Published in final edited form as:

Addict Behav. 2015 June ; 45: 134–138. doi:10.1016/j.addbeh.2015.01.032.

Impulsivity and Cigarette Craving among Adolescent Daily and Occasional Smokers

Amanda R. Mathew^{1,*}, Jessica L. Burris², Brett Froeliger^{1,3,4}, Michael E. Saladin^{1,5}, and Matthew J. Carpenter^{1,4}

¹Department of Psychiatry and Behavioral Sciences, Medical University of South Carolina, Charleston, SC

²Department of Psychology, University of Kentucky

³Department of Neurosciences, Medical University of South Carolina, Charleston, SC

⁴Hollings Cancer Center, Medical University of South Carolina, Charleston, SC

⁵Department of Health Science and Research, Medical University of South Carolina, Charleston, SC

Abstract

Introduction—Impulsivity is a multi-dimensional construct that is robustly related to cigarette smoking. While underlying factors that account for this relation are not well understood, craving has been proposed as a central mechanism linking impulsivity to smoking. In order to further refine our understanding of associations between impulsivity and cigarette craving, the current study examined the association between impulsivity and tonic and cue-elicited craving among a sample of adolescent smokers. We expected trait impulsivity would be positively associated with both tonic and cue-elicited craving, and that this relationship would be stronger among daily vs. occasional smokers.

Methods—106 smokers (ages 16–20) completed questionnaires and reported their cigarette craving prior to and immediately following presentation of each of three counterbalanced cue types: (a) in vivo smoking, (b) alcohol, and (c) neutral cue.

Results—Impulsivity was positively associated with tonic craving for daily smokers ($\beta=.38$; $p=.005$), but not occasional smokers ($\beta=.01$; $p=.95$), with a significant impulsivity x smoker group

© 2015 Published by Elsevier Ltd.

Correspondence concerning this article should be addressed to Amanda R. Mathew, Ph.D., Medical University of South Carolina, Department of Psychiatry and Behavioral Sciences, 67 President Street, 565-North, MSC 861, Charleston, SC 29425-6160; Phone: 843-876-2446; Fax: 843-792-7353; mathea@musc.edu.

CONTRIBUTORS

All authors have contributed to the final version of this manuscript.

CONFLICT OF INTEREST

All authors have no conflict of interest to declare.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

interaction ($\beta=1.31$; $p=.03$). Impulsivity was unrelated to craving following smoking or alcohol cue, regardless of smoker group (all p 's $>.16$).

Conclusions—Results suggest a moderated effect in which impulsivity is positively associated with tonic craving for daily smokers, but not occasional smokers. Tonic craving may serve as a mechanism linking impulsivity, smoking persistence, and nicotine dependence among daily smokers.

Keywords

Smoking; impulsivity; craving; cue reactivity; adolescence

INTRODUCTION

Impulsivity, broadly defined as action without foresight, is a multidimensional biobehavioral construct that is robustly related to cigarette smoking (Bloom, Matsko, & Cimino, 2013; Mitchell, 2004). Impulsivity is linked to progression from non-daily to daily smoking (Audrain-McGovern et al., 2004; Balevich, Wein, & Flory, 2013; Hu, Davies, & Kandel, 2006), greater nicotine dependence (Ryan, MacKillop, & Carpenter, 2013), greater withdrawal severity (VanderVeen, Cohen, Cukrowicz, & Trotter, 2008), and increased risk of relapse following quit attempt (Doran, Spring, McChargue, Pergadia, & Richmond, 2004; Krishnan-Sarin et al., 2007).

Craving is a likely mechanism linking impulsivity to smoking. High-impulsive individuals may be more sensitive to nicotine's reinforcing effects in early stage smoking (Perkins et al., 2008), as they endorse greater expectancies for the positive and negative reinforcement value of smoking (Doran, McChargue, & Cohen, 2007; Pang et al., 2014). Thus, enhanced reward value of cigarettes may explain increased level of craving among high-impulsive smokers. In several studies utilizing cue-exposure paradigms (Bourque, Mendrek, Dinh-Williams, & Potvin, 2012; Doran, Cook, McChargue, & Spring, 2009; Doran, Spring, & McChargue, 2007), cue-induced craving was greatest among smokers with higher levels of impulsivity. However, association of impulsivity with tonic or background craving (i.e., craving that smokers experience irrespective of situational cues; Ferguson & Shiffman, 2009) is less clear. While impulsivity is linked to tonic urge for cigarettes in anticipation of relief from negative affect or withdrawal among light smokers (Billieux, Van der Linden, & Ceschi, 2007), it is unknown whether this relationship holds for tonic craving among smokers who vary in level of smoking and nicotine dependence.

Risk factors that underlie maintenance of smoking, such as impulsivity, are particularly important to understand among adolescent smokers due to their marked risk of continued smoking and other negative health outcomes later in life (Chassin, Presson, Pitts, & Sherman, 2000; Counotte, Smit, Pattij, & Spijker, 2011; Engeland, Haldorsen, Andersen, & Tretli, 1996; Huxley et al., 2012; USDHS, 2011). As tonic and cue-elicited craving likely reflect separate smoking processes that associate differently with nicotine dependence (Ferguson & Shiffman, 2009) and response to treatment (Hitsman et al., 2013; Tiffany, Cox, & Elash, 2000; Waters et al., 2004), examining how each relates to impulsivity may provide valuable and clinically-relevant information about smoking behavior. Further, the

relationship between impulsivity and craving may differ across levels of smoking, as separate dimensions of impulsivity are thought to account for smoking initiation vs. persistence (Balevich et al., 2013; Dawe, Gullo, & Loxton, 2004). In the current study, we examined impulsivity as a predictor of 1) tonic craving and 2) craving in response to active situational cues, among daily and occasional smokers in late adolescence. Situational cues included both smoking and alcohol stimuli, as each is strongly associated with adolescent smoking behavior (Brown, Carpenter, & Sutfin, 2011; Lewinsohn, Brown, Seeley, & Ramsey, 2000; McKee, Hinson, Rounsaville, & Petrelli, 2004). Due to differences in level of nicotine dependence (Shiffman & Paty, 2006) and response to smoking-related cues (Curtin, Barnett, Colby, Rohsenow, & Monti, 2005; Haight, Dickter, & Forestell, 2012) among adolescent daily vs. occasional smokers, we chose to analyze these smoking groups separately. We expected impulsivity to be positively associated with both tonic and cue-elicited craving, and that this relationship would be stronger for daily smokers vs. occasional smokers.

METHODS

Participants

Data were drawn from a study on cue-elicited craving among daily (n=54) vs. occasional (n=52) adolescent smokers with all data available on measures of interest (Carpenter et al., 2014). Participants were recruited from the general community via radio, print, and social media advertising. Eligibility criteria included: a) age 16–20 (to control for legal drinking status), b) current daily or occasional smoker not currently trying to quit, c) no use of non-cigarette tobacco within past 6 months, d) ingestion of alcohol at least once in the past 30 days, and e) no past or current alcohol abuse or dependence. Consistent with prior research (Shiffman, Kirchner, Ferguson, & Scharf, 2009), a daily smoker was defined as smoking 5 cigarettes per day (cpd), on at least 26/30 days of each month for past 6 months, and confirmed via carbon monoxide (CO; >8ppm). Occasional smokers were defined as smoking 1 cigarette in each week of the past 8 weeks, with no more than 25 days of smoking per month, and no CO verification. Individuals who were “experimenting” and had very low levels of smoking, and also those who have previously smoked regularly but were currently smoking less, were excluded.

Procedure

After telephone pre-screening, participants attended an in-person baseline session involving assessment of study eligibility, informed consent, breath CO analysis, and administration of baseline assessments. Cue reactivity was administered at session 2 (M=6.1 days from baseline, SD=3.2), with > 90% of participants scheduled after 1:00 pm. All participants smoked one cigarette 30 minutes prior to the session to control for time since last cigarette. Participants began by viewing a 10-minute slideshow of nature scenes to acclimate to environment and settle autonomic responding. Each of the three cues (smoking, alcohol, and neutral) was 120 seconds in duration and consisted of in vivo visual and auditory presentation (see below). Order of cue presentation was counterbalanced, and a 10-minute washout consisting of nature scenes was administered between each. All procedures were granted appropriate approvals for Protection of Human Subjects.

For the smoking cue, participants were presented with their preferred brand of cigarettes and lighter and were instructed to open the pack, remove, smell, and light one cigarette. For the alcohol cue, participants' preferred alcoholic beverage was presented, with instructions to pour (beer only), look at, and repeatedly smell, but not ingest, the beverage. For the neutral cue, participants were presented with a pencil and eraser, and given comparable in vivo instructions to those given in the smoking cue.

Measures

Impulsivity was assessed with the Barratt Impulsiveness Scale-11 (BIS-11; Patton & Stanford, 1995). The BIS-11 provides a total scale score ($\alpha=.83$) with a possible range of 30–120. The BIS-11 also yields three subscales: 1) motor impulsiveness (e.g., “I do things without thinking”; $\alpha=.70$), 2) cognitive-attentional impulsiveness (e.g., “I concentrate easily”; $\alpha=.60$), and 3) non-planning impulsiveness (e.g., “I plan tasks carefully”; $\alpha=.74$).

Subjective craving was assessed prior to the first cue (i.e., after the acclimation period) and immediately following each cue with the Questionnaire of Smoking Urges-Brief (QSU; Cox, Tiffany, & Christen, 2001; Davies, Willner, & Morgan, 2000), a 10-item scale that yields a total craving score and two factors: 1) urge for cigarettes in anticipation of positive outcomes and 2) urge in anticipation of relief from negative affect/withdrawal. Items are rated on a 1–7 scale and averaged to create the total and factor-specific scores. Internal consistency of the QSU total score in the current study was high ($\alpha=.95$ to $.96$ across measurement points).

Analytic Strategy

Zero-order correlations were performed to examine relationships between demographic and smoking-related variables, and BIS scores. Linear regression models were run to examine the relationship between impulsivity and craving, stratified by smoker group (daily vs. occasional smokers), and results are reported as β -weights. We examined BIS total and subscale scores as individual predictors of 1) tonic QSU score and 2) QSU difference score (post-pre value for each cue type), covarying for neutral cue difference score. Lastly, we examined a full model with impulsivity, smoker group, and an impulsivity x smoking group interaction term as simultaneous predictors of QSU score.

RESULTS

Sample Characteristics

Participants were, on average, 18.9 years old ($SD=.95$), and primarily male (58.5%), Caucasian (81.1%), and high school graduates (88.5%); many of whom completed some college/technical school (58.7%). Detailed sample characteristics by smoker group are provided elsewhere (Carpenter et al., 2014). In brief, daily smokers smoked 28.5 of the past 30 days ($SD=4.9$), averaged 94.4 cigarettes/week ($SD=46.0$), and had been smoking for 4.1 years ($SD=2.1$) while occasional smokers smoked 14.1 of the past 30 days ($SD=6.0$), averaged 10.2 cigarettes/week ($SD=9.9$), and had been smoking for 2.8 years ($SD=1.6$). Descriptive information on BIS-11 and QSU measures by smoker group is provided in Table 1.

Impulsivity as a Predictor of Tonic Craving

For daily smokers, BIS total score ($\beta=.38$; $p=.005$) was positively associated with QSU total score. BIS non-planning subscale ($\beta=.30$; $p=.03$), inattention subscale ($\beta=.31$; $p=.03$), and motor subscale ($\beta=.35$; $p=.01$) were also associated with QSU total score. For occasional smokers, neither BIS total score ($\beta=.01$; $p=.95$) nor BIS subscale scores ($\beta's = -.04$ to $.05$, all $p's > .74$) was associated with QSU total score. The same pattern of findings was observed for each factor of QSU (data not shown).

Impulsivity as a Predictor of Cue-Elicited Craving

For daily smokers, BIS total score was not associated with QSU change score following either smoking ($\beta=-.02$; $p=.92$) or alcohol ($\beta=.19$; $p=.17$) cue exposure. Similarly, for occasional smokers, BIS total score was unrelated to QSU change score following smoking ($\beta=.04$; $p=.78$) or alcohol ($\beta=.16$; $p=.26$) cue. The same pattern held for BIS subscale scores ($\beta's = -.10$ to $.23$, all $p's > .09$) and QSU factor scores ($\beta's = -.03$ to $.22$; all $p's > .12$; data not shown).

Interaction Effects of Impulsivity by Smoker Group on Tonic Craving

We secondarily tested smoker group (daily vs. occasional) as a moderator of significant relations between impulsivity and tonic craving. When BIS total score, smoker group, and their interaction term were entered as simultaneous predictors in a linear regression model, the latter was significantly associated with tonic craving ($\beta=1.31$; $p=.03$). Results suggest a moderated effect in which impulsivity is positively associated with tonic craving for daily, but not occasional smokers (see Figure 1).

DISCUSSION

Although impulsivity is frequently assessed in relation to drug dependence, the relationship between impulsivity and cigarette craving is not yet well understood, particularly across levels of smoking behavior. In the current study, trait impulsivity was positively associated with tonic craving for daily, but not occasional, early stage smokers. However, trait impulsivity was unrelated to cue-provoked craving following exposure to either a smoking or alcohol cue.

Findings suggest the relationship between impulsivity and smoking differs across levels of smoking. While daily smokers were shown to have a strong positive relationship between trait impulsivity and tonic craving, this relationship was not evident for occasional smokers. It is possible that impulsivity confers risk for smoking persistence or difficulty quitting that is specific to daily smokers. Daily vs. occasional smokers are shown to vary significantly on personality variables such as sensation seeking, self-control (Kassel, Shiffman, Gnys, Paty, & Zettler-Segal, 1994), and experience of positive and negative affect (Dvorak & Simons, 2008), and these between-group differences are likely relevant to trait impulsivity as well. In particular, disinhibition is thought to index the frontal lobe dysfunction that underlies smoking persistence and nicotine dependence, but not smoking initiation (Dawe et al., 2004; Jentsch & Taylor, 1999), and is associated with the transition to persistent and regular use of cigarettes (Balevich et al., 2013; Flory & Manuck, 2009). Thus, findings of the current study

highlight tonic craving as a potential pathway by which impulsivity is associated with daily smoking and nicotine dependence. Alternatively, it may be that daily smoking is the cause of both higher tonic craving and heightened impulsivity. Nicotine exposure is shown to increase impulsive choice and behavioral disinhibition (Dallery & Locey, 2005; Kolokotroni, Rodgers, & Harrison, 2011), perhaps through its impact on frontostriatal brain functioning (Jentsch & Taylor, 1999). Further study is needed to elucidate directional pathways by which specific dimensions of impulsivity are associated with tonic craving, with particular attention given to the potentially unique role of disinhibition.

The finding that trait impulsivity was unrelated to cue-elicited craving was unexpected and inconsistent with several published studies (Bourque et al., 2012; Doran et al., 2009; Doran, Spring, et al., 2007), though not all (Doran, McChargue, & Spring, 2008; Salgado-García, Cooper, & Taylor, 2013). Findings may reflect differences among smoker populations, as the current study involved a sample of early stage smokers who were lower in nicotine dependence and years smoking than typical adult smokers. Additionally, smokers reported relatively low ratings of craving over the course of the cue exposure session, which limited our ability to detect changes in level of craving from pre- to post-cue. A longer duration of the interval period between cues may have better allowed for detection of cue-induced craving (Heishman, Saha, & Singleton, 2004). Further, as high-impulsive smokers are known to have greater craving during acute withdrawal (VanderVeen et al., 2008), examining cue-elicited craving following an abstinence period in future studies may increase sensitivity to detect an effect of impulsivity on cue-elicited craving in this population.

Despite some null findings, this study offers clinical significance. Impulsivity may be a relevant treatment target for smoking cessation efforts among daily smokers in late adolescence to early adulthood. Behavioral interventions such as mindfulness training (Brewer et al., 2011; Davis et al., 2014) and attentional retraining (Kerst & Waters, 2014) hold promise as potential adjuncts to standard smoking cessation treatment for high-impulsive smokers, as they target key deficits in cognitive regulation of craving and negative affect as well as responsivity to natural (non-drug) rewards (Garland, Froeliger, & Howard, 2013).

Some methodological considerations also warrant comment. Data were assessed cross-sectionally, which precludes understanding of how impulsivity influences smoking behavior within individuals over time. Consequently, further study is needed to examine if and how the relationship between impulsivity and craving changes as nicotine dependence develops. As impulsivity has been conceptualized and assessed in a number of ways, future research could further refine understanding of impulsivity and craving through inclusion of additional self-report measures that assess affective dimensions of impulsivity (e.g., UPPS Impulsive Behavior scale; Whiteside & Lynam, 2001), as well as behavioral measures of impulsivity, such as the Delay Discounting Task (Sweitzer, Donny, Dierker, Flory, & Manuck, 2008), Conners' Continuous Performance Task (Conners, 2004; McClernon et al., 2008), or cued Go/No-Go task (Kozink, Kollins, & McClernon, 2010).

In summary, the current study found impulsivity to interact with smoking group (daily vs. occasional smokers) to predict tonic, but not cue-elicited, craving in a sample of adolescents.

Findings suggest tonic craving may help account for the relationship between impulsivity and daily, persistent smoking. Further study is needed to cross-validate relations between impulsivity, craving, and nicotine dependence utilizing multiple methods of analysis.

Acknowledgments

ROLE OF FUNDING SOURCES

This research was supported by the National Institute on Drug Abuse (NIDA) of the National Institutes of Health under awards K23-DA020482, T32-DA007288, and F32-DA036947. NIDA had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit the paper for publication. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

- Audrain-McGovern J, Rodriguez D, Tercyak KP, Cuevas J, Rodgers K, Patterson F. Identifying and characterizing adolescent smoking trajectories. *Cancer Epidemiology Biomarkers & Prevention*. 2004; 13(12):2023–2034.
- Balevich EC, Wein ND, Flory JD. Cigarette smoking and measures of impulsivity in a college sample. *Substance Abuse*. 2013; 34(3):256–262.10.1080/08897077.2012.763082 [PubMed: 23844956]
- Billieux J, Van der Linden M, Ceschi G. Which dimensions of impulsivity are related to cigarette craving? *Addictive Behaviors*. 2007; 32(6):1189–1199.10.1016/j.addbeh.2006.08.007 [PubMed: 16997490]
- Bloom EL, Matsko SV, Cimino CR. The relationship between cigarette smoking and impulsivity: A review of personality, behavioral, and neurobiological assessment. *Addiction Research & Theory*. 2013; 10.3109/16066359.2013.867432
- Bourque J, Mendrek A, Dinh-Williams L, Potvin S. Neural circuitry of impulsivity in a cigarette craving paradigm. *Frontiers in Psychiatry*. 2013; 4(67):1–9. [PubMed: 23346060]
- Brewer JA, Mallik S, Babuscio TA, Nich C, Johnson HE, Deleone CM, Weinstein AJ. Mindfulness training for smoking cessation: results from a randomized controlled trial. *Drug and Alcohol Dependence*. 2011; 119(1):72–80.10.1016/j.drugalcdep.2011.05.027 [PubMed: 21723049]
- Brown AE, Carpenter MJ, Sutfin EL. Occasional smoking in college: who, what, when and why? *Addictive Behaviors*. 2011; 36(12):1199–1204.10.1016/j.addbeh.2011.07.024 [PubMed: 21849231]
- Carpenter MJ, Saladin ME, LaRowe SD, McClure EA, Simonian S, Upadhyaya HP, Gray KM. Craving, cue reactivity, and stimulus control among early-stage young smokers: effects of smoking intensity and gender. *Nicotine & Tobacco Research*. 2014; 16(2):208–215.10.1093/ntn/ntt147 [PubMed: 24042699]
- Chassin L, Presson CC, Pitts SC, Sherman SJ. The natural history of cigarette smoking from adolescence to adulthood in a midwestern community sample: multiple trajectories and their psychosocial correlates. *Health Psychology*. 2000; 19(3):223–231.10.1037/0278-6133.19.3.223 [PubMed: 10868766]
- Conners, CK. Conners' continuous performance test. Multi-Health Systems Incorporated; 2004.
- Counotte DS, Smit AB, Pattij T, Spijker S. Development of the motivational system during adolescence, and its sensitivity to disruption by nicotine. *Developmental Cognitive Neuroscience*. 2011; 1(4):430–443.10.1016/j.dcn.2011.05.010 [PubMed: 22436565]
- Cox LS, Tiffany ST, Christen AG. Evaluation of the brief questionnaire of smoking urges (QSU-brief) in laboratory and clinical settings. *Nicotine & Tobacco Research*. 2001; 3(1):7–16.10.1080/14622200020032051 [PubMed: 11260806]
- Curtin JJ, Barnett NP, Colby SM, Rohsenow DJ, Monti PM. Cue reactivity in adolescents: measurement of separate approach and avoidance reactions. *Journal of Studies On Alcohol*. 2005; 66(3):332–343. [PubMed: 16047522]
- Dallery J, Locey M. Effects of acute and chronic nicotine on impulsive choice in rats. *Behavioural Pharmacology*. 2005; 16(1):15–23.10.1097/00008877-200502000-00002 [PubMed: 15706134]

- Davies G, Willner P, Morgan M. Smoking-related cues elicit craving in tobacco “chippers”: a replication and validation of the two-factor structure of the Questionnaire of Smoking Urges. *Psychopharmacology*. 2000; 152(3):334–342.10.1007/s002130000526 [PubMed: 11105944]
- Davis JM, Goldberg SB, Anderson MC, Manley AR, Smith SS, Baker TB. Randomized trial on mindfulness training for smokers targeted to a disadvantaged population. *Substance Use & Misuse*. 2014; 49(5):571–585.10.3109/10826084.2013.770025 [PubMed: 24611852]
- Dawe S, Gullo MJ, Loxton NJ. Reward drive and rash impulsiveness as dimensions of impulsivity: implications for substance misuse. *Addictive Behaviors*. 2004; 29(7):1389–1405.10.1016/j.addbeh.2004.06.004 [PubMed: 15345272]
- Doran N, Cook J, McChargue D, Spring B. Impulsivity and cigarette craving: differences across subtypes. *Psychopharmacology*. 2009; 207(3):365–373.10.1007/s00213-009-1661-x [PubMed: 19756522]
- Doran N, McChargue D, Cohen L. Impulsivity and the reinforcing value of cigarette smoking. *Addictive Behaviors*. 2007; 32(1):90–98.10.1016/j.addbeh.2006.03.023 [PubMed: 16675149]
- Doran N, McChargue D, Spring B. Effect of impulsivity on cardiovascular and subjective reactivity to smoking cues. *Addictive Behaviors*. 2008; 33(1):167–172.10.1016/j.addbeh.2007.05.009 [PubMed: 17566665]
- Doran N, Spring B, McChargue D. Effect of impulsivity on craving and behavioral reactivity to smoking cues. *Psychopharmacology*. 2007; 194(2):279–288.10.1007/s00213-007-0832-x [PubMed: 17594080]
- Doran N, Spring B, McChargue D, Pergadia ML, Richmond M. Impulsivity and smoking relapse. *Nicotine & Tobacco Research*. 2004; 6(4):641–647.10.1080/14622200410001727939 [PubMed: 15370160]
- Dvorak RD, Simons JS. Affective differences among daily tobacco users, occasional users, and non-users. *Addictive Behaviors*. 2008; 33(1):211–216.10.1016/j.addbeh.2007.09.003 [PubMed: 17919829]
- Engeland A, Haldorsen T, Andersen A, Tretli S. The impact of smoking habits on lung cancer risk: 28 years’ observation of 26,000 Norwegian men and women. *Cancer Causes & Control*. 1996; 7(3): 366–376.10.1007/BF00052943 [PubMed: 8734831]
- Ferguson SG, Shiffman S. The relevance and treatment of cue-induced cravings in tobacco dependence. *Journal of Substance Abuse Treatment*. 2009; 36(3):235–243.10.1016/j.jsat.2008.06.005 [PubMed: 18715743]
- Flory J, Manuck S. Impulsiveness and cigarette smoking. *Psychosomatic Medicine*. 2009; 71(4):431–437.10.1097/PSY.0b013e3181988c2d [PubMed: 19251874]
- Garland EL, Froeliger B, Howard MO. Mindfulness training targets neurocognitive mechanisms of addiction at the attention-appraisal-emotion interface. *Frontiers in Psychiatry*. 2013; 4:1–16. [PubMed: 23346060]
- Haight J, Dickter CL, Forestell CA. A comparison of daily and occasional smokers’ implicit affective responses to smoking cues. *Addictive Behaviors*. 2012; 37(3):234–239.10.1016/j.addbeh.2011.10.006 [PubMed: 22078800]
- Heishman S, Saha S, Singleton E. Imagery-induced tobacco craving: duration and lack of assessment reactivity bias. *Psychology of Addictive Behaviors*. 2004; 18(3):284–288.10.1037/0893-164X.18.3.284 [PubMed: 15482084]
- Hitsman B, Hogarth L, Tseng LJ, Teige JC, Shadel WG, DiBenedetti DB, Niaura R. Dissociable effect of acute varenicline on tonic versus cue-provoked craving in non-treatment-motivated heavy smokers. *Drug and Alcohol Dependence*. 2013; 130(1):135–141.10.1016/j.drugalcdep.2012.10.021 [PubMed: 23201174]
- Hu MC, Davies M, Kandel DB. Epidemiology and correlates of daily smoking and nicotine dependence among young adults in the United States. *American Journal of Public Health*. 2006; 96(2):299–308.10.2105/AJPH.2004.057232 [PubMed: 16380569]
- Huxley RR, Yatsuya H, Lutsey PL, Woodward M, Alonso A, Folsom AR. Impact of age at smoking initiation, dosage, and time since quitting on cardiovascular disease in african americans and whites the atherosclerosis risk in communities study. *American Journal of Epidemiology*. 2012; 175(8):816–826.10.1093/aje/kwr391 [PubMed: 22396389]

- Jentsch JD, Taylor JR. Impulsivity resulting from frontostriatal dysfunction in drug abuse: implications for the control of behavior by reward-related stimuli. *Psychopharmacology*. 1999; 146(4):373–390.10.1007/PL00005483 [PubMed: 10550488]
- Kassel JD, Shiffman S, Gnys MA, Paty J, Zettler-Segal M. Psychosocial and personality differences in chippers and regular smokers. *Addictive Behaviors*. 1994; 19(5):565–575.10.1016/0306-4603(94)90012-4 [PubMed: 7832015]
- Kerst WF, Waters AJ. Attentional retraining administered in the field reduces smokers' attentional bias and craving. *Health Psychology*. 2014;10.1037/a0035708
- Kolokotroni KZ, Rodgers RJ, Harrison AA. Acute nicotine increases both impulsive choice and behavioural disinhibition in rats. *Psychopharmacology*. 2011; 217(4):455–473.10.1007/s00213-011-2296-2 [PubMed: 21503608]
- Kozink RV, Kollins SH, McClernon FJ. Smoking withdrawal modulates right inferior frontal cortex but not presupplementary motor area activation during inhibitory control. *Neuropsychopharmacology*. 2010; 35(13):2600–2606.10.1038/npp.2010.154 [PubMed: 20861830]
- Krishnan-Sarin S, Reynolds B, Duhig AM, Smith A, Liss T, McFetridge A, Potenza MN. Behavioral impulsivity predicts treatment outcome in a smoking cessation program for adolescent smokers. *Drug and Alcohol Dependence*. 2007; 88(1):79–82.10.1016/j.drugalcdep.2006.09.006 [PubMed: 17049754]
- Lewinsohn PM, Brown RA, Seeley JR, Ramsey SE. Psychosocial correlates of cigarette smoking abstinence, experimentation, persistence and frequency during adolescence. *Nicotine & Tobacco Research*. 2000; 2(2):121–131.10.1080/713688129 [PubMed: 11072450]
- McClernon FJ, Kollins SH, Lutz AM, Fitzgerald DP, Murray DW, Redman C, Rose JE. Effects of smoking abstinence on adult smokers with and without attention deficit hyperactivity disorder: results of a preliminary study. *Psychopharmacology*. 2008; 197(1):95–105.10.1007/s00213-007-1009-3 [PubMed: 18038223]
- McKee SA, Hinson R, Rounsaville D, Petrelli P. Survey of subjective effects of smoking while drinking among college students. *Nicotine & Tobacco Research*. 2004; 6(1):111–117.10.1080/14622200310001656939 [PubMed: 14982695]
- Mitchell SH. Measuring impulsivity and modeling its association with cigarette smoking. *Behavioral and Cognitive Neuroscience Reviews*. 2004; 3(4):261–275.10.1177/1534582305276838 [PubMed: 15812110]
- Pang R, Hom M, Geary B, Doran N, Spillane N, Guillot C, Leventhal A. Relationships between trait urgency, smoking reinforcement expectancies, and nicotine dependence. *Journal of Addictive Diseases*. 2014;10.1080/10550887.2014.909695
- Patton JH, Stanford MS. Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology*. 1995; 51(6):768–774.10.1002/1097-4679 [PubMed: 8778124]
- Perkins KA, Lerman C, Coddington SB, Jetton C, Karelitz JL, Scott JA, Wilson AS. Initial nicotine sensitivity in humans as a function of impulsivity. *Psychopharmacology*. 2008; 200(4):529–544.10.1007/s00213-008-1231-7 [PubMed: 18604520]
- Ryan KK, MacKillop J, Carpenter MJ. The relationship between impulsivity, risk-taking propensity and nicotine dependence among older adolescent smokers. *Addictive Behaviors*. 2013; 38(1):1431–1434.10.1016/j.addbeh.2012.08.013 [PubMed: 23006247]
- Salgado-García FI, Cooper TV, Taylor T. Craving effect of smoking cues in smoking and antismoking stimuli in light smokers. *Addictive Behaviors*. 2013; 38(10):2492–2499.10.1016/j.addbeh.2013.04.008 [PubMed: 23773957]
- Shiffman S, Kirchner TR, Ferguson SG, Scharf DM. Patterns of intermittent smoking: An analysis using Ecological Momentary Assessment. *Addictive Behaviors*. 2009; 34(6):514–519.10.1016/j.addbeh.2009.01.004 [PubMed: 19232834]
- Shiffman S, Paty J. Smoking patterns and dependence: contrasting chippers and heavy smokers. *Journal of Abnormal Psychology*. 2006; 115(3):509–523.10.1037/0021-843X.115.3.509 [PubMed: 16866591]
- Sweitzer MM, Donny EC, Dierker LC, Flory JD, Manuck SB. Delay discounting and smoking: Association with the Fagerström Test for Nicotine Dependence but not cigarettes smoked per day.

- Nicotine & Tobacco Research. 2008; 10(10):1571–1575.10.1080/14622200802323274 [PubMed: 18946776]
- Tiffany ST, Cox LS, Elash CA. Effects of transdermal nicotine patches on abstinence-induced and cue-elicited craving in cigarette smokers. *Journal of Consulting and Clinical Psychology*. 2000; 68(2):233–240.10.1037/0022-006X.68.2.233 [PubMed: 10780123]
- USDHS. Cigarette smoking—United States, 1965–2008. *MMWR*. 2011; 60:109–113.
- VanderVeen JW, Cohen LM, Cukrowicz KC, Trotter DR. The role of impulsivity on smoking maintenance. *Nicotine & Tobacco Research*. 2008; 10(8):1397–1404.10.1080/14622200802239330 [PubMed: 18686188]
- Waters AJ, Shiffman S, Sayette MA, Paty JA, Gwaltney CJ, Balabanis MH. Cue-Provoked craving and nicotine replacement therapy in smoking cessation. *Journal of Consulting and Clinical Psychology*. 2004; 72(6):1136–1143.10.1037/0022-006X.72.6.1136 [PubMed: 15612859]
- Whiteside SP, Lynam DR. The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences*. 2001; 30(4):669–689.10.1016/S0191-8869(00)00064-7

HIGHLIGHTS FOR REVIEW

- Relationship between impulsivity and cigarette smoking may be partly attributable to craving.
- Examined impulsivity, tonic and cue-provoked craving in daily vs. occasional adolescent smokers.
- Interaction of impulsivity by smoker group was associated with tonic, but not cue-provoked, craving.
- Tonic craving may help account for the relations between impulsivity and daily, persistent smoking.

Figure 1. Impulsivity as a Predictor of Tonic Craving for Daily vs. Occasional Smokers
Note. BIS-11 = Barratt Impulsivity Scale-11; QSU = Questionnaire of smoking urges.

Table 1

Descriptive Information for Measures of Impulsivity (BIS-11) and Craving (QSU) by Smoker Group

Measure	Daily Smokers (<i>n</i> = 55) <i>M</i> (<i>SD</i>)	Occasional Smokers (<i>n</i> = 52) <i>M</i> (<i>SD</i>)
1. BIS-11 total	70.8 (13.6)	71.1 (11.0)
2. BIS-11 non-planning	26.2 (5.9)	26.1 (4.9)
3. BIS-11 inattention	20.7 (5.2)	20.7 (4.1)
4. BIS-11 motor	24.5 (5.2)	24.7 (5.4)
5. QSU prior to first cue *	2.1 (0.9)	1.6 (0.6)
6. QSU for smoking cue ^{<i>I</i>}	0.2 (0.4)	0.2 (0.4)
7. QSU for alcohol cue ^{<i>I</i>}	0.7 (0.7)	0.7 (0.6)

Note. BIS-11 = Barratt Impulsivity Scale-11; QSU = Questionnaire of Smoking Urges.

^{*I*} Values reflect difference score of QSU following cue presentation – QSU prior to cue presentation.

* $p < .001$.