UPPS-P Model Impulsivity and Marijuana Use Behaviors in Adolescents: A Meta-Analysis

J. Davis VanderVeen†

Alexandra R. Hershberger

Melissa A. Cyders

Indiana University – Purdue University Indianapolis, Department of Psychology.
402 N Blackford St. Indianapolis, IN, USA 46202

†Corresponding author may be contacted by email at jodavand@iupui.edu

Abstract

BACKGROUND: Impulsivity is often included as a risk factor in models of adolescent marijuana use behaviors; however, the magnitude of the association between impulsivity and marijuana use behaviors is variable across studies. The present study reviewed existent literature to 1) quantify the relationship between separable impulsivity-related traits and both marijuana use and negative marijuana consequences and 2) quantify the size of the effect of gender on these relationships. METHOD: Thirty-eight studies (41 independent samples) were meta-analyzed using a random effects model to examine the relationship between impulsivity traits and marijuana use behaviors. RESULTS: Marijuana use was significantly related to all impulsivity-related traits except lack of perseverance (*r*'s ranging from 0.13 – 0.23, *p*'s <0.01). Negative marijuana consequences were only significantly related to sensation seeking, lack of planning, and positive urgency (r's ranging from 0.37 – 0.39, p's <0.01). Effects were small for marijuana use, but medium for negative marijuana consequences. Gender was not a significant moderator of any relationships. CONCLUSIONS: Impulsivity-related traits had more robust relationships with negative marijuana consequences than marijuana use, suggesting impulsivity-related traits

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are important in differentiating adolescents most likely to experience negative consequences from marijuana use. Few relationships examined gender and many of the impulsivity-related traits, other than sensation seeking. Data and trends suggest a more multi-dimensional approach to marijuana use and consequences is warranted.

Keywords: Impulsivity; marijuana; cannabis; UPPS-P model; meta-analysis

1.0 Introduction

Marijuana use poses many health risks including impaired memory, decline in cognitive reasoning, decline in learning abilities, suicidal thoughts, lung cancer, and heart attack (Hall, 2009; Hall and Degenhardt, 2009; Meier et al., 2012). These negative outcomes are more likely and problematic the earlier a person begins using marijuana (Castellanos-Ryan et al., 2013; Dévieux et al., 2002; Gruber et al., 2014). Adolescents make up the largest proportion of marijuana users and over 75% of people who begin using marijuana each year are aged 12-20 (NIDA, 2014). Adolescents that use marijuana have lower grades and exam scores, are less likely to attend college, are more likely to be unemployed, and have lower life satisfaction (Cobb-Clark et al., 2015; Johnston et al., 2014). Furthermore, adolescents that use marijuana are more likely to engage in other risk taking behaviors such as stealing, using weapons in acts of violence, having risky sex, and having accidental injuries (Brook et al., 1999; Castellanos-Ryan et al., 2013; Chassin et al., 2010; Churchwell et al., 2010; Crews et al., 2007; Dévieux et al., 2002). Using marijuana can stunt brain development, including development of socio-emotional areas (i.e., amygdala, ventral striatum, orbitofrontal cortex, medial prefrontal cortex, and superior temporal sulcus) and cognitive control (i.e., lateral prefrontal, lateral parietal, and anterior cingulate cortices) (e.g., Crews et al., 2007; Chassin et al., 2010; Gruber et al., 2014), leading to the more pronounced difficulties in adulthood (e.g., Hall, 2009; Hall and Degenhardt, 2009; Meier et al., 2012).

Despite the mounting evidence of the dangers of marijuana to adolescents, marijuana use is becoming more accepted and adolescents increasingly believe that marijuana is not a risky drug (SAMHSA, 2014). The changing perception of marijuana dangers has coincided with states passing bills decriminalizing and legalizing degrees of marijuana use (NCSL, 2016). While

adolescent use rates are higher in states that have passed such legislation (Harper et al., 2012; Mason et al., 2014; Wall et al., 2011), there is little evidence of causality between perception, use, and legality. These trends suggest understanding risk factors for adolescent marijuana use behaviors is of utmost importance.

Although many researchers agree that adolescence is a period of healthy experimentation, including drug use (Baker and Yardley, 2002), that is beneficial as it reflects a pattern of behavior shifting *from* parental control and *towards* autonomy (Laird et al., 2009; Loeber et al., 2000; Spear and Kulbok, 2004), problems arise when adolescents have an exaggerated inclination towards risk-taking, leading to more negative outcomes (Castellonos-Ryan et al., 2013; Stautz and Cooper, 2013). Thus, it is important to understand risk factors associated with marijuana use and negative marijuana-related consequences in order to more effectively identify and intervene on adolescents who are at greatest risk for such outcomes. We examine three main factors in the current study: separable impulsivity traits, gender, and differential relationships with marijuana use and negative marijuana-related consequences.

1.1 Separable Impulsivity Traits: The UPPS-P Model

Impulsivity is one of the most important personality-based risk factors for marijuana use (Barrera et al., 2001; Jessor et al., 1980; Steinberg, 2008; Willoughby et al., 2014). However, despite this well-acknowledge relationship, evidence for the role of impulsivity in adolescent marijuana use behaviors is mixed (Andrucci et al., 1989; Chabrol et al., 2012; Gerra et al., 2004; Malmberg et al., 2013). One potential explanation for these inconsistencies is that impulsivity is a multidimensional trait that comprises multiple separate, though related, tendencies toward impulsive action (e.g., Evenden, 1999). The current study uses the UPPS-P framework (Whiteside and Lynam, 2001), which identifies five separate, though related, impulsivity-related

traits: 1) *sensation seeking*, defined as the tendency to seek sensory pleasure and excitement, 2) *lack of planning*, the tendency to act without forethought, 3) l*ack of perseverance*, defined as the tendency to not finish tasks, 4) *negative urgency*, defined as the tendency to act rashly in negative emotional states, and 5) *positive urgency*, defined as the tendency to act rashly in positive emotional states (Lynam et al., 2007). Previous studies have shown these traits share between 6% and 27% of their variance, with negative and positive urgency sharing the largest proportion of variance (see Cyders and Smith, 2007). The measurement of separate aspects of impulsivity can clarify discrete relationships that might be masked or watered down when such constructs are combined (Smith et al., 2003). The use of the UPPS-P model has resulted in more discrete and robust relationships with adolescent risky behaviors, including alcohol use (Stautz and Cooper, 2013), tobacco use (Bloom et al., 2014), and risky sexual behavior (Dir et al., 2014), and is key to clarifying relationships with marijuana use behaviors and consequences. Although impulsivity-related traits have been implicated in risk for a wide range of substance use behaviors, the current study focuses primarily on marijuana use behaviors and consequences.

Previous work has suggested differential patterns of relationship between separate impulsivity-related traits and marijuana use behaviors. Sensation seeking is the most widely studied impulsivity-related trait for marijuana use and there is consistent evidence that sensation seeking is a robust predictor of marijuana use in both adults (e.g., Alston, 1994; Trocki et al., 2009; Quinn and Harden, 2013) and adolescents (e.g., Andrucci et al., 1989; Arnett and Balle-Jensen, 1993; Jaffee and D'Zurilla, 2009; Castellanos-Ryan et al., 2013; Felton et al., 2015). Adolescents high in sensation seeking are more likely to use marijuana (e.g., Martin et al., 2002; Stanton et al., 2001) and use marijuana more frequently (e.g., Donohew et al., 1999; Tercek, 2008; Felton et al., 2015). Additionally, adolescent sensation seekers are more likely to

experience negative marijuana consequences, including trouble at school and at home (e.g., Hendershot et al., 2011; Stautz and Cooper, 2014), and be diagnosed with marijuana dependence (e.g., Ames et al., 2005).

Evidence for other impulsivity-related traits is less available. There is preliminary evidence that negative urgency is associated with marijuana use (e.g., Pang et al., 2014; Robinson et al., 2014) and negative marijuana consequences (e.g., Stautz and Cooper, 2014; Churchwell et al., 2010). Lack of planning has been robustly associated with adolescent marijuana use and frequency in some studies (e.g., Xiao, 2008; Castellanos-Ryan et al., 2013) but unrelated in other studies (e.g., Kong et al., 2013; Leeman et al., 2014). Furthermore, lack of planning has been strongly related to negative marijuana consequences in some studies (e.g., Caspi et al., 1995; Churchwell et al., 2010) but weakly related in others (e.g., Stautz and Cooper, 2014). While there is less available research on lack of perseverance, current findings suggest this trait has limited associations with adolescent marijuana use behaviors (e.g., Tercek, 2008; Stautz and Cooper, 2014). The inconsistencies in the relationship between these traits and adolescent marijuana use behaviors warrant a more thorough review of existing literature.

1.2 The Importance of Gender

Gender plays an important role in marijuana use behaviors (e.g., Ames et al., 2005; Kong et al., 2013) and impulsivity trait levels (d'Acremont and Van der Linden, 2005; Cross et al., 2011; Cyders, 2013), such that adolescent boys tend to report higher levels of sensation seeking, positive urgency, and marijuana use (Williams et al., 2007; Schepis et al., 2011), although this gap is closing (see Johnson et al., 2015 for review). Adolescent boys begin using marijuana at an earlier age (Kosterman et al., 2000; Johnson et al., 2015) and are more likely to experience negative marijuana consequences (Ames et al., 2005). There are several possible, and likely

interacting, explanations for adolescent boy's higher propensity for marijuana use and impulsivity traits. For example, testosterone, which is higher in adolescent boys than girls, has shown to correlate with both risk-taking behaviors (i.e. marijuana use) and impulsivity traits (Archer, 2006). Adolescent boys have also been shown to positively weigh benefits of risk taking and impulsive behaviors more so than girls, particularly when in a group (Gardner & Steinberg, 2005). Additionally, protective social factors, including peer and parental disapproval of marijuana use, are less effective at reducing marijuana use (Butters, 2004). Researchers have implicated evolutionary processes in gender differences in impulsivity traits and marijuana use (e.g. Zuckerman, 2007), particularly mate competition being a significant driver in risk-taking behavior. Taken together, findings suggest there are biological, social, and cognitive factors resulting in gender differences in impulsivity traits and marijuana use. While these differences in impulsivity traits and marijuana use behaviors do not mean there are differential effects in the impulsivity and marijuana use relationship across boys and girls, they do suggest closer examination of gender as a potential moderator in this relationship.

1.3 Conceptualizing Marijuana Use Behaviors

Measurement of marijuana use behaviors has varied, including simple use behaviors (e.g., frequency and lifetime use) and the experience of negative marijuana use consequences (e.g., marijuana dependence and marijuana-related problems), leading to differences in findings and in how researchers have interpreted their results. For instance, marijuana use has been studied by asking about lifetime use with a yes or no answer (e.g., Martin et al., 2002; Stephenson and Helme, 2006), with rating scales for frequency of use (e.g., Baskir, 2006; Castellanos-Ryan et al., 2013), and more recently with timeline follow-back calendars (Robinson et al., 2014). Conversely, negative marijuana consequences have been studied using self-report

questionnaires asking about various types of problems experienced (e.g., Hendershot et al., 2011) and by comparing people that meet criteria for cannabis dependence according to criteria by the Diagnostic and Statistical Manual of Mental Disorders (DSM; APA, 2000) and people that do not (e.g., Caspi et al., 1995; Churchwell et al., 2010). It is likely that impulsivity and gender are differentially related to marijuana use and the experience of negative marijuana consequences.

1.4 Current Study

Given the increasing prevalence of marijuana use and the high risk for experiencing negative marijuana consequences among adolescents, the goal of the current meta-analysis was to examine how separable impulsivity traits, based on the UPPS-P model (Lynam et al., 2006), are related to marijuana use (e.g., frequency and lifetime use) and to negative marijuana consequences (e.g., marijuana-related problems like trouble at home or at school due to marijuana use, marijuana dependence) among adolescents, and how gender affects these relationships. This review contributes to the current literature by 1) quantifying the relationship between separable impulsivity-related traits and both marijuana use and negative marijuana consequences and 2) quantifying the size of the effect of gender on these relationships. Quantifying these relationships in adolescents is imperative to developing individually tailored treatments specifically targeting marijuana use prevention and reducing negative marijuana use consequences.

2.0 Methods

2.1 Selection of studies

Relevant studies were identified via literature searches, using *Medline, PsychInfo, PsychArticles, PubMed,* and *GoogleScholar* (published before January 2016), as well as reference section reviews, forward searches, and email alerts. Searches were conducted based on

all keyword combinations of terms for impulsivity and marijuana-related behaviors (Term 1: impuls*, urgen*, sensation seeking; Term 2: marijuana, THC, cannabis; Term 3: adolesc*, youth, teen), as used in previous reviews (e.g., Coskunpinar et al., 2013; Dir et al., 2014; Hoyle et al., 2000). The present study included both published and unpublished (dissertations) articles. Studies were included if they contained 1) both personality measures of impulsivity and marijuana outcomes (i.e., frequency, lifetime use, marijuana-related problems, or dependence) and 2) were based on a conceptualization of adolescence with a mean age between 10 and 19 years old (upper limit of 25 years; Eaton et al., 2010; Sales et al., 2012).

Although some have proposed that impulsivity can be assessed via self-reports and behavioral tasks, recent meta-analytic evidence suggests that these two domains share very little (~5%) variance to warrant calling them both impulsivity (Cyders & Coskunpinar, 2011). The authors suggest that trait and behavioral approaches measure different things (self-report assessments measuring more stable personality traits and behavioral tasks measuring impulsive states) and should not be combined (Cyders & Coskunpinar, 2011). We chose to focus our review on impulsivity traits because they have superior content and ecological validity as compared to behavioral tasks (Sperry, et al., 2016), reflecting cognitions, emotions and behaviors individuals experience in everyday life.

Studies were required to provide either an effect size representing the relationship between impulsivity and marijuana outcomes, compare marijuana users versus non-users on impulsivity, or compare groups on higher versus lower levels of impulsivity on marijuana use outcomes. Impulsivity measures were assigned to separate impulsivity traits based on a factor analysis by Whiteside and Lynam (2001) and by previous meta-analyses (Coskunpinar et al., 2013; Dir et al., 2014; Karyadi et al., 2014; Supplemental Table 1). Marijuana-related behaviors

we assigned were based on current conceptualizations of marijuana use (e.g., lifetime use, current use, frequency of use; Martin et al., 2002; Felton et al., 2015; Tercek, 2008) and negative marijuana consequences (e.g., dependence, marijuana-related problems; Hendershot et al., 2011; Stautz and Cooper, 2015; Ames et al., 2005).

Both correlational and longitudinal designs were included because 1) a longitudinal design was not required to answer study questions, 2) the present study questions pertain to a single time-point relationship, 3) longitudinal studies that report effects for multiple time-points were corrected for sample dependence (see Section 2.4), and 4) results followed the same patterns when excluding longitudinal studies as when both cross-sectional and longitudinal studies were included. The first study author initially coded all of the studies included in the meta-analysis and the second author coded a subset of 15 studies for inter-rater agreement, and re-training and discussion was undertaken until agreement could be reached on all codes. A flowchart, including numbers of studies excluded based on each criterion, is included in Figure 1.

2.2 Meta-analytic method

The present study used Pearson's *r* as the effect size statistic for the relationship between impulsivity and adolescent marijuana use and consequences. Effect sizes from studies not reporting a correlation were converted to *r* based on conversion formulas (Lipsey and Wilson, 2001; Borenstein et al., 2009). Effect sizes were coded such that higher positive values indicated higher level of impulsivity, higher levels of adolescent marijuana use, and higher levels of adolescent negative marijuana consequences. Mean effect sizes were calculated using SPSS 23.0 and macros provided by Wilson (2010). The relationships between specific impulsivity-related traits and marijuana use and specific impulsivity-related traits and negative marijuana

consequences were examined separately. Effect sizes were converted using a Fisher's Z transformation and weighted based on their inverse variance weight to account for differences in sample size. In addition to interpreting significance with a *p*-value less than 0.05, effect sizes of each relationship were examined based on Lipsey and Wilson's (2001) guidelines for small (r=0.10), medium (r=0.25), and large (r=0.40).

A random effects model was used because it assumes variability in effect sizes across studies beyond sampling error, making it a more conservative approach (Borenstein et al., 2009). The I^2 index was used to measure the proportion of heterogeneity in effect sizes, with values ranging from 0 to 1 (0-100%), with higher values indicating more true heterogeneity (Higgins and Thompson, 2002; Huedo-Medina et al., 2006). The I^2 index is preferable to the commonly used Q-test because it is able to quantify the amount of heterogeneity between effect sizes. Fail-safe N analyses were also conducted on statistically significant mean effects in order to estimate the number of studies with null findings that would be needed to drop the effect sizes to non-significance (Orwin, 1983; Lipsey and Wilson, 2001). Funnel plots were used to visually inspect the possibility of publication bias and Egger's regression test of asymmetry was used to statistically examine the presence of asymmetry and publication bias, with values significantly deviating from zero indicating a higher level of publication bias (Egger et al., 1997).

2.3 Moderator analyses

Gender (percent female) was coded as a continuous moderator variable and tested using meta-regression (MetaReg macro by Wilson, 2010). In addition to interpreting significance with a *p*-value less than 0.05, moderator effect sizes were examined based on Cohen's (1992) guidelines for small (R^2=0.01), medium (R^2=0.09), and large (R^2=0.25).

2.4 Dependent Samples

Dependence in meta-analytic studies occurs when a study includes more than one outcome measure, when there are multiple time points for the same participants, or when two or more treatment groups are compared with the same control group. Dependent samples are problematic, as they give more weight to studies reporting multiple effect sizes, reduce estimates of variance, and inflates the probability of making a Type I error (Borenstein et al., 2009; Cheung, 2014; Scammacca et al., 2014).

In order to assess the strength of impulsivity-related traits and their relationship to marijuana use and negative marijuana consequences, the shifting-units-of-analysis approach (Cooper, 1998) was used, with each individual impulsivity-related trait-marijuana use and negative marijuana consequences relationship examined in separate analyses. Lifetime use and frequency were combined to reflect the variable marijuana use because of a limited number of samples and there is a general consensus in the research community that these variables measure the same construct of marijuana use (see Johnson et al., 2015 for review). Similarly, marijuana related problems and marijuana dependence were combined to reflect the variable negative marijuana consequences. While this approach does not allow for direct statistical comparison of effect sizes, it is the most feasible approach in controlling for dependent samples.

3.0 Results

3.1 Sample

The final study sample consisted of 38 studies (35 peer-reviewed journal articles and 3 dissertation manuscripts) with 41 independent samples (some studies reported separate effects for multiple independent samples) conducted over the last 30 years (1986-2015). The mean sample size was 981.89 (*SD*= 1,596.97; range 36-9,600), with a mean age of 16.08 (*SD*=1.19; range 12.76-18.34). On average, samples were 44.86% female (*SD*= 24.05; range 0-100; *k*= 2

female-only samples) and 57.82% Caucasian (*SD*= 32.06; range 0-100% Caucasian; *k*= 9 Caucasian-only samples). The majority of samples were nonclinical (*k*= 37 non-clinical; *k*= 1 clinical samples; *k*= 3 juvenile detainee samples). Sensation seeking was the most common impulsivity construct measured (*n*= 52 associations), and marijuana use frequency was the most common marijuana behavior measured (*n*= 41 associations). All studies used self-report measures of marijuana use behaviors. On average, studies included 33.51% (*SD*=22.08%; range 2.95-81.70%) participants that reported having used marijuana (see Table 1 for studies and original study-reported effect sizes used in the current meta-analysis). Table 2 presents the mean effect sizes and related statistics for both the mean effect sizes and specific association effect sizes. There were a total of 65 specific association mean effect sizes. Studies included in the meta-analysis are denoted with * in the reference section.

3.2 UPPS-P Impulsivity Traits and Adolescent Marijuana Use.

The number of reported associations between marijuana use and each impulsivity trait ranged from 2 (lack of perseverance) to 38 (sensation seeking). The weighted mean effect sizes between adolescent marijuana use and both sensation seeking and lack of planning were small (*r*= 0.22, *r*=0.13, respectively) but significantly different than zero (*z*= 12.68, *p*<0.01; *z*= 5.33, *p*<0.01, respectively). There were too few effects for the lack of perseverance, negative urgency, and positive urgency relationships with adolescent marijuana use to use the random effects model (all *k*<6; see Table 2); therefore, the fixed effects models are reported. The weighted mean effect sizes for the relationships between marijuana use and negative urgency and positive urgency were both small (*r*=0.23, *r*=0.19, respectively), but significantly different from zero (*z*=3.90, *p*<0.01; *z*=3.35, *p*<0.01, respectively). The relationship between lack of perseverance and adolescent marijuana use did not differ from zero (*r*=0.16, *z*=0.19, *p*=0.85).

3.3 UPPS-P Impulsivity Traits and Adolescent Negative Marijuana Consequences.

The number of reported associations between negative marijuana consequences and each impulsivity trait ranged from 1 (lack of perseverance) to 4 (sensation seeking). There were too few effects for all UPPS-P traits and negative marijuana consequences relationships to report the random effects model (all $k<6$; see Table 2); therefore, the fixed effects models are reported. The weighted mean effect sizes between sensation seeking and negative marijuana consequences was medium and significantly different from zero ($r=0.39$, $z=3.93$, $p<0.01$). The weighted mean effect size between lack of planning and negative marijuana consequences was also medium and significantly different from zero ($r= 0.47$, $z= 9.51$, $p<0.01$). The weighted mean effect size between negative urgency and negative marijuana consequences was small and not significantly different from zero ($r= 0.26$, $z=1.22$, $p<0.22$). There was also one independent effect size reported for the relationship between positive urgency and negative marijuana consequences, which was medium ($r=0.37$, $p<0.01$). There was one independent effect size reported for the relationship between lack of perseverance and negative marijuana consequences, which was non-significant ($r= 0.06$, $p>0.05$).

3.4 Gender as a moderator

Gender was not a significant moderator of any of the relationships. There was a medium effect of gender moderating the sensation seeking and marijuana use relationship, which fell just short of significance ($\beta= -0.30$, $R^2= 0.09$, $p= 0.08$), suggesting a trend toward a stronger relationship in samples with more boys.

3.4 Exploratory Analyses

Other sample characteristics were examined as possible moderators. There were only enough effects reported for the sensation seeking and marijuana use and the lack of planning and

marijuana use relationships to conduct moderation analyses. There was a significant moderating effect of recruitment type on the sensation seeking and marijuana use relationship such that community based samples had the most robust effect sizes ($r_{middleschool}$= 0.12, $r_{highschool}$= 0.19, $r_{college}$= 0.25, $r_{community}$= 0.29, all p<0.05,$Q_{between}$= 21.49, p<0.01). There was no significant effect of recruitment type on the lack of planning and marijuana use relationship (all r's>0.15, p<0.05, $Q_{between}$= 0.43, p=0.51). There was a significant moderating effect of study design on the sensation seeking and marijuana use relationship such that longitudinal designs had the most robust effect sizes ($r_{correlational}$= 0.19, $r_{groupcomparison}$= 0.24, $r_{longitudinal}$= 0.31, all p<0.05, $Q_{between}$= 9.10, p=0.01). There was no such effect in the lack of planning and marijuana use relationship (all r's>0.10, all p<0.05, $Q_{between}$= 0.48, p=0.49). There were no differences in effect sizes for the sensation seeking and marijuana use or lack of planning and marijuana use relationships across sample type (all r's>0.20, p<0.05 for non-clinical, clinical, and juvenile detention samples; $Q_{between}$ for sensation seeking= 2.51, p=0.28; $Q_{between}$ for lack of planning< 0.01, p=0.95).

4.0 Discussion

Results indicate that the magnitude of the effect sizes between impulsivity-related traits and marijuana use behaviors in adolescents depends less on the specific impulsivity trait assessed and more on the type of marijuana behavior: Whereas there were primarily medium relationships between impulsivity-related traits and negative marijuana consequences, there were small effects between impulsivity-related traits and marijuana use. Gender was not a significant moderator of these relationships. There was little variability across impulsivity trait; all traits had similar effect sizes except lack of perseverance, which was unrelated to either marijuana use or marijuana consequences. However, lack of perseverance also had the fewest number of studies, which suggests limited power to find a meaningful effect.

The differences in the relationship between impulsivity-related traits and the type of marijuana behavior measured have important research and clinical implications. The medium and statistically significant associations between multiple impulsivity-related traits (i.e., sensation seeking, lack of planning, positive urgency, and negative urgency) and negative marijuana consequences suggests that these impulsivity-related traits might be most important to differentiate those adolescents most likely to experience negative consequences from marijuana use. In a study of young adults, impulsivity was not only related to negative marijuana consequences, but was also a vulnerability mechanism through which the relationship between frequency of use and marijuana related problems was strengthened (Simons and Carey, 2002). Notably, all the impulsivity-related traits had small relationships with marijuana use and lack of perseverance was unrelated to marijuana use or negative marijuana consequences. This suggests that sensation seeking, lack of planning, positive urgency, and negative urgency may constitute a unique mechanism by which marijuana use moves from recreational to problematic.

While gender did not significantly moderate any relationships, the small number of included studies (k=38), along with a trend toward a larger relationship between sensation seeking and marijuana use among boys, suggests that gender should be examined for potentially meaningful relationships in future work, as these relationship could change in the future. Because adolescent boys tend to report high levels of sensation seeking (d'Acremont and Van der Linden, 2005; Cyders, 2013) – the most commonly researched impulsivity trait in adolescent marijuana use – and higher rates of marijuana use (Williams et al., 2007; Schepis et al., 2011), it is possible that the gender trends could be meaningful in more appropriately powered analyses.

The general similarity in effect sizes across impulsivity traits (except lack of perseverance) highlights an important limitation in how research has examined the relationship

between impulsivity and marijuana use behaviors. The preponderance of studies have examined sensation seeking's relationship with marijuana use behaviors, while very few studies have examined other impulsivity-related traits. The present review did find patterns of small to moderate effects for negative and positive urgency on marijuana use and negative marijuana consequences, warranting further examination; however, data for the effects of positive and negative urgency on both marijuana use (k=1 and k=2, respectively), and negative marijuana consequences (k=3 and k=4, respectively) were limited. Thoroughly assessing other impulsivity-related traits in research and treatment is imperative, as other studies have found that, for example, positive and negative urgency traits are more strongly related to negative substance use consequences than general use (see Stautz and Cooper, 2013 for review) and interventions targeting negative and positive urgency in adolescents significantly reduce and produce sustained effects on alcohol use and negative alcohol consequences (Serafini et al., 2016). It is likely, then, that urgency is an important factor in reducing substance use consequences, including those resulting from marijuana use in both adolescents and adults. Future work should strive to develop a more comprehensive examination of impulsivity-traits traits that relate to marijuana use behaviors, especially positive and negative urgency. In particular, lack of perseverance was examined in the fewest number of studies, suggesting the possibility of being underpowered to find a relationship for this trait with marijuana use and consequences.

Present findings have significant implications for marijuana use interventions. Assessment for adolescent marijuana use should strive to incorporate multiple impulsivity-related traits, as such traits could be a potential marker for negative marijuana use consequences. Assessing risk for marijuana use and consequences is limited by insight and openness on part of the client; however, if impulsivity-traits traits are a marker of risk, measuring these multiple

impulsivity-related traits could aid in early identification and prevention approaches. Additionally, although sensation seeking has been primarily used as a prevention and intervention target for marijuana (Conrod et al., 2008; Conrod et al., 2010; Stephenson et al., 1999), this review suggests that positive urgency, negative urgency, and lack of planning might also be prime points of intervention to mitigate marijuana use consequences, resulting in better treatment outcomes and less health and economic burden related to marijuana use consequences. Treatments designed to mitigate effects on marijuana use and consequences would vary across these traits (as discussed by Zapolski et al., 2010). For example, in addition to prevention strategies targeted toward sensation seeking (Conrod et al., 2008; Conrod et al., 2010), prevention and intervention strategies could target learning to plan and stay with long-term goals (thus targeting effects related to lack of planning) or learning to manage emotional responses without engaging in marijuana use (thus targeting effects related to lack of planning).

An important issue not addressed in the current review is the role of these impulsivity-related traits for a wide range of substance-related behaviors. Of course, impulsivity is not a unique risk factor for marijuana alone, but often predicts engagement in multiple substance and behavioral addictions, including alcohol use (e.g., Coskunpinar, Dir, & Cyders, 2013), risky sexual behaviors (e.g., Dir, Coskunpinar, & Cyders, 2014), drug use (e.g., Zapolski, Cyders, and Smith, 2010), and gambling (e.g, Cyders & Smith, 2008). In many of these cases, separable impulsivity-related traits are differentially predictive of outcomes, such that sensation seeking is related to quantity or frequency of the behavior, whereas positive and negative urgency are more highly related to problematic levels of these behaviors. It is likely that many of the participants in the studies reviewed here not only engaged in marijuana use, but also in a constellation of substance use and illicit behaviors. Marijuana use is associated with alcohol use (Haardörfer et

al., 2016; Haas et al., 2015) and drug use (Moss et al., 2014; Palamar et al., 2015), which further suggests this might be true. It has been suggested that impulsivity is a transdiagnostic risk factor, making intervening on impulsivity of higher clinical relevance, in that interventions designed to mitigate impulsivity's effects are more likely to influence a wide range of substance-related and behavioral addictions, not just marijuana use.

Despite being the first empirical review applying a multidimensional conceptualization of impulsivity to the study of adolescent marijuana use behaviors, the present study has several limitations that affect the generalizability and application of its findings. First, because sensation seeking has been studied more extensively than other impulsivity-related traits, we are likely underpowered to detect moderators in the relationship between these traits and marijuana use behaviors. However, examining the effect sizes, rather than strictly significance testing, allows us to better understand these relationships. While the present review involved an exhaustive review of the extant literature, there are likely unpublished studies or data that were unavailable, which might overestimate effects. Also, data included in the present meta-analysis was self-report in nature, which is potentially limited by self-report bias. The majority of data was also obtained from correlational and non-clinical samples, limiting speculation on changes in impulsivity-related traits and marijuana use over time and generalizability to clinical populations.

5.0 Conclusions

The present review was the first to collect and examine data on separable impulsivity-related traits and marijuana use behaviors in adolescents. This was also the first to assess the relationships between multiple traits of impulsivity and marijuana use behaviors, and how these relationships may differ across impulsivity-related trait, marijuana use and negative marijuana consequences, and gender. Results from this review of 38 studies suggest that differences in

effect sizes are more strongly driven by the type of marijuana behavior assessed rather than the type of impulsivity trait assessed. Impulsivity-related traits are likely stronger risk factors for negative marijuana consequences than for simply using marijuana, and could be a prime marker for problematic use. Lack of perseverance was the only trait unrelated to either marijuana use or negative marijuana consequences, but was examined in very few studies. Additionally, research should examine gender and multiple traits of impulsivity when studying adolescent marijuana use behaviors, as the present review found some interesting, although underpowered, gender trends and small to moderate relationships with traditionally understudied traits (e.g., negative and positive urgency).

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Table 1. Studies and original effect sizes used in the meta-analysis

Study	Design	N	Mage (SD)	Age Range	Gender	Race	Sample Type	Recruit Type	Impulsivity Measure	ES Coded	Original ES
Ames (2001)	C	467	16.7 (0.96)	14-19	43	10	NC	HS	ZK ImpSS	SS- frequency	0.20
		266	16.7 (0.96)	14-19	0	10	NC	HS	ZK ImpSS	SS- problems	0.50
		201	16.7 (0.96)	14-19	100	10	NC	HS	ZK ImpSS	SS- problems	0.24
Ames et al. (2007)	C	121	16.7 (0.74)	15-19	36	5.6	NC	HS	ZK ImpSS	SS- frequency	0.25
Andrucci et al. (1989)	C	123	16.4 (0.89)	14-18	58.54	76.4	NC	HS	SSS	SS- use	0.45
Arnett & Balle-Jensen (1993)	C	1053	-	14-20	52.61	100	NC	HS	SSS	SS- use	0.05
Bates (1986)	L	933	-	15-18	26.9	90	NC	COM	SSS	SS- frequency	0.37
										SS- frequency	0.34
Caspi et al. (1995)	C	862	18 (0)	18	48.31	100	NC	COM	MPQ- C	LPL- dependence	0.47
Castellanos-Ryan et al. (2013)	L	871	-	12-17	0	100	NC	COM	IVE-Vent	LPL- frequency	0.18
	L	871	-	12-18	0	100	NC	COM	IVE-Imp	SS- frequency	0.21
Chédebois et al. (2009)	C	292	17 (1.30)	-	41.78	58.2	NC	HS	B-SSS	SS- frequency	0.24
Churchwell et al. (2010)	C	36	17.7 (0.82)	16-19	22.23	100	NC	HS	B-LPL	LPL- dependence	0.43
									B-LPL	LPL- dependence	0.06
									B-Attn	NUR- dependence	0.20
Felton et al. (2015)	C	204	-	12-19	43.63	53.9	NC	HS	B-SSS	SS- frequency	0.09
	C	163	-	12-19	43.63	53.9	NC	HS	B-SSS	SS- frequency	0.03
	C	114	-	12-19	43.63	53.9	NC	HS	B-SSS	SS- frequency	0.18
	C	102	-	12-19	43.63	53.9	NC	HS	B-SSS	SS- frequency	0.37
Gerra et al. (2005)	C	1076	17.11 (0.23)	14-19	43.49	100	NC	HS	SSS	SS- frequency	0.19
Grunberg et al. (2015)	L	375	18.34 (0.49)	18-21	46.93	72.9	NC	COL	TCI- NS	SS- frequency	0.42
Hampson et al. (2008)	G	351	-	10-21	50.3	86	NC	HS	3-items	SS- frequency	0.14

Hendershot et al. (2011)	C	124	16.07 (0.99)	-	45	10.6	JD	COM	B-SSS B-SSS	SS- frequency SS- problems	0.34 0.18
Jaffee & D'Zurilla (2009)	C	273	16.9	15-20	45	73	NC	HS	SURPS	SS- use	0.33
Kong et al. (2011)	C	1202	-	13-19	0	0	NC	HS	ZK PQ	LPL- use SS- use	0.02 0.03
	C	1826	-	13-19	100	100	NC	HS	ZK PQ	LPL- use SS- use	0.04 0.04
Kopstein et al. (2001)	C	1154	-	-	56.59	56.6	NC	COL	Hoyle & Donohew	SS- frequency SS- frequency SS- frequency SS- frequency	0.17 0.13 0.23 0.20
Leeman et al. (2014)	C	3106	15.86 (1.23)	13-18	54.6	76.6	NC	HS	ZK PQ	LPL- frequency SS- frequency	0.03 0.05
Malmberg et al. (2012)	L	758	12.88 (0.41)	12-14	53	100	NC	HS	SURPS	SS- use	0.29
Martin et al. (2002)	C	127	12.76 (1.22)	11-14	0	71.4	OP	COM	SSS-C	SS- use	0.44
Martins et al. (2008)	C	5049	-	12-18	49	66	NC	COM	B-SSS	SS- use	0.29
McWhirter (1996)	C	1440	-	12-17	64.5	-	NC	HS	Eys- I	SS- use	0.11
Pang et al. (2014)	C	585	14.5 (0.54)	12-16	51.3	24.1	NC	HS	UPPS-P	NUR- use NUR- frequency PUR- use PUR- frequency	0.42 0.20 0.34 0.14
Pederson et al. (1989)	C	957	-	16-19	52.35	100	NC	HS	SSS	SS- use	0.19
Pokhrel et al. (2010)	C	362	15.7 (0.75)	13-18	55	100	NC	HS	ZK ISS	SS- frequency	0.01
	C	965	15.1 (0.93)	13-18	49	31	NC	HS	ZK ISS	SS- frequency	0.12
Robbins & Bryan (2004)	C	208	15.3	12-17	27	23	JD	COM	ZK ISS	SS- use	0.16

Robinson et al. (2014)	C	1051	15.6 (1.20)	13-18	49	83.9	NC	HS	UPPS-R	NUR- use	0.17
										NUR- frequency	0.04
										PUR- use	0.26
										PUR- frequency	0.05
Rodríguez (2015)	C	415	14.76 (1.75)	12-18	48.2	100	NC	HS	J-SSS	SS- frequency	0.09
Roth & Liebe (2011)	G	1236	-	14-16	55	100	NC	HS	Arnett- SS	SS- use	0.17
										SS- frequency	0.13
Simon et al. (1994)	C	85	-	16-18	53.47	51.7	NC	HS	ZK ISS	SS- frequency	0.20
Slater (2003)	C	2391	-	13-15	49	79.1	NC	MS	2- items	SS- frequency	0.11
Stanton et al. (2001)	L	383	-	10-15	0	44	NC	COM	SSS	SS- use	0.09
		383	-	11-16	0	44	NC	COM	SSS	SS- use	0.18
		383	-	12-17	0	44	NC	COM	SSS	SS- use	0.19
		383	-	13-18	0	44	NC	COM	SSS	SS- use	0.29
Stautz & Cooper (2014)	C	270	16.79 (0.54)	16-18	73	24.7	NC	HS	UPPS-P	SS- problems	0.15
										LPS- problems	0.06
										LPL- problems	0.13
										PUR- problems	0.20
										NUR- problems	0.22
										SS- frequency	0.11
										LPS- frequency	0.09
										LPL- frequency	0.19
										PUR- frequency	0.13
										NUR- frequency	0.13
Stephenson & Helme (2006)	C	1256	-	13-16	53.67	52.7	NC	MS	B-SSS	SS- use	0.14
										SS- frequency	0.14
Stephenson et al. (1999)	G	1601	-	13-20	53	87	NC	HS	SSS-A	SS- use	0.30
Tang et al. (1996)	G	969	15.87 (1.75)	14-19	45.41	0	NC	COM	SSS	SS- frequency	0.27

Tercek (2008)	C	93	15.41 (1.18)	11-16	12.9	24.7	JD	COM	UPPS-R	SS- frequency LPS- frequency LPL- frequency	0.29 -0.02 0.11
Xiao (2008)	C	9600	-	10-19	51.2	83.9	NC	HS	B-SSS Donohew	NUR- frequency SS- frequency LPL- frequency	0.02 0.18 0.14

Note. Design: C= correlational study, G= group comparison, L= longitudinal study. Gender= percent of the sample female. Race= percent of the sample White. Sample Type: NC= nonclinical, IP= inpatient, OP= outpatient, JD= juvenile detention. Recruitment Type: MS= middle school, HS= high school, COL= college, COM= community. Impulsivity= impulsivity measure used- see Table 2 for full citations. ES Coded: effect size coded from study; IMP= general impulsivity, SS= sensation seeking, LPS= lack of perseverance, LPL= lack of planning, NUR= negative urgency, PUR= positive urgency.

Table 2. Mean effect size for each association

Impulsivity Construct	Marijuana Use Behavior	*k*	N	ES	*SE*	95% CI	*z*	*p*	I^2
Sensation Seeking	Use	38	53398	0.22	0.02	0.18 to 0.25	12.68	<0.01	33.36
Lack of Perseverance*	Use	2	363	0.03	0.85	-0.30 to 0.38	0.19	0.85	--
Lack of Planning	Use	7	16968	0.13	0.02	0.08 to 0.18	5.33	<0.01	66.43
Negative Urgency*	Use	4	3635	0.23	0.06	0.11 to 0.34	3.90	<0.01	--
PUR*	Use	3	3542	0.19	0.06	0.08 to 0.31	3.35	<0.01	--
Sensation Seeking	Consequences	4	861	0.39	0.09	0.18 to 0.54	3.93	<0.01	24.24
Lack of Perseverance*	Consequences	1	270	0.06	NA	NA	NA	>0.05	--
Lack of Planning*	Consequences	3	1204	0.47	0.57	0.37 to 0.57	9.51	<0.01	--
Negative Urgency*	Consequences	2	306	0.26	0.21	-0.16 to 0.68	1.22	0.22	--
PUR*	Consequences	1	270	0.37	NA	NA	NA	<0.01	--

Note. k= number of reported effects; N= number of participants included in association across studies; ES= weighted effect size; SE= standard error; 95% CI= 95% confidence interval for effect size; *z*= standardized difference from zero; I^2= Heterogeneity coefficient

*Fixed Effects model reported because of too few effects reported to calculate random effects model.

Table 3.

Moderator analysis of the effect of marijuana Outcome Measure on the impulsivity and marijuana behavior relationship

		Marijuana Outcome Measure		
Association	I^2	r (CI)	*z* (*k*)	Q_b (*p*)
Sensation Seeking – Marijuana Behavior	38.72	ES_U: 0.21**	12.19	3.88 (0.04)
		(0.18 to 0.25)	(*k*=38)	
		ES_C:0.38**	4.74	
		(0.22 to 0.53)	(*k*=4)	
Lack of Perseverance – Marijuana Behavior	NA	ES_U: 0.16	0.85	0.01 (0.92)
		(-1.50 to 1.83)	(*k*=2)	
		ES_C:0.01	0.01	
		(-2.68 to 2.70)	(*k*=1)	
Lack of Planning – Marijuana Behavior	77.35	ES_U: 0.13**	5.33	38.25 (<0.01)
		(0.08 to 0.18)	(*k*=7)	
		ES_C:0.47**	9.51	
		(0.37 to 0.57)	(*k*=3)	
Negative Urgency – Marijuana Behavior	66.67	ES_U: 0.23**	3.42	0.03 (0.86)
		(0.09 to 0.35)	(*k*=4)	
		ES_C:0.26**	1.21	
		(-0.16 to 0.68)	(*k*=2)	
Positive Urgency – Marijuana Behavior	15.64	ES_U: 0.19**	3.35	0.54 (0.46)
		(0.08 to 0.31)	(*k*=3)	
		ES_C:0.47**	1.61	
		(-0.08 to 0.81)	(*k*=1)	

Note. ES_U= effect size for marijuana use. ES_C= effect size for marijuana consequences.

Supplemental Table 1. Assignment of impulsivity measures to UPPS-P traits.

UPPS-P Trait	Measure	Reference*
Lack of Perseverance	UPPS OR UPPS-P- Lack of Perseverance subscale	Stautz & Cooper, 2014
		Tercek, 2008
Lack of Planning	Multidimensional Personality Questionnaire - Control Scale	Caspi et al., 1995
	UPPS OR UPPS-P- Lack of Planning subscale	Stautz & Cooper, 2014
		Tercek, 2008
	Eysenck IVE$_7$- Impulsivity Scale	Castellanos-Ryan et al., 2013
	Zuckerman-Kuhlman Personality Questionnaire- Impulsiveness Scale	Kong et al., 2011
		Leeman et al., 2014
	Barratt's lack of planning scale	Churchwell et al., 2010
	8-items from Donohew's (2000) Impulsivity Scale	Xiao, 2008
Sensation Seeking	Sensation Seeking Scale	Andrucci et al., 1989
		Arnett & Balle-Jensen, 1993
		Bates, 1986
		Donohew et al., 1999
		Gerra et al., 2004
		Pederson et al., 1989
		Stanton et al., 2001
		Tang et al., 1996
	Zuckerman-Kuhlman Impulsive Sensation Seeking Scale	Ames, 2001
		Ames et al., 2007
		Pokhrel et al., 2010
		Robbins & Bryan, 2004
		Simon et al., 1994
		Kong et al., 2011
		Leeman et al., 2014
	Brief Sensation Seeking Scale	Chedebois et al., 2009

		Felton et al., 2015
		Hendershot et al., 2011
		Martins et al., 2008
		Stephenson & Helme, 2006
		Xiao, 2008
	UPPS OR UPPS-P- Sensation Seeking subscale	Stautz & Cooper, 2014
		Tercek, 2008
	Substance Use Risk Profile Scale- Sensation Seeking Scale	Malmberg et al., 2012
		Jaffee & D'Zurilla, 2009
	Sensation Seeking Scale for Children	Martin et al., 2002
		Hampson et al., 2008
	Eysenck's IVE$_7$- Venturesomeness Scale	Castellanos-Ryan et al., 2013
		McWhirter, 1997
	Temperament and Character Inventory (TCI): Novelty Seeking Scale	Grunberg et al., 2015
	Sensation Seeking Scale for Adolescents	Stephenson et al., 1999
	Arnett Inventory of Sensation Seeking	Roth & Liebe, 2011
	6-items adapted from Hoyle, 1997 and Donohew,1999	Kopstein et al., 2001
	2-items: "How often do you 1) Do dangerous things for fun; 2) Do exciting things even if they are dangerous" (Items validated with Zuckerman (1978) Sensation Seeking Scale, Reliability Alpha =0.83)	Slater, 2003
Negative Urgency	UPPS or UPPS-P- Urgency or Negative urgency subscale	Pang et al.,2014
		Robinson et al., 2014
		Stautz & Cooper, 2014
		Tercek, 2008
	Barratt's attentional impulsivity	Churchwell et al., 2010
Positive Urgency	UPPS-P- Positive urgency subscale	Pang et al., 2014
		Robinson et al., 2014
		Stautz & Cooper, 2014

Figure 1.

Flow chart for selection of studies used in meta-analysis calculations.

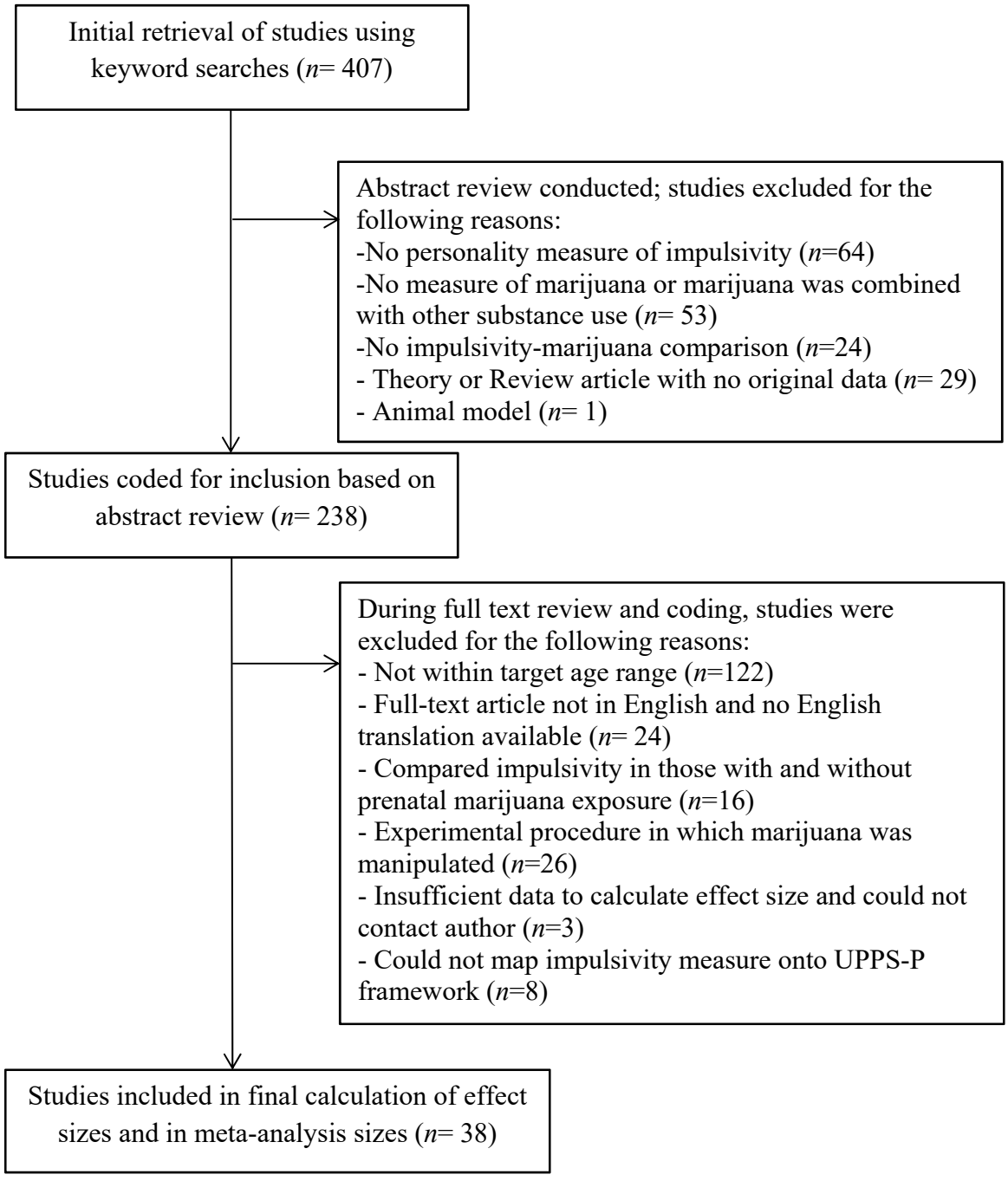

Figure 2.

Funnel plot of all effect sizes

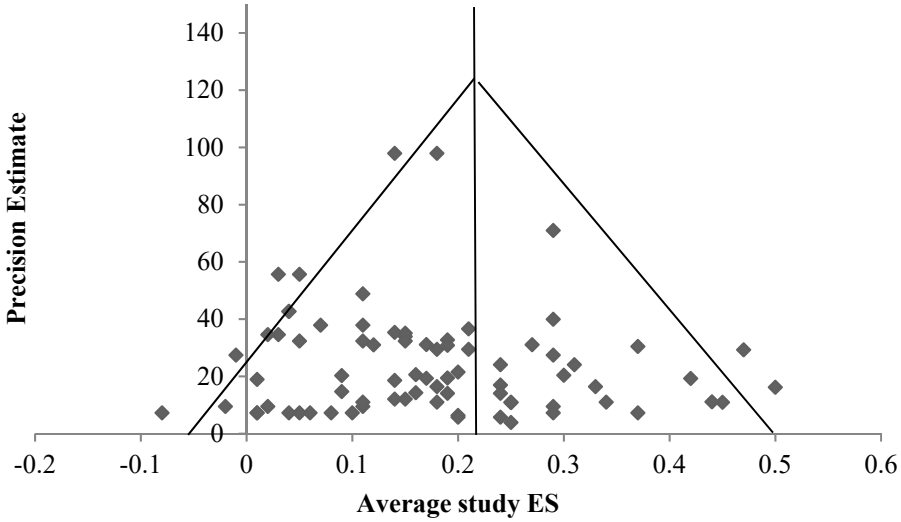

Figure 3.

Bar chart distribution of all overall effect sizes