Published in final edited form as:

Addict Behav. 2017 April ; 67: 58–65. doi:10.1016/j.addbeh.2016.12.004.

Relationship of nicotine deprivation and indices of alcohol use behavior to implicit alcohol and cigarette approach cognitions in smokers

Amy Cohn, PhD^{1,2}, Sarah Ehlke, MA^{1,3}, and Caroline O. Cobb, PhD⁴

¹Schroeder Institute for Tobacco Research and Policy Studies at Truth Initiative, Washington, DC, USA

²Department of Oncology, Georgetown University Medical Center, Lombardi Comprehensive Cancer Center

³Department of Psychology, Old Dominion University, Norfolk, VA, USA

⁴Department of Psychology & Center for Study of Tobacco Products, Virginia Commonwealth University, Richmond, VA, USA

Abstract

Alcohol and smoking frequently co-occur and alcohol is a primary trigger for smoking behavior and relapse back to smoking. This study examined whether several indices of alcohol use behavior and consequences of use would be associated with changes in implicit alcohol-approach versus implicit cigarette-approach cognitions under cigarette deprived and non-deprived cognitions in a 109 smokers who drank at risky or non-risky levels. An Implicit Association Task (IAT) measured how quickly respondents paired alcohol and cigarette pictures with approach and avoid words. Regression analyses examined the associations of quantity/frequency, proportion heavy drinking days, number of DSM-IV alcohol use disorder (AUD) symptoms, and risky drinking status to IAT scores under deprived conditions, controlling for IAT order effects, non-deprived IAT score, and deprived cigarette craving and withdrawal. Interactions with craving and withdrawal intensity were also examined. Results showed a significant positive association between proportion of heavy drinking days and stronger alcohol-approach than cigarette-approach motivations when deprived. There was also a conditional association of AUD symptoms to alcohol-approach motivations among respondents reporting more intense withdrawal when deprived. Alcohol quantity and frequency, as well as risky drinking status were unrelated to change in IAT scores. Findings

Corresponding author: Amy Cohn, 900 G Street NW, Fourth Floor, Washington, DC, 20001; phone: (202) 454-5918; acohn@truthinitiative.org.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Contributors: AC, SE, and CC were involved in data collection and study development and implementation; AC and SE were involved in data analysis; all authors were involved in manuscript writing and revisions. All authors have contributed to the preparation of this manuscript and have approved its final submission.

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.

suggest that cigarette deprivation may magnify motivation to drink, rather than smoke, among smokers who engage in more frequent bouts of heavy drinking and who report more alcohol-related problems. Results also show relative momentary and unconscious “preference” or choice for alcohol over cigarettes in some high-risk smokers, when cigarette craving and withdrawal are high.

Keywords

alcohol; smoking; heavy drinking; alcohol use disorder; implicit motivations; withdrawal; nicotine deprivation

1. Introduction

Alcohol use and cigarette smoking are highly co-morbid (Falk, Yi, & Hiller-Sturmhofel, 2006) and almost half of all daily smokers exceed the NIAAA-guidelines for risky drinking (McKee, Falba, O’Malley, Sindelar, & O’Connor, 2007). Alcohol use, problem drinking, and alcohol use disorders (AUDs) are implicated in persistent smoking, greater nicotine dependence, smoking relapse (Kahler, Spillane, & Metrik, 2010; Niaura et al., 1988), and less success (or attempts) at quitting smoking (Cooney et al., 2007). Research shows that nearly half of all smoking-related slips occur during a drinking episode, and even after a quit attempt, individuals are more likely to slip or relapse back to smoking on days in which any alcohol is consumed, compared to non-drinking days, and on heavy drinking days (Leeman et al., 2008). The effectiveness of psychological treatments for smoking cessation are likely to be enhanced by improved understanding of the factors linking drinking and cigarette smoking, particularly for smokers who engage in heavy and problematic drinking (Hartmann-Boyce, Stead, Cahill, & Lancaster, 2014; McKee & Weinberger, 2013). This study sought to answer questions about the cognitive mechanisms linking alcohol and cigarette smoking among smokers exhibiting the continuum of alcohol use behavior and related problems. Such processes could be targeted in interventions to reduce the risk of relapse among smokers who drink.

According to classic learning models, alcohol and smoking may be paired together under both positive and negative reinforcing conditions. In positive reinforcement conditions, nicotine in cigarettes can enhance the pleasurable depressant effects of drinking; or drinking can enhance the positively stimulating effects of nicotine (Rose et al., 2004). In negative reinforcement circumstances, alcohol can be used to alleviate negative affect, such as that associated with nicotine craving and withdrawal, or both alcohol and nicotine can be used together to synergistically counteract the effects of negative mood more generally (Brandon, 1994; Brandon, Wetter, & Baker, 1996). In both positive and negative reinforcement circumstances, alcohol and smoking may become strongly paired in an associative cognitive network, through repeated co-administration, such that the use of one automatically activates use, or desire to use the other without conscious or deliberate intention (Greenwald, Nosek, & Banaji, 2003; Wiers & Stacy, 2006). In an attempt to understand how alcohol use may lead to smoking during a cessation attempt, the current study focuses on the negative reinforcement condition that is associated with acute nicotine withdrawal and heightened

nicotine craving (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004), wherein deprivation from smoking may cue one's desire to drink to alleviate these nicotine-related side effects. Prior studies show a person's efforts to curb the negative side effects of nicotine withdrawal by having a drink can increase desire to smoke in the future, and thus enhance risk for a lapse or relapse (Kahler et al., 2010; Niaura et al., 1988).

Data from ecological momentary assessment (EMA) studies have elucidated some of the complex relationships underlying alcohol and nicotine co-use (Cooney et al., 2007; Piasecki et al., 2011; Piasecki, McCarthy, Fiore, & Baker, 2008). When alcohol was consumed, smokers reported cigarettes as having more positive subjective effects and reducing smoking urge, but importantly effects on smoking urge were only for cigarettes smoked more than 15 minutes prior (Piasecki et al., 2008). Among smokers in intensive outpatient treatment for alcohol dependence, EMA assessments showed that smoking episodes were associated with increased urges to drink (Cooney et al., 2007). A different EMA study among frequent drinkers who smoked showed an association between problem drinking (indexed by an alcohol dependence assessment) and alcohol and tobacco craving and negative reinforcement from drinking and smoking (Piasecki et al., 2011). Taken together these findings emphasize the role of nicotine deprivation/satiation status and the importance of drinking history (frequency, intensity) on motivational mechanisms for co-use.

The reinforcing effects of alcohol use on cigarette withdrawal and craving may be especially pronounced in risky drinking smokers; i.e., those who drink more often and in greater quantities. First, it may be that smokers who drink often have more opportunities to pair cigarettes and alcohol together; thereby strengthening the cognitive associations between smoking and drinking behavior and their reinforcing properties (Wiers & Stacy, 2006). Second, heavy are more likely to turn to alcohol as a method to cope with negative affective states compared to non-heavy drinkers (Amlung & MacKillop, 2014; Birch et al., 2004; Carpenter & Hasin, 1999; Cooney, Litt, Morse, Bauer, & Gaupp, 1997). Thus, activation of negative emotions, such as those experienced during cigarette withdrawal or intense craving for a cigarette, may trigger an appetitive desire to use alcohol (Baker et al., 2004; Brandon et al., 1996) among smokers who are prone to drinking more often or in greater quantities. Palfai, Monti, Ostafin, and Hutchison (2000) found that smokers who were hazardous drinkers showed increased drinking urges, alcohol-related expectancies, and alcohol consumption following 6 hours of nicotine deprivation. In contrast, we might expect that smokers with low levels of alcohol use behavior and problems may be more inclined to desire a cigarette during nicotine withdrawal (MacKillop et al., 2012; Sayette, Martin, Hull, Wertz, & Perrott, 2003), rather than an alcoholic drink, as they pair alcohol and cigarettes together less often. For example, Field, Mogg, and Bradley (2004) found that daily cigarette smokers with no reported history of problem drinking behavior gazed at smoking-related cues for longer periods of time than control (non-smoking) cues when deprived of nicotine. Thus, there may be different circumstances under which smokers show motivational preferences for alcohol versus cigarettes.

The implicit association task (IAT) is one of several implicit association measurement paradigms that has been used to study the cognitive mechanisms that underlie drug and alcohol use behavior (Ostafin & Palfai, 2006; Wiers et al., 2007). The IAT is a performance-

based categorization task that measures the strength of associations between congruent and incongruent mental concepts (Greewald, McGhee, & Schwartz, 1998) that are purported to be more strongly associated in memory (e.g., desire to “approach” alcohol use under nicotine withdrawal conditions), then dissimilar concepts (e.g., desire to “avoid” alcohol under nicotine withdrawal conditions). Results from this type of paradigm in drinking populations show that alcohol-approach associations are stronger for problem drinkers compared to non-problem drinkers, are associated with increased alcohol craving, and predict heavy episodic drinking (Cohn et al., 2012; Ostafin & Palfai, 2006; Palfai & Ostafin, 2003; Wiers, Van Woerden, Smulders, & De Jong, 2002). In relation to smoking, DeHouwer and colleagues (2006) found that smokers were more likely to approach smoking-related stimuli than to avoid them, and had significantly higher smoking-approach cognitions compared to non-smokers.

This study extends prior IAT research in several ways. While IATs have been used to examine cognitive schemas and implicit motivations for alcohol and tobacco use, all previous IAT studies have focused separately on attitudes toward alcohol or tobacco; none have examined implicit attitudes for these behaviors in relation to each other. Prior research has already demonstrated that smokers have strong approach to cigarettes and drinkers have strong approach for alcohol. What has not been studied is the relative comparison of these approach/avoid tendencies in a single task; when participants are able to make an unconscious and “real time” choice between the two. All paradigms to date have examined mean differences in IAT reaction times using two separate paradigms for alcohol and cigarettes, and comparing target stimuli to a neutral category. Prior research suggests that comparisons with neutral stimuli in IATs may be problematic and using a difference score between two separate IATs can import substantial measurement unreliability relative to a single measure (Blanton, Jaccard, Gonzales, & Christie, 2006; Greenwald et al., 2003; Greewald et al., 1998; Pinter & Greenwald, 2005). Tasks that are separate (i.e., examining mean differences in reaction times between two paradigms) provide less information about “momentary” and implicit preference for one product over the other and what drives some smokers to “reach for a drink” during the acute phases of cigarette craving.

In an effort to know more about the implicit motivational processes that link alcohol use to smoking in the acute phases of withdrawal and craving, we examined differences in implicit alcohol versus cigarette motivations among smokers reporting various levels of alcohol use and problems across cigarette deprived and non-deprived circumstances. As such, 109 adult smokers who were risky and non-risky drinkers completed an IAT that assessed the relative speed with which participants accurately paired alcohol versus cigarette pictures with approach (or avoid) words, under cigarette deprived and non-deprived conditions. We hypothesized that participants who were risky drinkers, and who endorsed a greater number of AUD symptoms, greater quantity/frequency of alcohol use, and who drank heavily more often would show stronger alcohol versus cigarette-approach tendencies when deprived versus not deprived of cigarettes. Additionally, we examined whether reports of cigarette withdrawal and craving during nicotine deprivation would moderate associations between alcohol use indices and changes in implicit smoking versus drinking motivations from non-deprived and deprived conditions. We hypothesized that the strength of association between alcohol use indices and alcohol-approach motivations would be greater for respondents

reporting more intense withdrawal and craving. Findings could suggest different treatment directions for smokers with and without problem drinking behavior and could inform targets for enhancing smoking cessation treatment by placing greater focus on the cognitive mechanisms underlying the link between heavy drinking and cigarette smoking.

2. Method

2.1 Participants and Procedure

Participants were adult smokers residing in a metropolitan area in the Northeast US who completed two laboratory sessions, one deprived of cigarettes and the other not deprived of cigarettes (abstinence of 6 hours). Participants were recruited through web and print advertisements and through word-of-mouth. Advertisements asked for “smokers who were regular drinkers”. Eligibility criteria included (1) between 18 and 65 years old, (2) consume 1 drink in the past month, (3) smoke 10 cigarettes per day, (4) report a desire to quit smoking in the next 6-months, and (5) show no evidence of psychiatric disturbance or potential for severe withdrawal from alcohol. A sampling method was employed to recruit 50% risky drinkers [> 2 drinks/day for men, > 1 for women; and > 14 drinks/week for men; > 7 drinks/week for women (NIAAA, 2008)] and 50% non-risky drinkers (consume at least 1 drink/week in the last 30 days but less than risky drinking levels).

Laboratory sessions were conducted on two separate days, with a minimum of 48 hours apart to reduce the probability of practice effects [similar to (Cooney et al., 2007; Sherman, Rose, Koch, Presson, & Chassin, 2003)]. After an initial screen, participants were randomized to either a deprived or non-deprived experimental condition at their initial assessment. Those in the deprived condition were required to abstain from cigarettes and other nicotine products for at least 6 hours prior to arrival at the laboratory; Colby and colleagues (2004) found that this period of nicotine abstinence was sufficient to induce negative affect and nicotine withdrawal symptoms. Per other published work, cigarette deprivation was verified by exhaled CO measures of 15 ppm and self-report of no smoking taken at the beginning of the session (Colby et al., 2004; Reid, Palamar, Raghavan, & Flammiano, 2007; Sherman et al., 2003). Participants also completed a blood alcohol concentration (BAC) breath test to ensure they were not intoxicated during the session (BAC = 0.00%). At the baseline session, participants provided informed consent, completed the baseline questionnaires (below) and the IAT. Measurements of alcohol and cigarette craving and cigarette withdrawal were taken at the start of each session and again immediately after completing the IAT. To ensure participants understood the IAT, the research assistant was present during all IAT administrations to answer questions and provide further clarification if need. Participants were compensated \$25 for completing each of the two IAT sessions (total of \$50). All procedures were approved by the Chesapeake Institutional Review Board, Inc.

2.2 Measures

2.2.1 Baseline Measures

2.2.1.1: Demographics were assessed at baseline including age, gender, race, ethnicity, marital status, employment status, annual income, and education level.

2.2.1.2: *Nicotine Dependence* was assessed using the 6-item Fagerstrom Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). A total score was calculated with scores ranging from 0 – 10. The FTND has demonstrated good reliability and validity in samples of daily smokers (Heatherton et al., 1991; Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994).

2.2.1.3: *Lifetime alcohol use disorder (AUD) symptoms* were assessed using the Structured Clinical Interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1998).

2.2.1.4: *Cigarette and alcohol consumption* in the 30 days prior to the baseline assessment were measured using the Timeline Follow-Back Interview (TLFB; Sobell & Sobell, 1992) which yielded indices of mean drinking days (MDD), drinks per drinking day (DPDD), percent heavy drinking days (≥ 6 drinks a day; PHDD), and cigarettes per day (CPD). The TLFB has shown high test-retest reliability (Brown et al., 1998; Donohue et al., 2004; Sobell & Sobell, 1992). Our threshold for PHDD aligned with criteria from the Alcohol Use Disorder Identification Test (World Health Organization, 2001).

2.2.2 Implicit Association Task—*Cigarette and alcohol motivations* were assessed using an Implicit Association Task (IAT; Greenwald et al., 1998) designed specifically for this study. Participants were instructed to sort words related to approach (e.g., forward, near) or avoid (e.g., further, escape) and pictures of cigarettes and. The stimuli for the IAT consisted of five approach-related words and five avoidance-related words, five alcohol picture stimuli, and five cigarette picture stimuli (see Appendix A). The pictures for alcohol were based on participant's preferred beverage type (beer, liquor, or wine). Images and words in the present study were drawn from stimuli used in previous studies of implicit motivations toward drinking (Cohn et al., 2012; Cohn et al., 2014; Palfai & Ostafin, 2003) and cue reactivity to smoking (Ariel, Oliver, Brandon, & Drobles, 2014; Brandon et al., 2011; Carter et al., 2006; Drobles, 2002; Oliver & Drobles, 2015) that have been shown to elicit craving. Images were selected so that objects could be easily identified and categorized (see Appendix).

In accordance with the recommendations of Greenwald et al. (2003), participants were presented with word and picture categories on the computer and asked to classify the stimuli into a target category (approach or avoid, alcohol or cigarette) based on pre-defined rules by pressing the “D” or “K” key on the keyboard. Reaction times for correctly classifying a word and a picture were recorded and analyzed, with positive scores indicating an association between alcohol stimuli and “approach” words (and an association between cigarette and avoid) and negative scores indicating an association between alcohol stimuli and “avoid” words (and an association between cigarette and approach).

Two IAT orders were used and were counterbalanced. One block showed the alcohol and approach (and cigarette and avoid) combination (the congruent block) presented first and one displayed the cigarette and approach (and alcohol and avoid) combination (the incongruent block) presented first.

2.2.3. Experimental Measures

2.2.3.1: *The Questionnaire on Smoking Urges-Brief* (QSU-Brief; Cox, Tiffany, & Christen, 2001) was administered at the beginning of each session and used as a validity check to determine the impact of cigarette deprivation on cigarette craving. Participants rated their level of cigarette craving and desire to smoke on 7-point Likert scale (1 = “Strongly Disagree” to 7 = “Strongly Agree”). A total score was computed, with higher scores representing stronger cravings for cigarettes. This measure has good psychometric indices among daily smokers (Littel, Franken, & Muris, 2011; Toll, Katulak, & McKee, 2006).

2.2.3.2: *The Minnesota Nicotine Withdrawal Scale* (MNWS; Hughes, 1992) is a 15-item questionnaire that was administered at the beginning of each session and used to examine changes in cigarette withdrawal symptoms between deprived and non-deprived sessions. Participants rated the severity of physical and psychological symptoms of withdrawal on a 5-point Likert scale (0 = “None” and 4 = “Severe”). A total score was computed, where higher scores indicate greater nicotine withdrawal. This measure has shown good reliability and predictive validity of smoking behavior following a period of abstinence among smokers (Toll, O’Malley, McKee, Salovey, & Krishnan-Sarin, 2007).

2.2.3.3: *The Alcohol Urge Questionnaire* (AUQ; Bohn, Krahn, & Staehler, 1995) was used to examine cravings for alcohol at the beginning of each experimental session. Participants rated their desire to drink (in the moment) on a 7-point Likert scale (1 = “Strongly Disagree” and 7 = “Strongly Agree”). A total score was computed, where higher scores indicate greater urges to drink. The AUQ has shown strong validity among heavy drinkers and alcohol-dependent adults (Drummond & Phillips, 2002; MacKillop, 2006) and has been shown to correlate with alcohol motivations using the IAT (Cohn et al., 2012).

2.3 Data Reduction

Of those eligible and recruited ($n = 124$), 117 completed both experimental sessions and reported drinking at least 1 day/week in the past 30 days. Individuals were included in the final analyses if they reported a CO of ≥ 15 ppm in their deprived session, or whose CO scores differed by ≥ 5 ppm (for heavier smokers) between the deprived and not deprived condition. Eight people were excluded because they did not meet these criteria. This left a final analytic sample of $n = 109$ ($n = 54$ non-risky drinkers and $n = 55$ risky drinkers).

The analysis of IAT data used the D measure, as suggested by Greenwald et al. (2003). The D measure takes into account the number of errors and average response latency to account for general test proficiency and calculates the IAT score by dividing the difference between test block means by the standard deviation of all the response latencies in the two test blocks, thereby yielding a total “reaction time” variable. As noted above, positive IAT scores reflect an association between alcohol and approach (and an association with cigarettes and avoid). Negative scores indicate an association with alcohol and avoid (and an association with cigarettes and approach). Said differently, positive scores indicate an approach association with alcohol, and negative scores indicate an avoid association with alcohol. In both case, larger magnitude scores indicate a stronger association, so that a D score of -0.8 is more strongly negative than a D score of -0.4 , and a D score of $+0.8$ is more strongly

positive than a D score of +0.4. We examined IAT data and transformed the data according to scoring guidelines set forth by Greenwald et al. (2003). No trials were deleted for extremely high or low response times (e.g., greater than 10,000 ms and less than 3,000 ms). There were differences between the congruent-first block and incongruent-second block, $F(1, 105) = 57.95, p < 0.001$. Thus, IAT order was used as a covariate in analyses.

2.4 Data Analyses

All analyses were performed using IBM SPSS Version 22. First, descriptive statistics were conducted to examine demographic and baseline characteristics of the sample and differences across risky and non-risky drinking smokers. To verify success of the deprivation manipulation, paired samples t-tests were then computed to examine mean differences in cigarette and alcohol craving, cigarette withdrawal, and exhaled CO between deprived and non-deprived sessions.

We conducted separate hierarchical linear regression models to examine the association of risky drinking status (1=risky drinker), number of AUD symptoms, MDD (frequency), DPDD (quantity), and PHDD to changes in IAT scores between non-deprived and deprived sessions. We also examined interactions of alcohol use factors with ratings of cigarette withdrawal and craving measured during the deprived session. Step 1 of each model controlled for IAT order, non-deprived IAT scores, deprived condition cigarette craving scores and deprived condition cigarette withdrawal scores. Step 2 included the relevant alcohol use independent variable (risky drinking status, number of AUD symptoms, MDD, DPDD, or PHDD) added individually to separate models. Step 3 included the interaction of alcohol use either craving or withdrawal. Interactions were examined following recommendations of Aiken, West, and Reno (1991). Continuous variables were z-transformed to reduce multi-collinearity and to account for scale invariance. Unstandardized betas are reported.

3. Results

3.1 Sample Characteristics

Table 1 displays demographic factors and baseline characteristics. The average age was 45 years (± 12.7) and participants were primarily male (56.9%), African American (83.5%), single (56.9%), and employed (53.2%). Participants completed 13 years (± 2.20) of education and had an average annual income of \$26,160 ($\pm \$23,133$). Additionally, participants reported an average of 19 drinking days (± 9.95) in the past 30 days, consumed an average of 6 drinks per drinking day (± 4.6), and smoked 12 cigarettes per smoking day (± 5.15).

As would be expected, compared to non-risky drinking smokers, risky drinker smokers reported higher MDD [$M = 27.25 \pm 4.68$ vs $M = 9.83 \pm 4.85$; $F(1, 108) = 363.16, p < .001$], PHDD [$M = 24.49 \pm 29$ vs $M = 7.2 \pm 11$; $F(1, 108) = 16.19, p < .001$], and number of AUD symptoms [$M = 6.33 \pm 2.54$ vs $M = 5.27 \pm 2.91$; $F(1, 106) = 4.02, p < .05$]. There were no differences between risky and non-risky drinking smokers on DPDD, CPD, or nicotine dependence severity.

3.2 Deprivation Manipulation Check

Deprived session CO levels were significantly lower ($M = 7.59 \text{ ppm} \pm 4.96$) than non-deprived CO levels [$M = 15.68 \text{ ppm} \pm 9.68$; $t(106) = -11.05$, $p < 0.001$]. Further, when deprived, participants reported significantly higher cigarette cravings as measured by the QSU-brief ($M = 43.67 \pm 15.16$) relative to not deprived [$M = 34.31 \pm 16.85$; $t(107) = 6.06$, $p < 0.001$]. Similarly, reports of nicotine withdrawal as measured by the MNWS were significantly higher when deprived ($M = 10.39 \pm 6.41$) than when not deprived [$M = 9.35 \pm 7.00$; $t(104) = 2.66$, $p < 0.01$]. Alcohol craving did not differ significantly between the deprived ($M = 19.28 \pm 10.70$) and not deprived sessions [$M = 19.63 \pm 11.44$; $t(107) = -0.33$, $p = 0.74$].

3.3 Effects of Nicotine Deprivation and Alcohol Use Indices on Implicit Cognitions

Table 2 shows main effect results of the regression models for the association of indices of alcohol use on changes in IAT scores across deprived and non-deprived conditions. Risky drinker status was not significantly associated with changes in IAT scores. There was a significant main effect association of PHDD on changes in IAT scores ($\beta = 0.15$, $p = 0.03$). Those who drank heavily more often held stronger alcohol-approach than cigarette-approach cognitions (i.e., quicker at pairing alcohol and approach words than pairing cigarette and approach words) when deprived of nicotine; whereas participants who reported fewer heavy drinking days were less likely to endorse alcohol-approach cognitions when deprived of nicotine. PHDD explained an additional 3% percent of variance [$R^2_{\text{chg}} = 0.03$, $F(5,97) = 24.82$, $p < 0.001$], above and beyond order effects, measures of nicotine craving and withdrawal, and non-deprived IAT scores.

There was a significant AUD symptoms x withdrawal intensity interaction ($b = 0.10$, $p < .05$) on changes in IAT scores (Figure 1). Explication of the interaction showed that, at higher levels of withdrawal intensity, smokers who endorsed a greater number of AUD symptoms had stronger alcohol-approach tendencies than cigarette approach tendencies ($b = 0.12$, $p < 0.05$). Number of AUD symptoms was unrelated to implicit alcohol approach tendencies for respondents reporting lower withdrawal intensity ($b = -0.10$, $p = 0.13$). No main effect of AUD symptoms was found. No other significant main effects or interactions with withdrawal or craving intensity were found.

4. Discussion

This study sought to identify cognitive processes linking drinking and smoking during nicotine withdrawal among smokers along the continuum of alcohol use behavior and problems. The experimental manipulation was successful. Individuals reported more intense cravings for cigarettes and nicotine withdrawal symptoms when they were deprived compared to when they were not deprived of cigarettes. Results from other studies used a similar length of nicotine deprivation demonstrate that this type of manipulation modestly impacts positive and negative implicit attitudes towards smoking measured via the IAT (Tibboel et al., 2011; Waters et al., 2007). Overall, we found that indices of problem drinking behavior and alcohol-related consequences were significantly associated with faster implicit pairings of alcohol stimuli and approach-related words, rather than pairing of

cigarette stimuli and approach-related words, when deprived of cigarettes. Risky drinking status and general quantity and frequency of use showed no differential association to alcohol versus cigarette stimuli when smokers were deprived.

Linear regression results were partially consistent with our hypothesis, in that some, but not all alcohol variables were associated with IAT scores. There was an interaction of withdrawal intensity and AUD symptoms, such that those reporting more intense cigarette withdrawal and who endorsed greater AUD symptomatology showed stronger alcohol-approach than cigarette-approach cognitions. In contrast, among smokers with lower levels of withdrawal intensity, AUD symptomatology was unrelated to motivational preference for alcohol versus cigarettes; that is, the reaction time pairings for alcohol versus cigarette stimuli were not significantly different from each other. A main effect for PHDD was also found, such that smokers who drank heavily more often showed stronger alcohol-approach than cigarette-approach motivations when cigarette deprived. Taken together, these findings extend prior research showing that heavier drinking is a risk factor for both smoking and relapse back to smoking relapse (Kahler et al., 2010; Koçak et al., 2015; Leeman et al., 2008; McClure, Wetter, de Moor, Cinciripini, & Gritz, 2002). Findings are also consistent with recent evidence that implicit smoking-drinking associations are strongest among heavier drinkers (Oliver & Drobles, 2015). This result suggests a tendency for smokers with proclivity toward heavy alcohol use and alcohol-related problems to seek alcohol preferentially in the context of cigarette deprivation, and a possible cognitive mechanism linking smoking (or lack thereof) and heavier drinking behavior together. Perhaps alcohol cues are more strongly conditioned in the relief of negative affect related to cigarette withdrawal among these smokers who engage in heavy drinking more often (Amlung & MacKillop, 2014; Birch et al., 2004; Burton & Tiffany, 1997).

It was somewhat surprising that quantity and frequency of use, as well as risky drinking status, were not associated with implicit motivation toward alcohol (vs cigarettes) when cigarette deprived. However, this finding is not unlike those reported in previous studies. Oliver and Drobles (2015) found that the association between implicit smoking and drinking cognitions was strongest among respondents with greater levels of alcohol use and dependence. Ostafin and Palfai (2006) also found that binge drinking, but not alcohol frequency, quantity, or consequences of use were correlated with alcohol-approach IAT scores in 88 hazardous drinking college students (score of 8 or higher on the AUDIT). General measurements of consumption (quantity/frequency of use) tap into dimensions of alcohol use behavior that are distinct from indices measuring problematic use (PHDD, AUD symptoms). Although this theory is plausible, it does not entirely explain the null effect of risky drinking status on implicit alcohol (versus) cigarette motivations. It is possible that alcohol cognitions could be impacted by time of day, in that they may be stronger in the evening when individuals are less likely to exhibit self-control over their drinking (Muraven, Collins, Shiffman, & Paty, 2005). Sessions for the current study were conducted primarily during the day and therefore motivations for alcohol use could have been low overall due to this factor. Lastly, because this study used an IAT that compared two different target categories in one paradigm, non-significant findings could suggest no difference in the reaction times to pairing alcohol pictures with approach words and cigarette pictures with approach words. Thus, smokers at the lower end of the alcohol use continuum may not have

a particular preference for alcohol or cigarettes during cigarette withdrawal, counter to our expectations.

The presence of an interaction between AUD symptom severity and withdrawal intensity on implicit alcohol motivations is notable, as withdrawal intensity may play a role in smoking lapse and relapse during the early phases of a quit attempt, particularly among smokers with greater alcohol-related problems (Kahler et al., 2010). Findings revealed that alcohol-related problems, alone, were not associated with increased tendency toward alcohol-approach motivations among smokers who are deprived of nicotine. However, when combined with more severe cigarette withdrawal symptoms, alcohol problems and withdrawal intensity operated conditionally, such that respondents reporting greater lifetime problems from their alcohol use and who experienced more severe cigarette withdrawal were the quickest at pairing alcohol pictures with “approach” related words. The IAT has been regarded as a promising method for investigating implicit motivational tendencies toward drug use behavior, which can translate to the development of interventions targeting these very cognitive processes (Wiers et al., 2007; Wiers & Stacy, 2006; Wiers, Van De Luitgaarden, Van Den Wildenberg, & Smulders, 2005). Information from our study can be used to further refine and improve smoking cessation interventions for heavy and problematic drinking smokers by concurrently addressing cognitive beliefs about alcohol as they relate to drinking to cope with withdrawal-related discomfort in the early phases of a quit attempt. Indeed, addressing drinking in the context of smoking cessation has been found to improve smoking cessation outcomes (Kahler et al., 2009; Kahler et al., 2008; Toll et al., 2015).

There were several limitations of this study. First, we did not assess explicit preference for alcohol versus cigarettes. However, previous studies show non-significant or weak associations between implicit cognitions concerning substance use and explicit reports of the same (Schmits, Maurage, Thirion, & Quertemont, 2015; Tibboel et al., 2011), which highlights the unique contribution of IAT designs. Second, participants were not asked to abstain from alcohol (although all had a BAC=0.00%), thus we could not determine the impact of alcohol withdrawal state on implicit preference for alcohol or cigarettes and potential interactions with cigarette withdrawal. The strength of association between alcohol use behavior and implicit motivations toward drinking and smoking may have been different if periods of alcohol abstinence were also required. Third, our paradigm is a slight departure from the traditional IAT paradigm that incorporates a neutral target (i.e., comparing alcohol or cigarettes to a neutral cue such as water). Scores at one dimension may reflect a tendency to associate alcohol with approach, but may also reflect a tendency to associate cigarettes with avoidance. Our use of two target groups within the same IAT allows us to determine the relative “preference” or choice for one substance over the other, thus capturing the truly implicit nature of one’s motivation to use, or desire, one drug over another in a moment of intense craving. Fourth, results from our study sample may not generalize to other geographical locations or racial/ethnic groups, as our sample was composed primarily of African-American respondents. While attempts were made to recruit a diverse sample, the racial make-up of the sample may reflect the sub-group of heavy drinking smokers in the region from which participants were recruited (Washington, DC); which is 48% African-American (United States Census, 2015). Rates of current smoking are almost 3.5 times higher among this African-American (26%) vs. 7.3% Whites living in Washington,

DC(Behavioral Risk Factor Surveillance System (BFRSS), 2014). Further, the age-adjusted prevalence of heavy drinking in the Washington, DC is higher than that of 46 other states in the US. Finally, although the unique effect of heavy drinking on deprived IAT scores was significant, the proportion of variance accounted for was small (Cohen, Cohen, West, & Aiken, 1983). It is important to note that other studies using the IAT as a dependent variable have shown similar effect sizes (Chassin, Presson, Sherman, Seo, & Macy, 2010; Cohn et al., 2014; Sherman et al., 2003). Our regression models controlled for a variety of factors that could be correlated with IAT scores, thus we can be more confident that our results represent a robust effect, even in the context of other risk factors. Other studies have used univariate ANOVAs, but rarely controlled for individual difference factors (Chassin et al., 2010; Macy, Chassin, Presson, & Sherman, 2015; Sherman et al., 2003; Tibboel et al., 2011; Waters et al., 2007).

5. Conclusions

This study is the first to our knowledge to demonstrate that indices of problematic alcohol use are associated with implicit motivational preference for alcohol versus cigarettes among adult smokers with and without risky drinking profiles who are cigarette deprived. Findings help bridge a gap between alcohol use and processes related to smoking behavior during a period of cigarette abstinence and increased cigarette craving. Continued work in this area will assist in the development of more refined cognitive interventions that seek to alter these maladaptive cognitive processes; such as targeting cognitive distortions about the role that alcohol may play in alleviating nicotine withdrawal symptoms. Refining or modifying screening and intervention approaches for smoking cessation that target heavier drinking smokers may be warranted. Future research should examine whether manipulation of other factors, such as reducing motivation to drink during cigarette withdrawal, could help improve longer-term smoking abstinence.

Acknowledgments

FUNDING: This work was supported by grant R03CA 175870-01A1S.

Source of Funding: This study was funded by R03CA 175870-01A1S awarded from the National Cancer Institute. Amy Cohn is an employee of Truth Initiative.

References

- Aiken, L.S., West, S.G., Reno, R.R. Multiple regression: Testing and interpreting interactions. Sage; 1991.
- Amlung M, MacKillop J. Understanding the effects of stress and alcohol cues on motivation for alcohol via behavioral economics. *Alcoholism: Clinical and Experimental Research*. 2014; 38(6): 1780–1789.
- Ariel, I., Oliver, J.A., Brandon, T.H., Drobes, D.J. Reliability and validity within and across smoking and alcohol picture sets. Post presented at the meeting of the Society for Research on Nicotine and Tobacco; Seattle, WA. 2014.
- Baker TB, Piper ME, McCarthy DE, Majeskie MR, Fiore MC. Addiction motivation reformulated: an affective processing model of negative reinforcement. *Psychological review*. 2004; 111(1):33–51. [PubMed: 14756584]
- Behavioral Risk Factor Surveillance System (BFRSS). 2014. Retrieved from http://www.cdc.gov/tobacco/data_statistics/index.htm

- Birch CD, Stewart SH, Wall AM, McKee SA, Eismor SJ, Theakston JA. Mood-induced increases in alcohol expectancy strength in internally motivated drinkers. *Psychology of Addictive Behaviors*. 2004; 18(3):231–238. [PubMed: 15482078]
- Blanton H, Jaccard J, Gonzales PM, Christie C. Decoding the implicit association test: Implications for criterion prediction. *Journal of Experimental Social Psychology*. 2006; 42(2):192–212.
- Bohn MJ, Krahm DD, Staehler BA. Development and initial validation of a measure of drinking urges in abstinent alcoholics. *Alcoholism: Clinical and Experimental Research*. 1995; 19(3):600–606.
- Brandon TH. Negative affect as motivation to smoke. *Current Directions in Psychological Science*. 1994; 3:33–37.
- Brandon TH, Drobos DJ, Unrod M, Heckman BW, Oliver JA, Roetzheim RC, ... Small BJ. Varenicline effects on craving, cue reactivity, and smoking reward. *Psychopharmacology*. 2011; 218(2):391–403. [PubMed: 21559801]
- Brandon TH, Wetter DW, Baker TB. Affect, expectancies, urges, and smoking: Do they conform to models of drug motivation and relapse? *Experimental and Clinical Psychopharmacology*. 1996; 4(1):29–36.
- Brown RA, Burgess ES, Sales SD, Whiteley JA, Evans DM, Miller IW. Reliability and validity of a smoking timeline follow-back interview. *Psychology of Addictive Behaviors*. 1998; 12(2):101.
- Burton SM, Tiffany ST. The effect of alcohol consumption on craving to smoke. *Addiction*. 1997; 92(1):15–26. [PubMed: 9060194]
- Carpenter KM, Hasin DS. Drinking to cope with negative affect and DSM-IV alcohol use disorders: a test of three alternative explanations. *J Stud Alcohol*. 1999; 60(5):694–704. [PubMed: 10487740]
- Carter BL, Robinson JD, Lam CY, Wetter DW, Tsan JY, Day SX, Cinciripini PM. A psychometric evaluation of cigarette stimuli used in a cue reactivity study. *Nicotine & Tobacco Research*. 2006; 8(3):361–369. [PubMed: 16801294]
- Chassin L, Presson CC, Sherman SJ, Seo DC, Macy JT. Implicit and explicit attitudes predict smoking cessation: moderating effects of experienced failure to control smoking and plans to quit. *Psychology of Addictive Behaviors*. 2010; 24(4):670–679. [PubMed: 21198227]
- Cohen, J., Cohen, P., West, SG., Aiken, LS. *Applied multiple regression/correlation for the behavioral sciences*. 1983.
- Cohn AM, Cameron AY, Udo T, Hagman BT, Mitchell J, Bramm S, Ehlke S. Delineating Potential Mechanisms of Implicit Alcohol Cognitions: Drinking Restraint, Negative Affect, and Their Relationship With Approach Alcohol Associations. *Psychology of Addictive Behaviors*. 2012; 26(2):318–324. [PubMed: 22369223]
- Cohn AM, Cobb C, Hagman BT, Cameron A, Ehlke S, Mitchell JN. Implicit alcohol cognitions in risky drinking nicotine users with and without co-morbid major depressive disorder. *Addictive behaviors*. 2014; 39(4):797–802. [PubMed: 24531633]
- Colby SM, Rohsenow DJ, Monti PM, Gwaltney CJ, Gulliver SB, Abrams DB, ... Sirota AD. Effects of tobacco deprivation on alcohol cue reactivity and drinking among young adults. *Addictive behaviors*. 2004; 29(5):879–892. [PubMed: 15219332]
- Cooney NL, Litt MD, Cooney JL, Pilkey DT, Steinburg HR, Oncken CA. Alcohol and tobacco cessation in alcohol-dependent smokers: analysis of real-time reports. *Psychology of Addictive Behaviors*. 2007; 21(3):277–286. [PubMed: 17874878]
- Cooney NL, Litt MD, Morse PA, Bauer LO, Gaupp L. Alcohol cue reactivity, negative-mood reactivity, and relapse in treated alcoholic men. *Journal of abnormal psychology*. 1997; 106(2):243–250. [PubMed: 9131844]
- 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. [PubMed: 11260806]
- De Houwer J, Custers R, De Clercq A. Do smokers have a negative implicit attitude toward smoking? *Cognition & Emotion*. 2006; 20(8):1274–1284.
- Donohue B, Azrin NH, Strada MJ, Silver NC, Teichner G, Murphy H. Psychometric evaluation of self- and collateral timeline follow-back reports of drug and alcohol use in a sample of drug-abusing and conduct-disordered adolescents and their parents. *Psychology of Addictive Behaviors*. 2004; 18(2):184–189. [PubMed: 15238061]

- Drobes DJ. Cue reactivity in alcohol and tobacco dependence. *Alcoholism: Clinical and Experimental Research*. 2002; 26(12):1928–1929.
- Drummond DC, Phillips TS. Alcohol urges in alcohol-dependent drinkers: further validation of the Alcohol Urge Questionnaire in an untreated community clinical population. *Addiction*. 2002; 97(11):1465–1472. [PubMed: 12410786]
- Falk DE, Yi H, Hiller-Sturmhofel S. An epidemiologic analysis of co-occurring alcohol and tobacco use and disorders. *Alcohol Research & Health*. 2006; 29(3):162–171. [PubMed: 17373404]
- Field M, Mogg K, Bradley BP. Eye movements to smoking-related cues: effects of nicotine deprivation. *Psychopharmacology*. 2004; 173(1–2):116–123. [PubMed: 14663552]
- First, MB., Spitzer, RL., Gibbon, M., Williams, JB. Structured Clinical Interview for DSM-IV Axis I Disorders: Patient Edition (February 1996 Final), SCID-I/P. Biometrics Research Department, New York State Psychiatric Institute; 1998.
- Greenwald A, Nosek B, Banaji M. Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of personality and social psychology*. 2003; 85(2):197–216. [PubMed: 12916565]
- Greewald A, McGhee DE, Schwartz JL. Measuring individual differences in implicit cognition: the implicit association test. *Journal of personality and social psychology*. 1998; 74(6):1464. [PubMed: 9654756]
- Hartmann-Boyce J, Stead LF, Cahill K, Lancaster T. Efficacy of interventions to combat tobacco addiction: Cochrane update of 2013 reviews. *Addiction*. 2014; 109(9):1414–1425. [PubMed: 24995905]
- Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The Fagerström test for nicotine dependence: a revision of the Fagerstrom Tolerance Questionnaire. *British journal of addiction*. 1991; 86(9):1119–1127. [PubMed: 1932883]
- Hughes JR. Tobacco withdrawal in self-quitters. *Journal of consulting and clinical psychology*. 1992; 60(5):689–697. [PubMed: 1401384]
- Kahler CW, Borland R, Hyland A, McKee SA, Thompson ME, Cummings KM. Alcohol consumption and quitting smoking in the International Tobacco Control (ITC) Four Country Survey. *Drug and Alcohol Dependence*. 2009; 100(3):214–220. [PubMed: 19056188]
- Kahler CW, Metrik J, LaChance HR, Ramsey SE, Abrams DB, Monti PM, Brown RA. Addressing heavy drinking in smoking cessation treatment: a randomized clinical trial. *Journal of consulting and clinical psychology*. 2008; 76(5):852–862. [PubMed: 18837602]
- Kahler CW, Spillane NS, Metrik J. Alcohol use and initial smoking lapses among heavy drinkers in smoking cessation treatment. *Nicotine & Tobacco Research*. 2010:781–785. [PubMed: 20507898]
- Koçak ND, Eren A, Bo a S, Aktürk ÜA, Öztürk ÜA, Arınç S, engül A. Relapse Rate and Factors Related to Relapse in a 1-Year Follow-Up of Subjects Participating in a Smoking Cessation Program. *Respiratory care*. 2015; 60(12):1796–1803. [PubMed: 26286738]
- Leeman RF, McKee SA, Toll BA, Krishnan-Sarin S, Cooney JL, Makuch RW, O'Malley SS. Risk factors for treatment failure in smokers: relationship to alcohol use and to lifetime history of an alcohol use disorder. *Nicotine & Tobacco Research*. 2008; 10(12):1793–1809. [PubMed: 19023831]
- Littel M, Franken IH, Muris P. Psychometric properties of the brief Questionnaire on Smoking Urges (QSU-Brief) in a Dutch smoker population. *Netherlands Journal of Psychology*. 2011:1–20.
- MacKillop J. Factor Structure of the Alcohol Urge Questionnaire Under Neutral Conditions and During a Cue-elicited Urge State. *Alcoholism: Clinical and Experimental Research*. 2006; 30(8):1315–1321.
- MacKillop J, Brown CL, Stojek MK, Murphy CM, Sweet L, Niaura RS. Behavioral economic analysis of withdrawal-and cue-elicited craving for tobacco: an initial investigation. *Nicotine & Tobacco Research*. 2012:1426–1434. [PubMed: 22416117]
- Macy JT, Chassin L, Presson CC, Sherman JW. Changing implicit attitudes toward smoking: results from a web-based approach-avoidance practice intervention. *Journal of behavioral medicine*. 2015; 38(1):143–152. [PubMed: 25059750]

- McClure JB, Wetter DW, de Moor C, Cinciripini PM, Gritz ER. The relation between alcohol consumption and smoking abstinence: Results from the Working Well Trial. *Addictive behaviors*. 2002; 27(3):367–379. [PubMed: 12125663]
- McKee SA, Falba T, O'Malley SS, Sindelar J, O'Connor PG. Smoking status as a clinical indicator for alcohol misuse in US adults. *Archives of Internal Medicine*. 2007; 167(7):716–721. [PubMed: 17420431]
- McKee SA, Weinberger AH. How can we use our knowledge of alcohol-tobacco interactions to reduce alcohol use? *Annual review of clinical psychology*. 2013; 9:649–674.
- Muraven M, Collins RL, Shiffman S, Paty JA. Daily fluctuations in self-control demands and alcohol intake. *Psychology of Addictive Behaviors*. 2005; 19(2):140–147. [PubMed: 16011384]
- NIAAA. The National Institute on Alcohol Abuse and Alcoholism Five Year Strategic Plan: FY09-14 "Alcohol Across the Lifespan". 2008 Retrieved from.
- Niaura RS, Rohsenow DJ, Binkoff JA, Monti PM, Pedraza M, Abrams DB. Relevance of cue reactivity to understanding alcohol and smoking relapse. *Journal of abnormal psychology*. 1988; 97(2):133–152. [PubMed: 3290304]
- Oliver JA, Drobos DJ. Cognitive manifestations of drinking–smoking associations: Preliminary findings with a cross-primed Stroop task. *Drug and Alcohol Dependence*. 2015; 147:81–88. [PubMed: 25561386]
- Ostafin BD, Palfai TP. Compelled to consume: The Implicit Association Test and automatic alcohol motivation. *Psychology of Addictive Behaviors*. 2006; 20(3):322–327. [PubMed: 16938070]
- Palfai TP, Monti PM, Ostafin B, Hutchison K. Effects of nicotine deprivation on alcohol-related information processing and drinking behavior. *Journal of abnormal psychology*. 2000; 109(1):96–105. [PubMed: 10740940]
- Palfai TP, Ostafin BD. Alcohol-related motivational tendencies in hazardous drinkers: assessing implicit response tendencies using the modified-IAT. *Behaviour Research and Therapy*. 2003; 41(10):1149–1162. [PubMed: 12971937]
- Piasecki TM, Jahng S, Wood PK, Robertson BM, Epler AJ, Cronk NJ, ... Sher KJ. The subjective effects of alcohol-tobacco co-use: an ecological momentary assessment investigation. *Journal of abnormal psychology*. 2011; 120(3):557–571. [PubMed: 21443289]
- Piasecki TM, McCarthy DE, Fiore MC, Baker TB. Alcohol consumption, smoking urge, and the reinforcing effects of cigarettes: an ecological study. *Psychology of Addictive Behaviors*. 2008; 22(2):230–239. [PubMed: 18540720]
- Pinter B, Greenwald AG. Clarifying the role of the "other" category in the self-esteem IAT. *Experimental Psychology*. 2005; 52(1):74–79. [PubMed: 15779533]
- Pomerleau CS, Carton SM, Lutzke ML, Flessland KA, Pomerleau OF. Reliability of the Fagerstrom tolerance questionnaire and the Fagerstrom test for nicotine dependence. *Addictive behaviors*. 1994; 19(1):33–39. [PubMed: 8197891]
- Reid MS, Palamar J, Raghavan S, Flammio F. Effects of topiramate on cue-induced cigarette craving and the response to a smoked cigarette in briefly abstinent smokers. *Psychopharmacology*. 2007; 192(1):147–158. [PubMed: 17345064]
- Rose JE, Brauer LH, Behm FM, Cramblett M, Calkins K, Lawhon D. Psychopharmacological interactions between nicotine and ethanol. *Nicotine & Tobacco Research*. 2004; 6(1):133–144. [PubMed: 14982697]
- Sayette MA, Martin CS, Hull JG, Wertz JM, Perrott MA. Effects of nicotine deprivation on craving response covariation in smokers. *Journal of abnormal psychology*. 2003; 112(1):110–118. [PubMed: 12653419]
- Schmits E, Muraige P, Thirion R, Quertemont E. Dissociation between implicit and explicit expectancies of cannabis use in adolescence. *Psychiatry research*. 2015; 230(3):783–791. [PubMed: 26575651]
- Sherman SJ, Rose JS, Koch K, Presson CC, Chassin L. Implicit and explicit attitudes toward cigarette smoking: The effects of context and motivation. *Journal of Social and Clinical Psychology*. 2003; 22(1):13–39.
- Sobell, LC., Sobell, MB. Measuring alcohol consumption. Springer; 1992. Timeline follow-back; p. 41-72.

- Tibboel H, De Houwer J, Spruyt A, Field M, Kemps E, Crombez G. Testing the validity of implicit measures of wanting and liking. *J Behav Ther Exp Psychiatry*. 2011; 42(3):284–292. [PubMed: 21349248]
- Toll BA, Katulak NA, McKee SA. Investigating the factor structure of the Questionnaire on Smoking Urges-Brief (QSU-Brief). *Addictive behaviors*. 2006; 31(7):1231–1239. [PubMed: 16226843]
- Toll BA, Martino S, O'Malley SS, Fucito LM, McKee SA, Kahler CW, ... Celestino P. A randomized trial for hazardous drinking and smoking cessation for callers to a quitline. *Journal of consulting and clinical psychology*. 2015; 83(3):445–454. [PubMed: 25419583]
- Toll BA, O'Malley SS, McKee SA, Salovey P, Krishnan-Sarin S. Confirmatory factor analysis of the Minnesota Nicotine Withdrawal Scale. *Psychology of Addictive Behaviors*. 2007; 21(2):216–225. [PubMed: 17563141]
- United States Census. Quick Facts: District of Columbia. 2015. Retrieved from <http://www.census.gov/quickfacts/table/PST045215/11>
- Waters AJ, Carter BL, Robinson JD, Wetter DW, Lam CY, Cinciripini PM. Implicit attitudes to smoking are associated with craving and dependence. *Drug and Alcohol Dependence*. 2007; 91(2): 178–186. [PubMed: 17658701]
- Wiers RW, Bartholow B, van den Wildenberg E, Thush C, Engels RC, Sher K, ... Stacy A. Automatic and controlled processes and the development of addictive behaviors in adolescents: a review and a model. *Pharmacology Biochemistry and Behavior*. 2007; 86(2):263–283.
- Wiers, RW., Stacy, AW. *Handbook of implicit cognition and addiction*. Sage; 2006.
- Wiers RW, Van De Luitgaarden J, Van Den Wildenberg E, Smulders FT. Challenging implicit and explicit alcohol-related cognitions in young heavy drinkers. *Addiction*. 2005; 100(6):806–819. [PubMed: 15918811]
- Wiers RW, Van Woerden N, Smulders FT, De Jong PJ. Implicit and explicit alcohol-related cognitions in heavy and light drinkers. *Journal of abnormal psychology*. 2002; 111(4):648–658. [PubMed: 12428778]
- World Health Organization. *Guidelines for use in primary care*. Geneva: World Health Organization; 2001. The alcohol Use disorders identification test.

Appendix A

Cigarette Stimuli (Pictures)

Woman smoking cigarette
 Man smoking cigarette
 Cigarette and ashtray
 Hand holding cigarette over ashtray
 Pack of cigarettes and ashtray

Beer Stimuli (Pictures)

Glass of beer
 Budweiser bottle and glass of beer
 Pitcher and glass of beer
 Samuel Adams bottle and glass of beer
 Corona bottle and glass of beer

Wine Stimuli (Pictures)

Glass of red wine
 Glass of white wine

Bottle and glass of red wine
Bottle and glass of white wine
Glass of red wine and cork

Liquor Stimuli (Pictures)

Glass of dark liquor
Martini glass drink
Bottle and shot glass of liquor
Bottle and glass of clear liquor
Hand pouring a shot of liquor

Approach Stimuli (words)

Approach
Closer
Near
Forward
Toward

Avoid Stimuli (words)

Avoid
Further
Escape
Reject
Leave

HIGHLIGHTS

- Problem drinking smokers had stronger implicit alcohol than cigarette motivations.
- Motivations toward drinking and smoking differed under cigarette deprivation for subgroups of smokers.
- Withdrawal intensity impacted associations between AUD symptoms and implicit cognitions.
- Cessation treatments should target drinking cognitions in smokers who drink heavily and who have more alcohol-related problems.

Figure 1.

Association between number of AUD symptoms and nicotine deprived withdrawal intensity on alcohol-approach vs cigarette-approach cognitions. Higher scores indicate stronger alcohol approach cognitions (and lower scores indicate cigarette avoid cognitions). Constant multiplied by 1 to improve interpretation.

Table 1

Demographic and baseline characteristics of the sample adult smokers (N = 109).

Characteristic	Percent (N)
Gender	
Male	56.9% (62)
Female	43.1% (47)
Race	
White	9.2% (10)
African American	83.5% (91)
Other	7.3% (8)
Hispanic (yes)	6.4% (7)
Relationship status	
Single	17.4% (19)
Married/Committed Relationship	56.9% (62)
Other	25.7% (28)
Employment status	
Employed	53.2% (58)
Unemployed	25.7% (28)
Other	21.1% (23)
Alcohol Use Disorder Diagnosis	
No lifetime AUD	5.5% (6)
Lifetime AUD	67.0% (73)
Current AUD	27.5% (30)
	Mean (SD)
Age (years)	44.83 (12.68)
Education (years)	12.99 (2.20)
Annual income	\$26,160 (\$23,134)
Mean drinking days (MDD)	18.62 (9.95)
Drinks per drinking day (DPDD)	5.70 (4.58)
Percent heavy drinking days (PHDD)	0.16 (0.24)
Number of AUD symptoms	5.81 (2.77)
Cigarettes per day (CPD)	11.98 (5.05)
Nicotine dependence severity	4.35 (2.21)

Note. Percent heavy drinking days = 6 or more drinks. Other employment = student, retired, disabled, homemaker, other (not listed).

Table 2
Main effect hierarchical regression models of indices of alcohol use predicting alcohol and cigarette approach IAT scores

Variable	R ² /	F	df	β	p
Step 1	0.54	28.74	4,98		
IAT Order				0.35	0.001
Not deprived IAT score				-0.46	0.001
Deprived cigarette withdrawal				-0.01	0.38
Deprived cigarette craving				0.00	0.23
Step 2					
Risky drinker (yes/no)	-0.00	0.00	1,97	0.001	.99
Step 1	0.54	28.74	4,98		
IAT order				0.35	0.001
Not deprived IAT score				-0.48	0.001
Deprived cigarette withdrawal				-0.07	0.30
Deprived cigarette craving				0.09	0.20
Step 2					
Percent heavy drinking days	0.03	4.76	1,97	0.15	0.03
Step 1	0.54	28.33	4,97		
IAT order				0.32	0.001
Not deprived IAT score				-0.50	0.001
Deprived cigarette withdrawal				-0.05	0.52
Deprived cigarette craving				0.09	0.19
Step 2					
Number of AUD symptoms	0.00	0.01	1,96	0.01	0.93
Step 1	0.54	28.74	4,98		
IAT order				0.33	0.001
Not deprived IAT score				-0.49	0.001
Deprived cigarette withdrawal				-0.06	0.38
Deprived cigarette craving				0.09	0.22
Step 2					

Variable	R ² / R ²	F	df	β	p
Drinks per drinking day					
Step 1	0.54	28.74	4,98		
IAT order				0.33	0.001
Not deprived IAT score				−0.49	0.001
Deprived cigarette withdrawal				−0.06	0.38
Deprived cigarette craving				0.09	0.22
Step 2					
Mean drinking days	0.00	0.01	1,97	−0.01	0.92

Note. Positive IAT scores indicate stronger cigarette-approach cognitions, negative IAT scores indicate stronger alcohol-approach cognitions. Percent heavy drinking days 6 drinks.