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Measuring smoking-related attentional bias with a change detection task

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Abstract

Despite well known health risks, cigarette smoking remains very prevalent in the United

States. In addition, those who attempt to quite are very likely to relapse. Cognitive

predictors have not been well examined to date, despite evidence from the Incentive-

Sensitization model of addiction that cognitive processes play a large role in relapse and

continued addictive behavior (Robinson & Berridge, 1993). To address if the cognitive

adaptations involved in the Incentive-Sensitization model are permanent or semi-permanent,

this current study examined the abilities of current smokers (n = 15), former smokers (n =

13), and never smokers (n = 15) to detect changes involving both smoking-related stimuli

and neutral stimuli using a flicker paradigm. Contrary to the hypotheses, the current smokers

did not exhibit a bias in attention toward smoking-related stimuli, and no group differed in

change-detection capabilities when compared to any other group. Possible reasons for the

unexpected findings are presented, as well as discussion about the construction of an

effective change-detection task.

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Introduction

Despite well known health risks such as lung cancer, heart attack, and stroke, roughly 23% of men and 18% of women in the United States currently smoke cigarettes (SAMHSA, 2009). Additionally, more than 60% of smokers who attempt to quit relapse in the first two weeks of abstinence, and over 95% relapse within a year (Garvey, Bliss, Hitchcock, Heirold, & Rosner, 1992; Hughes et al., 1992). Nicotine and/or bupropion replacement treatment can improve abstinence rates, but even in the best cases of treatment roughly 65% of smokers attempting to abstain relapse within 12 months (Jorenby et al., 1999). Additionally, according to a meta-analysis by Lancaster, Hajek, Stead, West, and Jarvis (2006), behavioral therapies have little to no long-term effect on nicotine relapse rates, whether or not there is additional substitutive therapy such as nicotine patches. In order to provide better cessation options to smokers and relapse prevention strategies to those who have quit, it is important to better understand the causes of, and contributors to, relapse to cigarettes. Therefore, the patterns and predictors of relapse require further examination.

A variety of perspectives have been used to understand relapse and its predictors (McKay, 1996). Commonly investigated predictors include negative emotional states, interpersonal problems, stress, and a lack of known coping mechanisms (McKay, Rutherford, Alterman, & Cacciola, 1996; Moos & Moos, 1984; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996; Tiffany, 1990). Another important, though less explored, set of predictors of relapse relate to cognitive factors. According to Tiffany (1990), automatic cognitive processes in addicted individuals can lead to increased craving and subsequent substance use. This theory indicates long-term substance users have a history of use in consistent environments and thus subconsciously (i.e. automatically) relate these environments and

associated stimuli with their substance of choice. Therefore, one demonstrated predictor of relapse is post-cessation exposure to familiar drug-related locations and stimuli, which act as triggers that cause formerly addicted individuals to crave their drug of choice, often inducing relapse. Despite previous evidence that automatic cognitive processes play a role in relapse, only very recently have cognitive processes become a focus for relapse-related research, and the amount of literature on the subject is still considerably smaller than the literature on other predictors of relapse.

Drawing off of Tiffany (1990), Robinson and Berridge (1993) introduced the incentive-sensitization model of addiction. This model theorizes that the repeated use of, and exposure to, substances leads to neuroadaptions that cause addicted individuals to associate the substance with reward. This model classifies "wanting" a drug as craving, rather than merely "liking" a drug (Robinson & Berridge, 2000). The authors describe this "wanting" as what the layperson calls "craving." The basis of this model is that the brain has both a "wanting" mechanism and a "liking mechanism" and that the brain eventually becomes sensitized to the former and desensitized to the latter. Robinson and Berridge (2000) call this wanting "incentive salience" and describe it as the process whereby certain stimuli related to the drug become more "eye catching." The authors state this can be long-lasting and possibly even permanent, although the estimated length of these neuroadaptions has not yet been well established.

Most addictive substances increase the amount of dopamine in the nucleus accumbens (i.e., the brain's reward center), which reinforces drug-taking behavior (De Vries & Shippenberg, 2002; Weiss & Porrino, 2002). It has also be shown that not only can a drug result in reward association; stimuli associated with drug consumption can also lead to an

increase of dopamine in the nucleus accumbens even *prior to drug administration* (Koob, Sanna, & Bloom, 1998). Hence, addicted individuals experience their drugs of choice and associated stimuli as rewarding phenomena. This leads to users noticing and attending to drugs and associated stimuli more often. A relative increase in exposure to drug related stimuli increases wanting for the drug, which typically promotes drug-seeking and drug-taking behavior (Robinson & Berridge, 2000).

The enhanced attention toward desired stimuli mentioned in Robinson and Berridge (1993) is known typically as attentional bias. Attentional bias has long been used as a cognitive measure in psychopathology research (Williams, Mathews, & Macleod, 1996), having been applied in studies ranging from depression (Gotlib & McCann, 1984) and anxiety (Mathews & Macleod, 1985), to research on arachnophobia (Watts, McKenna, Sharrock, & Trezise, 1986) and occupational stress (McKenna, 1986). Typically, when researchers present subjects with stimuli presumed to have incentive salience (e.g., spiders in arachnophobia studies) the subjects exhibit a bias in attention towards the stimuli (i.e., an arachnophobic subject is more likely to notice a spider than control/neutral stimuli). These findings also indicate that incentive salience towards a substance/stimuli will lead to an attentional bias.

The most commonly used measure of attentional bias in addiction research is the addiction Stroop task (Cox, Fadardi, & Pothos, 2006). Both substance-related and control words, matched for length, syllables, and other semantic properties are presented to the participant one at a time in different colors (one color per word). The participant must then respond to the color of the word and ignore the semantic meaning of the word. Typically, substance-related words create more interference than control words in addicted individuals,

resulting in significantly slower response times to substance-related words than control words. This difference in reaction time is what researchers consider a demonstration of attentional bias. The Stroop has found attentional bias in consumers of alcohol (e.g., Cox, Blount, & Rozak, 2000; Stormark, Laberg, Nordby, & Hugdahl, 2000), cocaine users (e.g., Copersino et al., 2004), heroin users (e.g., Franken, Kroon, Wiers, & Jansen, 2000), and nicotine users (e.g., Waters et al., 2003), amongst other substances.

However, the Stroop has some notable drawbacks. Though used as a measure of attentional bias, the Stroop task does not directly measure attention; rather it measures interference from presumed attention toward the emotionally salient word (Williams et al., 1996). Additionally, the Stroop does not directly present drug-related stimuli to subjects, but instead presents words associated with stimuli associated with drugs (e.g., the word "cigarette" instead of an image of a cigarette). Such an indirect measure opens itself to many confounds (Cox et al., 2006). For example, Stroop tasks have been shown to be influenced by such factors as subjective craving (Algom, Chajut, & Lev, 2004) and attempts to *avoid* substance-related stimuli instead of attending to them (Klein, 2007). Therefore, it can be argued that the Stroop task does not actually measure attentional bias, but rather either a substance users' attempts to suppress their own biases or their level of craving (Cox et al., 2006). There are also concerns that the Stroop induces a "carryover effect" in addiction research, where the interference caused by the addiction stimuli in one word presentation can actually influence the reaction times on subsequent word presentations (Waters, Sayette, & Wertz, 2003). Since attempts to suppress biases and individual levels of craving can vary from person to person, and because the Stroop possibly does not actually measure attentional bias, it should not be considered a preferred paradigm in attentional bias research.

More recently, there has been a shift towards direct measures of attentional bias in addiction research. The most common approaches for these measurements are visual probe tasks (i.e. dot-probe tasks) and change-detection paradigms (Field & Cox, 2008). Visual probe tasks simultaneously presents matched substance-related images and control images (e.g., a picture of a cigarette in an ashtray and a picture of a pen on a dish). Once the images disappear, a visual probe (e.g. a white dot) appears where one of the pictures used to be and the participants indicate, as rapidly as possible, when they see the probe. Similar to the visual probe task is the attentional cueing paradigm. The only difference from the visual probe task is that the attentional cueing task presents one stimuli at a time. Both of these paradigms are considered stronger paradigms than the addiction Stroop because they more accurately measure what the user specifically attends to, rather than interference cause by substance-related stimuli (Field & Cox, 2008).

Another, more recent direct measure of attentional bias relies on the phenomenon known as change-blindness. In past studies on change detection and change awareness, participants typically either do not notice alterations between two similar stimuli, or they at least take a significant amount of time to notice the change (Rensink, O'Regan, & Clark, 1997; Simons & Rensink, 2005). Despite changes not being intentionally hidden in any way, participants are initially unaware of the alterations. This "blindness" is known as change blindness. Cognitive processes behind change blindness remain undetermined, although it seems likely that under certain circumstances explicit attention may be required to detect change in these studies (Behmer, Hyman, Jantzen, & Graham, unpublished).

Typically, researchers use flicker paradigms to measure change detection (Rensink et al., 1997; Rensink, 2004). In these paradigms, an original image is presented for roughly a

quarter of a second, then a blank "mask" is presented for about an eighth of a second, and then an altered version of the original is presented for approximately a quarter of a second. As the two images rapidly change back in forth, it gives the illusion that the image flickers. The cycle repeats itself until the participant notices where the difference in images occurs. In some studies, the paradigm includes catch trials, where there is no change between the two pictures (e.g., Behmer, Hyman, Jentzen, & Graham, unpublished manuscript). These trials are to help ensure that participants are only indicating a change when they actually see a change.

Using a flicker paradigm, Rensink et al. (1997) found that participants were able to detect change more quickly when the change occurred in objects that had been previously assigned a high level of importance. Such a finding potentially links to Robinson & Berridge's (1993) incentive-sensitization model of addiction, because if certain substances are given high levels of incentive salience, that can be considered a high level of importance. Therefore, one might suspect that drug-related stimuli are assigned higher levels of importance and thus drug users would be able to detect changes them more quickly (Field & Cox, 2008). Indeed, a flicker paradigm has been used to measure attentional bias in recreational drinkers and cannabis smokers (Jones, Jones, Blundell, & Bruce, 2002; Jones, Jones, Smith, & Copley, 2003), as well as in cigarette smokers (Yaxley & Zwaan, 2005).

In Yaxley and Zwaan's (2005) study, 30 smokers and 30 non-smokers completed a change-detection task containing smoking-related stimuli. The paradigm consisted of 32 pairs of arrays of eight objects, some of which were smoking-related (e.g., a lighter, a cigarette, and matches) and some of which were neutral (e.g., a deck of playing cards, a roll of tape, and a bottle). In order to remove the potential attentional distracter of color, all of

the images were presented in black and white. In all of the paired arrays, the alteration between images was a rotation of the target object along its horizontal axis. Of the 32 paired arrays of objects, 16 contained one smoking-related object and 16 did not contain any. Of the 16 that did contain a smoking-related object, eight changed the orientation of the smoking-related object and eight changed the orientation of a neutral object. This study found that a) smokers were able to more quickly detect changes to smoking-related objects than changes to non-smoking objects and b) that smokers were able to detect changes in smoking-related objects more quickly than non-smokers were able to. The researchers concluded that smokers do have an attentional bias toward smoking-related objects and that the flicker paradigm is an effective tool to measure attentional bias in smokers.

However, the effect of this study was small (D = .210), and Yaxley and Zwaan (2005) did not assess whether or not they induced a visual search. A more accurate assessment of attentional bias using a change-detection task should include a measurement that tests if a visual search has been induced because Behmer et al. (unpublished manuscript) found that increasing the number of images in the array of a change-detection paradigm corresponds to an increase in change-detection times. Therefore, in order to ensure that one induces a visual search in a change-detection task, one should employ the use of an array of few distracters and compared it to reaction times in an array with many distracters.

At this point, there are two common paradigms of attentional bias; the Stroop, and the visual probe. The Stroop uses changes of reaction times in color naming on salient vs. non-salient words to measure a bias in attentional. Visual probe tasks use a more direct approach; they use visual probes to infer what a test subject attends to during the task. Visual probe tasks measure attentional bias as speed of reaction time, just like the Stroop, but instead of

measuring interference they measure what participants attend to. Thus, converse to the Stroop, faster reaction times indicate an attentional bias in visual probe tasks (as well as change-detection tasks). The major advantage of more direct measures (as opposed to the Stroop task) is that visual probe tasks have fewer potential confounds since they measure what subjects attend to, rather than interference. However, while the dot-probe task has become a mainstream measure in addiction-related attentional bias research, change-detection paradigms have barely been used despite having been shown to be effective. Therefore, more studies should implement the use of change detection paradigms to better understand the limits and benefits of their use in attentional bias research.

Attentional bias has been exhibited using these paradigms across users of nearly all psychoactive substances, including alcohol, heroin, cocaine, caffeine, and marijuana users (e.g., Copersino et al., 2004; Franken, Kroon, Wiers, & Jansen, 2000; Jones et al., 2003; Townsend & Duka, 2001; Yeomans, Javaherian, Tovey, & Stafford, 2005). Additionally, this attentional bias appears uniformly across multiple groups and individual characteristics (e.g. adolescents, African-Americans, personality types, etc.) using different paradigms (e.g. Stroop, dot-probe, change-detection). However, despite the fact that Robinson and Berridge based their model on the idea that craving caused incentive-salience, the connection between craving and attentional bias has not been clearly established (Field & Cox, 2008). It should thus be assessed in attentional bias research whether the level of bias in addicted individuals vary as a factor of their level of craving.

In specific regards to smoking (the focus of the current study), attentional bias has been measured since the mid-1990s (Barker & Graham, 2011). The two most widely used paradigms have been the Stroop (e.g., Mogg & Bradley, 2002; Waters et al., 2003), which

was used in about 45% of the identified studies, and the dot-probe task (e.g., Field, Mogg, & Bradley, 2004; Waters, Shiffman, Bradley, & Mogg, 2003) which was used in about 42% of the studies. Change detection paradigms, on the other hand, have barely been implemented, having been used less than 6% of the studies, despite their potential in attentional bias research. In addition, less than half (about 45%) of the total studies to date have used a non-smoking control group, though Field and Cox (2008) advocated the inclusion of such control groups, and more recent studies tend to include them. Barker and Graham (2011) also suggested that more studies should include groups of former smokers, as they have been underrepresented so far in the literature.

As indicated by Barker and Graham (2011), results of existing studies of attentional bias with cigarettes have been fairly uniform. First, it appears cigarette smokers usually exhibit attentional bias toward smoking related stimuli. In studies where control groups of non-smokers are included, these individuals do not tend to exhibit a bias toward smoking related stimuli. Therefore, at the very least, the paradigms work in that they are emotionally salient to smokers but not non-smokers. In addition, the most widely used paradigm is also the weakest in detecting attentional bias. Barker and Graham (2011) found that the Stroop task yielded the smallest effects, and were unable to differentiate between the strength of dot-probe tasks and change detection tasks because so few studies utilized change detection paradigms.

The most relevant application of attentional bias research in addicted individuals is that of relapse prediction. Waters et al. (2003) examined attentional bias as a predictor in initial lapses in smoking cessation. Participants were smokers who had expressed a desire to quit and enrolled in a smoking cessation program. They then completed the addiction Stroop

task and were subsequently monitored in their abstinence attempts for three months to note any lapses. Waters et al. found that participants who exhibited a greater attentional bias in the Stroop Task were more likely to have a lapse in their abstinence during the three month monitoring period. Waters et al. thus concluded that attention bias can be used as a tool to predict outcome in smoking cessation attempts.

More recently, Janes et al. (2010) combined fMRI and an addiction Stroop task to determine if heightened brain activity during presentation of smoking-related words could predict relapse rates amongst smokers trying to quit. They found that neuroactivity in the insula and the dorsal anterior cingulate cortex correlated with attentional bias as determined by delayed reaction times to smoking-related words on the Stroop task. Smokers who had lapses had less connectivity between the insula network and the brain regions associated with cognitive control, suggesting that these individuals had reduced top-down control of emotions that arise due to cue exposure. Additionally, the smokers who had lapses in the cessation attempts had slower reaction times to smoking-related words on the Stroop task, which once again suggests a link between attentional bias and relapse. However, to date these are the only two studies used to directly examine the link between attentional bias toward cigarette-related stimuli and relapse. Therefore, this area needs to develop further in order to better establish the all-important direct link between attentional bias and drug relapse.

Since attentional bias may predict relapse, it is important to understand at what point, if ever, attentional bias in former users disappears. Robinson and Berridge's (1993) model of addiction noted "permanent or semi-permanent" neurological alterations that led to the substance of use being recognized as reward. Therefore, it should be determined whether

this neuroadaption is permanent, and therefore if attentional bias is permanent. If the neuroadaption is "semi-permanent," then the substance of use and its associated stimuli would no longer be associated with reward over time and thus the attentional bias toward it would disappear. If attentional bias toward substance-related stimuli reached null levels, it should no longer be a predictor of relapse. Finding at what point, if any, attentional bias disappears can assist in the development and optimal timing of relapse prevention strategies. This requires the conduction of studies that examine the attentional bias of former smokers.

Munafo, Mogg, Roberts, Bradley, and Murphy (2003) examined current smokers', ex-smokers' (with at least six months cessation) and never-smokers' reaction times on the addiction Stroop task. Ex-smokers and never-smokers showed no significant difference in attentional bias toward smoking-related words, and when combined in one group their attentional bias was significantly less than that of current smokers. Similarly, Littel and Franken (2007) used event-related brain potentials on a Stroop task to measure processing bias in smokers, former smokers, and never smokers. The results were similar to Munafo et al. (2003) in that current smokers exhibited a processing bias, but neither former smokers nor never smokers exhibited a processing bias. However, Ehrman et al. (2002), using a dot-probe task on a similar group of participants, found that while current smokers and never smokers *did* differ in their response times, former smokers *did not* differ from either group. In both Munafo et al. (2003) and Littel and Franken (2007), the former smokers group had been abstinent for at least six months, and these studies do not show the what point at which attentional bias completely disappears. In contrast, Ehrman et al. (2002) only required that former smokers be abstinent for only one week. Therefore, even if incentive-salience toward smoking-related stimuli disappears at some point, it is not clear at what point this happens,

but it seems to be longer than one week and less than six months. Since Waters et al. (2003) suggested that attentional bias predicts relapse, an examination of relapse rates in smokers could clarify when attentional bias disappears during abstinence.

Hunt, Barnett, and Branch (1971) examined the relapse rates in smokers and found a relatively consistent three months asymptote where relapse rates level off considerably. In other words, the majority of relapses occur within the first 90 days of a cessation attempt. A subsequent, larger review of relapse rates in smokers and showed (a) similar homogeneity between relapse rates in alcohol and nicotine and (b) the same asymptote on the relapse curve between 70 and 100 days (Kirshenbaum, Olsen, & Bickel, 2009). Furthermore, Kirshenbaum et al. found this curve was very consistent across the 53 individual relapse curves corresponding to the studies in the meta-analysis. They concluded that the 100 day point in abstinence marked a significant milestone, and that after this point both one year and four years of abstinence served as roughly equal predictors of relapse, a result replicated by Daughton et al. (1999). This means that after 100 days of abstinence there does not appear to be a difference in relapse rates for the foreseeable future.

Despite the findings of Hunt et al. (1971) and Kirshenbaum et al. (2009), to date very little has been done to understand the predictors of this 70-100 day asymptote. Some theories propose extinction of learned behavior or incomplete transfer of a newly learned behavior of abstinence in multiple situations, but there is currently little to no empirical evidence to support these hypotheses (Kirshenbaum et al., 2009). In fact, to date very little has been done at to ascertain what consistent properties addicted individuals display that cause this uniform decrease in relapse rates over time. Since the 20 studies reviewed by Kirshenbaum et al. (2009) and the 84 reviewed by Hunt et al. (1971) presented a largely homogeneous

relapse curve, it is safe to infer that the majority of relapses occur before 100 days of sobriety. Given that it has been suggested by Munafo et al. (2003) and Little and Franken (2007) that attentional bias disappears at some point before six months, perhaps a decrease in attentional bias is partially responsible for the substantially lower relapse rates after the first three months of abstinence.

The purpose of this study was to use a change detection paradigm to measure attentional bias of current smokers, abstinent smokers who had been abstinent for between two weeks and ten weeks (i.e., between 14 and 70 days), former smokers who had been abstinent for longer than four months (i.e., over 100 days), and individuals who had never smoked to explore the presence, if any, of attentional bias during the time frame of the 70-100 day relapse rate asymptote (Kirshenbaum et al., 2009). Therefore, this was the first attentional bias study to attempt to examine two different groups of former smokers. The paradigm consisted of trials containing four different image array types: neutral stimuli with a smoking-related target (Pen →Cigarette), neutral stimuli with a neutral target (Pen → Pen), smoking-related stimuli with a neutral target (Cigarette → Pen), and smoking-related stimuli with a smoking target (Cigarette → Cigarette). Additionally, each image array type was presented with 4 images in the array and 16 images in the array to assess if a visual search is being induced.

Individuals with an attentional bias toward smoking-related stimuli should exhibit this bias by having the fastest reaction times to the Pen → Cigarette trials due to the incentive salience of the smoking-related target. In addition, the increased number of smoking-related distracters in Cigarette → Pen trials should cause these same individuals to react more slowly to its changes than the fully neutral Pen → Pen trials changes due to their attention being

allocated to the incentively-salient stimuli instead of the neutral target. It should also be that smokers and abstinent smokers would have reaction times that follow this pattern, thus indicating an attentional bias for these individuals. Non-smokers, who have never been constantly exposed to or used cigarettes, should have had the same reaction time to each block of stimuli and thus not indicate an attentional bias. Former smokers, for whom enough time has passed that the bias-inducing neuroadaptions no longer exist, should also not differ in reaction times between conditions.

Additionally, it is predicted that current smokers would exhibit attentional bias to a greater degree than abstinent smokers by having faster reaction times on the Pen → Cigarette trials and slower reaction times on the Cigarette → Pen trials, although abstinent smokers should have been faster on the Pen → Cigarette trials and slower on the Cigarette → Pen trials when compared to former and never smokers. Former smokers' and never smokers' reaction times should not differ from each other in any image array type. These predictions stem from the research that suggests current smokers exhibit high levels of attentional bias, former smokers without long term abstinence have not fully returned to null levels of attentional bias but have lower levels of it than current smokers, while never smokers and former smokers do not exhibit any attentional bias toward smoking related stimuli (Ehrman et al., 2002; Munafo et al., 2003). There should have been no difference in reaction times on displays with 4 distracters because with so few images in the array the participants should not utilize a visual search and thus changes will be detected immediately regardless of distracter or target type.

In summary, the hypotheses were:

1) Current smokers and former smokers will exhibit an attentional bias toward smoking-related stimuli.

2) Former smokers and never smokers will not show an attentional bias toward smoking-related stimuli.

3) Current smokers will exhibit a greater attentional bias toward smoking-related stimuli than will abstinent smokers.

4) Abstinent smokers will exhibit a greater attentional bias toward smoking-related stimuli than former smokers or never smokers.

5) Former smokers and never smokers will not differ in attentional bias.

Method

Participants

Participants were recruited via a convenience sample from fliers posted on Western Washington University's campus and the psychology department's SONA recruitment (i.e., online recruitment software designed to advertise studies available for participation). Both the SONA and the flyer recruitment asked for current and former smokers, as well as individuals who have never smoked. Current smokers were be defined as individuals who self-reported smoking at least 3 cigarettes per day over a minimum of the past 12 months. Former smokers and abstinent smokers were defined as individuals who self-reported previously smoking at least 3 cigarettes per day over a minimum of 12 months, and have not smoked a cigarette since their self-reported quit date. Former smokers were defined as individuals who had been abstinent for at least 100 days, while abstinent smokers were defined as individuals who had been abstinent for between 14 days and 70 days. Non-smokers were individuals who smoked ten cigarettes or fewer in their lifetime. All

participants were be given one hour of research credit for their involvement in the study and were entered into a lottery for $50. Participants who were ineligible for research credit were entered into a separate $15 lottery. All of the participants except for one were eligible to receive research credit. The one who was not automatically won the additional $15 lottery.

There were a total of 47 smokers, former smokers, abstinent smokers, and never smokers (26 males, 21 females) in this study. The majority of the sample (72.3%) was of White/Caucasian, followed by Asian (10.6%) and then Hispanic (8.5%), Arab (4.3%), and Native American (4.3%). Twenty participants were freshmen, 7 were sophomores, 16 were juniors, and 4 were seniors. Roughly half (46.8%) of the sample wore corrective eyewear. All of the participants were undergraduate university students.

A total of 15 never-smokers (8 female, 7 male) with an average age of 19.38 years ($SD = 0.66$) volunteered to participate. Of these participants, 11 were freshmen, 3 were sophomores, and 1 was a junior, with an average GPA of 3.23 ($SD = 0.43$). Eleven identified themselves as White/Caucasian, 2 identified as Asian or Asian-American, 1 identified as Native American, and 1 identified as Hispanic. Five of the never-smokers required corrective eyewear, and one was living with a smoker at the time of the study. Never-smokers on average had smoked 1.27 ($SD = 1.94$) cigarettes in their lifetime, with a mean score of 10.33 ($SD = .816$) on the Questionnaire for Smoking Urges-brief form (QSU-brief; Cox, Tiffany, & Christen, 2001).

A total of 13 former smokers (5 female, 8 male) with an average age of 21.19 years ($SD = 2.56$) volunteered to participate. Of these participants, 4 were freshmen, 2 were sophomores, 5 were juniors, and 2 were seniors, with an average GPA of 3.19 ($SD = 0.42$). Ten identified themselves as White/Caucasian, 2 identified as Hispanic, and 1 identified as

Native American. Seven of them required corrective eyewear. These participants had been abstinent from cigarettes for an average of 1.09 years ($SD = 1.27$), and had smoked 5.85 ($SD = 4.69$) cigarettes per day for an average of 3.13 years ($SD = 1.95$). They had a mean score of 19.77 ($SD = 10.51$) on the QSU-brief.

A total of 4 abstinent smokers (1 female, 3 male) with an average age of 21.33 years ($SD = 1.701$) volunteered to participate. Of these participants, 1 was a freshman and 3 were juniors, with an average GPA of 2.83 ($SD = 0.59$). Three identified themselves as White/Caucasian, and one identified as ¼ Japanese, ¾ White/Caucasian. Two of them required corrective eyewear. These participants had been abstinent from cigarettes for an average of 1.00 months ($SD = 0.46$), and had smoked 6.13 ($SD = 2.66$) cigarettes per day for an average of 2.42 years ($SD = 18.78$). They had a mean score of 21.00 ($SD = 5.72$) on the QSU-brief. This group was excluded from the remaining analyses due to a very small sample size.

A total of 15 current smokers (7 female, 8 male) with an average age of 21.51 years ($SD = 2.51$) volunteered to participate. Of these participants, 4 were freshmen, 2 were sophomores, 7 were juniors, and 2 were seniors, with an average GPA of 2.92 ($SD = 0.49$). Ten identified themselves as White/Caucasian, 2 identified as Arab, 1 identified as Asian/Asian-American, 1 indentified as Hispanic, and 1 identified as ½ Asian and ½ White/Caucasian. Eight of them required corrective eyewear, and 11 had attempted to quit smoking cigarettes at least once. These participants had been smoking 6.97 ($SD = 7.12$) cigarettes per day for an average of 4.17 years ($SD= 3.34$), and on average had last smoked a cigarette 4.42 hours ($SD = 7.37$) prior to participating. They had a mean score of 35.60 ($SD = 9.44$) on the QSU-brief.

One-way ANOVAs and Chi Squared tests assessed any variability in the demographic composition of the three groups included in further analyses (current smokers, former smokers, and never smokers). There was no statistically significant difference in GPA scores, $F(2, 39) = 1.93$, $MSE = 0.20$, $p = .160$; in the percentage that required corrective eyewear, $F(2, 40) = 0.78$, $MSE = 0.26$, $p = 0.470$; in ethnicity composition, $\chi^2(15) = 14.60$, $p = 0.481$; or in gender composition of the respective samples, $F(2, 40) = 0.29$, $MSE = 0.26$, $p = .748$. There was a difference in age between the three groups, $F(2, 39) = 4.26$, $MSE = 635.85$, $p = .021$; there was also a difference in level of craving, measured by scores on the QSU-brief, $F(2, 40) = 37.79$, $MSE = 65.58$, $p < .001$. A post-hoc REGWQ test investigated the differences in age and found that the sample of never smokers was younger than former smokers and current smokers, and that former smokers and current smokers did not differ in average age. Another post-hoc REGWQ test investigated scores on the QSU-brief and revealed that never smokers had lower average craving levels than former smokers, who in turn had lower average craving levels than current smokers.

Independent-samples t-tests examined any differences between current smoking habits of current smokers and former smoking habits of former smokers. There was no significant difference in the average number of cigarettes smoked per day, $t(26) = 0.48$, $p = .633$, and there was no significant difference in the average length of time the participant had smoked, $t(26) = 0.98$, $p = .338$. Therefore, there is no evidence that the smoking habits of current smokers differed from the previous smoking habits of former smokers.

Measures

Craving assessment

After receiving permission from its creator (See Appendix A, the Questionnaire of Smoking Urges-brief form (QSU-brief; Cox, Tiffany, & Christen, 2001) was administered to examine the role of craving on attentional bias, as shown in Appendix B. Cox et al. designed the QSU-brief to be a shorter version of the original Questionnaire of Smoking Urges (QSU; Tiffany & Drobes, 1991), so that it could be more efficiently applied in laboratory settings. It was designed based on responses from both currently smoking individuals and individuals with brief abstinence from cigarettes. Participants' rate on a scale of 1 (strongly disagree) to 7 (strongly agree) how much ten smoking-related statements relate to their current state (e.g., "If it were possible I would probably have a cigarette right now" and "Smoking would make me less depressed) (α = .97). Higher total scores indicate higher levels of craving. Tiffany and Drobes (1991) initially designed the QSU to assess different aspects of craving, but Cox et al. (2001) determined that the QSU-brief operates best as a general measurement of craving.

Change-detection task

A change-detection visual paradigm was used to measure attentional bias. In each condition there was a pair of pictures: an array of 4 or 16 distracters and a matched array where a target replaces one distracter. All distracter array types contained picture arrays with 4 distracters or 16 distracters. This was used to provide evidence that the paradigm induced a visual search, as reaction time should be slower when there are 16 distracters compared to when there are 4 distracters (Behmer et al., unpublished manuscript). It is important to induce a visual search because otherwise it is possible that all changes pop out to participants and

are immediately apparent, thus eliminating the possibility of detecting attentional bias.
Practice stimuli were color images of oranges and apples with different colored backgrounds.
Smoking-related stimuli were color photographs of cigarettes with a variety of backgrounds
(e.g. gravel, a keyboard, a sheet of paper), while neutral stimuli were color photographs of
ball-point pens with the same backgrounds.

The paradigm included one practice block followed by two experimental blocks. The
practice block consisted of orange images as distracters, with an apple image replacing an
orange image as the target, and apple distracters with an orange target. The experimental
blocks contained different types of image arrays. The Pen → Cigarette trials consisted of pen
images as distracters, and one cigarette image replacing a pen image as the target. The Pen
→ Pen trials consisted of pen images as distracters, and a different pen image replacing one
pen image as the target. The Cigarette → Pen trials consisted of cigarette images as
distracters, and one pen image replacing a cigarette image as the target. The Cigarette → Pen
trials consisted of cigarette images as distracters, and a different cigarette image replacing
one cigarette image as the target.

Both practice trials types and experimental trial types contained trials with 4
distracters and 16 distracters. Therefore, there are a total of four possible image array type
for practice trials (Apple → Orange, 4 distracters; Apple → Orange, 16 distracters; Orange
→ Apple, 4 distracters; Orange → Apple, 16 distracters) and eight possible image array types
for experimental trials (Pen → Cigarette, 4 distracters; Pen → Cigarette, 16 distracters; Pen
→ Pen, 4 distracters; Pen → Pen, 16 distracters; Cigarette → Pen, 4 distracters; Cigarette →
Pen, 16 distracters; Cigarette → Cigarette, 4 distracters; Cigarette → Cigarette, 16
distracters). The practice block contained all types of practice trials and each experimental

block contained all types of experimental trials. There were 40 trials in the practice block and 80 trials in each experimental block, and therefore each participant was exposed to 200 trials: 40 practice trials and 160 experimental trials. The order of the experimental blocks was randomized between each participant, and the paired picture presentation order was random within each block.

The a priori power analysis used a beta (i.e. probability of a Type II error) of .80, and effect sizes are Cohen's f. The number of participants listed is the number of participants required to detect a significant three-way interaction, which was the hypothesized finding of this study. To detect a small effect (f = .10), this study required 50 participants per group, for a total of 200 participants. An effect size this small was deemed to not be of practical value. To detect a medium effect size (f = .25), this study required 9 participants per group, for a total of 36 participants. To detect a large effect size (f = .40), this study required 5 participants per group, for a total of 20 participants. With the intended number of participants (15 per group, a total of 60), an effect size of f = .19 or greater could be detected.

The picture pairs were presented on a grey background 800 pixels wide and 600 pixels high, and objects were presented in one of 400 possible positions using a 20 x 20 grid. There was also a minimum required distance between images so as to prevent clusters of stimuli.

Procedure

The proceeding information closely followed the procedure of Behmer et al. (unpublished manuscript). First, participants signed informed consent (see Appendix C) and filled out a demographics form (see Appendix D). Participants then completed the task individually in an enclosed 6' x 8' room with no windows or ambient noise. They were

seated with their eyes approximately 14" from the screen. The paradigm was presented on a 21" monitor using custom software written in MATLAB (2009, The Mathworks, Natick, MA).

At the beginning of the task there was a fixation point in the middle of the screen for 500 ms, and then the picture presentation began. The first picture of the pair was presented for 400 msec, followed by a dark grey screen (i.e. a mask) for 200 msec, followed by the second picture of the pair containing the target for 400 msec, followed by the mask for 200 msec. This process continued until the participant pressed a button indicating he or she saw the change, or until 20 cycles passed (i.e., approximately 25 seconds). Once the change had been identified, the next trial began. Trials were separated by 1000 ms.

Participants gave their responses to the QSU-brief following completion of the change-detection task, and then were debriefed (see Appendix E). Due to ethical concerns regarding exposure to smoking-related stimuli potentially increasing nicotine craving in abstinent smokers and former smokers, participants in these groups were required to sit and wait with the experimenter for 20 minutes following the completion of the QSU-brief (Marissen, Franken, Blanken, van den Brink, & Hendriks, 2007). These participants were also given a list of smoking cessation and smoking abstinence resources should they have had any concerns about their abstinence capabilities (See Appendix F). This process took 30-60 minutes per participant.

Results

Demographics

There was no effect of vision quality on change detection time, as indicated by those who required vision-correcting not differing from those who did not for current smokers, F

(1, 14) = 0.54, *MSE* = 4.087, *p* = .477; former smokers, *F*(1, 12) < 0.01, *MSE* = 3.53, *p* = .967; or never smokers, *F*(1, 14) = 0.06, *MSE* = 3.06, *p* = .809. Men and women also did not differ in change detection time, whether they were current smokers, *F*(1, 14) = 0.87, *MSE* = 3.99, *p* = .367; former smokers, *F*(1, 12) = 0.61, *MSE* = 3.35, *p* = .452; or never smokers, *F*(1, 14) = 0.25, *MSE* = 3.02, *p* = .626. Year in school also had no effect on change detection time for current smokers, *F*(3, 12) = 0.34, *MSE* = 4.60, *p* = .796; former smokers, *F*(3, 10) = 0.26, *MSE* = 3.70, *p* = .850, or never smokers, *F*(2, 13) = 0.89, *MSE* = 2.91, *p* = .437.

A series of bivariate correlations investigated if any continuous demographic variables correlated with change detection time for any distracter array type with either 4 distracters or 16 distracters for current smokers, former smokers, and never smokers (see Table 1, Table 2, and Table 3, respectively). For smokers, the average number of cigarettes smoked per day significantly correlated with change detection time in Cigarette → Cigarette displays with 16 distracters, such that those who smoked more cigarette per day had slower change detection times (r = .629, *p* < .05). Additionally, for smokers the average GPA significantly correlated with change detection in Cigarette → Cigarette displays with 16 distracters, such that those with higher GPAs had slower change detection times (r = .561, *p* < .05). No other correlations were significant for current smokers, former smokers, or never smokers.

Smoking Status

The main analysis was a 2 (4 distracters and 16 distracters) x 4 (Pen → Pen array, Pen → Cigarette array, Cigarette → Pen array, and Cigarette → Cigarette array) x 3 (current smokers, former smokers, and never smokers) mixed model Analysis of Variance (ANOVA) using a Greenhouse-Geisser correction for violations of the assumption of sphericity, and

with the participants' median change detection time to each condition as the dependent variable. A 2 x 4 x 3 ANOVA using mean change detection time as the dependent variable yielded similar results, but using the median change detection time reduced the effect of outliers.

There was a main effect of number of distracters, $F(1, 40) = 11.04$, $MSE = .446$, $p = .002$, partial $\eta^2 = .216$; a main effect of distracter array type, $F(3, 120) = 205.789$, $MSE = .731$, $p < .001$, partial $\eta^2 = .837$; and no main effect of smoking status, $F(2, 40) = 1.522$, $MSE = 3.355$, $p = .231$, partial $\eta^2 = .071$. There was not an interaction between the number of distracters and smoking status, $F(2, 40) = .023$, $MSE = .446$, $p = .978$, partial $\eta^2 = .001$; there was an interaction between the number of distracters and the distracter array type, $F(3, 120) = 90.289$, $MSE = .855$, $p < .001$, partial $\eta^2 = .693$; and there was no interaction between distracter array type and smoking status, $F(6, 120) = 1.616$, $MSE = 1.228$, $p = .185$, partial $\eta^2 = .075$. There also was not a significant three-way distracter number by distracter array type by smoking status interaction, $F(6, 120) = 1.803$, $MSE = .855$, $p = .143$, partial $\eta^2 = .083$.

Two one-way ANOVA's with alpha at .025 for each examined the effect of distracter array type on change detection time at both 4 distracters and 16 distracters (see Figure 1). There was a significant effect of distracter array type with 16 distracters, $F(3, 126) = 52.34$, $MSE = 1.012$, $p < .001$, partial $\eta^2 = .556$; and a smaller significant effect of distracter array type with 4 distracters, $F(3, 126) = 6.92$, $MSE = 0.04$, $p < .001$, partial $\eta^2 = .141$. Critical differences for a post-hoc Tukey's test using the MSE of the one-way ANOVA were calculated to examine the effect with 16 distracters and with 4 distracters. Using the MSE from each respective one-way ANOVA is a more conservative estimate in calculating the critical difference than using the MSE from the interaction term, and is not too liberal

because the one way ANOVA did not have concerns regarding the violation of the assumption of sphericity (Kirk, 1995). The Tukey's test revealed that, with 16 distracters, change detection times were significantly faster for Pen → Cigarette and Cigarette → Pen displays than Pen → Pen and Cigarette → Cigarette displays. Change detection times also differed between Pen → Cigarette than Cigarette → Pen displays, such that change detection times were significantly faster in Pen → Cigarette displays than in Cigarette → Pen displays ($p < .05$). There was no difference between Cigarette → Cigarette and Pen → Pen displays ($p > .05$). See Table 4 for means, standard deviations, and marginal means.

A second post-hoc Tukey's test revealed that, with 4 distracters, change detection times were significantly faster in Pen → Cigarette and Cigarette → Pen displays than in Cigarette → Cigarette displays ($p < .05$). Change detection times did not significantly differ between Cigarette → Cigarette and Pen → Pen conditions, between Pen → Pen and Cigarette → Pen conditions, between Pen → Pen and Pen → Cigarette conditions, or between Cigarette → Pen and Pen → Cigarette conditions ($p > .05$).

For further clarification, paired samples t-tests with Bonferroni corrections ($\alpha = .0125$) were implemented to examine the effect of number of distracters for each type of distracter array (See Figure 2). This method was used because of violations of sphericity in the omnibus F test, which would make the use of simple effects too liberal (Kirk, 1995). There was a significant effect of number of distracters for Pen → Pen displays, $t(42) = 15.88$, $p < .001$; for Pen → Cigarette displays, $t(42) = 10.58$, $p < .001$; for Cigarette → Pen displays, $t(42) = 10.92$, $p < .001$; and for Cigarette → Cigarette displays, $t(42) = 13.86$, $p < .001$. All effects were the same, such that change detection times were significantly faster in 4 distracter conditions than in 16 distracter conditions.

Discussion

Overall, the demographic characteristics of the three tested samples (current smokers, former smokers, never smokers) were quite similar. Notable differences included never smokers being younger than former smokers and current smokers, which is consistent with other studies in this area (e.g., Ehrman et al., 2001). Additionally, never smokers reported the lowest levels of cigarette craving, followed by former smokers, and current smokers reported the highest levels of craving. This result is rather intuitive: never smokers do not have any regular cigarette use and thus essentially no craving for cigarettes, former smokers have previous exposure to cigarettes and thus harbor small but non-zero cravings for smoking, and current smokers of course have the highest levels of craving because they have current and repeated exposure to cigarettes. There were not any other notable differences in demographic characteristics between the three groups.

A notable similarity between smokers and former smokers was smoking behavior. These two groups smoked close to the same number of cigarettes per day on average, and had smoked for close to the same amount of time. It was important that these two groups have similar smoking behaviors in order to ensure that any variation in attentional bias between the two groups was likely due to smoking status alone, and not smoking behavior.

Very few individual differences were found to relate to change detection time. The most notable was that in Cigarette → Cigarette displays with 16 distracters, current smokers who smoked more cigarettes had slower change detection times. Current smokers with higher GPAs also had slower change detection times to this condition. Former smokers' and never smokers' individual differences in regards to demographic characteristics did not relate to change detection times in any condition. These results indicate that basic individual

characteristics generally had no effect on change-detection abilities for these participants, whether it be in regards to attentional bias toward smoking-related stimuli, or basic change detection abilities with neutral stimuli. Two exceptions to this conclusion are that it is possible that heavier smoking habits may lead to slower change-detection times with more complex cigarette arrays, and that smokers with higher GPAs may have slower change change-detection times with more complex cigarette arrays. It is also possible that either or both of these findings are due to random sampling error.

The overall change detection pattern was as follows: participants were able to detect changes faster with 4 distracters than with 16 in every distracter array. Participants were also slower in detecting changes in Cigarette $\rightarrow$ Cigarette conditions overall. Additionally, participants had slower change detection times in same-object changes with displays containing 16 distracters (i.e., Pen $\rightarrow$ Pen and Cigarette $\rightarrow$ Cigarette) when compared to different-object changes (Pen $\rightarrow$ Cigarette and Cigarette $\rightarrow$ Pen), and were faster in picking up changes in Pen $\rightarrow$ Cigarette conditions than Cigarette $\rightarrow$ Pen. Contrary to the hypotheses, this pattern did not differ between smoking statuses. Given that smokers who smoked more cigarettes per day had slower change detection times to Cigarette $\rightarrow$ Cigarette displays with 16 distracters, it is possible that a new sample of current smokers with heavier smoking habits would have resulted in current smokers being slower in Cigarette $\rightarrow$ Cigarette displays with 16 distracters when compared to former smokers and never smokers. In other words, if smokers' change detection times toward the Cigarette $\rightarrow$ Cigarette condition do slow as the number of cigarettes consumed increases, a heavier smoking sample of smokers may have even slower change detection times to this condition as a group. If this was the case, and the change detection times of former smokers and never smokers remained similar, there would

be bigger between-group differences in change detection time toward Cigarette → Cigarette

exposures with 16 distracters. Thus it is possible that individuals with sufficiently heavy

smoking habits were not recruited.

The first goal of this study was to design an effective change-detection task, and to

that end, it was hypothesized that change detection times would be faster in displays with 4

distracters than in displays with 16 distracters. A very clear and strong effect existed, in that

for all distracter array types, change detection times were faster in displays with 4 distracters

than in conditions with 16 distracters. It was also predicted that there would only be notable

variability in displays with 16 distracters, since changes in displays with 4 distracters would

likely be almost immediately apparent to the participants regardless of the stimuli within the

display. Although the variations found in this study were not the ones predicted in advance,

there was still considerable variability in distracter array types with 16 distracters. While

change detection times were slower in Cigarette → Cigarette displays with 4 distracters than

Pen → Cigarette or Cigarette → Pen displays with 4 distracters, this effect was quite small

and was likely only detected due to a very powerful within-subject design. Therefore, it

appears that the design of the manipulation was one that successfully induced a visual search

and thus was an effective change detection task.

The remaining hypotheses were based on the assumption that an effective assessment

of attentional bias toward smoking-related stimuli was designed. Assuming that all smokers

exhibit an attentional bias toward smoking-related stimuli, which has been found in most

previous studies, current smokers should have differed from never smokers in change

detection abilities toward Pen → Cigarette displays and Cigarette → Pen displays with 16

distracters. However, no differences in change detection times toward either of these

conditions between current smokers and never smokers were found. Furthermore, current smokers and never smokers did not differ in the pattern of responses to any condition, regardless of distracter array or number of distracters, which ran contrary to the initial hypotheses.

It was further hypothesized that current smokers would have faster change detection times to Pen → Cigarette trials than toward Pen → Pen trials with 16 distracters, and also slower change detection times toward Cigarette → Pen trials than toward Pen → Pen trials, while never smokers would not have a difference in change detection toward any distracter array type with 16 distracters. Such an effect would have indicated an attentional bias toward smoking-related stimuli. While smokers were faster toward Pen → Cigarette trials than Pen → Pen trials with 16 distracters, they were also faster toward Cigarette → Pen trials than Pen → Pen trials with 16 distracters. In addition, never smokers mirrored this pattern. This runs contrary to the claim that an effective assessment of attentional bias toward smoking-related stimuli was created, although the alternative interpretation is that smokers and former smokers in this study did not have a bias in attention toward smoking-related stimuli, and that the assessment of attentional bias in this study was a valid one.

Given that the latter interpretation contradicts a large body of past research, it appears that an effective measure of attentional bias toward smoking-related stimuli was not created, there was no support to the hypotheses regarding bias levels of each smoking status. As previously mentioned, the current smokers in this study did not show any bias toward smoking-related stimuli. Abstinent smokers proved to be particularly difficult to recruit; due to an insufficient sample size this group was not included in anything but descriptive analyses, and thus there was insufficient data to assess the hypothesis that they would exhibit

a bias in attention toward cigarettes and have lower bias levels than current smokers. In sum, the hypotheses were not supported since no group (most notably not even current smokers) exhibited a bias in attention toward cigarettes or differed from any other group in change detection times within any distracter array type.

In regards to the effect of number of distracters in the array, the results from this study mirror those of Behmer et al. (unpublished), in that change detection times are faster when fewer images are in the array. In Behmer et al.'s study, the researchers examined change detection times with 2 distracters in the array all the way to 20 distracters in the array, and found a strong linear trend such that change detection times were slower as more distracters were added to the array. The conclusion drawn was that with fewer images in the array, the changes would easily pop out to participants and therefore not adequately measure attentional bias, while when there were a greater number of images in the array the participants would have to conduct a visual search to find the changing image amongst the distracters. The findings of their research provided the framework for this current study, and indeed with 4 images in the array participants were able to detect changes very quickly, while when there were 16 images in the array participants took considerably longer to detect changes, indicating that they had to visually search for the changing image. Thus, the results from the current study are consistent with the findings of Behmer et al. (unpublished). Since it appears that an effective change-detection task was created, the next step was to see if the task could measure objects of importance to participants (Rensink et al., 1997; Yaxley & Zwaan, 2007).

Using a flicker paradigm, Rensink et al. (1997) found that participants were able to detect changes more quickly when the change occurred in objects that had been previously

assigned a high level of importance. The current study was not a direct replication of this research, because instead of having participants assign importance to the objects, the importance of the object was expected to be inherent (i.e., the importance of cigarettes to smokers). However, because both studies were based on the same basic principle of important objects being more visually salient to participants, the results were expected to be similar. While the exposure to cigarettes was successfully manipulated, as evidenced by the successful creation of a change-detection task, the results of this current study do not match the results of Rensink et al. (1997) because the pattern of change detection times did not indicate a bias in attention toward smoking-related stimuli for current smokers.

Yaxley and Zwaan (2005) used a change detection task to assess smoking-related attentional bias, and found that a) smokers were able to more quickly detect changes to smoking-related objects than changes to non-smoking objects and b) that smokers were able to detect changes in smoking-related objects more quickly than non-smokers were able to. Their conclusions supported the use of a change detection task when conducting research on attentional bias toward smoking-related stimuli. The current study implemented a change detection task, but did not appear to adequately assess smoking-related attentional bias, and thus cannot directly speak to supporting or disconfirming the results of Yaxley and Zwaan (2005). Furthermore, Yaxley and Zwaan (2005) were far from the first researchers to assess bias in attention toward smoking-related stimuli. Smokers' bias in attention toward smoking-related stimuli has been repeatedly replicated in previous research (Field & Cox, 2008), research that provided the foundation for much of the current study. In almost all published research, smokers have exhibited a tendency to notice smoking-related stimuli more than neutral stimuli and more than individuals who do not smoke. By comparing smokers to non-

smokers, and by presenting both smoking-related and neutral stimuli, support for these previous studies was expected. However, the results of the current research did not replicate these findings, and it appeared that the problem lied in the construction of the change-detection task.

In addition, a handful of prior studies examined former smokers' attentional bias toward smoking-related stimuli by comparing their bias levels to those of current smokers and never smokers (Ehrman et al., 2002; Littel & Franken, 2007; Munfao et al., 2003). For example, Ehrman et al. (2002) found that former smokers exhibited a level of bias similar to current smokers, while Littel and Franken (2007) and Munafo et al. (2003) found that former smokers had null bias levels, and did not differ from never smokers. This study attempted to clarify and expand upon the results of these studies by including different groups of former smokers with different lengths of abstinence, but due to methodological inadequacies, this current study could not appropriately expand upon the findings of previous research. This is partially due to difficulty in recruiting individuals who had very recently quit smoking, and partially because the change-detection task did not effectively measure smokers' bias in attention toward smoking-related stimuli.

The concept of bias in attention toward addictive stimuli is based on the Incentive-Sensitization model of addiction. According to the Incentive-Sensitization model of addiction, smokers associated smoking-related stimuli with reward and thus assign said stimuli a higher level of importance (Robinson & Berridge, 1993). The founders of this model describe it as the process whereby certain stimuli related to the drug become more eye catching, which is what in turn leads to an attentional bias. By not detecting an attentional bias toward smoking-related stimuli in smokers, this current study runs contrary to results

predicted based on the Incentive-Sensitization model of addiction. However, lack of support for this model, and for the studies based on it, appear to be due to the design of the change-detection task.

In order to support the conclusions of earlier research (e.g., Field & Cox, 2008; Rensink et al., 1997; Robinson & Berridge, 1993; Yaxley & Zwaan, 2005), current smokers in this study would have had to respond to changes that involve cigarettes faster than changes that involve pens, with never smokers exhibiting no such pattern. While current smokers were faster to respond to some changes that involve cigarettes (i.e., Pen → Cigarette displays and Cigarette → Pen displays), never smokers' pattern of responses was identical. Never smokers had likely not associated cigarettes with importance, and so it is safe to assume that their pattern of change detection represents the pattern of responses for those who do not have a bias in attention toward smoking-related stimuli. Since smokers' change detection pattern did not differ from never smokers, it appears that the variations in change detection times between distracter arrays were not due to a bias in attention towards cigarettes and thus the change detection task did not effectively measure attentional bias, but rather just change-detection capabilities in general.

Furthermore, in order to support Ehrman et al. (2002) this study would have needed to observe current smokers exhibiting a bias in attention toward smoking-related stimuli, and also the pattern of change detection for former smokers would have had to be the same as the pattern for current smokers but different from never smokers. Conversely, in order to support Littel and Franken (2007) and Munafo et al. (2003), the pattern of change detection for former smokers would have had to be the same as the pattern for never smokers but different from current smokers. There were no observed differences in the pattern of change

detection between any of the three groups, and so the results of this current study run contrary to all former published studies comparing current smokers, former smokers, and never smokers. Again, this could be due to unexpected effects stemming from the design of the change detection task.

In sum, although the results of this current study do not replicate the results of previous studies on smoking-related attentional bias, this current study does not necessarily refute the Incentive-Salience model of addiction or to the idea of smokers' bias in attention toward cigarettes. Additionally, it does not refute the findings of Yaxley and Zwaan (2005), nor does it indicate that the results of Rensink et al. (1997) cannot be generalized to addictive substances. Rather, the differences in findings could be due to an unexpected effect caused by the design of the change detection task. In order to keep the design of the change detection task simple, there were only two types of stimuli: cigarettes and pens. When a visual search was induced, all participants were faster at detecting changes when a different stimulus was introduced into the array (i.e., Cigarette → Pen displays and Pen → Cigarette displays), than when the same stimulus was introduced into the array (i.e., Cigarette → Cigarette displays and Pen → Cigarette displays).

One potential explanation for this effect is that when the distracter images are homogenous (i.e., all of the distracter images are of the same type of object) and the target differs from the distracter images, participants are able to perceive physical differences between the target and the distracters faster than they can interpret the semantic properties of the images in the array. For example, some pens have a clip on their base, and thus their shape differs from the shape of cigarettes. In addition, the colors of pens tend to differ from the colors of cigarettes. If a cigarette target enters and array of pen distracters, participants

may simply notice that an object with a different shape or color has entered the array, and so they can tell that *something* has changed more quickly than they can determine *what* has changed. According to Robinson & Berridge (1993), attentional bias is only possible when people can determine *what* the object is (i.e., discern its semantic meaning), and so if the ability to perceive the physical properties of a target object is faster than the ability to discern its semantic meaning with a homogenous array of distracters, it is not possible to assess attentional bias without some alterations to the task. Hummel (2001) outlines a model of object recognition that in part states that shape perception occurs prior to object recognition, thus indicating that people would notice physical properties of an object prior to identifying what the object is. Thus, it is possible that participants in this study noticed the physical differences between pens and cigarettes prior to identifying specifically what the target image was.

However, all of the images in this study had the same square shape because backgrounds were included in the pictures, and these backgrounds also contained many different kinds of shapes and colors. Every trial (including homogenous Cigarette → Cigarette and Pen → Pen arrays) had a target with the same square border as the distracters and with different shapes and colors within the image compared to the distracters, and yet an effect was only observed with non-homogenous (i.e., Pen → Cigarette and Cigarette → Pen) arrays. Since the physical properties of the whole images within the array were all similar, it does not seem likely that the differences observed were due to the physical appearance of the pictures. It is still possible that the unlike target in non-homogenous conditions was enough of a physical difference to influence change-detection time, but there is another possible explanation.

The results of this study indicate the possibility that individuals may be better able to determine when an object of a different semantic meaning has entered a homogenous array of images (e.g., Pen → Cigarette) than when an object of similar semantic meaning (e.g., Pen → Pen) enters the array. Damian, Vigliocco, and Levelt (2001) demonstrated that participants took less time to name pictures when objects of different semantic categories enter were introduced to a string of semantically similar pictures when compared to objects of similar semantic meaning. They framed their results as objects of similar semantic meaning interfering with perception capabilities, but for the purposes of this study another interpretation is that individuals can pick up on objects that are semantically dissimilar from the a group of images faster than they can pick out an object that is semantically similar. In other words, it isn't that the object is necessarily of different shape or color, but rather that the participant is capable of detecting that the target object is a different kind of object from the distracters, and the ability to detect a different kind of object in a homogenous array supersedes the ability to discern what exactly that object is. This again would result in participants detecting *that* something is changing and not having the opportunity to determine *what* is changing, and thus it would not be possible to measure attentional bias.

Regardless of whether it was the physical or semantic qualities of the target object that influenced the results of this study, future studies that wish to assess attentional bias should use images of multiple neutral (e.g., pens, hammers, forks, etc.) and smoking-related (e.g., cigarettes, lighters, cigarette packs, etc.) stimuli in the array, especially because Yaxley and Zwaan (2005) used an array of various neutral stimuli for their change detection task and were able to effectively measure attentional bias toward smoking-related stimuli. It may also be sufficient to replicate this study, but include distracter arrays that have a mix of cigarettes

and pens. It would furthermore be prudent to display images in black and white in order to remove the possible effect of color salience. In this way there is not an object of different color or shape or semantic meaning intruding on a homogenous image array because the array is no longer homogenous, and participants would likely be able to identify the semantic meaning of the target object itself. If future researchers employ these relatively small changes, they should be able to detect smokers' bias in attention toward smoking-related stimuli using methods similar to the current study's.

It is also possible that all of the participants were unintentionally cued to cigarettes. Though there were precautionary steps to not mention that the image arrays would include cigarettes, the demographics form (completed before the change detection task) included questions about smoking status. Additionally, it was necessary to recruit smokers and former smokers by specifically asking for people who currently smoked or used to smoke, so participants in these groups likely knew the study revolved around smoking in some way. This may possibly also explain why no group's change detection pattern differed from any other group's: if they were all cued toward cigarettes then they would all have a bias in attentional toward cigarettes (Yaxley & Zwaan, 2005). This could also explain why change detection times were faster for Pen → Cigarette displays with 16 distracters than Cigarette → Pen displays with 16 distracters. However, if all groups had an equivalent bias in attention toward cigarettes then they would have either been slower in Cigarette → Pen displays with 16 distracters than Pen → Pen displays with 16 distracters due to interference from cigarettes in the array, or they would have been faster in Cigarette → Cigarette displays with 16 distracters than Pen → Pen displays with 16 distracters because they were paying closer attention when cigarettes were in the array. Since neither was the case, it does not seem

likely that cigarettes were unintentionally cued. Nonetheless, in order to avoid cuing participants to cigarettes it is important for future researchers to minimize mentioning the inclusion of cigarette images to participants in studies such as these, if possible.

Another potential explanation for the lack of smoking-related attentional bias is that the current smokers in the sample did not have enough exposure to cigarettes; smokers in this current study did smoke fewer cigarettes per day (6.97 on average) than has been the average (13.82) for current smokers in similar studies (Barker & Graham, 2011). Robinson and Berridge (1993) stated that repeated exposure to addictive stimuli induces attentional bias toward said stimuli. Perhaps the sample of current smokers in this study simply did not smoke enough cigarettes to induce an attentional bias. It is true that participants who smoked more cigarettes per day had slower reaction times to Cigarette → Cigarette displays with 16 distracters, and no other smoking status elicited this same result. This explanation seems problematic though, because no other distracter array type yielded the same results. Furthermore, the Cigarette → Cigarette displays were the ones that were theoretically the least likely to measure attentional bias, because there were no neutral stimuli in the array. Additionally, those in the group of current smokers were habitual smokers, as evidenced by their measured higher levels of craving toward cigarettes. Therefore, it seems plausible that this group had enough exposure to cigarettes and that the lack of smoking-related attentional bias cannot be adequately explained by the smoking habits of the sample. Nonetheless, the inclusion of heavier smokers in this type of research is key in order to ensure that the sample has had sufficient exposure to smoking-related stimuli.

Additionally, it is still possible that participants may have not been truly addicted to cigarettes, and that the measurement of addiction based on the number of cigarettes smoked,

time spent smoking, and craving level was not sufficient. The DSM-IV text revision's definition of addiction not only include the difficultly in controlling use and withdrawal symptoms, but also includes lifestyle impacts such as neglecting activities and spending time or emotional energy on the habit (American Psychiatric Association [*DSM-IV-TR*], 2000). These latter definitions were not assessed in the current study, and perhaps a more complete operational definition of addiction would be useful in recruiting an appropriate sample of smokers.

It is also possible that this study did not effectively assess smokers' attentional bias toward smoking-related stimuli simply because of random sampling error, or because the effect sizes between the different smoking statuses was not large enough to be detected with the size of the sample. A future identical replication may still yield significant findings, especially if researchers include more participants in each group. Therefore, studies similar to this one could also be conducted with only minor changes.

Another suggestion for future research is to treat abstinence time as a continuous variable rather than a categorical variable. There are statistical limitations when categorizing a continuous variable because variability within the categories is largely ignored. Due to limited recruiting resources, this study had to target specific abstinence times in order to get enough participants to assess smoking-related attentional bias. Given the appropriate recruiting resources, a potentially improved methodology would establish a quit date for current smokers who have expressed a desire for abstinence, and then prospectively track their bias in attention toward cigarettes during the course of their abstinence attempts. Such a design would more directly measure the effect of abstinence on bias in attention toward smoking-related stimuli by eliminating between-subjects variability and by measuring

differences in abstinence times that had been removed by categorizing smoking statuses in the current study.

It is important to note that the results of this study are only generalizable to smokers, and not users of any other addictive substance. The change detection task used here may still prove to be effective with other substances (e.g., opiates, alcohol, etc.), as the attentional bias induced by these substances may be stronger than the effect of introducing a foreign image into a homogenous display. Even if this is not the case, studies similar to this one could be conducted with substances other than nicotine to further expand the understanding of attentional bias toward addictive stimuli.

The results of this study should also not be generalized to older populations. Older smokers may have higher levels of bias in attention toward smoking-related stimuli than younger smokers (Barker & Graham, 2011), and so it is possible that their levels of attentional bias are strong enough to overcome the effect of introducing a foreign image into a homogenous display. Even if their bias levels are not greater, the results still cannot be generalized to older smokers because older individuals have slower reaction times than younger individuals, and this may confound bias scores (Takahara, Miura, Shinohara, & Kimura, 2008).

This study nevertheless presents a couple of important implications. First, this study provides a framework for the development of future change detection tasks, both concerning addictive stimuli and in general. By underscoring the effect of introducing a different object into a homogenous display, future research can design their change detection tasks accordingly and more effectively. Should the researchers wish to develop a task to detect a bias in attention, this current study provides evidence to include multiple types of distracters

in the image array. This study also validates the research by Behmer et al. (unpublished) by replicating the effect that the number of images in the array has on change detection times.

Additionally, this study supports Field and Cox's (2008) advocating of control groups when studying attentional bias toward addictive substances. Without a control group of never smokers to compare current smokers to, it would have been possible to mistakenly conclude that an effective assessment of attentional bias toward smoking-related stimuli had been designed. Because change detection times for Pen → Cigarette displays with 16 distracters were faster than change detection times for the control displays (Pen → Pen displays with 16 distracters), without comparison to the control group of never smokers, it would appear in some ways that this design effectively assessed smoking-related attentional bias. This of course would be an erroneous conclusion, and would have obscured identifying the effect of introducing a different object into a homogenous display. Unfortunately, many previous studies in this area did not include never-smoking control groups (e.g., Bradley et al., 2003; Waters et al., 2003). Therefore, the results of this study support Field and Cox's (2008) encouragement for the inclusion of never-smoking control groups in research on attentional bias toward addictive substances.

In closing, this study reinforces the basic designs of change-detection tasks and provides a framework for future studies to examine bias in attention toward addictive stimuli. It also can be used to help design change detection tasks for studies investigating other visual stimuli (e.g., spiders for arachnophobic individuals). Most importantly, the current study gives direction for the design and conduction of studies on bias in attention toward smoking-related stimuli. A better understanding of this phenomenon, and thus the Incentive-Sensitization model of addiction, can aid in the development of better smoking cessation and

smoking abstinence strategies, and therefore promote healthy behavior in those who wish to

seek it.

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Appendix A

RE: QSU-brief

Hide Details
FROM: Stephen Tiffany
TO: Gordon Barker
Message flagged
Thursday, December 9, 2010 8:07 AM
Message body

Dear Gordon,

Yes, please feel free to use the QSU-Brief in your research. It is available for anyone to use.

Good luck with your research.

Regards,

Steve

Stephen T. Tiffany, Ph.D.
Empire Innovation Professor
Director of Clinical Training
Park 228
Department of Psychology
University at Buffalo, The State University of New York
Buffalo, NY 14260

Email: stiffany@bufflao.edu
Phone: 716-645-0244

==

From: Gordon Barker [mailto:barkerg2@students.wwu.edu]
Sent: Thursday, December 09, 2010 10:22 AM
To: stiffany@buffalo.edu
Subject: QSU-brief

Dr. Tiffany-

Hello. My name is Gordon Barker and I am a graduate student at Western Washington University. For my thesis I am researching smokers' and former smokers' attentional bias towards smoking-related stimuli, and would like to use the Questionnaire for Smoking Urges-brief form (Cox, Tiffany, & Christen, 2001). It is not clear to me if this assessment is copyrighted, but either way I would like your permission before I use it. The research is for my Master's thesis, so it will be put in the library here at WWU and I also intend on submitting it for publication. So, is it okay for me to assess my participant's cigarette craving using the QSU-brief? I appreciate your contributions to the field of addiction, particularly your investigation of the cognitive factors of drug use. Thank you for your time.

Gordon Barker
barkerg2@students.wwu.edu

Appendix B

Questionnaire for Smoking Urges

Please circle the number that indicates how much you agree with each statement.

(1 = Strongly Disagree, 7 = Strongly Agree)

1. I have a desire for a cigarette right now.

    1   2   3   4   5   6   7

2. Nothing would be better than smoking a cigarette right now.

    1   2   3   4   5   6   7

3. If it were possible, I probably would smoke now.

    1   2   3   4   5   6   7

4. I could control things better right now if I could smoke.

    1   2   3   4   5   6   7

5. All I want right now is a cigarette.

    1   2   3   4   5   6   7

6. I have an urge for a cigarette.

    1   2   3   4   5   6   7

7. A cigarette would taste good now.

    1   2   3   4   5   6   7

8. I would do almost anything for a cigarette now.

    1   2   3   4   5   6   7

9. Smoking would make me less depressed.

    1   2   3   4   5   6   7

10. I am going to smoke as soon as possible.

    1   2   3   4   5   6   7

Source: Cox, Tiffany, and Christen (2001).

Appendix C

CONSENT FORM

Project Title: **Differences in Change Detection Capabilities**

Purpose and Benefit:

The purpose of this research project is to better understand the attentional capabilities and visual search capabilities of different groups of individuals. Research of this type is important because it will help clarify the cognitive processes involved in visual searches, and factors that can affect attentional capabilities.

I UNDERSTAND THAT:

1) To take part in this study I must be at least 18 years of age
2) This research study will involve completing a brief demographics questionnaire and then participating in a change-detection task, followed by the completion of another brief questionnaire. It is estimated that the entire process will take between 40 and 60 minutes.
3) There are few risks/discomforts anticipated with participation in this study. These risks/discomforts include the time required to complete the tasks and mental fatigue from participation. Another risk is that current or previous smokers may experience a slight increase in cravings for cigarettes. Steps will be taken before I leave the study to help eliminate any cravings that emerge.
4) Possible benefits to my participation include becoming more informed about the cognitive processes of attention and contributing to the knowledge base of cognitive psychology.
5) In exchange for my participation, I will be entered into a lottery for $50. Additionally, should it be applicable I will receive credit for 1 hour's worth of research participation. If I am not eligible to receive research participation credit, I will be entered into an additional $15 lottery. My email address will be collected at the end of the study to inform me if I have won either or both of these lotteries.
6) My participation in this research is completely voluntary. This includes the right to not complete any particular item on the questionnaire should I find doing so distressful or otherwise problematic. If I do decide to participate, I may withdraw at any time without any explanation. If I do withdraw, I will still receive course credit if applicable, or be entered into a $15 lottery if course credit is not applicable. My data will not be included in the study if I decide to withdraw.
7) All information will be kept confidential. My signed consent form and email address will be kept in a locked cabinet separate from the questionnaire and visual search results. My name will be separated from my responses after I am assigned a participant identity. Only the principal researcher and his research assistants will have access to my name and the information that I provide.

8) It is expected that the results of this study will be shared in the following ways: published article, presentation at a scholarly meeting, and in a thesis defense meeting. A summary of the results will also be available to participants if they contact the researcher after the completion of the study.
9) Data from this study will be disposed of seven years after completion of the study. This will be done by shredding paper materials and erasing electronic data.
10) If you have questions or comments regarding this study, please contact the principal researcher, Gordon Barker, by e-mail at barkerg2@students.wwu.edu. If you have any questions about your participation or your rights as a research participant, you can contact the WWU Human Protections Administrator at (360) 650-3220. If during or after participation in this study you suffer from any adverse effects as a result of participation, please notify the researcher directing the study or the WWU Human Protections Administrator.

****

I have read the above description and agree to participate in this study.

_____ _____

Participant's Signature   Date

_____

Participant's PRINTED NAME

Are you interested in being contacted about future studies?   □ Yes □ No

Appendix D

Demographics

1. Gender (circle one):

Male   Female   Other (please specify):_____

2. Ethnicity (mark one):

_____ Aboriginal/American Indian/Native American

_____ Asian/Asian American

_____ Black/African American

_____ Hispanic/Latino/Mexican/Central American

_____ White/Caucasian/European Descent

_____ More than one ethnicity (please list):_____

_____ Other (please specify):_____

3. Birthday (mm/dd/yyyy): _____

4. Academic Standing (circle one):

Freshman   Sophomore   Junior   Senior

Graduate Student   Faculty   Staff

Other (please specify):_____

5. GPA (overall undergraduate, if applicable): _____

6. GPA (overall graduate, if applicable): _____

7. Do you require corrective eyewear (e.g., contacts, eyeglasses)?

Yes   No

8. If yes, are you wearing it right now?

Yes   No

9. Do you have any physical or health problems that would prevent you from repeatedly pressing a button?

Yes   No

10. Do you currently smoke cigarettes? (circle one)

Yes   No

*If you answered yes to question **10***, *please answer questions **11-14** on page 3.   If you answered no to question **10***, *please skip to question **15** on page 4.*

Answer questions 11-14 if you answered yes to question 10

11. How many cigarettes per day do you typically smoke?

_____

12. When did you start smoking (mm/yy)?

_____

13. Have you ever attempted to stop smoking? (circle one)

Yes   No

14. How many hours ago did you last have a cigarette?

_____

Thank you. You do not need to answer any more questions. Please turn in the questionnaire.

Answer question 15 if you answered no to question 10

15. Have you ever smoked cigarettes regularly? (circle one)

Yes   No

If you answered yes to question 15, please answer questions 16-18 on page 5. If you answered no to question 15, please skip to question 19 on page 6.

Answer questions 16-18 if you answered yes to question 15.

16. Back when you regularly smoked, how many cigarettes per day did you smoke?

_____

17. When did you start smoking (mm/yy)?

_____

18. When did you stop smoking (mm/dd/yy)?

_____

Thank you. You do not need to answer any more questions. Please turn in your questionnaire.

Answer questions 19 and 20 if you answered no to question 15

19. Do you currently live with, or in the past 6 months lived with, someone who smokes at least 5 cigarettes daily? (circle one)

Yes   No

20. How many cigarettes have you had in your lifetime?

_____

Thank you. Please turn in your questionnaire.

Appendix E

Debriefing Form

Project Title: **The Ability of Current Smokers, Abstinent Smokers, Former Smokers, and Never Smokers to Detect Changes in Smoking-Related Stimuli**

Purpose and Benefit:
Thank you for your involvement in this study. We are examining a phenomenon known as **attentional bias**. This is where individuals with certain substance use habits (in this case smoking) develop a bias toward seeing stimuli related to the substance of choice (in this case cigarettes).

As you may have noticed, the majority of trials that you participated in involved at least one cigarette as an image. The theory is that the presence of cigarettes in a picture array affects change detection times for smokers due to their attentional bias toward smoking-related stimuli. The purpose of this study is to examine if this attentional bias disappears following abstinence (hence the involvement of individuals who are used to smoke but no longer do so), and to test the effectiveness of this particular change-detection task as a measurement of smoking-related attentional bias.

The potential benefits of this study are a better understanding of the cognitive processes behind the use of cigarettes, both in current smokers and in former smokers. Results from studies such as this one can aid in the development of cessation and relapse-prevention strategies. Furthermore, change detection tasks have not been frequently used in attentional bias research, so this study can provide support for the effectiveness of such a task.

As mentioned in the informed consent, there is a concern that exposure to smoking-related stimuli can induce cigarette cravings in both individuals who smoke and in individuals who used to smoke. Therefore, if you are an individual who used to smoke cigarettes I must ask you to remain with me for 20 more minutes to allow for any potential cravings to subside. You will also be provided with a few resources you can utilize should you have any concerns about any cravings toward cigarettes.

Thank you very much for you participation in this study. Your assistance is greatly appreciated. If you have questions or comments regarding this study, please contact the principal researcher, Gordon Barker, by e-mail at barkerg2@students.wwu.edu. If you have any questions about your participation or your rights as a research participant, you can contact the WWU Human Protections Administrator at (360) 650-3220. If after participation in this study you suffer from any adverse effects as a result of participation, please notify the researcher directing the study or the WWU Human Protections Administrator.

Appendix F

Resources

WWU Prevention and Wellness Services

Old Main 560

(360) 650-2993

pws@wwu.edu

Washington State Health Department of Health Quitline

1-800-QUIT-NOW (1-800-784-8669)

http://www.quitline.com/

FREEDOM Tobacco Cessation Program

Peace Health St Joseph Vascular Surgery Clinic

2950 Squalicum Parkway, Suite B

Bellingham, WA 98225

(360) 788-6063

Bellingham Hypnosis Center

1523 - 4th Street

Bellingham, WA 98225

www.bellinghamhypnosis.com

(360) 734-9191

Table 1

Current Smokers' Bivariate Correlations of demographic variables and Change Detection Times For Each Distracter Array Type

Demographic Variable	Cigarette --> Cigarette		Cigarette --> Pen		Pen --> Cigarette		Pen --> Pen	
	4 Distracters	16 Distracters	4 Distracters	16 Distracters	4 Distracters	16 Distracters	4 Distracters	16 Distracters
GPA	-.236	.561*	-.034	.006	-.061	.211	-.170	.386
QSU-brief scores	-.156	.202	-.368	.038	-.278	-.389	-.338	.034
Cigarettes/day	-.124	.629*	-.168	.295	-.293	.103	-.187	.390
Years Smoked	-.143	.062	.022	-.043	-.137	.234	-.015	.264
Last Cigarette	-.184	-.054	-.265	-.055	.096	-.097	-.088	-.333

Note. GPA = grade point average, QSU-brief scores = scores on the Questionnaire for Smoking Urges-brief form (used to assess craving levels), Cigarettes/day = former smokers' average number of cigarettes smoked per day before abstinence, Years Smoked = number of years the former smoker smoked prior to smoking cessation, Last Cigarette = number of hours that have passed since the current smoker last had a cigarette. N = 15.

* p < .05

Table 2

Former Smokers' Bivariate Correlations of demographic variables and Change Detection Times For Each Distracter Array Type

Demographic Variable	Cigarette --> Cigarette		Cigarette --> Pen		Pen --> Cigarette		Pen --> Pen	
	4 Distracters	16 Distracters	4 Distracters	16 Distracters	4 Distracters	16 Distracters	4 Distracters	16 Distracters
GPA	.390	-.210	-.202	.050	.414	-.149	.014	-.235
QSU-brief scores	.356	.286	.130	-.090	.053	.186	.006	-.142
Cigarettes/day	.324	.044	-.164	-.026	.130	.141	.254	.253
Years Smoked	.542[t]	.222	.081	-.146	.151	.081	.355	.149
Time Abstinent	.231	-.057	.422	.127	.015	.027	.164	-.271

Note. GPA = grade point average, QSU-brief scores = scores on the Questionnaire for Smoking Urges-brief form (used to assess craving levels), Cigarettes/day = former smokers' average number of cigarettes smoked per day before abstinence, Years Smoked = number of years the former smoker smoked prior to smoking cessation, Time Abstinent = number of months that have passed since the former smoker last had a cigarette. N = 13.

[t]*p < .10*

Table 3

Never Smokers' Bivariate Correlations of demographic variables and Change Detection Times For Each Distracter Array Type

Demographic Variable	Cigarette --> Cigarette		Cigarette --> Pen		Pen --> Cigarette		Pen --> Pen	
	4 Distracters	16 Distracters	4 Distracters	16 Distracters	4 Distracters	16 Distracters	4 Distracters	16 Distracters
GPA	-.291	-.050	-.246	-.281	-.300	.040	-.313	.082
Total Cigarettes	-.158	.061	-.199	.153	-.267	-.052	-.226	-.040
QSU-brief scores	-.209	.076	-.198	-.154	-.252	-.098	-.274	-.256

Note. GPA = Grade point average, Total Cigarettes = the total number of cigarettes the non-smoker has had in his or her lifetime, QSU-brief scores = scores on the Questionnaire for Smoking Urges-brief form (used to assess craving levels). N = 15.

Table 4

Average Median (SD) Change Detection Times

Distracter Array Type	Number of Distracters	Smoking Status			Marginal Mean
		Current Smokers (N = 15)	Former Smokers (N = 13)	Never Smokers (N = 15)	
Pen → Pen	4 Distracters	1.87 (0.64)	1.51 (0.31	1.62 (0.51)	1.67
	16 Distracters	5.20 (1.75)	4.72 (1.17)	4.01 (0.90)	4.64
Pen → Cigarette	4 Distracters	1.61 (0.49)	1.50 (0.34	1.58 (0.50)	1.57
	16 Distracters	2.97 (0.98)	2.53 (0.93)	3.04 (0.84)	2.86
Cigarette → Pen	4 Distracters	1.69 (0.47)	1.56 (0.45)	1.63 (0.59)	1.63
	16 Distracters	3.67 (1.25)	3.03 (1.22)	3.08 (1.00)	3.27
Cigarette → Cigarette	4 Distracters	1.80 (0.49)	1.74 (0.37)	1.70 (0.49)	1.75
	16 Distracters	5.51 (1.91)	4.89 (1.56)	4.72 (1.36)	5.05
	Marginal Mean	3.04	2.69	2.67	

Marginal Means

Pen → Pen = 3.16

Pen → Cigarette = 2.22

Cigarette → Pen = 2.45

Cigarette → Cigarette = 3.40

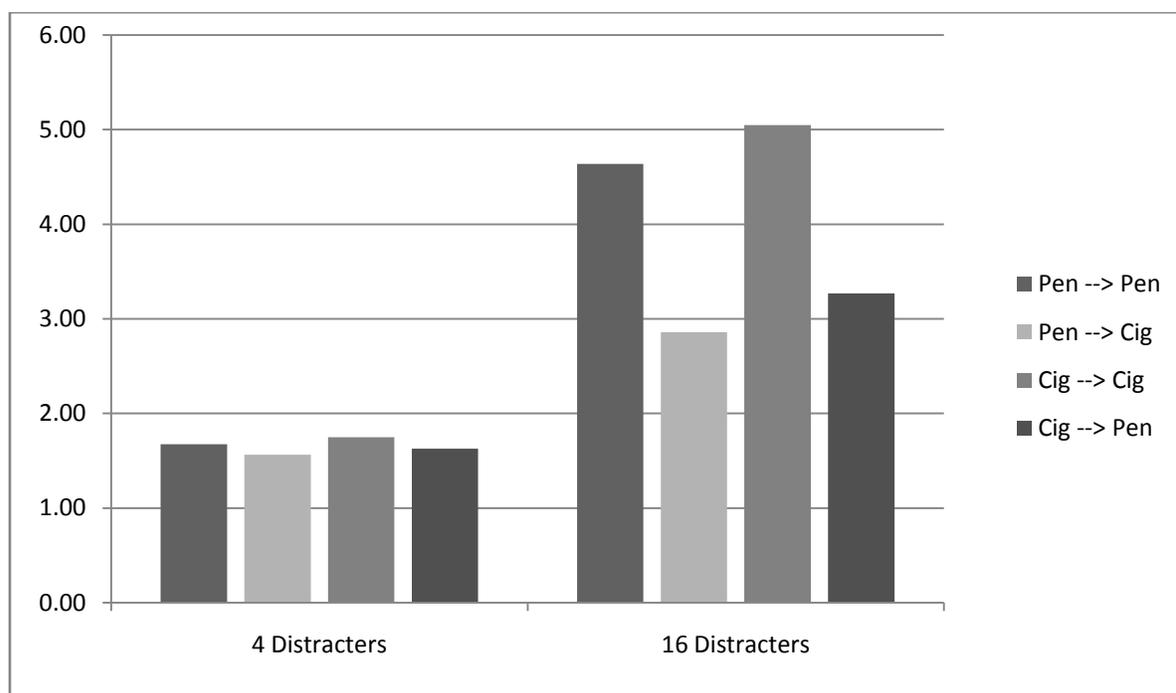4 Distracters = 1.66

16 Distracters = 3.96

Figures

Figure 1. Change Detection Times for Distracter Array Types with 4 Distracters and 16 Distracters.
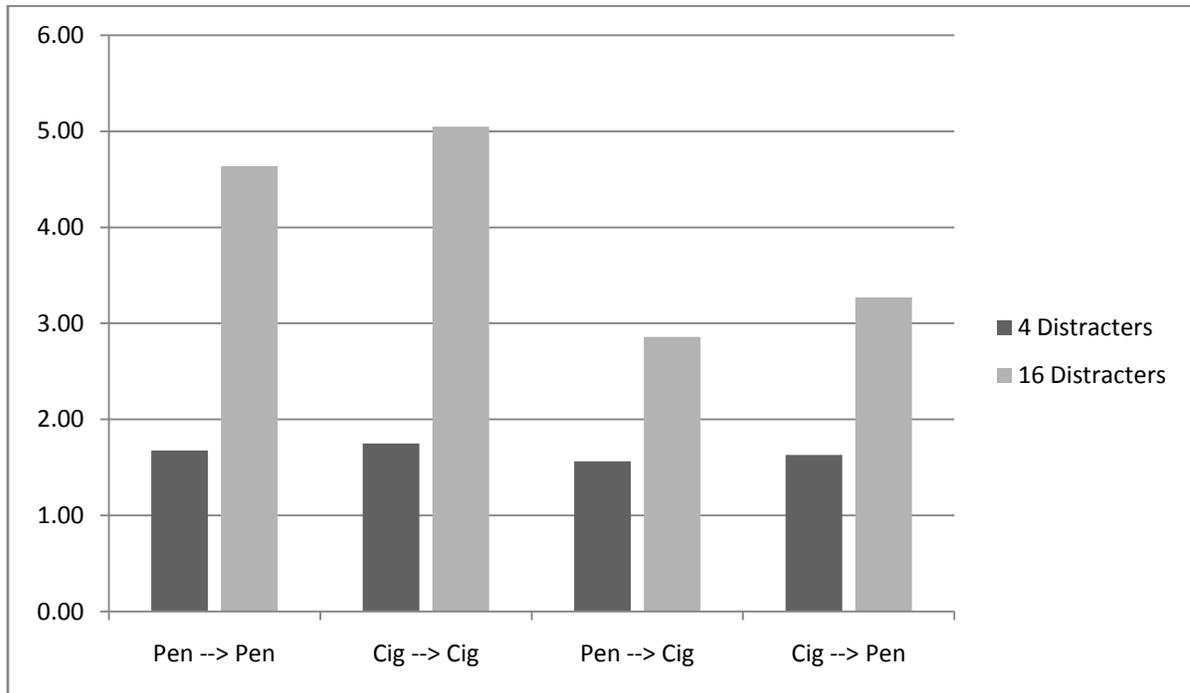
Figure 2. Change Detection Times for 4 Distracters and 16 Distracters at Each Distracter Array Type