Cigarette cravings impair mock jurors’ recall of trial evidence

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Abstract

Prior research has demonstrated that cravings for substances, such as cigarettes and food, impair performance on basic cognitive tasks. This experiment examined whether these effects translate to impaired cognition on an important task in an applied setting: jury duty. Forty-six smokers were randomly allocated to a high-craving or control condition of an in-vivo procedure designed to invoke cigarette cravings. Participants were then asked to act as mock-jurors, and read a written legal transcript based on evidence presented in an actual civil case. Later, participants were tested on their recall and recognition of information from the transcript. Participants in the high-craving condition recalled fewer correct facts from the transcript than participants in the control condition, but cravings did not significantly affect the recognition of trial information. These results are consistent with cognitive models of cravings, highlight the importance of providing jurors with sufficient breaks, and suggest that cravings may impair cognition in a variety of important applied settings.

**Keywords:** cognition; cravings; juror decision making; memory; recall
Cravings can be defined as a motivational state that alerts an individual to the desire to consume a particular food or substance (Madden & Zwaan, 2001). Experiencing a craving impairs performance on basic cognitive tasks. For example, cigarette cravings have been found to affect reaction time (Baxter & Hinson, 2001; Cepeda-Benito & Tiffany, 1996; Sayette & Hufford, 1994), language comprehension (Zwaan, Stanfield, & Madden, 2000; Zwaan & Truitt, 1998), attention (Gross, Jarvik, & Rosenblatt, 1993), and working memory performance (Madden & Zwaan, 2001). Similarly, food cravings have been shown to slow reaction time and reduce working memory capacity (Kemps & Tiggemann, 2009; Kemps, Tiggemann, & Grigg, 2008).

One influential model holds that cravings impair performance on cognitive tasks because the suppression of the associated consumption behavior requires cognitive resources (Tiffany, 1990). This model proposes that consumption behavior (e.g., smoking a cigarette or eating a chocolate bar) becomes automatic after many repetitions, and is stored in long-term memory as an action schema (Norman, 1981; Shallice, 1972). Action schemas for consumption can be activated by external cues (e.g., the smell of a cigarette) or internal cues (e.g., thinking about smoking) and, once activated, they require few cognitive resources to implement. In experienced smokers, this often results in automatized smoking behaviors (e.g., Field, Mogg, & Bradley, 2006). However, in some situations, action schemas are activated but cannot be implemented due to internal or external constraints; for example, when a smoker starts to think about smoking during a staff meeting at work. In such situations, cognitive resources must be used to consciously and deliberately suppress the implementation of the action schema.

This notion—that the suppression of cravings uses cognitive resources and, hence, leaves fewer resources for other tasks—has links to other domains of research. The process of consciously suppressing an action schema (in this case, cravings) has been likened to dual-
task performance (Cepeda-Benito & Tiffany, 1996), in which a person is required to perform a task while concurrently performing a second task. This necessitates allocating some resources to the second task, which leaves fewer resources available to direct toward the first task, resulting in effects such as increased reaction time on the first task (Baxter & Hinson, 2001; Cepeda-Benito & Tiffany, 1996). Applied to (cigarette) cravings, these findings indicate that attentional resources are directed towards suppressing automatic smoking behaviors, leaving fewer resources for the current task. The idea that the suppression of cravings uses cognitive resources is also consistent with theory and findings in the broader literature on self-control (Muraven & Baumeister, 2000). Numerous studies have found that exercising control over thoughts and urges uses important cognitive resources, leaving fewer resources available for a concurrent task (e.g., Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven, Tice, & Baumeister, 1998).

The detrimental effects of cravings on cognitive performance have important implications for applied settings—such as workplace and educational environments—where smoking is prohibited for extended periods of time. In such settings, cognitive resources are used in performing countless tasks that have substantial consequences. Whether it is a factory worker using complex machinery (which carries obvious health and safety risks) or an accountant handling multi-million dollar investments of client-corporations, people rely on effective and efficient cognition to perform tasks safely and well. Research has identified that multiple trials on a task may lead to the task requiring fewer cognitive resources (i.e., becoming more automatic), enabling efficient performance despite some resources being allocated to the suppression of cigarette cravings (Madden & Zwaan, 2001). However, there are many instances in which the experience is unfamiliar and dynamic, with stimuli presented of varying complexity, and thereby requiring sustained, or greater cognitive resources. Given that cravings are likely to occur in many applied settings, it is important to understand how
the known effects of cravings on performance of basic cognitive tasks might translate to effects on more realistic cognitive tasks that more closely match what might be undertaken in applied settings.

In this research, we examined the effect of cigarette cravings on cognition in an important applied setting: Juror processing of trial evidence. The context of jury service is especially relevant for study of the effect of cravings on cognition. Effective jury service demands constant attention, efficient language comprehension, retention, manipulation, and accurate recall of information while suppressing emotional reactivity to stimuli in order to present an impartial decision (ForsterLee, Horowitz, & Bourgeois, 1993; Horowitz, Bordens, Victor, Bourgeois, & ForsterLee, 2001; Winter & Greene, 2007). Jurors are often exposed to complex and unfamiliar stimuli, thereby reducing the likelihood that cognitive processing of information and proceedings will become automatic. That is, jury duty requires a sustained level of cognitive effort to be maintained in order for jurors to be able to process complex information and, in turn, make accurate judgments about the case. In addition, many jurisdictions require jurors to go for extended periods of time without a break, increasing the risk and intensity of cravings. Furthermore, some smokers have been found to experience cravings within minutes of finishing a cigarette (Brody et al., 2002), and perceive the intensity of their cravings to increase if left unsatisfied (Sayette, Loewenstein, Kirchner, & Travis, 2005). Together, these findings provide further support for the notion that cravings likely occur in the courtroom, with important implications for individual contributions to the jury deliberation process.

The primary aim of this research was to test whether cigarette cravings might impair jurors’ memory for evidence presented in a courtroom trial. Given that the ability to accurately recall and recognize evidence plays a crucial role in enabling jurors to form an appropriate verdict, it is important to identify any factors (such as cravings) that might impair
jurors’ memory for evidence. Prior research has shown that cravings impair performance on basic memory tasks (e.g., Kemps et al., 2008; Madden & Zwaan, 2001). Here, we examined the effects of cravings on jurors’ recall and recognition of details of evidence as might be presented in a civil case, which represents a considerably more naturalistic stimulus set and memory task than those used in previous cravings research.

The secondary aim of this research was to test whether any effects of cigarette cravings on jurors’ memory for evidence varied depending on task difficulty. Previous research indicates that the effect of cravings may be moderated by the difficulty of the task. That is, more complex tasks place greater demands on cognitive resources than do simpler tasks. As the inhibition of cravings also takes up limited cognitive resources, we would therefore expect that cravings would give rise to a greater decline in performance on more complex than on simpler tasks. Indeed, Zwaan and Truitt (1998) found that the adverse effects of cigarette cravings on performance on a language comprehension task became greater as the task became more difficult. This suggests that any effects of cravings on jurors’ processing of trial information may also be moderated by task difficulty, with cravings impairing cognition to a greater extent as the jurors’ task becomes more difficult.

To test this, we manipulated the complexity of the trial evidence presented to jurors. Prior research has demonstrated that evidence becomes more difficult for jurors to process as it becomes more complex; for example, as a result of numerous plaintiffs with individual injuries and claims in a civil case, or the presentation of evidence and legal principles of varying degrees of complexity and applicability to the trial (ForsterLee, Horowitz, & Bourgeois, 1994; Horowitz & Bordens, 2002; Horowitz, ForsterLee, & Brolly, 1996). Based on the reasoning outlined above, we expected that cravings would impair memory for trial information, but this effect would be more pronounced when the trial information is complex
(representing a relatively difficult cognitive task) than when it is simple (a relatively easy cognitive task).

In this study, we used an in vivo craving induction procedure to assess the effects of cigarette cravings on recall and recognition memory in mock jurors. We hypothesized that the presence of cigarette cravings would be associated with significantly poorer recall and recognition memory of information presented in a transcript of evidence and judicial instructions from a civil courtroom case. Additionally, we hypothesized that the effects of cravings on memory performance would be greater when the demands of the task were higher rather than lower (i.e., presentation of relatively complex versus simple evidence).

**Method**

*Participants and design*

Participants comprised 46 undergraduate students (15 males; 30 females; one sex-undisclosed) aged 18 to 52 years ($M = 27.39$ years, $SD = 8.95$) who received course credit or AUD$10 for their participation. All participants reported that they spoke English as their primary language, were eligible for jury service (over the age of 18, Australian citizens), and had been regularly smoking ten or more cigarettes per day for at least one year not taking into account variations in cigarette strength. Participants had, on average, been smoking 10 or more cigarettes a day for 9.57 years ($SD = 9.26$). Data from 10 additional participants were excluded from analyses on the basis that these participants primarily spoke a language other than English ($n = 1$), reported non-existent cravings for cigarettes ($n = 2$), or had CO breath readings that indicated they had not adhered to the experimental instructions ($n = 7$).

Participants gave informed consent prior to participation, and were randomly allocated to one condition of a 2 (craving: high, low) × 2 (transcript complexity: simple, complex) design: control/simple transcript ($n = 13$), control/complex transcript ($n = 12$), high-craving/simple transcript ($n = 10$), and high-craving/complex transcript ($n = 11$).
Materials and procedure

Participants completed the study individually in a quiet laboratory room, with each testing session taking approximately 30 minutes to complete. Upon arrival, participants provided demographic information and a carbon monoxide (CO) reading via a handheld Bedfont piCO+ Smokerlyzer® unit. Typical CO levels for non-smokers range from 3 to 8 parts per million (ppm), 10 to 25 ppm for light to moderate smokers, and 25 to 50 ppm for moderate to heavy smokers (Madden & Zwaan, 2001). Participants then underwent a craving induction procedure adapted from Sayette et al. (2005) that differed for high-craving and control groups.

Cigarette craving manipulation

Participants in the high-craving condition were asked to abstain from smoking for two hours prior to arrival at the laboratory and to bring with them their own packet of cigarettes. After providing a CO measure, high-craving participants were presented with their own packet of cigarettes and requested to remove one and look at it for 15 seconds while holding it comfortably in their preferred hand. The cigarette was then returned to the packet, which was left on the table in sight of the participant.

Participants in the control condition were instructed to continue smoking as usual prior to arrival at the laboratory. After providing a CO measure, control participants were presented with a roll of tape, and requested to hold it comfortably in their preferred hand and look at it for 15 seconds before placing it on the table (Sayette et al., 2005).

Juror task materials

Participants were then presented with a transcript of evidence and judicial instructions that was developed by Horowitz and Bordens (1988) and has been used in a number of investigations examining the effects of trial complexity and note-taking on juror decisions (ForsterLee et al., 1994; ForsterLee et al., 1993; Horowitz & Bordens, 1990; Horowitz et al.,
The transcript is based on a real civil case (*Wilhoite v. Olin Corp.*, 1985), whereby a toxic chemical was inappropriately dumped into an area of commerce, resulting in injuries sustained by a number of plaintiffs. In mock-juror studies, presenting trial evidence via a written transcript produces results that are very similar to those found with more realistic presentation methods, such as using live actors in a mock-courtroom setting (Bornstein, 1999; Kerr & Bray, 2005).

In order to manipulate complexity, we used a procedure based on that used by Horowitz et al. (1996). Two versions of the transcript were created: a relatively simple version and a relatively complex version. The two versions differed in terms of the number of plaintiffs claiming damages (three plaintiffs in the simple transcript and six in the complex transcript) and the complexity of language used. For example, one phrase describing the concept of proximate cause appeared in the simple version as: “Proximate cause means the cause of an event, without such cause, the event would not have occurred.” In the complex version, the equivalent phrase was: “Proximate cause means that cause which in a natural and continuous sequence produces an event, and without which cause, such events would not have occurred; and in order to be proximate cause, the act or omission complained of must be such that a person using ordinary care would have foreseen that the event, or some similar event, might reasonably result therefrom.”

This method of manipulating complexity was found by Horowitz et al. (1996) to be effective, with jury-eligible participants rating the simple transcript as significantly more comprehensible than the complex transcript. Our own pilot testing (*N* = 22) confirmed that the simple transcript was perceived as easier to understand than the complex transcript. Unlike in Horowitz et al. (1996), however, this difference did not reach the conventional level of significance; the effect size was nevertheless moderate (simple: *M* = 24.00, *SD* =
15.66 vs. complex: $M = 36.64$, $SD = 20.65$, on a scale of 0-100 where higher scores indicate greater difficulty of understanding), $t(20) = 1.62$, $p = .121$, $d = .69$.

**Memory tests**

After reading through the transcript once, participants were presented with two questionnaires designed to measure different functions of memory. Recall memory for transcript facts was measured via written responses in which participants were asked to write down all information they could remember from the transcript. Participants were given three minutes to complete this task. All participants completed the task within the time frame.

Recognition memory was measured via a questionnaire containing 30 statements about information from the transcript. Fifteen of these statements were correct facts from the transcript. The remaining 15 statements were lures, which consisted of information that could plausibly have appeared in the trial evidence, but was either incorrect or did not actually appear in the transcript. For each item, participants were asked to decide whether it appeared in the transcript they had read. Participants responded by providing a rating for each item from 1 (“definitely appeared”), to 6 (“definitely did not appear”), indicating their level of confidence regarding the presence of each statement in the transcript.

**Manipulation checks and other measures**

To test whether the craving manipulation was successful, participants provided measures of state-craving intensity via responses on three 100-mm visual analogue scales anchored at 0 (“absolutely no urge to smoke”) and 100 (“strongest urge to smoke I’ve ever experienced”). These three measures were taken retrospectively, such that participants were asked to indicate the intensity of cigarette cravings that they had experienced at three different time points during testing: (1) upon arrival to the lab, (2) following the craving manipulation only a few minutes later, and (3) approximately 25 minutes later at the end of
the study. Measurements were taken retrospectively so that the suggestion of cravings did not induce cravings in participants of the control condition (Kemps et al., 2008).

Participants were asked to rate how comprehensible they found the transcript on a 100 mm visual analogue scale anchored at 0 (“extremely easy to understand”) and 100 (“extremely difficult to understand”). Finally, nicotine dependence was measured using the Fagerström Nicotine Dependence Scale (FNDS; Heatherton, Kozlowski, Frecker, & Fagerström, 1991), which is a six-item multiple choice questionnaire with a score of five or greater indicating a strong nicotine addiction.

Results

Screening measures

To ensure compliance with the deprivation instructions, participants were asked upon arrival to indicate how long it had been since their last cigarette (min), to provide breath analyses that present an immediate CO reading, and to indicate their level of nicotine dependence via the FNDS. One-way ANOVA indicated that compared to controls, high-cravers reported significantly longer times since their last cigarette (high-craving: $M = 197$ min, $SD = 191$, 95% CI [110, 284] vs. control: $M = 44$ min, $SD = 108$, 95% CI [0, 89]), $F(1, 44) = 11.64, p = .001, d = 1.01$. Consistent with these self-reports, high-cravers had significantly lower CO readings than controls (high-craving: $M = 10$ ppm, $SD = 5$, 95% CI [8, 13] vs. control: $M = 23$ ppm, $SD = 14$, 95% CI [18, 29]), $F(1, 44) = 17.51, p < .001, d = 1.24$. However, high-craving participants also had lower levels of nicotine dependence, as measured with the FNDS, than control participants (high-craving: $M = 3.33$, $SD = 2.08$, 95% CI [2.39, 4.28] vs. control: $M = 4.80$, $SD = 2.60$, 95% CI [3.73, 5.87]), $F(1, 44) = 4.34, p = .043, d = .62$, indicating significant between-group differences that were unanticipated due to random allocation. Note that any effects of the craving manipulation cannot be attributed to this unanticipated difference in dependence, because the lower levels of dependence in the
high-craving condition would have acted against the manipulation (given that lower
dependence is associated with lesser cravings).

**Manipulation checks**

**State-craving intensity**

Analysis of retrospective ratings of craving intensity showed that the craving
manipulation was successful. A 2 (craving condition) × 3 (time) mixed ANOVA yielded a
significant between-subjects effect, indicating that high-craving participants reported
significantly higher retrospective craving intensities than controls ($M = 56.84, SD = 18.38$ vs.$M = 22.23, SD = 18.38$, respectively), $F(1, 44) = 40.50, p < .001$. Greenhouse-Geisser
corrected repeated measures ANOVA revealed a significant main effect of time on craving
intensities, $F(1.84, 81.07) = 29.23, p < .001, \varepsilon = .921$. Within-subjects contrasts indicate that
craving intensities consistently increased from time 1 to time 3 (see Figure 1), $F(1, 44) = 42.23, p < .001$. Craving intensities for control participants remained comparatively low upon
arrival and following the craving induction, with an increase in intensity by the end of testing,
which may be a combined effect of cigarette deprivation and task demands. The craving
condition × time interaction did not reach significance, $F(1.84, 81.07) = 2.78, p = .073, \varepsilon = .921$.

![INSERT FIGURE 1 ABOUT HERE]

**Trial complexity**

There was a trend toward participants reporting that the simple transcript was easier to
understand ($M = 32.04, SD = 29.33$) than the complex transcript ($M = 44.13, SD = 32.71$),
however this difference was not statistically significant, $t(44) = -1.32, p = .194, d = .39$.
Given that the pilot test and manipulation check both yielded non-significant differences in
perceived comprehensibility that were in the expected direction, we adopted a meta-analytic
approach that involved analyzing the overall effect of the complexity manipulation on
perceived comprehensibility across both tests (Cumming, 2012a, 2014). This analysis was conducted using Exploratory Software for Confidence Intervals (ESCI), an Excel-based statistical package designed for the estimation of effects (Cumming, 2012a, 2012b). This analysis yielded a difference of 12.41 points 95%CI [0.76, 24.06], $t = 2.09, p = .04$. Thus, taken together, the results of the pilot test and manipulation check suggest that participants perceived the complex version of the transcript as more difficult than the simple version, but this difference was subtle.

Memory measures

Recall

Raw data for the recall measure comprised free responses in sentence or dot-point form. Following ForsterLee et al. (1993), responses were scored on the basis of individual pieces of correct information recalled. For example, the sentence “one plaintiff ate fish that was contaminated with DBX, leading to a rare form of liver cancer” was segmented into individual pieces of information, where the participant would receive a point for each “one plaintiff ate fish”, “fish that was contaminated”, “DBX”, and “liver cancer”. The sum of these points represented the participant’s overall recall score. Two independent raters who were blind to the experimental conditions scored responses. Inter-rater reliability was high ($r = .93, p < .001$) and all discrepancies were resolved through discussion. Recall scores were subjected to a 2 (craving condition) × 2 (transcript complexity) ANOVA.

As shown in Figure 2, high-craving participants recalled fewer trial facts ($M = 7.06, SD = 3.35, 95\% CI [5.58, 8.54]$) than control participants ($M = 9.12, SD = 3.36, 95\% CI [7.76, 10.47]$), $F(1, 42) = 4.29, p = .045, d = .61$. The main effect of transcript complexity and craving × complexity interaction were non-significant, $F$s < 1.

[INSERT FIGURE 2 HERE]
We also examined whether the craving manipulation affected the number of incorrect trial facts that participants recalled. Information was scored as incorrect on the basis of incorrectly recalling information that was in the transcript (e.g., incorrectly naming the chemical, DBX; incorrectly recalling the number of plaintiffs), and recalling information that was not in the transcript. A 2 (craving condition) × 2 (transcript complexity) ANOVA yielded no significant main effects of craving condition, $F < 1$, or transcript complexity, $F(1, 42) = 2.46, p = .124, d = .04$, nor a significant interaction between these two factors, $F < 1$. Thus, the craving manipulation had no effect on the number of incorrect facts recalled by participants.

We also analyzed total word count for individual recall responses to determine whether differences in correct recall of facts may simply reflect a reduced propensity to report information in the craving condition. Although participants in the craving condition recorded somewhat fewer words ($M = 45$ words, $SD = 14, 95\% CI [37, 53]$) than participants in the control group ($M = 54$ words, $SD = 20, 95\% CI [47, 61]$), a 2 (craving condition) × 2 (transcript complexity) ANOVA showed no significant main effect of craving condition, $F(1, 42) = 2.64, p = .112, d = .48$. The transcript complexity main effect and interaction were also non-significant, $Fs < 1$.

Recognition

Participant recognition responses were used to calculate estimates of discriminability and response bias (Green & Swets, 1966; Macmillan & Creelman, 1991). Discriminability reflects each participant’s ability to discriminate facts from lures. Discriminability is indexed by the parameter $d’$, with a value of zero indicating no ability to distinguish facts from lures and higher values indicating greater ability. Response bias reflects each participant’s tendency to favor stating yes (i.e., that an item was present in the transcript) or no (i.e., that an item was not in the transcript). Response bias is indexed by the parameter $c$. A value of
zero indicates unbiased responding, with negative values indicating a tendency to say that items were present in the transcript (i.e., being too lenient in responding yes) and positive values indicating a tendency to say that items were not in the transcript (i.e., responding too conservatively).

For discriminability estimates ($d'$ values), ANOVA revealed no significant main effects of craving condition or complexity, and no significant craving condition × transcript interaction, all $F$s < 1. The absence of the expected effect of craving condition on discriminability does not appear to be due to a lack of statistical power: the difference in $d'$ between the control condition ($M = 1.39$, $SD = 0.84$) and high-craving condition ($M = 1.24$, $SD = .74$) represented an effect size of $d = 0.19$, which is below Cohen’s (1988) suggested cutoff for a small effect. This suggests that, even with a very large sample, the craving manipulation would have minimal effect on participants’ ability to discriminate correct trial facts among lures.

For response bias ($c$), the craving × transcript complexity interaction approached significance, $F(1, 42) = 3.94$, $p = .054$. This reflected a trend toward more lenient responding in the high-craving condition compared to the control condition for participants who read the simple transcript (high-craving: -0.35 vs. control: -0.08), $t(21) = 1.89$, $p = .073$, $d = 0.82$, but not those who read the complex transcript (high-craving: -0.27 vs. control: -0.39), $t < 1$. The main effects of craving ($F < 1$) and complexity ($F = 1.35$, $p = .25$) were non-significant.

**Discussion**

This research demonstrates that cigarette cravings can impair recall of information in the context of a mock juror task. Compared with controls, high-craving participants had poorer recall memory for trial evidence and judicial instructions presented in a legal transcript. The craving manipulation did not affect participants’ recognition of information from the transcript, in terms of distinguishing correct facts from lures (i.e., pieces of
information that did not appear in the transcript), although there was a trend toward the craving manipulation producing more lenient responding among participants who read the simple version of the transcript.

There was also a trend toward a reduction in the overall number of words recorded by the craving group in the recall task. This trend is certainly consistent with the notion that memory for trial information was poorer in the craving condition than the control condition. However, an alternative explanation might be that the craving manipulation did not impair participants’ recall of trial facts, but simply reduced participants’ willingness to report as much information in the recall test (perhaps because the manipulation reduced effort dedicated toward the task, or prompted participants to want to leave the study in order to have a cigarette). Although we cannot definitively rule out such an explanation, there are two reasons why this is unlikely to account for our data. First, if the manipulation simply reduced participants’ willingness to report information (via reduced effort or desire to leave the study) we would expect this trend to occur not only for correct facts, but also for incorrect facts. This was not the case: participants in the high-craving condition did not differ from those in the low-craving condition in the number of incorrect facts recalled. Thus, the trend for craving participants to report less information overall was clearly driven by a reduction in the recall of correct facts. Second, because the recall task was timed (participants were required to spend three minutes on the task), there was no possibility that writing less would enable participants to leave the study sooner. Hence, the most likely explanation for our data is that the craving manipulation impaired participants’ recall of trial information.

From an applied perspective, these results have clear implications for the scheduling of breaks in courtroom hearings. Factors that impair jurors’ memory for trial information can influence trial outcomes. The ease with which information can be recalled affects the extent to which that information affects judgments and decisions (Tversky & Kahneman, 1974).
Thus, if cravings impair the recall of important trial information, that information is less likely to shape individual jurors’ judgments about the case. Our results suggest that jurors should be given breaks sufficiently often to satisfy cigarette cravings so that processing of evidence is not impaired.

These results also extend knowledge about the effects of cravings on cognition. Prior research has established that cravings for substances including cigarettes and food impair performance on basic cognitive tasks, such as response time, attention and working memory tasks (e.g., Gross et al., 1993; Kemps et al., 2008; Madden & Zwaan, 2001). Our research demonstrates that such effects translate to a more realistic cognitive task that better maps onto what a person might be required to do in an applied setting, in terms of memory for more naturalistic and narrative-driven stimulus materials. The findings provide further support for Tiffany’s (1990) cognitive model of cravings, in that the presence of cigarette cravings resulted in poorer performance on a cognitive task, which is consistent with the idea that cravings consume limited cognitive resources.

Our results also align well with the broader literature demonstrating detrimental effects on cognition caused by dual-task performance (e.g., Baxter & Hinson, 2001; Cepeda-Benito & Tiffany, 1996) and the exertion of self-control (Baumeister et al., 1998; Muraven et al., 1998). It may be fruitful for future research to further examine parallels between these domains. For example, one interesting question relates to how quickly cognitive resources become available (and, hence, how quickly task performance recovers) when cravings are alleviated or self-control is no longer necessary. Exerting self-control depletes self-control resources, which then gradually replenish over time (Muraven & Baumeister, 2000). This implies that the negative effects of self-control on cognition may persist for some time, even after self-control is no longer necessary. It is unclear whether the recovery of cognitive
performance after cravings are alleviated follows a similar time course, or occurs more quickly.

There was minimal effect of the craving manipulation on discriminability in the recognition task, in contrast to the substantial detrimental effect of the manipulation on recall performance. The different effects on performance may be attributable to differences in the amount of cognitive resources required by the two memory tasks. There is evidence that the cognitive processes involved in recall require more attentional resources than the processes involved in recognition (e.g., Anderson, Craik, & Naveh-Benjamin, 1998). In the present study, it may be that cigarette cravings triggered active inhibition of action schema for smoking, and that this inhibition was sufficient to impair the processes involved in recall (which require a relatively large amount of attention) but not those involved in recognition (which require relatively less attention). To the extent that this account is true, the negative effect of cravings on cognition will be particularly evident for other naturalistic tasks that demand a substantial amount of attentional resources (e.g., Palmer, Brewer, McKinnon, & Weber, 2010). Another possible explanation is that the observed craving levels may have been sufficiently strong to affect recall, but not recognition. Participants in the craving group had been deprived of cigarettes for two hours. Following the craving induction protocol, they reported craving levels around the midpoint of the scale. It is possible that following a longer period of smoking deprivation, participants might have experienced stronger cravings, which might also have affected recognition performance, not just recall. However, the null effect of the manipulation on recognition performance was not anticipated and these explanations, although plausible, are speculative.

The effect of cigarette cravings on memory performance was not moderated by the complexity of the trial transcript. On one hand, this result provides evidence that the effects of cigarette cravings on recall generalize to two sets of stimuli that differ in terms of the
number of plaintiffs involved and the language used. However, this result was contrary to our hypothesis that the effects of the craving manipulation would be stronger for the complex transcript than the simple trial transcript, and to the results of Zwaan and Truitt (1998) who found that the effects of cravings on language comprehension were greater on a more difficult task compared to an easier one.

The lack of an interaction effect in the current study may be attributable to the subtlety of the complexity manipulation. Although the results of pilot testing and a manipulation check, taken together, indicated that participants perceived the complex version of the transcript as more difficult to understand than the simple version, this difference was small (approximately 12 points on a scale of 1-100). Consistent with the notion that the complexity manipulation was subtle, a post-hoc analysis of language readability using the Gunning Fog Index (GFI; Gunning, 1979) showed that the simple and complex transcripts require the equivalent of 13.51 and 13.50 years of education for comprehension, respectively. At first glance, this suggests that a stronger complexity manipulation may have produced the predicted interaction (with stronger effects of the craving manipulation for a more complex transcript than a less complex one). However, as shown in Figure 2, the pattern of means suggests that the effect of cravings was—if anything—stronger among participants who read the simple transcript than the complex one (i.e., the opposite to the predicted pattern). Thus, our recall data do not support the notion that cravings may have stronger effects on jurors’ recall of complex evidence than simple evidence. This suggests that in at least some applied settings, like jury duty, even relatively simple tasks are affected by cravings.

While this is the first study that has investigated the effect of cravings in a real-world task, there are some limitations that open avenues for future research. First, greater manipulation of task complexity to create a clear difference in the required cognitive effort may reveal a significant effect of cravings. Second, the difference in results for recall versus
recognition memory may translate to other forms of cognition. For example, research has demonstrated that cigarette cravings reduce working memory ability (Madden & Zwaan, 2001), which may show stronger impairments compared to recall memory due to differences in cognitive requirements. Third, the present study only included current smokers; future research could examine whether smokers and non-smokers differ in performance on applied tasks that require cognitive resources.

Finally, the present results have implications for applied settings in which people may experience cravings due to having limited access to craved substances such as cigarettes, food, and coffee. Our data represent the first step toward demonstrating that the detrimental effects of cravings on performance of basic cognitive tasks translate to performance on more realistic, everyday cognitive tasks. Our study specifically examined the effects of cigarette cravings on jurors’ memory for realistic information from a civil case. However, to the extent that these results generalize to other tasks and other cravings (e.g., food, coffee), they have implications for any setting in which people experience cravings while undertaking important tasks that require cognitive resources. Our results suggest that in any such situation, policies and practices regarding the scheduling of breaks should take into account potential effects of cravings on cognition.
References


Figure Captions

**Figure 1.** Craving intensity as a function of craving condition reported retrospectively for Time 1 (arrival at laboratory), Time 2 (immediately post-manipulation), and Time 3 (the end of the study). Error bars show 95% confidence intervals.

**Figure 2.** Recall Scores as a Function of Craving Intensity and Transcript Complexity. Error bars show 95% confidence intervals.