, *p*<0.001, respectively).

11. Linear Regressions examining the relationship between trait impulsivity and need to smoke for relief subscale of cravings at each of 3 time points

	Cravings2_T1			Cravings2_T2			Cravings2_T3		
Predictor variables	B	SE B	β	B	SE B	B	B	SE B	β
Smokers	0.253	0.274	0.093	0.144	0.271	0.055	0.386	0.282	0.135
Dual users	0.899	0.292	0.325**	0.732	0.289	0.276*	0.852	0.300	0.293**
Negative Urgency	-0.242	0.329	-0.104	-0.472	0.325	-0.212	-0.406	0.338	-0.167
Positive Urgency	0.800	0.269	0.400**	0.829	0.266	0.432**	1.068	0.277	0.507***
Lack of Premeditation	-0.847	0.349	-0.237*	-0.823	0.345	-0.240*	-0.867	0.359	-0.230*
Lack of Perseverance	0.127	0.330	0.044	0.354	0.326	0.129	0.206	0.339	0.068
Sensation seeking	0.067	0.173	0.034	0.003	0.171	0.002	0.030	0.178	0.015

Cravings2_T1: $F(7,95)=6.134$, $p=0.001$, $R^2=0.311$; Cravings2_T2: $F(7,95)=4.909$, $p<0.001$, $R^2=0.266$; Cravings2_T3: $F(7,95)=7.087$, $p<0.001$, $R^2=0.343$

*$p\leq0.05$, **$p\leq0.01$, ***$p\leq0.001$ uncorrected for multiple comparisons

Moods

Three linear regressions were conducted using negative mood as the criterion variable and smoking status, negative urgency, positive urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point. As shown in Table 12, analysis indicated that none of the impulsivity-related traits of the UPPS-P model was a significant predictor of the positive desire to smoke for reward subscale of cravings in any time point.

12. Linear Regressions examining the relationship between trait impulsivity and negative mood at each of 3 time points

	Negative_mood_T1			Negative_mood_T2			Negative_mood_T3		
Predictor variables	B	SE B	β	B	SE B	B	B	SE B	β
Smokers	-0.027	0.148	-0.019	-0.056	0.150	-0.037	-0.011	0.148	-0.007
Dual users	0.096	0.157	0.065	0.223	0.159	0.145	0.426	0.157	0.262**
Negative Urgency	0.305	0.177	0.247	0.268	0.179	0.208	0.256	0.177	0.188
Positive Urgency	0.235	0.145	0.220	0.295	0.147	0.265	0.339	0.145	0.288*
Lack of Premeditation	-0.435	0.188	-0.228*	-0.391	0.191	-0.197*	-0.464	0.188	-0.221*
Lack of Perseverance	0.312	0.177	0.204	0.273	0.180	0.171	0.321	0.178	0.191
Sensation seeking	0.022	0.093	0.021	0.042	0.095	0.039	0.022	0.093	0.019

Negative_affect_T1: F(7,95)=2.110, $p<0.001$, $R^2=0.301$; Negative_affect_T2: F(7,95)=6.841, $p<0.001$, $R^2=0.335$; Negative_affect_T3: F(7,95)=9.790, $p<0.001$, $R^2=0.419$

*$p\leq0.05$, **$p\leq0.01$, ***$p\leq0.001$ uncorrected for multiple comparisons

Similarly, three linear regressions were conducted using positive mood as the criterion variable and smoking status, negative urgency, positive urgency, sensation seeking, lack of premeditation, and lack of perseverance as predictors for each time point (Table 13). Again, the analysis revealed no significant association between any impulsivity-related traits and positive mood.

13. Linear Regressions examining the relationship between trait impulsivity and positive mood at each of 3 time points

	Positive_mood_T1			Positive_mood_T2			Positive_mood_T3		
Predictor variables	B	SE B	β	B	SE B	B	B	SE B	β
Smokers	0.348	0.143	0.256*	0.306	0.150	0.220*	0.155	0.147	0.112
Dual users	0.166	0.152	0.121	0.054	0.159	0.038	-0.002	0.157	-0.001
Negative Urgency	-0.287	0.172	-0.248	-0.289	0.180	-0.245	-0.325	0.177	-0.276
Positive Urgency	-0.114	0.141	-0.114	0.016	0.147	0.016	-0.104	0.145	-0.102
Lack of Premeditation	0.331	0.182	0.185	0.277	0.191	0.152	0.349	0.188	0.192
Lack of Perseverance	-0.296	0.172	-0.207	-0.379	0.180	-0.259*	-0.293	0.177	-0.201
Sensation seeking	0.099	0.091	0.102	0.052	0.095	0.052	0.031	0.093	0.031

Positive_affect_T1: F(7,95)=4.421, $p<0.001$, $R^2=0.246$; Positive_affect_T2: F(7,95)=3.619, $p=0.002$, $R^2=0.211$; Positive_affect_T3: F(7,95)=4.000, $p=0.001$, $R^2=0.228$

*$p\leq0.05$, **$p\leq0.01$, ***$p\leq0.001$ uncorrected for multiple comparisons