SUBSTANCE USE & MISUSE

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

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Introduction

Electronic cigarettes (e-cigarettes) represent the most important recent innovation in the smoking market. They are battery-operated devices that do not contain tobacco, but operate by heating nicotine and other chemicals in to a vapour that is inhaled. Since their introduction to the market in 2004, e-cigarette use has increased rapidly among adult populations, where recent research on tobacco product use has found that the prevalence of current e-cigarette use is second only to conventional cigarettes (Hu et al., 2016). The main reason for their increasing prevalence are that e-cigarettes are perceived as healthier, cheaper, less addictive, and more socially acceptable than conventional cigarettes (Peters et al., 2015; Pokhrel, Herzog, Muranaka, Regmi, & Fagan, 2014). While the long-term health effects of e-cigarette use are still being examined, studies conducted to date already suggest some negative health consequences of e-cigarette use, including negative influences on cardiovascular health and reduced immune defence in the lung (Siasos et al., 2012). Owing to conflicting information about the effects of e-cigarettes, combined with the increased rates of e-cigarette use, research is needed to better determine risk factors for e-cigarette use.

E-cigarettes are designed to look like, feel like, and provide a similar drug experience to, traditional cigarettes (Capponnetto et al., 2013); thus the comparison between e-cigarettes and cigarettes is inevitable. Such 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. Some literature suggests that attitudes towards e-cigarettes in both adult and adolescent smokers and non-smokers are generally favourable (Pepper & Brewer, 2015), and using e-cigarettes in public places is reported as being more acceptable than smoking tobacco cigarettes (Trumbo & Harper, 2015). Cross-sectional studies find that holding favourable attitudes towards e-cigarettes is associated with e-cigarette use among adult smokers (Blake et al., 2015). These findings were 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). Thus, attitudes towards e-cigarette use could be considered a potential risk factor for e-cigarette use.

Hershberger, Karyadi, VanderVeen, & Cyders (2017) adopted a more structured approach to assess e-cigarette beliefs by directly comparing them to cigarette beliefs. They developed and tested 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). They conducted exploratory factor analysis on these 17 items, eventually retaining only 10 items and identifying three factors: General benefits entailing general benefits perceived from e-cigarette use compared to cigarette use; general effects, entailing perceived positive effects e-cigarette use has compared to traditional cigarette smoking; and health benefits entailing perceived health benefits of e-cigarette use compared to traditional cigarettes. These factors were subsequently replicated via confirmatory factor analysis in an independent sample from a community adult population. The present study is utilizing this recently developed measure in order to assess participants' attitudes towards e-cigarette use. Additionally, it aims to assess its psychometric properties in

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order to establish a robust and reliable measure of attitudes towards e-cigarettes to help and uncover why individuals might be more likely to use e-cigarettes, and under what circumstances.

Hershberger, Connors, Um, & Cyders (2017) considered impulsivity as a potential risk factor for e-cigarette use in their study examining the relationship between attitudes towards e-cigarette use and e-cigarette use. Trait impulsivity, conceptualized as a tendency to engage rapidly in behavior without thinking about the consequences of this behavior (Evenden, 1999), can be described as a multidimensional construct. It comprises five separate, but related, impulsive traits: negative urgency (the tendency to act rashly in intense negative emotional states); positive urgency (the tendency to act rashly in intense positive emotional states); lack of premeditation (the tendency to act without planning); lack of perseverance (the tendency not to finish tasks); and sensation seeking (the tendency to seek out novel and exciting experiences). This has been termed the UPPS-P model of trait impulsivity (Cyders & Smith, 2007; Cyders et al., 2007). These traits have shown differential relationships with different addictive substances, with positive urgency and lack of premeditation showing the strongest positive association with cigarette use (Kale, Stautz, & Cooper, 2018), while sensation seeking and positive urgency showed the largest positive associations with alcohol consumption (Stautz & Cooper, 2013). However, research examining the relationship between e-cigarette use and the impulsivity-related traits based on the UPPS-P model has been limited. Some recent work suggests that sensation seeking and lack of perseverance are positively related to e-cigarette use (Cohn et al. 2015; Doran & Tully, 2018; Spindle et al., 2017).

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 behavior is influenced by an individual's intention to perform that behavior, which in turn is determined by three cognitive factors: attitudes, perceived behavioral control and the subjective norm (Ajzen, 1991). It further suggests that attitudes towards behaviors are a function of a person's accessible beliefs about the behavior (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), while they measured e-cigarette use with a single question about current use, without assessing participants' other smoking behavior.

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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, mostly based in Europe, where e-cigarettes containing nicotine are classified as a medicinal product (United Kingdom; Public Health England, 2015). On that basis, attitudes towards e-cigarettes might be different from a US population. Thus, 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. Secondly, to test the structural model examined by Hershberger, Connors et al (2017); that is, 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. It is important to understand the reasons behind e-cigarette use in order to design effective prevention and intervention strategies that can be generalized to any target population.

Methods

Participants

Participants were recruited as part of a larger research study on e-cigarette use and its relationships with impulsivity, smoking and other risk factors. Recruitment occurred online using three different methods; the Goldsmiths Psychology Department's research participation scheme, where participants took part in exchange for course credits, notice boards in social media (Facebook, e-cigarette user groups) and Prolific, which is an online web service that connects researchers with individuals willing to complete tasks for a wage (http://www.prolific.ac), where participants were paid £0.90 in return for 10 minutes participation time. After reading the description of the study and signing an informed consent document online, participants completed the study questionnaires (see Measures), and other measures not relevant to the present study, using the Qualtrics website (http://www.qualtrics.com).

We recruited 635 participants; 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 631.

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 (white or other), country of residence (living in the UK or not), and employment status (students, employed, unemployed). 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 list, were designated as 'e-cigarette users', while those choosing any other response apart from e-

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cigarettes were designated as 'non e-cigarette users'. We also conducted a second set of analyses with a subset of the total number of participants: that is, those who only use e-cigarettes and none of the other products (exclusive e-cigarette users), and those who replied 'none of these' (non users). Both sets of analyses showed similar results, so we present here only the former set of analyses conducted using all participants.

Attitudes towards e-cigarettes

The CEAC questionnaire (Hershberger, Karyadi et al. 2017) was used to assess attitudes towards e-cigarettes compared to cigarettes. The CEAC is a new 10-item questionnaire, using a five point Likert type scale measuring three factors: general benefits (5 items), health benefits (2 items), and general effects (3 items). 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). The alpha reliabilities 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).

Impulsivity

Impulsivity was measured with the UPPS-P Impulsive Behavior Scale (Cyders et al., 2007; Whiteside & Lynam, 2001), a widely used 59-item, scale assessing five dimensions of impulsivity: negative urgency (12 items), positive urgency (14 items), lack of planning (11 items), lack of perseverance (10 items), and sensation seeking (12 items). The scale uses a four point Likert type response format. A higher total score for each dimension indicates higher levels of impulsivity. The scales have been shown to display good convergent and discriminant validity (Smith et al., 2007). 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.

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. Correlation analyses were conducted to identify the relation between the separate impulsive personality traits of the UPPS-P scale and the three factors of the CEAC questionnaire. We then conducted confirmatory factor analysis 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 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

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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.

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). 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 33.81 (SD=11.09), ranging from 18 years to 68 years, the majority were female (53.5%), of white ethnicity (90.9%), in full-time employment (64.3%) and living in Europe (83.7%). The participants comprised of 322 (51%) e-cigarette users and 309 (49%) non e-cigarette users. Table 1 provides descriptive statistics by e-cigarette use status.

Less than 0.01% of CEAC and UPPS-P data appeared to be missing at random and was imputed using multiple imputation. Average scores on the UPPS-P scales ranged from 1 to 4, where 4 indicates higher trait expression, and CEAC subscales ranged from 1 to 5, where 5 indicates more favourable attitudes towards e-cigarettes. Table 2 provides mean scale scores by e-cigarette user status. E-cigarette users scored significantly higher in all CEAC subscales than non e-cigarette users, while the two groups differed significantly only on positive urgency and lack of perseverance, with e-cigarette users scoring higher on positive urgency (t(629)=-2.39, p=0.017), but lower on lack of perseverance, than non users (t(629)=2.22, p=0.027).

Correlation analyses showed that the UPPS-P scales were intercorrelated, and the CEAC scales were intercorrelated (Table 2).

Confirmatory Factor analysis and measurement invariance for the CEAC

Confirmatory factor analysis (Table 3) of the *a priori* structure for the CEAC questionnaire on the whole sample showed an adequate fit for the model : χ^2(df=32)=207.20,

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CFI=0.94, TLI=0.91, RMSEA=0.09 (0.08-0.11, 90% Confidence Interval), SRMR= 0.06. All items had robust factor loadings on their respective factor, and the three factors correlated positively and strongly with each other.

Table 4 shows the results of the analyses for testing measurement invariance across e-cigarette users and non e-cigarette users. As shown 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 0.01 or less.

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, where the CFI difference between model (3a) and model (2) was 0.007. 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).

Structural Path analysis

Fit indices for the model (figure 1) examining the relationship between impulsive personality traits, e-cigarette attitudes and e-cigarette use, as described by Hershberger, Connors et al (2017), were as follows: χ^2(df=2264)=5903.51, RMSE=0.048 (0.047-0.050, 90% Confidence Interval), SRMR=0.079, CFI=0.86, TLI=0.86. 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. 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. 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, β=0.14, p=0.032, was significantly and positively related to e-cigarette attitudes. Sensation seeking, β=0.10, p=0.06, showed roughly the same magnitude of relationship to e-cigarette attitudes as urgency, however this relationship was not significant. Deficits in conscientiousness, β=-0.23, p=0.001, were significantly negatively related to e-cigarette attitudes. 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=0.07, p=0.19; deficits in conscientiousness: β=0.001, p=0.99; sensation seeking: β=-0.06, p=0.20).

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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, electronic 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 are related with more positive attitudes towards e-cigarettes, and subsequent e-cigarette use. Both urgency, which is a tendency to engage in risky and disinhibited behavior when in a heightened emotional state, and sensation seeking, are positively related to e-cigarette attitudes and subsequently to e-cigarette use. Hersherbger, Connors et al. (2017) did not, however, find any relationship between sensation seeking and e-cigarette use. Moreover, the results of the present study show that there is no significant direct effect of impulsivity-related traits on e-cigarette use.

The fit of the structural model tested is 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 results of the present study support previous work that reported an association between e-cigarette use and trait impulsivity, similar with other addictive substances. Sensation seeking showed a modest positive relationship with e-cigarette attitudes, which in turn significantly predicted e-cigarette use. This supports previous research which has showed that sensation seeking predicts the frequency of engaging in risk behaviors in adolescent and adult samples (Spillane, Smith, & Kahler, 2010; Moreno et al., 2012).

A significant indirect path from urgency to e-cigarette use via attitudes towards e-cigarettes was also 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 behavior 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 behaviors, especially under conditions of high emotional intensity (Cyders & Smith, 2008; Dinc & Cooper, 2015). One possible explanation for such behavior is that individuals high in

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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 and sensation seeking engage with e-cigarettes because of positive expectancies and the novelty of e-cigarette use.

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. 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; however the present study sought to test the specific model outlined in Hershberger, Connors et al (2017).

The present study showed that the CEAC questionnaire could be considered a valid and reliable questionnaire to measure attitudes towards e-cigarettes use. Moreover, the present study 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

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communicating the risks associated with e-cigarette use both to non smokers and smokers. Reducing cigarette consumption and sustained dual use of cigarettes and e-cigarettes may 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.

Word count (4208)

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Table1. Descriptive statistics for present sample by e-cigarette use status

Variable	Non e-cigarette users n= 309		E-cigarette users n= 322			
	Mean	SD	Mean	SD	t(629)	*p*-value
Age	35.91	10.87	31.61	10.90	-4.96	<0.001
	No	%	No	%	Chi^2(df)	*p*-value
Gender						
Male	115	37.2	178	55.5	21.04 (1)	<0.001
Female	194	62.8	143	44.5		
Ethnicity						
White	280	90.6	291	91.2	0.07 (1)	0.790
Other	29	9.4	28	8.8		
Country of residence						
Europe	281	91.8	244	76.0	28.76 (1)	<0.001
Other	25	8.2	77	24.0		
Occupation						
Student	118	38.2	37	11.5	60.38 (2)	<0.001
Employed	162	52.4	243	75.7		
Unemployed	29	9.4	41	12.8		

SD=standard deviation

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Table2. Mean and standard deviations for the UPPS-P Impulsive Behavior Scale and Comparing E-cigarettes and Cigarette questionnaire (CEAC) and Pearson's r correlations

Measure	Subscale	Non e-cig users Mean (SD)	E-cig users Mean (SD)	UPPS-P Pearson's r				CEAC Pearson's r		
				2.	3.	4.	5.	6.	7.	8.
UPPS-P	1.Negative Urgency	2.47(0.64)	2.53(0.62)	0.77***	0.33***	0.44***	0.21***	0.07	0.01	0.09*
	2.Positive Urgency	2.06(0.71)[a]	2.20(0.73)		0.30***	0.31***	0.41***	0.15***	0.01	0.11**
	3.Lack of Premeditation	2.01(0.48)	1.99(0.48)			0.50***	0.08*	-0.10*	-0.07	-0.09*
	4. Lack of Perseverance	2.12(0.51)[b]	2.03(0.49)				-0.05	-0.15***	-0.09*	-0.09*
	5.Sensation Seeking	2.55(0.60)	2.63(0.63)					0.21***	0.08*	0.08
CEAC	6.General benefits	3.20(0.64)[c]	3.93(0.60)						0.55***	0.45***
	7.Health benefits	3.40(0.98)[d]	4.14(0.77)							0.59***
	8.General effects	2.87(0.94)[e]	3.74(0.82)							

SD=standard deviation.

Means reflect mean item scores for each subscale. Pearson's r correlations are presented between mean subscale of the UPPS-P and CEAC.

*$p<0.05$; **$p<0.01$; ***$p<0.001$

[a]$t(629)=-2.39, p=0.017$

[b]$t(629)=2.22, p=0.027$

[c]$t(629)=-14.97, p<0.001$

[d]$t(629)=-10.49, p<0.001$

[e]$t(629)=-12.47, p<0.001$

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Table 3. 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	0.79		
2. Electronic cigarettes are less expensive than traditional cigarettes	0.62		
3. Electronic cigarettes are more convenient or easier to use than traditional cigarettes	0.43		
4. Electronic cigarettes are more enjoyable to use than traditional cigarettes	0.50		
5. Electronic cigarettes are more socially acceptable to use than smoking traditional cigarettes	0.41		
2. Health benefits			
6. Electronic cigarettes are less harmful to the user's health than traditional cigarettes		0.88	
7. Electronic cigarettes are less harmful to the health of those in close proximity to the user than traditional cigarettes		0.86	
3. General effects			
8. Compared to traditional cigarettes, electronic cigarettes can improve health			0.66
9. Using electronic cigarettes, compared to traditional cigarettes, can improve my general sense of smell			0.90
10. Using electronic cigarettes, compared to traditional cigarettes, can improve my sense of taste			0.89
Factor Correlations			
1. General benefits	-		
2. Health benefits	0.78*	-	
3. General effects	0.65*	0.63*	-

*p<0.001

Table 4. 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	238.04	64	0.915	0.09(0.08-0.10)	0.06				
2. Metric	266.28	71	0.906	0.09(0.08-0.11)	0.07	0.009	28.24	7	<0.001
3.Scalar	306.50	78	0.890	0.09(0.08-0.11)	0.08		40.22	7	<0.001
3a. Scalar with partial invariance (item 8)	284.94	77	0.899	0.09(0.08-0.10)	0.08	0.007	18.66	6	0.001

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

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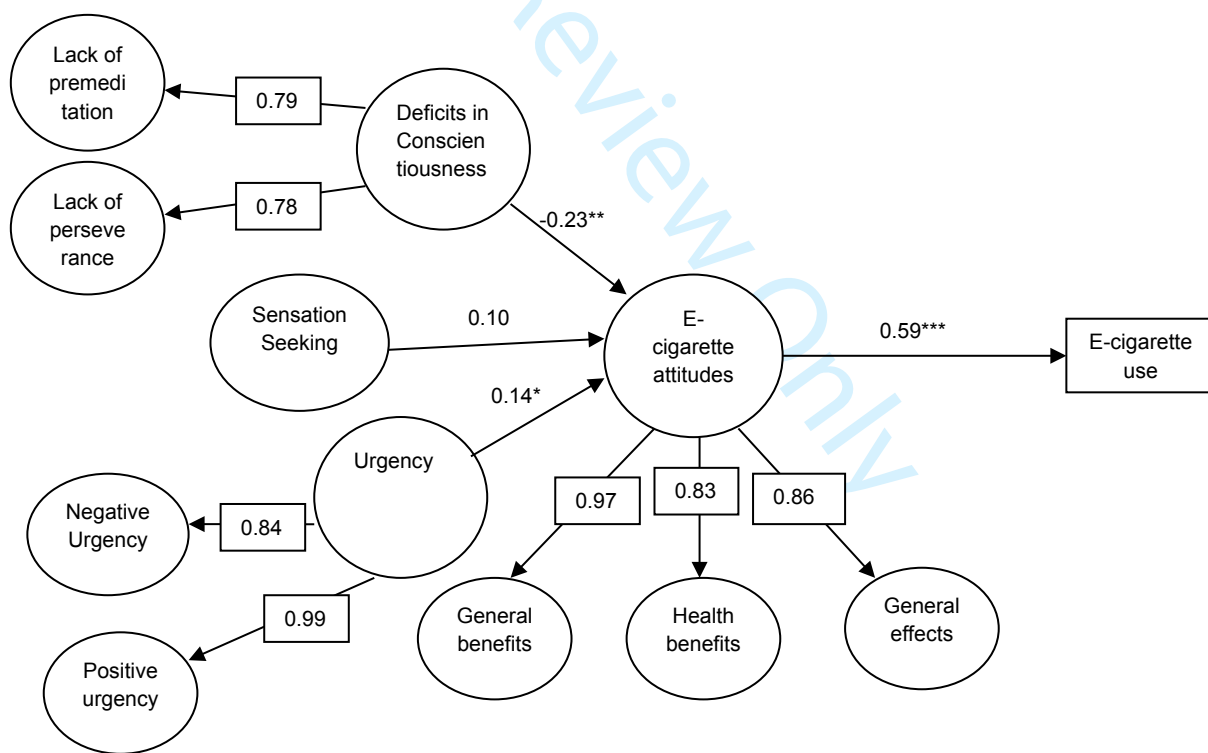
Figure 1. Structural path analysis examining the relationship between impulsive personality traits, e-cigarette attitudes and e-cigarette use, χ^2 (df=2264) =5903.51, CFI=0.86, TLI=0.86, RMSE=0.048 (0.047-0.050, 90% Confidence Interval), SRMR=0.079

 *p<0.05, **p=0.001, ***p<0.001

There were no significant direct paths from impulsivity traits to e-cigarette use.