‘The Difference in Smoking Motives, Habits and Attentional Bias
in Nicotine Dependent and Non-dependent Smokers’

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Abstract

Despite a lack of nicotine dependence, non-dependent smokers have a cessation failure rate comparable to dependent smokers (Tindle and Shiffman 2011). Attentional bias is the automatic allocation of attention to smoking-related stimuli and has been investigated as it may have a role in the maintenance of smoking and hinder cessation attempts (Field and Cox 2008). The current study utilised a visual dot probe task with three stimulus onset asynchronies (SOA: 200ms, 500ms and 2000ms) to explore different aspects of attention. Smoking and non-smoking university students and staff completed measures of smoking dependence, smoking motives, and attentional bias. Dependent smokers scored significantly higher on objective and subjective measures of nicotine dependence. Dependent smokers reported to be motivated by negative reinforcement and non-dependent smokers reported to be motivated by positive reinforcement. Dependent smokers, non-dependent smokers and non-smokers did not differ in attentional bias in each SOA condition. However, the study suffered from a lack of power and there are suggestions for the disparity with previous research. The practical implication of this study is the recommendation that smoking cessation therapy is individualised to dependent and non-dependent smokers as their smoking habit is maintained by different smoking motives.

1. Introduction

1.1. Overview of the Current Study

The current study investigated smoking habits, motives and attentional bias in nicotine dependent and non-dependent smokers. Attentional bias is the automatic allocation of attention to stimuli that are related to the drug one is dependent upon (Luijten, Field and Franken 2013). It is thought to have a role in the maintenance of smoking as the expectancy of an available drug produces attentional bias and craving which increases the likelihood of drug self-administration (Field and Cox 2008). The current study explored whether attentional bias was present in nicotine dependent and non-dependent smokers using a visual dot probe task. As non-dependent smokers have the same cessation failure rate as dependent smokers yet do not experience the aversive effects of nicotine withdrawal (Tindle and Shiffman 2011), attentional bias may contribute to the maintenance of smoking and hinder cessation attempts. Using self-report measures of smoking motives and habits, the aim was to create a comprehensive profile of nicotine dependent and non-dependent smokers. The report begins with an overview of smoking behaviour and the effects of nicotine. This leads to different theories of addiction, the presence of attentional bias, exploring different measures and finally the differences in smoking patterns in dependent and non-dependent smokers.

1.2. The Use of Cigarettes

1.2.1. Prevalence of smokers.

The population of smokers is estimated to be around 20% of adults in the UK (Health and Social Care Information Centre 2014). Prevalence fluctuates between age groups as the

rate of smoking in 16 to 19 year olds is 15%, but in 20 to 24 year olds it is 29% (Health and Social Care Information Centre 2014). There also appears to be a relationship between smoking prevalence and socioeconomic status as around 12% of higher earners report to smoke, compared to 31% of lower earners (Action on Smoking and Health 2015). However, smokers are not a homogeneous group, as the amount of smokers who are not dependent on nicotine form a large proportion of the smoking population: around 33% in the United States (Tindle and Shiffman 2011). Smoking dependence also interacts with socioeconomic status as 46% of high earning smokers consume less than 10 cigarettes per day, compared to 30% of lower earners (Action on Smoking and Health 2015). Variables such as socioeconomic status can be considered as risk factors once smoking has been established, but other risk factors have been identified for the initiation of smoking.

1.2.2. Risk factors for smoking initiation.

For those who smoke, around two-thirds begin when they are in adolescence (Action on Smoking and Health 2015). Known risk factors for smoking initiation include: peers who smoke (Killen, Robinson and Haydel 1997), low parental attachment and school involvement (Fleming, Kim and Harachi 2002), and emotional difficulties (Brook, Brook and Zhang 2008). It has been suggested that most risk factors are influential during late childhood which suggests it is a particularly vulnerable period (Garcia-Rodriguez, Blanco and Wall 2014). However, there appears to be separate risk factors for developing nicotine dependence. Independent of adolescent environmental factors, low educational attainment, relationship problems and personality disorders increase the likelihood of becoming dependent in adulthood (Garcia-

Rodriguez et al. 2014). There appears to be a complex interaction between developmental risk factors and environmental stressors that result in an individual starting to smoke and becoming dependent on nicotine. Despite the habit usually starting in adolescence and being pervasive through adult life, it is particularly harmful to public health.

1.2.3. Health impact of smoking.

Smoking is suggested to be the leading cause of preventable illness (Action on Smoking and Health 2013). In 2010, the public cost of smoking was estimated to be around £2.7 billion in hospital admissions and related costs (Health and Social Care Information Centre 2014). On an individual level, smoking can be attributed to around 90% of lung cancers, coronary heart disease and lung conditions such as emphysema (NHS Choices 2013). Even light smokers are associated with completing significantly less exercise and a greater use of emergency services (Halperin, Smith and Heiligenstein 2010). Due to the detrimental impact on public and individual health, it is important to understand what motivates people to smoke despite the health implications.

1.2.4. Delivering nicotine.

Nicotine is the primary addictive substance found in tobacco which is smoked within a cigarette and absorbed into the blood via the lungs (Advokat, Comaty and Julien 2014). Nicotine is an agonist for the nicotinic sub-type of acetylcholine receptor which are present throughout the central and peripheral nervous system (Advokat et al. 2014). Activating these receptors results in the subjective effects that smokers find desirable such as a head rush, drug high and

euphoria (Kalman 2002). Furthermore, nicotine is extremely rewarding as it increases the levels of dopamine in the mesocorticolimbic system which is important for motivational behaviour (Advokat et al. 2014). The rewarding effects of smoking are not subject to tolerance and combine with the rapid development of physical dependence to perpetuate drug use (Advokat et al. 2014). These two factors are important in the development of addictive behaviour through the concepts of positive and negative reinforcement.

1.3. Theories of Addictive Behaviour

1.3.1. Positive and negative reinforcement.

The initial positive reinforcement from the effects of nicotine combines with the negative reinforcement of withdrawal to stimulate repeated drug administration (Watkins, Koob and Markou 2000). The acute effects of nicotine are important in establishing drug use as the pervasiveness of nicotinic receptors throughout the peripheral and central nervous system result in a desirable drug high (Kalman 2002; Advokat et al. 2014). This is rewarding for the drug user which increases the likelihood of repeated administration through positive reinforcement. However, there is a shift from smoking for positive reinforcement, to smoking because of negative reinforcement (Koob and Le Moal 2008). The constant presence of nicotine in chronic smokers creates a new set-point where neurotransmitter systems are at an adapted level (Watkins et al. 2000). Abstinence from smoking decreases this set-point and creates a sense of unbalance which results in negative affective symptoms that characterises a state of withdrawal (Watkins et al. 2000). The administration of nicotine is therefore stimulated by negative reinforcement to remove the aversive symptoms and return to the habituated set-

point. This combination of positive and negative reinforcement is crucial in the initiation and maintenance of drug use leading to dependence.

1.3.2. Dependence and attentional bias.

The neural basis of positive and negative reinforcement is implicated in the development of attentional bias in two different theories: the 'incentive-sensitisation' and 'incentive-habit' theory. The 'incentive-sensitisation' theory suggests repeated administration of a drug sensitises the mesocorticolimbic system (Robinson and Berridge 2003). It is involved in motivational behaviour and is related to the drug user 'wanting' a substance that has been repeatedly administered (Hester and Luijten 2014). It needs to be emphasised that compulsively 'wanting' the drug is not equivalent to 'liking' it. This produces a desire for receiving a drug that is disproportionately larger than the pleasure it produces. It is this compulsion to receive the drug that characterises addictive behaviour (Robinson and Berridge 2003). Attentional bias results from a classical conditioning process where initially neutral stimuli such as lighters, cigarette packets and ash trays become related to the incentive-salience of the drug (Hester and Luijten 2014). The attention of a substance user therefore becomes involuntarily allocated to these stimuli as they create a 'wanting' for the drug due to the sensitisation of the mesocorticolimbic system. This theory has been influential for over two decades and has provided an important insight into addictive behaviour through the distinction between 'wanting' and 'liking' a drug (West and Brown 2013). 'Incentive-sensitisation' theory predicts that the severity of dependence one has on a substance is positively associated with

the level of attentional bias exhibited (Robinson and Berridge 2003). This suggests that greater dependence leads to increased attentional bias.

In terms of providing an explanation for the development of attentional bias, the 'incentive-habit' theory is similar to 'incentive-sensitisation'. Both theories emphasise the role of dopamine in motivational behaviour as the repeated administration of nicotine is rewarding and sensitises the mesocorticolimbic system (Di Chiara 2000). Importantly however, the two theories describe different paths of development as the 'incentive-habit' theory predicts continuous drug use changes the dopamine response to the drug as opposed to changing the response to conditioned stimuli (Di Chiara 2000). Repeated drug use does not continuously sensitise the mesocorticolimbic system, but leads to acute tolerance and desensitisation (Di Chiara 2000). Attentional bias is created through the same classical conditioning process where the rewarding effects of nicotine are associated with neutral stimuli. These stimuli then possess salient properties to attract the attention of the drug user. At this point, the 'incentive-habit' theory presents an alternative development, as habitual smoking does not require cues to promote administration, but the combined effect of habit and the negative reinforcement from avoiding withdrawal perpetuates drug use (Mogg, Field and Bradley 2005). Following the concept of classical conditioning, as the stimuli are no longer paired with sensitisation, the relationship is extinguished and drug-related stimuli are no longer salient. The theory predicts that light dependence will produce attentional bias but with heavier dependence, stimuli are not needed to perpetuate drug use, therefore attentional bias decreases (Mogg et al. 2005).

1.4. The Presence of Attentional Bias

1.4.1. Attentional bias in smokers and non-smokers.

The two theories relating to the development of attentional bias have conflicting predictions for dependent and non-dependent smokers. However, experimental evidence has found that smokers as an overall group show greater attentional bias than non-smokers. Using eye-tracking to directly monitor where the eyes are focusing, smokers maintained their gaze for significantly longer, and made the first fixation on smoking-related stimuli more than non-smokers (Mogg, Bradley and Field 2003). Moreover, attentional bias has been found using eye-tracking in a realistic environment (Baschnagel 2013). Smokers looked at drug-related stimuli placed around an office room significantly more than non-smokers but each group had no differences in the number of fixations on different objects around the room. This is important as it shows both groups visually explored the room but it was the salience of the smoking-related stimuli that attracted the smokers. Similarly, smokers were found to gaze significantly longer at smoking related pictures in comparison to neutral pictures (Kang, Chang and Jahng 2012). Using functional magnetic resonance imaging (fMRI) the study found that smoking related pictures produced greater activation in the mesocorticolimbic system than neutral pictures. This is important as both attentional bias and the motivational system implicated in the underlying theories were observed. However, although these findings provide convincing evidence, any conclusions must be interpreted with caution. The study had no non-smoking control group therefore any activation of the mesocorticolimbic system cannot be attributed to group differences but can only elucidate differences in the stimuli used. Despite this, the

research shows that smokers consistently show attentional bias to smoking-related stimuli when their eye movements are directly monitored.

Indirect measures of attentional bias have also found consistent results. Using a visual dot probe task, smokers reacted three times faster to cues replacing smoking-related pictures in comparison to non-smokers (Ehrman, Robbins and Bromwell 2002). This is supported by further research using a modified stroop task that showed that smokers show greater attentional bias to smoking-related words than neutral words (Drobes, Elibero and Evans 2006). Similarly, smokers reacted significantly faster to cues replacing smoking-related pictures using a visual dot probe task (Field et al. 2004). Although there was no non-smoking control group, the findings were supplemented by additional direct attentional bias measures. Smokers made significantly more initial fixations to smoking related stimuli. This shows that the stimuli were attractive enough to attract the gaze of smokers to affect their performance on the task. This collection of evidence from direct and indirect measures shows that smokers consistently exhibit attentional bias for smoking-related stimuli. However, the level of attentional bias displayed by smokers may be mediated by the level of dependence a particular smoking group has on nicotine.

1.4.2. Attentional bias in dependent and non-dependent smokers.

The evidence for the presence of attentional bias in dependent and non-dependent smokers has not been consistent. There have only been a small number of studies investigating the groups separately. Using a visual dot probe task, one study found that dependent smokers, classified through the concentration of carbon monoxide in their lungs, showed greater

attentional bias than smokers with little dependence (Vollstädt-Klein et al. 2011). This research supports the theoretical predictions of the 'incentive-salience' theory as greater dependency leads to greater attentional bias (Robinson and Berridge 2003). Repeated administration of nicotine leads to the mesocorticolimbic system being sensitised and the desire for the drug is linked to smoking-related stimuli, creating attentional bias. In contrast, Mogg et al. (2005) utilised a visual dot probe task with eye-tracking to show greater initial fixation and overall gaze duration to smoking-related stimuli in smokers with little nicotine dependence. Smoking dependence was classified through scores on the Fagerström Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski and Frecker 1991) where smokers with little dependence scored less than three. This is conflicting to both the theoretical predictions of the 'incentive-salience' theory and the results found in Vollstädt-Klein et al. (2011). However, it is consistent with the 'incentive-habit' theory as more heavily dependent substance users do not require the salient properties of drug-related cues for smoking maintenance (Di Chiara 2000). The same results were found by Hogarth, Mogg and Bradley (2003) who utilised a visual dot probe task and found that light smokers had significantly greater attentional bias than heavy smokers and non-smokers. These groups were created from the number of cigarettes the smokers consumed per day with less than 20 being classified as showing little dependence. Mogg et al. (2005) and Hogarth et al. (2003) provide support for the 'incentive-habit' theory whereas Vollstädt-Klein et al. (2011) provide support for the 'incentive-salience' theory. The current study aimed to clarify this conflict in results by thoroughly investigating if attentional bias is present in dependent and non-dependent smokers.

1.5. Measuring Attentional Bias.

1.5.1. Direct and indirect measures.

To investigate the disparity in results between dependent and non-dependent smokers, direct and indirect measures of attentional bias can be used. Direct experiments consist of recording eye movements towards different stimuli which allow the direction and duration of gaze to be monitored (Field and Cox 2008). Indirect methods infer attentional bias through a task being impaired by the presence of drug-related stimuli (Field and Cox 2008). Two common indirect measures of attentional bias are the modified Stroop task and the visual dot probe task. The modified Stroop task presents neutral and drug-related words in different colours to participants who are required to indicate the colour of the word being presented (Rzetelny, Gilbert and Hammersley 2008). Drug-related words attract the user's attention and distract them from the primary task of identifying the colour of the word, producing longer reaction times. A similar principle is used for the visual dot probe task, where two pictures are presented simultaneously to the participant: one consisting of a neutral image, the other consisting of a drug-related image (Ehrman et al. 2002). When they disappear, one picture is replaced by a cue which the participant has to indicate the position of using a keyboard. Attentional bias is inferred in this task by participants reacting faster to cues that replace drug-related images. This is due to the participants already looking at the location of the drug-related image which allows them to respond faster (Peuker and Bizarro 2014).

Previous research has questioned the assumption that the modified stroop task solely assesses attentional bias. It is suggested that the effect of slowing down reaction times can also be attributed to any minute differences in semantic content or word complexity (Field and Cox

2008). Furthermore, it has been highlighted that the modified Stroop task results in slower responses to any words with emotional content relative to neutral words (Algom, Chajut and Lev 2004). It can be considered to be oversensitive as it appears to show an individual displaying attentional bias towards words that have any emotional content. On the other hand, the visual dot probe task has been used extensively in attentional bias research and has consistently been able to differentiate between smokers and non-smokers (Ehrman et al. 2002; Field et al. 2004; Vollstädt-Klein et al. 2011). It is considered to be a more direct measure of attentional bias as rather than inferring the processing of drug-related words, it is inferring the location of attention which is analogous to the eye-tracking paradigm (Field and Cox 2008). Therefore, the current study used a visual dot probe task to explore the differences between dependent and non-dependent smokers.

1.5.2. Manipulating Stimulus Onset Asynchrony (SOA).

Using a visual dot probe task, the current study explored the presence of attentional bias by using multiple picture presentation times. This is known as the stimulus onset asynchrony (SOA) and it is the duration the pictures are presented for on the visual dot probe task before a cue is presented (Field and Cox 2008). The SOA is important as it measures a discrete snapshot of attention. Short times of 200 milliseconds (ms) or below measure the initial orientation to stimuli, whereas longer times of 500ms or more measure where the participant is maintaining their attention (Field et al. 2004). Previous research in attentional bias has been criticised for simplifying the whole attentional process by using only one SOA in the visual dot probe task (Field and Cox 2008). This is consistent for each of the previous studies

investigating differences between dependent and non-dependent smokers as Vollstädt-Klein et al. (2011) and Hogarth et al. (2003) used an SOA of 500ms, whereas Mogg et al. (2005) used an SOA of 2000ms. Considering this, the current study will utilise three different SOAs to provide a comprehensive insight into the presence of attentional bias in dependent and non-dependent smokers. The three times that will be used are 200ms, 500ms and 2000ms which allows a comparison with the three previous studies, and extends the literature to include a measure of initial orientation at 200ms. This has seemingly not been investigated before in smokers, but it has in alcohol drinkers. Heavy social drinkers showed greater attentional bias to alcohol related stimuli at 500ms and 2000ms, but not at 200ms (Field, Mogg and Zetteler 2004). This suggests that attentional bias is mainly present during the maintenance of attention, at least in heavy social drinkers. After considering this previous research, the current study explored the presence of attentional bias using three different SOAs. The aim of this was to clarify the conflicting research into differences between dependent and non-dependent smokers as each previous study has only provided a snapshot of attention by only using one SOA.

1.5.3. The classification of dependence.

To be able to classify smokers as dependent or non-dependent, the current study used scoring parameters from the FTND (Heatherton et al. 1991). This questionnaire measures behavioural indicators of dependence and has previously been used to classify smokers in attentional bias research (Mogg et al. 2005; Vollstädt-Klein et al. 2011; Kang et al. 2012). This method has been shown to create accurate groups as it formed statistically similar groups to the exhaled concentration of carbon monoxide which is considered an objective measure of

nicotine dependence (Vollstädt-Klein et al. 2011). The current study used a FTND scoring threshold of less than three to indicate a non-dependent smoker, and three or more to indicate a dependent smoker similar to Vollstädt-Klein et al. (2011). The exhaled concentration of CO is an objective measure of average cigarette exposure (Mogg et al. 2005) and was used as an additional measure of nicotine dependence.

1.5.4. The effect of craving and mood.

To accurately assess attentional bias, some considerations need to be made. Craving (Field, Munafò and Franken 2009) and mood (Bradley, Garner and Hudson 2007) have been suggested to affect attentional bias. Craving is theoretically linked with attentional bias in a reciprocal relationship where an increase in one is associated with an increase in the other (Field and Cox 2008). This has been exhibited by Kang et al. (2012) who found that attentional bias was positively correlated with subjective craving. Although it has a weaker relationship, there is a suggestion that mood can influence attentional bias. Negative affect produced a greater urge to smoke in one study (Bradley et al. 2007), and it has been found that there is a positive correlation between negative affect and attentional bias (Drobes et al. 2006).

Additionally, if participants are in a negative mood and are exposed to a negative stimulus, vigilance for neutral stimuli is impaired (Rokke and Lystad 2015). This may impact the attentional bias score and give the impression that smoking stimuli are being attended to faster, where in reality it is the neutral stimuli that are being attended to slower. The current study explored the potential effects of mood and craving in each group to be able to attribute any differences in attentional bias to the differences in nicotine dependence.

1.6. The Difference in Smoking Motives and Habits

1.6.1. Smoking motives.

To create a comprehensive profile of dependent and non-dependent smokers, the differences in what motivates each group to smoke was explored. Smokers who are not dependent on nicotine tend to smoke for the rewards they gain from the habit (Shiffman, Dunbar and Scholl 2012a). Shiffman et al. (2012a) reported that social influences, cue reactivity and taste sensation are important motivators for non-dependent smokers. On the other hand, dependent smokers use cigarettes in response to tolerance, cravings and habit. This can be related to the role of reinforcement in addiction as non-dependent smokers use cigarettes for their rewarding properties similar to new smokers, but dependent smokers use cigarettes to avoid experiencing withdrawal symptoms (Watkins et al. 2000). The importance of positive reinforcement in non-dependent smokers is emphasised by interesting findings using real-time measurements of the situations they smoke in. Non-dependent smokers recorded in an electronic diary that they were more likely to smoke when they were socialising and drinking alcohol (Shiffman, Dunbar and Li 2014). Non-dependent smokers can therefore be described as indulgent and tend to smoke when they are already enjoying a situation. Moreover, non-dependent smokers are not just 'social smokers' as a large proportion of their cigarettes are smoked alone (Shiffman et al. 2014). This shows that smoking is important for non-dependent smokers not only while they are socialising, but for a wide range of rewards they gain from smoking.

1.6.2. Smoking habits.

After considering what motivates dependent and non-dependent smokers, understanding their smoking patterns is essential in describing the differences between the two groups. Non-dependent smokers are abstinent for a large period of time, often having several days between smoking episodes which allows nicotine to be totally absent from the body (Shiffman, Tindle and Li 2012b). Furthermore, non-dependent smokers are not new to using cigarettes as many have been smoking for decades, and they are not smoking less in response to high cigarette prices (Shiffman et al. 2012b). This shows that they are an established group of smokers who are characterised by a low but extremely pervasive rate of consuming cigarettes. As around 60% of university students are under the age of 24 (Higher Education Statistics Agency 2013), a large number of student smokers are likely to have smoked for less than 10 years. University students were the target population for the current study, therefore the likelihood of smokers having a relatively short smoking duration needed to be considered. With an average age of 16, one study found that at a young age different types of smokers can already be differentiated (Rubinstein, Rait and Sen 2014). Those who smoked less than daily throughout the week consumed an average of four cigarettes less per day and tended to start smoking at a later age. Even at a young age, these participants can be described as non-dependent smokers as they show the defining characteristics of smoking in social situations and a low rate of consumption (Rubinstein et al. 2014). This collection of research shows that dependent and non-dependent smokers have significant differences in the smoking habits they show, even in relatively young smokers. The current study aimed to create a comprehensive

profile of dependent and non-dependent smokers by outlining their smoking habits, motives and attentional bias towards smoking-related stimuli.

1.7. Aims and Hypotheses

The smoking motives and habits of dependent and non-dependent smokers were assessed using self-report questionnaires in the aim of creating a comprehensive profile of each group. Similar to the results found in Shiffman et al. (2012a), it was predicted that dependent smokers would be motivated by factors relating to negative reinforcement, and non-dependent smokers would be motivated by factors relating to positive reinforcement. The current study aimed to investigate if attentional bias was present in dependent and non-dependent smokers by using a visual dot probe task. Some research has found that dependent smokers show greater attentional bias to smoking-related stimuli (Vollstadt-Klein et al. 2011) which is consistent with the 'incentive-sensitisation' theory of addiction (Robinson and Berridge 1993). Alternatively, non-dependent smokers have been observed to show greater attentional bias (Hogarth et al. 2003; Mogg et al. 2005) which is consistent with the 'incentive-habit' theory (Di Chiara 2000). It was predicted that there will be a significant difference between the two smoking groups, but the direction was unclear due to the conflict in previous research. As the three previous studies in dependent and non-dependent smokers only used one SOA, the current study aimed to explore if attentional bias was present using three different SOAs (200ms, 500ms and 2000ms). As this had seemingly not been investigated before in smokers, no specific predictions were made regarding the differences in attentional bias across each SOA.

2. Method

2.1. Design

The main research question was a 3 (smoking group) x 3 (stimulus onset asynchrony: SOA) mixed design. Smoking group was a between-participants independent variable and had three levels: non-smokers, dependent smokers and non-dependent smokers. Those who have never smoked regularly formed the non-smoking control group. Smokers were classified as dependent or non-dependent by their FTND score. Non-dependent smokers scored less than three and dependent smokers scored three or more (Vollstädt-Klein et al. 2011). The SOA was a within-participants independent variable and had three levels: 200ms, 500ms and 2000ms. The dependent variable was the attentional bias score from the visual dot probe task. This was calculated by subtracting the average reaction time to smoking-related stimuli from the average reaction time to neutral stimuli. A positive value indicates attentional bias as the individuals are faster to react to cues replacing the smoking-related stimuli. An attentional bias score was calculated for each SOA condition to investigate the full spectrum of attention.

2.2. Participants

A volunteer sample of 37 students and staff from Coventry University were used. There were 20 smokers (11 female) and 17 non-smokers (13 female). There was not a significant difference between the amount of males and females in each group, $\chi^2(1) = 1.70, p = .193$. The mean age of smokers was 25.75 ($SD=7.82$, range 18-44) and the mean age of non-smokers was 20.00 ($SD=1.70$, range 18-25). A Mann Whitney U test showed that smokers were significantly

older than non-smokers, $U=83.00$, $p=.007$. The students were studying psychology and were recruited from an online research participation scheme to receive course credits. Members of staff who were known smokers were contacted directly and asked if they would participate. General inclusion criteria included having no visual or neurological deficits that may impact performance on a computer-based task. Smokers were required to have used cigarettes for two years or more and abstain from smoking for an hour before their time slot. Non-smokers were required to have never smoked regularly.

2.3. Materials

2.3.1. Fagerström Test for Nicotine Dependence (FTND).

The FTND is a questionnaire that is used to determine how dependent an individual is on nicotine (Heatherton et al. 1991). Behavioural indicators of dependence are assessed using six questions with a total score ranging from 0-10. Topics the questions assess include: time till the first cigarette after waking; any difficulty refraining from smoking and continuing to smoke whilst severely ill. The scoring system is based on levels of dependence: very low (1-2); low (3-4); medium (5); high (6-7) and very high (8-10). However, there is no standardised score threshold to determine when an individual is dependent on nicotine. Previous research has used a score of <3 to indicate a non-dependent smoker, and ≥ 3 for a dependent smoker (Vollstädt-Klein et al. 2011). The questionnaire has satisfactory test-retest reliability ($r = 0.88$) and an acceptable internal consistency ($\alpha = 0.64$) (Pomerleau, Carton and Lutzke 1994).

2.3.2. Positive and Negative Affect Schedule (PANAS).

The PANAS is a questionnaire to assess mood using two 10 item scales measuring positive and negative affect (Watson, Clark and Tellegen 1988). The total score is calculated separately for each scale, with a range of 10-50 for each. A lower score indicates low positive or negative affect, and a higher score indicates high positive or negative affect. Participants rate how they feel by rating different adjectives on a scale of 1 (very slightly or not at all) to 5 (extremely). Words relating to positive affect include: interested; alert; enthusiastic and determined. Words relating to negative affect include: distressed; hostile; afraid and jittery. The PANAS has high internal consistency for both positive ($\alpha = 0.89$) and negative affect ($\alpha = 0.85$) (Crawford and Henry 2004).

2.3.3. The Brief Questionnaire of Smoking Urges (QSU-brief).

The QSU-brief assesses the craving associated with the use of cigarettes (Cox, Tiffany and Christen 2001). It is based on the Questionnaire of Smoking Urges (Tiffany and Drobes 1991) which has 32 items. The QSU-brief is designed to be less time consuming and is widely used (e.g. Mogg et al. 2005 and Kang et al. 2012). The questionnaire has 10 statements which are answered using a seven point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The answer to each question is summed to result in a total score ranging from 10-70. A lower score indicates low craving and a higher score indicates high craving. Examples of the statements that are presented include: 'I have a desire for a cigarette right now' and 'I could control things better right now if I could smoke'. In a non-clinical sample, the questionnaire has very high internal consistency ($\alpha = 0.97$) (Cox et al. 2001).

2.3.4. Wisconsin Inventory of Smoking Dependence Motives (WISDM-68).

The WISDM-68 explores different motives associated with smoking cigarettes (Piper, Piasecki and Federman 2004). There are 13 subscales that are assessed by 68 statements. Each statement is rated using a 7 point Likert scale ranging from 1 (not true of me at all) to 7 (extremely true of me). Each subscale receives a score by calculating the mean response in that subscale. A total score for the WISDM-68 can range between 13 and 91 which can be calculated by summing the means of each subscale, with a higher score indicating greater smoking dependence. These subscales are theoretically related to dependence and can be divided into two types of motive: primary and secondary (Shiffman et al. 2012a). Primary motives target physical indicators of dependence such as tolerance, craving, automaticity and loss of control. An example statement for the tolerance motive is 'I usually want to smoke right after I wake up'. Secondary motives target motivational aspects of dependence such as cue exposure, social goads, and positive reinforcement. One statement for the cue exposure motive is 'my life is full of reminders to smoke'. The internal consistencies for each subscale range from good to excellent with Cronbach's alpha scores between 0.73 to 0.95 (Piper et al. 2004).

2.4. Measures

2.4.1. Carbon monoxide.

To assess the amount of carbon monoxide (CO) present in the participant's lungs, the MicroCO Monitor (CareFusion Corporation, USA) was used. This handheld device measures the exhaled concentration of CO in the lungs in parts per million (ppm). Using exhaled CO is an

objective measure of average cigarette exposure which is being used as an additional indicator of nicotine dependence (Vollstädt-Klein et al. 2011).

2.4.2. Visual dot probe task and pictorial stimuli.

The pictorial stimuli were the same images used in Vollstädt-Klein et al. (2011). These consisted of one smoking-related image such as a hand holding a cigarette, presented together with a closely matched neutral image of a hand holding a pencil. They were validated by Vollstädt-Klein et al. (2011) who conducted a pilot study on an original set of 45 picture pairs. Craving, valence and arousal ratings were assessed by 30 participants to produce 20 pairs for use in their experiment. These 20 pictures received the highest craving and valence scores, and there were no significant differences in terms of arousal for the smoking-related pictures and their accompanying neutral images. Preceding their use in the current experiment, a short pilot study was conducted on the 20 image pairs. Five participants (3 female, mean number of years as a smoker = 15.80, $SD = 9.76$) rated the images on a 100 point visual analogue scale for craving, valence and arousal. For each picture, the participant responded to the following questions: 'how strong is the craving induced in this picture?'; 'how pleasant do you find this picture?' and 'how arousing do you find this picture?'. This validated the pictures for use in the current study as the original was conducted in Germany. The 15 smoking-related images and their corresponding neutral pair with the highest craving and valence scores were included in the visual dot probe task.

The task was presented using OpenSesame (version 2.8.3, Mathôt, Schreij and Theeuwes 2012), an open-source experiment builder. This program allowed the pictorial stimuli

to be presented to the participants and record their reaction time responses with millisecond accuracy. The picture pairs were in colour, 325x450 pixels in size each and were presented side by side with a distance of 620 pixels between them. One picture was replaced by an arrow facing either up or down. To record the response, participants were instructed to press either the up or down arrow key on the keyboard to match the arrow replacing the picture. For each picture pair, both images were presented twice on the left hand side and twice on the right hand side. For each position the response arrow replaced pictures on the left hand side twice and the right hand side twice. Each picture pair was therefore repeated four times, with this process repeated for each SOA. This equates to 180 trials for each participant, in which the order was randomised in each session. The experiment began with 12 practise trials to familiarise the participant with the task. Six neutral images were used for the practise trials which had never been used in the pilot study or the experimental task. For the experimental trials, each one began with a fixation cross being presented in the middle of the screen for 500ms. This was replaced by a picture pair being presented until they disappear and a response arrow appears in the location of one of the pictures until the participant responds. The participants are instructed to press the correct arrow as fast as they can throughout the experiment. Only the responses for the 180 experimental trials are included in the analyses.

2.5. Procedure

The study was approved by Coventry University Research Ethics Committee and the certificate of ethical approval can be found in Appendix 1. Participants who smoked were asked to refrain from smoking a cigarette an hour before the start of the experiment. Each participant

completed the experiment individually in a laboratory room within the university and was conducted over a three week period. Smokers completed the WISDM-68 and FTND before attending to reduce any priming effects. Participants gave informed consent by reading a participant information sheet and signing an informed consent form (Appendix 2 and 3 respectively). Each participant completed the PANAS and QSU-brief for a baseline measure of mood and craving alongside a demographics questionnaire (Appendix 4). The amount of exhaled CO was assessed using the CO monitor while the participants were standing. The visual dot probe task was conducted on a laptop (15.5 inch display with a screen resolution of 1366x768 pixels) that was positioned 80cm from the screen to the centre of the chair the participant was sat unrestrained on. The task began with a practise version and when the participants were comfortable with the task, they pressed a key to initiate the experiment which is described above. After completion, each participant filled out a second copy of the PANAS and QSU-brief in which the order was counterbalanced for each participant. At the end of the study session, each participant was thanked and provided with a debriefing form (Appendix 5).

3. Results

Prior to analysis, two smokers were excluded. One gave the incorrect response on more than half the visual dot probe trials indicating they did not fully understand the task instructions. The second was excluded for reporting to have smoked five minutes before their time slot which violated the inclusion criteria. The remaining 18 smokers and 17 non-smokers were included in the final analyses. The data were assessed for missing values and parametric assumptions. All participants provided complete data apart from one dependent smoker who missed one item on the WISDM-68. This was replaced using the method of replacing the missing value with the mean response from the remaining dependent smokers on the affiliative attachment subscale (Field 2013). All data is independent and is at an interval or ratio level. For the participant characteristics, the variables that were not normally distributed were investigated for group differences using Mann-Whitney U tests. For the variables that were normally distributed, independent samples t-tests were used to investigate group differences. Three separate 2 (measure before or after visual dot probe task) x 3 (smoking group) mixed design Analysis of Variance (ANOVA) tests were conducted to investigate differences in craving, and positive and negative affect. A 3 (SOA) x 3 (smoking group) mixed design ANOVA was conducted to investigate differences in attentional bias scores across the different groups and SOA conditions during the visual dot probe task. For each ANOVA, a Kolmogorov-Smirnov test showed that the majority of variables were normally distributed apart from four across all the tests. However, histograms indicated the data was not problematic and the ANOVAs were performed as they are able to be robust under minor violations of parametric assumptions (Field 2013). Pearson's r was calculated for each test between two comparable groups as an

indicator of effect size and should be compared to values of 0.10 for a small effect, 0.30 for a medium effect, and 0.50 for a large effect (Field 2013).

3.1. Participant Characteristics

3.1.1. Smoking habits and descriptive information.

Using their FTND scores, the remaining smokers were divided into two groups. Dependent smokers consisted of eleven participants (seven female) and non-dependent smokers consisted of seven participants (three female). Fisher's exact test indicated there were no differences in the number of males and females in each group ($p=0.63$). All smokers reported smoking seven days per week apart from one non-dependent smoker who reported smoking six days per week.

Table 1 provides a summary of the smoking habits and characteristics of dependent and non-dependent smokers. Each group was similar in age, $t(16)=-1.74$, $p=0.10$, $r=0.40$, number of years as a smoker, $U=21.00$, $p=0.11$, $r=-0.38$, and the age they started to smoke, $U=37.50$, $p=0.93$, $r=-0.02$. Dependent smokers consumed more cigarettes per day, $U=8.00$, $p=0.005$, $r=-0.66$, but each group was similar for the duration since their last cigarette, $U=20.50$, $p=0.09$, $r=-0.40$. Dependent smokers scored significantly higher on each measure of dependence including exhaled concentration of CO, $t(10.17)=-3.27$, $p=0.008$, $r=0.72$, FTND score, $U=0.001$, $p=0.001$, $r=-0.84$ and total WISDM-68 score, $t(16)=-2.36$, $p=0.03$, $r=0.51$. Finally, there was no difference in the number of quit attempts in each group, $U=32.50$, $p=0.57$, $r=-0.13$.

3.1.2. Smoking dependence motives.

The mean scores for each smoking group on the 13 WISDM-68 subscales are presented in Table 2. The subscales are grouped into primary and secondary dependence motives. Individual independent samples t-tests found that for primary dependence motives, dependent smokers scored significantly higher in automaticity, $t(16)=-3.43$, $p=0.003$, $r=0.65$, craving, $t(16)=-2.50$, $p=0.02$, $r=0.53$, loss of control, $t(16)=-3.98$, $p=0.001$, $r=0.71$, and tolerance, $t(16)=-6.26$, $p=0.001$, $r=0.84$. For secondary dependence motives, the two groups were not significantly different in affiliative attachment, $t(16)=-0.69$, $p=0.50$, $r=0.17$, behavioural choice, $t(16)=-1.38$, $p=0.19$, $r=0.33$, cognitive enhancement, $t(16)=-1.75$, $p=0.10$, $r=0.40$, negative reinforcement, $U=30.00$, $p=0.48$, $r=-0.18$, positive reinforcement, $t(16)=-0.82$, $p=0.43$, $r=0.20$, social goals, $t(16)=0.97$, $p=0.35$, $r=0.24$, and sensory/taste processes, $U=32.00$, $p=0.60$, $r=-0.14$. Dependent smokers scored significantly higher on the weight control subscale, $t(16)=-2.30$, $p=0.04$, $r=0.50$ and cue exposure was approaching significance, $U=17.00$, $p=0.06$, $r=0.46$.

Table 1.

Participant Characteristics for Smoking Related Variables in Dependent and Non-dependent Smokers

(S.D. and range are shown in parenthesis)

	Dependent smokers (<i>n</i> = 11)	Non-dependent smokers (<i>n</i> = 7)
Age (years)	28.64 (<i>SD</i> =8.65, range 18-44)	22.14 (<i>SD</i> =5.90, range 18-35)
Age started to regularly smoke (years)		
	17.18 (<i>SD</i> =5.02, range 13-31)	16.00 (<i>SD</i> =1.53, range 14-18)
Number of years as a smoker		
	11.36 (<i>SD</i> =7.39, range 2-25)	6.14 (<i>SD</i> =4.91, range 3-17)
Number of cigarettes per day		
	15.27 (<i>SD</i> =5.20, range 6-20)	6.43 (<i>SD</i> =3.55, range 2-10)*
Time since last cigarette		
(minutes)	108.18 (<i>SD</i> =23.59, range 70-150)	432.86 (<i>SD</i> =423.86, range 90-1140)
CO level, ppm	24.73 (<i>SD</i> =19.75, range 4-62)	5.14 (<i>SD</i> =1.46, range 4-8)*
FTND score	4.82 (<i>SD</i> =1.33, range 3-6)	1.00 (<i>SD</i> =0.82, range 0-2)*
WISDM-68 score	60.74 (<i>SD</i> =14.30, range 39-84)	44.51 (<i>SD</i> =14.14, range 24-60)*
Quit attempts	2.18 (<i>SD</i> =1.33, range 0-4)	1.71 (<i>SD</i> =1.38, 0-3)

Asterisk (*) indicates a significant difference between smoking groups

3.2. Craving and Mood

Mean values for each time point and group are presented in Table 3. The assumption of sphericity was violated in all three tests, therefore all within-participant results are presented using the Greenhouse-Geisser F value correction (Field 2013). For craving, a significant within-participants main effect of time period was found, $F(1,32)=7.17$, $p=0.01$, $r=0.43$, and there was a significant between-participants effect for smoking group, $F(2,32)=35.91$, $p=0.001$. Furthermore, there was a significant interaction effect between time period and smoking group, $F(2,32)=4.51$, $p=0.02$. Post-hoc analysis with Bonferroni corrections was performed to explore group differences. Craving was significantly higher in non-dependent smokers in comparison to non-smokers, $p=0.001$, and higher in dependent smokers in comparison to non-smokers, $p=0.001$. However, craving scores did not differ between dependent and non-dependent smokers, $p=0.96$. Simple effects with Bonferroni corrections indicated there was no difference in craving over the different time periods for non-smokers, $p=0.81$, and non-dependent smokers, $p=0.29$. Craving in dependent smokers significantly increased when it was measured after the visual dot probe task, $p=0.001$.

There was a significant within-participants main effect of time for positive affect, $F(1,32)=8.78$, $p=0.006$, $r=0.46$. There was no between-participants main effect, $F(2,32)=0.33$, $p=0.72$, or interaction effect, $F(2,32)=0.94$, $p=0.40$. Simple effects with Bonferroni corrections indicated that there was not a significant difference in time period for non-smokers, $p=0.22$, or non-dependent smokers, $p=0.22$, but dependent smokers significantly decreased in positive affect after the visual dot probe task, $p=0.01$.

Table 2.

Mean Scores for Dependent and Non-dependent Smokers on Primary and Secondary Smoking Motives from the WISDM-68

	Dependent smokers ($n = 11$)	Non-dependent smokers ($n = 7$)
Primary Motives:		
Automaticity	5.35 (SD=1.56)	2.86 (SD=1.39) *
Loss of Control	4.87 (SD=1.69)	2.14 (SD=0.78) *
Craving	5.07 (SD=1.16)	3.68 (SD=1.14) *
Tolerance	5.31 (SD=1.12)	2.11 (SD=0.94) *
Secondary Motives:		
Affiliative Attachment	3.34 (SD=2.24)	2.66 (SD=1.72)
Behavioural Choice	4.12 (SD=2.09)	2.82 (SD=1.71)
Cognitive Enhancement	4.61 (SD=1.38)	3.29 (SD=1.83)
Cue Exposure	5.69 (SD=0.71)	4.98 (SD=0.97)
Negative Reinforcement	5.33 (SD=1.52)	4.43 (SD=1.99)
Positive Reinforcement	4.89 (SD=1.58)	4.20 (SD=1.99)
Social Goads	4.07 (SD=1.75)	4.82 (SD=1.35)
Sensory/Taste Processes	5.04 (SD=1.21)	4.95 (SD=1.79)
Weight Control	3.05 (SD=1.60)	1.57 (SD=0.70) *
Asterisk (*) indicates a significant difference between smoking groups		

Negative affect did not have a main within-participants effect of time, $F(1,32)=0.05$, $p=0.82$, $r=0.04$, or interaction effect, $F(2,32)=0.11$, $p=0.89$. However, there was a significant between-participants main effect, $F(2,32)=4.31$, $p=0.02$. Post-hoc analysis using Bonferroni corrections highlighted there was no difference between non-smokers and non-dependent smokers, $p=1.00$, or between non-dependent and dependent smokers, $p=0.24$. Dependent smokers scored significantly higher on negative affect in comparison to non-smokers, $p=0.002$.

3.3. Visual Dot Probe Task

Before the analysis, reaction times were assessed for incorrect responses and extreme values. The total possible number of trials was 6300 between 35 participants. Incorrect responses occurred in 164 trials (2.60%) which were excluded and removed from the analysis. Extreme values were classified as being below 200ms or greater than 1000ms (Ehrman et al. 2002). Below 200ms indicates participants have reacted before the cue has been presented and greater than 1000ms indicates inattention.

Table 3.

Mean Scores for Craving and Mood Before and After Visual Dot Probe Task

	Non-smokers (<i>n</i> =17)	Dependent smokers (<i>n</i> =11)	Non-dependent smokers (<i>n</i> =7)
Pre-QSU-brief	10.53 (<i>SD</i> =2.18)	40.73 (<i>SD</i> =17.00)	37.14 (<i>SD</i> =12.99)
Post-QSU-brief	10.24 (<i>SD</i> =0.75)	46.18 (<i>SD</i> =16.46)	39.14 (<i>SD</i> =14.67)
Pre-PANAS- positive	33.12 (<i>SD</i> =7.01)	32.64 (<i>SD</i> =3.67)	32.14 (<i>SD</i> =6.26)
Post-PANAS- positive	31.47 (<i>SD</i> =8.02)	28.09 (<i>SD</i> =6.56)	29.57 (<i>SD</i> =9.54)
Pre-PANAS- Negative	12.65 (<i>SD</i> =3.16)	17.64 (<i>SD</i> =7.81)	13.43 (<i>SD</i> =3.05)
Post-PANAS- negative	12.24 (<i>SD</i> =3.03)	17.36 (<i>SD</i> =6.30)	13.71 (<i>SD</i> =4.15)

Extreme reaction times accounted for 49 trials (0.78%) being removed. This resulted in 6087 trials (96.61%) being included in the final analysis. The individual reaction times for smoking-related and neutral images are presented alongside the attentional bias score for each SOA condition in Table 4. The assumption of sphericity was violated therefore all within-participant results are presented using the Greenhouse-Geisser F value correction. There was a non-significant within-participants main effect of SOA condition, $F(1.38, 44.02)=0.30$, $p=0.66$, $r=0.08$, between-participants main effect, $F(2, 32)=0.79$, $p=0.46$, and interaction effect, $F(2.75, 44.02)=0.27$, $p=0.83$.

A 3(SOA) x 2(smoker or non-smoker) mixed design ANOVA was performed to explore if there were any collective differences in attentional bias as there was a significant difference in craving between both smoking groups and non-smokers. A Greenhouse-Geisser F value correction was used as the assumption of sphericity was violated. Consistent with separate smoking groups, there was no within-participants main effect, $F(1.38, 45.51)=0.35$, $p=0.63$, between-participants main effect, $F(1, 33)=0.13$, $p=0.72$, $r=0.06$, or interaction effect, $F(1.38, 45.51)=0.35$, $p=0.63$.

Table 4.

Mean Reaction Times (ms) for Smoking and Neutral Stimuli, and Attentional Bias Score in each SOA

Condition

	Non-smokers (<i>n</i> =17)	Smokers (<i>n</i> =18)	Dependent smokers (<i>n</i> =11)	Non-dependent smokers (<i>n</i> =7)
200ms smoking	537.30 (<i>SD</i> =52.67)	543.94 (<i>SD</i> =80.75)	567.83 (<i>SD</i> =92.65)	506.38 (<i>SD</i> =38.40)
200ms neutral	534.27 (<i>SD</i> =60.19)	550.84 (<i>SD</i> =74.77)	568.54 (<i>SD</i> =87.69)	523.04 (<i>SD</i> =39.31)
500ms smoking	541.23 (<i>SD</i> =67.88)	548.34 (<i>SD</i> =72.68)	566.39 (<i>SD</i> =83.37)	519.16 (<i>SD</i> =42.98)
500ms neutral	537.51 (<i>SD</i> =59.16)	545.43 (<i>SD</i> =67.68)	558.77 (<i>SD</i> =80.29)	524.47 (<i>SD</i> =37.37)
2000ms smoking	533.38 (<i>SD</i> =62.80)	540.86 (<i>SD</i> =65.41)	551.36 (<i>SD</i> =69.92)	524.36 (<i>SD</i> =58.79)
2000ms neutral	539.55 (<i>SD</i> =56.32)	542.35 (<i>SD</i> =66.15)	552.54 (<i>SD</i> =77.12)	526.34 (<i>SD</i> =44.68)
Attentional bias score 200ms	-3.03 (<i>SD</i> =28.61)	6.91 (<i>SD</i> =31.55)	0.71 (<i>SD</i> =31.95)	16.65 (<i>SD</i> =30.62)
Attentional bias score 500ms	-3.72 (<i>SD</i> =34.63)	-2.91 (<i>SD</i> =33.94)	-7.62 (<i>SD</i> =38.51)	4.51 (<i>SD</i> =26.23)
Attentional bias score 2000ms	6.18 (<i>SD</i> =37.24)	1.49 (<i>SD</i> =39.29)	1.18 (<i>SD</i> =46.89)	1.98 (<i>SD</i> =26.62)

4. Discussion

4.1. Summary of Results

The current study explored the smoking habits and motives in dependent and non-dependent smokers. Dependent smokers consumed significantly more cigarettes per day, had higher FTND and total WISDM-68 scores, and had a larger concentration of exhaled CO. It was hypothesised that dependent smokers would be motivated to smoke by negative reinforcement, and that non-dependent smokers would be motivated to smoke by positive reinforcement. Scores on the WISDM-68 were consistent with the hypothesis that dependent smokers would be motivated by negative reinforcement as they scored higher on subscales relating to primary dependence motives. The hypothesis that non-dependent smokers would be motivated to smoke by positive reinforcement was also supported as their highest scores were on the secondary dependence motives. Using a visual dot probe task, the current study investigated if attentional bias was present in dependent and non-dependent smokers. As there was a conflict in previous research to whether dependent or non-dependent smokers showed greater attentional bias, it was hypothesised that there would be a significant difference between the two groups but the direction was unclear. The visual dot probe task results were not consistent with the hypothesis and showed that dependent smokers, non-dependent smokers and non-smokers did not differ in attentional bias towards smoking-related stimuli. Due to the results consisting of several measures, each section will subsequently be explored in greater detail.

4.2. Exploration of Results

4.2.1. Participant characteristics.

The data (Table 1) show that dependent smokers were older on average and tended to have smoked for a longer period of time. Non-dependent smokers reported to start smoking at an earlier age but none of these differences were statistically significant. It should be noted that the difference in age and the number of years as a smoker received a moderate effect size and a post-hoc power analysis using G*Power (Version 3.1, Faul, Erdfelder and Lang 2007) found that they received a probability value of 0.12 and 0.11 respectively. This suggests that there was insufficient power to detect a difference between the two groups as a value of 0.80 or more represents sufficient power (Field 2013). It appears that both groups found it difficult to quit smoking as they had experienced a similar number of quit attempts. This is consistent with previous research in dependent and non-dependent smokers as it has been reported that both groups find it equally difficult to quit smoking (Tindle and Shiffman 2011). Similarities between the smokers also included the time since their last cigarette. Dependent smokers had a shorter duration since their last cigarette in comparison to non-dependent smokers but the difference did not reach statistical significance despite a moderate effect size. This is consistent with the results found by Mogg et al. (2005) who found that dependent smokers report a shorter duration since their last cigarette without being significantly shorter. In dependent smokers, the half-life of nicotine to be eliminated from the body is around two hours which makes this period of time comfortable for them to be without a cigarette (Advokat et al. 2014). After two hours, the individual begins to experience withdrawal effects and they are prompted to have another cigarette. This can be applied to the average duration for dependent smokers to have

had their last cigarette as it was between the hour smokers were asked to refrain from smoking and the two hour half-life of nicotine.

For measures of dependence, dependent smokers consumed more cigarettes per day, had higher scores on the FTND and WISDM-68, and had a higher concentration of exhaled CO which all received large effect sizes. The results are consistent with previous literature as the two smoking groups are characterised by differences in their dependence on nicotine. The number of cigarettes smoked per day was similar to the smokers in Shiffman et al. (2014) as dependent smokers consumed around 10 cigarettes more than non-dependent smokers. Furthermore, the pattern of results for the FTND score and CO concentration were comparable to the differences found in Mogg et al. (2005) and Vollstädt-Klein et al. (2011). This shows that on measures of nicotine dependence, the two smoking groups were consistent with previous research. The results have shown that the two smoking groups have significantly different smoking patterns and they report this habit to be maintained by different motives.

Dependent smokers scored significantly higher with large effect sizes on the WISDM-68 subscales relating to primary dependence motives (Table 2). These subscales measure tolerance, automaticity, craving and loss of control which relate to the physical indicators of dependence (Piper et al. 2004). This is consistent with previous research using the WISDM-68 as Shiffman et al. (2012a) found that dependent smokers scored significantly higher on primary dependence motives. This can be related to the theoretical basis of addiction as when a drug user becomes dependent on a substance, negative reinforcement is the primary motivator in continuing drug use (Watkins et al. 2000). This results in maintaining a constant level of nicotine to avoid experiencing withdrawal effects which the primary dependence motives aim to

measure. The results were consistent with this and suggest primary dependence motives are an important motivator for dependent smokers. This was also reflected in the total score of the WISDM-68 as dependent smokers produced a significantly higher value and each subscale was scored higher by the dependent smokers apart from social goads. This was expected as the total score provides an overall indicator of dependence (Piper et al. 2004), and like each of the other measures of dependence was significantly higher in smokers who were classified as dependent on nicotine. Moreover, consistent with Shiffman et al. (2012a) subscales relating to secondary dependence motives were scored higher than primary dependence motives by non-dependent smokers. Cue exposure, taste sensation and social goads were the most important motivators for non-dependent smokers in the current study and in Shiffman et al. (2012a). The importance of socialising as an indicator to smoke in non-dependent smokers has been reported previously in both younger (Rubinstein et al. 2014) and older smokers (Shiffman et al. 2014). Overall, the data suggests that dependent and non-dependent smokers are two distinct groups who are characterised by differences in their smoking patterns and motives. Before any conclusions can be made on the presence of attentional bias, the differences in mood and craving between each smoking and non-smoking group must be considered.

4.2.2. Craving and mood.

The subjective craving for cigarettes and mood was assessed before and after the visual dot probe task to investigate if any of the differences in attentional bias could be attributed to differences in craving or mood. Dependent and non-dependent smokers had increased subjective craving after the visual dot probe task but dependent smokers were the only group to significantly increase. Non-smokers craving ratings decreased slightly but remained relatively

stable at a low level. There was also a significant group and interaction effect. Dependent and non-dependent smokers had significantly higher craving ratings in comparison to non-smokers. It is unsurprising that non-smokers report almost the lowest possible score as craving is characteristic of a substance user (Field et al. 2009). However, subjective craving was not significantly different between dependent and non-dependent smokers. This is consistent with previous research as Mogg et al. (2005) found an increase in craving after the visual dot probe task in dependent and non-dependent smokers but there were no significant differences between the two groups. The positive affect dimension of mood received a significant effect of time, but there was no group or interaction effect. Table 3 shows that all three groups reported almost identical ratings of positive affect before the task was conducted. Each group reduced their rating of positive affect after completing the visual dot probe task but dependent smokers were the only group to significantly decrease. Negative affect did not receive a significant effect of time or an interaction. Table 3 shows that all three groups did not significantly change their rating of negative affect after the visual dot probe task was completed. There was a significant group effect as dependent smokers scored significantly higher in comparison to non-dependent smokers and non-smokers. A decrease in positive affect after completing a visual dot probe task has been observed previously (Attwood, O'Sullivan and Leonards 2008). However, negative affect increased after completing the visual dot probe task in Attwood et al. (2008) but there was no change in any of the groups in the current study. Mood was explored as negative affect has been suggested to have a positive correlation with attentional bias (Drobes et al. 2006), and craving was explored as it closely related to attentional bias (Field et al. 2009). Despite the

concern that mood or craving may affect attentional bias, there was no difference between the groups in attentional bias which suggests they did not have a large effect.

4.2.3. Attentional bias.

The presence of attentional bias in dependent or non-dependent smokers was investigated as there had been conflicting results in previous research. The current study found that there were no differences in attentional bias across each SOA condition between dependent smokers, non-dependent smokers and non-smokers. In the 200ms SOA condition, the dependent smokers had a small positive score and non-smokers had a small negative score which indicates they responded at roughly the same speed for neutral and smoking-related stimuli. The non-dependent smokers produced a higher attentional bias score than both of the other groups to suggest they responded faster to cues replacing smoking-related stimuli. An SOA of 500ms resulted in non-smokers showing attentional avoidance to smoking-related stimuli as they produced a small negative score similar to their results in the 200ms condition. Dependent smokers displayed greater attentional avoidance than non-smokers as they received a larger negative score. Non-dependent smokers still showed attentional bias for smoking-related stimuli, but resulted in a smaller score than in the 200ms condition. In the 2000ms condition, both dependent and non-dependent smokers produced attentional bias scores slightly over zero. On the other hand, although still relatively small, non-smokers produced a larger attentional bias score than both smoking groups. Despite the differences between the groups in each SOA condition, none reached statistical significance.

The results were inconsistent with the hypothesis and previous research as dependent smokers produced significantly higher attentional bias than non-smokers and non-dependent

smokers in Vollstädt-Klein et al. (2011), and non-dependent smokers showed greater attentional bias than dependent smokers in Hogarth et al. (2003) and Mogg et al. (2005). Although there was a conflict in previous research, there has consistently been a significant difference between the two smoking groups. To further explore if any differences were present, a second analysis was performed. The two smoking groups were collapsed into one collective smoking group and compared to non-smokers to investigate if there was a difference in attentional bias score across the three SOA conditions. Consistent with using two smoking groups, there was no effect of time, group or interaction when comparing attentional bias between smokers and non-smokers. This is inconsistent with a larger body of research as indirect and direct measures have found greater attentional bias in smokers in comparison to non-smokers (Ehrman et al. 2002; Mogg et al. 2003; Field et al. 2004; Drobles et al. 2006; Baschnagel 2013). Due to the inconsistency with a large amount of previous research, it is thought that the lack of differences between the groups does not accurately represent the presence of attentional bias and the data is not able to support the predictions of either the 'incentive-salience' theory (Robinson and Berridge 1993) or the 'incentive-habit' theory of addiction (Di Chiara 2000). In response to the inconsistency, some suggestions are made to try and explain this disparity.

4.3. Accounting for the Inconsistent Attentional Bias Results

The difference in the presence of attentional bias in the current study in comparison to previous research may be accounted for by the small smoking group sample sizes. Previous investigations into attentional bias in dependent and non-dependent smokers included over double the number of participants in each group (Mogg et al. 2005; Vollstädt-Klein et al. 2011).

Moreover, Field et al. (2004) had larger groups when they explored the differences in attentional bias over three different SOA conditions. A post-hoc power analysis was performed on the between-groups main effect and a probability value of 0.06 was calculated. Considering a value of 0.80 or more has been suggested to represent sufficient power (Field 2013), the current study did not possess the capability to detect any differences in attentional bias between the three groups. The attentional bias scores in the 200ms SOA condition have differences between the groups that are comparable to the results found in Vollstädt-Klein et al. (2011) when they used an SOA of 500ms. Therefore, the lack of power in the current study may have had an impact on detecting a difference between the groups in the 200ms SOA condition. However, the attentional bias scores for the 500ms and 2000ms SOA conditions were all closer to zero and were inconsistent with Vollstädt-Klein et al. (2011) and Mogg et al. (2005) who used an SOA of 500ms and 2000ms in their respective studies. In response to the lack of power, future research could utilise eye-tracking as a direct measure of attentional bias if the sample size is expected to be relatively small. A meta-analysis has found that studies using direct measures of attentional bias result in a larger effect size in comparison to indirect measures (Field et al. 2009). A lack of power may explain the results in the 200ms condition, but in the 500ms and 2000ms conditions the scores are close to zero which suggests a lack of power may not explain all the disparity with previous research.

The results suggest that both the smoking-related and the neutral images elicited the same response in the participants, indicated by the lack of attentional bias. It is unlikely that the images themselves failed to stimulate a response as they have been subjected to two pilot studies and they have been used in previous research (Vollstädt-Klein et al. 2011). The 15

images were judged by five smokers to have the highest craving inducing content in a pilot study preceding their use in the current experiment. This shows that they should have been able to elicit a response in at least one of the smoking groups. A lack of response in the smokers may not be directly related to the images that were used as it has been shown that environmental exposure to smoking-related stimuli can have an effect on the magnitude of attentional bias being produced. A study by Oliver and Drobles (2012) showed that prior exposure to smoking-related stimuli increased the amount of attentional bias that was produced in the initial orientation to stimuli, but decreased the amount of bias to the maintenance of attention on stimuli. As the current study was exploring both the initial orientation and maintenance of attention on smoking-related stimuli, prior environmental exposure before the study sessions may have had a confounding effect on the presence of attentional bias. Smokers were instructed to complete the FTND and WISDM-68 before completing the study to reduce any priming effects the smoking-related questions may have. However, the time they completed these questionnaires could not be determined and some smokers may have been exposed to smoking-related stimuli by completing it directly before they participated. A combination of the lack of the power in the study and the confounding influence of previous exposure to smoking-related stimuli may explain some of the disparity with previous research in dependent and non-dependent smokers. Considering this, it may be beneficial for future attentional bias research to control for the amount of exposure participants have to drug-related stimuli before conducting the study.

4.4. Weakness of the Current Study

The use of self-report in determining when smokers last consumed a cigarette can be considered a limitation. An inclusion criterion for smokers was to restrain from smoking for an hour before the study and violating this criterion would have resulted in the participant having to return at a later date. If a smoker had consumed a cigarette, there would have been no way of knowing if they had reported a longer time since their last cigarette to prevent them from having to return at a later date. This would have had important consequences as smoking has been shown to reduce the salience of smoking-related stimuli (Gilbert, Sugai and Zuo 2007), and selectively reduce the maintenance of attention on smoking-related stimuli (Field et al. 2004). If a smoker consumed a cigarette closer to the start of the study, they would exhibit decreased attentional bias and may have contributed to the lack of attentional bias shown by either smoking group. Future research could control for this possibility by comparing the attentional bias produced in dependent and non-dependent smokers in both a satiated and nicotine deprived condition. Overnight nicotine abstinence can be confirmed by the concentration of exhaled CO (Gilbert et al. 2007), which is a more reliable measure of cigarette exposure than self-report. This would remove the possibility of participants smoking after they have reported to do so and allow a comparison between the two smoking groups. The effect of acute nicotine deprivation has been shown to increase the presence of attentional bias in dependent smokers (Field et al. 2004; Gilbert et al. 2007) but it does not appear to have been investigated in non-dependent smokers. Although non-dependent smokers do not experience the withdrawal effects associated with nicotine deprivation (Tindle and Shiffman 2011), acute deprivation has been shown to increase the choice of cigarettes as part of a task where rewards

could be won in both dependent and non-dependent smokers (Lawn, Freeman and Hindocha 2015). Therefore, it would be beneficial to investigate how deprivation affects the presence of attentional bias in dependent and non-dependent smokers.

4.5. Future Research Direction

Future research could contribute to developing a comprehensive profile of dependent and non-dependent smokers by investigating how cue-reactivity affects attentional bias. Non-dependent smokers have increased subjective craving when they have been shown pictorial stimuli relating to smoking and alcohol (Shiffman, Dunbar and Kirchner 2013) and dependent smokers classified through the WISDM-68 report greater craving when they are exposed to pictorial cues (Dunbar, Shiffman and Kirchner 2014). Research into cue-reactivity usually only presents visual cues to the participants but the smell and taste of cigarettes are also an important sensory stimulus for smokers. This is exhibited by a study that showed that touching and smelling their preferred brand of cigarettes predicted future smoking behaviour in smokers (Carpenter, Saladin and De Santis 2009). Moreover, Carpenter et al. (2009) found that smokers with little dependence on nicotine showed a greater relationship between cue-reactivity and future smoking behaviour. This can be related to the results of the current study as non-dependent smokers reported that cue exposure and sensory sensations were some of the most important motivators for their smoking behaviour. Considering that touching and smelling cigarettes increases the likelihood of future smoking (Carpenter et al. 2009), and the perceived availability of a substance is related to craving and attentional bias (Field and Cox 2008), it would be useful to investigate how this affects attentional bias as the cues are usually visual. In the aim of creating a comprehensive profile of dependent and non-dependent smokers,

investigating how attentional bias is affected by olfactory and tactile cues would develop the understanding of what motivates each group to smoke.

4.6. Practical Implication

The current study has made a contribution to the understanding of dependent and non-dependent smokers. The results suggest that each smoking group is prompted to smoke by different motivating factors. Dependent smokers score significantly higher than non-dependent smokers on motives relating to the physical indicators of dependence such as craving and habit. Non-dependent smokers rate motives such as social goads and cue exposure as the most important motivators for their smoking behaviour. This has practical applications as dependent and non-dependent smokers have a similar cessation failure rate (Tindle and Shiffman 2011), but most pharmacological treatments aim to aid cessation by reducing the experience of withdrawal effects with nicotine replacement therapies (Advokat et al. 2014). Non-dependent smokers do not experience withdrawal effects as they are not dependent on nicotine and pharmacological therapies do not appear to be an effective treatment (Jiménez-Ruiz and Fagerström 2010). Considering the results of the current study where dependent and non-dependent smokers showed similar subjective craving, it may be more effective to focus on therapies that target the psychological addiction to smoking in non-dependent smokers such as strategies that aim to modulate craving (Kober, Kross and Mischel 2010).

4.7. Conclusion

To sum up, previous research has found that smokers can be divided into distinct groups based on how dependent they are on nicotine (Tindle and Shiffman 2011). Each group is characterised by their smoking behaviour and what motivates them to continue smoking

(Shiffman et al. 2012a; Shiffman et al. 2012b). The current study is consistent with this view as the data showed that dependent smokers consumed more cigarettes per day and scored significantly higher on objective and subjective measures of nicotine dependence in comparison to non-dependent smokers. Dependent smokers were motivated to smoke by factors relating to negative reinforcement, and non-dependent smokers were motivated to smoke by factors relating to positive reinforcement. This highlights that some smokers are not motivated to maintain their habit by avoiding the experience of nicotine withdrawal. Attentional bias is also thought to have a role in the maintenance of smoking as it is present alongside craving when the substance is perceived to be available (Field and Cox 2008). However, there has been a conflict in previous research to whether it is present in dependent and non-dependent smokers. The current study aimed to investigate this conflict by exploring different attentional processes using a visual dot probe task with three SOA conditions. The data was inconsistent with previous research as dependent smokers, non-dependent smokers and non-smokers did not have a significantly different attentional bias score in any SOA condition. This disparity with previous research may be due to a combination of a lack of power and the inability to determine when smokers were last exposed to smoking-related stimuli. Nevertheless, the current study has highlighted that smokers are not a homogeneous group and the practical implications are that smoking cessation therapies should target the motivating factors in each smoking group. Therapies that target the psychological motives behind smoking maintenance are likely to be more effective for non-dependent smokers than pharmacological treatments.

References

Action on Smoking and Health (2013) *Smoking and Disease (June 2013)* [online] available from http://www.ash.org.uk/files/documents/ASH_94.pdf [2 April 2015]

Action on Smoking and Health (2015) *Smoking Statistics: Who Smokes and How Much (January 2015)* [online] available from http://ash.org.uk/files/documents/ASH_106.pdf [31 March 2015]

Advokat, C. D., Comaty, J. E. and Julien, R. M. (2014) *Julien's Primer of Drug Action*. New York: Worth Publishers

Algom, D., Chajut, E. and Lev, S. (2004) 'A Rational Look at the Emotional Stroop Phenomenon: A Generic Slowdown, Not a Stroop Effect'. *Journal of Experimental Psychology: General* 133(3), 323-338

Attwood, A. S., O'Sullivan, H., Leonards, U., Mackintosh, B. and Munafò, M. R. (2008) 'Attentional Bias Training and Cue Reactivity in Cigarette Smokers'. *Addiction* 103(11), 1875-1882

Baschnagel, J. S. (2013) 'Using Mobile Eye-Tracking to Assess Attention to Smoking Cues in a Naturalized Environment'. *Addictive Behaviors* 38, 2837-2840

Bradley, B. P., Garner, M., Hudson, Mogg, K. (2007) 'Influence of Negative Affect on Selective Attention to Smoking-Related Cues and Urge to Smoke in Cigarette Smokers'. *Behavioural Pharmacology* 18(4), 255-263

Brook, D. W., Brook, J. S., Zhang, C., Whiteman, M., Cohen, P. and Finch, S. J. (2008) 'Developmental Trajectories of Cigarette Smoking from Adolescence to the Early Thirties: Personality and Behavioural Risk Factors'. *Nicotine and Tobacco Research* 10(8), 1283-1291

Carpenter, M. J., Saladin, M. E., DeSantis, S., Gray, K. M., LaRowe, S. D. and Upadhyaya, H. P. (2009) 'Laboratory-based, Cue-elicited Craving and Cue Reactivity as Predictors of Naturally Occurring Smoking Behaviour'. *Addictive Behaviours* 34, 536-541

Cox, L. S., Tiffany, S. T. and Christen, A. G. (2001) 'Evaluation of the Brief Questionnaire of Smoking Urges (QSU-Brief) in Laboratory and Clinical Settings'. *Nicotine and Tobacco Research* 3, 7-16

- Crawford, J. R. and Henry, J. D. (2004) 'The Positive and Negative Affect Schedule (PANAS): Construct Validity, Measurement Properties and Normative Data in a Large Non-Clinical Population'. *British Journal of Clinical Psychology* 43, 245-265
- Di Chiara, G. (2000) 'Role of Dopamine in the Behavioural Actions of Nicotine Related to Addiction'. *European Journal of Pharmacology* 393, 295-314
- Drobes, D. J., Elibero, A. and Evans, D. E. (2006) 'Attentional Bias for Smoking and Affective Stimuli: A Stroop Task Study' *Psychology of Addictive Behaviour* 20(4), 490-495
- Dunbar, M. S., Shiffman, S., Kirchner, T. R., Tindle, H. A. and Scholl, S. M. (2014) 'Nicotine Dependence, "Background" and Cue-Induced Craving and Smoking in the Laboratory'. *Drug and Alcohol Dependence* 142, 197-203
- Ehrman, R. N., Robbins, S. J., Bromwell, M., Lankford, M. E. and Monterosso, J. R. (2002) 'Comparing Attentional Bias to Smoking Cues in Current Smokers, Former Smokers, and Non-Smokers Using a Dot-Probe Task'. *Drug and Alcohol Dependence* 67, 165-191
- Faul, F., Erdfelder, E., Lang, A. G. and Buchner, A. (2007) 'G*Power 3: A Flexible Statistical Power Analysis Program for the Social, Behavioural and Biomedical Sciences'. *Behaviour Research Methods* 41, 1149-1160
- Field, A. (2013) *Discovering Statistics using IBM SPSS Statistics*. London: SAGE Publications
- Field, M. and Cox, W. M. (2008) 'Attentional Bias in Addictive Behaviors: A Review of its Development, Causes, and Consequences'. *Drug and Alcohol Dependence* 97, 1-20
- Field, M., Mogg, K. and Bradley, B. P. (2004) 'Eye Movements to Smoking-Related Cues: Effects of Nicotine Deprivation'. *Psychopharmacology* 173, 116-123
- Field, M., Mogg, K., Zetteler, J. and Bradley, B. P. (2004) 'Attentional Biases for Alcohol Cues in Heavy and Light Social Drinkers: The Roles of Initial Orienting and Maintained Attention'. *Psychopharmacology* 176, 88-93
- Field, M., Munafò, M. R. and Franken, I. H. A. (2009) 'A Meta-Analytic Investigation of the Relationship Between Attentional Bias and Subjective Craving in Substance Abuse'. *Psychological Bulletin* 135 (4), 589-607

Fleming, C. B., Kim, H., Harachi, T. W. and Catalano, R. F. (2002) 'Family Processes for Children in Early Elementary School as Predictors of Smoking Initiation'. *Journal of Adolescent Health* 30(3), 184-189

Garcia-Rodriguez, O., Blanco, C., Wall, M. M., Wang, S., Jin, C. J. and Kendler, K. S. (2014) 'Toward a Comprehensive Developmental Model of Smoking Initiation and Nicotine Dependence'. *Drug and Alcohol Dependence* 144, 160-169

Gilbert, D. G., Sugai, C., Zuo, Y., Rabinovich, N. E., McClernon, F. J. and Froeliger, B. (2007) 'Brain Indices of Nicotine's Effects on Attentional Bias to Smoking and Emotional Pictures and to Task-Relevant Targets'. *Nicotine and Tobacco Research* 9(3), 351-363

Halperin, A. C., Smith, S. S., Heiligenstein, E., Brown, D. and Fleming, M. F. (2010) 'Cigarette Smoking and Associated Health Risks Among Students at Five Universities'. *Nicotine and Tobacco Research* 12(2), 96-104

Health and Social Care Information Centre (2014) *Statistics on Smoking: England 2014* [online] available from <http://www.hscic.gov.uk/catalogue/PUB14988/smok-eng-2014-rep.pdf> [23 January 2015]

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C. and Fagerström, K. O. (1991) 'The Fagerström Test for Nicotine Dependence: A Revision of the Fagerström Tolerance Questionnaire'. *British Journal of Addiction* 86, 1119-1127

Hester, R. and Luijten, M. (2014) 'Neural Correlates of Attentional Bias in Addiction'. *CNS Spectrums* 19(3), 231-238

Higher Education Statistics Agency (2013) *Patterns and Trends in UK Higher Education* [online] available from <http://www.universitiesuk.ac.uk/highereducation/Documents/2013/PatternsAndTrendsInUKHigherEducation2013.pdf> [11 April 2015]

Hogarth, L. C., Mogg, K., Bradley, B. P., Duka, T. and Dickinson, A. (2003) 'Attentional Orienting Towards Smoking-Related Stimuli'. *Behavioural Pharmacology* 14(2), 153-160

Jiménez-Ruiz, C. A. and Fagerström, K. O. (2010) 'Advances in Smoking Cessation'. *Clinical Pulmonary Medicine* 17(3), 140-145

Kalman, D. (2002) 'The Subjective Effects of Nicotine: Methodological Issues, a Review of Experimental Studies, and Recommendations for Future Research'. *Nicotine and Tobacco Research* 4, 25-70

Kang, O-S., Chang, D-S., Jahng, G-H., Kim, S-Y., Kim, H., Kim, J-W., Chung, S-Y., Yang, S-I., Park, H-J., Lee, H. and Chae, Y. (2012) 'Individual Differences in Smoking-Related Cue Reactivity in Smokers: An Eye-Tracking and fMRI Study'. *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 38, 285-293

Killen, J. D., Robinson, T. N., Haydel, K. F., Hayward, C., Wilson, D. M., Hammer, L. D., Litt, I. F. and Taylor, C. B. (1997) 'Prospective Study of Risk Factors for the Initiation of Cigarette Smoking'. *Journal of Consulting and Clinical Psychology* 65(6), 1011-1016

Kober, H., Kross, E. F., Mischel, W., Hart, C. L. and Ochsner, K. N. (2010) 'Regulation of Craving by Cognitive Strategies in Cigarette Smokers'. *Drug and Alcohol Dependence* 106(1), 52-55

Koob, G. F. and Le Moal, M. (2008) 'Neurobiological Mechanisms for Opponent Motivational Processes in Addiction'. *Philosophical Transaction of the Royal Society B* 363, 3113-3123

Lawn, W., Freeman, T. P., Hindocha, C., Mokrysz, C., Das, R. K., Morgan, C. J. A. and Curran, H. V. (2015) 'The Effects of Nicotine Dependence and Acute Abstinence on the Processing of Drug and Non-drug Rewards' *Psychopharmacology* [online] in print, 1-15. available from <http://link.springer.com/article/10.1007%2Fs00213-015-3883-4> [20 April 2015]

Luijten, M., Field, M. and Franken, I. M. A. (2013) 'Pharmacological Interventions to Modulate Attentional Bias in Addiction'. *CNS Spectrums* 10, 1-8

Mathôt, S., Schreij, D. and Theeuwes, J. (2012) 'OpenSesame: An Open-Source, Graphical Experiment Builder for the Social Sciences'. *Behavior Research Methods* 44(2), 314-324

Mogg, K., Bradley, B. P., Field, M. and De Houwer, J. (2003) 'Eye Movements to Smoking-Related Pictures in Smokers: Relationship Between Attentional Biases and Implicit and Explicit Measures of Stimulus Valence'. *Addiction* 98, 825-836

Mogg, K., Field, M. and Bradley, B. P. (2005) 'Attentional and Approach Biases for Smoking Cues in Smokers: An Investigation of Competing Theoretical Views of Addiction'. *Psychopharmacology* 180, 333-341

NHS Choices (2013) *What are the Health Risks of Smoking?* [online] available from <http://www.nhs.uk/chq/Pages/2344.aspx?CategoryID=53> [23 January 2015]

Oliver, J. A. and Drobos, D. J. (2012) 'Visual Search and Attentional Bias for Smoking Cues: The Role of Familiarity'. *Experimental and Clinical Psychopharmacology* 20(6), 489-496

Peuker, A. C. and Bizarro, L. (2014) 'Attentional Avoidance of Smoking Cues in Former Smokers'. *Journal of Substance Abuse Treatment* 46, 183-188

Piper, M. E., Piasecki, T. M., Federman, E. B., Bolt, D. M., Smith, S. S., Fiore, M. C. and Baker, T. B. (2004). 'A Multiple Motives Approach To Tobacco Dependence: The Wisconsin Inventory of Smoking Dependence Motives (WISDM-68)'. *Journal of Consulting and Clinical Psychology* 72(2), 139-154

Pomerleau, C. S., Carton, S. M., Lutzke, M. L., Flessland, K. A. and Pomerleau, O. F. (1994) 'Reliability of the Fagerstrom Tolerance Questionnaire and the Fagerstrom Test for Nicotine Dependence'. *Addictive Behaviours* 18(1), 33-39

Robinson, T. E. and Berridge, K. C. (1993) 'The Neural Basis of Drug Craving: An Incentive-Sensitization Theory of Addiction'. *Brain Research Reviews* 18, 247-291

Robinson, T. E. and Berridge, K. C. (2003) 'Addiction'. *Annual Review of Psychology* 54, 25-53

Robinson, T. E. and Berridge, K. C. (2008) 'The Incentive Sensitization Theory of Addiction: Some Current Issues'. *Philosophical Transactions of the Royal Society B* 363, 3137-3146

Rokke, P. D. and Lystad, C. M. (2015) 'Mood-Specific Effects in the Allocation of Attention Across Time'. *Cognition and Emotion* 29(1), 27-50

Rubinstein, M. L., Rait, M. A., Sen, S. and Shiffman, S. (2014) 'Characteristics of Adolescent Intermittent and Daily Smokers'. *Addictive Behaviours* 39, 1337-1341

Rzetelny, A., Gilbert, D. G., Hammersley, J., Radtke, R., Rabinovich, N. E. and Small, S. L. (2008) 'Nicotine Decreases Attentional Bias to Negative-Affect-Related Stroop Words Among Smokers'. *Nicotine and Tobacco Research* 10(6), 1029-1036

Shiffman, S., Dunbar, M. S., Kirchner, T. R., Li, X., Tindle, H. A., Anderson, S. J., Scholl, S. M. and Ferguson, S. G. (2013) 'Cue Reactivity in Non-Daily Smokers: Effects on Craving and Smoking Behaviour'. *Psychopharmacology* 226(2), 321-333

Shiffman, S., Dunbar, M., Li, X., Scholl, S., Tindle, H., Anderson, S. J. and Ferguson, S. G. (2014) 'Smoking Patterns and Stimulus Control in Intermittent and Daily Smokers'. *Public Library of Science One* 9(3), 1-14

Shiffman, S., Dunbar, M. S., Scholl, S. M. and Tindle, H. A. (2012a) 'Smoking Motives of Daily and Non-Daily Smokers: A Profile Analysis'. *Drug and Alcohol Dependence* 126, 362-368

Shiffman, S., Tindle, H., Li, X., Scholl, S., Dunbar, M. and Mitchell-Miland, C. (2012b) 'Characteristics and Smoking Patterns of Intermittent Smokers'. *Experimental and Clinical Psychopharmacology* 20(4), 264-277

Tiffany, S. T. and Drobes, D. J. (1991) 'The Development and Initial Validation of a Questionnaire on Smoking Urges'. *British Journal of Addiction* 86, 1467-1476

Tindle, H. and Shiffman, S. (2011) 'Smoking Cessation Behavior Among Intermittent Smokers Versus Daily Smokers'. *American Journal of Public Health* 101 (7), 1-3

Vollstädt-Klein, S., Loeber, S., Winter, S., Lemenager, T., von der Goltz, C., Dinter, C., Koopmann, A., Wied, C., Winterer, G. and Kiefer, F. (2011) 'Attention Shift Towards Smoking Cues Relates to Severity of Dependence, Smoking Behaviour and Breath Carbon Monoxide'. *European Addiction Research* 17, 217-224

Watkins, S. S., Koob, G. F. and Markou, A. (2000) 'Neural Mechanisms Underlying Nicotine Addiction: Acute Positive Reinforcement and Withdrawal'. *Nicotine and Tobacco Research* 2, 19-37

Watson, D., Clark, L. A. and Tellegen, A. (1988) 'Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales'. *Journal of Personality and Social Psychology* 54(6), 1063-1070

West, R. and Brown, J. (2013) *Theory of Addiction*. Chichester: John Wiley and Sons Ltd.

Appendices

Appendix 1.

Certificate of Ethical Approval

Student:

James Bartlett

Project Title:

Investigating attention in smokers and non-smokers using a visual probe task.

This is to certify that the above named student has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

27 October 2014

Project Reference Number:

P27233

Appendix 2.

'Investigating attention in smokers and non-smokers using a visual probe task'

Participant Information Sheet

What is the purpose of the study? The study aims to explore attention as an aspect of cognitive function in smokers and non-smokers.

Why have I been chosen to participate? You classify yourself as either a smoker or non-smoker. Smoking participants should be active smokers and have been for two years or more. Non-smokers who have never smoked regularly are needed. Both groups of participants are required to have normal or corrected to normal vision. Additionally, both groups should have no known neurological deficits as the study requires looking at a computer screen.

Do I have to participate? No, taking part in this study is purely voluntary. It is your choice to participate and you may withdraw your data with no questions asked until two weeks after completion. If you wish to withdraw, please contact the researcher by the details at the bottom of this sheet and all your data will be removed and destroyed. Furthermore, if you wish to withdraw from the study during the experiment you may do so by alerting the researcher.

What will happen? Before the study, smokers are asked to not have a cigarette from an hour before they arrive and complete questionnaires on your smoking motives and dependence. Upon arrival, you will be required to sign a consent form and complete questionnaires relating to your demographics, mood and cigarette cravings. You will then have your breath carbon monoxide concentration assessed using a breathalyser. This should all take around 10 minutes. After the questionnaires have been completed, you will be asked to complete a visual probe task. This involves looking at a series of two adjacent pictures on a computer screen. After the presentation of a fixation point, the pictures will be presented and then disappear. When they disappear, an arrow will appear in the position of one of the pictures. Your task is to click a button as fast as you can to indicate whether it is facing up or down. There will be some practise attempts before the study will commence to familiarise you with the task. At the end of the study, you will be required to complete a second version of the mood and craving questionnaires.

What are the possible benefits of taking part? If you are a Psychology undergraduate, you will receive 60 research participation credits for your time. Furthermore, it will give you experience in participating in experimental research that may benefit you for your own final year research project.

Are there any potential disadvantages of participation? As the questionnaire concerns your smoking habits, you may become more aware of your smoking behaviour. You may withdraw from the study if you feel uncomfortable disclosing your smoking habits but the questions are not judgemental and you

will only be identified by a participant number. If you have any concerns at any point, please alert the researcher in person, or through the contact details provided at the bottom of this sheet.

Alternatively, you may wish to look at the following websites for any assistance:

<http://www.nhs.uk/smokefree>

<http://www.ash.org.uk/>

<http://www.covwarkpt.nhs.uk/coventrystopsmoking/Pages/default.aspx>

What if something goes wrong? There are no anticipated risks but if the study has to be terminated, *e.g.* because of a technical failure or fire alarm, you will still be awarded the full amount of research credits. Alternatively, you can reschedule the study for another time. If you have any complaints about the study, you can terminate the experiment at the time or withdraw all of your data until two weeks after completion.

Will my participation be confidential? Yes, all information will be kept entirely confidential. Your data will only be identified by a participant number and corresponding consent form. The paper questionnaires will be contained in a locked room after study completion. The visual probe data and all information used in the data analysis will be stored on a laptop that requires a password and backed up on a password protected memory stick. All data will be destroyed after the project is completed and moderated, usually within a year after study completion.

What will happen to the results of the study? The results of the experiment will provide the data for my third year research project. This may lead to the study being written up as a research article in a peer-reviewed journal.

Who is organising and funding the research? The research is organised solely by the researcher. No funding has been obtained for this project.

Who has reviewed the study? The university ethics board and my dissertation supervisor have reviewed and accepted the study.

Contact for Further Information: If you have any queries, please contact the researcher (James Bartlett) through bartle16@uni.coventry.ac.uk

Alternatively, the email address of my supervisor (Dr. Rebecca Jenks) is aa2557@coventry.ac.uk

If you wish to make a complaint with respect to any component of this project, you may contact Prof. Ian Marshall (Chair of Coventry University Ethics Committee) – email: Ian.Marshall@Coventry.ac.uk

Informed consent form

Name of researcher: James Bartlett

Please read the following statements and tick the corresponding box if you agree with them.

1. I have read the participant information sheet and understand what I am required to do	☐
2. I have asked all my questions and do not have any more regarding the study before I begin	☐
3. I fully understand that my participation is voluntary and I can withdraw all of my data until two weeks after I complete the study	☐
4. I understand that to withdraw my data, I need to contact the researcher using the contact details provided on the participation information sheet	☐
5. I understand that all data will remain confidential and I will only be identified by a participant number	☐
6. Data from the experiment will be used to write a third year research project which may develop into a research article in a peer-reviewed journal	☐
7. I agree to voluntarily take part in this research study	☐

Signature

Date

If you would like a copy of this consent form, please ask the researcher (James Bartlett) and a photocopied version will be provided to you. Alternatively, if you wish to make a complaint with respect to any component of this project, you may contact Prof. Ian Marshall (Chair of Coventry University Ethics Committee) through: Ian.Marshall@Coventry.ac.uk.

Demographic questionnaire

Please complete all of the questions. For participants who do not smoke, please ignore questions 6-16 as these concern smoking habits.

1. What is your age?	<input style="width: 50px; height: 30px; border: 1px solid black;" type="text"/>	Years
2. Are you male or female? (please circle)	M / F	
3. What is your ethnicity? (please circle)	<ul style="list-style-type: none"> • White British • Asian British: Indian/Pakistani/Bangladeshi • Asian British: Chinese • Asian British: other • Black British: Caribbean/African • Other 	
4. What would best describe your current smoking status? (please circle)	<ul style="list-style-type: none"> • Daily smoker • Less than daily • Do not smoke 	
5. What would best describe your previous smoking status? (please circle)	<ul style="list-style-type: none"> • Daily smoker • Less than daily • I have never smoked regularly 	
6. At what age did you begin to smoke regularly?	<input style="width: 50px; height: 30px; border: 1px solid black;" type="text"/>	Years
7. How long have you smoked at your current rate?	<input style="width: 50px; height: 30px; border: 1px solid black;" type="text"/>	Years/Month (delete appropriate)
8. On average, how many days per week do you smoke?	<input style="width: 50px; height: 30px; border: 1px solid black;" type="text"/>	Days
9. On average, how many cigarettes do you smoke on those days?	<input style="width: 50px; height: 30px; border: 1px solid black;" type="text"/>	
10. Have you attempted to quit smoking? (please circle)	Yes / No	
11. If you have attempted to quit smoking more than once, how many times have you attempted?	<input style="width: 50px; height: 30px; border: 1px solid black;" type="text"/>	
12. What was your reason to start smoking again? (please write a small sentence)	<div style="border-bottom: 1px solid black; height: 20px; width: 100%;"></div> <div style="border-bottom: 1px solid black; height: 20px; width: 100%;"></div>	

**13. When you made an attempt to stop smoking, what was the aid you used?
(Please circle all that apply)**

- None, attempted without aid
- Nicotine patches
- Nicotine gum
- NHS stop smoking service
- Other

14. How long has it been since your last cigarette? (please be as specific as possible, include hours and minutes)

**15. Do you use electronic cigarettes (E-cigarettes)?
(please circle)**

Yes / No

**16. If yes, in what environment do you smoke E-cigarettes?
(please circle all that apply)**

- At home
- At work
- Public transport
- Indoor public places (e.g. shops and pubs)
- Other

Appendix 5.

'Investigating attention in smokers and non-smokers using a visual probe task'

Debriefing sheet

Thank you, your participation is greatly appreciated. This study is investigating attentional bias towards smoking related stimuli in dependent and non-dependent smokers. There is a substantial amount of research into attentional biases towards drug-related stimuli as they are reported to be an important mechanism in drug-seeking behaviour (Field and Cox 2008). Attentional bias is the tendency for substance dependent users to involuntarily focus on drug-related stimuli originating from a classical conditioning process (Luijten, Field and Franken 2013). This means that repeated exposure to drug-related stimuli become associated with the use of the drug and usage is expected.

Attentional bias research has typically focused on smokers who are dependent on nicotine but a significant portion of smokers are not dependent and smoke less than daily (Shiffman, Dunbar and Scholl 2012). Despite the lack of nicotine dependence, these light smokers find it as difficult to quit as heavy smokers with a similar cessation failure rate (Tindle and Shiffman 2011). One of the few studies to investigate attentional bias in these different smoking sub-groups found dependent smokers showed attentional bias but non-dependent smokers seemed to avoid smoking-related stimuli (Vollstädt-Klein, Loeber and Winter 2011).

The current study builds on the Vollstädt-Klein et al. (2011) study as they only presented their pictures on the visual probe task for 500ms. Within the literature, short presentation times (<200ms) measure the initial orientation to stimuli and involves involuntary processes (Field and Cox 2008). Longer presentation times (>500ms) begin to involve voluntary attention and the participant can switch between stimuli (Field and Cox 2008). My study aims to investigate if different presentation times (200ms, 500ms and 2000ms) show different attentional bias results in the two smoking sub-groups. To my knowledge this has not been investigated before so no direct predictions can be made but it potentially has implications for the importance of attentional bias as a mechanism in drug-seeking behaviour. As non-dependent smokers have trouble quitting smoking without the effect of nicotine, if they also show no attentional bias at any presentation time it would indicate there are more important processes involved in drug-seeking behaviour.

Thank you again for participating in this research, it is greatly appreciated. If you have any questions after the experimental session please feel free to contact the researcher (James Bartlett) on bartle16@uni.coventry.ac.uk. I will remind you once again that if you want to withdraw your data from the study, you can contact the researcher up to two weeks after completion and have your data removed without question.

If you wish to make a complaint with respect to any component of this project, you may contact Prof. Ian Marshall (Chair of Coventry University Ethics Committee) through: Ian.Marshall@Coventry.ac.uk.

If you would like further information on smoking and help with quitting, here is a list of websites that may help you:

<http://www.nhs.uk/smokefree>

<http://www.ash.org.uk/>

<http://www.covwarkpt.nhs.uk/coventrystopsmoking/Pages/default.aspx>

If this research has interested you, here is a list of references for the research I have mentioned:

Field, M. and Cox, W. M. (2008) 'Attentional bias in addictive behaviors: A review of its development, causes, and consequences'. *Drug and Alcohol Dependence* 97, 1-20

Luijten, M., Field, M. and Franken, I. M. A. (2013) 'Pharmacological interventions to modulate attentional bias in addiction'. *CNS Spectrums* 10, 1-8

Shiffman, S., Dunbar, M. S., Scholl, S. M. and Tindle, H. A. (2012) 'Smoking motives of daily and non-daily smokers: A profile analysis'. *Drug and Alcohol Dependence* 126, 362-368

Vollstädt-Klein, S., Loeber, S., Winter, S., Lemenager, T., von der Goltz, C., Dinter, C., Koopmann, A., Wied, C., Winterer, G. and Kiefer, F. (2011) 'Attention shift towards smoking cues relates to severity of dependence, smoking behaviour and breath carbon monoxide'. *European Addiction Research* 17, 217-224