Elsevier Editorial System(tm) for Drug and Alcohol Dependence

Manuscript Draft

Manuscript Number: AL-17-0216R2

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

Article Type: Review Article

Keywords: impulsivity; smoking; meta-analysis; UPPS-P model; reward sensitivity

Corresponding Author: Ms. Dimitra Kale,

Corresponding Author's Institution: Goldsmiths, University of London

First Author: Dimitra Kale

Order of Authors: Dimitra Kale; Kaidy Stautz; Andrew Cooper

Abstract: Background: Although there is considerable evidence of an association between impulsivity and cigarette smoking, the magnitude of this association varies across studies. Impulsivity comprises several discrete traits which may influence cigarette use in different ways. The present meta-analysis 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.
Methods: Ninety-seven studies were meta-analysed using random-effects models to examine the relationship between impulsivity-related traits and smoking status and severity of nicotine dependence. A number of demographic and methodological variables were also assessed as potential moderators.
Results: 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 (r=0.20, r=0.24 respectively), while positive urgency showed the largest association with severity of nicotine dependence (r=0.23). 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.
Conclusions: Findings suggest that impulsivity is associated with an increased likelihood of being a smoker and greater nicotine dependence. Specific impulsivity-related traits differentially relate to smoking status and severity of nicotine dependence. Understanding the complexity of impulsivity-related traits in relation to smoking can help to identify potential smokers and could inform cessation treatment.

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

Dimitra Kale[a], Kaidy Stautz[b], Andrew Cooper[a]

[a] Goldsmiths, University of London, New Cross, London, SE14 6NW, UK

[b] Behaviour and Health Research Unit, University of Cambridge, Cambridge, UK

**Correspondence to:**

Dimitra Kale

Room WB314, Psychology Department

Goldsmiths, University of London

New Cross, London, SE14 6NW, UK

dkale001@gold.ac.uk

**Abstract**

**Background:** Although there is considerable evidence of an association between impulsivity and cigarette smoking, the magnitude of this association varies across studies. Impulsivity comprises several discrete traits that may influence cigarette use in different ways. The present meta-analysis 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.

**Methods:** Ninety-seven studies were meta-analysed using random-effects models to examine the relationship between impulsivity-related traits and smoking status and severity of nicotine dependence. A number of demographic and methodological variables were also assessed as potential moderators.

**Results:** 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 ($r$=0.20, $r$=0.24 respectively), while positive urgency showed the largest association with severity of nicotine dependence ($r$=0.23). 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.

**Conclusions:** Findings suggest that impulsivity is associated with an increased likelihood of being a smoker and greater nicotine dependence. Specific impulsivity-related traits differentially relate to smoking status and severity of nicotine dependence. Understanding the

complexity of impulsivity-related traits in relation to smoking can help to identify potential smokers and could inform cessation treatment.

**Keywords:** impulsivity; smoking; meta-analysis; UPPS-P model; reward sensitivity

## 1. 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, 2015). 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, 2015). 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.

### *1.1 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 suggests that the laboratory-based behavioural tasks are measuring different constructs from self-report personality traits (Cyders and Coskunpinar, 2011). Behavioral 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 and 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 and 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 and Lynam, 2001; Cyders and 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 and Lynam, 2001; Cyders and 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 and 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 and Loxton, 2004; Dave et al., 2004; Gullo and Dave, 2008). Measures of reward sensitivity were not included in the original factor analysis that generated the UPPS framework (Whiteside and Lynam, 2001). Reward sensitivity is related to the sensation seeking scale from the UPPS-P model, but research has shown that the two are distinct (Dawe and 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 and 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 and 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 and Hogarth, 2011; Flory and 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.

### *1.2 Present study*

There are a number of meta-analytic reviews that assess the relationship between trait impulsivity and different substances such as alcohol (Stautz and 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. The present meta-analysis also aims to highlight gaps in the existing research that future studies could address.

## 2. Method

### *2.1 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.

### *2.2 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 1 shows a flowchart of the study selection process, including numbers of excluded studies.

### *2.3 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 $\beta$ 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 and 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 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 and 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.

### *2.4 Data analyses*

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 and 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 $\beta$ values using traditional formulae (DeCoster, 2004; Lipsey and Wilson, 2001; Peterson and 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 and Rise, 2012; Littlefield and Sher, 2012) that reported results of the same population at two different time points; however, the sample 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 2.1, 2.2, 2.3, 2.4).

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 null findings that would cause the effect sizes found in a meta-analysis to fall 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.

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 that were 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 and Tipton, 2015) packages for R (R Development Core Team, 2015).

Due 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. 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.

## 3. Results

### *3.1 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). 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%).

### *3.2 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.

### *3.3 Meta-analytic findings*

*3.3.1 Impulsivity traits and smoking status.* 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 3). These findings suggest that the present results are unlikely to be substantially impacted by unpublished data.

*3.3.2 Impulsivity traits and severity of nicotine dependence.* In respect to specific UPPS-P traits and reward sensitivity, effect 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 3). These effect sizes are based on 30 studies and 4145 smokers.

### *3.4 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 consisted of 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 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.

### *3.5 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 discovered 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 excluded these scales in the analysis. The results were very similar to those when the scales were included, so the scales were retained in the analysis reported above.

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. Consequently, these studies were also retained in the present meta-analysis.

## 4. 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 with both smoking status and severity of nicotine dependence, while reward sensitivity was not associated with either outcome.

The majority of the 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 who are 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 and 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 and 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 and 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 being 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 upon 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 those found in a previous meta-analysis that assessed 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 and Cooper, 2013). Clearly, the association of reward responsiveness 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.

### *4.1 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 includes 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, 2017). 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.

### *4.2 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. Therefore, our analysis is 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 that 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 and 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 substantial difference in results when excluding these fourteen studies from the meta-analysis.

Fourth, the majority of studies reviewed were cross-sectional. Research suggest 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 (Corbet et al., 2009). In the present analysis, there were only eighteen studies that reported biological samples of nicotine use to validate self-report measures.

### *4.3 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 it 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.

**References**

Adam, P., Richoux, C., Lejoyeux, M., 2008. Screening for impulse control disorders among patients admitted to a French psychiatric emergency service. Open Psychiatr. J. 2, 30–36.

Addicott, M.A., Pearson, J.M., Wilson, J., Platt, M.L., McClernon, F.J., 2013. Smoking and the bandit: A preliminary study of smoker and nonsmoker differences in exploratory behavior measured with a multiarmed bandit task. Exp. Clin. Psychopharmacol. 21, 66–73.

Ames, S.L., Sussman, S., Dent, C.W., 1999. Pro-drug-use myths and competing constructs in the prediction of substance use among youth at continuation high schools: A one-year prospective study. Pers. Individ. Dif. 26, 987-1003.

Action on Smoking and Health (ASH), 2017. Action on smoking and health. Available at https://www.ash.org.uk.

Avram, X., Holmes, J., Hollinshead, M.O., Roffman, J.L., Smoller, J.W., Buckner, R.L., 2016. Individual differences in cognitive control circuit anatomy link sensation seeking, impulsivity, and substance use. J. Neurosci. 36, 4038–4049.

Bailey, U.L., 2011. Examining the role of personality, peers, and the transition to college on substance use. Univeristy of Kentucky Doctoral Dissertations. Paper 192.

Baker, B.T., Brandon, H.T., Chassin, L., 2004. Motivational influences on cigarette smoking. Annu. Rev. Psychol. 55, 463-491.

Balevich, E.C., Wein, N.D., Flory, J.D., 2013. Cigarette smoking and measures of impulsivity in a college sample. Subst. Abuse 34, 256–262.

Baumann, M.R., Oviatt, D., Garza, R.T., Gonzalez-Blanks, A.G., Lopez, S.G., Alexander-Delpech, P., Beason, F.A., Petrova, V.I., Hale, W.J., 2014. Variation in BAS-BIS profiles across categories of cigarette use. Addict. Behav. 39, 1477–1483.

Beaton, D., Abdi, H., Filbey, F.M., 2014. Unique aspects of impulsive traits in substance use and overeating: Specific contributions of common assessments of impulsivity. Am J Drug Alcohol Abuse 40, 1097–9891.

Bejerot, S., Von Knorring, L., Ekselius, L., 2000. Personality traits and smoking in patients with obsessive-compulsive disorder. Eur. Psychiatry 15, 395-401.

Berg, C.J., Haardorfer, R., Lewis, M., Getachew, B., Lloyd, S.A., Thomas, S.F., Lanier, A., Trepanier, K., Johnston, T., Grimsley, L., Foster, B., Benson, S., Smith, A., Barr, D.B., Windle, M., 2016. DECOY: Documenting Experiences with Cigarettes and Other Tobacco in Young Adults. Am. J. Health Behav. 40, 310-321.

Bernow, N., Kruck, B., Pfeifer, P., Lieb, K., Tüscher, O., Fehr, C., 2011. Impulsiveness and venturesomeness in German smokers. Nicotine Tob. Res. 13, 714-721.

Bickel, W.K., Odum, A.L., Madden, G.J., 1999. Impulsivity and cigarette smoking: Delay discounting in current, never and ex-smokers. Psychopharmacol. 146, 447-454.

Billieux, J., Van der Linden, M., Ceschi, G., 2007. Which dimensions of impulsivity are related to cigarette craving? Addict. Behav. 32, 1189-1199.

Bloom E.L., Matsko S., Cimino C., 2014. The relationship between cigarette smoking and impulsivity: A review of personality, behavioural and neurobiological assessment. Addict. Res.Theory 22, 386-397

Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H. R., 2009. Introduction to meta-analysis. Chichester, John Wiley and Sons, Ltd.

Buss, A.H.,Plomin, R., 1975. A temperament theory of personality development. New York, NY, John Wiley

Carton, S., Jouvent, R., Widlöcher, D., 1994. Sensation seeking, nicotine dependence, and smoking motivation in female and male smokers. Addict. Behav. 19, 219-227.

Carver, C.S., White, T.L.,1994. Behavioural inhibition, behavioural activation and affective

responses to impending reward and punishment: The BIS/BAS scales. J. Pers. Soc. Psychol. 67, 319-333.

Catts, S. V, Norman, T.R., Burrows, G.D., McConaghy, N., Parker, G., 1987. Low platelet monoamine oxidase and sensation seeking in males: An established relationship? Acta Psychiatry Scand. 75, 86–90.

Chase, H.W., Hogarth, L., 2011. Impulsivity and symptoms of nicotine dependence in a young adult population. Nicotine Tob. Res. 13, 1321-1325.

Chivers, L.L., Hand, D.J., Priest, J.S., Higgins, S.T., 2016. E-cigarette use among women of reproductive age: Impulsivity, cigarette smoking status, and other risk factors. Prev. Med. 92, 126-134.

Clayton, R.R., Segress, M.J., Caudill, C.A., 2007. Sensation seeking: A commentary. Addiction 102 (Suppl 2), 92–94.

Cloninger, C.R., 1989. The tridimensional personality questionnaire. Department of Psychiatry and Genetics, Washington University School of Medicine.

Cloninger, C.R., Przybeck, T.R., Svrakic, D.M., Wetzel, R.D., 1994. The temperament and character inventory (TCI): A guide to its development and use. St Louis, Missouri: Washington University, Center for Psychobiology of Personality.

Cohen., J., 1988. Statistical power analysis for the behavioural sciences (2nd ed.). Hillsdale, NJ, Erlbaum.

Coskunpinar, A., Dir, A.L., Cyders, M.A., 2013. Multidimensionality in impulsivity and alcohol use: A meta-analysis using the UPPS model of impulsivity. Alcohol Clin. Exp. Res. 37, 1441–1450.

Costa, P.T., McCrae, R.R., 1992. Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual. Odessa, FL, Psychological Assessment Resources.

Cui, Y., Robinson, J.D., Engelmann, J.M., Lam, C.Y., Minnix, J.A., Karam-Hage, M., Wetter, D.W., Dani, J.A., Kosten, T.R., Cinciripini, P.M., 2015. Reinforcement sensitivity underlying treatment-seeking smokers' affect, smoking reinforcement motives, and affective responses. Psychol. Addict. Behav. 29, 300-311.

Cyders, M.A., Coskunpinar, A., 2011. Measurement of constructs using self-report and behavioral lab tasks: Is there overlap in nomothetic span and construct representation for impulsivity? Clin. Psychol. Rev. 31, 965-982.

Cyders, M.A., Coskunpinar, A., 2012. The relationship between self-report and lab task conceptualizations of impulsivity. J. Res. Pers. 46, 121-124.

Cyders, M.A., Smith, G.T., 2007. Mood-based rash action and its components: Positive and negative urgency. Personal. Individ. Differ. 43, 839-850.

Cyders, M.A., Smith, G.T., 2008. Emotion-based dispositions to rash action: Positive and negative urgency. Psychol. Bull. 134, 807–828.

Dawe, S., Gullo, M.J., Loxton N.J., 2004. Reward drive and rash impulsiveness as dimensions of impulsivity: Implications for substance misuse. Addict. Behav. 29, 1389-1405.

Dawe, S., Loxton, N.J., 2004. The role of impulsivity in the development of substance use and eating disorders. Neurosci. Biobehav. Rev.28, 343-351.

DeCoster, J., 2004. Meta-analysis notes. Retrieved from http://www.stat-help.com/notes.html.

Dervaux, A., Baylé, F.J., Laqueille, X., Bourdel, M.C., Le Borgne, M.H., Olié, J.P., Krebs, M.O., 2004. Nicotine use in schizophrenia and disinhibition. Psychiatry Res. 128, 229-234.

Dickman, S.J.,1990. Functional and dysfunctional impulsivity: Personality and cognitive correlates. J. Pers. Soc. Psychol. 58, 95-102.

Dinn, W.M., Aycicegi, A., Harris, C.L., 2004. Cigarette smoking in a student sample: Neurocognitive and clinical correlates. Addict. Behav. 29, 107-126.

Doran, N., Khoddam, R., Sanders, P.E., Schweizer, C.A., Trim, R.S., Myers, M.G., 2013. A prospective study of the Acquired Preparedness Model: The effects of impulsivity and expectancies on smoking initiation in college students. Psychol Addict Behav. 27, 714-722.

Doran, N., Mcchargue, D., Spring, B., Vanderveen, J., Werth Cook, J., Richmond, M., 2006. Effect of nicotine on negative affect among more impulsive smokers. Exp. Clin. Psychopharm. 14, 287-295.

Doran, N., McChargue, D., Cohen, L., 2007. Impulsivity and the reinforcing value of cigarette smoking. Addict. Behav. 32, 90-98.

Doran, N., Cook, J., McChargue, D., Spring, B., 2009 Impulsivity and cigarette craving: Differences across subtypes. Psychopharmacology 207, 365-373.

Downey, K.K., Pomerleau, C.S., Pomerleau, O.F., 1996. Personality differences related to smoking and adult Attention Deficit Hyperactivity Disorder. J. Subst. Abuse 8, 129–135.

Durazzo, T.C., Meyerhoff, D.J., Mon, A., Abé, C., Gazdzinski, S., Murray, D.E., 2016. Chronic cigarette smoking in healthy middle-aged individuals is associated with decreased regional brain n-acetylaspartate and glutamate levels. Biol. Psychiatry 79, 481-488.

Dvorak, R., Simons, J., Wray, T., 2011. Impulsivity moderates the association between depressive rumination and number of quit attempt failures by smokers. Addict. Res. Theory 19, 283–288.

Etter, J. F., 2010. Smoking and Cloninger's Temperament and character inventory. Nicotine Tob. Res. 12, 919-926.

Evans, A.H., Lawrence, A.D., Potts, J., Macgregor, L., Katzenschlager, R., Shaw, K., Zijlmans, J., Lees, A.J., 2006. Relationship between impulsive sensation seeking traits, smoking, alcohol and caffeine intake, and Parkinson's disease. J. Neurol. Neurosurg. Psychiatry 77, 317–321.

Evenden J.L., 1999. Varieties of impulsivity. Psychopharmacol. 146, 348-361.

Eysenck, S.B., Easting, G., Pearson, P.R., 1984. Age norms for impulsiveness, venturesomeness and empathy in children. Personal. Individ. Differ. 5, 315-321.

Eysenck SBB, Eysenck HJ, 1978. Impulsiveness and venturesomeness: Their position in a dimensional system of personality description. Psychol. Rep. 43, 1247–1255.

Eysenck, S.B.G, Pearson, P.R., Easting, G., Allsopp, J.F., 1985. Age norms for impulsiveness, venturesomeness and empathy in adults. Pes. Individ. Dif. 6, 613-619.

Fagerström, K.O., 1978. Measuring degree of physical dependence to tobacco smoking with reference to individualization of treatment. Addict. Behav. 3, 235–241.

Fairweather-Schmidt, K., Wade, T.D., 2014. The Relationship between disordered eating and cigarette smoking among adult female twins. Int. J. Eat. Disord. 48, 708–714.

Fisher, Z., Tipton, E., 2015. Robumeta: Robust variance metaregression. R Package Version 1.6. Available at: http://CRAN.R-project. org/package=robumeta.

Fisher, R.A., 1928. Statistical methods for research workers (2nd ed.). London, Oliver and Boyd.

Flory, J.D., Manuck, S.D., 2009. Impulsiveness and cigarette smoking. Psychosom Med. 71,431-437.

Gau, S.S.F., Lai, M.C., Chiu, Y.N., Liu, C. Te, Lee, M.B., Hwu, H.G., 2009. Individual and family correlates for cigarette smoking among Taiwanese college students. Compr. Psychiatry. 50, 276-285.

Gilpin, E.A., Cavin, S.W., Pierce, J.P., 1997. Adult smokers who do not smoke daily.

Addiction 92, 473-480.

Glicksohn, J., Nahari, G., 2007. Interacting personality traits? Smoking as a test case. Eur. J. Pers. 21, 225-234.

Golding, J.F., Harpur, T., Brent-Smith, H., 1983. Personality , drinking and drug-taking cigarette smoking correlates of. Pers. Individ. Dif. 4, 703-706.

Gorber, S.C., Schofield-Hurwitz, S., Hardt, J., Levasseur, G., Tremblay, M., 2009. The accuracy of self-reported smoking: A systematic review of the relationship between self-reported and cotinine assessed smoking status. Nicotine Tob. Res. 11, 12–24.

Grace, J., Malloy, P.F., 2001. Frontal systems behavior scale: Professional manual. Lutz, FL, Psychological Assessment Resources, Inc.

Granö, N., Virtanen, M., Vahtera, J., Elovainio, M., Kivimäki, M., 2004. Impulsivity as a predictor of smoking and alcohol consumption. Pers. Individ. Dif. 37, 1693-1700.

Gray, J.A., 1991. The neuropsychology of temperament. In J. Strelau, A. Angleitner (Eds.), Explorations in temperament: International perspectives on theory and measurement. Perspectives on individual differences. (pp 105-128). New York, NY, Plenum Press.

Greenbaum, L., Kanyas, K., Karni, O., Merbl, Y., Olender, T., Horowitz, A., Yakir, A., Lancet, D., Ben-Asher, E., Lerer, B., 2006. Why do young women smoke? I. Direct and interactive effects of environment, psychological characteristics and nicotinic cholinergic receptor genes. Mol. Psychiatry 11, 312-322.

Guillot, C.R., Pang, R.D., Leventhal, A.M., 2014. Anxiety sensitivity and negative urgency: A pathway to negative reinforcement-related smoking expectancies. J. Addict. Med. 8, 189-194.

Gullo M.J., Dawe, S., 2008. Impulsivity and adolescent substance use: Rashly dismissed as “all-bad”? Neurosci. Biobehav. Rev. 32, 1507-1518.

Gurpegui, M., Jurado, D., Luna, J.D., Fernández-Molina, C., Moreno-Abril, O., Gálvez, R.,

2007. Personality traits associated with caffeine intake and smoking. Prog. Neuropsychopharmacol. Biol. Psychiatry 31, 997-1005.

Hathaway, S.R, McKinlet, J.C., 1951. Minnesota Multiphasic Persoanlity Inventory Manual. New York, The Psychological Corporation.

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., Fagerstrom, K. O., 1991. The Fagerstrom Test for Nicotine Dependence: A revision of the Fagerstrom Tolerance Questionnaire. Br. J Addict. 86, 1119–1127.

Heyman, G.M., Dunn, B.J., Mignone, J., 2014. Disentangling the correlates of drug use in a clinic and community sample: A regression analysis of the associations between drug use, years-of-school, impulsivity, IQ, working memory, and psychiatric symptoms. Front. Psychiatry, 70, 1-13.

Higgins, J., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003. Measuring inconsistency in meta-analyses. BMJ 327, 557-560.

Hogarth, L., Chase, H.W., Baess, K., 2012. Impaired goal-directed behavioural control in human impulsivity. Q. J. Exp. Psychol. 65, 305–316.

Holmes, A.J., Hollinshead, M.O., Roffman, J.L., Smoller, J.W., Buckner, R.L., 2016. Individual differences in cognitive control circuit anatomy link sensation seeking, impulsivity and substance use. J. Neurosci. 36, 4038-4049.

Hoyle, R.H., Stephenson, M.T., Palmgreen, P., Pugzles Lorch, E., Donohew, R.L., 2002. Reliability and validity of a brief measure of sensation seeking. Personal. Individ. Differ. 32, 401-414.

Hudspith, A.R., 2012. An investigation into the relationship between locus of control, sensation-seeking, and substance use. Indiana University of Pennsylvania, ProQuest Dissertations and Theses, 129.

Hughes JR., 2001. Why does smoking so often produce dependence? A somewhat different view. Tob. Control 10, 62-64.

Hyphantis, T., Antoniou, K., Tomenson, B., Tsianos, E., Mavreas, V., Creed, F., 2010. Is the personality characteristic "impulsive sensation seeking" correlated to differences in current smoking between ulcerative colitis and Crohn's disease patients? Gen. Hosp. Psychiatry. 32, 57-65.

Iancu, I., Sapir, A.P., Shaked, G., Poreh, A., Dannon, N., Chelben, J., Kotler, M., 2006. Increased suicidal risk among smoking schizophrenia patients. Clin. Neuropharmacol. 29, 230-237.

Jacobs, A.M., Luleen S. A., Champagne E., Karush N., Richman J. S., Knapp H. P., 1966. Orality, implusivity and cigarette smoking in men. Further findings in support of a thoery. J. Nerv. Ment. Dis. 143, 207-219.

Jacobs, M.A., Spilken, A.Z., 1971. Personality patterns associated with heavy cigarette smoking in male college students. J. Consult. Clin. Psychol. 37, 428–432.

Kao, Y.C., Liu, Y.P., Cheng, T.H., Chou, M.K., 2011. Cigarette smoking in outpatients with chronic schizophrenia in Taiwan: Relationships to socio-demographic and clinical characteristics. Psychiatry Res. 190, 193-199.

Kassel, J.D., Shiffman, S., Gnys, M.A., Paty, J., Zettler-Segal, M., 1994. Psychosocial and personality differences in chippers and regular smokers. Addict. Behav. 19, 565-575.

Kertzman, S., Kagan, A., Vainder, M., Lapidus, R., Weizman, A., 2013. Interactions between risky decisions, impulsiveness and smoking in young tattooed women. BMC Psychiatry. 13, 278.

Knorring, L. Von, Oreland, L., 1985. Personality traits and platelet monoamine oxidase in tobacco smokers. Psychol. Med. 15, 327–334.

Kohn, P.M., Coulas, J.T., 1985. Sensation Seeking, augmenting-reducing, and the perceived

and preferred effects of drugs. J. Personal. Soc. Psychol. 48, 99–106.

Krause, J.S., Cao, Y., Clark, J.M.R., Davis, J.F., Saunders, L.L., 2015. preinjury cigarette smoking among those with traumatic spinal cord injury. Rehabil. Psychol. 60, 322-327.

Kvaavik, E., Rise, J., 2012. How do impulsivity and education relate to smoking initiation and cessation among young adults? J. Study Alcohol Drugs 73, 804–810.

Lee, D.C., Peters, J.R., Adams, Z.W., Milich, R., Lynam, D.R., 2015. Specific dimensions of impulsivity are differentially associated with daily and non-daily cigarette smoking in young adults. Addict. Behav. 46, 82-85.

Lejuez, C.W., Aklin, W.M., Jones, H.A., Richards, J.B., Strong, D.R., Kahler, C.W., Read, J.P., 2003. The Balloon Analogue Risk Task (BART) differentiates smokers and nonsmokers. Exp. Clin. Psychopharmacol. 11, 26-33.

Leventhal, A.M., 2007. Subliminal processes in tobacco dependence. University of Houston Doctoral Dissertation. UMI Number: 3275120.

Lipkus, L.M., Barefoot, J.C., Williams, R.B., Siegler, I.C., 1994. Personality measures as predictors of smoking initiation and cessation in the UNC Alumni Heart Study. Health Psychol. 13, 149-155.

Lipsey, M.W., Wilson, D.B., 2001. Practical meta-analysis. Thousand Oaks, CA, Sage.

Littlefield, A. K., Sher, K. J., Wood, P. K., 2009. Is the "maturing out" of problematic alcohol involvement related to personality change? J. Abnorm. Psychol. 118, 360–374.

Littlefield, A.K., Sher, K.J., 2012. Smoking desistance and personality change in emerging and young adulthood. Nicotine Tob. Res. 14, 338-342.

Litvin, E.B., Brandon, T.H., 2010. Testing the influence of external and internal cues on smoking motivation using a community sample. Exp. Clin. Psychopharmacol. 18, 61-

70.

Livaditis, M., Samakouri, M., Kafalis, G., Tellidou, C., Tzavaras, N., 2001. Sociodemographic and psychological characteristics associated with smoking among Greek medical students. Eur. Addict. Res. 7, 24-31.

Luijten, M., Van Meel, C.S., Franken, I.H.A., 2011. Diminished error processing in smokers during smoking cue exposure. Pharmacol. Biochem. Behav. 97, 514-520.

MacKillop, J., Kahler, C.W., 2009. Delayed reward discounting predicts treatment response for heavy drinkers receiving smoking cessation treatment. Drug Alcohol Depend. 104, 197-203.

Martin, L.E., Cox, L.S., Brooks, W.M., Savage, C.R., 2014. Winning and losing: differences in reward and punishment sensitivity between smokers and nonsmokers. Brain Behav. 4, 915-924.

Mcchargue, D.E., Drevo, S., Herrera, M.J., Doran, N., Salvi, S., Klanecky, A.K., 2011. Trait-impulsivity moderates the relationship between rumination and number of major depressive episodes among cigarette smokers. Ment. Health Subst. Use 4, 96-104.

Meil, W.M., LaPorte, D.J., Mills, J.A., Sesti, A., Collins, S.M., Stiver, A.G., 2016. Sensation seeking and executive deficits in relation to alcohol, tobacco, and marijuana use frequency among university students: Value of ecologically based measures. Addict. Behav. 62, 135-144.

Mitchell, H.S., 1999. Measures of impulsivity in cigarette smokers and non-smokers. Psychopharmacol. 146, 455-464.

Morean, M.E., Camenga, D.R., Kong, G., Cavallo, D.A., Schepis, T.S., Krishnan-Sarin, S., 2014. Predictors of middle school students' interest in participating in an incentive-based tobacco prevention and cessation program in Connecticut. J. Addict. 2014, 915652.

Morean, M.E., Demartini, K.S., Leeman, R.F., Pearlson, G.D., Anticevic, A., Krishnan-Sarin, S., Krystal, J.H., O 'Malley, S.S., 2014. Psychometrically improved, abbreviated versions of three classic measures of impulsivity and self-control. Psychol. Assessment 26, 1003-1020.

Munyon, S., 2014. Impulsivity traits as determinants for smoking behavior. Theses and Dissertation 432. http://rdw.rowan.edu/etd/432.

NHS, UK. Smokefree Campaign. Available at https://www.nhs.uk/smokefree.

Nieva, G., Valero, S., Bruguera, E., Andión, Ó., Trasovares, M.V., Gual, A., Casas, M., 2011. The alternative five-factor model of personality, nicotine dependence and relapse after treatment for smoking cessation. Addict. Behav. 36, 965-971.

O'Connor, R.M., Stewart, S.H., Watt, M.C., 2009. Distinguishing BAS risk for university students' drinking, smoking, and gambling behaviors. Pers. Individ. Dif. 46, 514-519.

Omiya, S., Kobori, O., Tomoto, A., Igarashi, Y., Iyo, M., 2015. Personality and substance use in Japanese adolescents: The Japanese version of Substance Use Risk Profile Scale. Pers. Individ. Dif. 76, 153-157.

Orwin, R.G., 1983. A fail safe N for effect sizes in meta-analyses. J. Educ. Stat. 8, 157-159.

Ostacher, M.J., Lebeau, R.T., Perlis, R.H., Nierenberg, A.A., Lund, H.G., Moshier, S.J., Sachs, G.S., Simon, N.M., 2009. Cigarette smoking is associated with suicidality in bipolar disorder. Bipolar Disord. 11, 766-771.

Paelecke-Habermann, Y., Paelecke, M., Giegerich, K., Reschke, K., Kubler, A., 2013. Implicit and explicit reward learning in chronic nicotine use. Drug Alcohol Depend. 129, 8-17.

Pang, R.D., Hom BA, M.S., Geary BA, B.A., Doran, N., Spillane, N.S., Guillot, C.R., Leventhal, A.M., Leventhal, A.M., Hom, M.S., Geary, B.A., 2014. Relationships between trait urgency, smoking reinforcement expectancies, and nicotine dependence.

J. Addict. Dis. 33, 83–93.

Papadodima, S.A., Sakelliadis, E.I., Sergentanis, T.N., Giotakos, O., Sergentanis, I.N., Spiliopoulou, C.A., 2010. Smoking in prison: A hierarchical approach at the crossroad of personality and childhood events. Eur. J. Public Health. 20, 470-474.

Park, A.D., Farrahi, L.N., Pang, R.D., Guillot, C.R., Aguirre, C.G., Leventhal, A.M., 2016. Negative urgency is associated with heightened negative affect and urge during tobacco abstinence in regular smokers. J. Stud. Alcohol Drugs 77, 766–773.

Patkar, A.A., Gopalakrishnan, R., Berrettini, W.H., Weinstein, S.P., Vergare, M.J., Leone, F.T., 2003. Differences in platelet serotonin transporter sites between African-American tobacco smokers and non-smokers. Psychopharmacol. (Berl). 166, 221–227.

Patto, J.H., Stanford, M.S., Barratt, E.S., 1995. Factor structure of the Barratt impulsiveness scale. J. Clin. Psychol. 51, 768-774.

Peltzer, K., Malaka, D, Phaswana-Mafuya, N, 2001. Psychological correlates of substance use among South African university students. Soc. Behav. Pers. 29, 799–806.

Perkins, K.A., Gerlach, D., Brqge, M., Grobe, J.E., 2000. greater sensitivity to subjective effects of nicotine in nonsmokers high in sensation seeking. Exp. Clin. Psvehophaimacol. 8, 462–471.

Perkins, K.A., Lerman, C., Coddington, S.B., Jetton, C., Karelitz, J.L., Scott, J.A., 2008. Initial nicotine sensitivity in humans as a function of impulsivity. Psychopharmacol. 200, 529-544

Peterson, R.A., Brown, S.P., 2005. On the use of beta coefficients in meta-analysis. J. Appl. Psychol. 90, 175-181.

Plutchik, R., Van Praag, H.M., 1989. The measurement of suicidality, aggressivity band impulsivity. Pro. Neuropsychopharmacol. Biol. Psychiatry 13, 523-534.

Pomerleau, C.S., Pomerleau, O.F., Flessland, K.A., Basson, S.M., 1992. Relationship of tridimensional personality questionnaire scores and smoking variables in female and male smokers. J. Subst. Abuse 4, 143-154.

Pripfl, J., Neumann, R., Köhler, U., Lamm, C., 2013. Effects of transcranial direct current stimulation on risky decision making are mediated by "hot" and "cold" decisions, personality, and hemisphere. Eur. J. Neurosci. 38, 3778-3785.

R Development Core Team. 2015. R: A Language and environment for statistical computing. Vienna, The R Foundation for Statistical Computing.

Rass, O., Ahn, W.Y., O'Donnell, B.F., 2016. Resting-state EEG, impulsiveness, and personality in daily and nondaily smokers. Clin. Neurophysiol. 127, 409-418.

Reynolds, B., Patak, M., Shroff, P., Penfold, R.B., Melanko, S., and Duhig, A.M., 2007. Laboratory and self-report assessments of impulsive behavior in adolescent daily smokers and nonsmokers. Exp. Clin. Psychopharmacol. 15, 264–271.

Rezvanfard, M., Ekhtiari, H., Mokri, A., Djavid, G., Kaviani, H., 2010.Psychological and behavioral traits in smokers and their relationship with nicotine dependence level. Arch. Iran Med. 13, 395-405.

Ristache, R.M., Rotărescu, V.S., 2015. Differences in decision making of adult smokers and nonsmokers in risky situations. Cogn. Brain Behav. XIX, 313–325.

Roberts, W., Peters, J.R., Adams, Z.W., Lynam, D.R., Milich, R., 2014. Identifying the facets of impulsivity that explain the relation between ADHD symptoms and substance use in a nonclinical sample. Addict. Behav. 39, 1272-1277.

Schalling, D., 1978. Psychopathy related personallity variables and the psychophysiology of socialization. In R.D. Hare, and Bd. Schalling (Eds.), Psychopathic behaviour: Approaches to research. Chisester, Wiley.

Schiep, S., Cieślik, K., 2011. Original papers personality dimensions and nicotine

dependence and withdrawal symptoms: The mediating role of self-directness. Polish Psychol. Bull. 42, 169–177.

Sharma, P., Gale, T.M., Fineberg, N.A., 2012. Clinical correlates of tobacco smoking in OCD: A UK, case-controlled, exploratory analysis. J Beh. Addict. 1, 180-185.

Sharma, L., Markon, K.E., Clark, L.A., 2014. Toward a theory of distinct types of "impulsive" behaviors: A meta-analysis of self-report and behavioral measures. Psych. Bull. 140, 374-408.

Shokrgozar, S., Ahmadi, R., Yousefnezhad, A., Roshandelrad, M., Khosravi, T., Ellahi, M., Pakdaman, M., Eskandari, A., 2015. Drug addiction in patients with chronic schizophrenia and its relation with psychopathology and impulsiveness. Glob. J. Health Sci. 7, 131-136.

Skinner, M.D., Aubin, H.J., Berlin, I., 2004. Impulsivity in smoking, nonsmoking, and ex-smoking alcoholics. Addict. Behav. 29, 973-978.

Sousa, N.O., Grevet, E.H., Salgado, C.A.I., Silva, K.L., Victor, M.M., Karam, R.G., Vitola, E.S., Picon, F.A., Zeni, G.D., Rohde, L.A., Belmonte-de-Abreu, P., Bau, C.H.D., 2011. Smoking and ADHD: An evaluation of self medication and behavioral disinhibition models based on comorbidity and personality patterns. J. Psychiatr. Res. 45, 829-834.

Sperry S.H., Lynam, D.R., Kwapil, T.R., 2017, The convergence and divergence of impulsivity facets in daily life. J. Pers. 00, 1-12.

Spielberger, C.D., Reheiser, E.C., Foreyt, J.P., Poston, W.S.C., Volding, D.C., 2004. Personality determinants of the use of tobacco products. Pers. Individ. Dif. 36, 1073-1082.

Spillane, N.S., Smith, G.T., Kahler, C.W., 2010. Impulsivity-like traits and smoking behavior in college students. Addict. Behav. 35, 700-705.

Spinella, M., 2002. Correlations between orbitofrontal dysfunction and tobacco smoking. Addict. Biol. 7, 381–384.

Spinella, M., 2003. Relationship between drug use and prefrontal- associated traits. Addict. Biol. 8, 67-74.

Stautz, K., Cooper, A., 2013. Impulsivity-related personality traits and adolescent alcohol use: a meta-analytic review. Clin. Psychol. Rev. 33, 574–592.

Stautz, K., Dinc, L., Cooper, A. J., 2017. Combining trait models of impulsivity to improve explanation of substance use behaviour. Eur. J. Pers. 31, 118–132.

Stephenson, M.T., Velez, L.F., Chalela, P., Ramirez, A., Hoyle, R.H., 2007. The reliability and validity of the Brief Sensation Seeking Scale (BSSS-8) with young adult Latino workers: Implications for tobacco and alcohol disparity research. Addiction 102(Suppl 2), 79-91.

Stoltenberg, S.F., Batien, B.D., Birgenheir, D.G., 2008. Does gender moderate associations among impulsivity and health-risk behaviors? Addict. Behav. 33, 252-265.

Stoltenberg, S.F., Lehmann, M.K., Christ, C.C., Hersrud, S.L., Davies, G.E., 2011. Associations among types of impulsivity, substance use problems and Neurexin-3 polymorphisms. Drug Alcohol Depend. 119, e31-e38.

Strategic Business Insights, 2015.US Framework and VALS™ Types. 2015. Available at: http://www.strategicbusinessinsights.com/vals/ustypes.shtml.

Stuart, G.L., Meehan, J., Moore, T.M., Hellmuth, J., Morean, M., Follansbee, K., 2006. Readiness to quit cigarette smoking, violence and psychopathology among arrested domestically violent men. Am. J. Addict. 15, 256-257.

Sutherland, G., 2002. Current approaches to the management of smoking cessation. Drugs 62 (Suppl. 2), 53-61

Tabachnick, G.B., Fidell, S. L., 2001. Using multivariate statistics. (5th ed.) Boston,

Pearson/Allyn and Bacon.

Tapper, K., Baker, L., Jiga-Boy, G., Haddock, G., Maio, G.R., 2015. Sensitivity to reward and punishment: Associations with diet, alcohol consumption, and smoking. Pers. Individ. Dif. 72, 79-84.

Terracciano, A., Costa, P.T., 2004. Smoking and the Five-Factor Model of personality. Addiction 99, 472-481.

Terracciano, A., Lockenhoff, C.E., Crum,R.M., Bienvenu, J., Costa, P.T., 2008. Five-factor model personality profiles of drug users. BMC Psych. 8, 22.

Torrubia, R., Avila, C., Molto, J., Caseras, X., 2001. The sensitivity to punishment and sensitivity to reward questionnaire (SPSRQ) as a measure of Gray's anxiety and impulsivity dimensions. Personal. Individ. Differ. 31, 837-862.

Vanderveen, J.W., Cohen, L.M., Cukrowicz, K.C., Trotter, D.R.M., 2008. The role of impulsivity on smoking maintenance. Nicotine Tob. Res. 10, 1397-1404.

Vanderveen, J.D., Hershberger, R.A., Cyders, A.M., 2016. UPPS-P model impulsivity and marijuana use behaviors in adolescents: A meta-analysis. Drug Alcohol Depend. 168, 181-190.

Vasconcelos, A.G., Teodoro, M.L.M., Malloy-Diniz, L., Correa, H., 2015. Impulsivity components measured by the Brazilian version of the barratt impulsiveness scale. Psychology 28, 96-105.

Versace, F., Lam, C. Y., Engelmann, J. M., Robinson, J. D., Minnix, J. A., Brown, V. L., and Cinciripini, P. M., 2011. Beyond cue reactivity: Blunted brain responses to pleasant stimuli predict long-term smoking abstinence. Addict. Biol. 17, 991-1000.

Viechtbauer, W., Cheung, M.W.L., 2010. Outlier and influence diagnostics for meta-analysis. Res. Synth. Method 1,112–125.

Voigt, D.C., Dillard, J.P., Braddock, K.H., Anderson, J.W., Sopory, P., Stephenson, M.T.,

2009. Carver and White's (1994) BIS/BAS scales and their relationship to risky health behaviours. Pers. Individ. Dif. 47, 89-93.

Voracek, M., Pum, U., Dressler, S.G., 2010. Investigating digit ratio (2D:4D) in a highly male-dominated occupation: The case of firefighters. Scand. J. Psychol. 51, 146-156.

Weber E.U., Blais, A., Betz, N.E., 2002. A domain-specific risk-attitude scale:measuring risk perceptions and risk behaviors. J. Behav. Dec. Making 15, 263–290.

Weinstein, A., Dannon, P. 2015. Is impulsivity a male trait rather than female trait? Exploring the sex difference in impulsivity. Curr. Behav. Neurosci. Rep. 2, 9-14.

White, M.J., Young, R.M., Morris, C.P., Lawford, B.R., 2011. Cigarette smoking in young adults: The influence of the HTR2A T102C polymorphism and punishment sensitivity. Drug Alcohol Depend. 114, 140-146.

Whiteside, S.P., Lynam, D.R., 2001. The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. Pers. Individ. Dif. 30, 669-689.

Woicik, P.A., Stewart, S.H., Pihl, R.O., Conrod, P.J., 2009. The substance use risk profile scale: A scale measuring traits linked to reinforcement-specific substance use profiles. Addict. Behav. 34, 1042-1055.

World Health Organization, 2015. WHO Repost on the Global Tobacco Epidemic, 2015. Geneva, World Health Organization.

Zinser, M.C., Baker T.B., Sherman, J.E., Cannon, D.S., 1992. Relation between self-reported affect and drug urges and cravings in continuing and withdrawing smokers. J. Abnorm. Psychol. 101, 617–629.

Zuckerman, M., 1994. Behavioural expressions and biosocial bases of sensation seeking. New York, NY, Cambridge University Press.

Zuckerman, M., Ball, S., Black, J., 1990. Influences of sensation seeking, gender, risk

appraisal, and situational motivation on smoking. Addict. Behav. 15, 209-220.

Zuckerman, M., Kuhlman, D.M., 2000. Personality and risk-taking: Common biosocial factors. J. Pers. 68, 999-1029.

Zuckerman, M., Kuhlman, D.M., Joireman, J., Teta, P., Kraft, M., 1993. A comparison of three structural models of personality. The big three, the big five, and the alternative five. J. Pers. Soc. Psychol. 65, 757-768.

**Table**

Table 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

Table 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<br>17 NS | 34 | 42.86 | 45.71 | Community | CS | SSS-TAS<br>BIS-NP/MI<br>SSS-BS, DI | SS<br>Prem<br>Pers | ST | 0.16<br>0.26<br>0.13 |
| Addicott et al (2013) | 18S | 36 | 44.44 | 38.9 | Community | CS | SSS-TAS<br>BIS-NP/MI<br>SSS-BS, DI | SS<br>Prem<br>Pers | ND | -0.09<br>0.22<br>-0.0005 |
| Bailey (2011) | 229 | 18-20 | 52 | 81 | College | PR | UPPS | SS<br>NU | ST | 0.09<br>0.13 |
| Balevich, Wein & Flory (2013) | 141 S<br>102 NS | 19.4 | 46.5 | 62.55 | College | CS | SSS-TAS<br>BIS-NP, MI<br>SSS-BS, DI | SS<br>Prem<br>Pers | ST | 0.26<br>0.16<br>0.30 |
| Baumann et al | 950 S | | 44.67 | 80.92 | College | CS | BIS/BAS FS | SS | ST | 0.02 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (2014) | 891 NS | | | | | | BIS/BAS D, R | RS | | -0.03 |
| Beaton, Abdi & Fidley (2014) | 82 S<br>37 NS | 30.19 | 49.58 | | Community | CS | ZKPQ-SS<br>BIS-T | SS<br>Prem | ST | 0.33<br>0.32 |
| Bejerot, Knorring & Ekselius (2000) | 13 S<br>51 NS | 42 | 46.88 | | OCD patients | CS | KSP-I | Prem | ST | 0.38 |
| Berg et al (2016) | 455 S<br>2963 NS | 20.55 | 35.55 | 62.4 | College | CS | VAL-NS | SS | ST | -0.07 |
| Bernow et al (2011) | 82 S<br>119 NS | 43.21 | 25.37 | | Community | CS | I-7 Vert<br>I-7 Imp | SS<br>Prem | ST | 0.25<br>0.27 |
| Bickel, Odum & Madden (1999) | 23 S<br>43 NS | 33.97 | 39.3 | | Community | CS | EPQ | Prem | ST | 0.23 |
| Carton, Jouvent & Widlocher (1994) | 96 S<br>68 NS | 35.11 | 64 | | Community | CS | SSS-TAS<br>SSS-BS,DI | SS<br>Pers | ST | 0.14<br>0.21 |
| Chives et al (2016) | 400 S<br>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<br>BIS/BAS D, R | SS<br>RD | ND | 0.35<br>-0.014 |
| Dervaux et al (2004) | 67S<br>33 NS | 34.72 | 68 | | Schizophrenic patients | CS | SSS-TAS<br>BIS-NP,MI<br>SSS-BS,DI | SS<br>Prem<br>Pers | ST | 0.23<br>0.13<br>0.27 |
| Dinn, Aycicegi & Harris (2004) | 23 S<br>116 NS | 18.6 | 29.85 | | College | CS | TPQ-NS, I-7 Vert<br>I-7 Imp | SS<br><br>Prem | ST | 0.28<br>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<br>327NS | 18.3 | 45 | 40 | College | PR | UPPS | SS<br>Prem<br>Pers<br>NU | ST | 0.14<br>0.01<br>0.03<br>0.12 |
| Downey, Pomerleau & Pomerleau (1996) | 35 S<br>17 NS | 30.2 | 100 | 100 | Adults with ADHD | CS | TCI-NS | SS | ST | -0.11 |
| Durazzo et al (2015) | 35 S<br>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<br>1388 NS | 33.1 | 36.2 | | Community | CS | TCI-NS | SS | ST | 0.08 |
| Evans et al (2015) | 97 S<br>115 NS | 65.3 | 61.32 | 100 | Parkinson's patients/ Community | CS | BSSS | SS | ST | 0.18 |
| Fairweather-Schmidt & Wade (2014) | 21 S<br>63 NS | 33.5 | 0 | | Community | CS | BIS-T | Prem | ST | 0.10 |
| Gau et al (2009) | 263 S<br>2655 NS | 19.3 | 45.5 | | College | CS | TCI-NS | SS | ST | 0.13 |
| Glicksohn & Nahari (2007) | 121 S<br>111 NS | 20-34 | 45.26 | | Community | CS | I-7 Vert<br>I-7 Imp, BIS-T<br>SSS-BS, DI | SS<br>Prem<br><br>Pers | ST | 0.17<br>0.31<br>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<br>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<br>5376 NS | 43.3 | 11.06 | | Community | PR | KSP-I | Prem | ST | 0.06 |
| Greenbaum et al (2006) | 242 S<br>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<br>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,<br>BIS/BAS FS, RAS<br>BIS-MI | SS<br><br><br>Prem | ST | 0.13<br>0.05 |
| Hudspith (2012) | 58 S<br>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<br>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<br>37 NS | 41.19 | 57.5 | | Schizophrenic patients | CS | ICS | Prem | ST | 0.26 |
| Jacobs et al (1966) | 54 S<br>80 NS | 26 | 100 | | Community | CS | BUPI-TDS<br>BUPI-I | SS<br>Prem | ST | 0.13<br>0.28 |
| Jacobs et al (1966) | 54 S | | 100 | | Community | CS | BUPI-TDS<br>BUPI-I | SS<br>Prem | ND | 0.06<br>-0.04 |
| Jacobs & Spilken (1971) | 42 S<br>108 NS | 19 | 100 | | College | CS | BUPI-I | Prem | ST | 0.29 |
| Kao et al (2011) | 62 S<br>33 NS | 35.87 | 47.4 | | Schizophrenic patients | CS | BIS-NP, MI | Prem | ST | 0.20 |
| Kassel et al (1994) | 137 S<br>70 NS | 39.99 | 28.6 | 100 | Community | CS | SSS<br>EPI<br>SSS-BS/DI, EASIT-Inh.C | SS<br>Prem<br>Pers | ST | 0.22<br>0.13<br>0.12 |
| Kassel et al (1994) | 137 S | 39.32 | 30.66 | 100 | Community | CS | SSS<br>EPI<br>EASIT-Inh.C | SS<br>Prem<br>Pers | ND | -0.09<br>-0.03<br>-0.12 |
| Kertzman et al (2013) | 39 S<br>81 NS | 28.41 | 0 | | Community | CS | BIS-T | Prem | ST | 0.30 |
| Knorring & Oreland (1985) | 601 S<br>481 NS | 18 | 100 | 100 | Community | CS | SSS-TAS<br>EPI<br>SSS-BS | SS<br>Prem<br>Pers | ST | 0.08<br>0.15<br>0.15 |
| Knorring & Oreland (1985) | 601 S | 18 | 100 | 100 | Community | CS | SSS-TAS<br>EPI<br>SSS-BS | SS<br>Prem<br>Pers | ND | -0.02<br>0.17<br>0.05 |
| Kohn & Coulas (1985) | 78 | 18.5 | 23.08 | | College | CS | SSS<br>SSS-DI | SS<br>Pers | ST | 0.21<br>0.22 |
| Krause et al (2015) | 198 S<br>326 NS | 33.5 | 79.4 | 69.5 | Traumatic spinal cord patients | CS | ZKPQ-Imp | Prem | ST | 0.16 |
| Kvaavik & Rise (2012) | 523 S<br>1253 NS | 22.3 | 41.8 | 100 | Community | CS | EPQ<br>BIS-T | Prem | ST | 0.28 |
| Kvaavik & Rise (2012) | 523 S | 22.1 | 36.3 | 100 | Community | CS | EPQ<br>BIS-T | Prem | ND | 0.08 |
| Lee et al (2015) | 41 S<br>399 NS | 18.49 | 48 | 82.8 | College | CS | UPPS-P | SS<br>Prem<br>Pers<br>NU<br>PU | ST | 0.14<br>0.24<br>0.15<br>0.28<br>0.25 |
| Lee et al (2015) | 41 S | | | | College | CS | UPPS-P | SS<br>Prem | ND | 0.11<br>0.11 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Pers<br>NU<br>PU | | 0.11<br>0.26<br>0.24 |
| Lejuez et al (2003) | 26 S<br>34 NS | 20.1 | 50 | 68 | College | CS | SSS<br>I-7 Imp | SS<br>Prem | ST | 0.43<br>0.28 |
| Leventhal (2007) | 120 S<br>59 NS | 24.02 | 32 | 64.5 | College | CS | DII-DS | Prem | ST | 0.08 |
| Littlefield & Sher (2012) | 86 S<br>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<br>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<br>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<br>183 NS | 18-19 | 41.4 | 78.2 | College | CS | SSS | SS | ST | 0.45 |
| Mitchell (1999) | 20 S<br>20 NS | 21.55 | 50 | | College | CS | TCI-NS<br>SSS-TAS<br>BIS-NP, MI, EPQ<br>SSS-BS/DI<br>BIS-AI | SS<br><br>Prem<br><br>Pers<br>NU | ST | 0.34<br>0.33<br>0.29<br>0 |
| Morean et al (2014) | 779 S<br>658 NS | 33.56 | 51.08 | 70.84 | Community | CS | BIS/BAS FS<br>IBS<br>BIS/BAS D, R | SS<br>Prem<br>RS | ST | 0.05<br>0.03<br>0.01 |
| Munyon (2014) | 63 S<br>63 NS | | | | College | CS | UPPS-P | SS<br>Prem<br>Pers<br>NU<br>PU | ST | 0.24<br>0.12<br>0.16<br>0.21<br>0.29 |
| Nieva et al. (2011) | 103 S | 47.1 | 53.4 | | Community | CS | ZKPQ-SS<br>ZKPQ-Imp | SS<br>Prem | ND | -0.06<br>0.13 |
| O'Connor, Stewart & Watt (2009) | 112 S<br>421 NS | 18.9 | 32.27 | 58 | College | CS | BIS/BAS FS<br>BIS/BAS D, R | SS<br>RS | ST | 0.16<br>0.08 |
| O'Connor, Stewart & Watt (2009) | 112 S | | | | College | CS | BIS/BAS FS<br>BIS/BAS D, R | SS<br>RS | ND | -0.08<br>0.005 |
| Omiya et al (2015) | 182 | 19.99 | 28.57 | 0 | College | CS | BIS/BAS FS<br>SURPS-Imp | SS<br>Prem | ST | 0.17<br>0.09 |
| Ostacher et al (2009) | 31 S<br>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<br>PU | ND | 0.15<br>0.16 |
| Papadodima et al (2009) | 116 S<br>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<br>30 NS | 31.32 | 61.55 | 0 | Community | CS | BIS-NP, MI | Prem | ST | 0.29 |
| Peltzer, Malaka & Phaswana (2001) | 104 S<br>695 NS | 20.12 | 55.2 | | College | CS | RTS | SS | ST | 0.06 |
| Perkins et al (2000) | 55 S<br>37 NS | 31.13 | 48 | | Community | CS | SSS-TAS<br>SSS-BS, DI | SS<br>Pers | ST | 0.08<br>0.22 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pomerleau et al (1992) | 240 S<br>676 NS | 42.12 | 48.8 | | Community | CS | TCI-NS | SS | ST | 0.30 |
| Pripfl et al (2013) | 18 S<br>18 NS | 21.7 | 30.56 | | College | CS | SURPS-SS<br>SURPS-Imp,<br>BIS-T | SS<br>Prem | ST | 0.55<br>0.46 |
| Rass, Ahn & O' Donnell (2015) | 53 S<br>30 NS | 25.25 | 47 | 74.7 | Community | CS | SS-TAS<br>BIS-NP, MI<br>SSS-BS, DI<br>BIS-AI | SS<br>Prem<br>Pers<br>NU | ST | 0.23<br>0.23<br>0.20<br>0.12 |
| Rass, Ahn & O' Donnell (2015) | 53 S | 25.25 | 48.01 | 80.77 | Community | CS | SS-TAS<br>BIS-NP, MI<br>SSS-BS, DI<br>BIS-AI | SS<br>Prem<br>Pers<br>NU | ND | 0.11<br>0.19<br>0.10<br>0.03 |
| Rezvanfard et al (2010) | 59 S<br>30 NS | 24.36 | 100 | | College | CS | I-7 V<br>SS-TAS<br>TCI-NS<br>BIS-NP, MI<br>I-7 Imp<br>SSS-BS, DI | SS<br><br><br>Prem<br><br>Pers | ST | 0.32<br>0.19<br>-0.02 |
| Rezvanfard et al (2010) | 59 S | 24.12 | 100 | | College | CS | I-7 V<br>SS-TAS<br>TCI-NS<br>BIS-NP, MI<br>I-7 Imp<br>SSS-BS, DI | SS<br><br><br>Prem<br><br>Pers | ND | 0.43<br>0.24<br>0.25 |
| Ristache & Rotarescu (2015) | 55 S<br>115 NS | 25.76 | 10.1 | | College | CS | TPQ-NS | SS | ST | 0.33 |
| Roberts et al (2014) | 74 S<br>287 NS | 21.4 | 49.2 | 82.8 | College | CS | UPPS-P | SS<br>Prem<br>Pers<br>NU<br>PU | ST | 0.09<br>0.19<br>0.14<br>0.3<br>0.22 |
| Schiep & Cieslik (2011) | 149 S<br>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<br>10 NS | | 50 | | Adults with OCD | CS | TCI-NS<br>BIS-T | SS<br>Prem | ST | 0.79<br>0.71 |
| Shokrgozar et al (2015) | 50 S<br>50 NS | 33.67 | 79 | | Schizophrenic patients | CS | BIS-NP, MI | Prem | ST | 0.51 |
| Skinner, Aubin & Berlin (2004) | 326 S<br>74 NS | 43.33 | 66.75 | 90 | Alcohol dependents | CS | BIS-NP, MI | Prem | ST | 0.22 |
| Sousa et al (2011) | 181 S<br>241 NS | 34.12 | 51.66 | 100 | Adults with ADHD | CS | TCI-NS | SS | ST | 0.22 |
| Spielberger et al (2004) | 225 S<br>490 NS | 41.5 | 100 | 100 | Community | CS | NEO-PI-R | NU | ST | 0.09 |
| Spillane, Smith & Kahler (2010) | 139 S<br>87 NS | 18.97 | 41.5 | | College | CS | UPPS-P | SS<br>Prem<br>Pers<br>NU<br>PU | ST | 0.21<br>0.16<br>0.16<br>0.21<br>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<br>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<br>169 NS | 22.67 | 37.06 | 95.9 | College | CS | BIS-NP, MI | Prem | ST | 0.11 |
| Stoltenberg et al (2011) | 101 S<br>373 NS | 22.49 | 35.3 | 100 | College | CS | BIS-NP, MI | Prem | ST | 0.24 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stuart et al (2006) | 212 S<br>148 NS | 33.1 | 100 | 79 | Prisoners | CS | I-7 Imp | Prem | ST | 0.19 |
| Tapper et al (2015) | 46 S<br>138 NS | 33 | 0 | 92 | Community | CS | BIS/BAS FS<br>BIS/BAS D, R | SS<br>RS | ST | 0.32<br>0.0005 |
| Tapper et al (2015) | 46 S | | 0 | | Community | CS | BIS/BAS FS<br>BIS/BAS D, R | SS<br>RD | ND | 0.16<br>0.30 |
| Terracciano & Costa (2004) | 116 S<br>1638 NS | 60.3 | 50 | | Community | CS | NEO-PI-R | NU | ST | 0.12 |
| Terracciano et al (2008) | 318 S<br>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<br>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<br>BIS/BAS R | SS<br>RS | ST | 0.13<br>-0.01 |
| Voracek, Pum & Dressler (2010) | 49 S<br>85 NS | 36.3 | 100 | 100 | Community | CS | SS-TAS<br>SSS-BS, DI | SS<br>Pers | ST | 0.11<br>0.21 |
| Ward et al (1987) | 18 S<br>69 NS | 19.6 | 65.52 | | College | CS | SS-TAS<br>SSS-BS, DI | SS<br>Pers | ST | 0.15<br>0.17 |
| White et al (2011) | 47 S<br>85 NS | 19.44 | 53.03 | 100 | College | CS | BIS-T | Prem<br>RS | ST | 0.21<br>0.11 |
| White et al (2011) | 47 S | | 57.5 | 100 | College | CS | BIS-T<br>SPSRQ | Prem<br>RS | ND | 0.02<br>0.07 |
| Zuckerman, Ball & Black (1990) | 150 S<br>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

Table 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.

* $p<0.05$

** $p<0.01$

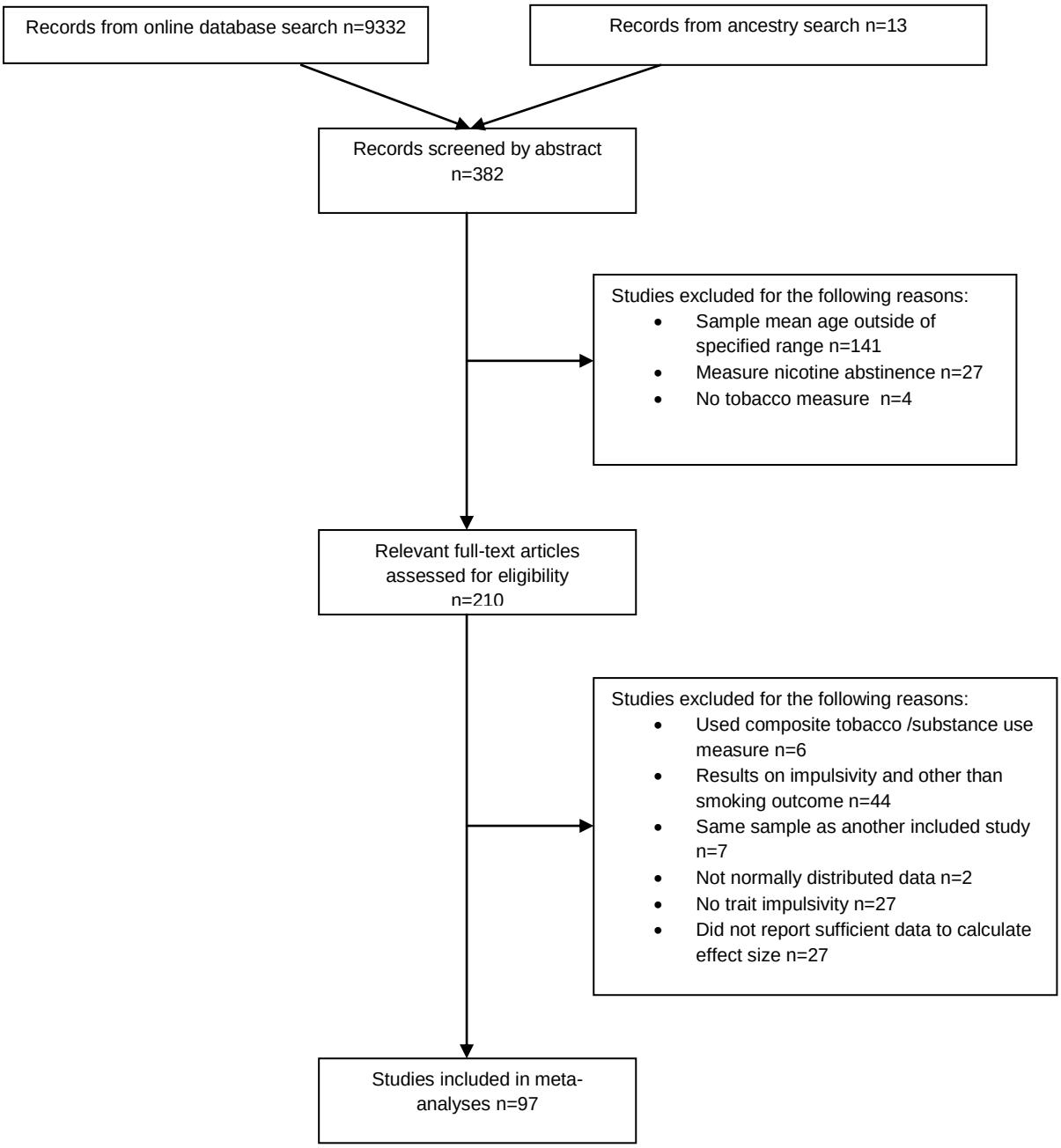
***$p<0.001$

Table 4.Moderator subgroup analyses (Impulsivity traits and smoking)

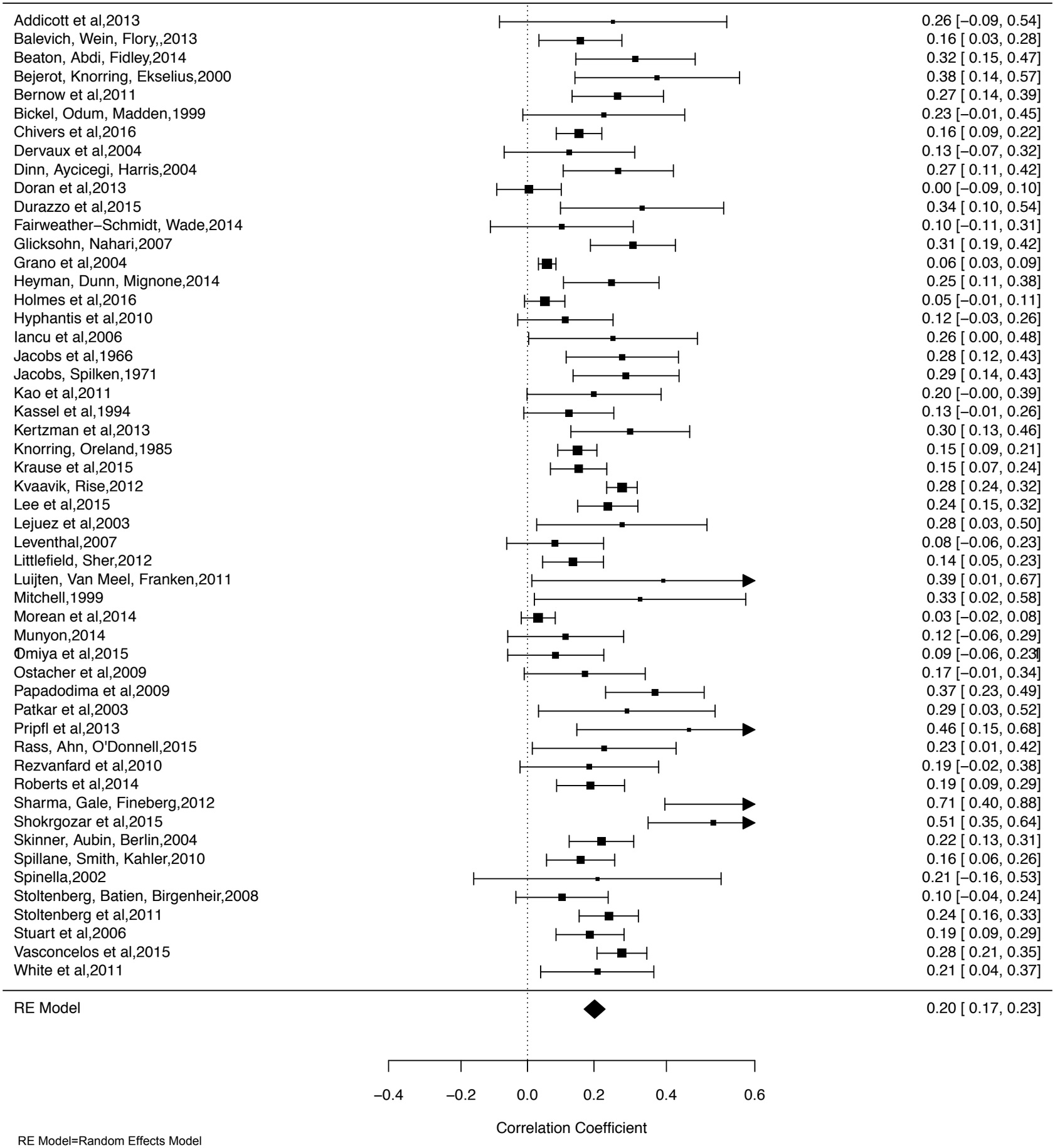
| | K | Q | P |
|---|---|---|---|
| **Lack of premeditation** | | | |
| Age | 50 | 0.73 | 0.39 |
| Ethnicity | 26 | 1.52 | 0.22 |
| Gender | 51 | 2.70 | 0.10 |
| Sample type | 52 | 2.60 | 0.11 |
| College students | 52 | 2.51 | 0.11 |
| Study type | 52 | 8.33 | 0.004 |
| **Lack of perseverance** | | | |
| 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

**Figure 1.**

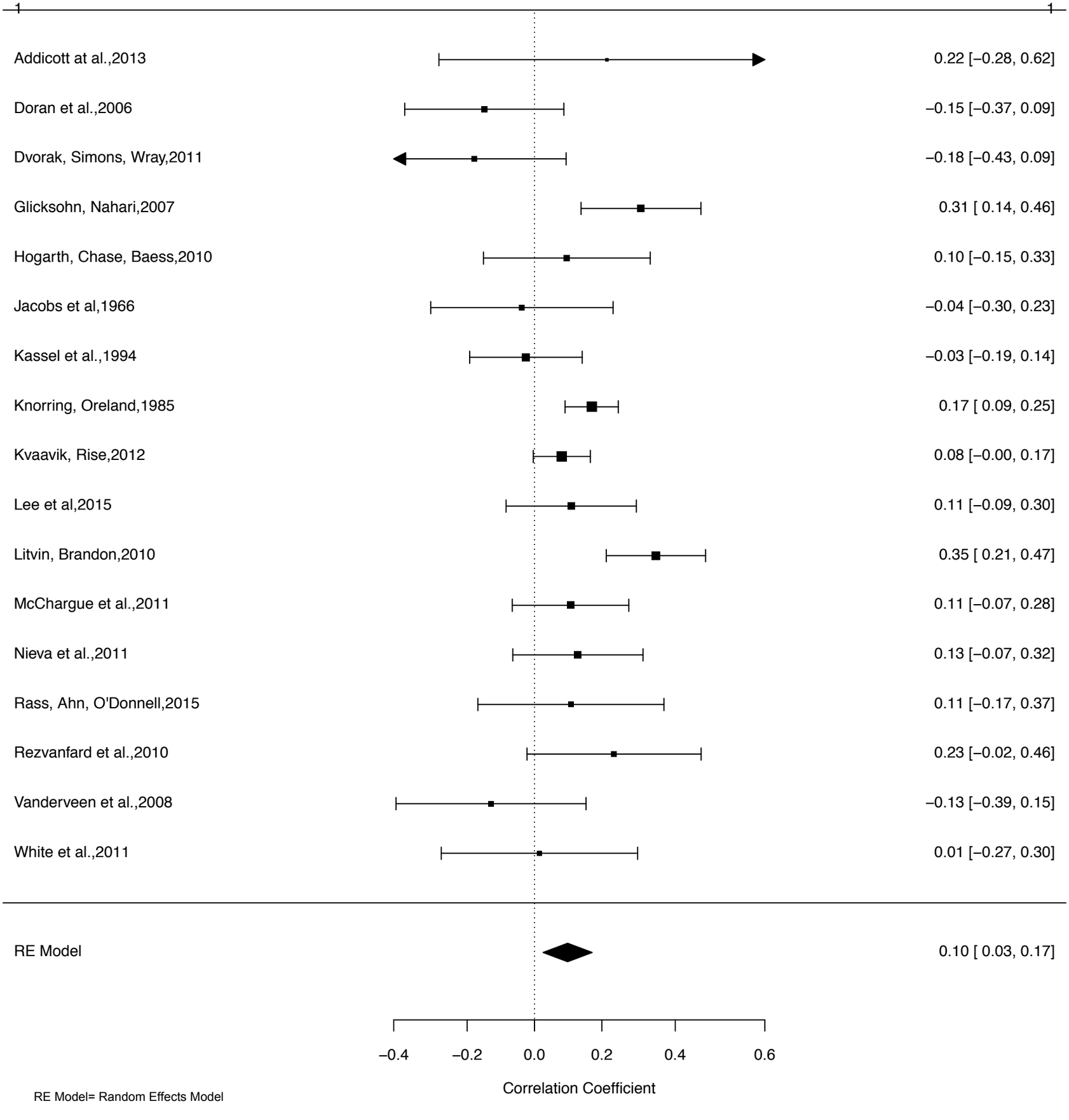

Records from online database search n=9332
Records from ancestry search n=13
Records screened by abstract n=382
Studies excluded for the following reasons:
Sample mean age outside of specified range n=141
Measure nicotine abstinence n=27
No tobacco measure n=4
Relevant full-text articles assessed for eligibility n=210
Studies excluded for the following reasons:
Used composite tobacco /substance use measure n=6
Results on impulsivity and other than smoking outcome n=44
Same sample as another included study n=7
Not normally distributed data n=2
No trait impulsivity n=27
Did not report sufficient data to calculate effect size n=27
Studies included in meta-analyses n=97

# Figure 2.1



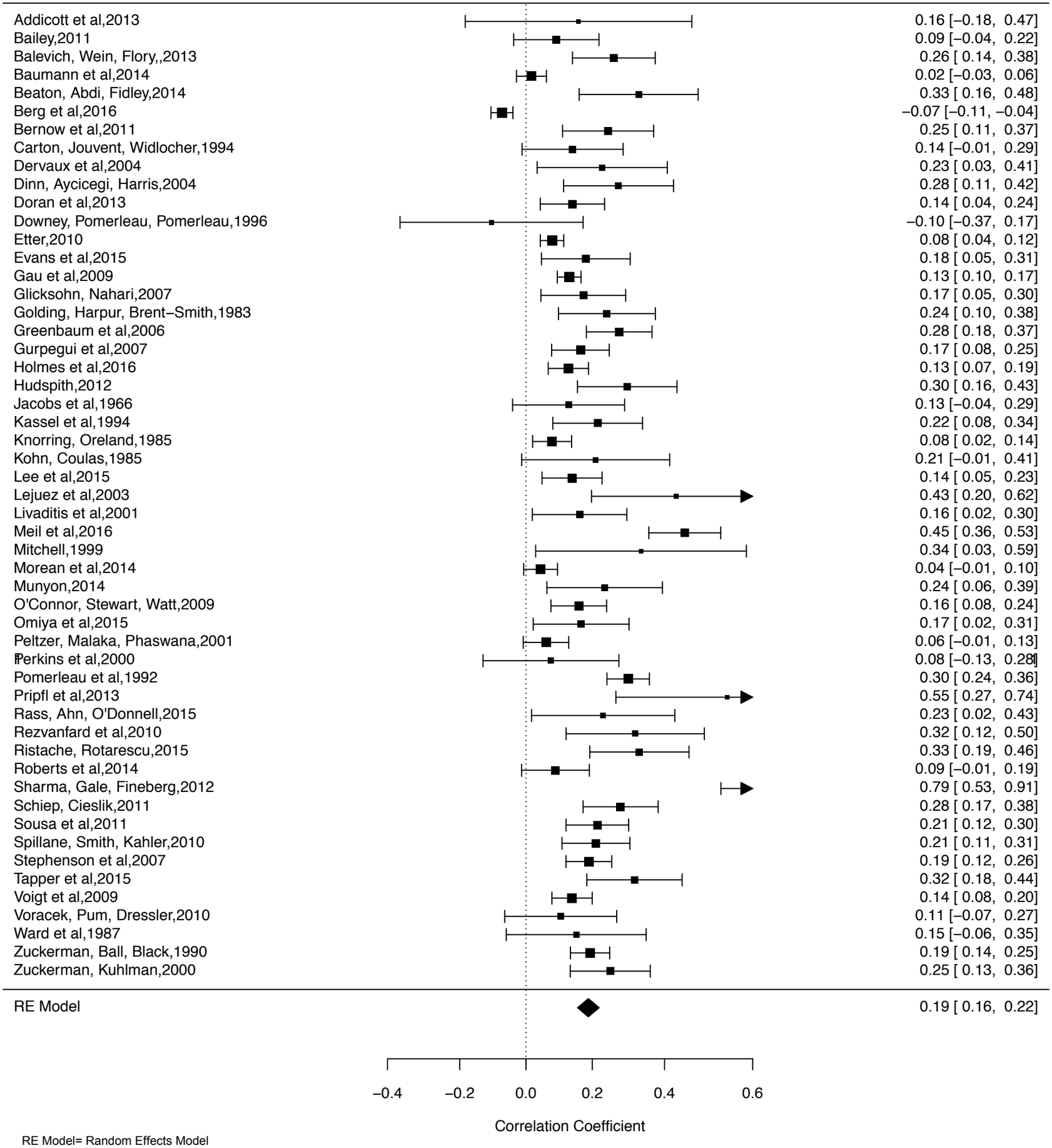

RE Model=Random Effects Model

# Figure 2.2



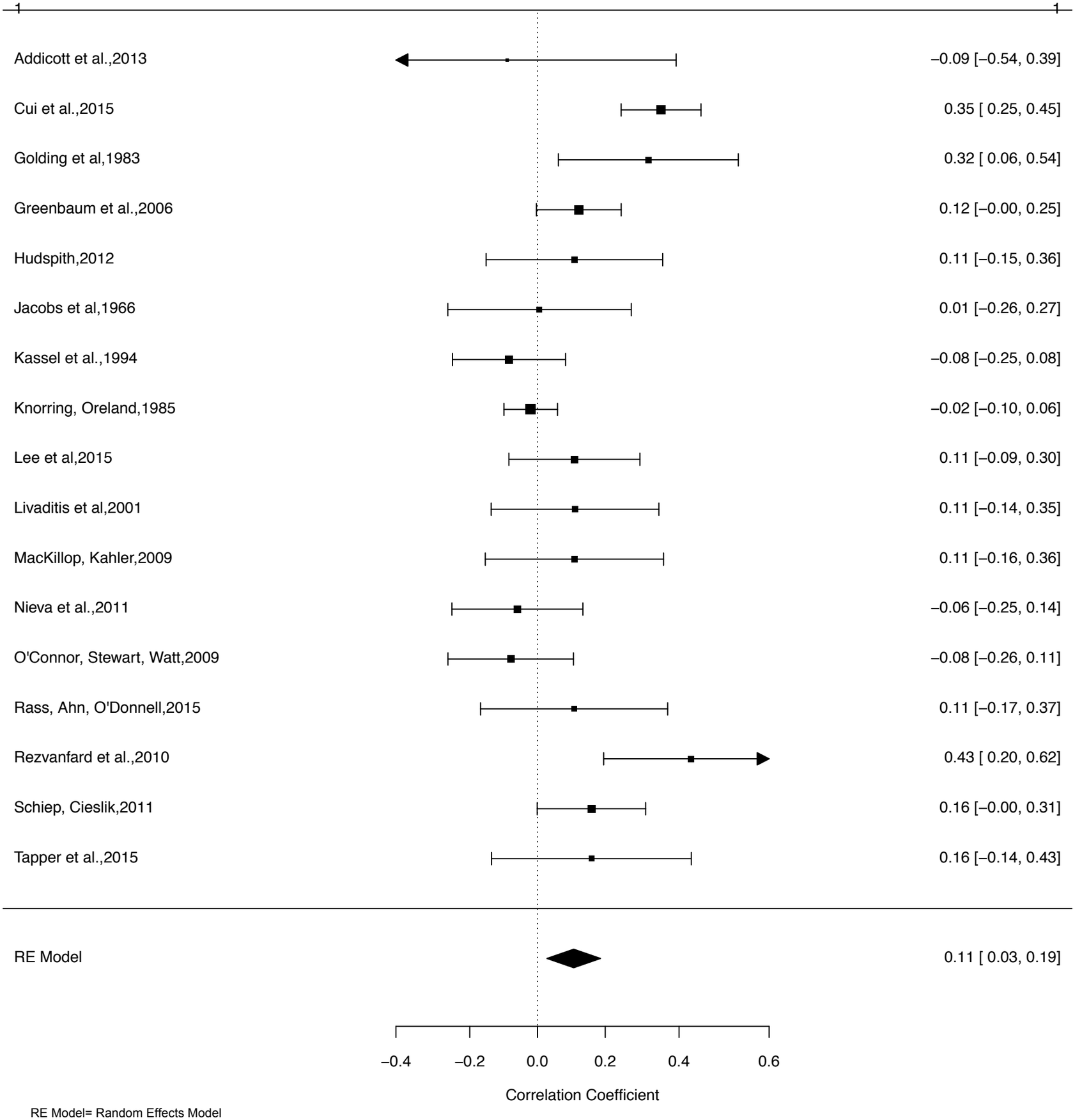

RE Model= Random Effects Model

# Figure 2.3




RE Model= Random Effects Model

# Figure 2.4




RE Model= Random Effects Model

## Figure Legends

**Figure 1**

Flowchart for study selection

**Figure 2.1**

Forest plot lack of premeditation and smoking status.

**Figure 2.2.**

Forest plot lack of premeditation and severity of nicotine dependence

**Figure 2.3**

Forest plot sensation seeking and smoking status

**Figure 2.4**

Forest plot sensation seeking and severity of nicotine dependence

## Authors Disclosures

**Role of funding Source:** This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Contributors**: Authors Dimitra Kale and Andrew Cooper designed the study. Author Dimitra Kale conducted the literature search, data-analysis, coded articles, reviewed scales and classified them on to a specific UPPS-P trait, and wrote the first draft of the manuscript. Author Andrew Cooper reviewed scales and classified them on to a specific UPPS-P trait and aided in compiling and editing the manuscript. Author Kaidy Stautz aided in data-analysis, compiling and editing the manuscript. All authors have approved the final manuscript.

**Conflict of interest:** No conflict declared

**Acknowledgements:** The authors would like to thank authors that provided additional data and methodological information for the studies used in the present meta-analysis: Meredith Addicott, Micahel Baumann, James Dillard, Jean-Francois Etter, Joseph Glicksohn, Alina Gomide, Manuel Gurpegui, James Krause, Meghan Morean, Voracek Martin, William Meil, Scott Stoltenberg, Katy Tapper, Melanie White

## Conflict of interest

No conflict declared

## Contributors

Authors Dimitra Kale and Andrew Cooper designed the study. Author Dimitra Kale conducted the literature search, data-analysis, coded articles, reviewed scales and classified them on to a specific UPPS-P trait, and wrote the first draft of the manuscript. Author Andrew Cooper reviewed scales and classified them on to a specific UPPS-P trait and aided in compiling and editing the manuscript. Author Kaidy Stautz aided in data-analysis, compiling and editing the manuscript. All authors have approved the final manuscript.

## Highlights

- Reviewed studies assessing six impulsivity-related traits and cigarette smoking
- Smoking status most associated with lack of premeditation and positive urgency
- Nicotine dependence most associated with positive urgency