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Out for a Smoke: The Impact of Cigarette Craving on Zoning Out During Reading

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Abstract

Cigarette craving has powerful effects on cognitive functioning, which may promote smoking behavior and relapse. One area of cognition that has had little impact on craving research is human consciousness. Developments in consciousness research using a mindless-reading paradigm permit examination of the effects of craving on both the occurrence and the awareness of mental lapses. Forty-four smokers, who were either nicotine deprived (crave condition) or nondeprived (low-crave condition), performed a mindless-reading task. This task assesses both self-caught and probe-caught mind-wandering episodes to distinguish between lapses that are within and outside of awareness. Compared with the low cravers, those in the cigarette-crave condition were significantly more likely to acknowledge that their mind was wandering when they were probed. When we adjusted for this more-than-threefold increase in zoning out, craving also lowered the probability of catching oneself. Results suggest that craving simultaneously increases mental lapses while reducing the metacognitive capacity to notice them.

Keywords

cigarette craving, smoking craving, mind wandering, zoning out

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As anyone who has tried to quit knows, the urge to smoke can be overwhelming, making craving a key predictor of relapse among smokers attempting to quit (Killen & Fortmann, 1997; Shiffman et al., 1997). Although craving has long been recognized as a cardinal feature of addiction (Wikler, 1948), researchers have just begun to explore cognitive processes that may lead cravings to trump the goal of quitting smoking (Curtin, McCarthy, Piper, & Baker, 2006; Kavanagh, Andrade, & May, 2005; Sayette, 2004; Tiffany, 1990).

Cigarette craving appears to affect a variety of cognitive processes, ranging from basic perception to higher-level decision making (see Sayette, 2004). For example, craving demands attentional resources, focusing attention on smoking cues and away from stimuli unrelated to smoking (Field, Munafò, & Franken, 2009). Moreover, craving-related attentional bias predicts smoking relapse (e.g., Waters et al., 2003). Craving also impairs performance on tasks requiring sustained attention (Wetter, Brandon, & Baker, 1992; Zwaan & Truitt, 1998). It therefore is unsurprising that most smokers report impaired concentration when abstaining (Van Rensburg & Taylor, 2008). This impairment can be dangerous. Waters, Jarvis, and Sutton (1998) reported a rise in workplace accidents on "No Smoking Day" in the United Kingdom (see also Giannakoulas, Katramados, Melas, Diamantopoulos, & Chimonas, 2003).

Of course, sustaining attention is challenging to more than just people who are craving. Yet, in many instances, mind wandering (referred to interchangeably as *zoning out*) during an important—though perhaps uninteresting—task is self-corrective. When most people's attention wanders, they notice and then summon the effort to reorient themselves to the task at hand. This feedback system requires sufficient monitoring to detect quickly that one has become distracted. Were craving also to interfere with this monitoring process, then the disruptive effects of zoning out would be exacerbated. That is, craving may increase smokers' vulnerability to distraction while simultaneously undermining their ability to notice that they have become distracted. Regarding this latter possibility, though findings are mixed, nearly a dozen brain-imaging studies have reported that craving leads to activation in the anterior cingulate cortex (ACC; see Wilson, Sayette, & Fiez, 2004). The ACC is a structure that has been implicated in conflict monitoring (Nitschke & Mackiewicz, 2006) and is active during episodes of unnoticed mind wandering (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009). Accordingly, when the ACC is focused on the conflicts inherent in the experience of craving, this may hamper recognition that one's mind has wandered (an experience that also conflicts with the stated

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task). More generally, craving may engage working memory and self-regulation resources that otherwise might be directed toward noticing that one has become distracted, thereby simultaneously increasing the occurrence of one's mind wandering and decreasing the probability of catching it. This study explored this possibility by examining the impact of craving on both occurrence and noticing of zoning out.

Zoning out during reading provides a useful paradigm for examining people's capacity for noticing distraction (Schooler, 2002; Smallwood, McSpadden, & Schooler, 2008). While they read, people's minds often wander without their realizing it (i.e., although fully conscious of the topic that has distracted them, they are unaware that they have been distracted). Eventually they realize that they have been zoning out and that they have been reading without understanding. The ability to periodically appraise current thought content (referred to as *meta-awareness*; Schooler, 2002) influences the impact of mind wandering, both in terminating it and in reducing its effects on performance.

The contribution of meta-awareness to zoning out is seen in studies showing that (a) when randomly probed, individuals are often caught mind wandering before they notice it themselves; (b) such "probe-caught" mind-wandering episodes are particularly linked to comprehension difficulties; and (c) when zone outs occur outside of awareness, performance is associated with different patterns of response times and brain activation relative to mind wandering characterized as having occurred with awareness (see Smallwood & Schooler, 2006). Thus, zoning out indexes the propensity for distraction, as well as the capacity for a higher-order form of monitoring (meta-awareness) in which people notice that their mind has wandered.

We examined whether cigarette craving affected the tendency to zone out and the ability to detect such lapses. We used a paradigm previously used to study zoning out during reading (Sayette, Reichle, & Schooler, 2009; Schooler, Reichle, & Halpern, 2004). Participants read text presented on a computer while also monitoring their reading performance and noting occurrences of when their mind wandered. Such self-caught instances indicate zoning out that has reached meta-awareness. Participants also intermittently responded to prompts to see if their mind had wandered. Such probe-caught instances indicate zoning out that has occurred without participants being aware that they were doing so. This experience-sampling procedure (Hurlburt, 1993) has advantages over mind-wandering assessments recorded after task completion (Smallwood & Schooler, 2006). Thus, by including both self-report and experience-sampling methods, we measured the frequency of mind wandering (using experience sampling) and meta-awareness of mind wandering (using the self-caught measure).

Participants performed the task while in a cigarette-craving (crave) or a low-crave (LC) state. We predicted that craving would increase the time spent zoning out (i.e., proportion of times that experience-sampling probes caught participants' mind wandering) and also interfere with the capacity to notice when the mind had wandered (i.e., the ratio of self-caught to probed-caught mind-wandering episodes).

Method

Participants

Forty-four native-English-speaking, literate, healthy female and male smokers ages 18 to 55 years were recruited via newspaper ads (using methods previously employed in our lab; e.g., Sayette, Martin, Hull, Wertz, & Perrott, 2003). Participants needed to smoke at least 15 cigarettes/day for at least 1 year (without a quit attempt) and could not have a medical condition that ethically contraindicated nicotine. After a brief screening where informed consent, a carbon monoxide (CO) reading, and photo identification occurred, eligible participants were invited to a 2-hr experimental session. They were told to refrain from smoking for at least 6 hr before arrival and not to drink alcohol, use nicotine replacement products, or use any recreational drugs for 24 hr before arrival. They also were told that breath measurement instruments would be used to confirm compliance.

Equipment

The experiment was implemented using an IBM-compatible computer and software (written in Borland C++ 4.0) that allowed participants to read text (chapters 1–5 of Tolstoy's, 1864–1869/1982, *War and Peace*) in a self-paced manner.

Procedure

On arrival, participants provided a CO sample to ensure smoking abstinence. CO samples needed to be below 15 ppm, or not more than half the initial nondeprived reading to continue. Participants randomly assigned to the LC condition were informed that they could smoke during the study, but crave-condition participants were not permitted to smoke. Participants completed a color-naming task (not reported here) to examine the effects of craving on subliminal perception (Wertz, 2003). LC participants then smoked a cigarette, after which all participants again recorded CO and completed questionnaires pertaining to the color-naming task, as well as the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) and a demographics form (Sayette et al., 2003). Next, participants completed a four-item urge questionnaire, in which they rated each statement on a scale ranging from 0, *none at all*, to 100, *strongest I've ever had*. The respective statements assessed whether participants craved, had an urge for, desired, and wanted a cigarette. Responses were averaged to create a composite urge score (Wertz, 2003).

All participants indicated they had never read *War and Peace.* They next were administered the mind-wandering task, which we have used previously (Sayette et al., 2009). Participants had 30 min to read up to 34 pages of *War and Peace* on a computer by pressing the "/" key (labeled "F") to advance to the next page and the "z" key (labeled "B") to return to the previous page. Before starting, participants read a description of zoning out,

including, "At some point during reading, you realize that you have no idea what you just read," and that "not only were you not really thinking about the text, you were thinking about something else altogether." Participants pressed the "b" key (labeled "ZO") whenever they caught themselves zoning out. Participants were prompted every 2 to 4 min after each prior prompt or self-caught zone out with a tone and the message, "Were you zoning out?" Participants then responded "yes" or "no" to these prompts by pressing the "1" and "2" keys, respectively. Participants could move backward through the text and reread any sections as soon as they had finished responding. After the session, participants completed up to 20 true/false questions (based on how many pages they had read) to determine reading comprehension. Participants then completed a postexperimental questionnaire, were debriefed, and were paid $50.

Results

Crave- and LC-condition participants did not differ on age, gender, ethnicity, income, initial CO, or FTND scores. As expected, after the smoking manipulation, crave-condition participants reported higher cravings (M = 47.8, SD = 25.5) and provided lower CO readings (M = 12.2, SD = 6.5) than did LC participants (M = 18.3, SD = 16.3, for craving; M = 26.2, SD = 12.8 for CO), Fs(1, 40) > 17, ps < .0001.

As with prior work using this task (Sayette et al., 2009), data from 2 participants (both in the crave condition) were excluded from analyses because reading comprehension was well below chance (proportion correct ≤ .33).

The crave group (M = 1,566 s, SD = 213) and LC group (M = 1,628 s, SD = 170) were similar in time spent reading (p = .32). Crave-condition participants (M = .64) performed worse than LC-condition participants (M = .77) on the comprehension test, $F(1, 41) = 5.46$, $p < .03$, $d' = 0.72$. Of particular interest were our two measures of mind wandering: (a) propensity to be caught mind wandering by prompts and (b) number of self-reported mind-wandering episodes.

Crave-condition participants were prompted (M = 7.44, SD = 1.85) a similar number of times to LC participants (M = 8.29, SD = 1.76; $p > .14$). When prompted, crave-condition participants acknowledged more (probe-caught) mind-wandering episodes (M = 1.48, SD = 1.33) than did their LC counterparts (M = 0.47, SD = 0.62), $F(1, 41) = 8.51$, $p < .006$, $d' = 0.97$. To correct for slight differences in the total number of probes, we examined the likelihood of being caught when one's mind was wandering given the absolute number of probes. (This measure is preferred to the absolute number of affirmative probe responses because it adjusts for the number of prompts; Sayette et al., 2009.) Crave-condition participants confirmed mind wandering on 19.9% (i.e., 1.48 ÷ 7.44) of the probes, whereas LC participants reported mind wandering on only 5.6% of the probes (i.e., 0.47 ÷ 8.29). The likelihood of acknowledging a mind-wandering episode when probed was 3.55 times greater in the crave condition than in the LC condition, $F(1, 41) = 9.62$, $p < .004$, $p_{rep} > .974$, $d' = 1.03$.

The second measure putatively indexes meta-awareness of mind wandering. Crave-condition participants (M = 1.52, SD = 1.83) and LC participants (M = 1.18, SD = 1.74) were similar in the frequency with which they caught their mind wandering ($p > .54$). That is, despite zoning out more than 3 times as often as participants in the LC condition, participants in the crave condition were not more likely to catch their mind wandering. As in prior research (Sayette et al., 2009), we quantified this observation by comparing the observed number of self-caught zone outs in the crave condition with the expected number of self-caught zone outs in this group, given that these participants were 3.55 times more likely than those in the LC group to be caught zoning out (by probes). To execute this analysis, we multiplied the mean number of self-caught zone outs in the LC condition (1.18) by 3.55 and compared this value (4.19) with the observed number of self-caught zone outs in the crave condition (1.52). The difference between these values (4.19 and 1.52) was significant, $F(1, 40) = 8.01$, $p < .008$, $p_{rep} > .960$, $d' = 1.50$. Although there were no significant associations between comprehension and the self-caught zoning out, the correlation between the probe-caught ratio and comprehension was marginally significant (using a directional test) in the crave condition, $r = –.32$, $t(23) = 1.62$, $p = .059$. The lack of significant associations may relate to the modest sample size and the ability to reread the text after zoning-out episodes.

Discussion

Cigarette craving led smokers to simultaneously increase zoning out while decreasing the propensity to notice such occurrences. Despite being caught zoning out more than 3 times as often as LC participants, participants in the crave condition were not more likely than their LC counterparts to catch themselves. Apparently, participants in the crave condition struggled to notice mind-wandering episodes, whereas LC participants were more capable of detecting mind wandering when it occurred.

While craving increased the frequency of zoning out, it reduced the proportion of such instances that reached meta-awareness. To our knowledge, these data are the first to indicate that craving disrupts individuals' meta-awareness of the current contents of thought. This conclusion is consistent with prior neurobiological evidence that craving inhibits processes related to meta-awareness, including engagement in conflict monitoring (Wilson et al., 2004).

The observation that craving may both impair sustained attention and reduce meta-awareness of this impairment has practical implications for domains in which craving can impair performance. The disruptive effects of craving on self-regulation (see Sayette, 2004) may partly reflect a compromised ability to appraise and regulate one's current state, thereby potentially contributing to the increase in workplace accidents when smokers try to quit (Waters et al., 1998). Although the present study focused on cigarette craving, LC smokers seemed to perform similarly to (noncraving) nonsmokers studied in Sayette et al. (2009).

Results indicated that craving impaired reading comprehension, which replicates prior work showing craving to disrupt performance on tasks requiring limited-capacity nonautomatic processing (Tiffany, 1990; Zwaan & Truitt, 1998). The present data extend this work by suggesting two distinct cognitive mechanisms (mind wandering and meta-awareness of its occurrence) that may underlie this disruption. (Because of reactivity concerns, we did not assess directly whether participants were thinking about smoking while mind wandering; see Kavanagh et al., 2005.) The findings thus offer new directions for examining factors that interfere with learning among students who smoke and must refrain throughout portions of the school day or through long college classes.

There is debate about whether cravings must be conscious (Sayette et al., 2000). While conventional wisdom holds that individuals are fully aware of their cravings, some suggest that cravings can occur unconsciously (Berridge & Robinson, 1995). This debate assumes that cravings must be either conscious or unconscious. The present study offers an alternative framework in which consciousness is divided into experiential consciousness (contents of experience) and meta-consciousness (explicit awareness of the contents of consciousness; Sayette et al., 2009; Schooler, 2002; Schooler & Mauss, 2009). With respect to craving, it seems reasonable that one can be conscious of craving but lack metaconsciousness of the fact that they are craving. Recognizing that one is craving requires that the craving experience be effectively monitored. Accordingly, even a benign self-report measure of craving can probe a smoker and transform a craving state from experiential consciousness to one that enters metaconsciousness. This possibility raises important questions regarding urge assessment that reach beyond the scope of this article (Sayette et al., 2000). If experientially conscious craving itself is a form of mind wandering, then it may be useful to develop laboratory methods that assess both probe- and self-caught urge states.

Traditionally, the occurrence of absentminded relapses suggested that cravings need not trigger relapse (Tiffany, 1990). Alternatively, absentminded relapses may be associated with craving states in which one lacks metaconsciousness of the cravings (see Cheyene, Carriere, & Smilek, 2006). By simultaneously promoting absentmindedness and decreasing meta-awareness, the unnoticed craving state may induce a unique condition in which individuals are maximally likely to engage in a relapse behavior and minimally likely to notice themselves doing so.

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