Cannabis
2022, Volume 5 (1)

researchmj.org
DOI: 10.26828/cannabis/2022.01.001

OPEN ACCESS

The Relation Between Impulsivity and Estimation of Marijuana Weight

Jamie E. Parnes[1], Shane D. Kentopp[1], Joshua Sommerfeld[1], Bradley T. Conner[1]
[1]Department of Psychology, Colorado State University

ABSTRACT

Until recently, marijuana research has often relied on self-reported frequency of use (e.g., days used per month). These estimations may oversimplify use at times, as they can only infer the quantity that one uses, rather than directly measure it. While some studies have estimated quantity (e.g., number of joints, grams), research has supported that user estimates of marijuana weight are often inaccurate and overestimate the true quantity. Since weight misestimation varies by participant, it may be important to identify individual difference factors (e.g., personality) that influence weight estimation. One such factor may be impulsivity, as it is known to relate to other marijuana-use measures (e.g., frequency, consequences). However, research has yet to examine the specific relation between impulsivity and misestimation of marijuana weights. The present study investigated impulsivity as a predictor of marijuana quantity estimation, using objectively weighed quantity data. We hypothesized that impulsivity facets would relate to marijuana quantity misestimation. We asked attendees at a marijuana-related event to roll a joint or pack a bowl, and then take, among a battery of measures, the SUPPS-P Impulsive Behavior Scale. We found that negative urgency, positive urgency, and lack of perseverance were not significantly associated with misestimation, while lack of premeditation was significantly negatively related to misestimation. Findings indicated that individuals who lacked in premeditation made more accurate quantity estimates than those higher in premeditation. Future directions should investigate the relation between impulsivity, marijuana intoxication, and marijuana quantity estimation.

Key words: = personality; cannabis; quantity

Recent publications examining self-reported marijuana use commonly measure frequency of use, such as days used per month or times used per day (e.g., Cerdá et al., 2017; Glowacz & Schmits, 2017; Prince et al., 2018; Vadhan et al., 2017). However, unlike alcohol and the definition of a standard drink, there is no commonly accepted standard dose of marijuana (Parnes et al., 2018). Having a standard dose allows for various forms of consumption (e.g., different alcoholic beverages like wine and beer; National Institute on Alcohol Abuse and Alcoholism, 2011) to be compared across frequency and quantity measures. In fact, the National Institute on Drug Addiction has indicated strong support for a standardized marijuana dose to facilitate research (Volkow & Weiss, 2020). A lack of a standardized marijuana dose prohibits estimating quantity used based on reported use frequency. Estimating quantity becomes additionally confounded by differing marijuana products and potencies available in dispensaries and illegal markets (Parnes et al., 2018, Prince et al., 2018;). Some studies have attempted to measure quantity used (e.g., Walden & Earleywine, 2008), however self-reported quantity used is often inaccurate and misestimated (Prince et al., 2018).

Most researchers would and do argue that when we measure marijuana use, we are attempting to measure the quantity of cannabinoids ingested, not how often marijuana is used (Freeman & Lorenzetti, 2020). Researchers interested in studying the psychoactive effects of marijuana are then interested in the amount of Δ9-tetrahydrocannabinol (THC) those using cannabis are ingesting. It is unclear how asking

Corresponding Author: Jamie E. Parnes, PhD, Department of Psychology, Colorado State University. 1876 Campus Delivery, Fort Collins, CO 80523. Phone: 585-708-9384. Email: Jamie_Parnes@brown.edu

research participants to self-report the frequency of their marijuana use gives researchers any information about the amount of THC ingested. Thus, it is vitally important that marijuana researchers assess both quantity and frequency of use and, when available, potency of the marijuana being used. Despite the importance of measuring both frequency and quantity consumed to depict marijuana use most accurately, as noted, most studies solely rely on reported frequency. As Prince and colleagues (2018) noted, frequency often is an oversimplified measurement of marijuana consumption. For example, two people may both report using 30 days per month; however, one individual could consume a small amount of cannabis in the evenings, while another could use throughout the day. These consumption habits are drastically different, but due to a limited measurement (i.e., 30-day frequency), the two disparate use patterns would likely both be identified as "daily users". This example is supported by latent profile analyses, which identified multiple groups of users with similar past 30-day use frequency but a differing number of sessions per use day (Pearson et al., 2017). This research, among others, supports the importance of measuring both quantity consumed and frequency of use.

Studying quantity is important, as the more marijuana consumed in one sitting directly correlates to a higher number of consumption sessions as well as a higher number of marijuana-related problems (Zeisser et al., 2012). However, the few studies that examined marijuana use quantity have employed inconsistent measures of quantity: estimated grams consumed per day or per week, number of joints consumed, or number of quarter ounces consumed per month (e.g., Buchan et al., 2002; Johnson, 2014; Walden & Earleywine, 2008; Williams & Nowatzki, 2005). This limited research relies on self-reported quantity, which may be inaccurate and varies across participants (Prince et al., 2018). One study examining marijuana quantity estimation found that when people are asked to weigh a specific amount of flower or concentrate, most people overestimated the quantity they used (Prince et al., 2018). Therefore, studies collecting self-reported quantity of use are likely relying on inaccurate data.

Another issue that complicates the assessment of THC ingested is the different methods of consuming marijuana (Freeman & Lorenzetti, 2020, Prince et al., 2018). While traditional methods for using marijuana rely on combustion of the flower and bud plant materials, either in joints, pipes, and bongs, to name a few, or digestion of baked good, with changes over time and changes in legislation, there have been significant advances in methods or routes of administration. Newer forms of consumption include, but are not limited to, use of concentrated marijuana in oils, waxes, and other substances, oral tinctures, capsules, tablets, topical ointments, and in liquid forms, while edible forms have increased to include gummies, lollipops, gum, popsicles, ice creams, and butters, and other types of foods. All of these advances have complicated issues related to estimating the amount of THC consumed during a marijuana use episode. For instance, it takes far less of a concentrated form of marijuana, which typically is upwards of 50% THC, and more commonly above 80%, to get to 5 mg of THC ingested (the suggested standardized dose endorsed by the National Institute on Drug Abuse [NIDA]; Volkow & Weiss, 2020) than it does when using flower, which typically maxes out at around 30% THC. Conversely, edibles are usually packaged in 5 mg quantities, making estimating THC content much easier. However, use of edibles leads to slower absorption of THC. In fact, the number of variables involved in estimating the amount of THC is much more than just quantity and frequency, with method of administration and % THC being among two of the most important. However, the last, and among the most important, is the source of information on THC. Most research still relies heavily on self-reported marijuana use estimates as the primary measurement. Thus, it is critical that researchers understand the advantages and short comings of self-reported marijuana use, especially individual difference variables, such as personality traits like impulsivity, that could introduce systematic error into these types of estimates.

Several past studies have linked impulsivity to marijuana use frequency (Moreno et al., 2012; Pearson et al., 2018; VanderVeen et al., 2016). These studies noted that increased impulsivity, including reduced inhibitory control and trait impulsivity, was associated with increased use frequency. A well-established multidimensional model of impulsivity describes four distinct facets:

positive urgency, negative urgency, lack of premeditation, and lack of perseverance (Whiteside et al., 2005). Although sensation seeking is sometimes included as part of impulsivity, research suggests that sensation seeking and impulsivity are separate constructs (Hare & Schalling, 1978; Magid et al., 2007; Quinn & Harden, 2013). Each of the other facets holds unique associations with marijuana use behavior. Positive urgency is defined as the tendency to have greater difficulty resisting urges when in a positively elevated mood (Whiteside et al., 2005). Robinson, Ladd, and Anderson (2014) discovered a direct relation between positive urgency and frequency of marijuana use, demonstrating its importance as a predictor of use. Negative urgency is defined as engaging in rash behavior in the presence of strong negative affect (Whiteside et al., 2005). Negative urgency is robustly associated with increased marijuana use and use-related consequences (Pearson et al., 2018; Robinson et al., 2014). Lack of premeditation is an inability to fully consider the consequences of one's actions (Whiteside et al., 2005). Limited research has found associations between lack of premeditation and marijuana use, as these individuals may have difficulty considering the outcomes of use when deciding whether or not to use (Bravo, Anthenien, et al., 2017; Bravo, Prince, et al., 2017). Individuals lacking in perseverance have difficulty continuing tasks (Gullo et al., 2014). This facet has been found to have no significant effect on one's marijuana use (VanderVeen et al., 2016).

Although it has been established that impulsivity is related to increased marijuana use and use-related harms (VanderVeen et al., 2016), there is no research examining the possible link between impulsivity and whether individuals can accurately estimate and report the quantity of marijuana they are using. Some research exists linking impulsivity to other types of estimation, particularly time estimation. The research on the topic has been mixed, as some studies have found no association between impulsivity and time estimation (Lennings & Burns, 1998), while others have found impulsive individuals tended to overestimate how much time passed (Baumann & Odum, 2012; Jokic et al., 2018). Therefore, impulsivity may play a role in various types of estimation. However, research on the relation between impulsivity and quantity estimation remains as a gap in the literature. As most, but not all, individuals tend to overestimate quantity (Prince et al., 2018), it may be important to understand if impulsivity relates to overestimation, underestimation, or bears no influence.

Given the importance of measuring quantity used, it is equally important to understand what individual difference factors may influence quantity misestimation. The present study addressed this gap in the literature by examining if impulsivity was related to marijuana quantity estimation. As no previous research has examined the role of impulsivity in quantity estimation, but that some research indicates that facets of impulsivity affect time estimation, we started with the broad hypotheses that greater amounts of each facet of impulsivity would predict increased marijuana quantity misestimation.

METHODS

Participants and Procedure

This secondary data analysis examines 79 participants who completed an extended testing battery at a research event at a marijuana club. Twenty one participants reported they did not use flower marijuana and were not administered the flower marijuana estimation task. Therefore, these participants were excluded from the analytic sample. Of the remaining 58 participants, $n = 46$ completed all relevant survey measures and were included in the final analytic sample. Among the analytic sample, 52.2% of participants were female and had an average age of 29.46 ($SD = 6.03$, range [22.16, 51.88]). 73.91% of participants were white (<1% American Indian/Alaskan native, 6.5% black, 8.7% other/multiracial) and 80.0% were non-Hispanic. Participants were asked, "On how many days during the last 30 days did you consume marijuana (in any form)?" The majority of participants (58.7%) reported consuming marijuana on 30 of the past 30 days ($M = 25.74$, $SD = 7.38$, range [3, 30]).

Data were collected from a marijuana use event at a private marijuana club that was open to adult (21 years old or older) marijuana users. In this observational study, participants were instructed to use marijuana flower (i.e., marijuana buds) that they brought with them to the club to either fill the bowl of a pipe or roll a joint according to their preferred method of use. Participants were then asked to estimate, in grams, the amount of marijuana flower they used. Next, participants placed the bowl or joint on a digital scale and researchers weighed and recorded the actual amount of marijuana. Participants then retrieved the packed or rolled marijuana from the scale and were free to do with it what they wanted, including consume it. Participants also completed a computerized survey as part of the larger study. Participants were given a $20 gift card for compensation. The study protocol was approved by the university's institutional review board. For more information on study participants and procedures, please see Prince and colleagues (2018).

Measures

Measures included the following demographic variables: age, sex, race, ethnicity, frequency of marijuana use, and whether the participant worked in the marijuana industry. To measure the various dimensions of impulsivity, participants were administered the SUPPS-P Impulsive Behavior Scale (Cyders et al., 2014). The SUPPS-P is a 20-item scale that measures positive urgency, negative urgency, lack of premeditation, sensation seeking, and lack of perseverance. Items related to sensation seeking were removed as sensation seeking is not conceptualized as a facet of impulsivity (Quinn & Harden, 2013). Items were measured on a 4-point Likert scale (1: "Strongly Disagree", 2: "Disagree", 3: "Agree", 4: "Strongly Agree") to assess positive urgency (4 items, $M = 1.80$, $SD = 0.80$), negative urgency (4 items, $M = 2.20$, $SD = 0.77$), lack of premeditation (4 items, $M = 1.65$, $SD = 0.48$), and lack of perseverance (4 items, $M = 2.08$, $SD = 0.38$). The SUPPS-P subscales demonstrated good internal consistency in this sample, Chronbach's α ranged from 0.75 to 0.90.

Because larger quantities allow for larger estimation errors (and vice versa), we accounted the covariance between misestimation and quantity by operationalizing misestimation as the proportion of error relative to the actual quantity. We subtracted the actual marijuana weight from the estimated marijuana weight and divided the difference by the actual weight. For instance, if a participant used 1.0g of marijuana flower, but estimated 1.2g, then the misestimation value would be 0.2. If a participant used 1.0g of marijuana flower, but estimated 0.9g, then the misestimation value would be -0.1. The resulting misestimation variable was normally distributed, with skewness of 1.64 ($SE = 0.350$). Average misestimation was 0.67 (SD = 1.15) and ranged from -0.76 to 4.56. Because filling the bowl of a pipe and rolling a joint both use flower, both methods of flower misestimation were collapsed into one variable. Participant flower estimates varied from .02g to 1.23g, while actual weights varied from .05g to 1.00g.

Analysis

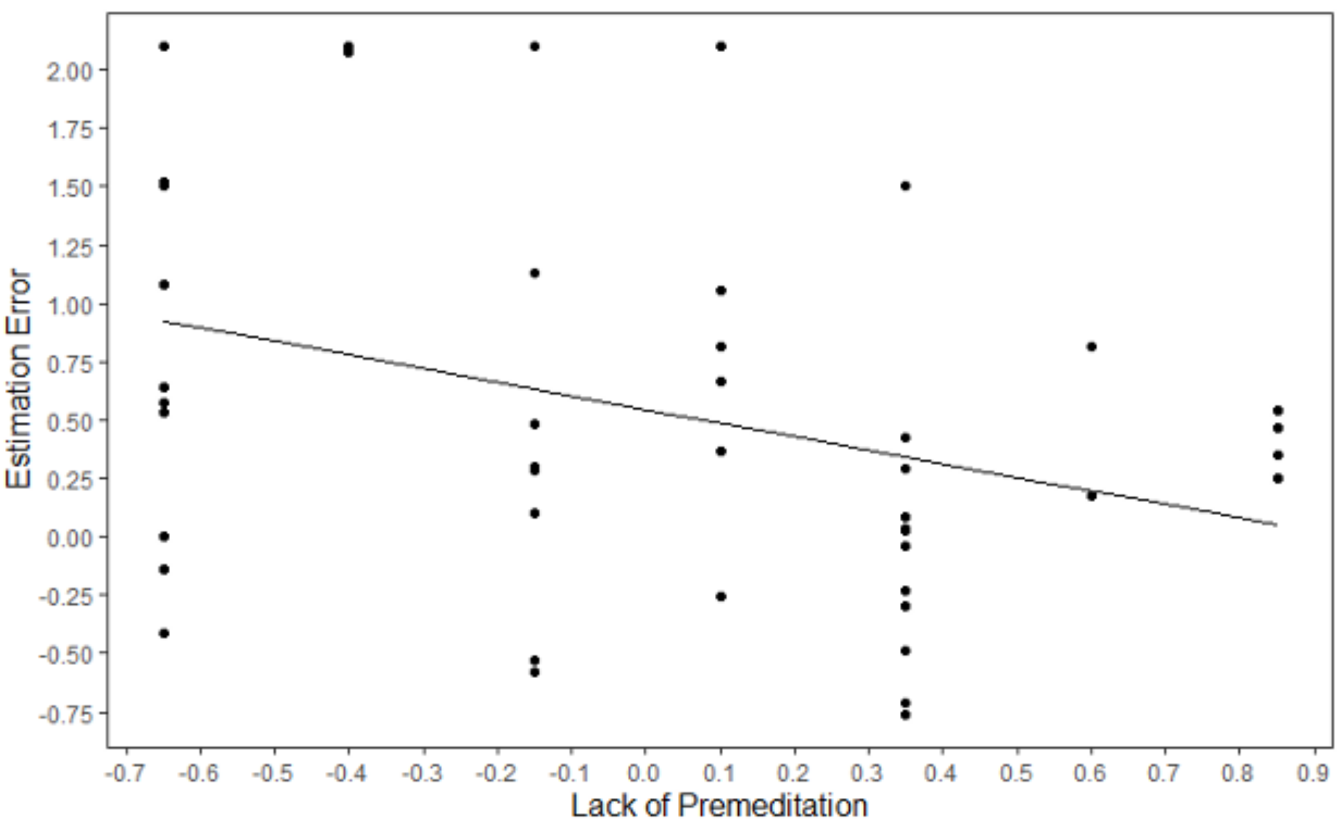
The study hypothesis was tested using linear regression with misestimation as the dependent variable and the facets of impulsivity as the independent variables. All cases with missing values for the dependent variable were deleted list wise. Because the dependent variable contained extreme values (e.g., 460% over-estimation), it was winsorized at its 90^{th} percentile. The independent variables were centered at their mean. An ordinary least squares regression model was estimated using R version 4.0.3. Because it is possible to underestimate as well as overestimate quantities, it should be noted that error estimation is not a monotonic construct. Estimation errors closer to zero reflect better accuracy, whereas estimation errors with large values (either positive or negative) reflect worse accuracy. Therefore, it is necessary to plot model results to fully understand the relation between impulsivity and estimation error. The fitted relation between significant predictors and estimation error, holding all other facets of impulsivity constant at their mean, was plotted alongside observed values.

Table 1. *Means, standard deviations, and correlations with confidence intervals*

Variable	*M*	*SD*	1	2	3	4
1. Negative Urgency	2.20	0.77				
2. Lack of Perseverance	2.08	0.38	.07 [-.22, .36]			
3. Lack of Premeditation	1.65	0.48	.35* [.06, .58]	.39** [.11, .61]		
4. Positive Urgency	1.80	0.80	.57** [.34, .74]	-.11 [-.39, .19]	.21 [-.08, .47]	
5. Misestimation	0.67	1.15	.02 [-.27, .31]	-.24 [-.49, .06]	-.32* [-.56, -.03]	.03 [-.26, .32]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$. ** indicates $p < .01$.

Figure 1. *Predicted marijuana weight estimation error as a function of lack of premeditation, with observed values*



RESULTS

A matrix of correlations among the study variables in presented in Table 1. Significant correlations were present between negative urgency and lack of premeditation (r = .35, p < .05), negative urgency and positive urgency (r = .57, p < .01), lack of perseverance and lack of premeditation (r = .39, p < .01), and lack of premeditation and estimation error (r = -.32, p < .05).

Impulsive traits explained approximately 15% of the total variability in estimation error (R^2 = 0.15), a medium effect (Cohen, 1988). Among the facets of impulsivity, lack of premeditation was a significant predictor of estimation error (b = -0.58, SE = 0.29, p < .05). The results indicated that for a one unit increase in an individual's lack of premeditation score, their predicted estimation error decreased by 58%. Positive urgency (b = -0.01, SE = 0.19, p = .96), negative urgency (b = 0.17, SE = 0.20, p = .38), and lack of perseverance (b = -0.29, SE = 0.35, p = .41) were not significant predictors of estimation error. Predicted values of estimation error are plotted as a function of lack of premeditation in Figure 1.

Intercorrelations among the facets of impulsivity and misestimation were examined, to assess for potential suppression effects (see Table 1). The positive correlations between negative and positive urgency, as well as between lack of premeditation and lack of perseverance, were consistent with previous research that suggests the UPPS-P subscales tend to load onto two higher-order factors representing general urgency and general lack of conscientiousness (Cyders & Smith, 2007). The significant positive zero-order correlation between lack of premeditation and misestimation suggests that the significant regression coefficient associated with lack of premeditation was not due to a suppression effect.

DISCUSSION

The purpose of the present study was to determine whether specific facets of impulsivity predicted weight misestimation of marijuana among marijuana-using adults. Lack of premeditation was found to significantly negatively predict misestimation, such that individuals higher in lack of premeditation (i.e., lower premeditation) had lower misestimation. Positive urgency, negative urgency, and lack of perseverance did not predict misestimation. Study findings were largely inconsistent with study hypotheses, which predicted that all impulsivity facets would be related to misestimation. However, the results indicate that individual differences can affect weight estimation. As researchers work to establish consistent measurement of %THC consumed, suggested as necessary by Freeman and Lorenzetti (2020) and supported by NIDA (Volkow & Weiss, 2020), we must also identify individual difference variables that could systematically bias weight estimations.

The results reported herein indicate that individuals lacking in premeditation were more accurate at estimating, rather than having greater misestimation. Previous research has found associations between impulsivity, including lack of premeditation, and marijuana use (Bravo, Anthenien, et al., 2017; Bravo, Prince, et al., 2017). In turn, individuals higher in premeditation may have greater previous use episodes, and thus possibly more experience estimating quantities of marijuana. Conversely, those higher in premeditation may have had relatively fewer use episodes and less familiarity with marijuana quantity. Another explanation, related specifically to premeditation, could be explained by the theory of overthinking. Past research investigating overthinking and motor performance demonstrated that greater amounts of time spent thinking about an action correlates to worse task performance (Flegal & Anderson, 2008). Moreover, overthinking when interacting with others can induce anxiety and cognitive distraction, which may further impair task performance (Talbert, 2017). Individuals higher in premeditation may have engaged in overthinking, thus impairing their estimation ability. Conversely, individuals who lack premeditation may be less likely to overthink and instead provide and unimpaired weight estimate. However, research has yet to examine if there are significant relations overthinking, impulsivity, and weight estimation; therefore, this is a tentative explanation for the observed findings.

Neither positive, nor negative, urgency significantly predicted participants' estimation error. While these results were contrary to what was hypothesized, it is important to remember that this was the first study to assess the role of impulsivity in the estimation of quantity of marijuana in joints, pipes, and bowls. It may be the case the negative and positive urgency play no role in estimation error as they specifically assess impulsive acts when an individual is experiencing positive or negative affect. Nothing about the task used in this study was designed to induce positive or negative emotional states. It may be the case that other individual difference factors, including other operationalizations of impulsivity, sensation seeking, cognitive ability, executive functioning, that may be more likely to impact quantity estimation.

These findings are important because the few studies that measure marijuana quantity rely on self-reported quantity rather than objective measurements. Our findings support that participants may be likely to misestimate marijuana quantities, and that certain facets of impulsivity accounts for some of the variance in misestimation. One implication of this finding is that self-reported quantity may be subject to distal individual difference influences (e.g., personality), which may limit predictive ability to quantity estimations. Therefore, it may be important to assess participant individual differences alongside marijuana quantity estimates to help account for these differences, particularly when using weight estimations. Additionally, since participants misestimated by different amounts, utilizing more accurate measurements of quantity (e.g., objective digital scales) may improve the reliability and predictive ability of quantity measurements. Misestimation may also lead to inaccurate beliefs about dose-dependent effects. Frequent overestimation, as seen in this study, may lead participants to associate larger quantities with subjective effects that are actually related to smaller amounts of marijuana. In turn, when given more objective weights (e.g., buying a one gram joint from a dispensary), participants may possibly overconsume marijuana based on their skewed perception of dose-dependent effects. Results can be used to identify individuals that may be more likely to misestimate marijuana quantity and inform personality-based interventions (e.g., Conrod et al., 2007).

There are several strengths to this study. One of the strongest aspects of this study is that the sample was adult marijuana users from the general population. Most studies assessing marijuana use college student samples, thus generalizing to college students rather than adult marijuana users. Our study took place at a community-based marijuana event, so the sample population is more likely to represent frequently using community adults. Another strength of this study is the use of objective measurements for marijuana. Most research that has been conducted relies on self-reports, which may be inaccurate (Prince et al., 2018). An objective quantity measurement removes potential biases and misestimation resulting from self-report data. In turn, conclusions drawn from objective data better estimate use quantity and related factors. One primary limitation is the small study sample, which may have limited the conclusions drawn from this study. Additionally, there may have been a selection bias within the study participants. It is still relatively novel for community individuals to be able to take part in studies using real marijuana products, so marijuana enthusiasts may be more likely to self-select into participating in this study. This population may differ from users who prefer to keep their use private or may not be as interested in participating in research. Similarly, participants in this sample reported frequent marijuana use, and therefore results may not generalize to infrequent marijuana-using adults. Lastly, this study solely examined marijuana flower estimations, and therefore, findings do not generalize to other forms of marijuana (e.g., concentrates, edibles).

There are several future directions recommended from this study. Foremost, studies should replicate these findings among other community samples to best understand the influence of impulsivity on marijuana quantity estimation. Additionally, researchers should identify other individual difference variables that may be associated with marijuana estimation (e.g., sensation seeking, emotion dysregulation, or executive functioning). Further research on marijuana quantity estimation may establish more accurate depiction and prediction of marijuana use patterns and outcomes. Continued quantity research may also help determine a standardized dose for marijuana, thus better informing individuals' dose-dependent effects and potential harms.

REFERENCES

Baumann, A. A., & Odum, A. L. (2012). Impulsivity, risk taking, and timing. *Behavioural Processes*, *90*(3), 408–414.

Bravo, A. J., Anthenien, A. M., Prince, M. A., & Pearson, M. R. (2017). Marijuana protective behavioral strategies as a moderator of the effects of risk/protective factors on marijuana-related outcomes. *Addictive Behaviors*, *69*, 14–21.

Bravo, A. J., Prince, M. A., & Pearson, M. R. (2017). Can I Use Marijuana Safely? An Examination of Distal Antecedents, Marijuana Protective Behavioral Strategies, and Marijuana Outcomes. *Journal of Studies on Alcohol and Drugs*, *78*(2), 203–212.

Buchan, B. J., L. Dennis, M., Tims, F. M., & Diamond, G. S. (2002). Cannabis use: Consistency and validity of self-report, on-site urine testing and laboratory testing. *Addiction*, *97*, 98–108.

Cerdá, M., Wall, M., Feng, T., Keyes, K. M., Sarvet, A., Schulenberg, J., O'Malley, P. M., Pacula, R. L., Galea, S., & Hasin, D. S. (2017). Association of State Recreational Marijuana Laws With Adolescent Marijuana Use. *JAMA Pediatrics*, *171*(2), 142–149.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). L. Erlbaum Associates. http://www.gbv.de/dms/bowker/toc/9780805802832.pdf

Conrod, P. J., Castellanos, N., & Mackie, C. (2007). Personality-targeted interventions delay the growth of adolescent drinking and binge drinking. *Journal of Child Psychology and Psychiatry*, *49*(2), 181-190, https://doi.org/10.1111/j.1469-7610.2007.01826.x

Cumming, G. (2014). The new statistics: Why and how. *Psychological science, 25*(1), 7-29.

Cyders, M. A., Littlefield, A. K., Coffey, S., & Karyadi, K. A. (2014). Examination of a short English version of the UPPS-P Impulsive Behavior Scale. *Addictive Behaviors*, *39*(9), 1372–1376.

Cyders, M. A., & Smith, G. T. (2007). Mood-based rash action and its components: Positive and negative urgency. *Personality and Individual Differences*, *43*(4), 839–850.

Flegal, K. E., & Anderson, M. C. (2008). Overthinking skilled motor performance: Or why those who teach can't do. *Psychonomic Bulletin & Review*, *15*(5), 927–932.

Freeman, T. P., & Lorenzetti, V. (2020). 'Standard THC units': A proposal to standardize dose across all cannabis products and methods of

Glowacz, F., & Schmits, E. (2017). Changes in cannabis use in emerging adulthood: The influence of peer network, impulsivity, anxiety and depression. *European Review of Applied Psychology*, *67*(4), 171–179.

Gullo, M. J., Loxton, N. J., & Dawe, S. (2014). Impulsivity: Four ways five factors are not basic to addiction. *Addictive Behaviors*, *39*(11), 1547–1556.

Hare, R. D., & Schalling, D. (1978). *Psychopathic Behaviour: Approaches to Research*. Wiley.

Johnson, T. P. (2014). Sources of Error in Substance Use Prevalence Surveys. *International Scholarly Research Notices*, *2014*, 1–21.

Jokic, T., Zakay, D., & Wittmann, M. (2018). Individual Differences in Self-Rated Impulsivity Modulate the Estimation of Time in a Real Waiting Situation. *Timing & Time Perception*, *6*(1), 71–89.

Lennings, C. J., & Burns, A. M. (1998). Time Perspective: Temporal Extension, Time Estimation, and Impulsivity. *The Journal of Psychology*, *132*(4), 367–380.

Magid, V., MacLean, M. G., & Colder, C. R. (2007). Differentiating between sensation seeking and impulsivity through their mediated relations with alcohol use and problems. *Addictive Behaviors*, *32*(10), 2046–2061.

Moreno, M., Estevez, A. F., Zaldivar, F., Montes, J. M. G., Gutiérrez-Ferre, V. E., Esteban, L., Sánchez-Santed, F., & Flores, P. (2012). Impulsivity differences in recreational cannabis users and binge drinkers in a university population. *Drug and Alcohol Dependence*, *124*(3), 355–362.

National Institute on Alcohol Abuse and Alcoholism. (2011, September 14). *What Is A Standard Drink?* https://www.niaaa.nih.gov/what-standard-drink

Parnes, J. E., Bravo, A. J., Conner, B. T., & Pearson, M. R. (2018). A burning problem: Cannabis lessons learned from Colorado. *Addiction Research & Theory, 26*(1), 3-10.

Pearson, M. R., Bravo, A. J., & Conner, B. T. (2017). Distinguishing subpopulations of marijuana users with latent profile analysis. *Drug and Alcohol Dependence, 172*, 1-8.

Pearson, M. R., Hustad, J. T. P., Neighbors, C., Conner, B. T., Bravo, A. J., & Marijuana Outcomes Study Team. (2018). Personality, marijuana norms, and marijuana outcomes among college students. *Addictive Behaviors, 76,* 291-297.

Prince, M. A., Conner, B. T., & Pearson, M. R. (2018). Quantifying cannabis: A field study of marijuana quantity estimation. *Psychology of Addictive Behaviors, 32*(4), 426-433.

Quinn, P. D., & Harden, K. P. (2013). Differential changes in impulsivity and sensation seeking and the escalation of substance use from adolescence to early adulthood. *Development and Psychopathology*, *25*(1), 223–239.

Robinson, J. M., Ladd, B. O., & Anderson, K. G. (2014). When you see it, let it be: Urgency, mindfulness and adolescent substance use. *Addictive Behaviors*, *39*(6), 1038–1041.

Talbert, B. (2017). Overthinking and Other Minds: The Analysis Paralysis. *Social Epistemology*, *31*(6), 545–556.

Vadhan, N. P., Corcoran, C. M., Bedi, G., Keilp, J. G., & Haney, M. (2017). Acute effects of smoked marijuana in marijuana smokers at clinical high-risk for psychosis: A preliminary study. *Psychiatry Research*, *257*, 372–374.

VanderVeen, J. D., Hershberger, A. R., & Cyders, M. A. (2016). UPPS-P model impulsivity and marijuana use behaviors in adolescents: A meta-analysis. *Drug and Alcohol Dependence*, *168*, 181–190.

Volkow, N. D., & Weiss, S. R. B. (2020). Importance of a standard unit dose for cannabis research. *Addiction*, *115*(7), 1219–1221.

Walden, N., & Earleywine, M. (2008). How high: Quantity as a predictor of cannabis-related problems. *Harm Reduction Journal*, *5*(1), 20.

Whiteside, S. P., Lynam, D. R., Miller, J. D., & Reynolds, S. K. (2005). Validation of the UPPS impulsive behaviour scale: A four-factor model of impulsivity. *European Journal of Personality*, *19*(7), 559–574.

Williams, R. J., & Nowatzki, N. (2005). Validity of Adolescent Self-Report of Substance Use. *Substance Use & Misuse*, *40*(3), 299–311.

Zeisser, C., Thompson, K., Stockwell, T., Duff, C., Chow, C., Vallance, K., Ivsins, A., Michelow, W., Marsh, D., & Lucas, P. (2012). A 'standard joint'? The role of quantity in predicting cannabis-related problems. *Addiction Research & Theory*, *20*(1), 82–92.

Funding and Acknowledgements: Research reported herein is supported by a grant (2017-3415) from the Colorado Department of Public Health and Environment, Denver, Colorado.