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Title:

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

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

Abstract

Aims: The present study aimed to investigate the relationship between impulsivity-related personality traits based on the UPPS-P model and e-cigarette use. The study used a sample of mainly European adults and compared e-cigarette users with non-smokers, cigarette smokers and dual users (those who currently smoke cigarettes and use e-cigarettes). Additionally, the relationship between impulsivity-related traits and frequency and intensity of e-cigarette use was examined, while the main reasons for e-cigarette use were also assessed.

Methods: Participants were 720 adults (234 non-smokers, 164 smokers, 150 e-cigarette users, 172 dual users), who completed online questionnaires regarding sociodemographics, smoking/e-cigarette use behaviour, and impulsivity (UPPS-P scale).

Results: Impulsivity-related traits did not significantly 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. Negative urgency also significantly differentiated smokers and non-smokers, with smokers having higher levels of the trait. No significant results were found examining the relationship between the impulsivity-related traits and e-cigarette behaviour (number of days vaping per month, number of times vaping per day, and millilitres of e-liquid used per day). The main reason given for e-cigarette use was the perception that it is less harmful than cigarettes.

Conclusion: The present study found that trait impulsivity differentiated e-cigarette users from cigarette smokers and dual users, but did not differentiate e-cigarette users from non-smokers. Such findings are important to not only help us identify factors associated with e-cigarette use, but also to potentially inform treatment plans and decisions.

Highlights: Trait impulsivity did not differentiate e-cigarette users from non-smokers. Lack of perseverance and negative urgency differentiated e-cigarette users from cigarette smokers.
Negative and positive urgency differentiated e-cigarette users from dual users
Trait impulsivity was unrelated to measures of frequency and intensity of e-cigarette use

Keywords: impulsivity, e-cigarette use, UPPS-P model, smoking

1.0 Background

Over the past few years, smoking prevalence has decreased in many Western countries, while the use of electronic cigarettes (e-cigarettes) has increased rapidly (McMillen, et al., 2015; Ghosh et al., 2019). Population surveys in the United Kingdom (UK) have found that the use of e-cigarettes has more than doubled between 2012 and 2018, rising from approximately 2% to 6% (Ash, 2019).

An e-cigarette is a battery-powered device that delivers nicotine to the respiratory system via a combustion-free tobacco inhalation process (Caponnetto et al., 2011). It does not contain tobacco and consumers may choose between several nicotine strengths, including non-nicotine liquids. Initial evidence indicates that e-cigarettes are less harmful compared to conventional cigarettes, as the exposure to cancer-related agents is reduced because no tobacco is burnt (Goniewicz et al., 2013). However, the risk of cardiovascular disease may be increased as e-cigarettes expose users to high levels of particulates (Siasos et al., 2012). Given the rapidly increasing rates of e-cigarette use and mixed findings to date regarding the health impacts associated with its use, there is a real need to better understand individual risk factors 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. It is suggested that the first group of people use e-cigarettes as a means of reducing or quitting smoking, as e-cigarettes appear to reduce cravings and withdrawal symptoms associated with abstinence from smoking, as an alternative in settings where cigarettes are banned (Dawkins et al., 2013), or for recreation and affect regulation (Brandon et al., 2019; Brikmanis, Petersen &Doran, 2017; Patel et al., 2019). The reasons for e-cigarette use in the second group are, however, not very well documented. 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 the reasons why individuals use e-cigarettes to help address potential progress into smoking early on.

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 male, younger, of White ethnicity and more highly educated was associated with higher likelihood of e-cigarette use (McMillen et al., 2012; Richardson et al., 2014; King et al., 2015). Less is known regarding personality traits, such as impulsivity, 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 et al., 2018).

Consensus is growing that trait impulsivity is best described as a multi-dimensional construct composed of five different personality dispositions: negative urgency (the tendency to act rashly in response to negative mood), positive urgency (the tendency to act rashly when experiencing intense positive mood), sensation seeking (the tendency to seek out novel experiences), lack of perseverance (the inability to remain focused on a task), and lack of premeditation (the tendency to act without thinking; Cyders & Smith, 2007; Cyders et al., 2007). A recent meta-analysis (Kale et al., 2018) showed that these five dispositions are positively associated with both smoking status and severity of nicotine dependence. In particular, it was found that positive urgency and lack of premeditation showed the largest mean associations with smoking status, while positive urgency showed the largest mean association with severity of nicotine dependence.

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 et al. (2016) on women of reproductive age has shown that trait impulsivity as measured by the Barratt Impulsiveness Scale-11 (Patton et al., 1995) did not predict e-cigarette use among current smokers, but only among never smokers. Studies on young adults have shown that sensation seeking (Cohn et al. 2015; Doran & Tully, 2018) and lack of perseverance (Spindle et al., 2017) positively predict e-cigarette use among smokers and non-smokers. Doran and Tully's study used a community sample. Clearly, the relationship between e-cigarette use and impulsivity warrants further investigation.

Most of the 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 United States of America (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 which contain high levels of nicotine (around 60mg/ml) capture 70% of the US vaping market (Spindle & Eissenberg, 2018). These devices are very popular, especially among young adults in the 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 &

3

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. Moreover, the present study examines the relationship between impulsivity-related traits and frequency and intensity of e-cigarette behaviour, as such relationship have not been examined elsewhere. Thus, 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. 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. First, we hypothesized that higher levels of trait impulsivity would predict membership of the e-cigarette use group compared to the non-smoking group, and lower levels of trait impulsivity would predict membership of the e-cigarette use group compared to the smoking and dual use groups. Secondly, that higher levels of trait impulsivity would 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 would be most important in the specific context of e-cigarette use. Thirdly, given the previous research linking impulsivity with cigarette smoking, we hypothesized that higher levels of the impulsivity-related traits of negative and positive urgency would be associated with cigarette smoking status and higher levels of nicotine dependence.

2.0 Methods

2.1 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; and via Prolific, which is an online web service that connects researchers with individuals willing to complete tasks for a wage. 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. Data collection occurred between November/2017 and May/2018. The study was

approved by the Goldsmiths, University of London, Psychology Department Ethics Committee.

2.2 Measures

Demographics: Participants reported age, gender, country of residence, employment status, and ethnicity. 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).

Smoking behaviour: Nicotine dependence of cigarette smokers was measured with the Fagerstrom test for Nicotine dependence (FTND), a widely used six-item questionnaire (range: 0-10), which assesses various aspects of smoking behaviour (Heatherton et al., 1991). The FTND has demonstrated good construct validity and internal consistency, and the alpha reliability was 0.72 in the present sample.

E-cigarette use behaviour: 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 using the 59-item UPPS-P Impulsive Behaviour Scale (Cyders et al., 2007; Whiteside & Lynam, 2001), which assesses five dimensions of impulsivity: negative urgency, positive urgency, lack of premeditation, lack of perseverance, and sensation seeking. 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 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.

2.3 Data analysis

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, occupation, country of residence and gender, to assess the predictive value of each impulsivity-related trait separately in differentiating the 4 groups of participants in this study. The ability of impulsivity traits to discriminate between pairs of levels of the categorical outcome variable were tested via planned contrasts. Three contrasts looked at the ability to discriminate e-cigarette from each of the other 3 groups. A final contrast tested the ability to discriminate cigarette smokers compared with non-smokers.

Further multinomial 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, occupation, country of residence 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.

All data were analysed using IBM SPSS version 23.

3.0 Results

3.1 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, 69.0%) had heard of, or seen, an e-cigarette, while a total of 20.8% (n=150) of respondents were e-cigarette users, 22.8% (n=164) were cigarette smokers, 23.9% (n=172) were dual users and 32.5% (n=234) were non-smokers.

Omnibus test for the four groups overall comparisons (Table 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.

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.

3.2 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).The planned contrast analyses focussing on the discrimination of pairs of user groups (and corrected for multiple comparisons) are detailed in Table 2. These showed that impulsivity-related traits did not differentiate e-cigarette users from non smokers.

Lack of perseverance (OR=1.80, 95% CI 1.09-2.80) was the only impulsivity related trait which differentiated e-cigarette users (Mean=2.01, SD=0.52) from cigarette smokers (Mean=2.17, SD=0.52) after correcting for multiple comparisons. A 1-point increase in lack of perseverance was associated with 1.8 times the odds of being in the cigarette smokers group than in the e-cigarette group. However, negative urgency (OR=1.53, 95% CI 1.05-2.25) was able to differentiate cigarette smokers (higher negative urgency scores) from e-cigarette users (lower negative urgency scores) 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=1.94, 95% CI 1.35-2.80) and positive (OR=2.04, 95% CI 1.47-2.84) urgency significantly differentiated dual smokers (Negative Urgency: Mean=2.64, SD=0.63; Positive Urgency: Mean=2.36, SD=0.75) from e-cigarette users (Negative Urgency: Mean=2.40, SD=0.59; Positive Urgency: Mean=2.02, SD=0.65), when used as single predictors. Thus, a 1-point increase in negative urgency was associated with 1.94 times the odds of being a dual user than an e-cigarette user, while a 1-point increase in positive urgency was associated with just over twice the odds of being a dual user than an e-cigarette user. 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 significantly (OR=1.96, 95% CI 1.11-3.42; a 1-point increase in positive urgency was associated with 1.96 times the odds of being a dual user than an e-cigarette user). Separate analyses using each impulsivity scale as a predictor showed that negative urgency (OR=1.85, 95% CI 1.28-2.67) was the only impulsivity trait which significantly differentiated smokers (Mean=2.55, SD=0.63) from non-smokers (Mean=2.34, SD=0.58) after correcting for multiple comparisons. Thus, a 1-point increase in positive urgency was associated with 1.85 times the odds of being a smoker than a non-smoker. However, positive urgency (OR=1.60, 95% CI 1.15-2.22), lack of premeditation (OR=1.74, 95%CI 1.10-2.74) and lack of perseverance (OR=1.69, 95% CI 1.09-2.64) were able to differentiate cigarette smokers from non-smokers to a lesser extent, with smokers having higher scores on all these three impulsivity-related traits relative to non-smokers; 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.

3.3 Examining the relationship between impulsivity-related traits and nicotine dependence (cigarette smokers only group)

The mean FTND score for smokers was 2.68 (SD=2.40), showing low nicotine dependence. 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.

3.4 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). 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.

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%).

3.5 Examining the relationship between impulsivity-related traits and frequency and intensity of e-cigarette use (e-cigarettes only group)

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.

4.0 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 than cigarette smokers, while they 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 significantly 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 only, 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, people who smoke cigarettes and use an e-cigarette. We offer a speculative post hoc explanation for these results: it might be that lack of perseverance, the inability to remain focused on the goal of stopping a behaviour, is higher in cigarette smokers only than e-cigarette users in particular 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). The smokers may therefore be less persistent in their attempts to use an alternative such as an e-cigarette to replace cigarette smoking completely and so return exclusively to cigarettes. Dual users fall between the other groups in terms of lack of perseverance. Any post-hoc explanation about such differences, or lack of differences, between these groups is limited by the probable heterogeneity in the motivations and reasons for e-cigarette use in both e-cigarette and dual user groups.

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

9

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/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). Our findings

also suggest that the main reason for e-cigarette use is not smoking cessation, in line with emerging evidence (Brandon et al., 2019; Patel et al., 2019).

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 et al., 2018), as smoking to alleviate negative and positive mood states is a common motivation for smokers (Doran et al., 2009; Spillane at al., 2010).

Should the current findings 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 (Farsalinos & Polosa, 2014), although recent evidence has linked e-cigarette use with six deaths in USA (Centers for Disease Control and Prevention, 2019), and that e-cigarette use may serve as a useful smoking cessation aid (Public Health England, 2015). 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). 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).

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

recently been found to be an important factor for e-cigarette use (Brandon et al., 2019). We carried out quite a large number of statistical comparisons in this study without making any correction for this. While many of the key comparisons had small p-values that would have survived such a correction, others did not. We illustrated the effects of applying a conservative Bonferroni correction for multiple comparisons in Table 2. 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.

4.1 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.

Conflict of interest:

No conflict declared

Contributors:

Authors Dimitra Kale and Andrew Cooper designed the study. Author Dimitra Kale coordinated study data collection, conducted the statistical analysis and wrote the first draft of the manuscript. All authors have contributed to and have approved the final manuscript.

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Table 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**	**%**	**Chi² 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 of these	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

Table 2. Impulsivity-related characteristics by smoking status

Variable	1.Non-smokers n=234		2. Smokers n=164		3. E-cig users n=150		4. Dual users n=172		Contrasts (logistic regression for each impulsivity-related trait separately) Odd Ratio (95%CI)			
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	1 vs 2	1 vs 3	2 vs 3	3 vs 4
Lack of Premeditation	1.94	0.49	2.04	0.43	1.98	0.46	2.00	0.49	1.74 (1.10-2.74)*	0.67 (0.41-1.11)	1.17 (0.71-1.91)	1.13 (0.70-1.82)
Lack of Perseverance	2.08	0.46	2.17	0.52	2.01	0.52	2.05	0.46	1.69 (1.09-2.64)*	0.97 (0.59-1.58)	**1.80 (1.09-2.80)****	1.33 (0.82-2.14)
Sensation Seeking	2.53	0.59	2.55	0.61	2.57	0.61	2.66	0.61	1.20 (0.82-1.75)	0.83 (0.54-1.25)	0.99 (0.65-1.49)	1.41 (0.94-2.10)
Negative Urgency	2.34	0.58	2.55	0.63	2.40	0.59	2.64	0.63	**1.85 (1.28-2.67)*****	0.83 (0.56-1.22)	1.53 (1.05-2.25)*	**1.94 (1.35-2.80)*****
Positive Urgency	1.93	0.65	2.14	0.70	2.02	0.65	2.36	0.75	1.60 (1.15-2.22)**	0.94 (0.65-1.34)	1.49 (1.06-2.11)	**2.04 (1.47-2.84)*****

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

*$p<0.05$, **$p<0.01$, ***$p<0.001$ unadjusted for multiple comparisons. We conducted 20 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. The Bonferroni-adjusted critical alpha for these analyses would be 0.0025. Bold cells indicate which comparisons survive this conservative correction.

1 versus 2: contrast between non-smokers and smokers (reference category=non-smokers)

1 versus 3: contrast between non-smokers and e-cigarette users (reference category= e-cigarette users)

2 versus 3: contrast between smokers and e-cigarette users (reference category= e-cigarette users)

3 versus 4: contrast between e-cigarette users and dual users (reference category= e-cigarette users)

Table 3. 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	%	Chi² 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

20

Highlights:

- Trait impulsivity did not differentiate e-cigarette users from non-smokers.
- Lack of perseverance and negative urgency differentiated e-cigarette users from cigarette smokers.
- Negative and positive urgency differentiated e-cigarette users from dual users
- Trait impulsivity was unrelated to measures of frequency and intensity of e-cigarette use