The Smoking Stroop Task: Attentional Bias towards Smoking-Related Stimuli in Student Smokers

Ava Ivitsky Molleson **University of Groningen**

Evidence suggests that an automatic attentional bias for substance-related environmental stimuli plays a major role in the provocation of cravings and, therefore, in the maintenance of addiction (Davey, 2015; Franken, Kroon, Wiers & Jansen, 2000). A modified Smoking Stroop Task was used to measure the amount of attentional bias exhibited by smokers and nonsmokers. The aim of this study was to determine whether smokers could be distinguished from nonsmokers by their attentional bias (measured in reaction time). Uniquely, only student smokers (n=29) and nonsmokers (n=46) were recruited. As hypothesised, smokers were found to exhibit an attentional bias that nonsmokers did not exhibit. However, this difference was hard to detect due to high unsystematic variance. Thus, more research with a larger sample size and more stringent inclusion requirements is necessary to settle whether or not the Smoking Stroop Task designed for this thesis is a suitable tool for distinguishing smokers from nonsmokers.

The nature of addiction has been a fruitful subject for investigation across many disciplines largely because, as of yet, we seem not to have reached a consensus as to how much agency an addict has. Academic inquiry spanning the entire disciplinary spectrum, from free will philosophy to class struggle to genetics, has contributed to the debate on to what extent addiction is a choice (Heyman, 2009; Leshner, 1999; Coyne & Hall, 2017; Davey, 2015). On the one side of the debate is the idea that "behavior is driven by a compulsive craving for the drug" not a "voluntary" choice (Leshner, 1999). While on the other side of the debate is the idea that addicts do have agency over their decisions to keep using substances and can choose to stop (Heyman, 2009). Our current reality is more aligned with this latter stance, substance use disorder is more stigmatised than other psychiatric disorders and taking or carrying many addictive substances is punishable by sizable prison sentences, although this varies from country to country (Yang, Wong, Grivel & Hasin, 2017; gov.uk, 2020; Loyns, 2016). Whether our current treatment of addicts is warranted or cruel is dependent on whether addicts have agency over their decisions to continue to use substances or not (Heyman, 2009).

The main arguments on both sides of the debate largely revolve around the relationship between automaticity and intention. There is evidence that much of human behaviour is a result of unconscious, automatic processes triggered by environmental stimuli, rather than being the result of calculated choices (Meyers, 2014). Addictive behaviour is often taken as an example of such environment-dependent, automatically-governed behaviour (Tiffany, 1990; Lumer, 2017). This poses obvious challenges to traditional ideas of intentionality and responsibility; if an addict uses a substance despite having the intention not to then can he/she be held responsible for that action (Lumer, 2017)?

The answer to this question is dependent on to what extent automaticity negates responsibility (if at all). Perhaps this is a question best left to the philosophers, however, the neurological nature of automaticity very much informs this discussion. Neuroscientific and psychological evidence that cravings may be provoked by an *automatic* attentional bias is crucial to understanding the role that automaticity plays in substance-use behaviour (Canamar & London, 2012; MacLeod, 1991; Tiffany, 1990). The following pages will delve into the nature of this automatic attentional bias in addicts from a neurological standpoint, however, one should not lose sight of the larger societal implications of scientific inquiry into the automatic processes involved in addiction and cognition generally; how addicts are treated very much depends on how addiction is understood or conceptualised (Leshner, 1999).

One paradigm which has contributed greatly to our understanding of attentional bias and has allowed quantitative measurement of this phenomenon is the Stroop Task (Scarpina & Tagini, 2017). There are a great many modifications of the Stroop Task, amongst this multitude are addiction-specific modifications tailored to measuring the attentional bias underlying cravings called Addiction Stroop Tasks (MacLeod, 1991). This thesis will focus on one of the more prevalent Addiction Stroop Tasks, the Smoking Stroop Task (SST) which is, as the name suggests, tailored to nicotine addiction. This task quite elegantly demonstrates the existence of the automatic attentional bias which underpins the previously outlined debate (Cox, Fadardi & Pothos, 2006). In the following paragraphs I will outline the foundational theory and literature on the original Stroop Colour and Word Task (SWCT), the Emotional Stroop Tasks and finally the SST. This is roughly a chronological evolution of the various modifications that lead to the SST.

The original SCWT was proposed by J Ridley Stroop in 1935 in the second experiment of his paper *Studies of Interference in Serial Verbal Reactions*. The task involved presenting participants with colour words printed in different colours of ink, the participant then had to name the colour of the ink rather than the word written. For example, if the word "brown" was presented printed in red ink then the participant had to say "red" not "brown" in order to be correct (Stroop, 1935). If the word and the ink colour did not match (as in the previous example) the stimulus is said to be *incongruent*. If the stimulus does not contain a mismatch between the word and the colour of the ink then the stimulus is *congruent* (Stroop, 1935). The most common and well-established setup of congruent stimuli in the SCWT is colour words printed in the same colour as the word reads, for example "red" printed in red ink (Scarpina & Tagini, 2017). This differs slightly from the original setup of congruent stimuli used by Stroop himself; Stroop used colour words printed in black ink (MacLeod, 1991; Stroop, 1935). The task is surprisingly difficult as when one is presented with an incongruent stimulus the task of reading the word interferes with the task of naming the colour of the ink (Scarpina & Tagini, 2017). It is much easier to respond correctly to congruent stimuli as there is no interference generated; congruent stimuli act as a control for the task of naming the colour when there is no interference from the word written (Stroop, 1935). The slower reaction time (RT) associated with increased interference of "word stimuli upon naming colors" in incongruent trials allows the interference effect of the stimulus to be measured in time (Stroop, 1935). For each participant the average RT of responding to congruent stimuli (e.g., the word "yellow" printed in yellow) can be subtracted from the average RT of responding to incongruent stimuli (mismatch between the word and the ink colour) to get the Stroop Effect. The Stroop Effect is a measure of the ability to inhibit automatic responses, known as inhibitory control functioning (PsyToolKit, 2019; Domier et al., 2007). Scoring methods of the Stroop Effect is one aspect in which modifications differ greatly, however RT and accuracy are most common (Scarpina & Tagini, 2017). Additionally there are many studies that explore the effect of different conditions on the Stroop Effect. For example, Stroop examined the effect of practice on the phenomenon that he observed in his original version of the SCWT and found that 8 days of practice could reduce cognitive interference and, subsequently, reduce the Stroop Effect observed (Stroop, 1935).

The Stroop Effect has become one of the best-known and most-studied psychological phenomena. This is largely because, as previously mentioned, the SCWT is thought to robustly demonstrate something fundamental about attention (MacLoed, 1991). In his paper, *Half a Century of Research on the Stroop Effect: An Integrated Review*, Colin M. MacLoed (1991) gives an articulate synopsis of the main theories in the abundant literature explaining the Stroop Effect and what it reveals about attention. Despite the paper being written in 1991, it is still cited as giving an accurate account of the theories on the Stroop Effect (PsyToolKit, 2019). The first theory discussed by MacLoed is the Relative Speed-of-Processing Theory. This theory hypothesizes that the task of reading words is performed faster than the task of naming colours (MacLeod, 1991). The faster process interferes with the slower process (Forin & MacLeod, 2017). The second prominent theory that MacLeod described is Automaticity Theory. This theory relies on the premise that naming the colour requires far more attention than reading the word. Automatic processes generally require less attention, thus, the asymmetry of attention required implies that colour naming is a less automatic task than word reading. The more automatic task interferes with the less automatic task (MacLoed, 1991). A plausible reason that naming the colour is a less automatic task is that it is novel. Novel tasks are less automatic but with practice tasks can become more automatic, which demonstrates the role of learning or practice in how automatic a task is (Cohen, 1990; Stroop, 1935). It is difficult to refute or confirm Automaticity or Relative Processing-Speed theory as we lack ways to measure automaticity and at what point interference occurs (MacLeod, 1991). However, Automaticity Theory is particularly important to understanding that automatic information processing, such as reading a word, grabs one's attention impulsively due to requiring little or no attention to execute (MacLoed, 1991; Franken, Kroon, Wiers & Jansen, 2000). It then requires effortful "attentional-allocation" (or selective attention) to direct one's efforts towards the processing of the desired information (MacLoed, 1991). In this way the Stroop Effect demonstrates a fundamental relationship between attention and automaticity.

Both Relative Speed-of Processing and Automaticity Theory are sequential in that cognitive processing was thought to be done in distinct stages, however more recent science moves away from this idea and towards conceptualising cognition with network models (known as *connectomics*) (Fornito, Zalesky & Bullmore, 2016). Connectomics puts emphasis on "neural context" rather than viewing processes or functions as distinct or isolated (Mcintosh, 2000; Kalan et al., 2007). Most noteworthy in the time of MacLoed was a parallel distributed processing model proposed by Jonathan Cohen, Kevin Dunbar and James McClelland (1990).

The model is a multilevel network corresponding to the activation pathways involved in the processing of the two tasks in the SCWT, naming the colour and reading the word. The input of the two different tasks (reading and naming) in a single stimulus simultaneously activates two pathways in the network that may intersect, causing conflicting activation or interference (Cohen, Dunbar & McClelland, 1990; MacLeod, 1991). They stress that automaticity and selective attention ("control") both play vital roles in the Stroop Effect; both alter the "strength of processing" of a particular task in the network (Cohen, Dunbar & McClelland, 1990; MacLoed, 1991). Although the model by Cohen, Dundar and McClelland was designed in the 1990 it is still very topical. However, in 2002 Marsha Lovett designed another model of the Stroop Effect called *Not Just Another Model of Stroop (NJAMOS)* which also included parallel information processing but additionally integrated learning and goal-orientated cognition (Lovett, 2002). Lovett's model also accounts for the fact that participants will use different strategies at a "high-level" to try to counter "low-level attentional phenomena" (Lovett, 2002). Such connectionist network models are very exciting and integrate the soundest parts of previous theories to create a more holistic model of the information processing involved in the Stroop Effect (Lovett, 2002).

In order to examine the effect of an attentional bias a slightly different setup from the SCWT is required. The Emotional Stroop Task (EST) is a modification of the SCWT whereby participants are presented with salient words and neutral words rather than colour words (Williams, Mathews & Macleod, 1996). An attentional bias for stimuli which are emotionally salient causes increased latency in naming the colour when the word printed is salient to that individual (Muris & Merckelbach, 1998). For example naming the colour of the word "grief" may take longer as the word is emotionally charged (thus, salient) (Williams, Mathews & Macleod, 1996). Macleod explains the reason for this latency concisely, "the more meaningful the ... word, the more interference it caused" (MacLoed, 1991). An attentional bias towards the semantic content of the stimulus hinders the naming of the colour because one struggles to effortfully shift attention away from the word, essentially exhibiting abnormal patterns of selective attention (Franken, Kroon, Wiers & Jansen, 2000).

Some words, such as "grief" may be emotionally salient to all of us, however, ESTs are usually tailored to examine attentional bias in certain psychopathologies (Williams, Mathews & Macleod, 1996). An attentional bias for condition-related words can be detected using different versions of the EST in many target groups, including those with anxiety, eating disorders, phobias, alcohol dependency or even gambling addictions (Franken, Kroon, Wiers & Jansen, 2000). Here we see that the attentional bias towards addition-related cues exhibited by addicts is similar to that exhibited by those with other psychopathologies. Attentional biases are thought to play an important role in the development and maintenance of psychopathologies (including addictions) due to the creation of a positive feedback loop which constantly reinforces the condition (Williams, Mathews & MacLeod, 1996). For example, an individual with anxiety may be subconsciously hyper-perceptive to tiny threats in their environment (an attentional bias) which leads them to panic which, in turn, leads them to further over-attend to any threat (Williams, Mathews & MacLeod, 1996). It is obvious how this vicious cycle can be applied to addicts, cues trigger cravings and cravings make cues even more salient.

Exactly what words are used in salient and neutral stimuli varies between ESTs as there is no set standard even for particular target populations. However, there are some limitations that should be taken into consideration when designing an EST. Words that occur more frequently in the English language create more interference than less frequently occuring words, thus, salient and neutral words must be matched for frequency (Cox, Fadardi & Pothos, 2006). Additionally, the salient words will belong to a semantic category (for example, panic-related words) and, thus, so too should the neutral words so as to control for internal priming (Cox, Fadardi & Pothos, 2006). For example, neutral words may all be household objects (Mogg & Bradley, 2002).

The EST allows for attentional bias to be quantified; once an EST has been completed, the Emotional Stroop Effect can be calculated by subtracting the RT to name the colours of neutral words from RT to name the colours of emotional words, just as congruent is subtracted from incongruent in the SCWT (Mathews, Williams & MacLeod, 1996). The Emotional Stroop Effect is a quantitative measure of "attentional bias toward threatening or emotional information" (Frings & Englert, 2010). Calculating the Emotional Stroop Effect means that groups can be compared and changes within individuals can be tracked in terms of the amount of attentional bias exhibited (Mathews, Williams & MacLeod, 1996; Cox, Fadardi & Pothos, 2006) .

While ESTs are very similar methodologically to SCWT, there are a few important differences. The first is linked to the fact that ESTs demonstrate an attentional bias for salient stimuli whereas the SCWT does not; the nature of the interference is different (Mckenna & Sharma, 2004). In ESTs there is no conflicting semantic interference of word meaning on the task of naming the colour as in the SCWT (e.g "red" and blue), instead there is attentional interference of emotional content on the task of naming the colour (McKenna & Sharma, 2006). In other words, there is no conflict but rather a distraction (Cox, Fadardi & Pothos, 2006). Secondly, EST studies on different groups show very different amounts of interference, for example studies on those with Posttraumatic Stress Disorder (PTSD) generally demonstrate a high amount of interference compared to other psychopathologies (McKenna & Sharma, 2004). This highlights that the groups studied using ESTs are very heterogeneous and so comparisons of results between ESTs performed on different target populations may not be appropriate. Thirdly, emotional interference is quickly eliminated with time and so response times should be limited to ensure that initial emotional interference can be measured (Sharma & McKenna, 2001). These are important factors to consider when designing and interpreting an EST.

As previously stated, the Smoking Stroop Task (SST) is one of the many modified versions of the EST. As the name would suggest, the SST is for investigating attentional bias in nicotine dependent participants (Canamar & London, 2012). As previously established attentional bias plays an important role in addictive behaviour. To reiterate, addiction-related cues in an addict's environment automatically grab their attention and incite cravings which, in turn, intensify the attentional bias (Davey, 2015; Field, Rush, Cole & Goudie, 2006). Cravings pose a major challenge to abstinence and can be triggered by anything from a person or place to an object that somehow resembles the substance (Canamar & London, 2012; Davey, 2015). The SST essentially exposes participants to cues in the form of words related to smoking. Smoking-related stimuli grab the smoker's attention because of their subjective salience causing latency in naming the colour of smoking-related words (Field, Rush, Cole & Goudie, 2006).

Most SST studies explore the effect of abstinence on attentional bias (Mogg & Bradley, 2002; Canamar & London, 2012; Domier et al., 2007; Gross, Jarvik & Rosenblatt, 1993; Cox, Fadardi & Pothos, 2006). There is quite some evidence that abstinence increases the attentional bias measured in the SST; generally the effect size is greatest in experiments that compared abstinent smokers with non-abstaining smokers or nonsmokers (Canamar & London, 2012; Cox, Fadardi & Pothos, 2006). Abstaining smokers may exhibit a more pronounced attentional bias due to increased cravings making smoking-related words harder to ignore (Mogg & Bradley, 2002). Additionally, sudden abstinence is thought to reduce cognitive efficiency while resumption after abstinence is thought to have the opposite effect and increase cognitive efficiency (Azizian, Nestor, Payer, Monterosso, Brody & London, 2009). Thus, recent smoking may enhance cognitive performance in the test, counteracting the latency in response caused by the smoking-related cues (Fehr, Wiedenmann, & Herrmann, 2006). Thus, smokers who have recently smoked may not perform very differently to nonsmokers.

Manipulating abstinence is not the only way to increase interference. Firstly, heaviness of smoking is also often associated with increased interference although less so than abstinence (Cox, Fadardi & Pothos, 2006; Zack et al., 2000; Mogg & Bradley, 2002). Secondly, sequencing trials in blocks of stimulus type so that addiction-related stimuli are presented separately from neutral stimuli rather than in a random order increases interference; if presented in a random order, distraction and latency caused by a salient stimulus can carry over onto the next neutral stimulus causing a latency on that trial too (Cox, Fadardi & Pothos, 2006). The effect of an attentional bias for smoking-related stimuli on latency during presentation of the stimulus is known as the fast effect, while the effect of the attentional bias on the succeeding stimulus is known as the slow effect (Cane, Sharma & Albery, 2009). Blocking essentially controls for the slow effect of an attentional bias. Unsurprisingly given that cues in the environment incite cravings, the environment that smokers take the SST in also has an effect on their attentional bias. For example, if smokers are in a room with someone smoking a cigarette then their latency will likely increase (Field, Rush, Cole & Goudie, 2006). SST studies vary greatly in methodology and in experimental design and so there is no standard SST; this experiment will use a particularly thorough and articulate SST study by Karin Mogg and Brendan Bradley (2002) as a template.

Part of the variation in experimental design is in the definition of a smoker; what constitutes a smoker seems to differ greatly between studies. The definitions given by the Center for Disease Control and Prevention in their National Health Interview Survey are as follows: *smokers* are those who have smoked more than 100 cigarettes in their lifetime and smoke most days while *nonsmokers* are those who have smoked less than 100 cigarettes in their lifetime (NHIS, 2017). However, studies exclude many participants who fulfill the medical definitions and instead place quotas and requirements on smoking habit characteristics to ensure that there is discrepancy between smokers and nonsmokers (Cox, Fadardi & Pothos, 2006; Canamar & London, 2012; Domier et al., 2007; Field, Rush, Cole & Goudie, 2006). The most common requirement is smoking at least x cigarettes on average per day; however, x can be any number from 1 to 15 (Mogg & Bradley, 2002; Canamar & London, 2012; Munafo, Mogg, Roberts, Bradley & Murphy, 2003). A minimum of 2 years of regular smoking is also sometimes a requirement (Canamar & London, 2012; Domier et al., 2007). In more complicated studies additional measures such as urge to smoke (as measured by a visual analog scale), dependence (as measured with the Fagerstrom Test for Nicotine Dependence) and breath carbon monoxide levels (as measured by the Bedfont Smokerlyzer) help to account for individual variation between smokers (Mogg & Bradley, 2002). Studies which include many additional variables are often looking to add to the body of knowledge on what predicts attentional bias in smokers.

Lastly, it has been shown that age may increase latency in the SCWT due to slower processing speed in older individuals (West & Alain, 2000). However, very recent studies suggest that age may have the opposite effect in ESTs such that interference may be more pronounced in young people compared to older people, however, thus far, this has only been demonstrated in a classic EST (using negatively charged stimuli on a non-clinical population), a PTSD Stroop Task and (less conclusively) an Alcohol Stroop Task (McAteer, Hanna & Curran, 2018; Beilecki, Popiel, Zawadzki & Sedek, 2017; Ashley & Swick, 2009). The only investigation into the effect of a young demographic on the SST might be a study by Zack et al, (2000) called *Effects of Abstinence and Smoking on Information Processing in Adolescent Smokers* which, as the name suggests, looks into attentional bias in abstaining adolescent smokers. Thus, age is a rather neglected area of study. In this sense studies exclusively recruiting a certain age group are unusual but valuable as, if age is negatively correlated with attentional bias in ESTs, it is methodologically sound to control for age.

Taking into consideration all of the above, this paper will explore if the SST can be used to discriminate between smokers and nonsmokers in a student population. Considering the previously laid out research I hypothesis that smokers will have an attentional bias towards smoking-related cues which is not present in nonsmokers. In order to test this hypothesis smokers and nonsmokers will be asked to name the colour of smoking-related words (cues) and neutral words in an SST. Smokers will respond slower to smoking-related words than neutral words as compared to their nonsmoker counterparts, making the two groups distinguishable.

Method

Participants

75 participants (26 males and 49 females) were recruited through snowball sampling; a link and participant requirements were posted on my personal facebook page and in WhatsApp groups and were encouraged to be shared and re-shared. 46 participants (61.3%) were nonsmokers and 29 (38.7%) were smokers; ex-smokers were excluded from the study (as per the Center for Disease Control and Prevention definitions). Participants were University students aged 17-27 years. The mean age of smokers was 22.1 years and the mean age of nonsmokers was 21 years and 3 months. Participants were required to have normal colour vision. As per the Center for Disease Control and Prevention definition, smokers were required to have smoked more than 100 cigarettes in their lifetime and smoke most days; additionally, the number of cigarettes smoked per day, number of years of smoking and current abstinence level were recorded.

Materials

The SST used was programmed using the open source online software PsyToolKit (https://www.psytoolkit.org/). A classic Stroop task was used as a template and modified to be a SST. The final SST was based on one by Mogg and Bradley (2002) with 12 neutral words [blanket, garage, shampoo, handle, sofa, curtain, switch, bathroom, vase, hallway, duster and lounge] and 12 smoking-related words [cigarette, fags, lighter, matches, inhale, ashtray, smoke, nicotine, cigar, tobacco, puff and filter] (Mogg & Bradley, 2002). The word *fags* was replaced with *butt* due to the fact that fags is a British slang word that is not suitable for the a mixed nationality study. *Duster* was replaced with the word *carpet* because a duster is a rather old fashioned item that students will not own, thus, will not use often. Carpet and butt are matched with duster and fags in terms of word length but could not be matched for frequency. However, carpet and butt are of very similar frequency (Corpus of Contemporary American English, 2010). All other words were matched for word frequency (Field, Rush, Cole & Goudie, 2007).

Each stimulus consisted of a single word in coloured lettering, arial font, on a black background. All 24 words displayed once in each colour (yellow, green, blue and red) resulting in a total of 96 distinct stimuli. Each stimulus was displayed once individually in a random order of words and colours making for 96 trials. The SST was embedded in a survey which asked for age, gender and smoking status; if the participant was a nonsmoker then the survey jumped straight to the SST; however, if the participant was a smoker, additional questions gauging deprivation, heaviness and number of years of smoking were asked before the SST began. The experiment could be run on any laptop or computer but not a phone as a separate keyboard was necessary to measure the RT of the participants' response. The experiment ran through the link https://www.psytoolkit.org/cgi-bin/psy2.6.1/survey?s=BxjMB and so required internet access and a browser.

Design

There was one between-subject variable (smoker and nonsmoker) and one within-subject variable (smoking-related words and neutral words). Thus, the factors were smoking status and stimulus type. The dependent variable was RT. Three moderator variables were accounted for in smokers: heaviness of smoking, current deprivation from smoking and length of time of smoking habit. Deprivation was measured in hours since the participant's last cigarette, heaviness in how many cigarettes on average the participant had smoked per day over the last month and the number of years of smoking was measured by the age that the participant started smoking (as per the definition from the NHIS).

Procedure

The experiment began with an information and informed consent slide which acted as a briefing. The informed consent included that the test was not suitable for those who are very colour blind. In order to proceed participants had to tick the box which was labeled "I give formal consent". The SST was embedded in a survey as outlined in the *Materials* and *Design*. Once the survey had been completed the SST displayed full screen on the participant's laptop or computer. Two instruction slides were displayed. The first explained the task of naming the colour not the word and explained that the participant should respond by pressing the keyboard key corresponding to the first letter of the colour of the lettering; an example was given from the original SCWT, if the word "green" is printed in red then the correct response is to press the "r" key on the keyboard. The second instruction slide established what keys must be pressed with examples from the original SCWT; "r" for red lettering, "g" for green lettering, "y" for yellow lettering and "b" for blue lettering. The participant had to press the spacebar once they had read the instructions. The trials then started. Only one stimulus was displayed at a time. The time it took for the participant to press the keyboard key corresponding to the first letter of the colour was automatically recorded for each trial as RT. If the correct key was pressed the "correct" feedback slide would appear, if not the "incorrect" feedback slide would appear. After the feedback slide the fixpoint slide (a white cross on a black background) was displayed for 0.5 seconds before the next stimulus was displayed (with a 0.2 second pause before and after the fixpoint so that it appeared to flash once). Each stimulus was only displayed for 2 seconds, after which the participant could not answer and the "incorrect" feedback would be given. Thus, there was substantial time pressure. The accuracy, number of correct or incorrect (even if only due to timeout) responses, was also automatically recorded along with the RT.

Once the participant had completed all 96 trials in a random order the average RT for smoking-related words and neutral words were separately calculated by the program. The final slide displayed the participants average smoking-words and neutral words RT in ms and displayed the sentence "Your Stroop effect is smoking-related words minus non-smoking-related words: [insert participants Stroop Effect] ms". The program did the calculation for each participant. The participant could then close the tab.

The online software that the experiment was designed and run on automatically recorded the data for each participant and made an .xls spreadsheet with the survey results and .txt files with the SST results for each participant. Participants were not given a unique code and were therefore anonymous.

Results

Participant Characteristics

222 potential participants clicked on the link, however, only 76 participants fully completed the experiment. Thus, 147 incomplete experiments were excluded from the analysis. Additionally the first complete experiment was a trial run to see if the experiment worked properly and so this data set was also excluded. This left 75 complete data sets (N=75).

Analysis of the characteristics of smoking habits of the 29 smokers who completed the experiment revealed a large amount of variation between smokers. The average and standard deviation (*SD*) of heaviness of smoking, number of years of smoking and abstinence from smoking were calculated. Smokers consumed an average of 8.85 cigarettes per day (*SD*=5.96), had been smoking for an average of 4.79 years (*SD*=2.4) and had abstained from smoking for an average of 11.12 hours (*SD*=20.16). One can see from the standard deviations that there was much variation between smokers in all three measures.

Smoking Stroop Task: Primary Analysis

It was hypothesised that smokers would take longer to respond to smoking-related words than neutral words when compared to nonsmokers (control group). This would mean that, in a student population, smokers could be distinguished from nonsmokers using the SST designed for this experiment.

In the primary analysis a 2X2 repeated measures ANOVA was used to determine if there were changes in participant RT as a result of an interaction between the type of stimulus and participants' smoking status. Smoking status (2 levels: smoker/nonsmoker) was the between-group factor and stimulus type (2 levels: smoking-related words/neutral words) was the within-subject factor. It was found that there was no significant interaction between smoking status and stimulus type, $F(1,73)=0.96$, $p=.33$, $p>.05$, and no significant effect of smoking status on RT, $F(1,73)=1.06$, $p=.31$, $p>.05$. In other words, smokers were not slower than nonsmokers to respond to smoking-related words, as compared to neutral words, as was hypothesised and smokers and nonsmokers did not perform differently on the SST in terms of overall RT (irrespective of stimulus type). However, there was a significant main effect of stimulus type on RT such that participants (regardless of smoking status) were slower to react to smoking-related words than neutral words, $F(1,73)=5.61$, $p=.02$, $p<.05$. These results can be seen in Figure 1.

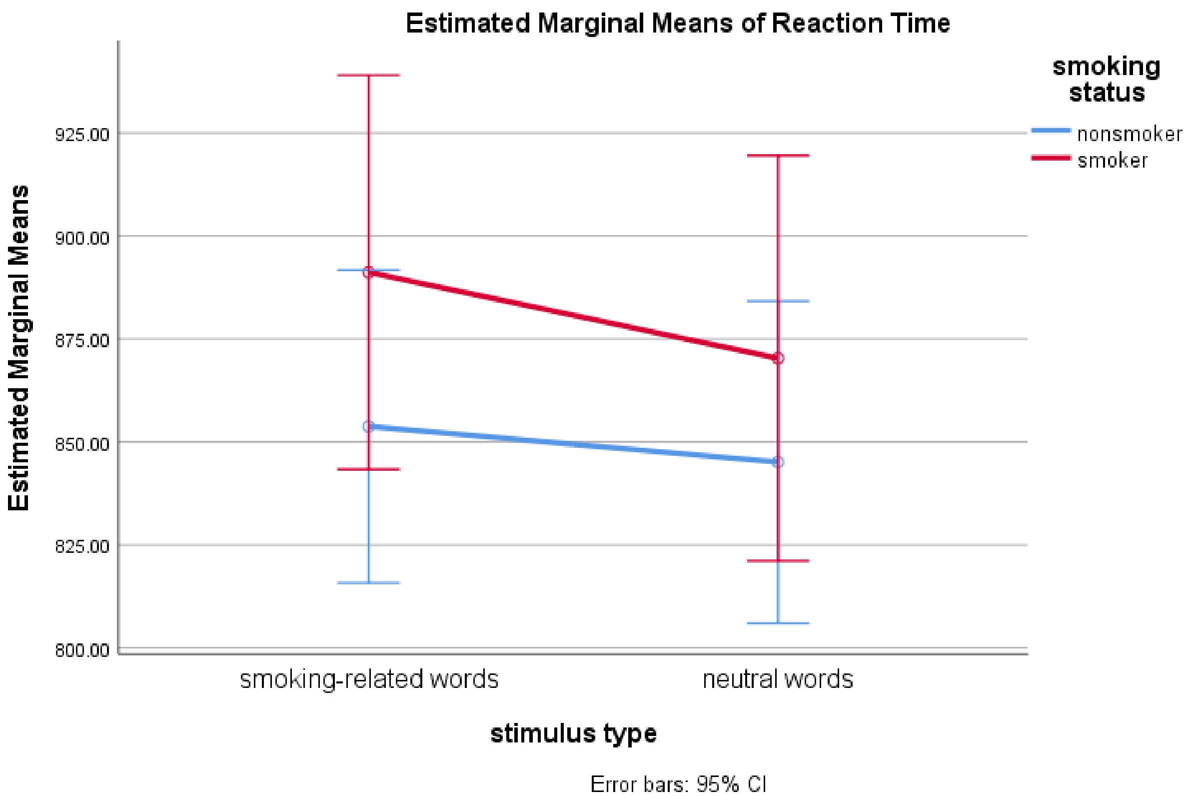

Figure 1 Mean RT for stimulus type, with smoking status shown as separate lines. The units for Estimated Marginal Means is milliseconds. p<0.05 for stimulus type.

Smoking Stroop Task: Follow-Up Analysis

One can see from the plotted lines in Figure 1 that the effect of stimulus type (the signal) appears to be visibly more pronounced in smokers than in nonsmokers, which seems counterintuitive given that no significant interaction between smoking status and stimulus type was detected in the primary analysis. However, one can also see in Figure 1 that the 95% Confidence Interval (CI) error bars (representing variance, or noise) are very large and overlap greatly; this high unsystematic variance may explain the statistical insignificance of the interaction between smoking status and stimulus type in the primary analysis. These observations prompted a follow-up analysis whereby two distinct one-way repeated measures ANOVAs were performed to determine the magnitude of the effect of stimulus type on each group (smokers and nonsmokers) separately. This revealed that stimulus type had a significant effect on smokers, $F(1,28)=5.13$, $p=.03$, $p<.05$, but an insignificant effect on nonsmokers, $F(1,45)=1.17$, $p=.29$, $p>.05$. Thus, the significant effect of stimulus type detected in the primary analysis is likely to have been driven by the smoker group alone. This aligns with the hypothesis that smokers were affected by stimulus type while nonsmokers were not and also indicates that this interaction may have failed to reach significance in the primary interaction analysis due to high unsystematic variability in the entire sample.

Smoking Habit Characteristics

Pearson's correlations between the Emotional Stroop Effect and heaviness, length of time and deprivation from smoking were calculated to determine if these three characteristics of smoking habits were indicative of latency when presented with smoking-related stimuli. Firstly, the Emotional Stroop Effect was calculated by subtracting the average neutral words RT from the average smoking-related words RT for each participant. This number represents the amount of interference caused by the smoking-related stimuli. Secondly, the age that smokers reported having started smoking was subtracted from their current age to calculate the number of years of smoking. Then, Pearson's correlations were performed between the Emotional Stroop Effect and the three smoking habit characteristics, heaviness, deprivation and length of time smoking.

No significant correlations were found between Emotional Stroop Effect and length of time smoking, $r(27)= -.08$, $p=.67$, $p>.05$, deprivation from smoking, $r(27)= -.12$, $p=.55$, $p>.05$, or heaviness of smoking, $r(27)=.33$, $p=.11$, $p>.05$. However, the smoking habit characteristics were inter-correlated such that heaviness of smoking was significantly negatively correlated with deprivation, $r(27)= -.46$; $p=.03$; $p<.05$, and significantly positively correlated with length of time smoking, $r(27)=.41$, $p=.04$, $p<.05$.

Discussion

Implications

The results indicate that, as hypothesised, smokers were slower than nonsmokers to name the colour of smoking-related stimuli as compared to neutral stimuli. In other words, smokers exhibited an attentional bias which nonsmokers did not exhibit. Thus, one can reject the null hypothesis that there was no difference between the attentional bias exhibited by smokers and nonsmokers. However, the fact that the difference between smokers and nonsmokers could not be detected in the primary analysis suggests that there was high variability in the entire sample. Thus, this thesis has fairly low statistical power. Moderator analyses of smokers' Emotional Stroop Effects showed that deprivation, heaviness and number of years of smoking did not predict attentional bias in smokers.

The observation of an exaggerated attentional bias towards smoking-related stimuli in smokers aligns with the literature on the SST (Mogg & Bradley, 2002; Canamar & London, 2012; Fehr, Wiedenmann & Herrmann, 2006; Field, Rush, Cole & Goudie, 2006; Azizian, Nestor, Payer, Monterosso, Brody & London, 2009; Domier et al., 2007). The fact that the pattern of results is similar to most studies in the SST literature indicates that young participants (students age 17-27) may not exhibit a different attentional bias to older participants. This aligns with the findings of Zack et al, (2000) who found that adolescent smokers exhibit a similar attentional bias to adult smokers. A future study which includes multiple distinct age groups is important to formally test possible effects of age.

It would seem that smokers and nonsmokers in a student population *can*, in theory, be told apart using the SST designed for this experiment. However, the difference between the attentional bias exhibited by smokers and nonsmokers was rather difficult to detect with a sample size of 75 participants due to high unsystematic variance. This suggests that the discrepancy between the average smoker and nonsmoker's RT might be quite small in SSTs, making the interaction effect hard to detect without a very large sample size. Additionally, the fact that there was such high variability in the entire sample suggests that the SST is sensitive to individual differences. This is supported by findings from more complicated SST studies where is was found that the most accurate predictors of attentional bias in smokers are measures of individual differences, such as subjective urge to smoke, self-reported negative symptoms of withdrawal and the personality trait of Sensitivity to Reward (Mogg & Bradley, 2002; Canamar & London, 2012; Munafo, Mogg, Roberts, Bradley & Murphy, 2003). Such variables are difficult or impossible to experimentally manipulate and contribute to high sample variance in smokers. With this in mind, the SST may not be a particularly practical method of quantifying the difference between smokers and nonsmokers as detecting an interaction appears to be fairly difficult.

The lack of results in the moderator analysis at least somewhat aligns with the SST literature. It would appear that not finding any significant correlation between Emotional Stroop Effect and deprivation is consistent with many studies which account for deprivation (Mogg & Bradley, 2002; Munafo, Mogg, Roberts, Bradley & Murphy, 2003) but not all (Gross, Jarvik & Rosenblatt, 1993; Domier et al., 2007). Finding no effect of years of smoking is also consistent with the results of Marcus Munafò, Karin Mogg, Sarah Roberts, Brendan Bradley and Michael Murphy (2003) in their study *Selective Processing of Smoking-Related Cues in Current Smokers, Ex-Smokers and Never-Smokers on the Modified Stroop Task*. Most SST studies use more complicated moderator variables than heaviness of smoking, such as Carbon Monoxide in expired air, to gauge nicotine intake (Canamar & London, 2012; Domier et al., 2007). However, Mogg and Bradley (2002) found a strong correlation between heaviness of smoking and attentional bias and Miles Cox, Javad Fadardi and Emmanuel Pothos (2006) suggest that heavy smoking may increase interference induced by smoking-related stimuli. Thus, finding no relationship between heaviness of smoking and attentional bias does not seem to align with the limited amount of previous research. As previously stated, the best predictors of performance on the SST appear to be individual differences, such as subjective urge to smoke, rather than smoking habit characteristics (Mogg & Bradley, 2002; Canamar & London, 2012; Munafo, Mogg, Roberts, Bradley & Murphy, 2003). Thus, future research should follow suit with current research and include measures of individual differences as moderator variables in order to accurately account for variability between smokers.

Limitations

Importantly, this thesis had fairly low statistical power. There are three main ways in which one might hope to prevent this in future research: firstly, by increasing the amount of participants, secondly, by placing more stringent requirements on inclusion and, thirdly, by controlling for deprivation. Increasing the number of participants increases the likelihood of detecting a difference between two rather similar samples (if one exists). As previously mentioned, the large amount of unsystematic variance in this thesis suggests that a very large sample size may be necessary to accurately detect an interaction effect. Thus, future studies should look to replicate this thesis with a larger sample size in order to decipher if the effect found in this thesis is robust or not. Secondly, more stringent requirements for inclusion such that smokers' should be very heavy smokers and nonsmokers should have never smoked ensures that the two groups are as different as possible (Cox, Fadardi & Pothos, 2006). The two groups being at opposite extremes of the spectrum of smoking habits increases the likelihood of detecting a difference between them. Thirdly, manipulating deprivation may increase the attentional bias of smokers, further widening the discrepancy between smokers and nonsmokers (Mogg & Bradley, 2002; Canamar & London, 2012; Domier et al., 2007; Gross, Jarvik & Rosenblatt, 1993; Cox, Fadardi & Pothos, 2006). The following paragraphs will explore the limitations that led to these three recommendations not being implemented in this thesis.

Unfortunately, the number of available participants for this thesis was limited. This was partly attributable to the fact that this thesis was conducted within the confines of the Coronavirus Crisis. This put limitations on the administration of the experiment such that participants had to be recruited and tested digitally and remotely. Inconveniently, the full experiment could not be run on a smartphone, thus, it is suspected that only those participants who happened to be on their laptop when they saw the link on social media fully completed the experiment. It is also possible that many participants did not read the description put on social media and realised only after starting the experiment that they did not meet the requirements to complete it. Alternatively, they may simply have gotten bored. For any one or a combination of these reasons 147 potential participants only partially completed the experiment (making their data unusable) and only 29 smokers fully completed the experiment, despite using an incredibly inclusive definition of a smoker. Had this experiment been conducted under different circumstances participants could have been actively recruited in person around the University when already on their laptops (or offered my own laptop). Participants could also have been recruited in public smoking areas making it easier to recruit smokers. In addition to reaching out through social media, future research should try a more personal sampling strategy in order to increase the sample size.

Secondly, the inclusion requirements used in this thesis were perhaps not rigorous enough. The inferior inclusion criteria used in this thesis were based on the National Health Interview Survey (NHIS) by the Center for Disease Control and Prevention: *smokers* were those who have smoked more than 100 cigarettes in their lifetime and smoke most days and *nonsmokers* were those who have smoked less than 100 cigarettes in their lifetime (NHIS, 2017). This inclusive sampling strategy hindered detecting an interaction effect because, rather than having two distinct levels of smoking status, the entire continuous spectrum of smoking habits were included. Most participants were probably in between the extremes making the smoker and nonsmoker groups too similar, over-sampling the extremes would have been advisable. The literature suggests that ten cigarettes per day on average is an advisable minimum requirement for inclusion to ensure that smokers' habits are extreme enough (Mogg & Bradley, 2002; Field, Rush, Cole & Goudie, 2006). Additionally, nonsmokers should have smoked a maximum of five cigarettes in their lifetime or, ideally, never smoked (Domier et al., 2007; Munafo, Mogg, Roberts, Bradley & Murphy, 2003; Cox, Fadardi & Pothos, 2006).

Thirdly, deprivation was not manipulated in this thesis. The rationale for controlling for deprivation is that increased abstinence, theoretically, increases latency in smokers' RT (thus, exaggerating the interaction effect) by lessening cognitive efficiency and heightening cravings (Mogg & Bradley, 2002; Azizian et al., 2009). Recent smoking may enhance cognitive performance which counteracts the latency induced by smoking-related cues (Fehr, Wiedenmann & Herrmann, 2006; Azizian et al., 2009). Thus, manipulating deprivation would have increased the discrepancy between the smoking status levels (smokers and nonsmokers) (Cox, Fadardi & Pothos, 2006).

The intercorrelation between smoking habit characteristics further supports that deprivation should have been manipulated. Heaviness was found to be positively correlated with the number of years of smoking and negatively correlated with deprivation, thus, deprivation was lowest amongst the heaviest smokers who would otherwise have been expected to exhibit the most pronounced attentional bias (Mogg & Bradley, 2002). In other words, the heaviest smokers had generally smoked the most recently and, as a result, may not have exhibited their maximal attentional bias. This may explain the lack of a relationship between heaviness of smoking and attentional bias (as measured by Emotional Stroop Effect) in the moderator analysis.

When manipulating deprivation it has to be recognised that the nature of addiction is such that addicts find it difficult to abstain (Davey, 2015). Thus, it is standard practice to distribute monetary rewards to incentivise participants if any abstinence is required (Canamar & London, 2012; Mogg & Bradley, 2002). Unfortunately, this was not feasible for this thesis. It is suspected that demanding abstinence without any monetary reward would have resulted in almost no heavily smoking participants taking part. Thus, when future research recreates this experiment with manipulation of deprivation, monetary rewards should be offered in order to incentivise participants to abstain.

SST studies vary greatly in methodology, this makes it difficult to make valid comparisons between studies (Domier et al., 2007). However, Cox, Fadardi and Pothos (2006) have attempted to address this issue by publishing a paper called *The Addiction–Stroop Test: Theoretical Considerations and Procedural Recommendations* which looks to guide studies in the field of Addiction Stroop Tasks. This thesis did not align with all of the recommendations of Cox, Fadardi and Pothos as stimuli were displayed in a random order of word type and colour rather than in blocks. Blocking the stimuli by word type, in other words, displaying the smoking-related words and the neutral words separately, may have increased interference (Cox, Fardardi & Pothos, 2006). The slow effect of the attentional bias exhibited by smokers may have caused latency on neutral trials that immediately followed smoking-related trials (Cane, Sharma & Albery, 2008). This error was due to the fact that the SST was adapted from a classical SCWT which was randomised and this change was overlooked at the programming stage. Some SST studies do not use blocked display and find significant results (Field, Rush, Cole & Goudie, 2007; Zack et al, 2001), however, in order to be more thorough, future studies should display stimuli in a blocked rather than randomised format as is advised by Cox, Fadardi and Pothos (2006).

As a final suggestion, it may also have been advisable to exclude nonsmokers who smoke joints. In the Netherlands many who would be considered nonsmokers regularly smoke marijuana with tobacco (joints). Thus, their nicotine intake may be higher than the number of cigarettes they have smoked accounts for. Whether or not this could have an effect on results or not is unknown. Few studies exist on the Marijuana Stroop Effect and none examine the effect of regular smoking of Marijuana with tobacco (joints) on the SST (Cane, Sharma & Albery, 2008). This may be an interesting direction for future study in the field of Addiction Stroop Tasks.

What do the results demonstrate about automaticity and agency?

The results show that smokers exhibited an attentional bias that nonsmokers did not. As previously outlined, this attentional bias for substance-related stimuli is automatic and thought to play a major role in the provocation of cravings (Canamar & London, 2012; Franken, Kroon, Wiers & Jansen, 2000; Tiffany, 1990). Whether or not the fact that this process is automatic means that the smoker cannot control their drug-use behaviour is very much debatable. This is a question of the relationship between automaticity and agency or intention; this issue is far too big to tackle holistically in the last two paragraphs of this thesis, however, delving into some of the literature on the topic may help to see how the SST (a measure of automatic and nonautomatic processes) could be interpreted in a broader context.

Although not the most recent paper, Stephen Tiffany (1990) makes a strong case for his theory that while substance-related stimuli initiate substance-use behaviour automatically, a strong enough nonautomatic urge to impede the automatic substance-use behaviour can prevail (Tiffany, 1990). This is backed by evidence that automatic skills can be effortfully counteracted in other contexts (Tiffany, 1990). Perhaps the SST could be viewed as an example of this; smoking participants had to try to successfully inhibit their automatic response by selectively attending to the colour of the stimulus instead of the salient semantic information (Domier et al., 2007). However, Tiffany (1990) very much recognises the difficulties in inhibiting automatic substance-use behaviour. An addiction is conditioned over time by positive reinforcement, thus, completing the automatic action of using the substance will be both easy and rewarding (Tiffany, 1990). Additionally, resisting using the substance will likely result in unpleasant withdrawal (Mogg & Bradley, 2002; Tiffany, 1990). Thus, the determination of the addict must be profound.

The idea that it is possible but very difficult to resist substance-use behaviour does not fully discredit nor fully support either side of the agency debate outlined in the first section of this thesis. If one possesses a strong enough urge to abstain one can take certain preventative measures, such as removing oneself from the environment that is conducive to drug use (Tiffany, 1990). This aligns fairly well with the arguments of Gene Heyman (2009) and Christoph Lumer (2017) that addiction is a choice. However, for those who do not have a strong enough urge to impede their automatic behaviours, it may not be so easy not to use the substance. In fact, according to Tiffany (1990), an addict in an environment that does not hinder substance use (such as an environment where there is easy access to the substance) may use a substance without the slightest intention to do so, which backs up the argument of Alan Leshner (1999) and Ingmar Franken, Linda Kroon, Reinout Wiers and Anita Jansen (2000) that addiction is not a choice. Thus, I tentatively suggest that if one is truly determined it may be possible to *choose* to resist substance-use behaviour, however, it is an incredibly difficult choice to make.

Ashley, V., & Swick, D. (2009). Consequences of emotional stimuli: age differences on pure and mixed blocks of the emotional Stroop. *Behavioral and Brain Functions*, *5*(1), 14. doi: 10.1186/1744-9081-5-14

Azizian, A., Nestor, L. J., Payer, D., Monterosso, J. R., Brody, A. L., & London, E. D. (2009). Smoking Reduces Conflict-Related Anterior Cingulate Activity in Abstinent Cigarette Smokers Performing a Stroop Task. *Neuropsychopharmacology*, *35*(3), 775–782. doi: 10.1038/npp.2009.186

Bielecki, M., Popiel, A., Zawadzki, B., & Sedek, G. (2017). Age As Moderator of Emotional Stroop Task Performance in Posttraumatic Stress Disorder (PTSD). *Frontiers in Psychology*, *8*. doi: 10.3389/fpsyg.2017.01614

Brysbaert, M. (2019, July 19). Journal of Cognition. Retrieved from https://www.journalofcognition.org/articles/10.5334/joc.72/

Canamar, C. P., & London, E. (2012). Acute cigarette smoking reduces latencies on a Smoking Stroop test. *Addictive Behaviors*, *37*(5), 627–631. doi: 10.1016/j.addbeh.2012.01.017

Cane, J., Sharma, D., & Albery, I. (2008). The addiction Stroop task: examining the fast and slow effects of smoking and marijuana-related cues. *Journal of Psychopharmacology*, *23*(5), 510–519. doi: 10.1177/0269881108091253

Cohen, J. D., Dunbar, K., & McClelland, J. L. (1988). On the Control of Automatic Processes: A Parallel Distributed Processing Model of the Stroop Effect. doi: 10.21236/ada218914

Corpus of Contemporary American English. (2010). Word frequency data. Retrieved from https://www.wordfrequency.info/free.asp?s=y

Cox, W. M., Fadardi, J. S., & Pothos, E. M. (2006). The Addiction-Stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin*, *132*(3), 443–476. doi: 10.1037/0033-2909.132.3.443

Coyne, C. J., & Hall, A. R. (2017, April 12). Four Decades and Counting: The Continued Failure of the War on Drugs. Retrieved from https://www.cato.org/publications/policy-analysis/four-decades-counting-continued-failure-war-drugs

Davey, G. (2015). *Psychopathology: research, assessment and treatment in clinical psychology*. London: The British Psychological Society.

Domier, C. P., Monterosso, J. R., Brody, A. L., Simon, S. L., Mendrek, A., Olmstead, R., … London, E. D. (2007). Effects of cigarette smoking and abstinence on stroop task performance. *Psychopharmacology*, *195*(1), 1–9. doi: 10.1007/s00213-007-0869-x

Fehr, T., Wiedenmann, P., & Herrmann, M. (2006). Nicotine Stroop and addiction memory—an ERP study. *International Journal of Psychophysiology*, *62*(2), 224–232. doi: 10.1016/j.ijpsycho.2006.01.011

Field, M., Rush, M., Cole, J., & Goudie, A. (2006). The smoking Stroop and delay discounting in smokers: effects of environmental smoking cues. *Journal of Psychopharmacology*, *21*(6), 603–610. doi: 10.1177/0269881106070995

Fornito, A., Zalesky, A., & Bullmore, E. T. (2016). *Fundamentals of brain network analysis*. Amsterdam: Elsevier/Academic Press.

Forrin, N. D., & Macleod, C. M. (2017). Relative speed of processing determines color–word contingency learning. *Memory & Cognition*, *45*(7), 1206–1222. doi: 10.3758/s13421-017-0721-4

Franken, I. H. A., Kroon, L. Y., Wiers, R. W., & Jansen, A. (2000). Selective cognitive processing of drug cues in heroin dependence. *Journal of Psychopharmacology*, *14*(4), 395–400. doi: 10.1177/026988110001400408

gov.uk. (n.d.). Drugs penalties. Retrieved from https://www.gov.uk/penalties-drug-possession-dealing

Gross, T. M., Jarvik, M. E., & Rosenblatt, M. R. (1993). Nicotine abstinence produces content-specific stroop interference. *Psychopharmacology*, *110*(3), 333–336. doi: 10.1007/bf02251289

Heyman, G. M. (2009). Addiction : A Disorder of Choice. Harvard University Press.

Kaplan, G. B., Şengör, N., Gürvit, H., & Güzeliş, C. (2007). Modelling the Stroop effect: A connectionist approach. *Neurocomputing*, *70*(7-9), 1414–1423. doi: 10.1016/j.neucom.2006.05.009

Kufs, C. (2012, June 24). There's Something About Variance. Retrieved from https://statswithcats.wordpress.com/2010/08/01/there's-something-about-variance/

Leshner, A. I. (1999). Science-Based Views of Drug Addiction and Its Treatment. *Jama*, *282*(14), 1314–1316. doi: 10.1001/jama.282.14.1314

Lovett, M. C. (2002). Modeling selective attention: Not just another model of Stroop (NJAMOS). *Cognitive Systems Research*, *3*(1), 67–76. doi: 10.1016/s1389-0417(01)00045-6

Lumer, C. (2017). Automatic actions: Agency, intentionality, and responsibility. *Philosophical Psychology*, *30*(5), 616–644. doi: 10.1080/09515089.2017.1291928

Lyons, K. (2016, March 24). From cannabis cafes to death row: drugs laws around the world. Retrieved from https://www.theguardian.com/society/2016/mar/24/from-cannabis-cafes-to-death-row-drugs-laws-around-the-world

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, *109*(2), 163–203. doi: 10.1037/0033-2909.109.2.163

McAteer, A. M., Hanna, D., & Curran, D. (2018). Age-related differences in alcohol attention bias: a cross-sectional study. *Psychopharmacology*, *235*(8), 2387–2393. doi: 10.1007/s00213-018-4935-3

McIntosh, A. (2000). Towards a network theory of cognition. *Neural Networks*, *13*(8-9), 861–870. doi: 10.1016/s0893-6080(00)00059-9

McKenna, F. P., & Sharma, D. (2004). Reversing the Emotional Stroop Effect Reveals That It Is Not What It Seems: The Role of Fast and Slow Components. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*(2), 382–392. doi: 10.1037/0278-7393.30.2.382

Meyers, C. D. (2014). Automatic Behavior and Moral Agency: Defending the Concept of Personhood from Empirically Based Skepticism. *Acta Analytica*, *30*(2), 193–209. doi: 10.1007/s12136-014-0239-3

Munafò, M., Mogg, K., Roberts, S., Bradley, B. P., & Murphy, M. (2003). Selective Processing of Smoking-Related Cues in Current Smokers, Ex-Smokers and Never-Smokers on the Modified Stroop Task. *Journal of Psychopharmacology*, *17*(3), 310–316. doi: 10.1177/02698811030173013

Muris, P., & Merckelbach, H. (1998). Specific Phobias. *Comprehensive Clinical Psychology*, 461–474. doi: 10.1016/b0080-4270(73)00237-6

Mogg, K., & Bradley, B. P. (2002). Selective processing of smoking-related cues in smokers: manipulation of deprivation level and comparison of three measures of processing bias. *Journal of Psychopharmacology*, *16*(4), 385–392. doi: 10.1177/026988110201600416

National Health Interview Survey (NHIS) - Adult Tobacco Use - Glossary. (2017, August 29). Retrieved from https://www.cdc.gov/nchs/nhis/tobacco/tobacco_glossary.htm

PsyToolKit, (13 March 2019). Stroop Effect, www.psytoolkit.org/lessons/stroop.html.

Scarpina, F., & Tagini, S. (2017). The Stroop Color and Word Test. *Frontiers in Psychology*, *8*. doi: 10.3389/fpsyg.2017.00557

Sharma, D., & Mckenna, F. P. (2001). The role of time pressure on the emotional Stroop task. *British Journal of Psychology*, *92*(3), 471–481. doi: 10.1348/000712601162293

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*(6), 643–662. doi: 10.1037/h0054651

Tiffany, S. T. (1990). A cognitive model of drug urges and drug-use behavior: Role of automatic and nonautomatic processes. *Psychological Review*, *97*(2), 147–168. doi: 10.1037/0033-295x.97.2.147

West, R., & Alain, C. (2000). Age-related decline in inhibitory control contributes to the increased Stroop effect observed in older adults. *Psychophysiology*, *37*(2), 179–189. doi: 10.1111/1469-8986.3720179

Williams, J. M. G., Mathews, A., & Macleod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*(1), 3–24. doi: 10.1037/0033-2909.120.1.3

Zack, M., Belsito, L., Scher, R., Eissenberg, T., & Corrigall, W. A. (2001). Effects of abstinence and smoking on information processing in adolescent smokers. *Psychopharmacology*, *153*(2), 249–257. doi: 10.1007/s002130000552