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Working Memory Moderates the Association Between Smoking Urge and Smoking Lapse Behavior After Alcohol Administration in a Laboratory Analogue Task

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Abstract

Introduction: Lapses after smoking cessation often occur in the context of alcohol use, possibly because alcohol increases urge to smoke. Poor working memory, or alcohol-induced decrements in working memory, may influence this relationship by making it more difficult for an individual to resist smoking in the face of smoking urges.
Methods: Participants ($n = 41$) completed measures of working memory and urge to smoke before and after alcohol administration (placebo, 0.4 g/kg, and 0.8 g/kg, within subjects) and then participated in a laboratory analogue task in which smoking abstinence was monetarily incentivized.
Results: Working memory moderated the relationship between smoking urge and latency to smoke: for those with relatively poorer working memory, urge to smoke was more strongly and negatively associated with latency to smoke (i.e., higher urges were associated with shorter latency).
Conclusions: Those with weak working memory may need additional forms of treatment to help them withstand smoking urges.

Introduction

Initial lapses back to smoking following a quit attempt often occur in the context of alcohol consumption,[1,2] which may be due, in part, to alcohol's ability to induce urges to smoke. Alcohol administration increases urge to smoke,[3,4] and greater urges have been shown to predict relapse during a cessation attempt.[5,6] However, urge only partially mediates alcohol's acute effect on the ability to resist smoking when abstinence is monetarily incentivized,[7] suggesting that other variables may be important to consider.

Working memory, which is a process that includes the ability to monitor incoming information for relevance to the task at hand and act accordingly,[8] may play a key role in the ability to resist smoking, especially in the context of alcohol consumption—this may happen in two ways. Alcohol use acutely reduces working memory performance[9–12] in a dose-dependent manner[13] and may contribute to smoking lapses, in part, by reducing the ability to block automatic tendencies to smoke in response to a smoking urge. Second, according to the dual process model, there are two processes that guide behavior: an automatic process that occurs quickly and without reflection and a reflective, controlled process (such as working memory; Grenard et al.[14] and Thush et al.[15]) that takes more time and resources.[16,17] Difficulty maintaining abstinence from cigarettes can result from strong automatic processes coupled with relatively weaker reflective processes.[16–18] Consistent with this possibility, better baseline working memory is associated with slower resumption of smoking after abstinence.[19] Thus, from this perspective, those with strong baseline working memory, or those whose working memory is less affected by alcohol, may be better able to manage the urges to smoke that accompany alcohol consumption. These hypotheses have not been tested to date.

Aims and Hypotheses

The purpose of the current study was to test the relative contributions of baseline working memory, acute alcohol-induced changes in working memory, and urge to smoke on latency to smoke after alcohol administration in a laboratory analogue task in which smoking abstinence was monetarily incentivized. Using a subsample from the Kahler et al.[7] study who completed a measure of working memory, we tested the hypotheses that (1) alcohol would dose dependently reduce working memory performance and (2) baseline working memory or (3) reductions in working memory would moderate the effect of changes in urge to smoke on smoking latency, such that increases in urge to smoke would be more strongly predictive of inability to resist smoking for people with relatively weaker working memory or greater reductions in working memory due to alcohol consumption.

Methods

Participants

Participants from the community met the following inclusion criteria: 21–65 years old, smoking 10–30 cigarettes a day, a carbon monoxide (CO) level >10 ppm, drinking ≥5 drinks per occasion for men, ≥4 drinks for women, at least twice a month, and reported no history or intention to seek alcohol treatment. Exclusion criteria were: using other tobacco products or nicotine replacement therapy, plan to quit smoking in the next month, incapable of abstaining from alcohol for 24 hr without significant withdrawal symptoms, positive breath alcohol at any session, current affective disorder or psychotic symptoms, current pregnancy or nursing, illicit drug use on more than four occasions in the past 4 weeks, medical issues or medications contraindicated for alcohol consumption, and weighing greater than 250 lbs. Participants for the current study were a subsample (n = 41; those who completed the measure of working memory) of a larger study of 100 participants.[7]

Design

The current study was a three-session, within-subjects, repeated measures experimental design in which participants were administered in random order a placebo (trace amount of alcohol), 0.4 g/kg (moderate) dose, and 0.8 g/kg (high) dose of alcohol. Drink volumes were adjusted for weight and gender. Research assistants were blind to the beverage condition.

Procedure

Procedures are described in detail elsewhere[7] and were approved by the Brown University IRB. In each of three sessions on separate days, participants smoked one cigarette then completed a measure of working memory. Three hours after last smoking and a light meal, they completed measures of self-reported urge to smoke, consumed an experimental beverage within 15 min, and repeated the measures of working memory (3 min after drink completion) and urge (25 min after drink completion). Fifty minutes from the start of drinking, participants were given the opportunity to smoke during a 50-min period while being monetarily incentivized for remaining abstinent. Participants were paid $50 for each session, $150 for completing all sessions, up to $14 for the smoking lapse task, and $35–45 per session for completion of behavioral tasks, of which the working memory task was one. Participants were paid up to $462 total for involvement in the study.

Measures

Severity of nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence (FTND, Heatherton et al.[20]). The Timeline Followback Interview[21] was used to assess past 60-day alcohol and cigarette use.

Urge to smoke was assessed with three measures: the Brief Questionnaire of Smoking Urges,[22] a single item visual analogue scale, and two items measuring expected satisfaction from smoking from the Cigarette Expectancies Scale (CES; Westman et al.[23]). Given the high correlations among these measures, a composite urge score was created by scaling each measure on a 0–100 scale and taking the average of the three scores (see Kahler et al.[7] for further description). Change in urge to smoke reflects the difference of predrinking (Time 1) values of urge and self-reported urge 25 min after drinking completion (Time 2).

Working memory was assessed at the beginning of the participant's first session (Time 1 Trails B) with the Trails B[24] portion of the Trail-Making Test (TMT, Reitan and Wolfson[25]). TMT has been used to measure several constructs, including working memory.[26,27] In one study, it was found that performance on a task of working memory (when compared to other tasks of executive function) accounted for the greatest percentage of variance in Trails B performance[24] and this is consistent with other findings (e.g., Crowe et al.[28]). T-scores[25,29] adjusted for age, gender, and education were used. Change in working memory after alcohol consumption was measured by calculating a change score from Trails B after drink administration in each session (Time 2 Trails B) and Time 1 Trails B. Alternate versions of TMT were used at each session in order to decrease the likelihood of practice effects.[30]

Latency to smoke in minutes (range = 0–50 min) was measured using a task that incentivized delayed smoking.[31,32] For each 5 min, participants delayed smoking in a 50-min smoking period, they earned $1, for a maximum of $10. Participants were given a $4 "tab" to purchase cigarettes, which were available for $0.50 each. They kept unspent money from their "tab," which was paid at the end of the session.

Data Analysis Plan

We used generalized estimating equations (GEE), an extension of regression analysis used to account for repeated (i.e., nonindependent) measures data,[33] to test the independent effects of alcohol dose on Trails B performance and urge to smoke at Time 2. We then used GEE to test the effects of Time 1 Trails B performance, urge to smoke, change in Trails B performance, and change in urge to smoke, along with the interaction of these variables, on latency to initiate smoking across the three experimental sessions. Session number was included to control for order effects.

Results

Participants were 36% female and 75% White, with a mean age of 41.1 (SD = 9.9) and 12 years of education (SD = 2). Participants smoked a mean of 15.2 cigarettes per day (SD = 4.4) and had a mean FTND score of 5.31 (SD = 1.9). Participants drank an average of 52% of the past 60 days (SD = 25%), with six drinks on a typical drinking day (SD = 3).

After controlling for Time 1 performance and session number, participants performed more poorly on Trails B only after the high dose of alcohol ($B = -3.42$, $p = .01$), providing partial support for our first hypothesis. It appears that the practice effect evident after placebo and moderate dose is not evident after the high dose of alcohol. Urge to smoke increased following beverage administration, regardless of alcohol content (see Table 1), and neither Time 1 Trails B nor baseline urge to smoke by themselves predicted latency to smoke (see Table 2). Change in urge to smoke predicted latency to smoke, such that those who exhibited greater increases in urge smoked with shorter latency; this is not a surprising finding, as the parent study found that urge to smoke increased after drink administration.[7]

Our second hypothesis was supported; the interaction of Time 1 Trails B by change in urge was significant, such that for those with worse performance on Time 1 Trails B, the association between change in urge to smoke and latency to smoke was stronger. Model-based estimates indicated that at 1 *SD* above the mean on Time 1 Trails B, the effect of change in urge on latency smoke was weak and nonsignificant ($B = -0.04$, 95% CI = −0.31, 0.22, $p = .74$), whereas at 1 *SD* below the mean, the effect was strongly negative and significant ($B = -0.38$, 95% CI = −0.61, −0.16, $p = .0009$). We did not find support for the third hypothesis: the effect of change in Trails B performance after drink administration on latency to smoke approached significance. The interaction of change in Trails B by change in urge was nonsignificant.

Discussion

This study presents evidence that baseline working memory moderates the effect of increases in urge to smoke after drinking on the ability to resist smoking. Urge to smoke was a better predictor of more quickly resuming smoking after drinking among people with poorer, as opposed to better, baseline working memory. People with better working memory may be better able to mobilize coping resources when trying to keep from smoking in high-risk situations, including those that involve alcohol. Smokers with poorer working memory may need more intensive behavioral coping skills practice, pharmacologic treatment for reducing urge to keep from relapsing, or working memory training. There is evidence in the alcohol literature that working memory can be effectively strengthened over 1 month, leading to lower alcohol use among individuals with relatively stronger positive implicit associations with alcohol.[34] Working memory training may assist individuals with not acting upon the inevitable urges to smoke that accompany the early stages of smoking cessation.

High-dose alcohol worsened Trails B performance, consistent with previous research.[13] We did not find an effect of working memory by itself on latency to smoke after drinking in this laboratory task. This is inconsistent with other reports, which provide evidence that working memory has an effect on a range of substance-related outcomes, including alcohol use[35,36] and smoking.[19] However, there is also evidence that working memory alone may not be a sufficient predictor of behavior. For example, working memory may interact with implicit processes,[15,18] such that strong implicit processes combined with poorer working memory was associated with increased alcohol use. There is a relative dearth of published literature on the interaction of implicit processes with working memory in the prediction of smoking, despite the value this information might have for treatment efforts.

Our findings support the idea that acute alcohol consumption affects urge to smoke, which puts individuals who drink while attempting to abstain from cigarettes at increased risk for smoking

Table 1. Trails B Time and Urge to Smoke Pre- and Postdrink Administration

	Time 1 Trails B, *M* (*SD*)	Time 2 Trails B, *M* (*SD*)	Time 1 urge, *M* (*SD*)	Time 2 urge, *M* (*SD*)
	51.56 (10.25)			
Placebo		54.4 (10.2)	54.0 (21.4)	61.0 (25.2)**
Moderate dose		53.3 (11.5)	56.9 (20.2)	65.7 (21.0)***
High dose		51.6 (11.4)	54.6 (22.3)	62.1 (24.9)*

Note. Trails B scores are *t*-scores (higher scores indicate better performance); urge ratings on 0 (low) to 100 (high) scale; Time 1 to Time 2 urge: **p* < .01, ***p* < .001, ****p* < .0001.

Table 2. Generalized Estimating Equations Predicting Latency to Smoke in Minutes

Steps and predictors	*B*	*SE* (*B*)	95% CI	*p*
Step 1: main effects				
Time 1 Trails B	0.09	0.32	−0.53 to 0.71	.78
Change in Trails B	0.37	0.20	−0.03 to 0.77	.07
Time 1 urge	−0.07	0.11	−0.29 to 0.14	.49
Change in urge	−0.28	0.09	−0.45 to −0.10	.002
Step 2: interactions				
Time 1 Trails B	−0.07	0.32	−0.69 to 0.55	.82
Change in Trails B	0.21	0.22	−0.23 to 0.65	.35
Time 1 urge	−0.08	0.10	−0.28 to 0.12	.45
Change in urge	−1.45	0.44	−2.30 to 0.59	.0009
Change in Trails B by change in urge	0.02	0.01	−0.008 to 0.04	.17
Time 1 Trails B by change in urge	0.02	0.008	0.007 to 0.04	.005

Note. Analyses include alcohol dose and session number, both *n*s; variables were not centered; Trails scores are *t*-scores; urge is measured on a 0 (low) to 100 (high) scale; change in Trails B = Trails B *t*-score postdrink administration minus Time 1 Trails B *t*-score; change in urge = urge postdrink administration minus Time 1 urge score.

relapse. Based on our support for Hypothesis 2, we find that this is especially true for people who have relatively lower baseline working memory performance. The lack of support for Hypothesis 3 does not detract from this finding; it is simply that alcohol-induced changes in working memory are less relevant than baseline working memory in predicting smoking relapse. These findings are most consistent with dual process models, which hold that weak reflective processes (and not necessarily changes in reflective processes), coupled with strong automatic processes, can influence behavior. More research is warranted to determine the circumstances under which changes in reflective and/or automatic processes may affect substance use. Some limitations are worth noting, including the small sample size, which could only provide adequate power of 0.80 for detecting large between-subjects effects (equivalent to a *d* of 1.0 or higher) such as the interaction between working memory and craving. In addition, we used only one measure of working memory (Trails B). Lastly, the use of an analogue task among individuals who were not explicitly trying to quit smoking can be considered a limitation; future research might use a treatment-seeking population.

Conclusions

Dual process models provide a useful framework for conceptualizing many types of addictive behaviors.[16,17] Results from the current study indicate that there is an interaction of smoking urge with the cognitive process of working memory to predict latency to smoke after alcohol administration. This may have relevance for clinical practice, in which individuals attempting to quit smoking should be made aware of the influence of increases in urge to smoke that occur after drinking, and that those who have relatively weaker working memory skills may need more intensive treatment efforts directed at increasing their working memory capacity.

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Declaration of Interests

The authors have no conflicts of interest to report. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs.

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