Smoking Attentional Bias:

The Role of Automaticity, Affect and Cognitive Control

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MEMORANDUM

The research for this thesis was conducted at the School of Psychology, University of Kent, whilst the author was a full-time post-graduate student.

The theoretical and empirical work presented within the thesis are the independent work of the author. Intellectual debts are acknowledged within the text and referenced. The studies reported in the thesis were conducted with limited practical and technical assistance from others.

The author has not been awarded a degree by this, or any other university, for the work included in this thesis.

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Table of Contents

APPENDICES

List of Tables

List of Figures

Abstract

This thesis examines the presence of smoking attentional bias across smokers, smokers attempting to quit, and never-smokers and the role that affect, automaticity and cognitive control play in smoking attentional biases. It does so by: i) examining the relationship between smoking attentional bias and smoking status, ii) examining whether smoking attentional bias is automatic, iii) examining whether smoking attentional bias stems from the affective relationship of smoking stimuli, and iv) examining the interaction between smoking attentional bias and cognitive control.

The thesis begins by describing theoretical models of attentional bias in addictions and the approaches taken to measure addiction-related attentional bias. It then examines previous findings in relation to abstinence, affect, automaticity and cognitive control and their role in smoking attentional bias. Finally, it presents seven empirical studies which examine the role of abstinence, affect, automaticity and cognitive control in relation to smoking attentional bias.

In summary, the findings show strong evidence for smoking attentional bias in smokers and the presence of smoking attentional bias in smokers attempting to quit under certain conditions. Specifically, i) where there is explicit awareness of the presence of smoking stimuli, ii) where exposure to smoking stimuli is relatively long and iii) in conditions that yield greater anxiety. The findings also show evidence that smoking attentional bias is automatic in early stages of attentional processing and that it is unrelated to the explicit affective ratings of stimuli or smoking behaviour measures. There is also evidence that smoking attentional bias can be manipulated. It is concluded that previous models of addiction-related attentional bias do not sufficiently explain the underlying mechanisms of smoking attentional bias. Furthermore, it suggests that interventions which decrease the salience of smoking and decrease the exposure to smoking stimuli and anxiety will be more effective in reducing smoking attentional bias during quit attempts.

Introduction

Ever since Christopher Columbus discovered tobacco in 1492 and Sir Walter Raleigh introduced tobacco to the English courts in the 1580's (Gilman & Zhou, 2004), tobacco has had a turbulent history in the western world. Some heralded tobacco to have healing properties and suggested that smoking tobacco helped to balance the bodily humours (Gilman & Zhou, 2004). Others, such as King James I in the 17th century, opposed the use of tobacco, with King James I himself writing the 'Counterblaste to Tobacco', a text against tobacco smoking, in which he proclaims smoking to be:

> ... a custome loathsome to the eye, hatefull to the nose, harmefull to the braine, dangerous to the lungs and in the blacke stinking fume thereof, nearest resembling the horrible Stigian smoke of the pit that is bottomless.
>
> (as cited in Burns, 2007, p.46)

Over the following centuries, tobacco became more popular and it was not until the mid 19th century that serious concerns began to be raised about the negative impact on health of tobacco smoking. Early reports suggested it was responsible for a number of ailments including lunacy, cerebral haemorrhage, paralysis, impotence, flatulence, baldness, and skin diseases amongst other things (Eysenck & Brody, 1965). However, it was not until the 1930s that it was suggested that there may be a possible association between smoking and lung cancer and other serious diseases, and that smoking should be examined further as a harmful behaviour (Eysenck & Brody, 1965).

Health impact of smoking

Over the past fifty years, evidence has now been mounting regarding the negative health impact of smoking (Welshman, 2004). Indeed, it has now been shown that smoking is associated with a number of serious medical conditions including, but not limited to, strokes, myocardial infarction, pulmonary disease, immune dysfunction, erectile dysfunction, osteoporosis, rheumatoid arthritis, pancreatic disorder, thyroid disease and all forms of cancer (Owing, 2005). This corresponds with reports suggesting that around 445,100 hospital admissions in England are directly attributable to smoking each year, accounting for approximately 5% of all hospital admissions (National

Statistics UK, 2009). Furthermore, the World Health Organization (WHO) reports that smoking is "the single leading preventable cause of death" and is responsible for the premature death of nearly 1.6 million people a year across Europe (WHO, 2009).

In response to such reports, governments within the UK (Parliament, Scottish Executive, Welsh Assembly, Northern Ireland Assembly) have introduced a number of measures to reduce the prevalence of smoking. These measures include the introduction of stop-smoking advertising campaigns, smoking cessation helplines, smoking cessation groups, increased taxes on tobacco products, and the introduction of pharmacological interventions on the National Health Service including nicotine replacement therapy (NRT), buproprion (Zyban), and varenicline (Department of Health, 2009). Even with these measures in place and the negative effects of tobacco smoking being widely publicised, the prevalence of smoking remains relatively high in the UK. The most recent national survey suggests that around 24% of the UK population smoke[1], a figure that has remained relatively consistent over the past decade (see National Statistics UK, 2009)

Lapse episodes in smoking

The consistency in the number of smokers over the past two decades is thought to be due to the fact that smokers find it extremely difficult to break away from their smoking habit (see Ockene et al., 2000; Shiffman, 2006). In 2007, nearly three quarters of smokers in the UK reported that they wanted to give up their smoking habit, but around 59% them also said they would find it extremely difficult to go without a cigarette for a whole day (National Health Service, 2008). Indeed research has shown that if individuals attempt to quit, even with the use of some form of smoking cessation treatment, the chances of a lapse back to smoking behaviour is still extremely high (Waters, Shiffman, Sayette et al., 2003). Studies show that 70%-80% of patients following a successful smoking cessation intervention relapse within 6-12 months (Fiore, Smith, Jorenby, & Baker, 1994). Therefore, identifying and understanding the

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[1] These statistics were collected prior to the introduction of the smoking bans in the UK. Ban introduction dates were: Scotland: 26th March 2006; Wales: April 2nd 2007; Northern Ireland: 30th April 2007; England: 1st July 2007

underlying factors that affect lapse episodes and the maintenance of smoking behaviour is essential for improving smoking cessation success.

Smoking as an addiction

One factor that plays a role in lapse episodes, that has been extensively researched, is the highly addictive nature of nicotine in relation to tobacco smoking (see Benowitz, 1996; Rose, 1996). Tobacco dependence is listed under substance-related disorders in the Diagnostic and Statistical Manual of Mental Disorders (4^{th} Edition) and is also listed within the WHO International Classification of Diseases (ICD-10). Nicotine, the primary psychoactive agent of tobacco smoke, is thought to be central to the early development of addiction to tobacco use and the maintenance of tobacco addiction (Watkins, Koob, & Athina, 2000). Nicotine acts by stimulating the neuronal nicotinic cholinoreceptors (Clarke, 1990) which subsequently lead to increases in neurotransmission at dopamine–secreting synapses in the mesolimbic system of the brain (Corrigall, Franklin, Coen, & Clarke, 1992). This area is involved in modulating behavioural responses, reward and motivation (Tisch, Silberstein, Limousin-Dowsey, & Jahanshahi, 2004). Furthermore, nicotine consumption produces euphoric effects (Pomerleau & Pomerleau, 1992), and smokers report experiencing arousal and relaxation in times of stress as a result of smoking (Benowitz, 1996; Stolerman & Jarvis, 1995). These effects, it has been argued, enhance the addictive nature of nicotine and are central to the development and maintenance of tobacco smoking behaviour (Watkins et al., 2000).

However, whilst the presence of nicotine is important in the development of smoking addiction, the continuation and maintenance of addictions are also thought to be reliant on accompanying drug-related behaviours, situations, and cognitions (Shiffman & Jarvick, 2006). The current research will examine one such cognitive mechanism that could potentially influence the development and maintenance of smoking, namely 'attentional bias'.

Attentional bias

Attentional bias is a manifestation of selective attention (Bruce & Jones, 2006), and involves the predisposition of attention towards a specific category of stimuli. Attentional bias is classed as an implicit behaviour that drug-users are thought not to be aware of consciously (Fadardi, Cox, & Klinger, 2006). For example, a drug user's attention is thought to be biased towards stimuli which are involved in drug consumption (e.g. a cigarette in relation to smoking, a pint of lager in relation to alcohol). Research examining attentional biases in addictions has generally shown that users have a greater propensity to attend towards drug-related stimuli specific to their own drug use compared to stimuli unrelated to their drug-use (see Franken, 2003). In particular, addiction-related attentional biases have been shown to be present in social drinkers and heavy drinkers to alcohol cues, in cocaine users to cocaine related –stimuli, in heroin users to heroin-related stimuli, in cannabis users to cannabis-related stimuli, and in smokers to smoking-related stimuli (see Franken, 2003).

Attentional bias is thought to be important in addictions as it may mediate the link between the perception of drug-related stimuli and resultant drug-seeking and drug-use behaviour (Field, Mogg, & Bradley, 2006). Research has provided evidence to support this claim showing that the strength of attentional bias is often related to an individual's own drug use and the level of drug-consumption (Robbins & Ehrman, 2004). In relation to smoking specifically, attentional bias is thought to be clinically important as it is related to relapse during cessation attempts. Research has shown that increased attentional bias for smoking-related cues is related to increased chances of relapsing during a quit attempt (Waters, Shiffman, Sayette et al., 2003). This argues for the importance of smoking attentional bias in relation to the maintenance of smoking behaviour and relapse.

One advantage of researching addiction through implicit measures, such as attentional bias, is that it overcomes problems associated with previous research, which rely on self-reports of users' attitudes and perceptions of their own drug use. This explicit approach to studying addiction is problematic because it assumes the user is aware of the mechanisms that dictate their own drug-use behaviour (Albery, Sharma, Niazi, & Moss, 2006). Whilst this approach has proved beneficial in determining a number of factors that have been shown to influence the chances of lapses back to smoking behaviour (e.g. low self-efficacy, weight concerns, and the number of previous quit attempts; Ockene et al., 2000), explicit reports of addictive behaviours are thought to suffer from self-presentation biases, especially because addictive behaviours, such as smoking, are often seen as stigmatized activities (Huijding, De Jong, Wiers, & Verkooijen, 2005). In light of this, more recently, researchers have adopted an *implicit* approach to the study of addiction and have begun to examine implicit cognitions that underlie the development and maintenance of addictive behaviours. By adopting implicit measures of behaviour and cognitions, the present research aims to identify components of addictive behaviours which users may not be explicitly aware of but which may play a key role in the development of drug-use and the maintenance of drug-use behaviour (De Houwer, 2006).

The aim of the current research is to study how attentional bias influences the development and maintenance of smoking behaviour. The research aims to develop our understanding of attentional bias and will examine three factors in relation to this phenomenon: affect, automaticity and cognitive control. This information could help to explain lapse episodes and the maintenance of smoking behaviour. Furthermore, the research will identify whether attentional biases can be manipulated. In this way the research may have clinical relevance as it will inform cessation attempts.

Affect: Research on attentional bias in addictions largely stems from research examining attentional bias in relation to emotion (e.g. MacLeod, Mathews, & Tata, 1986). Indeed, the methods used to examine attentional bias in addictions have largely been developed from those used to examine attentional bias and emotion (such as the emotional Stroop task and visual probe task). Research into attentional bias and emotions has shown that people are biased towards negative stimuli perceived to be threatening but are not necessarily biased towards positive stimuli (e.g. Fox, Russo, & Dutton, 2002; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Andrew Mathews & MacLeod, 1986). For example, an image of a person with an angry face will be attended to more readily and for longer than a image of a person with a happy or neutral expression (Fox et al., 2002). Furthermore, these effects have been reported to be more pronounced in anxious individuals (MacLeod et al., 1986) and phobic-specific stimuli are attended to a greater extent among phobics than non-phobics (e.g. Foa & McNally, 2005; Kolassa, Musial, Kolassa, & Miltner, 2006; Watts, Trezise, & Sharrock, 1986).

These findings have implications for how we understand attentional bias among smokers. Across the attentional bias literature it is commonly suggested that attentional bias to drug-related stimuli stem from the stimuli's drug-relatedness (see Field et al., 2006). However, in light of the research on attentional bias and emotion, it has been suggested that the emotional value of drug-related stimuli may be driving the attentional bias effects noted across addiction studies (see Cox, Fadardi, & Pothos, 2006). That is, smoking-related stimuli may grab attention because they are seen as threatening or desirable. To shed light on this important issue, the present research will examine the relationship between smoking stimuli, attentional bias and emotion. The role of emotion is examined across all chapters.

Automaticity: Research has suggested that attentional bias in addictions are automatic and may not be under conscious control. This suggestion is based on research showing that attentional bias occurs after short stimulus presentations (e.g. Bradley, Field, Mogg, & De Houwer, 2004; Ehrman et al., 2002). However, it has also been argued that although attentional bias can be rapid, this does not necessarily mean that attentional bias is not under conscious control (see Field, 2006). If attentional bias is not automatic, this has implications for the development of smoking cessation programmes: smokers could be trained to consciously control their own attention, which could then help to reduce smoking behaviour and prevent relapse. The current research will examine this issue by examining whether individuals can control their attention when exposed to smoking-related stimuli. Specifically, the research will identify whether shifts in attention occur even when explicit instructions are given not to shift attention to smoking stimuli. The effects of automaticity are examined in Chapter 3.

Cognitive control: One potential consequence of attentional bias is that it may disrupt other activities individuals are engaged in. In the case of smokers, exposure to smoking stimuli while completing another task could disrupt or distract them from that task. Research has shown that exposure to smoking cues is detrimental to concurrent cognitive tasks (e.g. Juliano & Brandon, 1998; Sayette & Hufford, 1994). The present research will examine whether the extent to which individuals are distracted by smoking stimuli can be reduced by manipulating cognitive control. Also, as described above, attentional bias may be due to the *affective* associations of smoking stimuli, in addition to their smoking relatedness. In the same way, the distraction caused by smoking stimuli could be due to the affective association of the stimuli, rather than the smoking relatedness of the stimuli. The current research examines this important question. The research also identifies the extent to which smoking attentional bias affects cognitive control in comparison to emotion attentional bias. The effects of cognitive control are examined in Chapters 6 and 7.

Aim of the thesis and implications

In summary, the overall aim of this thesis is to examine the presence and role of affect, automaticity and cognitive control in relation to attentional biases in smoking. By doing so this research has both theoretical and practical implications. In terms of theoretical implications, the research will identify and increase understanding of the factors that influence lapse episodes and the maintenance of smoking behaviour. Specifically the research will inform theories concerning 'attentional bias' in relation to smoking and other addictive behaviours. The research will also address questions surrounding the automaticity of attentional bias, cognitive control and will untangle smoking and emotion attentional bias. In this way, the findings will inform cognitive theories concerning both attentional bias and cognitive control. This information will be useful in helping to identify the underlying mechanisms of smoking attentional bias and will help inform future theories of how attentional bias relates to smoking behaviours and cessations attempts. The findings will also inform future research in attentional bias, as the reliability of a number of methods of measuring attentional bias will be examined.

In terms of practical implications, the research will identify and increase understanding of the factors that influence lapse episodes and the maintenance of smoking behaviour. This information will be useful for health professionals and smoking cessation organisations, as well as general addiction groups. In addition, the research will test whether smoking attentional bias can be manipulated and the means by which this can be achieved. This will have direct implications for future development of smoking cessation interventions and programmes.

Overview of thesis

Chapter 1 outlines a number of theoretical perspectives that have been put forward to explain how attentional biases in addictions develop, the roles of automatic and non-automatic processes in attentional bias, and theoretical perspectives on the relationships between attentional bias and smoking behaviour and craving. The chapter also explores theories that examine the role of cognitive control in relation to attentional processes and how these might explain attentional bias. The implications of these theories are then discussed in relation to attentional bias and smoking behaviour.

Chapter 2 describes and critically evaluates the main methodological approaches that have been adopted to examine attentional bias in relation to addiction. It then goes on to examine the empirical findings of previous research in relation to smoking attentional bias. Specifically, the effects of abstinence, affect, automaticity and cognitive control on attentional bias will be examined.

Chapter 3 presents the findings from Studies 1 and 2. These were conducted in an aim to identify the relationship between smoking attentional bias and emotion and to examine the automaticity of attentional bias. To do this, studies 1 and 2 examined shifts in visual attention to smoking, negative, and neutral images using eye-tracking techniques. Participants were smokers, smokers attempting to quit and never-smokers. This allowed us to examine attentional bias effects among current smokers, during a quit attempt and in comparison with a non-smoking control group. In Study 1, shifts in visual attention were examined when participants were free to examine image pairs (smoking-neutral, negative-neutral, and control-neutral) in any order. It was found that under these conditions initial shifts in visual attention were quicker to negative stimuli, compared to smoking and neutral stimuli and gaze was maintained for longer on both smoking and negative stimuli. However, these shifts in visual attention were unrelated to emotion ratings of stimuli, smoking status, smoking behaviour, and craving. Study 2 extended the findings of Study 1 by examining whether shifts in attention to smoking and negative stimuli were automatic, occurring when there are explicit instructions to keep gaze on a simultaneously presented neutral stimulus. Findings indicated that there were exogenous shifts in attention to smoking and negative stimuli in the early stages of attentional processing but these were not evident in later stages of attentional processing. Again, these shifts were unrelated to smoking status, smoking behaviour, craving and emotion ratings of stimuli.

Chapter 4 presents the findings from Studies 3 and 4. These studies examined the effects of the England smoking ban on smoking attentional bias, the emotional rating of smoking stimuli and smoking behaviours. By doing so, this allowed us to identify if an external factor could influence affective associations and subsequently affect smoking attentional bias. Study 3 measured attentional bias using a Stroop task and visual probe task on three occasions over a two month period (immediately prior to the smoking ban, one month after the introduction of the ban and two months after introduction of the ban). Findings indicated that attentional bias did decrease across both measures following the introduction of the ban. However, there were no changes in smoking behaviour, craving or the emotional rating of smoking stimuli over this time. Study 4 was conducted to put the findings of study 3 in a wider context by examining changes in smoking behaviour and smoking environments over the same two-month period through an online survey. The survey revealed that smoking behaviours did not change even if there was some intention to quit in light of the smoking ban. Furthermore, Study 4 revealed a decrease in the number of smoking items participants reported that they were exposed to, indicating that smoking may have been less salient in the months after the smoking ban. It is suggested that the reported decrease in the number of smoking items as a result of the ban could explain the decrease in attentional bias shown in Study 3.

Chapter 5 presents the findings from Study 5 which examined the effectiveness of a technique called 'attentional retraining' in manipulating smoking attentional bias across smokers, smokers attempting to quit and never-smokers. It also examines whether manipulation of attentional bias affects subsequent nicotine dependence and craving. Results indicated that attentional retraining was effective in manipulating attentional bias shown in smokers, both when smokers were trained to attend away from smoking stimuli and when they were trained to attend towards smoking stimuli. Whilst these effects did not affect subsequent nicotine dependence or cravings measured one week and one month after the experimental sessions, the findings did generalise to novel stimuli and to a Stroop task following training.

Chapter 6 presents findings from Study 6 which also examined the manipulation of attentional bias by varying cognitive control. Cognitive control was manipulated by changing the number of incongruent trials in a classic Stroop task. An increase in incongruent trials has been shown to increase focus on the colour-naming task and decrease the distraction from words. Therefore, it was predicted that increasing focus on the colour-naming task would decrease distraction from smoking stimuli, thus reducing smoking attentional bias. Findings indicate that this manipulation, contrary to expectations, led to increases in smoking attentional bias rather than decreases in attentional bias, particularly in smokers attempting to quit.

Chapter 7 presents the findings from Study 7 which builds on the findings of Study 6 by examining whether smoking attentional bias interrupts cognitive control. By interleaving smoking, negative, and neutral trials with incongruent and congruent trials the effects of the specific stimuli on cognitive control could be examined. Findings indicated that the context of the stimuli had little effect on cognitive control as measured through responses to incongruent trials. However, the results also indicated that smoking stimuli appeared to produce a general cognitive slow-down in comparison to neutral and negative stimuli.

Chapter 8 summarises the findings from the seven empirical studies and examines the findings in relation to the theoretical approaches examined in chapter 2 and the previous research examined in chapter 3. It also examines the limitations, and implications, of the current research and the possibilities for future research in relation to attentional bias, smoking and addictions in general.

Chapter 1 – The role of attentional bias in addiction: Theoretical perspectives

The following chapter reviews a number of models of addiction and the theoretical propositions put forward to explain the development of attentional bias in addictions. It examines positive and negative reinforcement, incentive and motivational perspectives, and the role that emotion and cravings play in relation to attentional bias and the development and maintenance of addictive behaviours. The chapter concludes by describing the predictions for attentional bias made by contemporary models which propose reciprocal links between attentional bias and craving. The implications of these factors in relation to smoking attentional bias are discussed throughout the chapter.

Over the past three decades, a number of models of addiction have been put forward to explain both the initiation and maintenance of addictive behaviours. During this time, the role of attentional bias within these models has developed. Early models of addiction often described phenomena, such as attentional bias, in a somewhat peripheral role placing a greater emphasis on conditioning processes involved in the development and maintenance of addictive behaviours (e.g. Stewart, de Wit, & Eikelboom, 1984). In more contemporary models, attentional bias has taken a central role and these models have emphasised the importance of relationships between attentional bias and other motivational attributes associated with addiction, such as craving (e.g. Field & Cox, 2008; Franken, 2003). Furthermore, there has been much debate about the role of emotion within addiction processes, and specifically whether cue-reactivity results from the emotional relatedness or the salience of the drug-related stimuli. The following chapter examines both early and contemporary theoretical models that have been put forward to explain cue-reactivity and attentional bias in addiction processes. The chapter examines the roles that affect, automaticity, and cognitive control play in relation to addictive behaviour and what predictions these roles make with regard to smoking attentional bias.

1.1 - The role of affect in conditioning processes

Integral to a number of models of addiction which describe drug-cue reactivity is the idea that reactions to drug-related cues are the product of conditioning processes whereby drug-related stimuli become associated with the affective associations that accompany drug consumption or drug abstinence. These models either emphasise positive reinforcement processes, whereby drug-related stimuli mimic the pleasurable effects of a substance (Stewart et al., 1984), or negative reinforcement processes, whereby drug-related stimuli become associated with avoidance from negative affective states commonly associated with abstinence (Baker, Morse, & Sherman, 1987). Whilst it is thought that addictive behaviours do not result solely from positive-reinforcement processes or negative-reinforcement processes (Jaffe, 1992), each process yields separate predictions for the occurrence of attentional bias and its role in the initiation and maintenance of addictive behaviours.

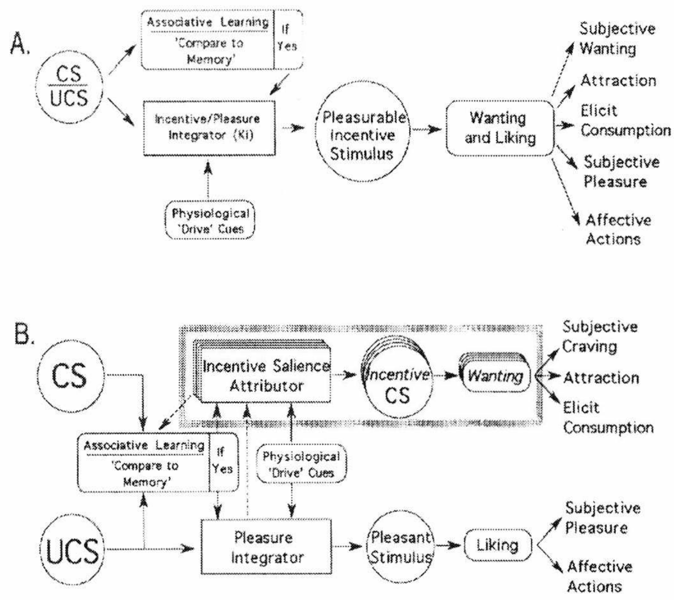
1.1.1 - Positive-reinforcement models

Positive reinforcement models are largely based on empirical evidence showing that drugs produce pleasurable effects on consumption (see Baker, Morse, & Sherman, 1986; Pomerleau & Pomerleau, 1992; Stewart et al., 1984). These pleasurable effects can take a number of different forms including subjective positive feelings, whereby drugs elicit positive feelings of which the user is aware; physiological changes that lead to positive effects, such as the activation of dopaminergic systems; and positive functional effects, such as enhancing performance on tasks (Glautier, 2004). In the case of smoking, all three types of positive effects have been shown to be present. Subjectively, smoking has been shown to produce reports of positive effects including euphoria, relaxation under stress, and heightened arousal (Benowitz, 1996; Pomerleau & Pomerleau, 1992; Stolerman & Jarvis, 1995). Physiologically, nicotine has been shown to activate regions of the brain that are closely associated with reward and motivation, such as the dopaminergic pathways of the mesolimbic systems (Corrigall et al., 1992; Stewart et al., 1984). Functionally, smoking and nicotine consumption have been shown to improve cognitive function, particularly on vigilance tasks (Koelega, 1993; Parrott, Garnham, Wesnes, & Pincock, 1996). Thus, with particular relation to smoking, there are a number of positive effects that could act as reinforcers and promote the maintenance of smoking behaviours.

Stewart et al. (1984) were among the first to propose a positive reinforcement model of drug-use which incorporated a concept of drug-cue reactivity. They suggested that drug-use is driven by appetitive motivational states that result from positive affective states. Furthermore, they argued that a mechanism in which the continued pairing of stimuli with the pleasurable outcome of taking a drug leads to drug-related stimuli being seen as pleasurable themselves and thus initiating responses towards the stimuli. Once conditioned, drug-related stimuli mimic the pleasurable effects of the drug, activating reward pathways that are commonly activated during drug consumption. This activation, they argued, leads to the increased probability of drug-related thoughts and actions that subsequently can lead to physiological responses and the increased chance of drug consumption.

The model proposed by Stewart et al. reflects earlier models of incentive learning, such as the Bindra-Toates model of incentive motivation (Bindra, 1974) (see Figure 1.1, Panel A), in which the positive effects of the substance are also described as the primary driver behind reinforcement processes. In the Bindra-Toates model it is proposed that conditioned and unconditioned stimuli that have pleasurable incentive properties lead to a wanting (or liking) for the stimuli that subsequently result in outcomes including attraction, consumption, subjective pleasure and affective actions. Thus, according to the Bindra-Toates model conditioned and unconditioned stimuli are sought as a result of their association with the pleasurable effects of substance consumption rather than the consequences of withdrawal.

In both the Stewart and the Bindra-Toates' models three key assumptions are proposed which encapsulate early positive reinforcement models: i) that conditioned stimuli develop some form of hedonic value through their association with the pleasurable effects that accompany substance consumption, ii) that the 'pleasantness' which results from the hedonic value initiates responses which may lead to substance consumption, and iii) that liking and wanting are treated as identical concepts, a proposition which has come under criticism from subsequent models of addiction (e.g. Robinson & Berridge, 1993).



Taken from Toates (2008)

Figure 1.1, Panel A: **The Bindra-Toates model showing wanting and liking as a single concept, and *Panel B*: The incentive sensitization model proposed by Robinson and Berridge (1993) showing liking and wanting as two separate concepts.**

Robinson and Berridge (1993) argued that the subjective positive effects of drugs are not sufficient to counteract the negative experiences often associated with drug-use. They state that the pleasurable effects from drug-consumption would have to be 'enormous' to evoke drug-seeking and drug-taking behaviour alone. Instead, Robinson and Berridge argued that drug-use results from a 'wanting' that stems from the incentive-salience of drug-related stimuli rather than the subjective pleasurable effects associated with drug use. In their now widely cited Incentive-Sensitization Theory of Addiction, Robinson and Berridge (1993, see Figure 1.1 Panel B) posited that drugs, such as nicotine, have the ability to produce neurological changes in reward systems of the brain and following repeated use of a drug these reward systems become sensitised to the incentive value of the drug and the drug-related stimuli. This sensitisation, they further suggest, leads to a 'wanting', rather than a subjective liking, not only of the drug itself (e.g. nicotine) but also for drug related stimuli (e.g. cigarette, lighter, ashtray), manifesting itself behaviourally in approach and attentional biases to drug-paired stimuli that may result in drug use.

The important distinction of 'wanting' and subjective 'liking' proposed by Robinson and Berridge counteracts criticisms made of previous positive reinforcement models, as drugs and drug-related stimuli are not necessarily sought for their hedonic value but are sought instead as a result of their incentive salience. Furthermore, the processes of 'wanting' and 'liking', which lead to the same outcomes in the Bindra-Toates model, lead to separate outcomes in the Incentive-sensitisation model. Pleasurable stimuli, in the Incentive-Sensitization model, evoke a 'liking' that subsequently lead to subjective pleasure and affective actions, whereas conditioned stimuli that have incentive value lead to a wanting which subsequently leads to subjective craving, attraction, and elicit consumption. Thus, Robinson and Berridge argue that 'wanting' rather than 'liking', resulting from incentive-salience, plays a central role in determining continued drug consumption. The model also predicts that even after behaviours associated with drug-taking are extinguished the incentive value of drug-related stimuli will still be salient and therefore will possibly lead to craving and relapse.

With regard to attentional bias, the contrasting approaches of the positive-reinforcement models and the Incentive-Sensitization model yield different predictions. The positive-reinforcement models proposed by Stewart et al. and Bindra-Toates would predict that drug-stimuli would 'grab' the attention of a user only due to its association with the pleasurable effects of consuming the drug. This is in contrast to the Incentive-Sensitization model in which the attention of the user would be grabbed as a result of the incentive-salience of the stimuli, irrespective of the subjective pleasurable (or aversive) feelings associated with the stimuli. Furthermore, the Incentive-Sensitization model would predict that attentional biases would be present after drug-taking behaviours have been extinguished. This is due to the long-term neuroadaptations in the reward systems of the brain which lead to increased sensitivity of attentional systems to drug-related stimuli.

1.1.2 - Negative-reinforcement models

In contrast to positive-reinforcement models, negative reinforcement models are based on the assumption that users are trying to avoid the negative effects of withdrawal. In general, negative effects of withdrawal in relation to smoking oppose the subjective feelings, physiological changes, and positive functional effects that were described previously for positive affect. In particular, users who are abstaining from smoking subjectively experience anxiousness, guilt, restlessness, difficulty concentrating, impatience, irritability, anxiety, and dysphoria (Hughes & Hatsukami, 1986; Hughes et al., 1984; Mcdairmid & Hetherinton, 1995; Monti, Rohsenow, & Hutchison, 2000). Furthermore, they do not experience the same activation of reward systems commonly experienced during drug-consumption and perform worse on cognitive tasks (Parrott et al., 1996; Parrott & Roberts, 1991). Importantly, it has been shown that negative affective states are reported prior to over half of smoking lapse episodes (Marlatt & Gordon, 1980).

Koob (1996) proposed a model of negative reinforcement in drug-use based on evidence of such negative effects during abstinence. In this model, Koob argued that drug-seeking and drug-taking behaviour stemmed from a users need to achieve "*hedonic homeostasis*". He suggested that dopamine levels are reduced during abstinence which is representative of a non-normal state, whereas dopamine levels during drug-use represented a normal state. Koob argued that users are implicitly trying to avoid the non-normal dopamine state and so seek to consume drugs to achieve their 'normal' dopamine state, or 'hedonic homeostasis'. Furthermore, Koob proposed that the experience of negative affective states are a prerequisite of drug dependence.

Baker, Piper, and McCarthy, et al. (2004) placed a similar emphasis on the role of negative affective states in maintaining drug behaviour, proposing a model in which they argue that the experience of negative affective states inflate the incentive value of drugs subsequently initiating responses that might result in drug-use. Furthermore, they argue that as negative affect increases so does the salience of drug related stimuli increasing the chances that attention, or behaviours, are directed towards the stimuli. Thus, according to Baker et al. negative affective states that inflate the salience of drug-related cues are key to the initiating of behavioural reactions which may lead to drug use.

Evidence for the propositions put forward by Koob and Baker et al. comes from research showing that increases in negative affect and psychosocial stress are predictors of smoking urges in the first month of abstinence (Doherty, Kinnunen, Militello, & Garvey, 1995). Furthermore, significant increases in the desire to smoke (craving) have been shown in smokers when not smoking (Pomerleau, Fagerstrom, Marks, Tate, & Pomerleau, 2003). Indeed, it has also been argued that there is a close relationship between the experience of withdrawal symptoms and craving. Both factors have been implicated in affecting the chances of relapse during smoking cessation (Killen, Fortman, Newman, & Varady, 1991; S. Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996) and craving has even been described as a "*psychological or cognitive correlate of a subclinical, conditioned withdrawal syndrome*" (Ludwig & Wikler, 1974, p. 114).

In relation to attentional bias, negative reinforcement models would predict that attention is 'grabbed' by drug-related stimuli when users are experiencing negative affect. However, a number of criticisms are levelled against negative reinforcement models. Firstly, relapse back to compulsive drug-use has been shown after long periods of cessation, at which point withdrawal symptoms and associated negative affective states are often not present (O'Brien, 1997). In addition, there is no evidence that negative affect increases after a period of 12 hours post-abstinence, particularly in minimally stressful and relaxed situations (Arci & Grunberg, 1992; Meliska & Gilbert, 1991). Secondly, relapse occurs in relation to drugs where there are no strong withdrawal symptoms, and in cases where drug-use elicits strong withdrawal effects but is not related to compulsive drug-use (Robinson & Berridge, 2000). Thirdly, drug withdrawal effects are not immediately apparent after a short period of taking a drug, instead they tend to appear after drug-taking has taken place over a prolonged period of time and thus cannot explain early drug use (Falk, et al. 1982). However, it has also been argued that whilst withdrawal symptoms cannot explain early stages of drug seeking behaviour, withdrawal can provide powerful incentives to seek drugs after extended periods of drug administration (Glautier, 2004).

1.1.3 - The dual-affect model and the elaborated intrusion theory of desire

The dual-affect model proposed by Baker et al. (1987) provides a contrast to these relatively polarized views of positive and negative reinforcement models discussed previously, and proposes that craving is controlled by dynamic-emotional processes, whereby positive and negative emotions interact. They suggest that cravings are represented in both positive and negative cognitive networks that become activated when environmental stimuli match the information in the network. For instance, negative networks are activated when aversive cues such as withdrawal, drug unavailability, and negative emotional states are present and positive systems are activated when positive cues such as drug-availability and positive emotions are present. These networks, Baker argues, are mutually inhibitory in that as one becomes more active the other becomes less active. Thus, suggesting that whilst craving can exist in relation to both positive and negative affective states they cannot be experienced simultaneously.

In a similar vein to Baker et al. (1987), Kavanagh (2005) proposed the Elaborated Intrusion Theory of Desire in which both positive and negative affective states play a role in drug-seeking mechanisms. They suggest that conscious desires and craving are responsible for determining target acquisition (e.g. biasing attention towards a certain category of stimuli) and that these desires or cravings directly affect cognition. Central to their theory is the role of desire, which they describe as a "strong motivational force" (Kavanagh, 2005, p.4), cognitive elaboration, and intrusive thoughts. Desire, they suggest, is not exclusively positive or negative and can take both affective forms, being pleasurable when consumption is imminent and being aversive during abstinence and when trying to prevent consumption. These desires stem from intrusive thoughts which are triggered from external stimuli, for example a cigarette might lead to an intrusive thought about smoking which instigates a desire to smoke. Once a desire is manifested it is elaborated on with sensory information (such as the smell of a cigarette), generic characteristics (such as how a cigarette looks) and specific episodes (such as remembering a time when a cigarette was had with a friend) which are recalled from long-term memory (Kavanagh, 2005). These lead to the desire and craving being amplified to the extent where drug-use may take place. As with the Dual-

Affect model proposed by Baker et al. (1987), the Elaborated Intrusion Theory of Desire counteracts some of the criticisms of previous models by showing that processes leading to drug-taking behaviour are not solely reliant on positive reinforcement processes or negative reinforcement processes but instead can be both appetitive and aversive in their form.

Evidence for both the Dual-Affect model and the Elaborated Intrusion Theory of Desire is provided in an examination of subjective views of smoking behaviours by Pomerleau, Fagerstrom, Marks, et al. (2003). They found that positive reinforcement factors were associated with higher scores for novelty seeking, reward dependence, and alcohol dependence, whereas negative reinforcement factors were associated with higher scores for nicotine dependence, depression, anxiety and harm avoidance. Their results suggest evidence for both the positive reinforcement predicted by Stewart et al. (1984) and negative reinforcement model developed by Baker et al. (2004). Furthermore, Pomerleau et al. suggest that their results indicate that, subjectively, smokers could be placed on a 'reinforcement continuum' from positive to negative, and thus smoking does not result from positive or negative reinforcement properties exclusively. In addition, their results suggest that positive reinforcement factors, particularly novelty seeking, are representative of early smoking behaviours whilst negative reinforcement factors, such as increased nicotine dependence and anxiety and depression which are associated with withdrawal, are representative of longer-term smoking behaviours.

1.2 - Automatic and non-automatic processes and cognitive control

Whilst the previous models described focus on the emotional and incentive influences of drug-cue reactivity, other models have emphasised the role of habit, and in particular automatic and non-automatic cognitive processes that underlie substance-use behaviour.

The concept of automatic and non-automatic cognitive processes in psychology is not new. Indeed, Posner and Snyder (1975) and Schiffrin and Sneider (1977) suggested the occurrence of such processes in direct relation to attention over three decades ago. In particular they proposed that attention was subject to 'controlled' (non-automatic) processes and 'automatic' processes. Both controlled processes and automatic processes have specific properties and different effects on concurrent cognitive processes. Controlled, non-automatic processes, they argue are relatively slow, require attention and are voluntary, whereas automatic processes are fast, relatively stable and resistant to change and do not require attention.

These processes described by Posner and Schneider and Shiffrin and Schneider are thought to play a central role in addiction processes. Indeed, Tiffany (1990) proposed the Cognitive Model of Drug Urges and Drug-Use Behaviour incorporating the concept of automatic and non-automatic processes. In particular, Tiffany proposed that drug use is principally controlled by automatic processes being reliant on habitual behaviours, whilst cravings and drug urges are controlled by non-automatic processes. Tiffany states that automatic, habitual, processes develop through the consistent pairing of a stimulus (e.g. a cigarette) with a response (e.g. smoking), and that these 'automatic processes', once developed, are associated with a number of specific properties: i) They become less variable and faster with practice, ii) they are stimulus bound (i.e. a stimulus alone may initiate an automised set of actions), iii) they are not under explicit control, iv) they require little attention or cognitive effort, and v) they are often undertaken in the absence of conscious awareness.

In contrast, the non-automatic processes that control craving and drug urges possess properties of being slow, under conscious control, effortful, and dependent on attention and inattention. It is these non-automatic drug urges which Tiffany suggests subsequently elicit attentional bias. Tiffany further suggests that non-automatic processes become particularly prominent when automatic processes are interrupted, for instance, when a smoking stimulus is encountered but smoking behaviour is unavailable (e.g. through a quit attempt). Thus, Tiffany's model predicts that attentional bias should be most prominent during abstinence, when drug-use behaviour is not possible, rather than when drug-use behaviour is possible.

Another important prediction that Tiffany's model makes is that drug-use behaviours that have become automatic should have little impact on concurrent tasks, especially tasks which are cognitively effortful. This is in contrast to non-automatic processes, such as drug urges, which themselves are thought to be cognitively effortful, and therefore may have deleterious effects on concurrent tasks. These detrimental effects, Tiffany argues, may subsequently result in negative affective states and physiological reactions, such as increases in heart rate. Therefore, the level to which tasks are disrupted can be a good index of the degree to which drug-use behaviour has become habitual (Tiffany, 1990).

Similar propositions have been posited in direct relation to smoking. For instance, Di Chiara (2000) argues that for users in the early stages of nicotine dependence drug-related behaviours are controlled largely by incentive learning and the positive outcomes of nicotine consumption. However, after repetition of the behaviours that accompany nicotine consumption, habitual behaviours develop which make users less responsive to the incentive properties of nicotine and nicotine-related stimuli. Furthermore, Di Chiara argues that once habitual behaviours have developed they act independently of nicotine reward and that disruption of these habitual behaviours leads to explicit drug-seeking and craving.

More recently dual process models of attention developed in relation to social behaviour have examined the interaction between automatic and controlled processes. In these theories attention is often described as being stimulus-driven (also called bottom-up or exogenous processing) or goal-directed (also called top-down or endogenous processing), relating to automatic and controlled processes respectively (Barrett, Tugade, & Engle, 2004). The interaction of these stimulus-driven and goal-directed processes has been used to explain effects on attentional processes, general effects on cognitive control, and the automaticity of self-regulation (Barrett et al., 2004; Palfai, 2006).

One of the central tenets of dual-task theories is that the perception of stimuli can lead to the automatic activation of internal representations of knowledge structures and internal goal-states subsequently leading to behavioural responses, thoughts, or feelings (Bargh & Chartrand, 1999; Barrett et al., 2004). These automatic responses are thought to be a default response to stimuli rather than an exceptional response to stimuli. Furthermore, at any one time a number of representations may be activated by environmental stimuli and the strongest is the one most likely to lead to a behavioural response (Barrett et al., 2004). However, such behavioural responses might not be suitable for the current situation or fit with a person's goals and as such the role of conscious control of attention comes into play. Controlled attentional processes influence whether the automatic representation will lead to a particular behavioural response especially where there is some conflict between the activation of representations and a person's goals (e.g. the activation of the representations of smoking is in conflict with a person's goal to give up smoking). It has been argued that controlled processes work by suppressing goal-irrelevant representations and enhancing attention on goal-relevant representations, thus making it more likely that goal-relevant representations will lead to desired behaviour, thoughts or feelings (Bargh & Chartrand, 1999).

Recent research in relation to alcohol, however, suggests that under certain circumstances these controlled processes may become impaired, increasing the chance that automatic processes will lead to undesired thoughts, behaviours and feelings. In their dual-process model of the alcohol-behaviour link, Moss and Albery (2009) suggest that alcohol, being a cognitive suppressant, will lead to a reduction in controlled processing during consumption and will subsequently increase the probability that automatic associative representations will determine the behaviour. Their model involves two stages (see Figure 1.2) a pre-consumption stage and a consumption stage with the association activation in both stages relating to automatic activation of representations, and the propositional reasoning relating to controlled processes which influence whether representations lead to behaviour. In the pre-consumption stage Moss and Albery suggest that the activation of representations may already be occurring however, these representations are being effectively dealt with by propositional reasoning. However, following consumption the influence of propositional reasoning on behaviour becomes attenuated allowing for the default activation of behaviours through automatic routes to become increasingly possible.

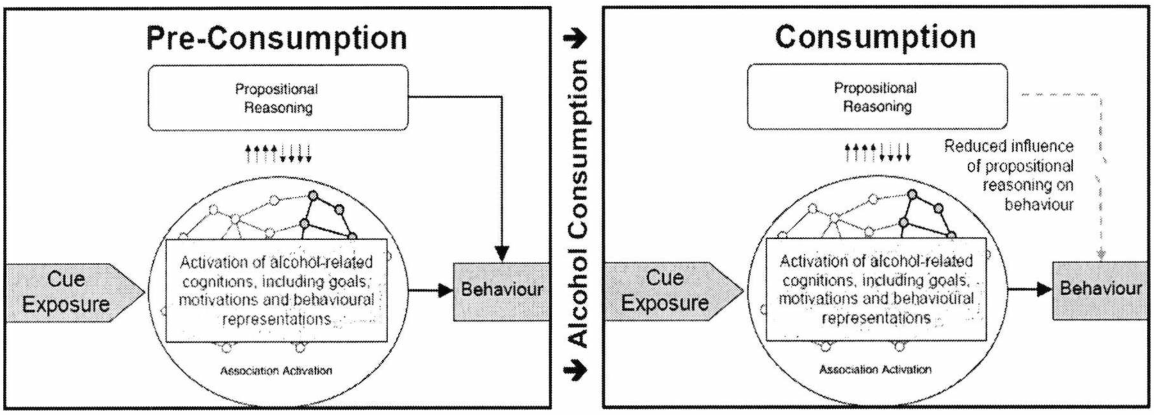


Figure 1-2 **Model of the alcohol-behaviour link proposed by Moss and Albery (2009)**

It is unclear at this stage the implications of Moss and Albery's model for smoking behaviour, especially considering alcohol has differential effects on cognitive performance compared to smoking. Specifically, alcohol consumption has been shown to lead to impairment of cognitive function (Dawson & Reid, 1997; Moss & Albery, 2009), whereas nicotine consumption leads to increased cognitive performance (see Kassel, 1997; Rusted, Caulfield, King, & Goode, 2000). It is possible that deleterious effects on cognitive function described by Moss and Albery (2009) in relation to alcohol consumption are similar, albeit to possibly a lesser extent, to the deleterious effects on cognitive function experienced during abstinence from nicotine in smokers (see Provost & Woodward, 1991; Warburton, 1992). If this were the case then there may be an impairment of controlled goal-directed processes during abstinence and it would explain why there is a high propensity to relapse during a quit attempt.

The interruption of controlled processes have also been examined in relation to emotion and anxiety. In particular, the Attentional Control Theory proposed by Eysenck, Derakshan, Santos, and Calvo (2007) asserts that anxiety interrupts controlled processes instigated by the Central Executive decreasing the effectiveness of top-down control. It has also been suggested that persons who are experiencing anxiety try to compensate by increasing effort in tasks. This compensatory process does not necessarily lead to erroneous responses as increased effort is applied to the primary task. However, it has been argued that they may lead to increased reaction times due to this increased effort. These increased response times are often indicative of attentional bias effects (see Chapter 2, section 2.1.1, *The addiction Stroop task*). These theoretical propositions may have far reaching consequences in relation to smoking given that smoking, and particularly abstinence from smoking has been shown to be related to increases in anxiety (see Chapter 1, section 1.1.2). This further indicates that under deprivation, controlled processes would be attenuated and lead to automatic behavioural responses to smoking stimuli being more prevalent.

Another theory that has been proposed to explain the regulatory control over automatic responses in relation to attention is the Conflict Monitoring and Cognitive Control Theory (Botvinick, Braver, Barch, Carter, & Cohen, 2001). This theory was primarily used to explain effects of cognitive control in relation to the classic Stroop task (Stroop, 1935). In the classic Stroop task participants are presented with colour words (e.g. red, blue, green, yellow) in different coloured inks. The classic Stroop task involves three types of trials: congruent trials in which the colour word matches the colour of the ink (e.g. the word red in red ink), incongruent trials in which colour word does not match the colour of the ink (e.g. the word yellow presented in the colour red) and neutral trials in which a neutral word unrelated to colour are presented in a coloured ink (e.g. house in the colour blue). The participants' task is to name the colour of the ink as quickly and as accurately as possible whilst ignoring the actual word. Where there is no conflict between the colour word and the colour of the ink, as in congruent trials, response latencies are usually quicker than to neutral trials. This effect is commonly termed facilitation. Where there is a conflict between the colour word and the colour of the ink, as in incongruent trials, response latencies are usually slower than neutral trials. This effect is commonly termed interference, due to relatively automatic colour-word reading interfering with colour-naming responses.

Using a version of the Stroop task Tzelgov, Henik, & Berger (1992) noted that if participants were presented with an increased number of incongruent trials then, counter-intuitively, interference effects decreased (i.e. participants were faster to colour-name incongruent stimuli). Botvinick et al. (2001) proposed the Conflict Monitoring and Cognitive Control theory to explain this and other effects relating to the Stroop task. In their theory it is suggested that when there is response conflict, for instance responding to blue ink colour when the colour word is red, a conflict monitoring system in the anterior cingulated cortex (ACC) is activated. This conflict monitoring system compensates for the conflict by biasing responses away from task-irrelevant responses (saying the colour word) and towards task-relevant responses (responding to the ink colour). Thus, where there are increased incongruent trials in the Stroop task compensatory responses leads to decreased colour-naming response times.

Whilst the Conflict Monitoring and Cognitive Control Theory was primarily proposed to explain responses in the classic Stroop task, it has further implications for the interaction of controlled and automatic responses in addiction. It suggests that automatic responses of attending to addiction-related stimuli may be attenuated when there is conflict between the automatic response (e.g. attending to smoking stimuli) and a particular task or goal (e.g. quitting smoking). That is the goal to quit smoking should make it less likely that automatic responses to stimuli will be acted upon, leading to smoking behaviour. However, this model has been further developed to incorporate the role of emotion. Wyble, Sharma, and Bowman (2008) suggest that the conflict monitoring system and subsequent cognitive control is influenced by an affective component in the ACC. When activated this affective component inhibits cognitive control suggested previously, thereby disrupting the compensatory effects of cognitive control. In relation to smoking this has important implications. Given that negative affective states are more pronounced in smokers particularly during abstinence, Wyble et al.'s model would predict that this would in effect attenuate the compensatory effects of cognitive control particularly during a quit attempt.

Whilst these effects have not been considered in direct relation to smoking, Chiamulera (2005) proposed a Multiple Action Model of nicotine which provides evidence of both bottom-up and top-down processes in relation to smoking based on evidence from imaging and lesion studies. Chiamulera suggests that bottom-up processes are involved in automatic processing in a parallel fashion, which leads to an activation of attentional functions that direct attention towards relevant stimuli (i.e. smoking-related cues). In contrast, top-down processes are involved in the modulation of sensory inputs and motor control that facilitate responses in relation to the cues perceived. As with the automatic processes described previously, Chiamulera shows that bottom-up processes are relatively fast and occur without conscious control, whereas top-down processes are relatively slow and occur in a serial fashion, and are generally under conscious control. Nicotine, Chiamulera suggests, increases the information processing in both of these aspects of attention increasing the positive reinforcement attributes of nicotine.

In summary, a number of theories have been put forward to explain both the interaction of automatic and controlled processes that might influence the maintenance of smoking behaviour and the attention given to smoking stimuli. These theories have highlighted the relatively fast aspects of bottom-up automatic processes and the slow, conscious aspects of top-down controlled processes. Furthermore, latter theories have suggested that addictive behaviours, such as alcohol consumption, and emotion may interrupt controlled process leading to increased chances that automatic responses to stimuli will result in unwanted drug-related behaviours and thoughts.

1.3 - Motivational Model of Drug-Use Behaviour

Whilst the previous models described have focussed on conditioning processes, affective influences and the role of automaticity and cognitive control in relation to drug-cue reactivity, Klinger and Cox (Klinger & Cox, 2004) have focussed on the role of current concerns in driving drug-use and drug-seeking behaviour. In their Theory of Current Concerns Klinger and Cox (Klinger, 1975, 1977; Klinger & Cox, 2004) describe the motivational processes which occur between the moment a person is committed to pursuing a goal and the attainment of that goal. They suggest that during this period the motivational state associated with the goal directs cognitive processes towards goal-related stimuli. They further suggest that abandoning or achieving goals leads to different affective consequences. For instance, if a goal is achieved then this can result in positive emotions, such as happiness, whereas abandoning a goal leads to negative emotions, such as anger or disappointment. In relation to attentional bias, Klinger and Cox's model predicts that users, whose ultimate goal is to consume drugs, have a predisposition to attend to drug-related cues as this facilitates them reaching their goal. Whereas, abstinent users goal is to avoid drugs and so they lack this predisposition of attention towards drug stimuli.

1.4 - Attentional Bias in Contemporary models

As mentioned previously the role of attentional bias within models has developed over the decades and a number of recent models have placed attentional bias explicitly at the heart of such models. For instance, Ryan (2002) proposed a model that suggests drug-related stimuli are preferentially processed by attentional systems which subsequently leads to craving and behavioural responses which may lead to drug-use behaviour. There are two major components to Ryan's model, i) that there is a direct link between the attentional bias to drug-related stimuli and craving, and ii) that attentional bias mediates the relationship between the perception of drug stimuli and drug-seeking behaviour. The idea of a link between attentional bias and craving is also suggested by Franken (2003). However, in contrast to Ryan, Franken suggests a mutually excitatory link between craving and attentional bias (see Figure 1.3), in that attentional bias increases can lead to increases in craving and conversely, increases in craving can lead to increases in attentional bias. Franken also suggests that it is the experience of craving that can directly lead to relapse.

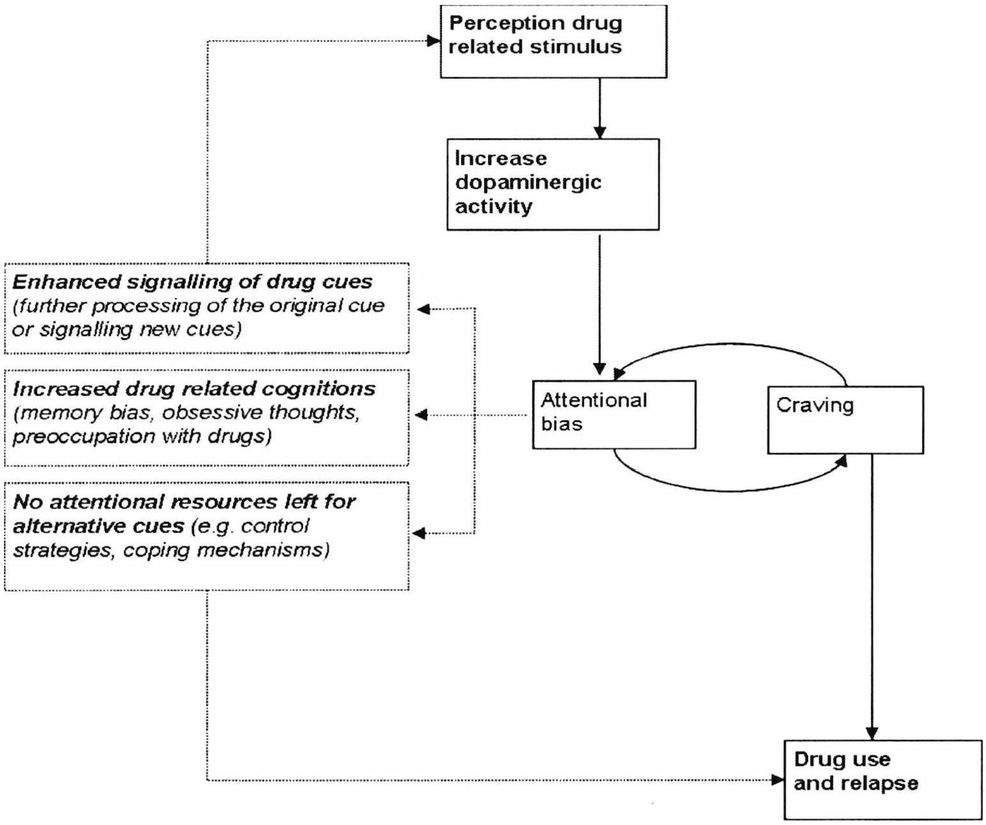


Figure 1-3 **-Franken's model showing the possible role of attentional bias in craving, drug use and relapse** (Reproduced from Franken, (2003)

In a similar vein, Field and Cox (2008) also promote the idea of a mutually excitatory link between attentional bias and craving (see Figure 1.4). In a review of the attentional bias and craving literature, Field and Cox (2008) describe an integrated model which suggests that conditioned substance cues lead to expectations of substance availability. This expectation subsequently leads to both increases in subjective craving and attentional bias for substance-related stimuli which have a mutually excitatory relationship. The model also states that individuals who are impulsive, who lack inhibitory control, or who are trying to suppress attentional bias or cravings are more likely to succumb to increases in attentional bias or craving. The suggestion of Field and Cox that both subjective craving and attentional bias are related to impaired executive cognitive function and compromised inhibitory control directly relates to dual-task models. In particular, it relates to the propositions put forward by Moss and Albery (2009) that impaired cognitive function through alcohol would lead to increases in automatic alcohol-related representations, subsequently leading to thoughts, feelings and behaviours relating to alcohol.

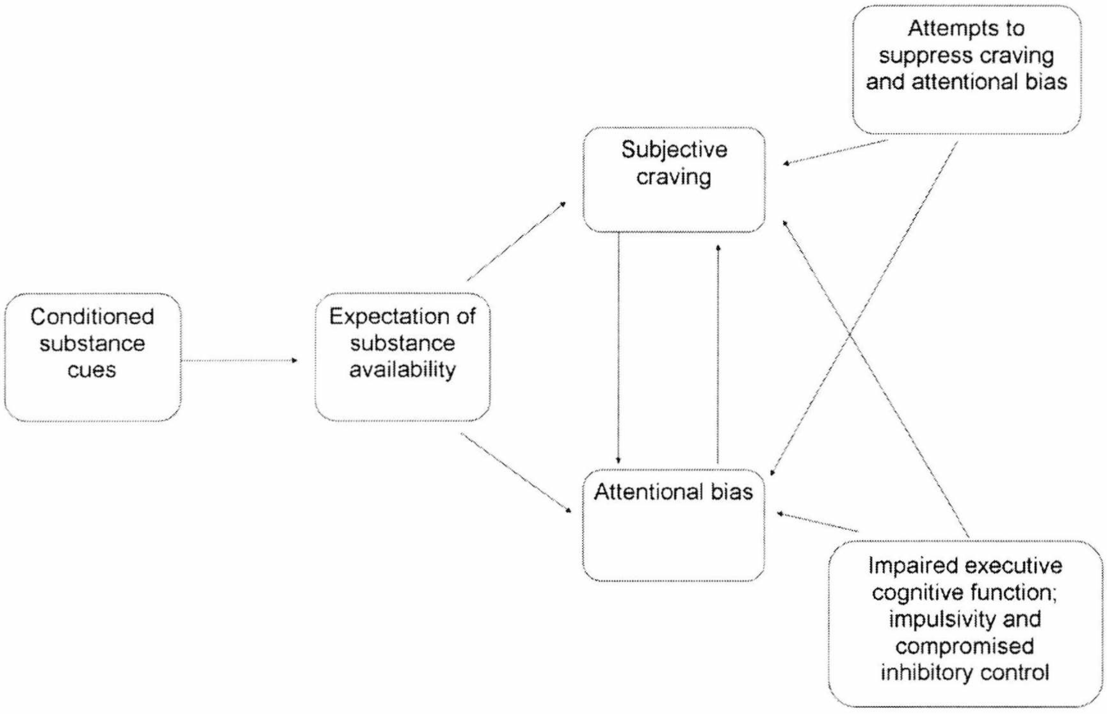


***Figure 1-4* - Field and Cox's integrated model showing the role of attentional bias and the mutually excitatory link with subjective craving** (Reproduced from Field and Cox, 2008)

Thus, in relation to smoking these models suggest that attentional bias may be more apparent under conditions where cognitive function is impaired and where craving is more apparent. Given that previous research has shown that craving and cognitive function is reduced during periods of deprivation these models would predict that attentional bias would be more apparent during periods of abstinence.

1.8 – Conclusion

In conclusion, this chapter has described and considered a number of theoretical approaches that have been proposed to explain the development and maintenance of addictions, the presence of attentional bias, and the role of affect, cognitive control and automatic responses in relation to attentional bias in addiction.

Affect: Early models emphasised the role of emotion in the development of addiction and attentional bias. These models outlined the role of positive and negative reinforcement processes. However, these theories have been superseded by models that stress incentive-sensitisation mechanisms and the neurological changes that occur following repeated drug administration. According to these models, the role of emotion becomes less apparent after continued drug use with attentional bias effects reflecting a sensitisation to stimuli rather than emotional response to stimuli. Therefore, if attentional bias effects result from the affective association of smoking stimuli they should be less apparent after prolonged periods of repeated drug administration.

In contrast, according to the Dual Affect model, and as elaborated in Kavanagh's (2005) Theory of Desire, negative affective states can also be apparent during periods of abstinence and withdrawal. This suggests that attentional bias for smoking stimuli may be more pronounced during periods of abstinence, especially if attentional bias results from the affective association with smoking stimuli. Furthermore, if stimuli are responded to because of their affective associations, this implies that situational and environmental influences on affective associations should lead to subsequent changes in attentional bias. For example, a change in a smokers' environment that could increase negative associations with smoking, such as the introduction of a smoking ban, could increase attentional bias to smoking stimuli.

Automaticity and cognitive control: It can be concluded from the review in this chapter that both automatic and non-automatic processes may be integral to addiction mechanisms and may explain the phenomena surrounding attentional control and cognitive control in relation to addictions. In particular, impairments in cognitive function may lead to increases in automatic responses to drug stimuli leading to behavioural actions (Moss & Albery, 2009). In relation to smoking, this suggests that attentional bias may be more apparent during periods when controlled processes are muted. Given the findings of previous research, for smokers this would be during periods of abstinence when cognitive function is less apparent and anxiety is increased.

Furthermore, these theories suggest that increased cognitive control would decrease the opportunity for automatic processes that lead to smoking attentional bias to operate, therefore reducing attentional bias and subsequent smoking behaviour. This has important implications for efforts to change smoking behaviours. The manipulation of cognitive control might be a route to changing smoking-related attentional bias and subsequent smoking-related behaviour. Field and Cox (2008) and Franken (2003) suggest a mutually excitatory link between craving and attentional bias. Therefore, it is plausible that the manipulation of attentional bias may produce subsequent changes in smoking craving and other smoking behaviours.

The review of the literature, as outlined in this chapter, suggests that the current models proposed to explain attentional bias focus around three main themes: emotion (e.g. Baker,et al., 2004), automatic and non-automatic processes (e.g.Di Chiara, 2000; Moss & Albery, 2009), and motivations (Klinger & Cox, 2004). The current research will pursue one of these main themes, 'emotion', but by doing so will also take into account automatic and non-automatic processes involved in attentional bias.

The main thrust of this thesis will be to examine the role of negative emotion in smoking attentional bias. In this way, the thesis will closely examine the propositions put forward by Baker (2004). According to this theory, negative affective states inflate the incentive value of drugs, thereby increasing the chance of attentional bias. This thesis will expand on Baker's theory in the following way. While Baker focused on the association between negative affective states and attentional bias, this thesis will test the relationship between smoking stimuli, which may have negative associations, and smoking attentional bias. For instance, during a quit smokers may be more likely to associate smoking stimuli with negative emotions, thereby causing these stimuli to capture their attention.

Furthermore, the thesis will bring new insight to this line of research by building on Baker's theory and examining the relationship between negative emotions associated with smoking stimuli and cognitive control and automaticity. Whilst Baker makes no specific predictions regarding the relationship between smoking stimuli, cognitive control and automaticity, previous research suggests that stimuli that have a negative emotional component can influence both cognitive control (Wyble et al., 2008) and the presence of automatic pre-attentive shifts in attention to these stimuli (see Pessoa, 2005). However, the relationship between smoking stimuli and negative stimuli and their effects on cognitive control and automatic shifts in attention, have not yet been examined together. The current research will advance this field of research by increasing our understanding of the relationship between these variables.

The theoretical approaches described in this chapter have provided a framework for empirical research in relation to addiction to be conducted, which will be examined further in Chapter 2.

Chapter 2. Methodological approaches, empirical findings, and links with underlying processes

This chapter examines the methodological approaches and empirical findings of studies examining the role of attentional bias in addiction, with particular focus on smoking. It begins by examining the methods which have been commonly adopted in this research area, examining the benefits and criticisms of each paradigm and the way they have been applied to examine attentional bias in relation to smoking and other addictions. It then goes on to discuss empirical findings, specifically in relation to smoking attentional bias, examining effects of abstinence, correlates with explicit reports of smoking behaviour, the role of emotion in smoking attentional bias, and the interactions between smoking, smoking attentional bias and cognitive control.

The previous chapter outlined a number of theoretical perspectives that have been put forward to explain how attentional biases in addictions develop, the roles of automatic and non-automatic processes in attentional bias, and theoretical perspectives on the relationships between attentional bias and smoking behaviour and craving. The present chapter builds on these theoretical perspectives by examining the main methods through which attentional bias in addiction has been measured and the main findings of empirical research in specific relation to smoking behaviour, emotion, automaticity, and cognitive control.

2.1 - Methodological Approaches

Studies that have examined attentional bias in relation to addiction have adopted a wide variety of methodological approaches. Commonly these include paradigms developed in cognitive psychology alongside more explicit reports of behaviours relating to substance use (e.g. Cane, Sharma, & Albery, 2008; Mogg & Bradley, 2002). The choice of methodological approach is an important one, as it not only determines the sensitivity to the effects of attentional bias but also determines whether a study is simply theoretically relevant or whether it is also clinically relevant. Waters and Leventhal (2006) differentiate between these two types of study and suggest that for cognitive measures in studies of addiction to be clinically, and not just theoretically, relevant they should cover three main criteria:

i) they should be associated with measures of use and dependence

ii) they should be associated with clinically relevant outcomes and show incremental prediction over self report measures, and

iii) they should be modifiable by drug, behavioural, or cognitive interventions

(Waters & Leventhal, 2006 pp. 249)

Thus, in addition to accurately gauging implicit responses, such as attentional bias to addiction-related stimuli, studies should also include measures of dependency and substance-use behaviour and identify whether attentional bias can be manipulated either situationally or experimentally to be clinically relevant.

As well as being clinically important, attentional bias measures should also be sensitive to different facets of attention. Research has suggested that there are a number of different aspects of attention, such as attentional capture, modulation of attention, and maintained attention. Furthermore, both Allport (1989) and LaBerge (1995) have suggested that attention is not unitary and different mechanisms may underlie the initial orienting and maintenance of attention. Indeed, the mechanisms that underlie attention are far from simple and this has led to research along a number of psychological domains in relation to attention (see Posner, 2004). Thus attentional bias research needs to be sensitive to these complexities to truly understand the nature of attentional bias in addictive processes.

2.1.1 - Measures of attentional bias

Studies examining addiction-related attentional bias have adopted a number of different cognitive paradigms, the most common being the addiction Stroop task, the visual probe task, dual-task paradigms and more recently eye-tracking methods. The following describes each of these commonly adopted methods and examines their effectiveness in identifying attentional bias and the criticisms, if any, that have been levelled against them. Although attentional bias research, in general, has adopted a number of additional paradigms to the ones listed above, this review is limited solely to those paradigms which have proven effective in identifying attentional bias in relation to smoking.

The addiction Stroop task

The addiction Stroop task has been employed across the majority of studies examining attentional bias in relation to addiction and is a development of the classic Stroop task (see Chapter 1, section 1.2). The addiction Stroop task involves two types of trials: an addiction-related trial in which addiction-related words (e.g. cigarette, ashtray, tobacco) are presented in different coloured inks and neutral trials in which neutral words unrelated to the addiction (e.g. house, car, and shoe) are presented in different coloured inks. In line with the classic Stroop effect it is predicted that if the addiction-related words are 'attention grabbing' (e.g. among drug-users) then this should disrupt the colour-naming task to a greater extent, leading to slower colour-naming. Thus, an attentional bias for addiction-related words is thought to be denoted when the colour-naming of addiction-related words is slower than the colour-naming of neutral words. Such effects have been shown across a number of addiction-related attentional bias studies with users commonly showing increased colour-naming response latencies compared to non-users (see Cox et al., 2006 for a review).

Stroop effects in general have been described as one of the most reliable phenomena in the cognitive sciences (Macleod, 1991) and in relation to addiction specifically, the addiction-Stroop task has been shown to be particularly effective in measuring different facets of addiction-related attentional bias (see Cox et al., 2006). Specifically, it has been argued that the addiction-Stroop task is effective in distinguishing users from non-users, in providing 'convergent validity', in that interference resulting from addiction-related words is often accompanied with physiological effects, and in indexing the probability of resuming drug-use following abstinence (Cox, Fadardi & Pothos, 2006). Furthermore, a modified version of the addiction Stroop task developed by McKenna and Sharma (2004) has been shown to be effective in identifying immediate effects on attention which happen during stimulus presentation, called the fast effect, and 'lingering' effects on attention which occur on trials following the critical stimulus presentation, called the 'slow' or 'carryover' effect. Measured using a sequence involving an addiction-related word followed by a number of counterbalanced neutral words the fast effect is characterised by slower colour-naming during the presentation of the addiction-related word. Meanwhile, slow effects are characterized by slower colour-naming on neutral stimuli which immediately follow the addiction-related stimuli. Adopting this particular design helps distinguish between attentional-grabbing processes (fast effect) and difficulty to disengage or rumination (the slow effect; Cane et al., 2009; Waters, Sayette, Franken, & Schwartz, 2005; Waters, Sayette, & Wertz, 2003). These effects are thought to represent bottom-up stimulus salience responses and top-down response regulation, respectively.

Studies adopting the addiction Stroop task have provided evidence of effects indicative of attentional bias across a number addictions including alcohol use (e.g. Duka & Townshend, 2004; Field, Duka et al., 2007; Sharma, Albery, & Cook, 2001; Sharma, Albery, & Fernandez, 2004), tobacco smoking (e.g. Cane et al., 2009; Drobes, Elibero, & Evans, 2006; Fehr, Wiedenmann, & Herrmann, 2006; Johnsen, Thayer, Laberg, & Asbjornsen, 1997; Mogg & Bradley, 2002), cocaine use (Hester, Dixon, & Garavan, 2006), cannabis use (Cane et al., 2009; Field, 2005), heroin use (Marissen et al., 2006; Waters et al., 2005), and gambling behaviour (Boyer & Dickerson, 2003). Furthermore, the addiction-Stroop task has been shown to be sensitive to levels of drug-use identifying differences in attentional bias between heavy and light social drinkers (Bruce & Jones, 2004; Cox, Yeates, & Regan, 1999), and smokers and smokers attempting to quit (Cane et al., 2009).

The addiction Stroop task has also proven beneficial in identifying the chances of success in cessation outcome and the chances of relapse in relation to alcohol (Cox, Hogan, Kristian, & Race, 2002), heroin (Marissen et al., 2006), cocaine (Carpenter, Schreiber, Church, & McDowell, 2006), and tobacco smoking (Waters, Shiffman, Sayette et al., 2003). Thus, the Stroop task has been shown to be effective not only in measuring effects indicative of attentional biases in addictions but has also shown its clinical use across a number of different addictions.

There has, however, been some argument as to what extent the Stroop task measures attentional bias per se (see Field, 2006). The mechanisms that underlie Stroop effects still remain relatively unclear and some researchers argue that slower colour-naming response latencies shown in the Stroop task are not necessarily the product of the 'attention grabbing' properties of stimuli. Early researchers in the field suggested that the meaning of words 'capture' attention and lead to disruption of the colour-naming task (Gross, Jarvic, & Rosenblatt, 1993). Indeed, Williams, Mathews and MacLeod (1996) suggest that colour-naming interference on Stroop tasks stems from the limitation of parallel processing capacities of attentional systems. They argue that when presented with a word with semantic content while completing a colour-naming task, processing resources are preferentially allocated to the semantic content of the word before identifying the colour of words, leading to slower colour-naming (Cox et al., 2006).

Other researchers have suggested that slower colour-naming may also stem from the experience of cravings, emotions or anxiety which are elicited in response to drug-stimulus perception (e.g. Algom, Chajut, & Lev, 2004). Such a suggestion is based on the proposition that craving, negative emotion, feelings of anxiety and even the suppression of addiction-related thoughts are cognitively effortful (Tiffany,1990; Cepeda-Benito,1996; Klein 2007) leading to a reduction in the availability of cognitive resources for concurrent tasks and leading to a general cognitive slow-down (Algom et al., 2004). However, data from studies examining fast and slow effects of attentional bias (e.g. Cane et al., 2009; Waters et al., 2005; Waters, Sayette et al., 2003) has shown that slower colour-naming is present only on neutral trials following addiction-related stimuli, thereby negating suggestions of a general cognitive slow-down and showing that any slow-down is specific or very proximal to the addiction-related stimuli.

It has also been argued that attentional biases for addiction-related stimuli as seen in the addiction Stroop task are a product of impaired cognitive functioning of users, leading to slower colour-naming. Evidence for this comes in the form of generally slower reaction times on reaction time tasks across users compared to non-users (Cox et al., 2006). Indeed, studies have shown that in respect to tobacco smoking, and even prenatal or adolescent exposure to tobacco smoke, deleterious effects on both visual and auditory attentional performance are apparent (Jacobsen, Slotkin, Mencl, Frost, & Pugh, 2007). However, whilst some studies have shown that substance-user groups have generally slower reaction times in the Stroop task compared to non-user groups (see Cane et al., 2009; Waters & Green, 2003 for evidence of these effects), the findings across studies that reaction times for addiction-related words are relatively slower to neutral words within user-groups (e.g. Cane et al., 2009; Cox et al., 2002; Mogg & Bradley, 2002; Sharma et al., 2001) indicates that lack of cognitive functioning cannot be the cause of these effects. Thus, whilst it is unclear what the exact mechanisms behind addiction-Stroop effects are, evidence suggests that they are not the product of a general cognitive slow-down nor impaired cognitive functioning, but they are indeed an effect of attentional bias towards certain stimuli.

Visual Probe Task

In contrast to the Stroop task, the visual probe task involves two stimuli being displayed on a screen simultaneously. When used in relation to addiction-related attentional bias, one of the stimuli is addiction-related (e.g. ashtray or lighter) and the other is neutral (e.g. brick or shoe). Following stimuli presentation a probe (usually either one dot or two dots, or an arrow in different orientations) assumes the position of one of the stimuli. The participants' task is to respond as quickly and as accurately as possible to the probe shown. It is thought that respondents may be quicker to respond to probes which are presented in the area where their attention has been directed. For instance, if respondents' attention is grabbed by an addiction-related stimuli they should be quicker to respond to probes which replace these stimuli. Thus an addiction-related attentional bias in the visual probe task is indicated by faster response times when probes replace addiction-related stimuli, compared with response times when probes replace neutral stimuli.

It has been argued that the visual probe task is a fairly direct measurement of visuo-spatial attention as visual attention has to be given to the area of the stimulus before the probe can be correctly detected (Field, 2006). Furthermore, the task has been consistent in revealing effects which are indicative of attentional bias for addiction-related stimuli across a number of addictions, including alcohol (e.g. Duka & Townshend, 2004; Field, Mogg, Zetteler, & Bradley, 2004), smoking (Ehrman et al., 2002; Mogg & Bradley, 2002), and cannabis (Field, 2005).

The visual probe has also provided interesting findings across a number of studies that have manipulated the time period that stimuli are presented for prior to probe presentation. The time period that stimuli are presented for will be referred to as *stimulus duration* for the remainder of the thesis. It is thought that the manipulation of stimulus duration helps to distinguish between initial orientation, or 'attention grabbing' effects, and effects which are indicative of maintenance of attention on a stimulus. Responses to probes after short stimulus durations (commonly <500ms) are thought to represent immediate 'attention grabbing' effects, whilst responses to probes after longer stimulus durations (commonly >2000ms) are thought to represent the maintenance of attention on a stimulus (Bradley, Mogg, Wright, & Field, 2003b). These are comparable with the fast and slow effects shown in the Stroop task described previously (see p.33). Shorter stimulus durations correspond to bottom-up stimulus salience responses and longer stimulus durations correspond to top-down regulation of control. Thus, the visual probe task, like the addiction Stroop task, is not only an effective measure of attentional bias but can also distinguish between fast and slow, 'lingering' effects of attentional bias.

As with the Stroop task there has been some criticism of the visual probe task. One limitation of the paradigm is that it only measures responses at stimulus offset and does not provide evidence of effects which occur during the actual stimulus presentation. Recent studies have dealt with such criticisms by also including eye-tracking measures simultaneously with the visual probe task, thus allowing visual attention during stimulus presentation to be measured in addition to probe responses.

Another criticism was put forward by Waters and Green (2003) who argued that the visual-probe task was susceptible to conscious strategies to complete the task which may affect the results. Specifically, they argued that participants are aware that probes are always presented at two relevant locations and so subjects may purposefully shift their attention constantly between the two locations where the probe might be presented. This has the effect of increasing their chances of responding to the probe correctly but adversely influencing results that are subsequently taken to be indicative of attentional bias. Whilst such a suggestion is possible, the consistency and uniformity of findings across studies adopting the visual probe task suggest that the effects do not result from participants constantly shifting attention. Thus, the visual probe task is thought to be an effective measure of attentional bias to stimuli.

Dual-task paradigms

Dual-task paradigms, as the name suggests, involve two concurrent tasks. In one task the user is presented with drug-related or neutral stimuli, and in a second task participants complete a reaction time task which is cognitively demanding. As with the Stroop task, slowing down on the reaction time task indicates that attention is being captured by the addiction-related stimulus. To date the use of dual-task paradigms in studies of attentional bias in addictions has been limited. However, in studies unrelated to smoking the adoption of the dual-task paradigm have shown some interesting results.

For instance, Waters and Green (2003) adopted a dual-task paradigm in a group of abstinent alcoholics and a group of control subjects. For their dual-task procedure, the reaction time task required participants to respond to odd and even numbers shown centrally on a screen and for the secondary addiction-related task they asked participants to respond to words (alcohol and neutral words) and non-words *'out of the corner of their eye'.* Using this task they found that abstaining alcoholics were slowed on the odd-even task when the peripheral cues were alcohol-related words compared to when the peripheral words were neutral, thus indicating that attention was allocated to alcohol stimuli to a greater extent than neutral stimuli. Such studies indicate the potential of the dual-task methodology in the study of smoking attentional bias.

Dual-task paradigms are conceptually similar to the Stroop task paradigms, in that slowing down on one task is a product of reactions to a specific stimuli, and so have come under similar criticism to those put forward with respect to the Stroop task. However, Waters and Green (2003) suggest that the dual-task procedure they used provides stronger evidence for attentional bias effects than the Stroop task and the visual probe task because, unlike the Stroop task, responses are more likely to represent active shifts in visuo-spatial attention towards addiction-related stimuli, and unlike the visual probe task, results are less likely to result from shifting attention across two locations.

Eye-tracking methods

Eye-tracking methods have only recently been used to measure attentional biases in relation to addiction. However, studies which have adopted these methods have the benefit of accurately measuring visuo-spatial attention. It has been suggested that eye-movements are a good measure of where attention is being deployed (Duchowski, 2007) and have proved effective in measuring numerous phenomena relating to attention and vision across a great number of studies (see Findlay & Gilchrist, 2003 for a review).

Eye-movement methods are particularly insightful when used in attentional bias studies as they can help infer about different aspects of attentional processes, including attentional capture, modulation in attention, and maintained gazes, both during and following stimulus presentation. However, there is evidence that whilst eye-movement measures are beneficial they may not always fully capture different features of attention

(Shepherd, Findlay, & Hockey, 1986). Such a suggestion stems from evidence that whilst it is not possible to make an eye-movement without a corresponding shift in attention it is possible to direct attention towards an area without corresponding eye-movement (Shepherd et al., 1986). Thus, under certain circumstances attention might, or might not, be given to a particular stimulus but this would not necessarily be reflected in eye-movement measures. Therefore, even with such an accurate measure of visuo-spatial attention some caution should be shown in the interpretation of results.

Within the field of addiction the majority of studies adopting eye-tracking measures have been in relation to smoking (e.g. Bradley, Garner, Hudson, & Mogg, 2007; Field, Mogg, & Bradley, 2004; Kwak, Na, Kim, Kim, & Lee, 2007; Mogg, Bradley, Field, & De Houwer, 2003). One of the benefits of using eye-tracking methods to study attentional processes in addiction is that they can be used alongside other attentional bias measures (e.g. the visual probe task) that have shown evidence of smoking attentional bias. By doing so, researchers are able to examine the underlying mechanisms of attentional bias in greater detail. Research using eye-tracking methods has shown that smoking attentional bias comprises both maintenance of attention on and initial orientation of attention to smoking stimuli (see Bradley et al., 2007; Field, Mogg et al., 2004; Kwak et al., 2007). Findings in relation to eye-movement measures and smoking attentional bias will be discussed in greater detail in section 2.2 of the present chapter.

The use of word and pictorial stimuli

Across the measures described there has also been some variation in the type of stimuli used, with word and pictorial stimuli used to different extents across paradigms and studies. Many studies adopting the Stroop task and dual-task procedures have used word stimuli (e.g. Cane, Sharma, & Albery, 2009; Johnsen et al., 1997; Waters, Shiffman, Sayette et al., 2003; Waters & Green, 2003), and studies adopting the visual probe task and eye-tracking measures using pictorial stimuli (e.g. Field, Mogg, & B. Bradley, 2004; Mogg et al., 2003; Waters, Shiffman, Bradley, & Mogg, 2003). In recent years however, pictorial stimuli have been used in the addiction Stroop task also (e.g. Bruce & Jones, 2004).

Whilst it has been argued that pictorial stimuli yield greater ecological validity (Lubman, Peters, Mogg, Bradley, & Deakin, 2000), it has also been argued that pictorial stimuli are possibly too specific to yield the type of attentional bias effects usually seen in the lexical version of the Stroop task (Kindt & Brosschot, 1999). For instance, in a study of spider-phobics by Kindt and Brosschot (1999) it was shown that phobics showed attentional bias to spider-related words but this was not evident when pictures were used. Kindt and Brosschot argue that these effects may have been due to the inability of phobics to quickly generalise the picture stimuli to the category of spiders. In the same way, pictorial stimuli in relation to addiction may be too specific to initiate addiction-specific thoughts or craving. One example of this might be that a different brand of cigarette is used in the stimuli to the one normally smoked by the individual. This may lead to the inability of the stimuli to prime the individuals own concept of smoking. Given the limited research of a direct comparison between picture and word stimuli in relation to addiction it is difficult to identify whether pictorial stimuli may have a detrimental effect on identifying attentional bias. However, the above argument must be borne in mind when examining affects of attentional bias using different stimuli types.

In summary, a number of methodological approaches have been commonly used to measure and examine attentional bias in relation to substance-use. The most commonly adopted being the addiction Stroop task, the visual probe task, dual-task paradigms, and eye-movement measures. The Stroop task has shown consistent results and has shown effects which are clinically relevant. The visual probe task has similarly proved to be an effective measure of effects indicative of attentional bias across a number of studies. The dual-task paradigm and eye-tracking, whilst they have been used to a lesser extent, have also shown validity in measuring attentional biases in relation to addictions.

2.2 Empirical findings in relation to smoking attentional bias

Using the methods described in the previous section, a growing number of studies have examined the presence and nature of attentional biases in relation to smoking. These studies have taken various forms and have identified different facets and correlates of attentional bias to smoking-related cues. The following section reviews the findings of smoking attentional bias studies. Specifically it examines the relationship between smoking attentional bias and smoking behaviour, the effects of abstinence on smoking attentional bias, and the role of affect, automaticity and cognitive control in relation to smoking and smoking attentional bias.

2.2.1 - Evidence of attentional bias and relationship with smoking behaviour and craving

In line with the theoretical propositions put forward by Robinson and Berridge (1993, Chapter 1, section 1.1), evidence of smoking-related attentional bias across smoking groups has come from a number of studies. The addiction Stroop task has been particularly prominent in showing effects which are indicative of attentional bias towards smoking-cues. The majority of Stroop studies have shown that smoking groups are slower to colour-name smoking-related stimuli compared to colour-naming of neutral stimuli (e.g. Cane et al., 2009; Drobes et al., 2006; Johnsen et al., 1997; Mogg & Bradley, 2002; Munafò, Mogg, Roberts, Bradley, & Murphy, 2003). Effects indicative of attentional bias have also been shown in the visual probe task, eye-tracking studies and dual-task paradigms. In visual probe studies, smokers have generally been shown to respond more quickly to probes replacing smoking words compared to probes replacing neutral words (Bradley, Field, Healy, & Mogg, 2008; Bradley et al., 2007; Ehrman et al., 2002; Mogg & Bradley, 2002; Waters, Shiffman, Bradley et al., 2003). In eye-tracking studies, smoking groups have been shown to initially fixate and maintain attention on smoking-related stimuli to a greater extent than neutral stimuli and, across dual-task studies, the presence of smoking stimuli (e.g. when a participant is holding a cigarette) has been shown to have a detrimental effect on performance on a secondary task in smoking groups (e.g. Baxter & Hinson, 2001; Juliano & Brandon, 1998; Sayette & Hufford, 1994; Sayette, Martin, Wertz, Shiffman, & Perrott, 2001; Waters et al., 2004).

In addition, studies that have directly compared effects of smokers and non-smokers have commonly shown that non-smoking groups, unlike smoking groups, show no evidence of attentional bias for smoking-related cues (e.g. Bradley et al., 2008; Bradley et al., 2004; Cane et al., 2009; Johnsen et al., 1997; Munafò et al., 2003). Thus, there is robust evidence of the relationship between smoking and the presence of smoking attentional bias across studies and methodologies, indicating that smoking attentional bias is specific to smoking behaviours and/or smoking-related cognitions.

There is, however, inconsistent evidence across measures of smoking attentional bias for the relationship between smoking attentional bias and explicit reports of smoking behaviour. In relation to the Stroop task, a number of studies have shown no evidence of an association between smoking behaviour measures and interference in the Stroop task even when smoking Stroop effects are evident (Munafò et al., 2003; Munafò, Johnstone, & Mackintosh, 2005). However, a few significant relationships have emerged. For instance, Mogg and Bradley (2002) found significant correlations between smoking Stroop attentional bias and a number of smoking behaviour measures including a greater number of cigarettes smoked, higher number of previous quit attempts, greater urges to smoke and increased nicotine dependence. Cane et al. (2009) have also shown significant positive correlations between nicotine dependence and Stroop attentional bias in smokers attempting to quit but not in smokers, and Zack et al. (2001) found a positive correlation between the number of cigarettes smoked daily and Stroop attentional bias in novice adolescent smokers. All of these effects indicate that factors associated with increased nicotine dependence are related to increases in attentional bias. More recently, Field, Christiansen, Cole, & Goudie (2007) have shown that when smokers are exposed to smoking-related stimuli (e.g. a lit cigarette) their subjective craving increases and they show greater increases in Stroop attentional bias for smoking stimuli.

Furthermore, researchers have also found a relationship between smoking Stroop attentional bias and future smoking behaviour. Waters and Feyerband (2000) examined the relationship between attentional bias and time to first cigarette on the following morning across ninety-six smokers. They found that the degree of attentional bias shown in the Stroop task predicted the latency to the first cigarette the following morning, with increased smoking attentional bias leading to a shorter time to first cigarette. Similarly, Waters, Shiffman, and Sayette et al. (2003) examined the relationship between smoking attentional bias and cessation outcome in a group of 158 smokers on the first day of their quit attempt. They found that smokers who had increased smoking attentional bias in the Stroop task were more likely to lapse back to smoking in the short-term. Thus, these two studies indicate that smoking Stroop attentional bias may have some clinical utility in indexing future smoking behaviour and the chances of relapse during a cessation attempt.

Relationships between explicit reports of smoking behaviour and smoking attentional bias have also been evident in studies adopting the visual probe task. In particular these studies have shown that attentional bias in the visual probe task is related to a greater urge to smoke (Mogg et al., 2003), greater approach tendencies to smoking-related cues (Mogg et al., 2003; Mogg, Field, & Bradley, 2005) and time since last cigarette, with longer latencies to last cigarette being associated with increased attentional bias (Mogg et al., 2005). Hogarth, Mogg, Bradley, Duka, and Dickinson, (2003) also provided evidence of a significant quadratic relationship between the number of cigarettes per day and attentional bias. This finding indicates that increased tobacco consumption leads to reductions in attentional bias. Hogarth et al. (2003) suggest that, in line with Tiffany (1990; see Chapter 1, section 1.2), this may be due to the smoking behaviour in heavy smokers becoming relatively automatic and less reliant on attention to smoking-related cues. However, a number of studies adopting the visual probe task have also shown a non-significant relationship between attentional bias effects and explicit smoking behaviour measures (Bradley et al., 2008; Ehrman et al., 2002; Mogg & Bradley, 2002; Waters, Shiffman, Bradley et al., 2003). Furthermore, Waters, Shiffman, and Bradley et al. (2003) have shown that vigilance in the visual probe task does not predict the chances of relapsing in the short-term during a cessation attempt.

With respect to dual-task paradigms, there has been consistent evidence of a relationship between attentional bias and an increased urge to smoke (Juliano & Brandon, 1998; Sayette & Hufford, 1994; Sayette et al., 2001). This suggests that attentional bias in the dual-task procedure is a good index of smoking-related cravings. However, a study by Waters et al. (2004) on a group of smokers undertaking a quit attempt has shown that cue-reactivity effects shown in a dual-task procedure did not predict cessation outcomes.

In summary, across studies and different measures of attentional bias there are mixed findings regarding the relationships between attentional bias and explicit reports of smoking behaviour. It has been suggested that this may be, in part, due to the fact that different measures tap different aspects of attentional bias (see Field & Cox, 2008). Indeed, there is little evidence of significant correlations between attentional bias yielded from different measures (Field, 2006). One finding that is evident across the different measures of attentional bias is the relationship between smoking urges or cravings and smoking attentional bias. This relationship is particularly evident in studies adopting the dual-task paradigm. Thus, there is some evidence to suggest that urges and cravings may play a key role in smoking attentional bias, as suggested in the integrated model put forward by Field and Cox (2008; see Chapter 1, section 1.4).

2.2.2 - Effects of abstinence on smoking attentional bias

Researchers have further extended our understanding of smoking attentional bias by examining the relationship between abstinence and smoking attentional bias. Such research is beneficial for a number of reasons: i) it helps to identify the role that nicotine plays in attentional bias, ii) it helps identify whether different cognitions and emotional states that occur during abstinence (see Chapter 1, section 1.1) affect the presence of attentional bias, iii) it helps identify any changes in attentional bias that occur in the transition from smoker to ex-smoker during a quit attempt, and iv) it helps identify the role that attentional bias plays in lapse episodes and the maintenance of smoking behaviour. Therefore, this approach not only helps identify the underlying mechanisms of smoking attentional bias but also helps understand the potential clinical importance of smoking attentional bias in cessation treatment.

Across studies there are two approaches that have been adopted to examine the relationship between abstinence and smoking attentional bias. One approach has been to examine effects in smokers who have been experimentally deprived, that is deprived as part of experimental procedures. In contrast, the second approach examines the effects of abstinence on attentional bias by using smokers undergoing a quit attempt, or ex-smokers. These two approaches have yielded different findings with regards to the presence of attentional bias during abstinence. These will be discussed further in the following sections.

Smoking Attentional Bias in Deprived smokers

Across the majority of studies abstinence has been experimentally manipulated with smokers being asked to refrain from smoking for fixed periods of time. Studies adopting these methods have commonly used deprivation periods of 12 and 24 hours.

Using deprived smokers in the Stroop task, studies have generally shown that smokers under deprivation show increased smoking attentional bias compared to non-deprived smokers. One such study conducted by Gross, Jarvic, and Rosenblatt (1993), measured verbal response times to smoking-related cues using a blocked card version of the Stroop task in a group of smokers who had not smoked for 12 hours compared to a group of smokers who continued with normal smoking patterns. Their results showed that deprived smokers were slower at colour-naming smoking-related words than control words, and in contrast, smokers who were non-deprived were quicker at naming the colour of smoking words than control words. Thus, indicating an attentional bias to smoking stimuli in deprived smokers but not in non-deprived group. Similar effects have been shown by Zack, Belisto, Scher, Eissenberg, and Corrigall (2001) in a group of adolescent smokers. Measuring attentional bias using the Stroop task after a period of overnight abstinence they found effects which were indicative of attentional bias. However, when measuring the same group immediately after smoking they found that attentional bias had decreased, indicating stronger effects during smoking deprivation.

These effects have been replicated in a study by Waters and Feyerband (2000) who used both blocked and unblocked versions of a computerised Stroop task with smokers who had not smoked for 24 hours and smokers who had just smoked. In the blocked version, they found effects that were consistent with the findings of Gross et al. (1993). Abstinent smokers were slower to colour-name smoking words compared to those who had just smoked.

In contrast, three studies utilising the Stroop task have shown no effect of deprivation on attentional bias, with smoking attentional bias occurring similarly in both deprived smokers and non-deprived smokers. Rusted et al. (2000) adopted a computerised version of the Stroop task with smokers who had just smoked and deprived smokers (greater than 2 hours). Mogg et al. (2002) used both the masked and unmasked Stroop task on non-deprived smokers and smokers who had been deprived for 12 hours, and Rzetelny et al. (2008) measured effects of deprivation across a group of smokers who had not smoked for 12 hours, half of whom were given a nicotine patch (14mg) and half of whom were given a placebo patch. In all three of these studies it was found that attentional bias was present to a similar extent in both deprived and non-deprived groups.

Furthermore, this absence of difference between deprived and non-deprived groups has also been shown in a study by Hendricks, Ditre, Drobes, and Brandon (2006). They examined the time–course of abstinence and withdrawal effects on smoking behaviours. Hendricks and colleagues took a number of self-report measures of state traits as well as a smoking Stroop measure every 30 minutes for 4 hours after participants had smoked their last cigarette. Whilst they noted increases in anger, anxiety, concentration and difficulty in the deprived group compared with a non-deprived smoking group, they found that both groups exhibited similar levels of smoking attentional bias.

As described above the Stroop task has shown inconsistent findings regarding the relationship between deprivation and smoking attentional bias. However, emerging findings using the visual probe task may further clarify the role of deprivation on smoking attentional bias.

Mogg and Bradley (2002) measured attentional bias in a group of smokers who were tested twice; once immediately after smoking and once after abstaining for 12 hours. Using a stimulus duration of 500ms they found that both groups were faster to respond to probes replacing smoking images compared to probes replacing neutral images. However, these effects were unaffected by deprivation. Similar findings were observed in a study conducted by Field, Mogg, and Bradley (2004) who used the visual probe task with stimulus durations of 2,000ms in a group of smokers immediately after smoking and after abstaining for over 10 hours. Consistent with the findings of Mogg and Bradley (2004), Field et al. showed faster responses to probes replacing smoking images compared to probes replacing neutral images but these were unaffected by the level of deprivation. In the same study, these effects were somewhat corroborated by evidence from the simultaneous measurement of eye-movements. They found that both deprived and non-deprived smokers were more likely to shift their gaze towards smoking-related pictures compared to neutral images. However, deprived smokers maintained their gaze on smoking-related images for longer than non-deprived smokers.

The evidence for increased attentional bias for smoking cues during deprivation indicate that smoking attentional bias may be a result of withdrawal. Indeed, Gross et al. (1993) argue that the slower colour-naming shown across deprived groups may result from the preoccupation with smoking, their inability to suppress the meaning of the smoking words and intrusive thoughts in relation to smoking. They also suggest that a general decline in cognitive functioning due to deprivation cannot explain the slower colour-naming effects to smoking words, as slower colour-naming of neutral words was not present. Importantly, Waters and Feyerband (2000) argue that such increases in attentional bias during deprivation may hinder cessation attempts.

Based on these findings there is clear evidence that attentional bias is present in experimentally deprived smokers to a greater or similar extent as non-deprived smokers. Whether attentional bias occurs as a direct result of withdrawal as is suggested by Gross et al. (1993) is unclear. However, the findings from these studies indicate that under short-term abstinence, which is not part of a cessation attempt, attentional bias is present and may be an important factor in influencing the maintenance of smoking behaviour.

Abstinent quitting smokers

Whilst the majority of smoking attentional bias studies have examined the effects of abstinence using experimentally deprived smokers, studies have also examined differences in attentional bias among smokers who were actively attempting to quit or ex-smokers. Johnsen et al. (1997) suggests a change from smoker to non-smoker during a quit attempt may cause a change in attitude to smoking behaviour and this may result in differential priming of memories during an experiment involving smoking cues. For instance, smokers attempting to quit are more likely to remember negative aspects of smoking rather than remembering the positive aspects of smoking when faced with smoking stimuli. Furthermore, Cane et al. (2009) suggest that examining smoking attentional bias between smokers actively attempting to quit compared to smokers is clinically important and can help understand changes in attentional bias that occur in the transition from smoker to non-smoker during a cessation attempt.

In contrast to research examining attentional bias in deprived smokers, research examining attentional bias in quitting smokers has indicated that attentional bias is reduced during a quit attempt. For instance, one study conducted by Johnsen et al. (1997) using a blocked card format of the Stroop task examined the effects of attentional bias in current smokers, non-smokers and smokers who were attending a smoking cessation program and who had been abstinent for three days. In contrast to studies examining deprivation, Johnsen et al. found slower colour-naming of smoking words in recent smokers compared to abstaining smokers and non-smokers. They suggest that abstaining smokers undergoing active treatment through a cessation program may have more attentional control when faced with smoking-related cues compared to current smokers, thus making them able to deal with intrusive smoking-related thoughts to a greater extent than smokers. They also suggest that the slower colour-naming in smokers may result from smokers being more susceptible to the 'negative aspects of their role as a smoker' (Johnsen et al., 1997, p. 817) leading to negative moods and general cognitive slow-down.

In a similar experiment, Munafò et al. (2003) compared attentional bias effects among ex-smokers, deprived smokers (24 hour deprived), non-deprived smokers, and non-smokers. In line with previous studies they found attentional bias across the smoking groups (deprived and non-deprived) compared to non-smoking groups (never-smokers and ex-smokers). However, attentional bias was unaffected by deprivation in the smoking groups. Furthermore, there were no significant difference in attentional bias shown between ex-smokers and non-smokers. This indicates that ex-smokers responded to smoking stimuli in the same way as non-smokers. Based on these results Munafò et al. suggest that attentional bias is not a permanent feature of nicotine addiction and may be extinguished during cessation.

Effects of abstinence following a quit attempt have similarly been shown in the visual probe task. Ehrman et al. (2002) used the visual probe task to assess smoking attentional bias across groups of smokers, former smokers and non-smokers using images displayed for 500ms. Whilst smokers showed the greatest level of attentional bias for smoking-related cues, former smokers showed moderate levels of attentional bias which did not significantly differ from either smokers or non-smokers, and non-smokers showed no attentional bias for smoking-related cues. Similar effects were shown in a study by Waters, Shiffman, Bradley, and Mogg (2003) who used the visual probe task in a group of heavy smokers who were enrolled in a smoking cessation program prior to quitting. Waters et al. measured the length of smoking deprivation using a self-reported time of deprivation. They found that attentional bias to smoking-related cues was evident in non-deprived and minimally deprived participants compared to deprived participants.

In contrast to Johnsen et al. (1997), Munafò et al (2003), and Ehrman et al (2002) other studies have identified effects indicative of attentional bias in abstinent ex-smoker groups. One such study was conducted by Cane, Sharma, and Albery (2009) who measured the slow and fast effects of attention in the Stroop task in direct relation to abstinence. Adopting a Stroop design which measures the fast and slow effects of attention (see Chapter 2, section 2.1.1: *The addiction Stroop task*) they measured the presence of fast and slow effects in a group of smokers, smokers attempting to quit, and non-smokers. Smokers attempting to quit were smokers actively undergoing a quit attempt who had been abstinent for anywhere between 24 hours to 2 years. They found that both smokers and smokers attempting to quit showed fast effects of attention toward smoking-related stimuli which were indicative of the 'attention grabbing' effects of smoking stimuli. However, only smokers attempting to quit showed slow effects of attention to smoking-related cues, which are indicative of maintenance of attention or rumination. Non-smokers showed no attentional bias to smoking-related cues. Thus, Cane et al.'s results indicated that smokers show relatively short-lived effects of attentional bias whereas smokers attempting to quit show lingering effects of attention to smoking-related cues and that these were specifically related to abstinence.

In line with these results, an earlier experiment conducted by Waters, Shiffman, Sayette et al. (2003) examined attentional bias in a group of smokers attempting to quit on the first day of their cessation attempt. As with Rzetelny et al. (2008) they randomly gave participants a nicotine patch (35mg) or a placebo patch. They found that both groups showed an attentional bias for smoking-related stimuli but, in line with the studies of deprived smokers (e.g. Gross et al., 1993; Waters & Feyerabend, 2000; Zack et al., 2001), they found that smokers with the active nicotine patch showed decreased attentional bias for smoking stimuli and made fewer errors on smoking-related trials. They also found that increased attentional bias on the Stroop task across both patch conditions led to increased chance of a lapse episode in the short-term during their quit attempt again indicating the possible clinical importance of smoking attentional bias.

In addition to these findings, Munafò, Johnstone and Mackintosh (2005) attempted to understand the mechanisms underlying the relationship between abstinence and the presence of attentional bias by examining the possible genetic correlates of smoking attentional bias. They found that attentional bias shown in the Stroop task in ex-smokers may be moderated by a serotonin transporter gene, 5HTT-LPR. The 5HTT-LPR genotype has been associated with reduced serotonin activity, depression and even suicide (Young, Bonkale, HolComb, Hicks, & German, 2008).

Moreover, a review of the relationship between smoking behaviour and the 5HTT-LPR genotype showed that it was associated with reduced likelihood of smoking cessation (Munafò, Clark, Johnstone, Murphy, & Walton, 2004). Munafò et al. (2005) examined the expression of 5HTT-LPR genotype in relation to the presence of attentional bias to smoking-related stimuli in the masked and unmasked Stroop tasks and an attentional blink task. Although they found no overall attentional bias in the Stroop and attentional blink tasks they did find that the presence of the genotype was related to greater attentional bias across both the unmasked Stroop task and the attentional blink task. Munafò et al. suggest a number of speculative reasons for the moderating effects of this genotype on smoking behaviour. One suggestion is that smokers with this genotype might be more susceptible to the negative affective consequences of smoking cessation. Another suggestion is that the gene might interfere with stimulus-reward associations, making it difficult for ex-smokers to switch from the association of smoking with a reward to associating smoking with no reward. Munafò et al. further point out that these findings are tentative and until further research is carried out on the presence of the 5HTT-LPR genotype in relation to attentional bias the role it plays in smoking attentional bias is unclear.

Interestingly, studies have also shown differences in responses to smoking-related stimuli during cessation using Event Related Potential (ERP) measures. Littel and Franken (2007) examined the differences in P300 and Slow Positive Wave (SPW) responses to smoking-related images in smokers, ex-smokers and non-smokers. They found that smokers showed enhanced P300 and SPW responses to smoking-related stimuli compared to ex-smokers and never-smokers. They further noted that P300 and SPW responses to neutral stimuli did not differ between the three groups and that responses to smoking-related stimuli did not differ between ex-smokers and non-smokers. Littel and Franken suggest that these results indicate that ex-smokers and non-smokers display the same low-level processing of stimuli and that processing bias decreases after periods of prolonged abstinence.

In summary, these findings provide somewhat inconsistent evidence as to the presence of attentional bias in abstinence during a quit attempt compared to during normal smoking. This may be due in part to the inconsistency of the periods of abstinence of the groups used, as large differences in the cessation periods are shown across these studies. However, the majority of studies indicate that attentional bias is reduced during a quit attempt. These findings provide an interesting contrast to studies examining deprived smokers as they suggest that it is an active quit attempt or long-term cessation that reduces attentional bias rather than the simple effect of deprivation. However, evidence from Cane et al. (2009) highlight the potential role of slow effect during a quit attempt and Munafò et al. (2004) suggest that genetic correlates of attentional bias exist in ex-smokers. These previously unmeasured components of smoking attentional bias may play an important role in relapse during a cessation attempt.

Given the possible clinical importance of examining attentional bias in relation to a quit attempt and the inconsistent findings shown across studies, the present research will extend these findings by further examining attentional bias in smokers who are attempting to quit in comparison to current smokers.

2.3 Underlying processes of attentional bias

2.3.1 Affect and smoking attentional bias

As mentioned in Chapter 1, it has been suggested that smoking has a close relationship with emotion particularly during periods of abstinence (see Chapter 1, section 1.1), with some theorists suggesting that smoking attentional bias may be a product of the affective associations of smoking stimuli (e.g. Baker et al., 1987). Attentional bias to emotional stimuli, particularly aversive stimuli, has been shown across a number of emotional attentional bias studies particularly in participants with anxiety disorders (Leppänen, 2006; MacLeod et al., 1986; Mineka & Sutton, 1992). However, until recently little research had been conducted on the relationship between smoking attentional bias and the affective properties of smoking stimuli. Researchers examining the relationship between smoking attentional bias and emotion have adopted a number of different approaches. These are: i) examining the relationship between valence ratings of smoking stimuli and the presence of smoking attentional bias, ii) examining the relationship between attentional bias to emotion stimuli compared to attentional bias to smoking stimuli, or iii) manipulating mood or emotion and examining the effects these manipulations have on attentional bias to smoking stimuli. Findings related to each of these approaches will be outlined below.

i) The relationship between valence ratings of smoking stimuli and the presence of smoking attentional bias

Research examining the affective properties of smoking stimuli (unrelated to attentional bias) has indicated that smoking stimuli are pleasurable for smoking groups (see Cane et al., 2009; Geier, Mucha, & Pauli, 2000; Payne, McClernon, & Dobbins, 2007). For instance, a study by Geier, Mucha, and Pauli (2000) used a non-subjective measure, the acoustic startle reflex (ASR), to assess the affective components of smoking stimuli. Previous research has shown the ASR to be effective in determining the non-subjective pleasantness of stimuli (Hamm, Cuthbert, & Vaitl, 1997; Lang, Bradley, & Cuthbert, 1990) with ASR decreasing linearly as stimuli go from unpleasant to pleasant. Using the ASR measurement technique Geier et al. found that in dependant smokers, smoking stimuli appeared positive and were not aversive. Furthermore, they showed that these effects were unaffected by abstinence and withdrawal. Conversely, non-smokers appeared to find the smoking stimuli aversive. Similarly, Payne, McClernon and Dobbins (2007) examined automatic affective associations of smoking stimuli across smokers at different stages of withdrawal. They found that smokers under withdrawal when there was a motivation to smoke responded to smoking stimuli as positive. However, under withdrawal with *no* motivation to smoke, as would be the case during a quit attempt, smoking stimuli were responded to negatively.

These affective relationships of smoking stimuli have similarly been shown across attentional bias studies (e.g. Bradley et al., 2008; Cane et al., 2009). However, there has been little evidence of a relationship between emotional ratings of smoking stimuli and the presence of attentional bias. Indeed, Cane et al. (2009) showed that even though smokers rated smoking stimuli as positive, and smokers attempting to quit rated stimuli as negative these ratings did not correlate with smoking attentional bias. Similarly, Bradley et al. (2008) specifically measured whether attentional bias was related to motivational salience or the affective properties of a drug by examining reactions to positive and negative smoking-related cues. They found that smokers showed increased attentional bias for both pleasant and negative smoking-related cues similarly compared to non-smokers when images were presented for 2,000ms. This, they suggest, indicates that the maintenance of attention on smoking-related cues in smokers is related to the drug relevance rather than the relationship the drug stimuli have with affect.

Therefore, whilst research has shown consistent evidence that emotional ratings of stimuli are related to smoking status, it also suggest that explicit ratings of stimuli are not associated with smoking attentional bias. These studies provide limited evidence for suggestions of positive and negative reinforcement models (e.g. Baker et al., 1986; Stewart et al., 1984) that drug related cues capture attention and reinforce drug-use behaviour as a result of their relationship with affect (see Chapter 1, section 1.1).

ii) The relationship between attentional bias to emotion stimuli compared to attentional bias to smoking stimuli

In contrast to studies examining the subjective rating of smoking stimuli, studies examining the direct relationship between smoking attentional bias and attentional bias to emotional stimuli using the Stroop task have shown evidence of significant relationships between smoking attentional bias and attentional bias to aversive stimuli. For example, Drobes, Elibero, & Evans (2006) examined attentional biases to smoking-related stimuli and emotional stimuli using the Stroop task in a group of smokers. They showed evidence of attentional biases for both smoking and negative-affect words, but not positive-affect words. They also found a significant positive correlation between attentional bias to smoking-related stimuli and attentional bias to negative-affect stimuli.

Similarly, Cane et al. (2009) examined the subjective valence ratings of smoking and negative-related stimuli as well as examining the fast and slow effects of attentional bias to smoking and negative-emotion stimuli. This research was conducted across three groups: smokers, smokers attempting to quit and never-smokers to identify whether attentional bias and the affective ratings of stimuli changed during a quit attempt. In line with Drobes et al. (2006), they found that smokers and smokers attempting to quit showed significant fast and slow effects of attentional bias to negative stimuli (see Figure 2.1). Such effects were not shown in non-smokers indicating that smokers and smokers attempting to quit are comparably more sensitive to negative-emotion stimuli compared to non-smokers. Cane et al. suggest that this may be because smokers and smokers attempting to quit are more susceptible to negative mood and higher levels of anxiety. In line with the findings of Drobes et al. (2006) they also found correlations between the slow effects of smoking attentional bias and the slow effects of negative emotion attentional bias in smokers attempting to quit. This relationship was further corroborated by the findings that attentional bias to smoking-related stimuli reflected patterns of attentional bias shown to negative emotion stimuli in the smokers attempting to quit group. Cane et al. suggest that the similarity between patterns could indicate a common cause: the emotionality of the stimuli.

Kwak, Na, Kim, Kim and Lee (2007) also found evidence for attentional bias to aversive stimuli in smoking groups. They measured eye-movement reactions to both smoking and aversive stimuli in a group of smokers and non-smokers. They presented aversive and neutral cues simultaneously for 2,000ms. They found that smokers initially fixated on the aversive images over control pictures and smoking pictures and were more likely to maintain their gaze on smoking images. However, in contrast to Cane et al. (2009) they found that initial orientation to aversive images was also evident in non-smokers. This apparent contradiction between Cane et al. and Kwak et al. may be due to the anxiety exhibited in the groups. Cane and colleagues showed evidence that smokers and smokers attempting to quit exhibited greater levels of anxiety during experimental procedures, whereas Kwak et al. showed no evidence of differences in anxiety between their smoking and non-smoking groups. This indicates, in line with previous emotion-related research that anxiety increases the propensity to attend to aversive stimuli (see MacLeod et al., 1986).

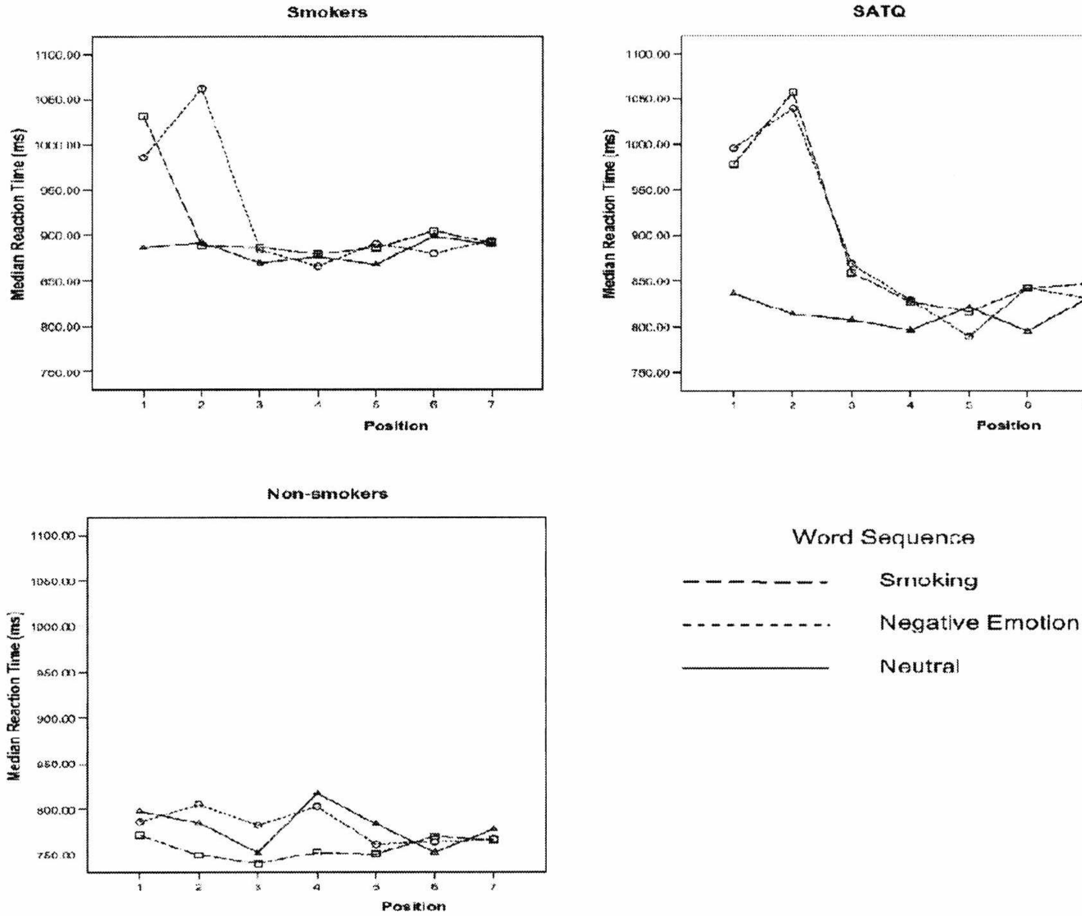


Figure 2-1 **- Fast and slow effects to smoking, negative and neutral cues for smokers, smokers attempting to quit and never-smokers (Taken from Cane et al., 2009)**

The findings of Drobes et al. (2006), Kwak et al. (2007) and Cane et al. (2009) suggest that smoking groups are particularly responsive to aversive stimuli and that smoking attentional bias may reflect a bias to the emotional component of smoking stimuli. Powell, Tait, and Lessiter (2002) shed further light on this issue. They found evidence which partially replicates the findings of both Cane et al. (2009), Kwak et al. (2007) and Drobes et al. (2006). Powell and colleagues adopted a card version of the Stroop task using threat-related, pleasure-related and neutral words across a group of smokers who were tested twice, once after smoking as they would normally and once after overnight abstinence. Their results revealed greater attentional bias to both positive and negative stimuli after smoking normally compared to when participants had been abstinent overnight. Furthermore, in line with Kwak et al. (2007), they found that the effects shown in the recent smokers were similar to effects shown in a group of non-smokers, and that this was not the case for abstinent smokers. As Powell et al. did not measure anxiety in there groups it is unclear whether anxiety may have influenced the propensity of smokers and non-smokers to attend to negative stimuli as has been previously suggested (see Cane et al., 2009). However, they do make the argument that abstinence is associated with abnormal functioning, and that responses to emotion-related stimuli in smokers and non-smokers is relatively normal. Thus, they suggest that smoking corrects the abnormal responses to emotion stimuli shown in abstaining smokers.

These findings are further corroborated by a study conducted by Rzetelny et al. (2008), who found that direct administration of nicotine through a nicotine patch during experimental procedures led to reduced attentional bias to negative stimuli, but that nicotine did not attenuate smoking attentional bias. According to Rzetelny and colleagues, this finding indicates that the administration of nicotine improves attentional control in the presence of stimuli unrelated to smoking and so this leads to a decrease in attentional bias to negative stimuli. However, Rzetelny et al. also showed evidence of a positive correlation between smoking attentional bias and attentional bias to negative emotion stimuli, in line with the findings of Drobes et al. (2006) and Cane et al (2008).

Interestingly, other researchers have found an association between smoking attentional bias and *positive* emotion ratings. Dawkins, Powell, West, Powell, and Pickering (2006) found evidence that nicotine administration is associated with higher self-reported pleasure expectancies and increased number of errors to pleasure-related stimuli in the Stroop task. Thus, during nicotine consumption, reactions to pleasurable stimuli are greater. Both Powell et al. (2002) and Dawkins et al.'s (2006) findings fit with the suggestions of Robinson and Berridge (1993) that drugs are able to prime reward pathways leading to increased reactivity to positive stimuli.

Similarly, Mogg, Bradley, Field, and De Houwer (2003) measured eye movements whilst participants completed a visual-probe task using smoking-related and control pictures. They also measured the valence of images. Results indicated that smokers spent significantly longer looking at smoking images than non-smokers and that smokers were more likely to initially attend to smoking-related pictures compared to neutral pictures. Furthermore, they showed that duration of gaze on smoking pictures was associated with smokers rating smoking stimuli more positively.

In addition to the visual probe and Stroop task, the role of emotion in smoking attentional bias has also been examined using Electro-Encephalograph (EEG) measures. Gilbert et al. (2007) examined whether nicotine reduced the distraction normally seen to smoking-related stimuli and aversive stimuli by examining P3b brain responses to a task-relevant target digit. They used negative-, positive-, neutral- and smoking-related pictures preceding target-digits in a rapid visual information processing task, where participants had to decide whether they had seen three even digits or three odd digits in a row. Participants were smokers who were tested on two occasions: in one session nicotine patches were applied, and in the other session a placebo patch was applied (all participants were abstinent for more than 12 hours). Results showed that nicotine enhanced responses to negative pictures bilaterally and to smoking-related pictures in the right hemisphere. There were no effects shown in the P3b to positive and neutral stimuli. This indicates that nicotine reduces distraction to smoking and aversive stimuli and promotes attention to task related stimuli, thus providing further evidence for the link between smoking attentional bias and emotion.

iii) Manipulating mood or emotion and examining the effects these manipulations have on attentional bias to smoking stimuli

Bradley et al. (2007) examined the theoretical proposition that negative affective states increase the incentive value of drug-stimuli (Baker et al., 2004). They did this by manipulating negative affect using negative and neutral mood induction procedures and then measuring attentional bias to smoking stimuli using a visual probe task and eye-movement measures. They found that smokers, after the negative mood induction, were significantly more likely to initially fixate on smoking-related images compared to neutral images. Bradley et al. do, however, suggest caution in interpreting these results as non-smokers also showed a greater tendency to initially fixate on smoking-related cues irrespective of the mood manipulation. Also, the mood manipulation did not affect the maintenance of attention on smoking pictures or reaction times to probes following smoking pictures in smokers. However, it did affect maintenance of attention on smoking pictures in non-smokers, with non-smokers looking at smoking pictures for longer following the negative mood induction compared to the neutral mood induction. This suggests that mood manipulation can increase smoking attentional bias among both smokers and non-smokers and implies that if negative mood is decreased then this should lead to reduced smoking attentional bias.

In summary, there is clear evidence that attentional bias to negative emotion stimuli exists in smoking groups. This may be a result of smokers' inability to deal effectively with negative emotion stimuli as a result of increased anxiety levels which are commonly shown across smokers (see Parrott, 1994; 1998). However, there is contrasting evidence of the presence of this attentional bias across abstinent groups, with findings indicating that attentional bias to negative stimuli is absent in deprived smokers but is present in smokers who are actively attempting to quit. These findings suggest that a quit attempt compared to deprivation may make smokers more responsive to negative emotion stimuli. Interestingly, the relationships between attentional bias to negative emotion stimuli and smoking-related stimuli indicate a possible common cause and suggest that smoking attentional bias may be a product of the negative associations of smoking. Furthermore, the finding by Cane et al. (2009) that the associations only exist in the slow components of attentional bias indicate that the slow effect may be particularly sensitive to the stimuli's relationship with negative affect. Evidence for such a suggestion comes from studies which have shown that the slow component is present when there are negative affect associations with stimuli used (McKenna & Sharma, 2004; Sharma et al., 2001). There is also evidence from these studies that during smoking and nicotine administration attentional bias for positive stimuli is present. This possibly stems from the activation of dopamine reward systems leading to sensitivity to pleasurable stimuli. The fact that these effects have not been shown in relation to deprived or abstinent smokers indicate that an attentional bias to positive stimuli in smokers is specific during nicotine administration.

2.3.2 Manipulating attentional bias

As well as examining the role that emotions play in smoking attentional bias researchers have also begun to examine whether attentional bias can be manipulated. Research related to manipulating attentional biases is still in its infancy. However, one particular method, commonly termed attentional retraining (AR), has been shown to be effective in changing attentional biases to emotional stimuli (MacLeod, Rutherford, & Campbell, et al., 2002), alcohol-related stimuli (Field, Duka, & Eastwood, et al. 2007; Field & Eastwood, 2005; Schoenmakers, Wiers, & Jones, et al., 2007) and more recently smoking-related stimuli (Attwood, O'Sullivan, Leonards, Mackintosh, & Munafò, 2008; Field, Duka, Tyler, & Schoenmakers, 2009). AR is based on the classic visual probe task and was first developed by MacLeod, et al. (2002) in an attempt to manipulate emotional vulnerability and the attention given to emotional stimuli in students with normal levels of anxiety. MacLeod et al. manipulated the classic visual Probe design, where probes replace emotion-related stimuli and neutral stimuli equally, so that attention could be directed towards emotional stimuli or towards neutral stimuli. In their experiment participants were divided into 'attend negative' and 'attend neutral' training conditions. In the 'attend negative' condition the majority of probes replaced the position of the negative stimuli, therefore training attention towards negative stimuli. In the 'attend neutral' condition the majority of probes replaced the position of the neutral stimuli, training attention away from negative stimuli and towards neutral stimuli. A number of test trials were placed randomly throughout the training trials to measure the change in attentional biases to negative and neutral stimuli. Using this technique MacLeod et al. (2002) found that participants who were trained towards the neutral stimuli showed a reduced attentional bias for negative stimuli whereas participants in the 'attend negative' condition showed a greater attentional bias for negative stimuli. In addition, they found that those in the 'attend neutral' condition showed an attenuation of negative mood state following a post training stress task. Thereby, MacLeod et al. not only showed that AR could be effective in reducing attentional bias to negative stimuli but also that this manipulation resulted in changes of subsequent mood levels.

AR has since been developed to examine its effectiveness in manipulating attentional biases to smoking-related and alcohol-related stimuli. Adopting a similar design to that utilised by MacLeod et al. (2002), but replacing negative stimuli with smoking stimuli, Attwood, et al. (2008) assessed the effectiveness of AR in changing attentional bias to smoking-related cues in a group of smokers who had been abstinent from smoking for 12 hours. They found that attentional bias for smoking–related stimuli increased in the 'attend smoking' condition and decreased in the 'avoid smoking' condition. They also observed greater increases in smoking craving in male participants in the 'attend smoking' condition. Attwood and colleagues suggest this indicates that attentional retraining may have some clinical utility in males but not females, but also report that the reason for these sex differences remains unclear. Thus, it appears that attentional bias to smoking-related stimuli can be manipulated and that these manipulations may be important in affecting subjective smoking cravings in males.

Similar findings were shown in a recent study by Field et al. (2009) who also showed that attentional bias for smoking stimuli increased in comparison to a baseline measurement in the 'attend smoking' condition and decreased in the 'avoid smoking' condition (they do assert, however, that the latter effect only approached significance). However, in contrast to Attwood et al. (2008), Field et al. (2009) also showed that the modification of attentional bias had no associative changes in craving.

Whilst the effects shown by Attwood et al. (2008) and Field et al. (2009) seem somewhat promising, Field et al. (2009) also showed that these effects do not generalise to novel stimuli (i.e. stimuli that were not used during training sessions), to a different attentional bias measure (the pictorial Stroop task), and did not persist when attentional bias measures were completed on the following day. This suggests that the effects of AR as implemented by Attwood et al. and Field et al. may be task specific. That is, they may be specific to stimuli used and that the effects may only occur during the training procedure.

These findings are corroborated by two studies examining AR in relation to alcohol. Schoenmakers, et al. (2007) administered the flicker task in conjunction with the AR technique and Field, et al. (2007) used a modified Stroop task, a flicker induced change paradigm and a stimulus-response compatibility test in conjunction with AR training. Both studies showed decreases in attentional bias to alcohol stimuli in 'avoid alcohol' conditions during the AR task and Field et al. (2007) showed an increase in attentional bias in the 'attend alcohol' condition in the AR task. However, as in the previous smoking studies, these effects did not generalise to the other measures of attentional bias used. In addition, Field et al. (2007) showed limited generalisation to novel alcohol stimuli, with effects only generalising to novel stimuli in the 'attend alcohol' condition of the visual probe task. These findings indicate that although the AR manipulations can be effective they may also be limited in the effects they have on subsequent cognitive processing of addiction-related stimuli.

In summary, previous research has shown that smoking attentional bias can be manipulated though AR, suggesting that such a technique could be an effective means of reducing smoking attentional bias during a cessation attempt. These findings therefore are of great clinical importance. However, research suggests that the effects of attentional bias manipulation may not generalise to novel stimuli or to different measures of attentional bias. Furthermore, AR in its current form appears to have inconsistent effects on subsequent smoking craving and therefore may be limited in its effectiveness in a clinical setting. Therefore, further research is required in order to clarify whether such a technique could be used effectively as part of a smoking cessation programme.

2.3.3 Automaticity and conscious control – evidence of bottom-up and top-down effects

Automaticity here refers to the automatic, unconscious nature of attention, whereas conscious control refers to the slower conscious shifts in attention or control over automatic attentional processes. Two commonly used indicators of automaticity and conscious control in relation to attentional bias in the Stroop task are the fast and slow effects respectively (see section 2.1.1). This is particularly the case in addiction research with fast and slow effects being examined in relation to alcohol use (Sharma et al., 2001), heroin use (Waters et al., 2005), and tobacco smoking (Cane et al., 2009; Waters, Sayette et al., 2003). As mentioned previously, fast and slow effects may relate to different underlying mechanisms of attention. Fast effects are thought to be related to the automatic 'attention grabbing' effects of stimuli, or the bottom-up stimulus salience, and slow effects are thought to be related to the more controlled maintenance of attention or the top-down stimulus response regulation. Previous research suggests that there is a strong relationship between the slow effect and negative affect, in that negative affect is thought to interfere with top-down regulation leading to the increases in bottom-up influences (Eysenck, Derakshan, Santos, & Calvo, 2007; Wyble et al., 2008). Therefore, these slow effects may be indicative of implicit emotional reactions to stimuli or underlying negative affective states. Given the relationship between smoking and negative affective states mentioned previously, identifying the presence of the slow effects in relation to smoking may be particularly important.

Research into the presence of fast and slow effects in relation to smoking is in its infancy, and to date there has been little research conducted directly examining the presence of slow effects in relation to smoking. However, three studies have shown evidence of fast and slow effects of attentional bias to smoking stimuli.

Waters et al.(2003) found evidence of slow effects among smokers across two studies. Similarly, Cane et al. (2009) examined the presence of fast and slow effects across smokers, smokers attempting to quit, and non-smokers to both smoking, negative-emotion, and neutral stimuli. They found that in relation to negative-emotion stimuli, both fast effects and slow effects were shown in smokers and smokers attempting to quit. However, neither fast or slow effects to negative emotion stimuli were shown in non-smokers, indicating that the smoking groups were more reactive to negative emotion stimuli. In contrast, both smokers and smokers attempting to quit showed fast effects to smoking stimuli but only smokers attempting to quit showed slow effects to smoking-related stimuli. Furthermore, Cane et al. (2009) showed that the slow effect in relation to smoking-stimuli was correlated with the slow-effect in relation to negative stimuli. Thus, these findings indicate that the slow effect shown by Cane et al. may be a product of negative affective states that occur during a cessation attempt.

Whilst fast and slow effects have not been explicitly studied in direct relation to the visual probe task and eye-movement studies, a number of studies have examined effects of initial orientation to stimuli and the maintenance of attention on stimuli. Such effects may directly correspond with the fast and slow effect respectively. For instance, Bradley et al. (2008) used changes in stimulus duration to examine the presence of attentional bias in a group of smokers. Adopting stimulus durations of 200ms and 2,000ms, they found that in trials where probes replaced images after 200ms there was no evidence of attentional bias for smoking-related stimuli, whereas in trials where stimuli were presented for 2,000ms attentional bias for smoking stimuli was present. Bradley et al. suggest that these findings indicate a bias for maintaining gaze on smoking pictures rather than a bias for initially orienting to smoking images in smokers.

In contrast to Bradley et al. (2008), studies which have included slightly longer stimulus presentations of 500ms, rather than 200ms, have shown evidence for smoking attentional bias. For instance a study by Ehrman et al. (2002) which used a stimulus duration of 500ms found smoking attentional bias to be present in smokers. Similarly, smoking attentional bias was also evident in an experiment conducted by Bradley, Mogg, Wright, and Field (2003a), in which images were presented for 500ms before being replaced by a probe. However, in contrast to Ehrman et al. (2002), Bradley et al. (2003b) found that smoking attentional bias was only present at 500ms in smokers who had more than two previous quit attempts. In a second experiment, Bradley et al. replicated these results but also showed that the number of quit attempts did not affect smoking attentional bias to stimuli presented at 2,000ms. Their findings thus indicate that initial orientation may be affected by the number of previous quit attempts, whereas maintenance of attention seemed to be primarily associated with smoking status.

Bradley et al. (2003b) suggest two possible reasons for the relationship between increases in initial orientation to smoking cues and an increase in the number of previous quit attempts. Firstly, they suggest that the susceptibility of smokers to initially orient their attention to smoking stimuli indicates their inability to ignore smoking-related stimuli and this may be driving their susceptibility to relapse. Secondly, they suggest that repeated attempts to quit smoking may increase the 'incentive salience' of smoking-related stimuli increasing their attention grabbing effects on smokers.

Studies using eye-movement measures have also provided evidence of differences in the initial orientation to smoking-related cues and the maintenance of attention on smoking-related stimuli. Mogg et al. (2003) found that smokers spent significantly longer time looking at smoking pictures than non-smokers and that smokers were more likely to initially attend to smoking-related pictures compared to neutral pictures. However, they also point out that the difference shown in the initial orientation in smokers did not significantly differ to that shown in non-smokers, indicating that while there is a difference between the maintenance of attention between smoking groups and non-smoking groups the initial orientation of attention may not be related to smoking status.

Increased maintenance of gaze on smoking pictures in smoking groups was also evident in a study by Mogg, Field, and Bradley (2005). In their study Mogg et al. compared a group of smokers who were low-nicotine dependant with a group of smokers who were moderately nicotine dependent. Their results showed that the low nicotine dependant group exhibited greater maintenance of attention to smoking-related cues. In addition, longer gaze times were associated with both lower levels of nicotine dependence and higher levels of craving.

In another eye-tracking study in which the visual probe task was not used Kwak, Na, Kim, Kim, and Lee (2007) examined the presence of initial orientation and maintenance of attention. Kwak et al.'s study involved the simple presentation of smoking-related, negative and neutral pictures whilst recording eye-movements. In line with the findings of Mogg et al. (2005) and Mogg et al. (2003) they found that both smokers and non-smokers initially shifted their gaze towards smoking cues. However, smokers maintained their gaze on smoking-related stimuli to a greater extent than neutral stimuli. Recent research has indicated that smoking related stimuli can be detected even when presented subliminally. Leventhal, Waters, Breitmeyer, Miller and colleagues (2008) found that deprived smokers exhibited a processing bias for smoking related stimuli in comparison to neutral stimuli when stimuli were presented for 17ms and were followed by a mask. This suggests that abstinence appears to increase smokers' pre-attentive processing of smoking-related (vs. neutral) stimuli. Leventhal et al. (2008) recommend that future research should investigate whether pre-attentive biases toward smoking-related stimuli influence relapse.

In summary, the Stroop task has yielded effects which are specific to the fast and slow effects of attention. In particular they have shown that slow effects are present in smoking groups and smokers attempting to quit. Also, the presence of a relationship between the slow effects of smoking attentional bias and the slow effects of negative – attentional bias indicate they may stem from a common source. Whilst studies adopting the visual probe task and eye-tracking methods have not been used to directly examine fast and slow effects, it is possible that effects shown in the initial orientation and maintenance of attention on smoking cues may be representative of these effects. Throughout the majority of these studies, there is inconsistent evidence concerning initial orientation to smoking cues in smokers but clear evidence of increased maintenance of attention towards smoking-related cues which is not present in non-smoking groups. However, recent research (e.g. Leventhal et al., 2008) suggests that smoking stimuli can be attended to pre-attentively.

2.3.4 - Attentional Control

It has been argued that the effects of attentional bias, particularly in the Stroop task, may stem from the users' limited cognitive functioning as a result of craving and/or substance related thoughts which monopolize cognitive resources. Similarly, it has been suggested that emotions may interfere with cognitive control on tasks (see Chapter 1, section 1.2). In light of these suggestions a limited number of studies have examined reactions on a colour Stroop task in relation to measures of smoking attentional bias, to identify whether cognitive control and attentional function is generally affected by smoking.

Early studies examining the effects of nicotine on cognitive performance showed that nicotine led to increased speed and accuracy on cognitive tasks which involved vigilance (Provost & Woodward, 1991; Warburton, 1992; Wesnes & Warburton, 1978). This suggested that the consumption of nicotine improved cognitive performance. For instance, with specific regard to the Stroop task Wesnes and Warburton (1978) suggested that nicotine had beneficial effects on selective attention in such a way that it improves focus on the colour-naming task and decreases the propensity to read the colour words. In contrast, Provost and Woodward (1991) suggest that nicotine acts as an incentive to improve colour-naming responses, thus leading colour-naming to be more automatic over periods when nicotine is consumed. This suggests that smoking attentional bias will be more prevalent among smokers when nicotine has not been consumed (e.g. when under abstinence).

Studies which have directly compared smoking attentional bias with performance on a colour Stroop task have showed no relationship between the two measures (Johnsen et al., 1997). However, there is evidence that smoking status may affect performance on the colour-Stroop task. A study by Johnsen et al. (1997) has provided evidence that, compared to non-smokers and abstinent smokers, smokers are quicker to colour name incongruent colour words, but, smokers also show slower colour-naming to smoking-related cues. These findings have since been replicated by Rzetelny et al. (2008) who showed faster colour-naming of colour-word stimuli when nicotine was administered through a nicotine patch but that the administration of nicotine did not affect smoking attentional bias. These findings indicate that whilst recent administration of nicotine may make smokers more distracted by smoking stimuli it may make them less distracted by stimuli unrelated to smoking through increasing attentional focus. Indeed, Rzetelny (2008) suggests that nicotine has the ability to reduce task-irrelevant distraction (e.g. attention grabbing effects of incongruent or negative stimuli) and improve task-relevant performance (e.g. colour-naming). They further suggest that these effects are possibly indicative of the anxiolytic effects of nicotine.

Therefore, these studies provide evidence that the consumption of nicotine improves cognitive performance when the task is unrelated to smoking (e.g. during a classic Stroop task). However, when the task involves smoking stimuli cognitive performance on a task is interrupted even during the direct consumption of nicotine.

Furthermore, they suggest that cognitive performance and cognitive control may deteriorate during periods of abstinence. This deterioration of cognitive control during abstinence may lead to individuals being unable to deal effectively with factors that may influence a lapse episode. This therefore may explain the influence of smoking attentional bias on the maintenance of smoking. To date, there are limited studies examining such a suggestion and as such this theme will be examined further in this thesis.

2.4 - Conclusion

Overall, this chapter has shown that there are a number of methods used for measuring attentional bias each with their own advantages and disadvantages. The Stroop task has yielded fairly robust results and has the ability of measuring fast and slow effects of attention. However, the mechanisms underlying Stroop effects are still relatively unclear. Other methods such as the visual probe task and eye-tracking methods have provided less robust results but have still shown some interesting findings in relation to smoking attentional bias. To overcome this limitation, the current research will examine smoking attentional bias using three methods: visual probe, Stroop and eye-tracking methods.

Empirical evidence using these methods from studies thus far has shown that smoking attentional bias is present in smoking groups but not in non-smoking groups and that these smoking attentional bias effects persist under deprivation. However, studies have shown inconsistent results with regards to the presence of attentional bias during a quit attempt and the relationship between smoking behaviours and smoking attentional bias. There does however, appear to be emerging evidence of a relationship between smoking urges or craving and smoking attentional bias as predicted by the integrated model proposed by Field and Cox (2008). Furthermore, whilst there is inconsistent evidence concerning initial orientation to smoking cues, recent research (e.g. Leventhal et al., 2008) suggests that smoking stimuli can be attended to pre-attentively.

With regards to emotion there is good evidence for the relationship between smoking attentional bias and attentional bias to negative stimuli particularly in abstinent smokers, and that attentional bias for positive stimuli may emerge during the consumption of nicotine. Furthermore, attentional control is affected by nicotine but the direct effects of smoking attentional bias on other aspects of attentional control are less clear. The thesis will build on past research and conflicting findings by testing the relationship between smoking stimuli and negative emotion across different stages of smoking (i.e. smokers, smokers attempting to quit and non-smokers). The thesis will also examine how these affective associations will affect cognitive control and will assess automatic responses to smoking stimuli, in light of the recent findings of Leventhal et al., (2008). The following chapters will present evidence from a series of studies which have be undertaken to build on previous research and provide further evidence for the role that smoking attentional bias plays in the maintenance of smoking behaviour.

Chapter 3. Comparison of eye-movements to smoking and negative valence pictures across smokers, smokers attempting to quit and never-smokers

Chapter 3 presents the findings from Studies 1 & 2. These studies examined shifts in visual attention to smoking, negative, and neutral images across smokers, smokers attempting to quit and never-smokers using eye-tracking techniques. In Study 1, shifts in visual attention were examined when participants were free to examine image pairs (smoking-neutral, negative-neutral, and control-neutral) in any order. Under these conditions initial shifts in visual attention were quicker to negative stimuli, compared to smoking and neutral stimuli and gaze was maintained for longer on both smoking and negative stimuli. However, these shifts in visual attention were unrelated to emotion ratings of stimuli, smoking status, smoking behaviour, and craving. Study 2 extends on the findings of Study 1 by examining whether shifts in attention to smoking and negative stimuli are automatic, occurring when explicit instructions to keep gaze on a simultaneously presented neutral stimulus are included. Findings showed exogenous shifts in attention to smoking and negative stimuli in the early stages of attentional processing but not in later stages of attentional processing. Again, these shifts were unrelated to smoking status, smoking behaviour, craving and emotion ratings of stimuli.

As discussed in the previous chapter, the use of the Stroop task, visual probe task, and dual-task paradigms have proven effective in identifying both the presence of and specific aspects of smoking attentional bias (see Chapter 3). However, the relationship between emotion, abstinence and smoking attentional bias still remains relatively unclear (see Chapter 2, section 2.3.1). Furthermore, criticisms of some of the methods adopted in attentional bias studies (see Chapter 2, section 2.1.1) means that interpretation of results is open to question. Therefore, in line with the primary aims of this thesis, this chapter examines the presence of attentional bias across smokers, smokers attempting to quit and never-smokers and the role that emotion plays in smoking attentional bias. Furthermore, it aims to overcome some of the methodological problems that have been identified in previous attentional bias studies by making use of eye-tracking methods recently applied in attentional bias studies in relation to emotion.

The study of emotion in relation to smoking attentional bias is both practically and theoretically important. Practically, identifying the emotional components of smoking attentional bias may help in identifying effective ways of manipulating and reducing attentional bias through emotional manipulation. Theoretically, examining the relationship between emotion and smoking attentional bias will help to test a number of theoretical propositions that have been proposed in relation to the role of emotion in attentional bias in addiction (e.g. Baker et al., 2004; Stewart et al., 1984 see chapter 1, section 1.1). Furthermore, it will help identify the role of emotion with regards to the underlying mechanisms of smoking attentional bias.

To date there is contrasting evidence regarding the presence of a relationship between emotion and smoking attentional bias (see chapter 2, section 2.3.1). Research has consistently shown that attentional bias to negative emotion stimuli is present in smoking groups, but not non-smoking groups (see Cane et al., 2009, see also Chapter 2, Section 2.3.1). However, the picture is less clear for abstinent smokers and this may be due, in part, to differences in the samples used to represent abstinence. The majority of studies have used experimentally deprived smokers to represent abstinent smokers (See Chapter 2, section 2.3.1) finding no attentional bias to negative stimuli (e.g. Powell, Tait, & Lessiter, 2002). However, attentional bias to negative emotional stimuli has been shown in smokers during a quit attempt (see Cane et al., 2009).

There are two possible reasons for these mixed findings. Firstly, attentional bias to negative stimuli may only be present when there is no opportunity to smoke. Experimentally deprived smokers will be aware that they still have an opportunity to smoke following experimental procedures, while smokers during a cessation attempt would expect not to smoke again. Thus, smokers attempting to quit might assign more negative attributes to smoking-related stimuli, and have increased negative affect, leading to increased attentional bias to smoking-related stimuli and to negative emotion stimuli (see Chapter 2, section 2.3.1). This suggestion is supported by previous research using the Stroop task which has shown that smokers attempting to quit do assign more negative emotion to smoking-related stimuli compared to current smokers and that this may be related to increases in attentional bias (e.g. Cane et al., 2009). Secondly, smokers attempting to quit may be relatively more anxious than deprived smokers due to acute withdrawal symptoms and therefore may be more responsive to negative emotion stimuli and stimuli with negative attributes. However, research findings are mixed regarding increased anxiety during a quit attempt. Some studies have shown increased state and trait anxiety in smokers attempting to quit compared to smokers and never-smokers (e.g. Cane et al., 2009) and other studies have shown no increases in anxiety following smoking cessation (West & Hajek, 1997). Therefore, the relationship between smoking cessation and anxiety needs to be clarified in order to determine the veracity of this explanation.

In contrast to experimentally deprived smokers the examination of attentional bias in smokers undergoing a quit attempt is more clinically relevant, and yields greater ecological validity (Johnsen et al., 1997, also see chapter 2, section 2.2.2). Moreover, examining the relationship between smoking, attentional bias, and negative affect among smokers attempting to quit may be more beneficial when examining possible routes for intervention during cessation.

With regards to the paradigms adopted, the majority of studies that have examined the relationship between smoking attentional bias and negative affect have used either the Stroop task or the visual probe task (see Chapter, 2, Section 2.2). As described in Chapter 2, there have been a number of criticisms levelled at these measures. For the Stroop task, it is unclear whether slower colour-naming is a product of attentional bias towards the stimuli or a cognitive slow-down due to craving or emotions associated with smoking (see Chapter 2, section 2.1.1: *The addiction Stroop task*). Meanwhile, the visual probe task only measures reactions to stimulus off-set and it does not measure responses during stimulus presentation (See Chapter 2, section 2.1.1: *Visual probe task*). In recent years, to overcome these limitations, some studies have adopted eye-tracking measures to monitor eye-movements in response to stimuli. Monitoring eye-movement allows for a more exact measure of visuo-spatial attention and can help identify effects of attention during stimulus presentation, allowing researchers to distinguish more precisely between the initial orientation of attention and the maintenance of attention (See Chapter 2, section 2.1.1: *Eye-tracking methods*).

Indeed, studies adopting eye-tracking methods have found little difference in the initial orientation to smoking-related stimuli between smokers and non-smokers but have found evidence that smokers maintain their attention longer on smoking cues, compared to non-smokers (see chapter 2, section 2.2.1).

To our knowledge there have been two studies to date which have used eye-tracking techniques to study the relationship between smoking attentional bias and emotion. Bradley et al. (2008) examined the relation between smoking attentional bias and emotion using the visual probe task with concurrent eye-tracking measures. Using smokers and non-smokers they found that attentional bias was present to smoking-related stimuli irrespective of their associated affective valence. However, Bradley et al. (2008) did not examine smokers undergoing a quit attempt, with whom the relationship between smoking attentional bias and emotion is likely to be strongest. Kwak et al. (2007) used eye-tracking techniques to examine how withdrawal affects attentional bias to smoking-related cues. They found that both deprived smokers and non-smokers initially oriented their attention to smoking and negative cues. However, only deprived smokers maintained their gaze longer on smoking and negative cues. This suggests that a relationship exists between smoking attentional bias and negative emotion among smokers undergoing withdrawal (see Chapter 2, section 2.3.1 for more detailed outline of these studies).

Whilst these findings are interesting, they may not be representative of responses to smoking and negative stimuli that may be present during a quit attempt. Furthermore, both Kwak et al. (2007) and Bradley et al. (2008) used paradigms in which images were presented in two possible locations, with Kwak et al. (2007) adopting a free-view task and Bradley et al. (2008) presenting images in the visual probe task. This is problematic because participants will become practiced in looking in these locations, and may try to predict the onset location of the next stimulus (see Chapter 2, section 2.1.1: visual probe task). Furthermore, in the visual probe task visual responses to stimuli might be influenced by expectation of the location of the next probe to be responded to, thus responses may not necessarily be a true reflection of reactions to stimuli (see Chapter 2, section 2.1.1: visual probe task). Moreover, neither Bradley et al. (2008) nor Kwak et al. (2007) controlled for low level features of the images presented (e.g. luminance, contrast, complexity) which have been shown to influence visual attention towards stimuli (Nummenmaa, Hyönä, & Calvo, 2006).

In addition to the above limitations, another weakness of previous research is that it is generally assumed that attentional bias in relation to addictions are relatively automatic (see Field, 2006). However, the empirical evidence to support such an assumption largely stems from research examining the presence of non-automatic processes during drug-urges, rather than research directly examining automatic processes (Field, 2006). Research examining non-automatic processes have generally shown that there is a detrimental, slowing-down effect on performance when normal drug-behaviours are not possible (e.g. Baxter & Hinson, 2001; Cepeda-Benito & Tiffany, 1996; 2000; also see Chapter 2, section 2.3.3). The most convincing evidence for the presence of automatic attentional bias processes comes from studies that have manipulated stimulus presentation in the visual probe task. Studies demonstrating attentional bias following short stimulus presentations of 100ms, 200ms or 500ms indicate that automatic processes may exist (e.g. Bradley et al., 2004; Bradley, Mogg, Wright, & Field, 2003a; Ehrman et al., 2002; Stormark, Field, Hugdahl, & Horowitz, 1997; also see chapter 2, section 2.3.3). However, there is also contradictory evidence across a number of studies showing that attentional bias is not present during short stimulus durations (e.g. Bradley et al., 2008; also see chapter 2, section 2.3.3) and this is further emphasised by the lack of findings in relation to the initial orientation of attention to addiction-related stimuli in eye-tracking studies (e.g. Mogg et al., 2005).

Considering the theoretical and practical importance of identifying factors relevant to a quit attempts, further research, that overcomes the above limitations, is required in order to fully understand the relationship between smoking behaviour, smoking attentional bias and emotion particularly in relation to changes that occur during smoking cessation.

Studies 1 and 2 overcome the above problems by drawing upon the methodology implemented in two studies conducted by Nummenmaa et al. (2006) who examined attentional bias to emotional stimuli using eye-tracking methods. Across both studies Nummenmaa et al. (2006) used positive, negative, neutral and control images which were manipulated in order to control for low level features (e.g. complexity, luminance, contrast, saturation). These images were presented for 3,000ms in pairs that included either positive-control, negative-control, and neutral-control images. On each presentation, target images (positive, negative and neutral) were presented in one of the four corners of the viewing screen and the paired image (control) was presented in the opposite corner. In their first study, participants were asked to compare the emotional content of the images whilst being freely allowed to view images in any order they wanted. Using this procedure Nummenmaa et al. found that participants were more likely to initially fixate on emotional images (both positive and negative) than neutral images and were more likely to have longer gaze durations and more fixations on emotional compared to neutral images.

In their second study, Nummenmaa et al. (2006) examined whether these responses to emotional stimuli resulted from automatic exogenous (bottom-up) shifts of attention and whether they could be controlled by conscious, endogenous (top-down) control of attention. To examine these automatic and conscious effects on visual attention participants were instructed to either keep their gaze on the emotional picture or to keep their gaze on the neutral picture. Thus, any movement to neutral images when the 'attend emotional' instruction was given was representative of an exogenous shift of attention away from emotional stimuli and any movement towards emotional stimuli when the 'attend neutral' instructions were given would be indicative of exogenous shifts of attention towards emotional stimuli. Using this procedure, Nummenmaa et al. (2006) found that participants eye-movements were congruent with instructions during the maintenance of attention (i.e. in gaze duration and the proportion of total time spent looking at image variables). However, initial fixations were more likely to be incongruent with instructions to 'attend to neutral images', indicating that in early stages of processing there are more exogenous shifts in attention to emotional stimuli. In addition, Nummenmaa et al. (2006) found a linear trend in the presence of possible exogenous shifts in attention, with biased shifts in attention to emotional stimuli in early processing stages (probability of first fixation), moderate shifts at intermediate stages (gaze duration on first pass) and no biased shifts in late processing stages (total fixation time; see Figure 3.1).

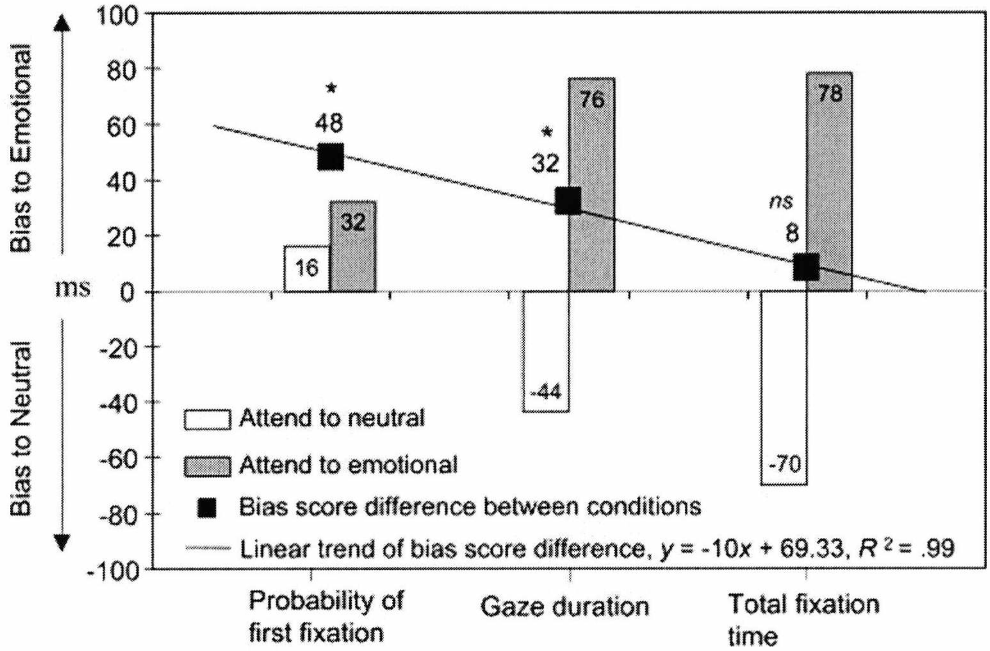


***Figure 3-1* - Nummenmaa et al. (2006) showing linear trend in bias to emotional and neutral stimuli across early (Probability of first fixation), intermediate (Gaze duration), and late stages (Total fixation time) of attentional processing**

Given the effectiveness of the methodological approach adopted by Nummenmaa et al. (2006) in examining both the visuo-spatial attention to emotion stimuli and exogenous and endogenous shifts in attention, Studies 1 and 2 will adopt these methods to examine eye-movement responses to smoking-related cues as well as negative emotion cues. By doing so, this will allow an examination of the role of visual attention in relation to attentional bias to smoking-related and negative stimuli. This methodology will also clarify the roles of conscious control of attention and the automatic exogenous shifts of attention to smoking-related and negative emotion stimuli.

Study 1 and study 2 will also examine the relationship between attentional bias, smoking behaviour and craving. Theories and research examining attentional bias in addiction have suggested that a relationship may exist between smoking behaviour and the presence of attentional bias (Robinson & Berridge, 1993; Robinson & Berridge, 2001, see Chapter 1, section 1.1). Moreover, contemporary theories have suggested a reciprocal relationship between smoking attentional bias and subjective craving (Field &

Cox, 2008; Franken, 2003, see Chapter 1, section 1.4). Therefore, Study 1 will measure subjective reports of craving and smoking behaviour and examine whether these are indeed related to attentional bias to smoking and negative emotion stimuli.

Previous research has also shown that responses to smoking-related stimuli and negative emotion stimuli may be related to increases in anxiety, emotional vulnerability, and emotion ratings of stimuli (e.g. Cane et al., 2009; Williams et al., 1996; see Chapter 2, section 2.3.1). As described in Chapter 3, there are a number of ways to test the relationship between smoking attentional bias and emotion, including mood manipulation, measuring the valence of smoking stimuli and comparing attentional bias to smoking cues with attentional bias to emotional cues. Studies 1 and 2 utilised the latter two techniques in order to reliably examine this relationship. Furthermore, to examine the extent to which anxiety is related to increases in attentional bias to both smoking-stimuli and negative emotion-related stimuli measures of anxiety, anxiety sensitivity and emotion relatedness were also taken.

3.1 - Study 1

For study 1, smokers, non-smokers and smokers attempting to quit were presented with smoking-related, negative emotion and neutral images whilst having their eye movements recorded. To ensure that the effects of attention on stimuli did not result from the low-level properties of the stimuli (e.g. luminance, complexity, saturation etc.) these were controlled for across stimulus types. Images were presented in one of four possible locations, in the following pairs: smoking–neutral, negative-neutral or control-neutral and participants were asked to compare the emotion-relatedness of the stimuli. Following the eye-tracking task, these images were also rated for valence by the participant and measures of anxiety were completed.

Firstly, it was predicted that smokers and smokers attempting to quit would initially orient to smoking and negative images more frequently and for longer than non-smokers. Likewise, it was predicted that smokers and smokers attempting to quit would maintain their gaze on smoking images for longer than non-smokers, and this effect would be more pronounced for stimuli that are rated more negatively. Secondly, it was predicted that smokers attempting to quit would rate smoking pictures more negatively, and this would increase smoking attentional bias among this group, in comparison to smokers and non-smokers. Finally, it was expected that there would be a relationship between attentional bias to smoking cues and negative emotion cues in smokers attempting to quit, but not among smokers and non-smokers.

3.1.1 - Method

Participants

Forty-nine participants were recruited through the University of Kent Jobshop and the University of Kent's research participation scheme. Participants recruited through the Jobshop were given £5 for their participation and participants recruited through the University of Kent research participation scheme were given 3 course credits. Participants were selected on the criteria that they were either native English speakers or fluent in spoken English and had visual acuity within normal limits, and fit into one of three categories: i) Current Smokers, ii) Smokers Attempting to Quit (SATQ), or iii) Never-Smokers. Participants were classed as current smokers if they had smoked a cigarette within the past 24 hours and had smoked over five cigarettes daily in the past year, SATQ if they were smokers who had abstained from smoking for over twenty-four hours and within the past two years and were actively attempting to quit, and never-smokers if they had never smoked. Of these 49 participants, 3 were excluded from the final sample because of problems collecting eye-movement data. Therefore, the final sample consisted of 46 participants (14 male, 32 female; mean age= 22.29, *SD* = 3.64, age range = 19-34). Of those who took part, 16 were classed as active smokers, 14 were classed as SATQ, and 16 were classed as non-smokers. All participants were treated in accordance with the ethical standards of the British Psychological Association. In addition, ethical approval was obtained from the University of Kent at Canterbury's Department of Psychology ethics committee before recruiting participants and proceeding with the experiment.

Apparatus & Stimuli

Stimuli Presentation

Stimuli were presented using Arrington PC60 eye-tracking Software version 2.8.3 (Arrington Research, Inc., Scottsdale, AZ) run on a Dell precision 3.06GHz computer with an Intel (R) Xeon processor. This was connected to a Dell Precision 3GHz computer with an Intel Pentium 4 Processor running E-Prime version 1.1 which selected specific trials to present and also to collect trial data. Stimuli were presented on a 17in Dell monitor. Specific eye movement measures were recorded by the Arrington software at a sampling rate of 60Hz, and spatial resolution better than 0.5°.

Manual Responses

Manual responses to the task-specific question, 'were the pictures equally pleasant' were collected using a response box utilising two buttons at either end of the box. The left button was labelled 'no' and the right button was labelled 'yes'. These labels were written in black ink above each allocated button and were also shown in the relevant position on the display screen.

Breath Carbon Monoxide (BCO) measure

Breath Carbon Monoxide (BCO) was taken as a measure of smoking recency using the Bedfont Smokerlyzer (Bedfont Scientific Ltd, Kent, UK). Levels of BCO were not used to categorize participants into a smoking category, rather they were used alongside subjective reports to corroborate subjective reports of smoking recency. BCO levels of over 8 p.p.m. were indicative of current smoker status.

Stimuli

Stimuli consisted of 16 smoking images, 16 unpleasant images, 16 neutral images and 48 control images. Unpleasant, neutral and control stimuli were originally taken from the International Affective Picture System (IAP; Lang, Bradley, & Cuthbert, 2005)[2] which, with the exception of two unpleasant stimuli, were also stimuli chosen by Nummenmaa, Hyönä, and Calvo (2006). Two of the unpleasant stimuli used in Nummenmaa et al. (2006) were removed from the present study, one which involved a graphic scene of accidental death and one which contained smoking-related stimuli. These were replaced with two stimuli from the IAPS which matched the valence and

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2 IAPS pictures used – Control: 5390, 5395, 5661, 5900, 6000, 6150, 7000, 7002, 7004, 7006, 7009, 7010, 7020, 7025, 7030, 7031, 7035, 7036, 7037, 7038, 7039, 7040, 7041, 7050, 7060, 7080, 7090, 7095, 7096, 7100, 7130, 7140, 7150, 7161, 7170, 7175, 7179, 7180, 7205, 7190, 7211, 7217, 7224, 7233, 7234, 7235, 7236, 7600. Negative: 2095, 2375, 2750, 2800, 2900, 3051, 3301, 3053, 3550, 6243, 6570, 6838, 9040, 9254, 9421, 9435. Neutral: 2190, 2191, 2215, 2235, 2393, 2487, 2516, 2745, 2840, 2850, 2870, 7493, 7496, 7550, 8311, 9070 – (Smoking pictures used are shown in Appendix A1)

arousal ratings of the removed stimuli. An additional 32 control stimuli, that were used by Nummenmaa et al. (2006) as filler displays to balance the number of emotional and neutral pictures, were also removed to ensure the stimuli groups (smoking, unpleasant and control) were balanced equally. Unpleasant stimuli were images of threatening people or people who were the victims of threat or harm. Neutral stimuli involved pictures of people in non-emotional environments and non-emotional states. Smoking stimuli were images taken from public image posting sites on the internet (e.g. Flickr, google image), and were chosen if they contained items that were related to smoking or that showed a person smoking tobacco but did not contain people with any particular emotional expression or which were related to any particular emotional setting. Control stimuli were pictures of inanimate objects (Smoking images are shown in Appendix A1).

To achieve uniform luminance values across all picture categories, the luminance level for all pictures was manipulated using Paintshop Pro 7.0. In line with Nummenmaa et al. (2006) luminance values, root mean square (RMS) contrast, and complexity (number of bytes in compressed JPEG format) for each image were measured and compared across groups of images. This was done using a specific image analysis tool written for the present study. RGB colour saturation levels were measured using Paintshop Pro 7.0 (see Table 3-1 for mean and standard errors of luminance, RMS contrast, complexity and colour saturation, valence and arousal values). To identify any differences in complexity, luminance, RMS contrast and red, green and blue saturation levels between the picture groups a series of one-way analysis of variance (ANOVAs) were conducted. These ANOVAs used the values of each of the image measures as the dependent variables and Picture Group (Smoking, Negative, & Neutral) as the independent variable. These analyses revealed no significant differences between the picture groups for complexity, luminance, RMS contrast, Red, green and blue saturation levels $Fs < 2.36$, $ps > .05$). To examine whether there were significant differences between the IAPS ratings of valence and arousal between negative, neutral, and control stimuli[3] two separate one-way ANOVAs were conducted. These included valence and arousal ratings as the dependent variables and Picture Type (smoking, negative, and neutral) as the independent variable. This analyses revealed a significant

[3] IAPS ratings of valence and arousal were not available for smoking pictures as these pictures were taken from alternative sources

difference for both valence ($F(2, 77) = 54.15, p <.001$) and arousal ($F(2, 77) = 36.08, p < .001$) between the different picture groups. Subsequent independent t-tests conducted between each picture group showed significant differences in valence and arousal between negative and control pictures (valence: $t(61) = 22.98, p < .001$, arousal: $t(61) = -11.18, p < .001$) and between Negative and Neutral (valence: $t(28) = -22.81, p < .001$; arousal: $t(28) = 9.55, p < .001$; see Table 3-1). No significant differences in valence and arousal were shown between control and neutral pictures (all *ps*>.05).

Table 3-1

Image characteristics for each picture group

	Unpleasant		Neutral		Smoking		Control	
	M	*(SE)*	*M*	*(SE)*	*M*	*(SE)*	*M*	*(SE)*
IAPS valence ratings[a]	2.11	*(.09)*	5.22	*(.10)*	-	-	5.06	*(.07)*
IAPS arousal ratings[a]	5.58	*(.16)*	3.40	*(.62)*	-	-	3.08	*(.79)*
Emotion ratings of target pictures[b]	-3.40	*(.07)*	.92	*(.12)*	-.93	*(.18)*	-	-
Smoking ratings of target pictures[c]	.30	*(.08)*	.40	*(.09)*	4.70	*(.06)*	-	-
Luminance	79.05	*(25.69)*	87.16	*(5.04)*	95.84	*(7.14)*	93.26	*(4.04)*
Complexity	313.96	*(202.22)*	386.84	*(189.57)*	358.61	*(394.89)*	326.33	*(108.18)*
RMS contrast	.81	*(.05)*	.72	*(.04)*	.62	*(.04)*	.73	*(.31)*
Red channel saturation	82.81	*(9.90)*	90.83	*(4.72)*	103.59	*(7.80)*	99.65	*(3.68)*
Green channel saturation	73.79	*(7.32)*	79.58	*(5.01)*	93.63	*(7.21)*	91.80	*(4.19)*
Blue channel saturation	61.12	*(7.33)*	68.83	*(5.02)*	84.61	*(7.93)*	76.30	*(5.47)*

[a] – 1= most negative, 9 = most positive – values not available for smoking pictures as these were not taken from the IAPS

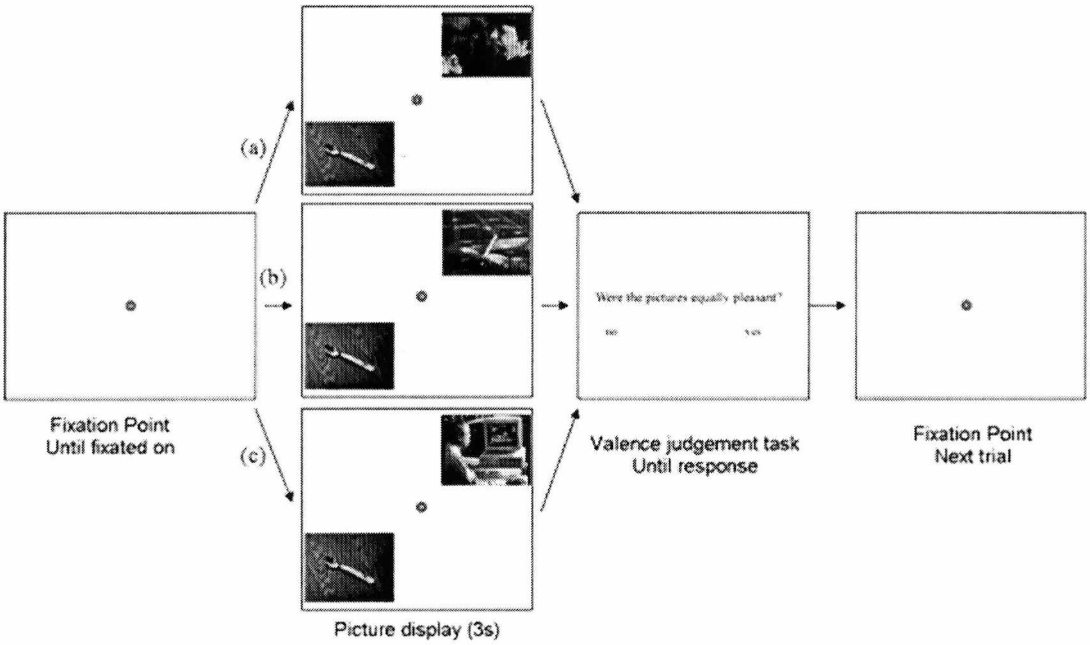
[b] - Emotion relatedness was scored on a nine-point scale from -4 = highly negative emotion, through 0=neutral, to 4 = highly positive emotion. Participants only rated target picture categories so no values are available for control pictures.

[c] - Smoking relatedness was scored on a six-point scale from 0-not related to smoking, to 5-highly related to smoking. Participants only rated target picture categories so no values are available for control pictures.

Stimuli Displays

Stimuli displays were based on the design used by Nummenmaa et al. (2006) and consisted of a pair of pictures displayed in opposing corners of the screen (either top left/bottom right, or top right/bottom left) on white background (see Figure 3-2). Based on the dimensions detailed in Nummenmaa et al. (2006) the size of the pictures was 250 x 188 pixels, which equals to 12.5°x 9° of visual angle at a viewing distance of 60 cm. Each pair consisted of one target picture and one control picture. Target pictures were either unpleasant, smoking-related, or neutral images making three stimulus pair-types: unpleasant-control, smoking-control, and neutral-control. Over the course of the experiment each target picture was presented four times, once in each of the four corners of the screen. The target pictures were randomly paired with control pictures so that the same stimulus was paired with a different control picture on each of its four presentations. In total there were 64 negative-control stimuli, 64 neutral-control stimuli, and 64 smoking-control stimuli leading to 192 trials in total. Stimuli were randomly presented and were split into two halves of 96 trials to allow participants to take a break half way through the experiment. All participants in all groups completed all 192 of the experimental trials.

Figure 3-2 - Sequence of display screens for (a) unpleasant, (b) smoking, and (c) neutral target pictures*



*- across trials pictures were displayed in all four corners and control pictures were displayed in opposite corners

Measures

Eye movement measures

Eye movement measures were recorded in accordance with Nummenmaa et al. (2006) and included: (a) the position of fixations, (b) the duration of fixations, (c) the duration between fixations, and d) the sequence of fixations. Of these measures four variables were constructed for the basis of analysis, these were: (a) the latency of the first fixation on a target picture, either directly or with an intervening fixation on non-target picture, (b) the probability of first fixation; (c) the gaze duration on the picture (summed duration of fixations made on the picture when looking at it for the first time) and (d) the number of the first-pass fixations (the number of fixations made on the first viewing of an image). Initial orienting was assessed by the latency and the probability of first fixation on the target picture; attentional engagement was assessed by gaze duration and the number of first-pass fixations.

For eye-tracking data in this study, and for reaction-time data in the subsequent studies median reaction times were used. Median reaction times are preferable over mean reaction times and transformed reaction times as they have been shown to be effective in controlling for outliers and dealing effectively with data which is positively skewed (Hays, 1981; Heathcote, Popiel, & Mewhort, 1991).

In addition to eye-tracking measures, additional measures of anxiety and emotion, and smoking behaviour were taken. These measures were adopted across all studies presented in this thesis (unless otherwise indicated in the particular studies).

The State-Trait Anxiety Inventory (STAI; Spielberger, 1983)

The STAI contains 40-items, 20 of which relate to state anxiety and 20 which relate to trait anxiety. These include statements such as, 'I feel at ease' and, 'I worry too much over something that really doesn't matter'. Participants rated each statement on a scale of 1 (Almost Never), to 4 (Almost Always). The sum of the ratings to these statements gives a separate score for both perceived State anxiety and perceived Trait anxiety. The scores can range from 20-80, with low scores indicating lower anxiety, and higher scores indicating higher anxiety.

Anxiety Sensitivity Inventory (ASI; Peterson & Reiss, 1992)

The ASI is a sixteen-item questionnaire which measures the perceived threat of anxiety-related bodily sensations. Respondents rate how much they agree with statements relating to anxiety sensitivity based on a 5-point scale from 1 (very little) to 5 (very much). Items include statements such as 'It scares me when I feel shaky' and 'If my heart beats rapidly I worry that I might be having a heart attack'.

The Fagerstrom Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991)

The FTND is commonly used to classify smokers according to their degree of nicotine dependence. It contains eight items, such as 'How soon after you awake do you smoke your first cigarette?' and 'Does the brand you smoke have a low, medium, or high nicotine content?'. The items are rated on a scale of 0 - 1or 0 - 2 depending on the question being asked. From these items, responses can be totalled to produce a tolerance score, which can range from, 0-11, with any score greater than 7 suggesting a physical dependence to nicotine. So that smokers who were undergoing a quit attempt could also respond to these questions in relation to their past smoking habits each item was amended slightly so that it also referred to the past tense as well as the present tense (see Appendix B1). For instance, 'How many cigarettes a day do you smoke?', was changed to, 'How many cigarettes a day do you/did you smoke?'. Participants were also asked if they used any aids to help them give up, when they had last smoked a cigarette and their estimation of how much they crave cigarettes, scored on a likert scale from 0 (never) to 7 (always).

Brief Questionnaire on Smoking Urges (QSU-Brief; Cox, Tiffany, & Christen, 2001)

The Brief Questionnaire on Smoking Urges (Cox, Tiffany & Christen, 2001) contains 10 items which measure urges and craving to smoke. The questionnaire asks respondents to indicate how strongly they agree or disagree with certain statements relating to urges and cravings on a scale from 1 (strongly disagree) to 7 (strongly agree). Included in the QSU-brief are statements such as 'I have a desire for a cigarette right now' and ' I am going to smoke as soon as possible'.

Picture-Relatedness

Participants were asked to rate each of the target pictures shown in each of the three categories (smoking, negative emotion, and neutral) on two scales; smoking relatedness and emotion relatedness (see Appendix B2). Smoking relatedness was scored on a six-point scale from 0-not related to smoking, to 5-highly related to smoking, and emotion relatedness was scored on a nine-point scale from -4 (highly negative emotion), through 0 (neutral), to 4 (highly positive emotion).

Procedure

On arrival participants were asked to complete the modified Fagerstrom questionnaire, the Questionnaire on Smoking Urges, and gave a Breath Carbon Monoxide (BCO) sample. Participants were then familiarised with the eye-tracking equipment and were placed into a head-rest to ensure head-movements were kept to a minimum during eye-tracking recording and the eye-tracker was calibrated. Participants were told that they would initially be shown a fixation point followed by a pair of pictures and during the presentation of the pictures they would have to compare the emotional content of the pictures. Following picture presentation they would have to respond to whether or not the pictures were emotionally similar by pressing either the 'no' button or the 'yes' button. Participants were then given four practice trials to get them accustomed to the task. Following the practice trials participants completed 96 experimental trials before taking a break. During the break participants were removed from the head-rest for two minutes and when this time was up participants were placed back in the head brace and the eye-tracker was re-calibrated. Participants then completed the second half of the experimental trials. Throughout the practice trials and experimental trials the blinds in the laboratory were closed and the lights dimmed to reduce any reflections from the monitor displaying the stimuli.

Following experimental trials participants were taken out of the head-rest and completed the STAI, the ASI and the picture rating task before being fully debriefed both verbally and via a debriefing sheet.

3.1.2 – Results

Group Characteristics

A series of one-way ANOVAs were used to identify any between group differences in state and trait anxiety, anxiety sensitivity, the emotion ratings of smoking and emotional stimuli and the smoking ratings of smoking and emotional stimuli. Each ANOVA included Group (smokers, SATQ, and never-smokers) as the independent variable and each measure as the dependent variable. These analyses revealed no significant differences in anxiety levels, anxiety sensitivity, the emotion ratings of emotional and neutral stimuli, and the smoking ratings of smoking, emotional, and neutral stimuli between the groups (all $Fs < 1.54$, $ps > .2$; see Table 3-2 for anxiety measures and Table 3-1 for rating measures). However, the analysis did reveal a significant difference in the emotional rating of smoking stimuli between the groups ($F(2, 44) = 14.28$, $p < .001$). Subsequent post hoc analysis with Bonferronni correction revealed that never-smokers and SATQ rated smoking-related pictures significantly more negatively than smokers, who rated stimuli as slightly positive ($p < .05$; see Table 3-1). There were no significant differences in emotion ratings of smoking-related cues between never-smokers and SATQ ($p > .1$; see Table 3-1).

Similarly, a series of independent t-tests were conducted on Fagerstrom scores, smoking urges scores (QSU), subjective craving scores and length of smoking career between smokers and SATQ. The analyses revealed no significant differences in Fagerstrom scores, smoking urges, and length of smoking career between the two groups (*ts* < 1.8, *ps*>.05; see Table 3-2). However, the analyses did reveal a significant difference in subjective craving scores with smokers reporting greater craving than SATQ ($t(27) = -3.69$, $p=.001$; see Table 3-2).

Table 3-2

Comparison of Anxiety measure scores and smoking measures across each group

	Group		
Measure	Smokers	SATQ[a]	Never-smokers
State Anxiety	51.06 (4.91)	50.62 (8.05)	49.75 (4.49)
Trait Anxiety	48.94 (3.07)	49.92 (1.68)	48.81 (2.40)
ASI	37.56 (4.11)	36.17 (2.41)	18.54 (11.59)
Fagerstrom Scores	9.93 (1.82)	8.71 (2.67)	-
QSU	26.67 (9.66)	19.93 (10.49)	-
Subjective craving	4.12 (1.11)	2.21 (1.53)	-
How long smoked for (years)	6.09 (3.57)	4.35 (3.69)	-
Time since last cigarette	1.6 hours (3.21)	82.49 days (121.32)	-
BCO (ppm)	15.13 (7.71)	3.79 (1.05)	2.06 (1.06)

*PA= Positive Affect, NA=Negative Affect [a] SATQ = smokers attempting to quit

NB. Data presented are Means (SD)
[b] - Emotion relatedness was scored on a nine-point scale from -4 = highly negative emotion, through 0=neutral, to 4 = highly positive emotion. Participants only rated target picture categories so no values are available for control pictures.
[c] - Smoking relatedness was scored on a six-point scale from 0-not related to smoking, to 5-highly related to smoking. Participants only rated target picture categories so no values are available for control pictures.

Eye-tracking data

Median eye-movement data for each eye-movement measure (probability of first fixation, time elapsed to target picture, duration of first pass, no. of first pass fixations) were subjected to a 3 x 3 mixed measures ANOVA with Picture Type (smoking, negative, neutral) as the within-subject factor and Group (smokers, SATQ, and never-smokers) as the between subject factor.

Attentional orientation

Probability of first fixation

Analysis for the probability of first fixation did not reveal any significant main effects or interactions (*Fs < 1, ps >.05; see Table 3-3).*

Table 3-3

Means (SD) for the probability of first fixation by image type for each group

	Image Type		
	Neutral	Negative	Smoking
Smokers	.52 *(.02)*	.52 *(.03)*	.53 *(.02)*
SATQ[a]	.54 *(.02)*	.51 *(.03)*	.52 *(.02)*
Never-smokers	.50 *(.02)*	.51 *(.03)*	.51 *(.02)*

[a] *SATQ = Smokers attempting to quit*

Time elapsed to target picture

Analysis showed that the time taken to fixate on a region was significantly affected by the Picture Type ($F(2, 86) = 6.68$, $p=.005$, *partial* $\eta^2 = .13$) and by smoking Group ($F(2, 43) = 4.42$, $p < .05$, *partial* $\eta^2 = .17$). Post hoc analyses using Bonferroni correction were conducted to further examine the main effect of Picture Type. Analyses showed that it took a significantly shorter time for participants to fixate on negative pictures (*M*=473ms, *SE* = 18ms) compared to neutral (*M*=522ms, *SE* = 20ms; $p < .005$) and smoking pictures (*M*=532ms, *SE* = 19ms; $p < .01$). There was no significant difference in the time taken to fixate on neutral and smoking pictures ($p>.05$). Similar post hoc analyses conducted to examine the main effect of group revealed that SATQ were significantly quicker to fixate on pictures (*M*=466ms, *SE* = 29ms) than never-smokers (*M*=576ms, *SE* = 27ms; $p < .05$). There were no significant differences in the time taken to fixate on pictures between SATQ and smokers (*M*=485ms, *SE* = 27ms), and between never-smokers and smokers (*ps* > .05). This analysis did not reveal a significant interaction of Picture Type by Group ($F(4, 86) = 1.28$, $p= .28$, *partial* $\eta^2 = .06$).

Attentional engagement

Duration of First Pass

For the length of gaze durations made on the first pass main effects of Picture Type ($F(2, 86) = 9.04, p < .001$, *partial* $\eta^2 = .17$) and Group ($F(2, 86) = 9.04, p < .001$, *partial* $\eta^2 = .13$) were revealed. Subsequent post hoc analyses with Bonferroni correction to examine the main effect of Picture Type revealed that gaze durations to negative stimuli (M=439ms, SE = 23ms) and smoking stimuli (M=420ms, SE = 22ms) were significantly longer than gaze durations to neutral stimuli (M=373, SE = 20) (Neutral and Negative $p < .001$; Neutral and Smoking $p < .05$). However, there were no significant differences in gaze durations between smoking and negative stimuli (p=.73). For the main effect of group post hoc analyses revealed significantly longer gaze durations in SATQ (M = 480ms, SE = 35ms) compared to never-smokers (M = 352ms, SE = 33ms; $p < .001$). However, there were no significant differences in gaze duration between SATQ and smokers (M = 401ms, SE = 33ms, $p > .05$), and never-smokers and smokers ($p > .05$). This analysis did not reveal a significant interaction of Picture Type by Group (F (4, 86) = 1.14, p= .35, *partial* η^2 = .06).

Number of first pass fixations

Analysis of the median number of fixations occurring on the first pass revealed a significant main effect of Picture Type (F (2, 86) = 4.64, $p < .05$, partial η^2 = .10). Post hoc analyses with Bonferronni correction revealed that there were significantly more fixations to negative pictures (M = 2.30, SE = .10) compared to neutral pictures (M = 2.02, SE = .1; $p < .005$). There were no significant differences in the number of fixations made between neutral and smoking pictures (M = 2.24, SE = .11) and between smoking and negative pictures (ps>.05). The analysis did not reveal a significant interaction of Picture Type x Group (F (4, 86) = 1.05, p= .39, *partial* η^2 = .05).

Correlation analyses

Eye-movement measures

Correlation analyses were conducted for bias scores for each eye-movement measure (duration of first pass, number of first pass fixations, probability of first fixation, and time elapsed to stimuli) to examine relationships between responses to smoking, negative and neutral stimuli for each group. Bias scores were calculated by subtracting responses to neutral stimuli from responses to smoking and negative stimuli separately, thus yielding a bias score for smoking stimuli and a bias score for negative stimuli between which correlation analyses were conducted. Analyses revealed significant correlations between negative bias scores and smoking bias score in SATQ and never-smokers (see table 3-4). Specifically, analyses for SATQ showed significant positive correlations between smoking and negative bias scores in measures of the early orientation of attention (probability of first fixation and time elapsed to stimuli. Similarly, analyses for never-smokers showed a significant positive correlation between smoking and negative emotion bias in the probability of first fixation, but also showed significant positive correlations in the intermediate maintenance of attention (Duration of Fist Pass and Sum of Fixations on First Pass).

Table 3-4

Pearson's correlation analyses between bias scores[a] for eye-movement responses to smoking and negative stimuli for each group

		Bias[a] Mean (SD)			Correlation Values (*r*)		
		Smokers	SATQ[b]	Never-smokers	Smokers (N=16)	SATQ[b] (N=14)	Never-smokers (N=16)
Probability of First Fixation	Smoking	.007(.11)	-.025(.12)	.003(.08)			
	Negative	.001(.08)	-.035(.07)	.004(.08)	.03	.56*	.55*
Time elapsed to stimuli (ms)	Smoking	-12(113)	-14(102)	57(142)			
	Negative	-57(60)	-40(92)	-49(128)	.25	.59*	.23
Duration of First Pass (ms)	Smoking	91(12)	37(16)	12 (53)			
	Negative	89(88)	55(84)	52(83)	.40	.50	.71**
Sum of Fixations on First Pass	Smoking	.38(.72)	.25(.89)	.03(.56)	.06	.36	.76**
	Negative	.38(.59)	.21(.47)	.25(.48)	.39	.46	.46

**<.05 **- <.005*

[a]- Bias scores were calculated by subtracting responses to neutral stimuli from responses to smoking stimuli and responses to negative emotion stimuli

[b] = Smokers attempting to quit

Smoking variables and eye-movement measures

To identify if responses to stimuli were a product of self-reported smoking behaviour and craving correlation analyses were conducted between responses given in smoking questionnaires and bias scores for eye-movement variables (see table 3-5). These analyses revealed a number of significant positive correlations between subjective crave scores and eye-movement responses to negative trials. For smokers subjective craving was positively correlated with the duration of first pass and the sum of fixations on first pass. For SATQ subjective craving scores were positively correlated with time elapsed to first fixation. Also for SATQ a significant positive correlation was revealed between Fagerstrom scores and the sum of fixations on the first pass to negative images. Smoking urges were positively correlated with the duration of first pass of negative images in smokers.

Table 3-5

Pearson's correlation analyses between sum of bias scores for the smoking trials and negative trials and smoking-related measures

		Negative Trials				Smoking Trials			
		PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]	PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]
Fagerstrom	SM[b]	-.27	-.08	.21	.02	.07	-.22	.24	.19
	SATQ[c]	-.21	.25	.12	.57*	.26	-.22	-.41	-.14
Subjective crave score	SM[b]	-.49	-.25	.57*	.54*	.10	-.32	.46	.47
	SATQ[c]	-.07	.56*	.14	.47	.07	-.04	-.34	-.04
QSU	SM[b]	.15	-.31	.59*	.49	.00	-.11	-.11	-.05
	SATQ[c]	-.03	.45	.34	.43	-.12	-.04	-.01	.17
BCO reading	SM[b]	-.29	-.11	-.23	-.13	.09	-.16	.40	.44
	SATQ[c]	.04	-.01	.09	.18	.15	-.11	-.25	-.14

*- $p < .05$, ** - $p < .005$ [b] *SM* = Smokers [c] SATQ=smokers attempting to quit [d] NS=Never-Smokers

[a] Eye-movement measures are: PoFF – Probability of First Fixation ; TEtFF – Time Elapsed to First Fixation; DoFP – Duration of First Pass; SoFFP – Sum of Fixations on First Pass

Emotion ratings and eye-movement measures

In order to identify whether responses to stimuli were a product of emotion-relatedness correlation analyses were conducted between subjective emotion rating of stimuli (smoking and negative) and bias scores for eye-movement variables (see table 3-6). These analyses revealed a significant positive correlation between the sum of fixations on first pass to smoking stimuli and the emotion rating of negative stimuli for SATQ. The analysis also revealed a significant negative correlation between the emotional rating of negative stimuli and the time elapsed to fixate on negative images suggesting that the more negative the stimuli were rated the shorter the time taken to fixate on negative images.

Anxiety measures and eye-movement variables

To identify if responses to stimuli were a product of anxiety, correlation analyses were conducted between responses given on anxiety measures and bias scores for eye-movement variables (see table 3-6). These analyses revealed significant positive correlations between state anxiety and time elapsed to region and sum of fixation on first pass for SATQ. However, state anxiety was negatively correlated with the probability of first fixation to smoking images in smokers and positively correlated with the sum of fixations on first pass in never-smokers. As well as correlations of state anxiety, significant negative correlations were revealed between anxiety sensitivity and the duration of first pass to negative images and the sum of fixations to smoking images in SATQ participants; as anxiety sensitivity increased the propensity to keep gaze on smoking and negative stimuli decreased.

Table 3-6

Pearson's correlation analyses between sum of bias scores for the smoking trials and negative trials and anxiety / emotion measures.

		Negative Trials				Smoking Trials			
		PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]	PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]
State Anxiety	SM[b]	.03	.08	-.01	-.08	-.53*	.43	-.24	-.26
	SATQ[c]	-.62*	.56*	.42	.62*	-.49	.34	.15	.14
	NS[d]	-.20	.34	.44	.48	-.12	.17	.29	.51*
Trait Anxiety	SM[b]	.28	.30	-.15	.11	.30	-.19	.21	.34
	SATQ[c]	-.19	.17	.14	-.08	-.36	.56	.16	-.01
	NS[d]	.23	-.08	-.29	-.36	.47	.04	-.33	-.42
ASI	SM[b]	.26	-.40	.18	.17	-.07	.03	-.05	-.12
	SATQ[c]	.32	.14	-.72**	-.53	.37	.41	-.50	-.67*
	NS[d]	.21	-.16	-.17	-.09	-.48	.26	-.28	-.12
Smoking - Emotion	SM[b]	.40	-.07	.04	.16	.08	.03	.12	.24
	SATQ[c]	-.26	.02	.31	.34	-.11	-.17	.08	.03
	NS[d]	-.15	.31	.01	-.15	.10	.18	-.03	.17
Negative - Emotion	SM[b]	.18	-.57*	.06	.15	-.27	.17	-.14	-.17
	SATQ[c]	-.45	.16	.42	.52	-.32	-.21	.43	.57*
	NS[d]	-.45	.31	.07	.37	-.18	.16	-.17	.06

*- $p < .05$, ** - $p < .005$ [b] *SM* = Smokers [c] SATQ=smokers attempting to quit [d] NS=Never-Smokers

[a] Eye-movement measures were: PoFF – Probability of First Fixation ; TEtFF – Time Elapsed to First Fixation; DoFP – Duration of First Pass; SoFFP – Sum of Fixations on First Pass.

3.1.3 Summary of findings for Study 1

In summary, the main findings of study 1 show that visual responses to smoking images and negative images are unaffected by smoking status. Specifically, the findings showed that negative images were fixated more quickly than smoking and neutral images, and that there was increased maintenance of visuo-spatial attention on smoking and negative images compared to neutral images. These findings were shown similarly across smokers, smokers attempting to quit and never-smokers, indicating that these effects of attention are unrelated to current, or previous smoking behaviour. Furthermore, as the responses to smoking images only emerge in the latter stages of attentional processing (gaze duration, and sum of fixations) this indicates that these effects may have resulted from the conscious control of attention rather than automatic shifts in attention.

The extent to which attention was given to smoking-related stimuli was not related to any of the smoking behaviours measured. However, Study 1 did reveal significant correlations between anxiety measures and the attention given to smoking images. In particular, it was shown that increased anxiety sensitivity was associated with decreased attentional bias to smoking stimuli in smokers attempting to quit. Furthermore, in smokers increases in attention to smoking stimuli was shown to be related to increased state anxiety.

Whilst Study 1 provides little evidence of exogenous shifts in attention to smoking stimuli, it does provide some evidence towards exogenous shifts in attention to negative emotion stimuli, given that the initial orientation of attention was quicker to negative images compared to smoking and neutral images. Furthermore, in smokers both smoking urges and subjective craving scores were positively correlated with the attention given to negative stimuli and Fagerstrom scores in smokers attempting to quit were positively correlated with responses to negative emotion stimuli. This suggests that smoking behaviour may affect the extent to which attention is biased to negative stimuli, particularly in late stages of attentional processing. The implications of these findings will be discussed further in the general discussion section at the end of this chapter.

One limitation of Study 1 is that the design does not allow differentiation between automatic and controlled responses. Therefore, we cannot know for sure whether the observed pattern of results are due to participants consciously controlling their visual attention or whether they are due to automatic reactions to stimuli. This issue is examined further in Study 2, which looks at *automatic* attentional bias to smoking, negative-emotion, and neutral images among smokers, smokers attempting to quit and never-smokers.

3.2 - Study 2

In Study 2, participants were asked to move their gaze to either negative, smoking or neutral pictures, and were told to keep their gaze on that picture throughout the image presentation. This design served to identify any exogenous shifts in attention towards pictures that participants were not instructed to look at. In this way by pairing, for instance, neutral and smoking stimuli, if participants are instructed to gaze at the neutral stimuli, any exogenous gaze to smoking pictures could be detected. Furthermore, this design helps to examine whether explicit instructions to attend away from smoking and negative stimuli can help reduce the attentional bias given to smoking and negative stimuli.

In addition, one possible explanation for the initial orientation to negative stimuli but not to smoking stimuli observed in Study 1 is that the concurrent task directly required participants to compare the emotional content of the images presented and so may have primed participants to respond specifically to emotional images. Therefore, this concurrent task is removed from study 2 in line with the methodological procedures of Nummenmaa et al. (2006, expt. 2).

It was predicted that using this procedure all groups would show exogenous shifts in attention to negative emotional stimuli, but that these shifts may be more frequent in smokers attempting to quit as a result of increases in anxiety or craving. Secondly, it was expected that both smokers and smokers attempting to quit would show exogenous shifts in attention to smoking-related stimuli but that these shifts would not be present in never-smokers. Furthermore, it was expected that shifts to smoking-related stimuli in smokers attempting to quit might be associated with increases in negative ratings of smoking stimuli.

3.2.1 - Method

Participants

Sixty-one participants were recruited through the University of Kent Jobshop and the University of Kent's research participation scheme. Participants recruited through the Jobshop were given £5 for their participation and participants recruited through the University of Kent research participation scheme were given 3 course credits. As with Study 1, participants were selected on the criteria that they were either native English speakers or fluent in spoken English and had visual acuity within normal limits, and fit into one of three categories: i) Current Smokers, ii) Smokers Attempting to Quit (SATQ), or iii) Never-Smokers. Participants were classed as current smokers if they had smoked a cigarette within the past 24 hours, SATQ if they were smokers who had abstained from smoking for over twenty-four hours and under two years and were actively attempting to quit, and never-smokers if they had never smoked. Of these 61 participants 11 were excluded from the final sample because of problems collecting eye-movement data. Therefore, the final sample consisted of 50 participants (20 males, 30 females; Age M = 22.74, SD = 4.01, age range =18-37). Of those who took part 18 were classed as active smokers, 15 were classed as SATQ, and 17 were classed as never-smokers. All participants were treated in accordance with the ethical standards of the British Psychological Association. In addition, ethics approval was obtained from the University of Kent at Canterbury's Department of Psychology ethics committee before recruiting participants and proceeding with the experiment.

Stimuli, Apparatus & Measures

Stimuli, apparatus, and measures were the same as adopted in Study 1, apart from the neutral pictures of Study 2 which were the control pictures used in Study 1. In addition, neutral-control pairs were used as filler trials to balance stimuli displays with smoking, emotional, and non-emotion/non-smoking stimuli, these neutral-control pairs were not used in the analyses for Study 2.

Procedure

The procedure was the same as in Study 1 with the following exceptions. Stimuli displays were split into four different blocks, two emotion-neutral stimuli blocks and two smoking-neutral stimuli blocks. Dependant on the type of block, participants were either told to either, direct their gaze to the emotion/smoking picture and keep it there for as long as the pictures were presented or to direct their gaze to the neutral picture and keep it there for as long as the pictures were presented. All participants completed all four blocks: attend-smoking whilst neutral pictures were present, attend-emotional whilst neutral pictures were present, attend-neutral whilst smoking pictures were present and, attend neutral whilst emotional pictures were present. In Study 2, participants were not asked to compare the emotional content of pictures. The order of blocks and trials were randomized and the eye-tracker was calibrated between blocks.

3.2.2 - Results

Group Characteristics

A series of one-way ANOVAs were used to identify any between group differences in state and trait anxiety, anxiety sensitivity, emotion ratings of smoking, neutral and emotional stimuli and smoking ratings of smoking, neutral and emotional stimuli. Each ANOVA included Group (smokers, SATQ, and never-smokers) as the independent variable and each measure as the dependent variable. These analyses revealed no significant differences in age, anxiety levels, anxiety sensitivity, the emotion ratings of emotional stimuli, and the smoking ratings of emotional stimuli between the groups (all $Fs < 1.54$, $ps > .2$; See Table 3-7).

Similarly, a series of independent t-tests were conducted to test whether smokers and SATQ differed significantly on Fagerstrom scores, smoking urges scores, subjective craving scores and length of smoking career. Analyses revealed that smokers had significantly longer smoking careers than SATQ ($t(31) = 2.07$, $p < .05$; See Table 3-7). However, there were no significant differences in subjective craving scores, Fagerstrom Scores, or smoking urge scores between the two groups all ($ps > .05$; see Table 3-7).

Table 3-7

Comparison of anxiety measure scores, smoking measures and emotion ratings across each group

Measure		Group: Smokers	SATQ[a]	Never-smokers
State Anxiety		56.00 (5.59)	57.13 (6.84)	55.41 (4.94)
Trait Anxiety		48.17 (2.20)	46.73 (3.61)	48.94 (1.85)
ASI		34.44 (2.71)	32.93 (3.86)	33.47 (1.97)
Fagerstrom Scores		9.19 (1.47)	8.80 (1.57)	-
QSU		26.72 (13.18)	27.87 (16.19)	-
Subjective craving		3.56 (.71)	3.07 (1.67)	-
How long smoked for (years)		7.03 (5.26)	3.97 (2.42)	-
Time since last cigarette		3.90 hours (5.48)	39.72 days (94.92)	-
BCO (ppm)		16.67 (7.05)	4.80 (3.28)	3.06 (3.21)
Emotion Ratings	Smoking images	.33 (1.36)	-1.44 (1.04)	-1.48 (1.13)
	Negative images	-3.26 (.38)	-3.22 (.27)	-3.42 (.47)
	Neutral images	.29 (.40)	.18 (.44)	.61 (.52)
Smoking Ratings	Smoking images	4.31 (.42)	4.06 (.87)	4.68 (.34)
	Negative images	.31 (.16)	.28 (.33)	-.23 (.24)
	Neutral images	.07 (.15)	.04 (.09)	.20 (.26)

NB. Data presented are Means (SD) [a] SATQ = smokers attempting to quit

[b] - Emotion relatedness was scored on a nine-point scale from -4 = highly negative emotion, through 0=neutral, to 4 = highly positive emotion. Participants only rated target picture categories so no values are available for control pictures.

[c] - Smoking relatedness was scored on a six-point scale from 0-not related to smoking, to 5-highly related to smoking. Participants only rated target picture categories so no values are available for control pictures.

Eye-movement data

For analyses it was necessary to classify stimuli as either 'critical images' or 'control images'. Both negative and smoking stimuli were classified as 'critical images' , whereas neutral stimuli were classified as 'control images'.

All eye movement measures were subjected to a 2 x 2 x 2 x 3 mixed measures ANOVA with Block (emotion block; smoking block), Attend (attend critical image; attend control image), and Picture Type (critical image; control image) as the within subject factors and Group (Smokers; Never-smokers; SATQ) as the between subjects factor.

In addition to the eye -tracking measures in Study 1, and in line with Nummenmaa et al. (2006), an additional measure of total time was used to identify if the proportion of time spent on images differed in relation to the images presented and the attend instructions given. Also in line with Nummenmaa et al. (2006), bias scores were computed as a measure of the exogenous shifts in attention which were incongruent with attend instructions across all eye-movement variables: probability of first fixation, time elapsed to first fixation, duration of first pass, sum of fixations on first pass and proportion of total time. These variables provide measures of allocation of attention during early stages of stimulus presentation (probability of first fixation, time elapsed to first fixation), intermediate stages of stimulus presentation (duration of first pass, sum of fixations on first pass) and late stages of stimulus presentation (proportion of total time). Therefore, the presence of exogenous shifts can be mapped over stimulus presentation.

Bias scores were calculated by subtracting eye-movement scores for neutral stimuli away from eye-movement scores for critical stimuli (i.e. smoking or negative emotion stimuli dependant on the block type). These calculations thus gave positive bias scores for increases in attention to critical stimuli (i.e. smoking or negative emotion stimuli) and negative bias scores for increases in attention given to neutral stimuli. These bias scores were then summed across the attend conditions (attend-to-emotion plus attend-to-neutral, or attend-to-smoking plus attend-to-neutral) to give a measure of voluntary control. Nummenmaa et al. (2006) suggest that if voluntary control is given to critical stimuli and neutral stimuli equally then attend-to-neutral bias scores and attend–to-emotion bias scores should sum to zero. Therefore, increases in exogenous shifts to critical stimuli would yield positive scores and, conversely, increases in exogenous shifts to neutral stimuli would yield negative scores. These summed bias scores were tested to identify whether they were significantly different from zero using one-sample t-tests for each of the five eye-movement variables used. As such, these analyses examined the extent to which exogenous shifts in attention were present in the initial orientation of attention, the intermediate allocation of attention, and later stages of attentional engagement.

Attentional Orienting

Probability of first fixation

For the probability of first fixation (see figure 3-3), analyses revealed significant main effects of Block ($F(1, 47) = 103.58, p < .001$, *partial* $\eta^2 = .69$), Attend ($F(1, 47) = 6.76, p < .05$, *partial* $\eta^2 = .13$) and Picture Type ($F(1, 47) = 339.73, p < .001$, *partial* $\eta^2 = .88$), subsumed under significant two-way interactions of Block x Attend ($F(1, 47) = 20.31, p < .001$, *partial* $\eta^2 = .30$), Block x Picture Type ($F(1, 47) = 4.68, p < .05$, *partial* $\eta^2 = .90$), and Attend x Picture Type ($F(1, 47) = 225.18, p < .001$, *partial* $\eta^2 = .83$).

For the Block x Attend interaction, the simple main effect of Attend within the emotion block was significant ($F(1, 47) = 15.96, p < .001$, *partial* $\eta^2 = .25$) indicating that participants were less likely to make fixations on images in the Attend Emotion ($M = .47$, $SE = .003$) condition compared to Attend Neutral condition ($M = .46$, $SE = .003$) ($p < .001$). These effects were spurious and appeared to be a result of some trials where no fixations were allocated to either image and therefore were not considered theoretically relevant. There was no simple main effect of Attend in the smoking block ($F(1,47) = 2.42, p > .1$, *partial* $\eta^2 = .04$; Attend Neutral ($M = .49$, $SE = .002$), Attend Smoking ($M = .49$, $SE = .003$).

Simple effects analyses for the Block x Picture Type interaction indicated there was no difference in the number of fixations to critical images under emotional block ($M = .64$, $SE = .01$) compared to the smoking block ($M = .64$, $SE = .01$; $F(1, 47) = .5$, $p > .1$, *partial* $\eta^2 = .001$). However, there were greater number of fixations on neutral images on smoking block ($M = .35$, $SE = .01$) than emotional block ($M = .29$, $SE = .01$; $F(1, 47) = 15.73, p < .001$, *partial* $\eta^2 = .25$).

For the Attend x Picture Type interaction, analysis of simple main effects of Picture Type for the Attend Critical condition was significant ($F(1, 47) = 609.58, p < .001$, *partial* $\eta^2 = .93$), indicating that participants were more likely to initially fixate on critical stimuli (smoking or negative images; $M = .79$, $SE = .01$) than neutral stimuli ($M = .16$, $SE = .01$). In contrast, the simple main effect of Picture Type was not significant in the attend control condition ($F(1, 47) = .002, p > .1$, *partial* $\eta^2 < .001$). Participants initially fixated on critical stimuli (smoking and negative; $M = .48$, $SE = .01$) to a similar extent as neutral stimuli ($M = .48$, $SE = .02$), indicating that in the attend control condition eye-movements were not congruent with the attend instructions given.

Examination of the bias scores for the probability of first fixation (See Figure 3-8 & Figure 3-9) indicated general biases towards negative and smoking images irrespective of the attend instructions given. To examine whether the sum of biases (indicated by black squares in Figure 3-8 & Figure 3-9) for each block were significantly different from zero one-sample t-tests were conducted separately for each group. These analyses revealed significant differences from zero across all groups (Smokers: negative $t(18) = 7.48, p < .001$, smoking $t(18) = 9.34, p < .001$; SATQ: negative $t(14) = 11.37, p < .001$, smoking $t(14) = 9.32, p < .001$; Never-smokers: negative $t(15) = 8.35, p < .001$, smoking $t(15) = 6.54, p < .001$). This indicates that participants were making exogenous shifts in the initial orientation of attention to smoking and negative stimuli irrespective of the attend instructions given.

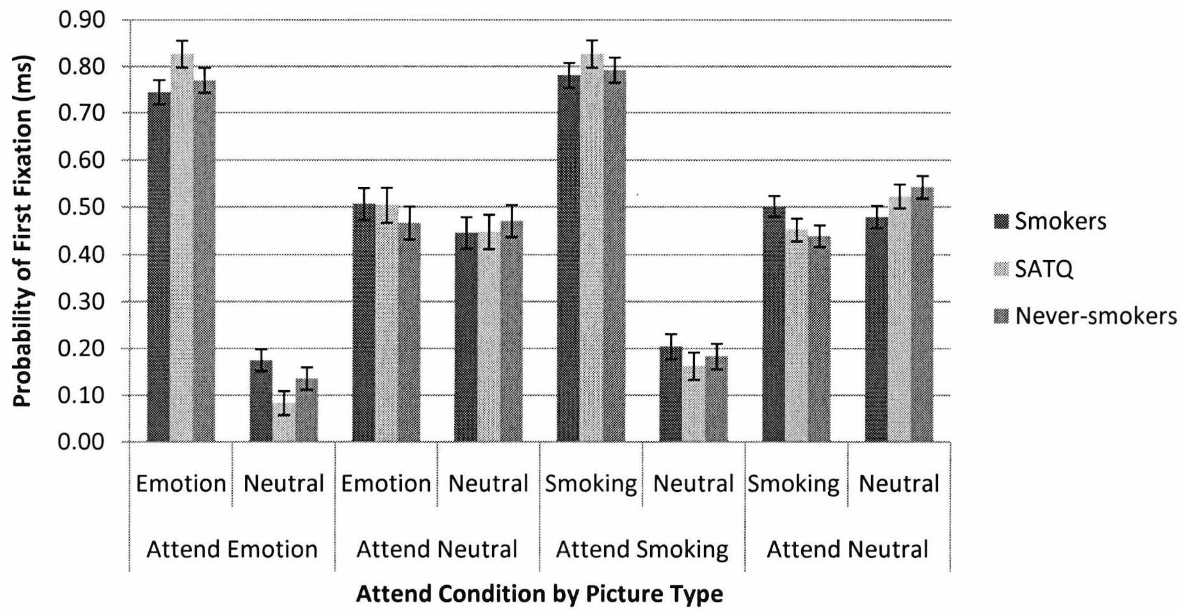


Figure 3-3 **- Block x Attend x Picture Type x Group interaction for probability of first fixation**

Elapsed time to region

Analysis conducted for elapsed time taken to make an initial fixation revealed a main effect of Picture Type ($F(1, 46) = 14.59, p < .001$, *partial* $\eta^2 = .24$; see Figure 3-4). The analysis also revealed significant main effects of Attend ($F(1, 46) = 44.58, p < .001$, *partial* $\eta^2 = .49$) and a two-way interaction of Block x Picture Type ($F(1, 46) = 8.68, p = .005$, *partial* $\eta^2 = .16$), Attend x Picture Type ($F(1, 46) = 278.70, p < .001$, *partial* $\eta^2 = .85$). However, these main effects and interactions were qualified by two significant three way interactions of Block x Picture Type x Group ($F(2, 46) = 3.13, p = .05$, *partial* $\eta^2 = .12$) and Attend x Picture Type x Group ($F(2, 46) = 4.82, p < .05$, *partial* $\eta^2 = .17$).

For the Block x Picture Type x Group interaction, ANOVAs conducted for each group separately revealed a significant Block x Picture Type interaction in never-smokers ($F(1, 15) = 10.59, p = .005$, *partial* $\eta^2 = .41$), but this was not significant in smokers ($F(1, 14) = .92, p = .35$, *partial* $\eta^2 = .06$) or SATQ ($F(1, 14) = 2.75, p > .1$, *partial* $\eta^2 = .16$). Within never-smokers, the simple main effect of Picture Type for the emotion block was significant ($F(1, 15) = 13.26, p < .005$, *partial* $\eta^2 = .47$), indicating significantly longer latencies to fixate on neutral images (M = 502ms, SE = 39ms) compared to negative images (*M* = 403ms, *SE* = 28ms, $p < .005$). There was no significant difference in the time taken to fixate on smoking images (*M* = 493ms, *SE* = 40ms) and neutral images (*M* = 476ms, *SE* = 31ms) in the smoking block ($F(1, 16) = .60$, $p > .1$, *partial* $\eta^2 = .06$).

For the Attend x Picture Type x Group interaction, ANOVAs conducted separately for each Picture Type revealed a significant interaction of Attend x Group for critical images ($F(2, 47) = 8.43$, $p = .001$, *partial* $\eta^2 = .26$) but this interaction was not significant for neutral images ($F(2, 46) = .89$, $p > .1$, *partial* $\eta^2 = .04$). For critical images, simple main effects analysis revealed a marginally significant effect of group for the attend critical condition ($F(2, 47) = 2.67$, $p = .08$, *partial* $\eta^2 = .10$). This marginal effect was indicative of smokers taking longer to fixate on critical images (*M* = 588ms, *SE* = 34ms), compared to SATQ (*M* = 490ms, *SE* = 37) and never-smokers (*M* = 491ms, *SE* = 35). However, using Bonferroni correction these differences became non-significant (all *ps*>.1). There was no main effect of Group in the attend control condition ($F(2, 47) = 1.60$, $p > .1$, *partial* $\eta^2 = .06$; smokers: *M* = 365ms, *SE* = 24; SATQ: *M* = 347ms, *SE* = 26ms; never-smokers *M* = 408ms, *SE* = 24ms).

Bias scores (See Figure 3-8 & Figure 3-9, Time Elapsed to First Fixation), indicated slight bias towards negative emotion images over neutral images, but relatively equal bias for smoking images and neutral images. One sample t-tests showed that the sum of bias scores for the negative trials was significantly different from zero for never-smokers ($t(15) = 3.31$, $p = .005$) and also when bias scores were summed across all participants ($t(48) = 8.91$, $p < .005$). However, one sample t-tests conducted for smokers and SATQ indicated that the sum of bias scores for negative images did not differ from zero (smokers: $t(17) = 1.14$, $p > .1$; SATQ: $t(14) = 1.67$, $p > .1$). For smoking trials the sum of bias scores across all groups were not significantly different from zero (smokers: $t(17) = -.27$, $p > .1$; SATQ: $t(14) = 1.39$, $p > .1$; never-smokers: $t(16) = -1.23$, $p > .1$). This indicates that there were exogenous shifts in attention to emotion stimuli in never-smokers, but these did not occur in SATQ or smokers. Furthermore, there was no evidence in exogenous shifts to smoking stimuli for elapsed time to region.

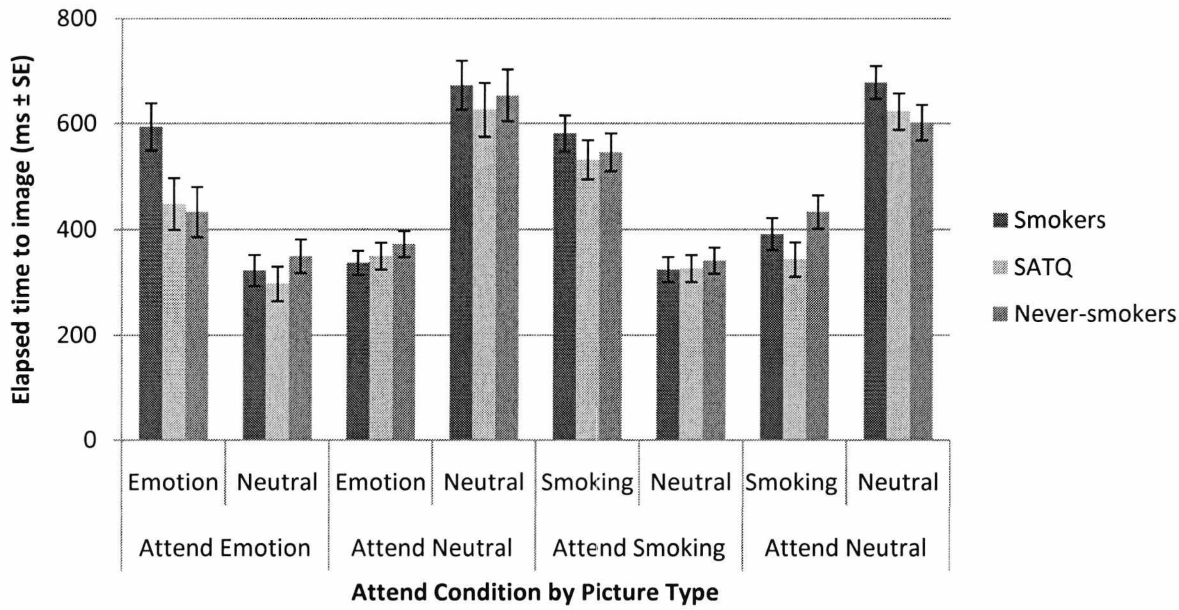


Figure 3-4 **- Block x Attend x Picture Type x Group interaction for elapsed time to region**

Attentional engagement

Sum of Fixations on First Pass

Analyses of the number of fixations made on the first pass revealed a significant main effect of Picture Type ($F(1, 47) = 7.74, p = .001$, *partial* $\eta^2 = .21$) which was qualified by a significant two-way interaction of Attend x Picture Type ($F(1, 47) = 842.46, p < .001$, *partial* $\eta^2 = .96$; see figure 3-5). Simple main effects analysis confirmed that there were significantly more fixations to critical stimuli ($M = 5.89$, $SE = .18$) compared to neutral stimuli ($M = .27$, $SE = .05$), in the attend critical condition ($F(1, 47) = 919.91, p = .001$, *partial* $\eta^2 = .38$) and conversely, significantly more fixations on neutral stimuli ($M = 5.56$, $SE = .22$) compared to critical stimuli ($M = .04$, $SE = .02$) in the attend neutral condition ($F(1, 47) = 6.46, p < .001$, *partial* $\eta^2 = .93$). These effect were indicative of participants complying with the attend instructions given.

Examination of the bias scores for the sum of fixation on first pass (See Figure 3-8 & Figure 3-9) in the negative blocks indicated slight bias to negative images over neutral images across all groups. However, only a slight bias to smoking images over neutral images was indicated in never-smokers. One-sample t-tests showed that the sum of bias scores was significantly different from zero in negative and smoking trials in never-smokers (negative: $t(16) = 2.74, p < .05$; smoking; $t(16) = 2.83, p < .05$). The sum of bias scores for negative and smoking trials were not significantly different from zero in smokers (negative: $t(17) = 1.79, p > .1$; smoking: $t(17) = .41, p > .1$) and SATQ (negative: $t(14) = 2.07, p > .05$; smoking: $t(14) = 1.09, p > .1$). However, when analyses were conducted across all participants, irrespective of group status, sum of bias scores were significantly different for both smoking trials ($t(49) = 2.82, p = .01$) and negative trials ($t(49) = 3.67, p < .001$).

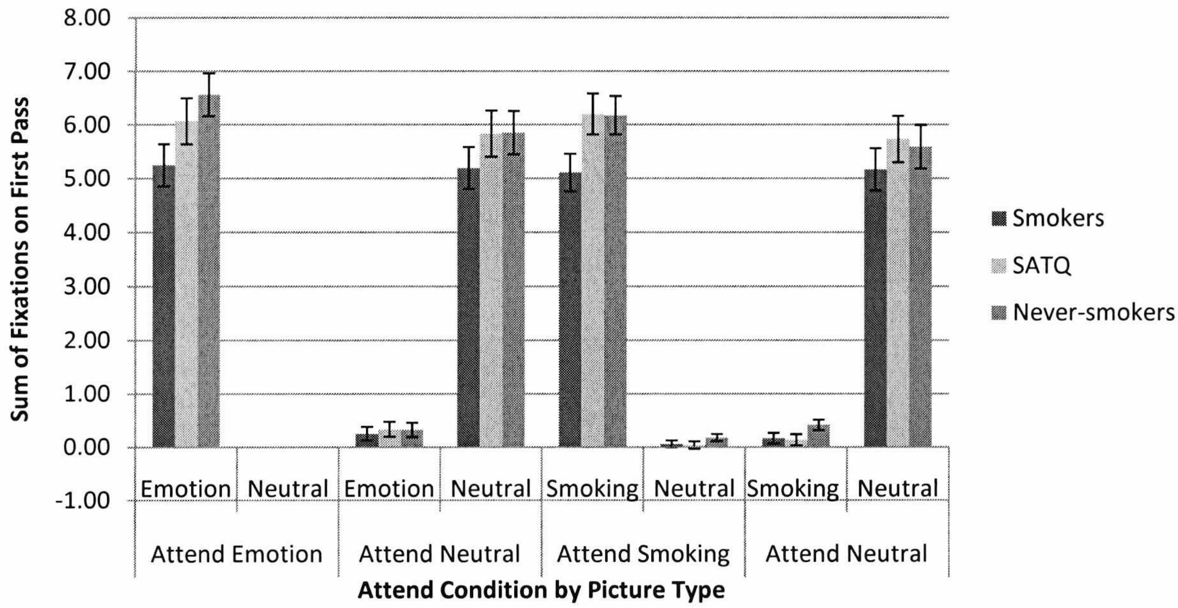


Figure 3-5 **- Block x Attend x Picture Type x Group interaction for sum of fixations on first pass**

Duration of First Pass

Analysis of the durations on first pass revealed a significant main effect of Picture Type ($F(1, 46) = 4.12, p < .05$, *partial* $\eta^2 = .08$), Group ($F(2, 46) = 5.39, p < .008$, *partial* $\eta^2 = .19$), and a significant two-way interaction of Attend x Picture Type ($F(2, 46) = 302.62, p < .001$, *partial* $\eta^2 = .87$), which were subsumed under significant three-way interactions of Attend x Picture Type x Group $F(2, 46) = 4.23, p < .05$, *partial* $\eta^2 = .16$) and Block x Attend x Picture Type ($F(1, 46) = 3.93, p < .05$, *partial* $\eta^2 = .08$; see figure 3-6).

For the Attend x Picture Type x Group interaction ANOVAs conducted for each Attend condition separately revealed a significant interaction of Picture Type x Group for the attend critical condition. ($F(2, 47) = 4.87$, $p < .05$, *partial* $\eta^2 = .18$). Simple main effects analysis revealed a significant main effect of Group for critical images ($F(2, 47) = 6.57$, $p < .005$, *partial* $\eta^2 = .22$) with smokers spending significantly less time on critical pictures on the first pass (M = 1,051ms, SE = 108ms) compared to SATQ (M = 1,515ms, SE = 118, $p < .05$) and never-smokers (M = 1,561ms, SE = 111ms, $p < .01$). There was no significant difference in time spent on neutral images between SATQ and never-smokers ($p > .1$). Furthermore, there was no significant difference between groups in the duration of first pass for neutral pictures in the attend critical condition ($F(1, 46) = 1.55$, $p > .1$, *partial* $\eta^2 = .06$; smokers: M = 154ms, SE = 37; SATQ: M = 161ms, SE = 40ms; never-smokers: M = 241ms, SE = 39).

There was also a significant Picture Type x Group interaction for the Attend Control condition ($F(2, 47) = 3.40$, $p < .05$, *partial* $\eta^2 = .13$). Simple main effect analysis revealed a significant simple main effect of Group for neutral images ($F(1, 47) = 4.10$, $p < .05$, *partial* $\eta^2 = .15$). This indicates significantly shorter first pass durations on neutral stimuli in smokers (M = 1,031ms, SE = 123) compared to never-smokers (M = 1,506ms, SE = 127, $p < .05$). There was no significant difference in the duration of first pass between smokers and SATQ (M = 1,417ms, SE = 135ms, $p > .1$) and between SATQ and never-smokers ($p > .1$). Furthermore there were no significant between group differences in duration of first pass to critical stimuli in the attend neutral condition ($F(2, 47) = 2.00$, $p > .1$, *partial* $\eta^2 = .08$; smokers: M = 177ms, SE = 24ms; SATQ: M = 206ms, SE = 27ms; never-smokers: M = 247, SE = 25ms).

For the Block x Attend x Picture Type interaction, ANOVAs conducted for each Block revealed significant Attend x Picture interactions for both the emotion block ($F(1, 46) = 3.87$, $p < .05$, *partial* $\eta^2 = .14$) and the smoking block ($F(1, 47) = 233.40$, $p < .001$, *partial* $\eta^2 = .83$). Simple effects analysis revealed that the interaction resulted from a significant shorter gaze duration to neutral stimuli in the attend emotion condition (M = 164ms, SE = 8ms) compared to emotion stimuli in the attend neutral condition (M = 198ms, SE = 10ms; $F(1, 46) = 9.42$, $p < .005$, *partial* $\eta^2 = .17$). In contrast, there were no significant differences in the gaze duration between neutral stimuli in the attend smoking condition (M = 208ms, SE = 42ms) compared to smoking stimuli in the attend neutral condition (M = 223ms, SE = 28ms; $F(1, 47) = .69$ $p > .1$, *partial* $\eta^2 = .01$).

Similarly, gaze durations were not significantly different between emotion images in the attend emotion condition (*M* = 1,423ms, *SE* = 70ms) and neutral images in the attend neutral condition of the emotion block (*M* = 1,345, *SE* = 80ms; $F(1, 47) = 1.49, p > .1$, *partial* $\eta^2 = .03$), or between smoking images in the attend smoking condition (*M* = 1,328ms, *SE* = 74ms) and neutral images in the attend neutral condition of the smoking block (*M* = 1,291ms, *SE* = 76ms; $F(1, 47) = .45, p > .1$, *partial* $\eta^2 = .01$).

Examination of the bias scores for the duration of first pass (See Figure 3-8 & Figure 3-9) indicated relatively equal bias across negative trials and smoking trials. One-sample t-tests conducted separately for each group confirmed that the sum of bias scores was not significantly different from zero for negative trials across all groups (all $t < 2.1, ps > .05$) and in smoking trials for SATQ and never-smokers (all $ts < 1.5, ps < .05$). However, in smokers the sum of bias scores was significantly different from zero ($t(17) = 2.08, p < .05$), indicating a positive bias towards smoking over neutral stimuli. Also, when analyses were conducted across all participants, irrespective of group status, sum of bias scores were significantly different for both smoking trials ($t(49) = 2.83, p= .01$) and negative trials ($t(48) = 3.11, p < .005$).

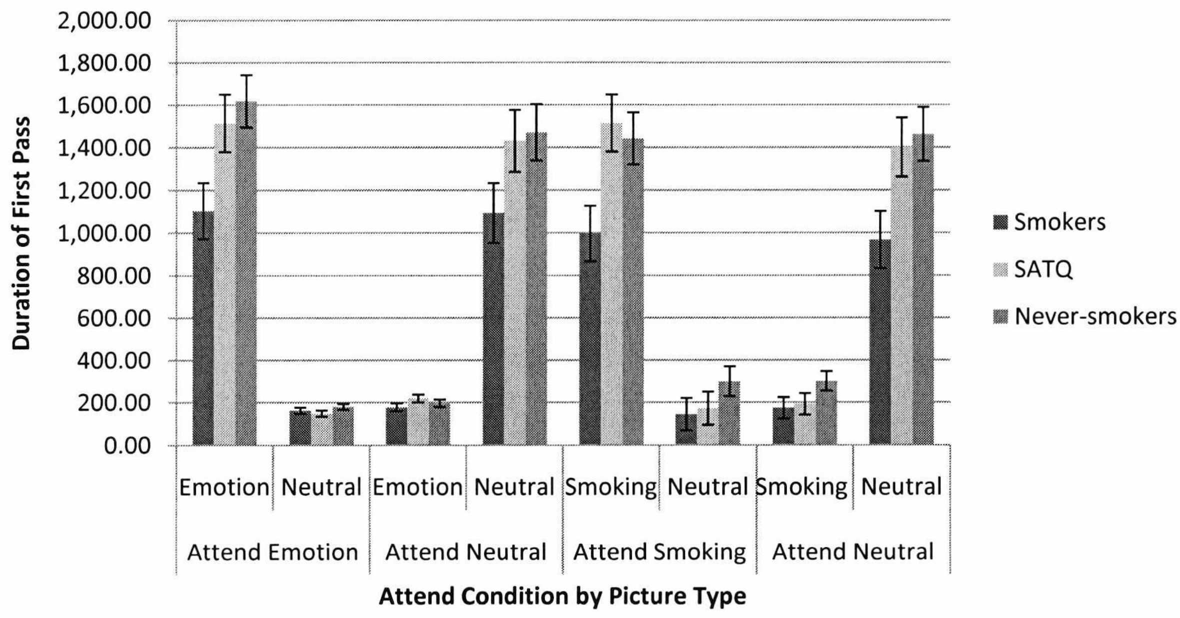


Figure 3-6 **- Block x Attend x Picture Type x Group interaction for duration of first pass**

Proportion of Total Time

An examination of Proportion of Total Time spent in image locations using repeated measure ANOVAs revealed a number of significant main effects and interactions. In particular, the analysis revealed a main effect of Attend ($F(1, 46) = 4.28$, $p < .05$, *partial* $\eta^2 = .09$), Picture Type ($F(1, 46) = 14.95$, $p < .001$, *partial* $\eta^2 = .25$), and group ($F(1, 46) = 8.91$, $p = .001$, *partial* $\eta^2 = .28$) and a two–way interaction of Attend x Picture Type ($F(1, 46) = 713.79$, $p < .001$, *partial* $\eta^2 = .94$; see Figure 3-7). These main effects and interaction were qualified under two three-way interactions of Attend x Picture Type x Group ($F(2, 46) = 6.38$, $p < .005$, *partial* $\eta^2 = .22$) and Block x Attend x Picture Type ($F(1, 46) = 4.67$, $p < .05$, *partial* $\eta^2 = .09$).

For the Attend x Picture Type x Group interaction ANOVAs conducted for each Attend condition separately revealed a significant interaction of Picture Type x Group for the attend critical condition. ($F(2, 46) = 7.63$, $p < .001$, *partial* $\eta^2 = .25$). Simple main effects analysis revealed a significant main effect of Group for critical images ($F(2, 47) = 11.11$, $p < .001$, *partial* $\eta^2 = .32$) with smokers spending significantly less time on critical pictures (M = 1,326ms, SE = 88ms) compared to SATQ (M = 1,734ms, SE = 97, $p < .05$) and never-smokers (M = 1,882ms, SE = 91ms, $p < .01$). There was no significant difference in time spent on critical images between SATQ and never-smokers ($p > .1$). There was no significant difference between groups in the proportion of total time for neutral pictures in the attend critical condition ($F(1, 46) = 2.75$, $p > .05$, *partial* $\eta^2 = .11$; smokers: M = 182ms, SE = 14ms; SATQ: M = 166ms, SE = 15ms; never-smokers: M = 186ms, SE = 15).

There was also a significant Picture Type x Group interaction for the Attend Control condition ($F(1, 47) = 4.81$, $p < .05$, *partial* $\eta^2 = .17$). Simple main effect analysis revealed a significant simple main effect of Group for neutral images ($F(1, 47) = 6.30$, $p < .005$, *partial* $\eta^2 = .21$). First pass durations were significantly shorter on neutral stimuli in smokers (M = 1,268ms, SE = 87ms) compared to never-smokers (M = 1,682ms, SE = 89, $p = .005$) and SATQ (M = 1,614ms, SE = 95ms, $p < .05$). There was no significant difference in time spent on neutral images between SATQ and never-smokers ($p > .1$). Furthermore there were no significant between group differences in duration of first pass to critical stimuli in the attend neutral condition ($F(2, 47) = 1.90$, $p > .1$, *partial* $\eta^2 = .08$; smokers: M = 190ms, SE = 25ms; SATQ: M = 213ms, SE = 28ms; never-smokers: M = 260, SE = 25ms).

For the Block x Attend x Picture Type interaction, ANOVAs conducted for each Block revealed significant Attend x Picture interactions for both the emotion block ($F(1, 46) = 749.83, p < .001$, *partial* $\eta^2 = .94$) and the smoking block ($F(1, 46) = 469.39$, $p < .001$, *partial* $\eta^2 = .91$). Simple effects analysis revealed that the interaction resulted from significantly shorter gaze duration to neutral stimuli in the attend emotion condition ($M = 178$ms, $SE = 8$ms) compared to emotion stimuli in the attend neutral condition ($M = 206$ms, $SE = 10$ms; $F(1, 46) = 6.02, p < .05$, *partial* $\eta^2 = .12$). Gaze durations were also significantly different between emotion images in the attend emotion condition ($M = 1,647$ms, $SE = 53$ms) and neutral images in the attend neutral condition of the emotion block ($M = 1,547$ms, $SE = 58$ms; $F(1, 47) = 5.08, p < .05$, *partial* $\eta^2 = .10$), and between smoking images in the attend smoking condition ($M = 1,561$, $SE = 55$ms) and neutral images attend neutral condition of the smoking block ($M = 1,495$ms, $SE = 52$ms; $F(1, 47) = 4.00, p = .05$, *partial* $\eta^2 = .08$). In contrast, there were no significant differences in the gaze duration between neutral stimuli in the attend smoking condition ($M = 220$ms, $SE = 41$ms) and smoking stimuli in the attend neutral condition ($M = 237$ms, $SE = 29$ms; $F(1, 47) = .97, p > .33$, *partial* $\eta^2 = .02$).

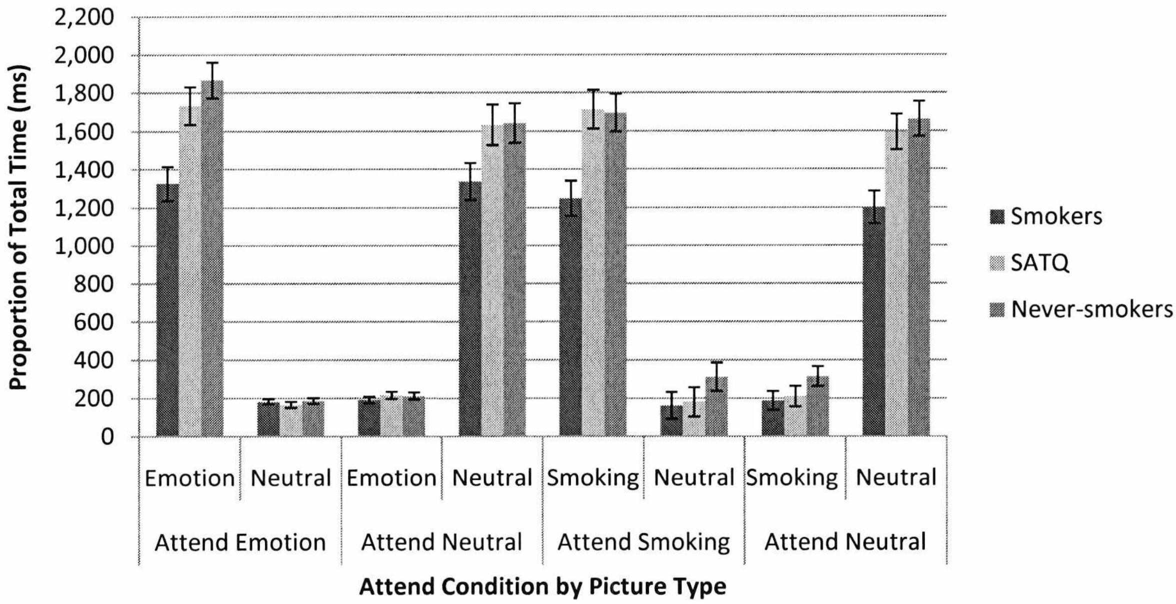


Figure 3-7 **- Block x Attend x Picture Type x Group interaction for proportion of total time**

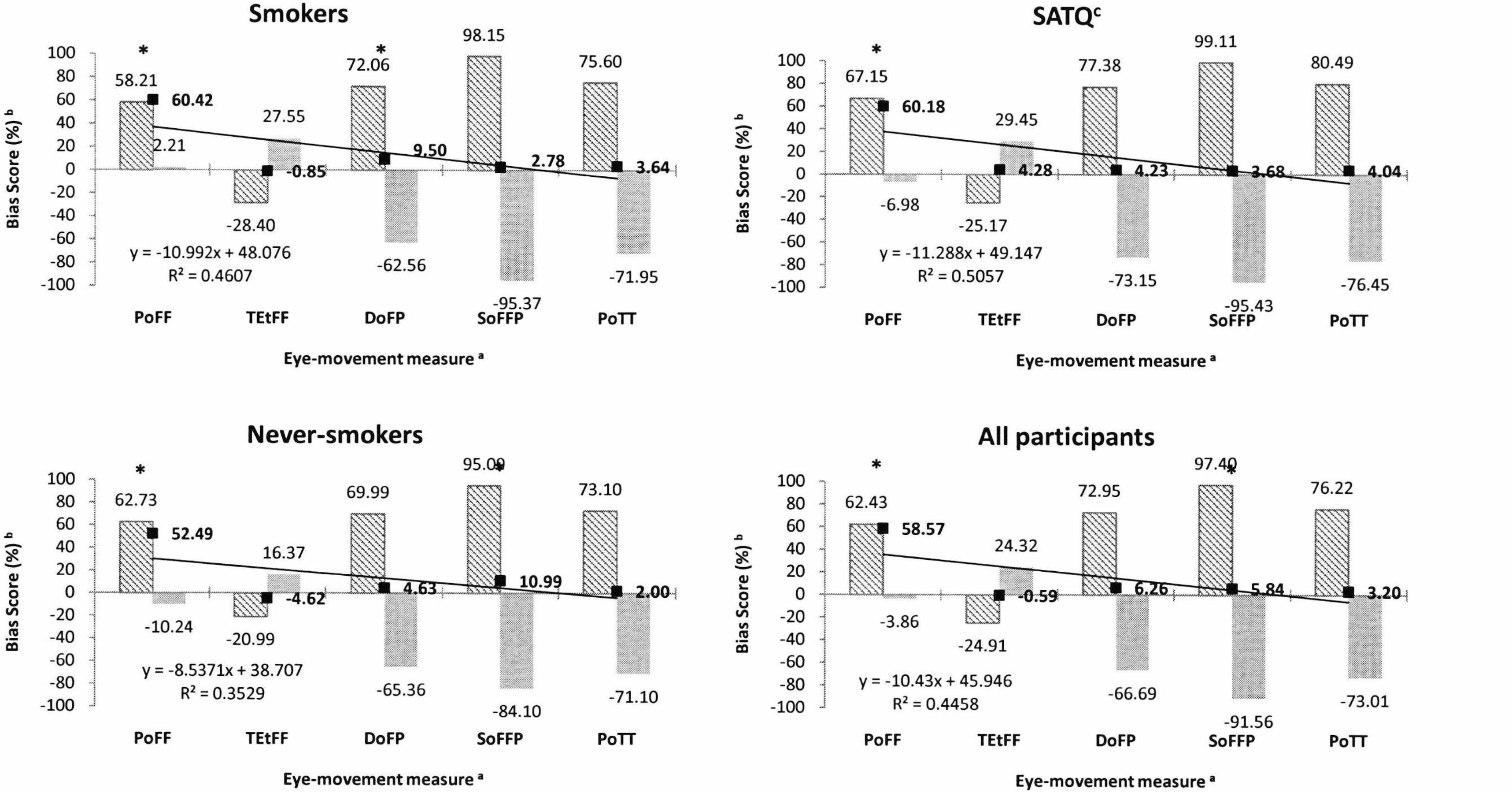
Examination of the bias scores for the proportion of total time (See Figure 3-8 & Figure 3-9) indicated relatively equal bias across negative trials and smoking trials. One-sample t-tests conducted separately for each group confirmed that the sum of bias scores was not significantly different from zero for smoking trials in smokers and never-smokers across (*ts* <2.1, *ps*>.05). However, they were significantly different from zero in SATQ ($t(14) = 2.36, p < .05$). In contrast, sum of bias scores for negative trials were significantly different from zero in never-smokers ($t(15) = 2.24, p < .05$) and SATQ ($t(14) = 3.51, p < .005$), but not in smokers ($t(17) = .68, p > .1$). However, when analyses were conducted across all participants, irrespective of group status, sum of bias scores were significantly different from zero for both smoking trials ($t(49) = 2.38, p < .05$) and negative trials ($t(48) = 3.38$, p = .001).

Bias scores across eye-movement measures

In addition to the main analyses shown above, an examination of the bias scores (see Figure 3-8 and Figure 3-9) indicated that there was greater bias towards emotional and smoking pictures during early attentional orientation (shown by probability of first fixation), compared to during intermediate and late attentional engagement (shown by duration of first pass, sum of fixations on first pass and proportion of total time). To examine if there were any significant differences in the sum of bias scores across eye-movement measures (probability of first fixation, time elapsed to first fixation, duration of first pass, sum of fixations on first pass, proportion of total time) mixed measure ANOVAs were conducted using smoking sum of bias scores and negative sum of bias scores separately. These ANOVAs incorporated Measure (probability of first fixation, time elapsed to first fixation, duration of first pass, sum of fixations on first pass, proportion of total time) as the within group factor and Group (smokers, SATQ and never-smokers) as the between group factor. These analyses revealed a significant main effect of Measure for both the negative sum of bias scores ($F(4, 184) = 98.24, p < .001$, *partial* $\eta^2 = .68$) and smoking trials ($F(4, 188) = 106.16, p < .001$, *partial* $\eta^2 = .69$). The main effect of Group or interaction of Measure x Group were not significant (*Fs* <.5, *ps*>.1). Post hoc analyses using Bonferroni correction for the main effect of Measure revealed significantly greater bias to negative and smoking stimuli in the probability of first fixation compared to any of the other eye-movement measures (all *ps* <.001). There were no significant differences in the sum of bias scores between time elapsed to first fixation, duration of first pass, sum of fixations on first pass, and proportion of total time). Furthermore, examination of the linear trend for the sum of bias scores across eye-movement measures revealed relatively low R^2 values (all R^2's $<.57$) indicating that the data did not conform to a good linear fit.

With regards to exogenous shifts of attention these findings show that attentional shifts were most congruent with attend instructions during the intermediate and late attentional engagement stages and were least congruent with attend instructions during early attentional orientation stage. This indicates that the initial orientation of attention was more susceptible to involuntary exogenous shifts in attention to smoking and negative stimuli compared to latter attentional engagement.

Figure 3-8 - **Bias to smoking images for each eye-movement measure also showing measure of voluntary control (sum of bias scores) for each group**



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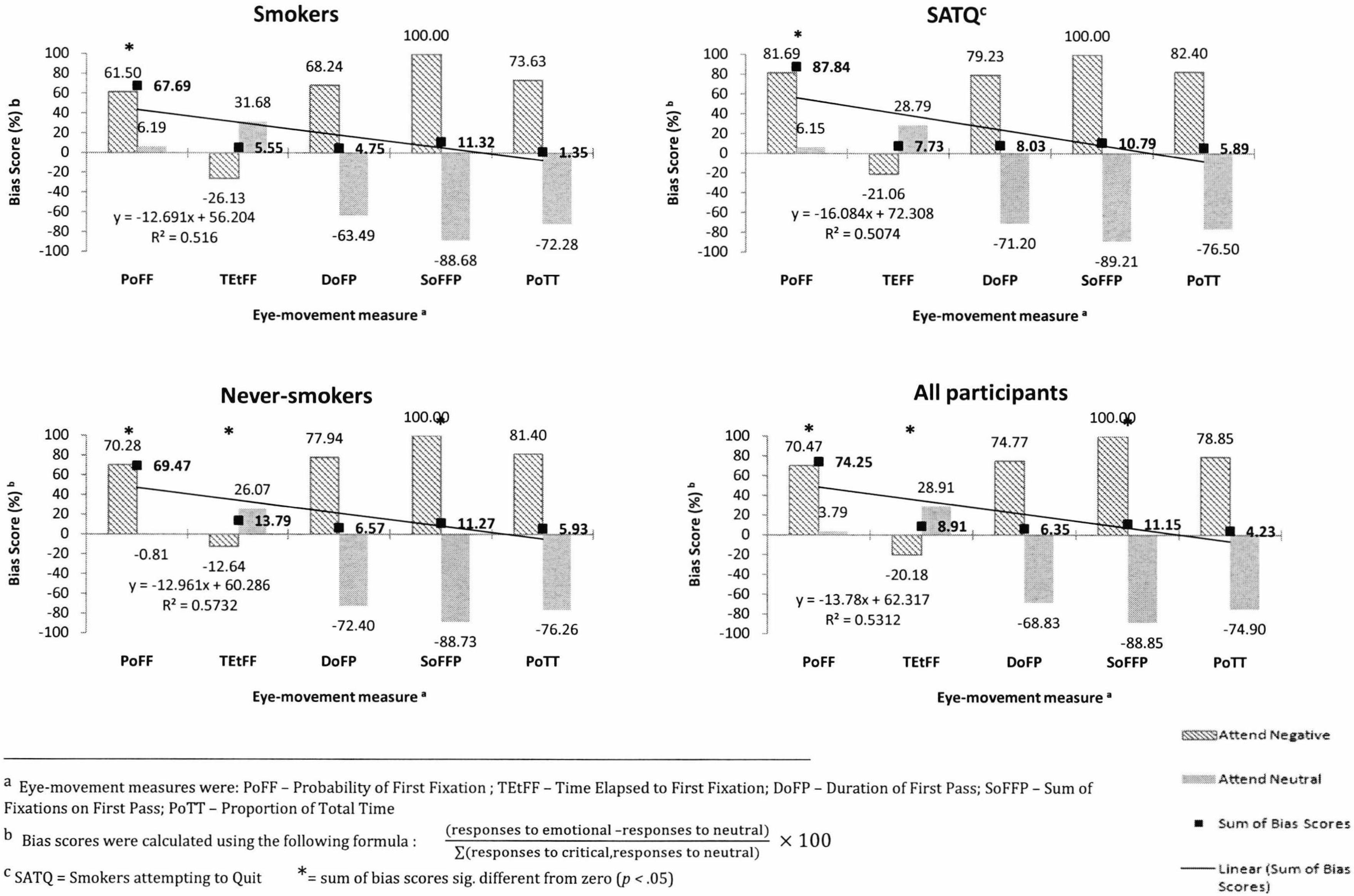
[a] Eye-movement measures are: PoFF – Probability of First Fixation; TEtFF – Time Elapsed to First Fixation; DoFP – Duration of First Pass; SoFFP – Sum of Fixations on First Pass; PoTT – Proportion of Total Time

[b] Bias scores were calculated using the following formula : $\frac{\text{(responses to smoking} - \text{responses to neutral)}}{\sum\text{(responses to critical, responses to neutral)}} \times 100$

[c] SATQ = Smokers attempting to Quit *= Sum of bias scores sig. different from zero (*p* <.05)

Figure 3-9 - Bias to negative emotion images for each eye-movement measure also showing measure of voluntary control (sum of bias scores) for each group



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[a] Eye-movement measures were: PoFF – Probability of First Fixation ; TEtFF – Time Elapsed to First Fixation; DoFP – Duration of First Pass; SoFFP – Sum of Fixations on First Pass; PoTT – Proportion of Total Time

[b] Bias scores were calculated using the following formula : $\frac{\text{(responses to emotional} - \text{responses to neutral)}}{\sum\text{(responses to critical,responses to neutral)}} \times 100$

[c] SATQ = Smokers attempting to Quit * = sum of bias scores sig. different from zero ($p < .05$)

Correlation Analyses

Correlation analyses between sum of bias scores

Correlation analyses were conducted to examine the relationship between the sum of bias scores for negative stimuli and the sum of bias scores for smoking stimuli, for all eye-movement measures (probability of first fixation, time elapsed to stimuli, duration of first pass, sum of first pass fixations, and proportion of total time; see Table 3-8). These analyses revealed no significant correlations (all *rs* <.5, *ps*>.1).

Table 3-8

Pearson's correlation analyses between the sum of bias scores for smoking trials and the sum of bias scores for negative trials for each eye-movement measure

	Smokers (N=18)	SATQ[a] (N=15)	Never-smokers (N=17)
Probability of first fixation	.40	.15	.26
Time elapsed to first fixation	.43	.26	-.36
Duration of first pass	.19	-.44	.32
Sum of first pass fixations	.25	.10	-.11
Proportion of Total Time	-.05	-.22	.11

* - *p <.05* [a] = Smokers attempting to quit

** - *p < .005*

Correlation analyses between smoking variables and sum of bias scores

In order to identify whether responses to smoking and negative emotion stimuli were related to self-reported smoking behaviour and craving, correlation analyses were conducted between responses given in the smoking questionnaires and bias scores for smoking stimuli separately for smokers and SATQ (see table 3-9). For smokers these analyses revealed a number of negative correlations between smoking measures and eye-movement measures for smoking image trials. In particular, these showed that time elapsed to first fixation was negatively correlated with how long smoked for, duration of first pass was negatively correlated with Fagerstrom scores, and the proportion of total time spent on smoking images was negatively correlated with subjective craving scores and Fagerstrom scores. There were no significant correlations between smoking behaviour measures and eye-movement measures to negative images in smokers. For SATQ, the proportion of total time spent on smoking images was negatively correlated with craving and Fagerstrom scores, but was positively correlated with the time since last cigarette. Also, the duration of first pass to smoking images was negatively correlated with Fagerstrom scores, and the time elapsed to region for smoking images was negatively correlated with length of smoking career. A negative correlation was also shown between smoking urge score and the bias scores for probability of first fixating on smoking images in SATQ.

Correlation analyses between anxiety variables and sum of bias scores

To identify if responses to smoking and negative emotion stimuli were associated with anxiety or emotion relatedness of stimuli, correlation analyses were conducted (see Table 3-10). These analyses used responses given in anxiety and emotion questionnaires, and bias scores to smoking and negative stimuli separately for each group. These analyses revealed no significant positive correlations for never-smokers. However, significant correlations were noted for smokers and SATQ. In particular, for smokers a significant positive correlation was shown between anxiety sensitivity scores and the proportion of total time for negative images and a negative correlation was shown between emotion rating of negative images and the duration of the first pass on negative images. The latter indicated that the more negative the images were rated the higher the bias of gaze duration towards negative images. For SATQ these analyses showed a significant positive correlation between trait anxiety and the bias scores for sum of fixations for smoking images. They also revealed a significant positive correlation between the emotional rating of negative images and the sum of fixations for negative images; the more positive the rating of negative images the greater the sum of fixations bias to negative images. The analyses also revealed a significant negative correlation for SATQ between state anxiety and the duration of first pass on negative images.

Table 3-9

Pearson's correlation analyses between the sum of bias scores for smoking trials and negative trials and smoking-related measures

		Negative Trials					Smoking Trials				
		PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]	PoTT[a]	PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]	PoTT[a]
Subjective Crave Score	SM[b]	.02	-.02	-.09	-.05	.02	-.04	-.43	-.35	.08	-.56*
	SATQ[c]	-.47	-.40	.09	.07	-.02	.07	-.26	-.54*	-.59*	-.55*
Fagerstrom	SM[b]	-.39	.22	-.43	-.19	-.25	-.03	-.32	-.59*	-.16	-.58*
	SATQ[c]	-.04	-.16	.13	.01	-.36	-.11	-.38	-.09	-.08	-.30
QSU	SM[b]	-.13	-.35	-.13	-.11	-.05	.04	-.23	-.12	-.01	-.17
	SATQ[c]	-.56*	-.39	.10	.06	-.31	.17	-.33	-.05	-.30	-.42
How Long Smoked For	SM[b]	-.25	-.01	.11	.12	.13	-.34	-.48*	.27	.41	-.04
	SATQ[c]	-.02	-.02	-.22	.00	-.38	-.05	.08	-.16	-.11	-.28
Time Since Last Cigarette	SM[b]	.08	-.26	.23	.10	.25	-.08	.00	.36	-.28	.36
	SATQ[c]	-.19	-.23	.08	-.21	.06	.17	.04	.35	-.14	.60*

*- $p < .05$, ** - $p < .005$ [b] *SM* = Smokers [c] SATQ=smokers attempting to quit

[a] Eye-movement measures were:

PoFF – Probability of First Fixation ; TEtFF – Time Elapsed to First Fixation; DoFP – Duration of First Pass; SoFFP – Sum of Fixations on First Pass; PoTT – Proportion of Total Time

Table 3-10

Pearson's correlation analyses between the sum of bias scores for smoking trials and negative trials and anxiety / emotion measures

		Negative Trials					Smoking Trials				
		PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]	PoTT[a]	PoFF[a]	TEtFF[a]	DoFP[a]	SoFFP[a]	PoTT[a]
State Anxiety	SM[b]	.18	-.10	.14	.05	.28	.10	.22	-.04	-.33	-.22
	SATQ[c]	-.25	-.07	-.55*	-.05	-.40	-.18	.01	.11	.00	.18
	NS[d]	.12	.16	-.32	.38	-.34	.32	-.31	-.04	-.16	.06
Trait Anxiety	SM[b]	.06	.15	-.11	.09	-.01	.03	-.11	.27	-.15	-.01
	SATQ[c]	.44	.19	-.23	.16	-.12	.13	-.07	.29	.58*	-.19
	NS[d]	.18	.26	-.11	.22	-.10	.04	-.34	-.05	.03	.12
ASI	SM[b]	.37	.25	.36	.07	.51*	.03	-.04	.06	-.31	.19
	SATQ[c]	-.37	-.12	.15	-.28	.12	-.35	-.09	.03	-.15	.41
	NS[d]	.06	-.35	.39	-.22	.42	.07	.44	.29	-.16	.19
Smoking - Emotion	SM[b]	-.09	.13	-.31	-.03	-.29	-.18	-.01	.25	-.10	.20
	SATQ[c]	-.08	.29	.35	-.08	.42	-.20	.05	-.15	.05	.23
	NS[d]	.04	-.03	.30	-.08	.23	.02	-.01	-.31	-.13	-.30
Negative - Emotion	SM[b]	-.10	.06	-.31	-.53*	-.31	-.07	-.37	-.34	-.09	-.31
	SATQ[c]	-.20	-.06	-.29	.68**	.10	-.16	.11	-.01	.27	.18
	NS[d]	-.12	.30	.22	.11	.18	.21	-.07	-.31	.05	-.33

*- $p < .05$, ** - $p < .005$ [b] *SM* = Smokers   [c] SATQ=smokers attempting to quit   [d] NS=Never-Smokers

[a] Eye-movement measures were:

PoFF – Probability of First Fixation ; TEtFF – Time Elapsed to First Fixation; DoFP – Duration of First Pass; SoFFP – Sum of Fixations on First Pass; PoTT – Proportion of Total Time

3.2.3 - Summary of findings study 2

The main findings of Study 2 indicate that in line with predictions both smokers and smokers attempting to quit showed increases in early attentional engagement towards smoking-related stimuli. However, contrary to predictions these effects are also shown in never-smokers. Furthermore, the findings also showed that whilst participants were more likely to fixate on smoking stimuli in the attend smoking condition, they fixated on smoking and neutral stimuli to an equal extent in the attend control condition. This suggests that these shifts towards smoking stimuli and away from neutral stimuli towards critical stimuli were exogenous.

These effects were also shown with respect to negative stimuli, with attention being given to negative stimuli to a greater extent than neutral stimuli across both attend conditions for the probability of first fixation. Similarly, results indicated that in the attend neutral condition these effects were due to exogenous shifts in attention rather than endogenous control of attention.

Attentional bias to smoking and negative stimuli was also shown in intermediate and late stages of attentional processing. However, in contrast these biases were significantly lower than those shown in the initial orientation of attention. Eye-movements were relatively congruent with attend instructions at these later stages of attentional processing.

Study 2 also showed evidence of negative correlations between craving scores, Fagerstrom scores and attentional bias towards smoking-related stimuli during intermediate and late stages of attentional processing across smokers and smokers attempting to quit. Results suggested that as craving and nicotine dependence increased the bias of attention towards smoking stimuli decreased. Furthermore, for smokers a negative correlation was revealed between time since last cigarette and the bias of attention to smoking images. This indicates that as the time since the last cigarette increased attentional bias to smoking images decreased. The implications of these findings in relation to the findings of Study 1 are discussed below.

3.3 - General Discussion

This chapter presented two studies that adopted eye movement measures to examine attention shifts to smoking, negative and neutral stimuli in current smokers, SATO, and never-smokers. The first study examined eye-movements to stimuli when participants received no instruction to attend to a certain type of stimuli but instead were asked to compare the pleasantness of stimuli. The second study examined eye-movements to stimuli when instructions were given to attend to a specific stimulus type in the pairs of stimuli presented. Through adopting these approaches, it was possible to examine a number of specific aspects in relation to attentional bias to smoking-related stimuli. Firstly, it was possible to examine the time course of attentional shifts to smoking-related and negative emotion stimuli. Secondly, it was possible to examine the relationship between smoking attentional bias, negative emotion attentional bias and associated emotions. Thirdly, differences in smoking attentional bias which may be due to smoking and smoking cessation could be examined, and, finally and most importantly, it was possible to examine and map out the presence of exogenous and endogenous shifts of attention to smoking-related, negative emotion and neutral stimuli.

3.3.1- Early attentional processing

Contrary to predictions, in Study 1 it was shown that there was no difference in the likelihood of an initial fixation on smoking, negative or neutral images. However, all groups in Study 1 were quicker to fixate on negative images than smoking and neutral images. These findings replicate the findings of Nummenmaa et al. (2006), who showed that attention was initially oriented on emotion images (both positive and negative) to a greater extent than neutral stimuli. Furthermore, these findings corroborate findings from other studies conducted in relation to attentional capture by emotional stimuli (e.g. Fox et al., 2002; Macleod et al., 1986; Mathews & Macleod, 1994; McKenna & Sharma, 2004) and suggest that negative emotion images capture the attention of all participants to a similar extent, regardless of smoking status.

In contrast, in Study 2 participants were more likely to initially orient attention to both negative emotion images and smoking images compared to neutral images. Furthermore, this initial orientation of attention to negative emotion and smoking-related images occurred even when specific instructions were given to attend to a neutral stimulus. As such initial orientation to smoking and negative stimuli may be, to some extent, exogenous. It is, however, unclear why there was no initial orientation to smoking stimuli in Study 1 but this was present in Study 2. One possibility for these findings is that the instructions given in Study 1, to compare the emotional content of stimuli, primed participants to respond to emotional stimuli but did not prime participants to respond to smoking and neutral stimuli. Similarly, another possibility is that the specific instructions in Study 2, to attend to smoking images on some blocks and to attend to emotion stimuli on other blocks, may have primed participants in Study 2 to respond to smoking stimuli in the same way as emotion stimuli.

The findings of study 2 also indicate that the initial orientation of attention to smoking cues is similarly present across all groups, smokers, smokers attempting to quit and never-smokers. Whilst the presence of attentional bias to smoking stimuli in never-smokers contradicts the majority of research that has examined attentional bias to smoking stimuli using the Stroop task and visual probe task (e.g. Bradley et al., 2008; Bradley et al., 2004; Cane et al., 2009; Johnsen et al., 1997; Munafò et al., 2003), two studies have shown similar effects using eye-tracking methods (Kwak et al., 2007; Mogg et al., 2003). Indeed, both Mogg et al. (2003) and Kwak et al. (2007) have shown that the initial orientation to smoking-related images does not differ between smoking groups and non-smoking groups. It is unclear why this may be the case. However, one possibility is that never-smokers may be explicitly aware they are taking part in a smoking experiment and thus may be primed towards smoking images. This is unlikely, as similar responses to smoking-related cues are not shown in other studies of smoking attentional bias who adopt non-smoking groups. Another explanation is that the low-level properties of smoking images may be capturing attention. Whilst this may be the case for Mogg et al. (2003) and Kwak et al. (2007), this is less likely in the present study as a number of low-level image properties were controlled for across image type. There are, of course, additional low-level stimulus properties (e.g. number of lines, texture) which were not controlled for in the present study that could have affected the results. One further explanation is that eye-movement studies are not as sensitive to between-group differences as other measures of attentional bias (e.g. the addiction Stroop task, the visual probe task). Furthermore, eye-movements may be an accurate measure of visuo-spatial attention but may not be sensitive to all aspects of covert attention. Thus, further research is required to identify the relationship between eye-movements and other measures of attentional bias.

3.3.2 - Maintenance of attention

With regards to the maintenance of attention, results for Study 1 show that gaze duration for negative images was longer than for neutral stimuli. These findings replicate those shown by Nummenmaa et al (2006), who similarly showed attentional bias to negative stimuli during later stages of attentional processing. Previous research examining the presence of attentional bias to negative stimuli across smoking groups has shown contradictory findings. For instance, Powell et al. (2002) showed that attentional bias to negative stimuli was present across smokers and non-smokers. However, Cane et al. (2008) showed that attentional bias was present in smokers and smokers attempting to quit but was not present in non-smokers. The findings of Study 1 replicate Powell et al. (2002) by showing that the maintained bias of attention towards negative stimuli did not differ between groups, indicating that responses to negative stimuli are a common feature of attention irrespective of any group status or pathology.

In Study 1, it was also noted that participants fixated on smoking images with a similar frequency as that for both negative and neutral pictures. This finding is contrary to the findings of previous research and suggests that smoking pictures hold the attention of smokers, non-smokers and smokers attempting to quit to a similar extent. These effects somewhat mirror the effects shown in Study 2 with respect to the initial orientation of attention to smoking-related stimuli. The findings are also consistent with that of Bradley et al. (2008) who showed increases in maintenance to smoking cues in both smokers and non-smokers similarly following a mood manipulation. As mentioned previously, the low-level properties of the images were controlled for in the present study therefore it is unlikely that this is a causal factor for these responses. It is more likely, given that these effects emerged during the maintenance of attention, that the novelty or 'interestingness' of the stimuli led to conscious control of attention towards these stimuli. Indeed, the negative stimuli used in these studies would be relatively infrequent in peoples' everyday lives and so could be seen as novel, and therefore more interesting. Similarly, smoking-related stimuli would, more than likely, be relatively infrequent everyday objects in never-smokers and smokers attempting to quit. However, it is hard to relate such a suggestion to smokers, especially those who are highly nicotine dependent, as smoking stimuli should be relatively prevalent in smokers' day-to-day lives, and may also be more prevalent than some of the neutral images presented. However, the findings from Study 2 corroborate the suggestion that attention is under conscious control during these intermediate and late stages. In particular, Study 2 showed that whilst there is some evidence of exogenous shifts in attention to smoking and negative emotion stimuli during these intermediate and late stages, the bias for smoking and negative stimuli is small in comparison to those shown in the initial orientation of attention.

3.3.3 - Relationships with emotion, anxiety and smoking behaviour

In addition to the above, the present studies also highlighted a number of significant correlations. Of particular interest are the correlations between eye-movement to smoking and negative images and smoking behaviour measures. In Study 1, there was no evidence that smoking behaviours were related to the presence of a bias to smoking images. However, in Study 2 there were significant positive correlations between subjective craving scores, Fagerstrom scores and bias to negative images. These relationships provide further evidence of a link between smoking and attentional bias to negative stimuli, which has been shown in previous studies (Cane et al., 2009). In contrast, the majority of correlations shown in Study 2 were between attentional bias to smoking images and smoking behaviours. In particular, a number of negative correlations were shown between craving, Fagerstrom scores and attentional bias to smoking images for intermediate and late stages of attentional processing. These findings contradict the propositions of the integrated theory put forward by Field and Cox (2008) who suggest that there is a mutually excitatory link between attentional bias drug stimuli and craving. Furthermore, they contradict the propositions put forward in Incentive Sensitisation Theory (Robinson & Berridge, 1993) that those who habitually consume drugs would be sensitised to a greater extent to drug related stimuli.

Also of interest are the positive correlations shown in Study 1 between eye-movements to smoking stimuli and eye-movements to negative stimuli. These relationships were shown across both smokers attempting to quit and never-smokers, but not smokers. These relationships suggest that, in these groups, the attention given to smoking stimuli and negative stimuli may stem from a common cause. This finding partially replicates that of Cane et al. (2009) who found a significant correlation between smoking attentional bias and attentional bias to negative emotion stimuli in smokers attempting to quit but not non-smokers or smokers. Furthermore, the finding that this relationship was not evident in smokers indicates that the underlying mechanisms of attention to smoking-related stimuli and negative emotion stimuli in smokers may differ from that suggested in smokers attempting to quit and never-smokers. However, these relationships were not replicated in Study 2 where significant relationships between attentional bias to smoking and attentional bias to negative stimuli were not found. One possible explanation for this difference between studies is that the task in Study 1 was highly dependent on participants assessing the emotional content of stimuli. Subsequently this could have amplified the emotion relatedness of smoking stimuli within smokers attempting to quit and never-smokers. This explanation is corroborated by the finding that smokers attempting to quit and never-smokers in Study 1 rated smoking stimuli more negatively than smokers, whereas this was not the case in Study 2. The emotional rating of stimuli was administered following the eye-movement task across both studies, and this therefore suggests that it was the instructions given the eye-movement task of Study 1 that may have made the emotion content of smoking stimuli more salient in these two groups.

As well as the correlations shown between eye-movement to smoking images and eye-movements to negative emotion images in Study 1, significant correlations were also found between anxiety measures (STAI & ASI) and eye-movement responses to negative and neutral images. In particular, the findings showed that for smokers attempting to quit, decreased state anxiety was related to increased probability of first fixation on negative stimuli. However, in contrast, on subsequent measures of time elapsed to fixation and sum of fixations on first pass correlations between state anxiety and attention to negative stimuli became positive. These findings indicate that increased anxiety may lead to increased non-automatic attention to smoking cues whilst increase anxiety might lead to avoidance of negative stimuli under automatic shifts in attention. These findings also go some way in replicating findings that anxious states increase the propensity to attend to negative stimuli, as has been shown in previous studies examining attentional bias to negative and threat stimuli (e.g. Williams et al., 1996).

In contrast to state anxiety, increases in anxiety sensitivity were shown to be related to increases in the duration of gaze on neutral images rather than increases on negative images as would be expected. Given that anxiety sensitivity is thought to measure a stimulus–outcome expectancy (i.e. a stimulus is believed to precede anxiety-related bodily symptoms; Brown, Kahler, Zvolensky, Lejuez, & Ramsey, 2001; Reiss & McNally, 1985), one possible reason for this is that those who score high on anxiety sensitivity might seek neutral images to avoid viewing negative images. Such avoidance would reduce the chances of inducing anxiety-related bodily sensations that are often reported in those with high anxiety sensitivity (Peterson & Reiss, 1992). The findings of Study 1 were, however, were not replicated in Study 2, in which it was shown that increased anxiety sensitivity led to increases in the attention given to negative stimuli in smokers. Thus, across studies these relationships do not appear to be robust and may be influenced by the task instructions given during the eye-movement task.

In conclusion, the findings of the present studies have provided evidence for the initial orientation and maintained attention on both smoking stimuli and negative emotion stimuli irrespective of smoking status. Furthermore, Study 2 has shown that the initial orientation of attention to smoking and negative stimuli appears to be relatively automatic and occurs even when voluntary attention is guided to stimuli elsewhere. In contrast, later stages of attentional processing appear to be relatively free of exogenous shifts in attention to smoking and negative emotion stimuli allowing for the voluntary control of attention. These findings have interesting implications for future research examining the manipulation of smoking attentional bias. In particular, they suggest that whilst later stages of attentional processing may be relatively responsive to attempts to explicitly manipulate attention to smoking-related stimuli, the initial orientation of attention to smoking-related stimuli might be relatively irresponsive to similar manipulations. Studies 3 and 4 will examine the manipulation of smoking attentional bias further, by examining how the external influences, of a smoking ban, affects smoking attentional bias.

Chapter 4. An examination of the effect of the England smoking ban on smoking attentional bias and smoking behaviour

Chapter 4 presents the findings from Studies 3 and 4. These studies examine the effects of the England smoking ban on smoking attentional bias, the emotional rating of smoking stimuli and smoking behaviours. This allowed us to identify if an external factor could influence affective associations and subsequently affect smoking attentional bias. Study 3 measures attentional bias using a Stroop task and visual probe task on three occasions over a two month period (immediately prior to the smoking ban, one month after the introduction of the ban and two months after introduction of the ban). Findings indicate that attentional bias decreased across both measures following the introduction of the ban. However, there were no changes in smoking behaviour, craving or the emotional rating of smoking stimuli over this time. Study 4 was conducted to put the findings of study 3 in a wider context by examining changes in smoking behaviour and smoking environments over the same two-month period through an online survey. The survey revealed that smoking behaviours did not change even if there was some intention to quit in light of the smoking ban. Furthermore, Study 4 revealed a decrease in the number of smoking items participants reported that they were exposed to, indicating that smoking may have been less salient in the months after the smoking ban. It is suggested that the reported decrease in the number of smoking items as a result of the ban could explain the decrease in attentional bias shown in Study 3.

Study 1 and 2 examined the presence of smoking attentional bias among smokers, smokers attempting to quit, and never-smokers using eye-tracking measures. Furthermore, they examined the presence of exogenous shifts in attention to smoking and negative emotion stimuli. These studies showed evidence of initial orientation bias and a bias of maintained attention to both smoking-related stimuli and negative emotion stimuli. In addition, the initial orientation of bias to smoking stimuli was present even when instructions were given to direct attention to neutral stimuli. Indeed, one of the key findings of Study 2 was that attention to smoking, negative and neutral stimuli could be manipulated through explicit instructions during the late stages of attentional processing but appeared to be relatively automatic, and did not change under explicit instruction, in the initial orientation of attention. However, both the initial orientation bias and the bias of maintained attention were unrelated to smoking status, with never-smokers showing similar effects to smokers and smokers attempting to quit. Whilst such findings have been shown in previous research using eye-tracking methods and smoking-related stimuli (e.g. Kwak et al., 2007; Mogg et al., 2003; see Chapter 2, section 2.3.3), these findings contradict the majority of previous findings in studies adopting the Stroop task and visual probe task which have generally shown that non-smoking groups show no attentional bias towards smoking stimuli (e.g. Bradley et al., 2008; Bradley et al., 2004; Cane et al., 2009; Johnsen et al., 1997; see Chapter 2, section 2.2.1).

There may be a number of possible reasons for differences in findings between eye-tracking methods and the Stroop task and visual probe task. Firstly, eye-tracking methods may be limited in their ability to detect subtle between group differences in shifts of attention. However, this is unlikely as eye-tracking techniques are thought to be one of the most accurate measures of visuo-spatial attention and have proven to be effective in examining a number of different aspects of attention (See Chapter 2, section 2.1.1: Eye-tracking methods). Secondly, the smoking stimuli used in Studies 1 and 2 may not have been attended to because of their smoking relatedness but may have been attended to because of their novelty value or their interestingness. However, pictorial stimuli have been used in the visual probe task in which differences in attentional shifts to smoking-related stimuli between smoking groups and non-smoking groups have been shown. A third explanation is that eye-tracking measures can effectively measure visuo-spatial attention (Duchowski, 2007; also see Chapter 2, section 2.1.1) but may not measure shifts in covert attention.

Studies 3 and 4 aimed to extend the findings of Study 1 and Study 2 by examining whether attentional bias could be manipulated through the external influence of a smoking ban, how the smoking ban affected the relationship between emotion and smoking-related stimuli, and how the smoking ban affected smoking-related behaviours and intentions about quitting. Furthermore, in response to the above criticisms and the findings of Study 2, Study 3 examined the relationship between emotion and smoking attentional bias, using a different methodology that has proven to be a reliable test of attentional bias, and that is sensitive to differences in bias across groups with different smoking status. Specifically, Study 3 adopted the addiction Stroop task and the visual probe task (See Chapter 2, section 2.1.1: *The addiction Stroop task/ Visual probe task*). Using both these techniques, this also allows us to test further whether both techniques are measuring the same underlying mechanisms of attentional bias (see Chapter 2, section 2.1.1).

Studies 3 and 4 were conducted in the context of the England Smoking Ban, which came into effect on the 1st of July, 2007, and involved a ban on smoking in all public places in England. This ban was introduced with an aim to, i) reduce the negative effects on health of second-hand smoke and, ii) to help reduce the number of tobacco smokers (UK Department of Health, 2006). Whilst such bans are thought to reduce smoking behaviour (Fichtenberg, 2002), little is known about the influence these smoking bans have on the smoking-related cognitions of smokers. However, it is possible that a smoking ban could increase the association between smoking and negative emotions. This could occur through a number of different mechanisms. Firstly, when a ban is introduced, the media and other channels increase the salience of negative aspects of smoking (Hammond, McDonald, Fong, Brown, & Cameron, 2004). Tiffany (1990) suggests that smoking behaviours are relatively automatic in habitual smokers. Therefore, under normal circumstances they would not attend to the negative aspects of smoking. However, the ban might make the negative consequences of smoking more salient. Secondly, smokers may experience increased stigmatization as a result of the ban (see Kim & Shanahan, 2003). This may cause some smokers to give up smoking, but smokers who continue to smoke throughout the ban may have increased negative thoughts about their own smoking behaviour, and thus increase the association between smoking and negative emotions. The smoking ban may also lead to a reduction in smoking behaviour, due to decreased opportunity to smoke, particularly in social settings (e.g. bars). This may subsequently lead to a reduction in smoking attentional bias which might reciprocally decrease smoking behaviour further. Changes in smoking behaviour may also lead to increases in withdrawal symptoms to which negative affective states are extremely common. Therefore, the smoking ban may prove to be clinically important in efforts to reduce smoking behaviour and this may be indexed by, and have an effect on, smoking attentional bias.

Possible changes in attentional bias resulting from the smoking ban may yield different results in relation to the fast and the slow effect found in the Stroop task. The fast effect is most probably associated with smoking behaviour, whereas the slow effect is possibly associated with the relationship between stimuli and negative emotion (Cane et al., 2009; McKenna & Sharma, 2004; see Chapter 2, section 2.1.1). Therefore, any transient changes in smoking behaviour may lead to similar changes in the fast effect but should be relatively independent of the slow effect. In contrast, any changes in the relationship between smoking and negative emotion resulting from the smoking ban may yield greater changes in the slow effect compared to the fast effect.

Study 3 was conducted to experimentally examine the effect of the England smoking ban on smoking attentional bias, smoking-related behaviours and associated emotions and anxiety within a group of smokers. In contrast, Study 4 was conducted so that any effects shown in Study 3 could be examined in a wider context. It did this by examining the effects of the England smoking ban on smoking-related behaviours, intentions, and the situational changes with respect to smoking through an online survey.

In both Studies 3 and 4, participants were recruited prior to the introduction of the smoking ban. In order to examine the relationship between the smoking ban, smoking behaviour and attentional bias, a longitudinal design was adopted whereby participants were tested immediately prior to the introduction of the ban, 1 month after the ban and 2 months after the ban. This longitudinal design not only helped identify effects relating to the smoking ban but also helped to examine how robust the relationship between smoking behaviour and smoking attentional bias is over time.

For Study 3 specifically, measures of attentional bias using the Stroop task and visual probe task, and self-reported smoking behaviour and craving were obtained. Furthermore, participants were all smokers. This is because we wanted to detect changes in behaviour and attentional bias as a result of the ban, and not as a result of a quit attempt. Also, smokers who continue to smoke during the ban are more likely to be affected by negativity and increased stigmatism about smoking. To directly examine the relationship between attentional bias and the affective nature of smoking-related stimuli, participants rated valence of smoking-related words across the three points of testing.

It was predicted that if attentional bias was closely associated with smoking behaviour then smoking attentional bias may decrease if the smoking ban had the desired effect of reducing smoking behaviour. It was also predicted that if the association between smoking-related stimuli and negative emotions increased as a result of the smoking ban this would be associated with an increase in attentional bias, especially in the slow effect, usually not prominent in smokers (Cane et al., 2009). It was hypothesised that the slow effect, if present, would be relatively independent of smoking behaviour: even if participants maintained the same level of smoking, smoking attentional bias may still change. Meanwhile, the fast effect was expected to change alongside changes in smoking behaviour.

4.1 - Study 3

4.1.1 - Method

Participants

Fourteen participants (9 males, 5 females; mean age=28.72, *SD*=9.89, age range = 19-50) were recruited through advertisements in the University of Kent Jobshop. All participants were given £12 for their participation (£4 on each of the 3 experimental sessions). Although requested to do so not all participants took part in all three time points; 14 participants took part at Baseline, 11 of the Baseline participants took part at 1-month follow-up, and 10 of the original Baseline participants took part at the 2-month follow-up, representing a 21.5% attrition rate at 1-month follow-up, and a 29% attrition at 2-month follow-up. All participants who took part were active smokers at the time of initial testing (Mean number of years smoked = 7.31, *SD*= 9.03) and were either native English speakers or fluent in spoken English. Table 4-1 shows pre-test measures taken at each time point. All participants were treated in accordance with the ethical standards of the British Psychological Association and approval was obtained from the University of Kent at Canterbury's Department of Psychology ethics committee before recruiting participants and proceeding with the experiment.

Design

Stroop task

A 2 x 4 within subject design was used for the Stroop task with Word Sequence (smoking and neutral) and Position (1-4) as the within subject factors. Each Stroop task contained five sequences with each sequence containing a category specific word at position 1 (e.g. a smoking word or a neutral word) followed by three neutral words (positions 2-4). The words in each sequence at position 1 remained at position 1 whenever the sequence was presented, however, words in positions 2-4 were counterbalanced using a Latin-Square design. Therefore, each of the five sequences of 4 trials were presented three times. In total there were 60 trials for each category (smoking and neutral), giving 120 trials overall. Sequences were displayed randomly within the Stroop task.

Visual probe task

A repeated measure design was adopted for the visual probe task with all participants completing both test trial types (smoking & neutral). Each trial on the visual probe task involved the presentation of three items: a fixation signal, the word pairs and the probe. The initial fixation consisted of the words "next trial" which were presented for 1000ms. The initial fixation served to alert the participant to the next trial and to ensure fixation of gaze on the centre of the screen. After the initial fixation the word pairs were presented for 500ms after which the probe (either one dot . or two dots ..) was presented and stayed on the screen until a selection was made. A blank screen was presented for 500ms between trials.

Twelve practice trials were included in the visual probe task to accustom participants to the task. The practice trials adopted the same procedure as the main trials but used strings of letters in place of word stimuli (e.g. xxxx/ccc). Stimuli in the main task consisted of 40 pairs of words (1 pair = 1 smoking word & 1 neutral word) split into two subsets. In total the visual probe task involved 80 trials (2 x 40 trials). Probes replaced the smoking and neutral words an equal number of times and the placement of the probe (replace smoking, replace neutral) was randomised throughout the trials.

Stimuli

Stimuli used in Study 3 are shown in Appendix A2. Twenty-five smoking-related words and twenty-five neutral words were chosen as the key target words for the experiment. These words were to be used in the key position 1 in the Stroop task or in the visual probe task. Smoking words were largely taken from three studies that had assessed attentional biases in smokers (Waters, Shiffman, & Sayette, et al., 2003, Munafò et al., 2003; Cane, et al., 2009). Additional smoking words were adopted if they had any relation to smoking behaviour or smoking-related products. Similarly, neutral words were also taken from three previous studies examining smoking attentional bias (Waters, Shiffman, & Sayette, et al., 2003, Munafò et al., 2003, Cane, et al, 2009) and additional neutral words were adopted if they had no relation to smoking-related behaviour or products. Neutral words were chosen if they matched the frequency and word length of each of the five smoking stimuli. In addition to the smoking and neutral key words chosen for position 1, an additional 3 neutral words were chosen to be presented with each smoking and neutral key word at positions 2-4 in the Stroop task. These additional neutral words were matched for length and frequency with their respective keywords. In total there were an additional 150 neutral words. Where words were matched for length and frequency using the Celex English Lexical Database, Release 2 (Baayen, Piepenbrock, & Gulikers, 1995).

To avoid effects of habituation across the tasks the experimental program randomly allocated one set of five smoking sequences and a matched set of five neutral sequences to the Stroop task and the remaining 20 smoking and 20 neutral keywords were assigned to the visual probe task. This word allocation procedure was conducted for each participant and on each experimental session (baseline, 1-month follow-up, and 2-month follow-up). The stimuli for the Stroop task were 0.6cm high, 2cm wide and in one of four colours; red, green, blue or yellow on a black background and the words used in the visual probe task were also 0.6 cm high, 2cm wide but displayed in white on a black background. Participants sat approximately 60cm from the screen.

Apparatus

Task presentation and recording

The Stroop task and visual probe task were written, run and the reaction times logged using E-prime computer program version 1.1. Stimuli were presented using a ATX p5/200 MMX computer connected to a 14in RM video monitor screen. Manual responses to the colour of stimuli for the Stroop task were collected using a response box utilising four buttons. Each of the buttons were labelled with the presented ink colours (RED, GREEN, BLUE, & YELLOW), these labels were written in black ink above each colour allocated button. For the Visual probe task participants made their selections using the buttons on a mouse, they pressed the left mouse button if they saw one dot and the right mouse button if they saw two dots. The left mouse button had one small circular sticker placed on it and the right mouse button had two circular stickers placed on it so that participants could remind themselves of the correct response button by feel if needed.

Breath Carbon Monoxide (BCO)

BCO levels were measured using the Bedfont Smokerlyzer adopted in experiments 1 and 2.

Measures

ASI, STAI, Fagerstrom questionnaires, and subjective craving scores were used as in Studies 1 and 2. As places previously associated with smoking might influence the activation and maintenance of smoking-related cognitions participants were also asked to estimate how many times they had visited places where smoking was permitted in the two weeks prior to the England smoking ban coming into effect.

Word-Relatedness

As with Study 1, participants were asked to rate stimuli shown at position 1 and in each of the two categories (smoking and neutral) on two scales; smoking relatedness and emotion relatedness. Smoking relatedness was scored on a six-point scale from 0 (not related to smoking), to 5 (highly related to smoking), and emotion relatedness was scored on a nine-point scale from -4 (highly negative emotion), through 0 (neutral), to 4 (highly positive emotion).

4.1.2 - Results

Analyses of smoking-related measures

To examine whether nicotine dependence, craving, BCO and the number of times smoking places were visited changed over the three experimental sessions (see Table 4-1) one-way repeated measure ANOVAs were conducted separately for each measure using Time (baseline, 1-month follow-up, 2-month follow-up) as the within-subjects factor. These analyses revealed that there were no significant differences across the experimental sessions for any of the measures (all *Fs* < 3.0, *ps*>.05).

Analyses of anxiety measures

As with the smoking-related measures repeated measures ANOVAs were conducted for state and trait anxiety and anxiety sensitivity measures (see Table 4-1) using time as the within-subjects factor. These analyses revealed no significant differences over experimental test sessions (all *Fs* < 1.5, *ps*>.05).

Analyses of word-relatedness measures

To examine whether there were any changes in the emotion ratings of neutral and smoking stimuli, and the smoking ratings of neutral and smoking stimuli, over the three measurement times two separate 2x3 repeated-measures ANOVAs were conducted. Both analyses included Word (smoking and neutral) and Time (baseline, 1month-follow up, 2-month follow up) as the within subject factors. The dependent variables were emotion ratings of stimuli and smoking ratings of stimuli. For emotion ratings the analyses revealed a significant effect of Word (F (1, 13) = 9.05, $p < .05$, *partial* $\eta^2 = .41$), with smoking words ($M = .25$, $SE = .04$) being rated significantly less positively than neutral words ($M = .50$, $SE = .04$). Similarly, the analyses for smoking ratings revealed a significant main effect of Word (F (1, 13) = 10843.77, $p < .001$, *partial* $\eta^2 = .99$), with smoking-related stimuli being rated as significantly more smoking related ($M = 4.12$, $SE = .04$) than neutral stimuli ($M = .06$, $SE = .02$). Both emotion ratings and smoking ratings were unaffected by time of testing (all *Fs* < 2.12, *ps*>.1).

Table 4-1

Smoking-, anxiety-, and emotion-related measures and Stroop and visual probe smoking attentional bias at baseline, 1-month follow-up and 2-month follow up

		Baseline (N=14)				**1 Month (N=11)**				**2 Month (N=10)**			
Number of cigarettes smoked daily		5-10	10-15	15-20	20+	5-10	10-15	15-20	20+	5-10	10-15	15-20	20+
% (N)		50 (7)	14.3 (2)	14.3 (2)	21.4 (3)	30 (3)	30 (3)	30 (3)	10 (1)	20 (2)	50 (5)	30 (3)	0
BCO		13.00 *(7.04)*				8.90 *(5.61)*				13.80 *(9.24)*			
FTND		6.79 *(1.72)*				6.09 *(0.70)*				6.20 *(0.92)*			
Subjective Crave Score		3.29 *(1.14)*				3.54 *(1.21)*				3.30 *(1.49)*			
Smoking places visited		10.44 *(7.07)*				11.27 *(7.47)*				13.60 *(10.57)*			
Time since last cigarette (days)		2.78 *(4.31)*				1.43 *(2.58)*				.75 *(1.13)*			
State Anxiety		41.50 *(12.68)*				41.00 *(13.45)*				43.00 *(10.46)*			
Trait Anxiety		48.07 *(6.99)*				48.90 *(9.51)*				48.80 *(6.55)*			
ASI		41.50 *(12.27)*				40.70 *(12.39)*				41.50 *(10.84)*			
Emotion ratings	Smoking	.27 (.21)				.24 (.35)				.23 (.31)			
	Neutral	.43 (.16)				.55 (.19)				.51 (.19)			
Smoking ratings	Smoking	4.15 (.13)				4.10 (.17)				4.10 (.15)			
	Neutral	.05 (.09)				.06 (.08)				.08 (.09)			
Stroop attentional bias		30.68 *(31.93)*				28.26 *(29.33)*				23.36 *(29.68)*			
Visual Probe attentional bias		38.93 *(25.56)*				21.91 *(33.77)*				35.85 *(24.30)*			

Values are Mean (SD) for BCO, FTND, crave score, Smoking places visited, time since last cigarette, and anxiety and emotion measures. Values are Mean (SE) for Stroop and visual probe bias scores.

Analysis of Reaction Time and Error Data

Outliers

Initial analysis of RT data revealed that in both the Stroop task and the visual probe task less than 1% of all RTs were outside 300ms and 4000ms, the RTs outside of these limits were therefore treated as outliers and were removed from subsequent analyses.

Analysis of Errors

Overall error rates were low (M = 2.0%). Mean error rates for each Stroop session (Baseline, 1-month follow-up, 2-month follow-up) were subjected to separate 2 x 4 repeated measures ANOVAs with Word Type (smoking, neutral) and Position (1-4) as within subject factors. No significant main or interaction effects were found (all $Fs <$ 1.67, $ps>.05$).

Stroop Task

Median correct reaction times were subjected to a 3 x 2 x 4 repeated measures ANOVA with Test Session (Baseline, 1-month follow-up, 2-month follow-up), Word Type (Smoking, Neutral) and Position (1-4) as the within subject factors. These analyses revealed a significant main effect of Word Type ($F(1, 8) = 11.24, p < .05$, *partial* $\eta^2 = .58$; see Figure 4-1) with participants being slower to colour name smoking-related stimuli (M = 782.73, SE = 53.24) compared to colour-naming neutral stimuli (M = 761.06, SE = 51.70). However, all other main effects and interactions were non-significant (all $Fs <$ 3.0, all $ps>.05$), indicating that attentional bias to smoking stimuli did not change across the test sessions and did not change across position within each Stroop task.

However, it was likely that the lack of interaction with time may have resulted from the fact that some participants did not return for follow up sessions thus reducing the sample size, and power, of the initial ANOVA. To counteract this problem and increase the sample size for analyses further ANOVAs were also conducted for each time point separately. Furthermore, separate ANOVA analyses were also conducted between baseline and 1-month follow-up bias scores[4], between baseline and 2-month-

[4] Bias scores were calculated by subtracting smoking stimuli reaction times from neutral reaction times separately for each test session.

follow up bias scores, and between 1 month follow-up and 2-month follow-up bias scores to identify any possible changes in smoking attentional bias over time whilst yielding greater sample size.

Analyses for each test session

Median correct reaction times for each Test Session (Baseline, 1-month follow-up, 2-month follow-up) were entered into three separate 2 x 4 repeated measures ANOVAs with Word Type (Smoking, Neutral) and Position (1-4) as the within subject factors.

Baseline

For the Baseline test session these analyses revealed a significant main effect of Word Type (F (1, 13) = 11.90, $p < .005$, *partial* $\eta^2 = .48$) and a marginally significant interaction of Word Type x Position (F(3, 39) = 2.34, $p = .09$, *partial* $\eta^2 = .15$; see Figure 4-1). The main effect was indicative of slower reaction times to colour name smoking words (M = 792.29, SE = 40.39) compared to neutral words (M = 761.63, SE = 38.67, $p < .005$). For the marginal Word Type x Position interaction subsequent t-tests with Bonferroni correction were conducted to examine the simple main effects. These revealed a significant difference at position 2 ($p < .01$) but not at positions 1, 3, and 4 (ps>.05). These effects were indicative of slower colour-naming of smoking stimuli (M = 816.50, SE = 40.63) compared to the colour-naming of neutral stimuli (M = 764.07, SE = 46.99) at position 2.

1-month follow-up

For the 1-month follow-up test session this only revealed a significant main effect of Word Type (F (1, 10) = 5.70, $p < .05$, *partial* $\eta^2 = .36$; see Figure 4-1), with slower colour-naming of smoking words (M = 767.63, SE = 43.13) compared to the colour-naming of neutral words (M = 743.44, SE = 43.23, $p < .05$). The interaction of Word x Position was not significant for the 1-month follow-up test session (F <.1, p > .1).

2-month follow-up

For the 2-month follow-up the main effect of word only approached significance (F (1, 9) = 3.75, p = .085, *partial* η^2 = .29; see Figure 4-*1*). Post hoc analysis revealed that although there was slower colour-naming of smoking words (*M* = 777.14, *SE* = 46.60) compared to colour-naming of neutral words (*M* = 755.84, *SE* = 46.60, $p < .05$) this difference was not significant ($p > .05$). Furthermore, there was also no interaction of Word x Position ($p > .05$).

Bias comparisons across test sessions

To examine whether the bias shown to smoking cues differed between the test sessions, paired sample t-tests using bias scores were conducted between baseline and 1-month follow-up, baseline and 2-month follow-up, and between 1-month follow-up and 2-month follow-up. Given the lack of findings in relation to position at 1-month follow-up and 2-month follow-up, bias scores were collapsed across positions 1-4 (see table 4-1). These analyses revealed no significant differences in bias scores between the test sessions (baseline vs. 1-month: $t(10) = .12, p < .1$; baseline vs. 2-month: $t(9) = .27, p > .1$; 1-month vs. 2-month: $t(8) = .07, p > .1$).

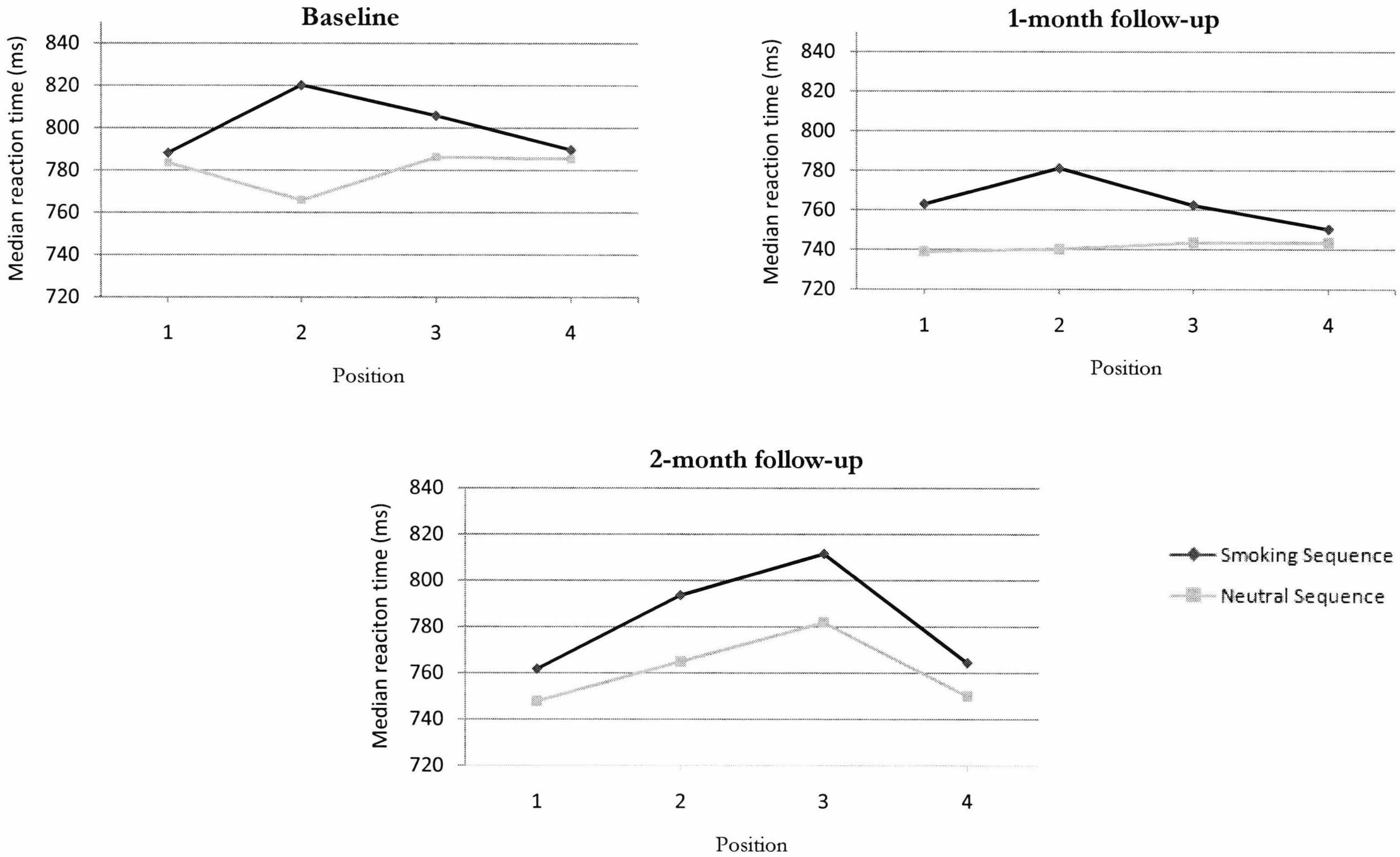

Figure 4-1 **- Stroop median correct reaction times for each word sequence and position for each test session**

Visual Probe task

Median correct reaction times for the visual probe task were entered into a 3 x 2 repeated measures ANOVA with Test Session (Baseline, 1 month follow-up, 2 month follow-up) and Word Type (Smoking, Neutral) as the within subject factors. These analyses revealed a main effect of Word Type ($F(1, 8) = 9.11, p < .05$, *partial* $\eta^2 = .53$) with participants responding quicker to probes replacing smoking-related stimuli compared to probes replacing neutral stimuli. The analyses did not reveal a significant interaction of Word Type x Test Session ($F(2, 16) = 2.11, p = .15$, *partial* $\eta^2 = .21$; see Figure 4-2).

As with the Stroop task, the non-significant interaction of Word Type x Test Session may be due to not all participants completing 1-month follow-up test sessions and 2 month follow-up test sessions thus reducing the sample size of the ANOVA conducted across test sessions. To counteract this problem, paired sample t-tests were conducted for each test session separately and further paired t-test analyses were then conducted between baseline and 1-month follow-up bias scores[5], between baseline and 2-month-follow up bias scores, and between 1-month follow-up and 2-month follow-up bias scores. These latter t-tests were conducted to identify any possible changes in smoking attentional bias over test sessions.

Analyses for each test session

Paired t-tests conducted for each test session separately revealed significantly quicker reaction times to probes replacing smoking stimuli compared to probes replacing neutral stimuli at Baseline ($t(13) = 6.35, p < .001$) and in the 2-month follow-up ($t(9) = 2.58, p < .029$)(see figure 4-2 and table 1). These differences were indicative of faster responses to probes replacing smoking-related stimuli (baseline: $M = 507.50$, SD=58.19; 2-month follow-up: $M = 483.45$, SD=38.52) compared to probes replacing neutral stimuli (baseline: $M = 555.04$, SD=67.00; 2-month follow-up: $M = 514.70$, SD=37.56). Thus, indicating the presence attentional bias towards smoking-related stimuli at Baseline and 2-month follow-up. However, there was no significant difference

[5] Bias scores were calculated by subtracting smoking stimuli reaction times from neutral reaction times separately for each test session.

in reaction times to probes replacing smoking and neutral words in the 1-month follow-up (Smoking: M = 502.05, SD=62.22; Neutral: M = 524.41, SD=62.22; $t(10) = 1.74, p < .1$).

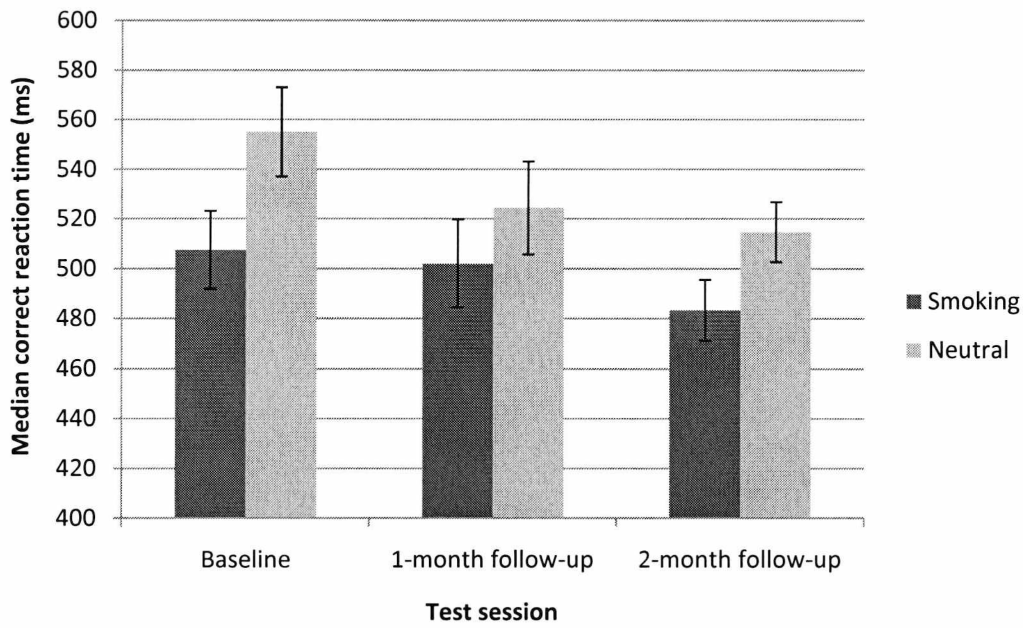

Figure 4-2 **- Visual probe median correct reaction times at baseline, at 1-month Follow-up and at 2-month follow-up**

Bias comparisons across test sessions

To examine whether the bias shown to smoking cues differed between the test sessions, paired t-tests using bias scores were conducted between Baseline and 1-month follow-up, between Baseline and 2-month follow-up, and between 1-month follow-up and 2-month follow-up. These analyses revealed significantly greater bias at the Baseline test session compared to the bias shown in the 1-month follow-up session (see Table 4-1 ; $t(10) = 2.32, p < .05$). However, t-tests of bias scores between Baseline and 2-month follow-up and 1-month follow-up and 2-month follow-up revealed no significant differences in bias scores (Baseline vs. 2-month: $t(8) = .73, p > .1$; 1-month vs. 2-month: $t(9) = 1.43, p > .1$).

Correlation analyses of Stroop task and visual probe task bias scores

Correlation analyses were conducted to examine whether there was any relationship between smoking attentional bias in the Stroop task and smoking attentional bias in the visual probe tasks separately at each time point. For these analyses bias scores were used which were collapsed across position for the Stroop task. The analyses revealed no significant correlations between bias scores in the Stroop tasks and bias scores in the visual probe task in each of the test sessions (all *rs* < .35, *ps*>.1).

Correlation analyses with measures

To examine any relationships between pre-test measures (smoking questionnaires, anxiety and anxiety sensitivity questionnaires, and the emotion ratings of smoking stimuli) and smoking attentional bias in the Stroop task and visual probe task at each time-point correlation analyses were conducted. These analyses revealed no significant correlations across Baseline, 1-month follow-up or 2-month follow-up (all *rs* < .35, *ps*>.05).

4.1.3 - Summary of findings

In Study 3 the effect of the smoking ban on smoking attentional bias and the association of emotion with smoking stimuli was examined. It was found that smoking attentional bias was initially present at baseline in both the Stroop task and the visual probe task. In the Stroop task, the colour-naming of stimuli in the smoking sequence was slower than the colour-naming of stimuli in the neutral sequence at position 2. These effects indicate the presence of the slow effect of smoking attentional bias. In the visual probe task, responses to probes replacing smoking stimuli were quicker than probes replacing neutral stimuli at baseline. These trends also indicate the presence of smoking attentional bias.

Effects indicative of smoking attentional bias were also evident in the Stroop task at the 1-month follow-up. However, in the visual probe task the effects of attentional bias shown in the visual probe task at baseline were attenuated in the 1-month follow-up. In the 2-month follow-up opposite effects were shown, with the Stroop task indicating an attenuation of smoking attentional bias and the visual probe task showing evidence of smoking attentional bias. Thus, in sum these effects show a decrease in attentional bias in the Stroop task, but a decrease then a return of attentional bias in visual probe task.

Furthermore, in the baseline Stroop task there was evidence of slow effect with respect to the smoking sequence. However, this slow effect diminished over the test sessions and only a general bias to stimuli in the smoking sequence, rather than specific fast and slow effects were shown in the 1-month follow-up session. Together these findings indicate that the smoking ban may have had an effect on smoking attentional bias in this group of smokers.

However, it was also indicated from the smoking-related measures of Study 3 suggested that craving, nicotine dependence, BCO and the number of smoking places visited did not change over time. Furthermore, there were no correlations between these indicators and the strength of smoking attentional bias, indicating that smoking attentional bias was occurring relatively independently of smoking behaviour. Similarly, there were no significant differences in the degree of emotion assigned to smoking-related stimuli or anxiety shown across the three test sessions. Indeed, in contrast to predictions, smokers rated smoking stimuli as being slightly positive rather than negative as expected. Furthermore, both the emotion ratings and state and trait anxiety were not significantly related to the presence of smoking attentional bias. This indicates that the presence of smoking attentional bias was independent of the emotion assigned to stimuli and the anxiety levels of the participants.

To put these findings in a wider context regarding the smoking ban, Study 4 presents the findings from a smoking ban survey conducted simultaneously as the laboratory experiment with smokers. Therefore, the findings of Study 3 will be further discussed in relation to the findings of Study 4 in the general discussion at the conclusion of this chapter.

4.2 - Study 4

Whilst Study 3 showed evidence of changes in attentional bias to smoking stimuli in the period following the introduction of the smoking ban, it was not clear what effect the smoking ban was having on smoking-related behaviours in a wider context, nationally. Therefore, in addition to the experiment presented in Study 3, a more large-scale smoking ban survey was carried out to examine general changes in smoking behaviour, intentions to quit smoking and the effects of the smoking ban on smoking environments. The survey was open to people of different smoking status (e.g. smokers, smokers attempting to quit, and never-smokers) so that group-specific changes that occurred as a result of the smoking ban could be identified. That is, the effects of the smoking ban on intentions to quit and early stage quit attempts in smokers and lapse episodes in smokers attempting to quit could be examined separately. Furthermore, non-smoking groups may be aware of changes in smoking behaviour resulting from the smoking ban in friends and household members who smoke and thus these could changes could be captured through the survey. Furthermore, the survey adopted the same longitudinal design over the same time periods as in Study 3, so that the wider context changes of the smoking ban would be relevant to any changes in attentional bias shown in Study 3.

One major aim of the survey was to identify whether there were any changes in the occurrence of smoking stimuli in people's environments throughout the initial period of the ban. It is possible that smoking bans might lead to a decrease in the occurrence of smoking-related objects (e.g. cigarettes, ashtrays) but may lead to an increase in items which promote quitting smoking (e.g. television adverts, leaflets). Such changes in occurrence of smoking items in the environment may subsequently have an impact on smoking attentional bias. For instance making smoking stimuli more novel and leading to increased attentional bias in smokers. Alternatively, making smoking more salient could lead to habituation effects and decreases in smoking attentional bias. In addition to this main aim, intentions regarding quitting in light of the smoking ban and views about whether the smoking ban might aid a quit attempt were also measured to identify whether smoking groups thought that the smoking ban might aid smoking behaviour change.

It was expected that the smoking behaviour survey would show that intentions to quit in light of the smoking ban would be high across the smokers and that this would lead to decreased smoking behaviour among smoking groups. Furthermore, it was expected that there would be relatively little evidence of relapse amongst smokers attempting to quit particularly during the latter stages of the Smoking Ban (e.g. 2-month follow-up) when smoking behaviour should be significantly reduced. Finally, it was expected that smoking-related items and number of smokers observed may decrease but the number of smoking quit items may increase over the period of the smoking ban survey.

4.2.1 - Method

Participants

Seventy-two participants (13 males, 59 females; mean age = 26.38, age range = 18-60) were recruited by email in the week prior to the England smoking ban (23rd-31st June, 2007) to complete the survey. All participants were resident in England over the two months in which the survey took place. Of the seventy-two participants who took part at baseline, fifty-two completed the 1-month follow-up survey (11 males, 43 females; mean age = 26.98, age range = 18-60) and forty-four completed 2-month follow-up survey (9 males, 35 females, mean age = 27.68, age range = 18-60). With respect to smoking status the final samples consisted of 24 smokers, 16 smokers attempting to quit (SATQ) and 32 never-smokers at baseline; 16 smokers, 15 SATQ, 21 never-smokers at the 1-month follow-up; and 14 smokers, 13 SATQ, and 17 never-smokers at the 2-month follow-up. All participants gave informed consent to take part in the study and received a debriefing by email following each of the Survey test sessions. All participants were treated in accordance with the ethical standards of the British Psychological Association also approval was obtained from the University of Kent at Canterbury's Department of Psychology ethics committee before recruiting participants and proceeding with the experiment.

Baseline survey

The baseline survey comprised of four sections (see Appendix B3 for survey items) and was delivered using the University of Kent's online questionnaire system (QMS). Section one contained items asking about the participants' sex, age, current country of residence (to identify any respondents who were not resident in England at the time of the survey) and current smoking status. For the smoking status participants were asked if they were 1) a current smoker 2) a smoker attempting to quit or 3) a non-smoker. Definitions of all smoking status types were given to the participants. Smokers were described as somebody who has smoked for at least a year, smokes more than 5 cigarettes a day, and is not currently attempting to quit. SATQ were defined as people who had smoked regularly (at least 5 cigarettes a day) over the past year but had not smoked for 24 hours and up to 2 years and were actively attempting to quit. Non-smokers were defined as people who had never-smoked or who had given up over 2 years ago and were not intending on returning back to smoking. The choice of smoking status determined the next part of the survey the participants completed. If the participant indicated that they were a current smoker or a smoker attempting to quit they were then directed to section 2 of the survey. If they were a non-smoker they were directed to section 4 of the survey.

Section 2 comprised questions relating to smoking behaviour. Participants were asked about the time since last cigarette, the number of years smoked for, the number of previous quit attempts during their smoking career, the number of previous quit attempts during their smoking career that had lasted more than six months, and in which type of environment they were most likely to relapse back to smoking following a quit attempt (e.g. in a pub, whilst driving, before an exam). Furthermore, section 2 included the modified version of the Fagerstrom questionnaire as described in Study 1. Following section 2, smokers and SATQ were directed to section 3 of the survey.

Section 3 contained items specifically about the smoking ban. These questions were: 'Are you intending to quit or have you quit in light of the England smoking ban?', 'If you were to attempt to quit, or if you have quit, do you think that the England smoking ban will help?', and 'Did you give up smoking because of the England smoking ban?'. Participants responded either 'yes' or 'no' for each question. This section also contained a measure of craving as described in Study 1. Following section 3 smokers and SATQ were directed to section 4.

Section 4 comprised items designed to measure 1) how participants' exposure to smoking stimuli and smoking environments had changed as a result of the ban and 2) how participants friends' and household members' smoking behaviour (e.g. whether they had given up smoking) had changed as a result of the ban. In order to measure exposure to smoking environments and stimuli, participants were asked to report, in the past two weeks, the total number of places they visited where smoking was common before the smoking ban and how many places they went to where there would be areas specifically designated for smoking. Participants were also asked whether they currently work in a place where smoking was common before the smoking ban. In order to measure participants' exposure to smoking stimuli, they were presented with a list of possible smoking stimuli they may have been exposed to. These items included items relating to the smoking ban (e.g. smoking ban leaflets, advertisements), items relating to quitting smoking (e.g. health adverts, nicotine patch adverts and leaflets), smoking objects (e.g. cigarettes, lighters, cigarette butts), and people smoking. Participants were asked to think back and report how many of each item they had come across over the past two weeks. In order to measure how participants friends' and household members' smoking behaviour had changed as a result of the ban, participants were asked 1) how many of their friends and household members smoke and 2) how many of them may be intending to quit in light of the smoking ban.

1-month follow-up and 2-month follow-up survey

For both the 1-month follow-up survey and the 2-month follow-up survey participants were contacted again via email 1-week before survey responses were due for each follow-up survey. These follow-up surveys included the same items and procedures as presented for the baseline survey. However, participants who had indicated themselves as smokers attempting to quit on the previous survey and who had not changed their smoking status, were not required to give their details of previous smoking behaviour again in section 2 and so were directed to section 3 after completing section 1. If smoking status had changed from smoker attempting to quit back to current smoker then they completed questions in line with the procedure adopted for smokers.

Analysis of smoking ban survey data

The analyses that could be conducted on the smoking ban survey data were limited due to the low response rate (i.e. low N meant that regression analysis could not be conducted reliably). Furthermore, the number of smokers who changed their behaviour over the three survey time-points was low therefore only descriptive analyses and Chi-Squared analyses could be used reliably. However, to identify any differences in the measures across the survey sessions mixed measure ANOVAs could reliably be conducted. Therefore, ANOVAs were used on smoking-related measures, reports of the number of friends and household members who smoked and also the number of smoking objects to examine the effects of the smoking ban over time.

4.2.2 - Results

Intention to quit

It was hypothesised that participants who had intended quit in light of the smoking ban would be more likely to quit, or stay quit, over the time of the survey. To examine whether this was the case the numbers of smokers changing their status over the follow-up survey times was examined in relation to their intention to quit.

Examination of the frequencies indicated that, at baseline, 50% of smokers (N=12) showed that they intended to quit in light of the smoking ban. Similarly, 50% of SATQ at baseline (N=8) indicated that they had intended to quit in light of the smoking ban, however, only two of the SATQ reported that the actual reason they did quit smoking was because of the smoking ban. Furthermore, 79% of smokers at baseline (N=19) and 87.5% of SATQ at baseline (N=14) reported that they thought the smoking ban might help them to quit smoking. Three SATQ had started using nicotine patches to help them quit, all other SATQ did not use any cessation aids or services.

Of the smokers who completed the baseline and 1-month follow-up, only two smokers at time 2 had changed their baseline status of 'smoker' to 'smoker attempting to quit', indicating they had quit smoking in the first month of the smoking ban. Furthermore, their status remained as 'smokers attempting to quit' in the 2-month follow-up. Both of these participants had indicated their intention to quit in light of the smoking ban at baseline. Furthermore, they had both reported that the smoking ban was the reason for them quitting smoking and that they thought that the smoking ban would help them quit smoking. One further smoker had quit by the 2-month follow-up, this smoker had also indicated the intention to quit in light of the smoking ban, had reported that the smoking ban was the reason for quitting and reported that the smoking ban might help them quit smoking.

In SATQ, one participant had returned back to 'smoker' status at the 1-month follow-up. This participant's status was still a 'smoker' at the 2-month follow-up. Examination of this participant's baseline responses indicated that they had not intended to quit in light of the smoking ban. However, they reported that the smoking ban was the main reason for them quitting and they thought that the smoking ban might help them quit smoking. A further smoker attempting to quit had returned back to smoking status at the 2-month follow-up. Examination of this participant's baseline responses indicated that they had intended to quit in light of the smoking ban, had reported that the smoking ban was the reason for them quitting and had reported that they thought that the smoking ban might help them quit.

Chi-squared analyses indicated that the intention to quit was not associated with a change in smoking status (i.e. from smoker to smoker attempting to quit, or from smoker attempting to quit to smoker) for smokers ($\chi^2(1, N=24) = 1.04, p > .1$) and SATQ ($\chi^2(1, N=16) = 1.07, p > .1$). Furthermore, chi-squared analysis revealed that the belief that the smoking ban would help a quit attempt was not significantly associated with the change in smoking status for both smokers ($\chi^2(1, N=24) = .45, p > .1$) and SATQ ($\chi^2(1, N=16) = .70, p > .1$).

Smoking behaviour

To examine if there were any changes among smokers in nicotine dependence over the three test sessions a one-way ANOVA on Fagerstrom scores was conducted. This analysis revealed no significant differences ($F(2, 18) = .31, p > .74$, partial $\eta^2 = .01$), indicating that nicotine dependence remained relatively stable over the three survey sessions (see Tables 4-2 & 4-3).

To examine if there were significant differences in craving over the three survey sessions and between smokers and SATQ a 3 x 2 mixed measures ANOVA was conducted. This ANOVA incorporated Time (baseline, 1-month follow-up, 2-month follow-up) as the within subject factor and Group (smokers, smoker attempting to quit) as the between subject factor. This analysis revealed no significant effect of time ($F(2, 50) = 1.01, p > .1$, partial $\eta^2 = .04$) or interaction of time x group ($F(2, 50) = .25, p > .1$, partial $\eta^2 = .01$) (see tables 4-2 & 4-3). However, a significant main effect of group was revealed ($F(1, 25) = 7.40, p < .05$, partial $\eta^2 = .23$). Inspection of the means showed significantly higher craving in smokers ($M = 3.09$, $SE = .32$) compared to SATQ ($M = 1.81$, $SE = .35$).

Similarly, to examine whether the number of household members who smoked and the number of friends who smoked significantly differed over the three survey sessions and between smoking groups two separate mixed measure ANOVAs were conducted. These ANOVAs both incorporated Time (baseline, 1-month follow-up, 2-month follow-up) as the within subject factor and Group (smokers, smoker attempting to quit, never-smokers) as the between subjects factor. These analysis revealed no significant main effects or interactions for either the number of household members who smoked or the number of friends who smoked (all *Fs* < 1.80, *ps*$>.1$, see Table 4-2). Thus, indicating that the number of friends and household members who smoked did not differ over the two months following the introduction of the smoking ban or between the different smoking status groups.

A mixed measures ANOVA was also conducted to examine if the number of household members and friends who considered quitting in light of the smoking ban differed significantly between the survey sessions and between the groups. This ANOVA also incorporated Time (baseline, 1-month follow-up, 2-month follow-up) as the within subject factor and Group (smokers, smoker attempting to quit, never-smokers) as the between subject factor. This analysis revealed a significant main effect of time ($F(2, 76) = 5.97, p < .005$, partial $\eta^2 = .14$), but not a significant main effect of Group($F(2, 38) = .43, p > .1$, partial $\eta^2 = .02$). Also there was a non-significant interaction of Group x Time ($F(4, 76) = .38, p > .1$, partial $\eta^2 = .02$). For the main effect of Time, post hoc analyses using Bonferronni correction for multiple comparisons revealed that there were significantly more friends and household members intending to quit in light of the smoking ban at baseline ($M = 2.61$, $SE = .49$) compared to the 1-month follow-up ($M = 1.47$, $SE = .16$). There were no significant differences between the number of friends and household members who were intending to quit at baseline compared to 2-month follow-up ($M = 1.82$, $SE = .30$), or between the 1-month follow-up and the 2-month follow-up.

Number of smoking ban related stimuli

To examine whether the number of smoking items differed over the survey sessions mixed measure ANOVAs were conducted separately for smoking ban related items (smoking ban information, smoking ban adverts), quit smoking-related items (adverts and information for smoking cessation services, adverts for nicotine patches), smoking objects (lighters, cigarettes, cigarette butts, cigarette/tobacco packets, ashtrays), people smoking, and all smoking items (including no smoking signs) grouped together. These analyses used the number of items/objects/people smoking as the dependent variable, Time (baseline, 1-month follow-up, 2-month follow-up) as the within subject variable and Group (smokers, SATQ, non-smokers) as the between subject variable.

Firstly, an ANOVA was conducted to identify any differences in the number of smoking ban related items that participants came across in the month prior to each test session. This analysis revealed only a main effect of Time ($F(2, 76) = 10.41, p < .001$, *partial* η^2*=.22)* . There was a significant decrease in the number of smoking ban related items reported between baseline to 1-month follow-up ($p < .01$) and between the baseline and 2-month follow-up ($p = .001$), but there was no significant difference in the smoking ban items reported between the 1-month follow up and the 2-month follow-up ($p > .05$, see Table 4-4). The main effect of Group and the interaction of Group by Time were not significant (all $Fs < 1.5$, $ps > .05$).

The ANOVA conducted for quit smoking-related items also revealed a significant main effect of Time ($F(2, 76) = 7.35, p = .001$, partial $\eta^2 = .16$). In contrast to smoking ban related items, for quit smoking related items there was no significant difference in the number of items reported between baseline and 1-month follow-up ($p > .05$). However, there was a significantly lower number of quit smoking items reported in the 2-month follow-up compared to baseline ($p < .001$) and the 1-month follow-up ($p < .05$, see Table 4-4). The main effect of Group and the interaction of group by time were not significant (all $Fs < 2.8$, $ps > .05$).

For the number of smoking objects the ANOVA revealed a main effect of Group ($F(2, 38) = 9.38, p < .001$, partial $\eta^2 = .33$). Inspection of the means showed that there were more smoking-related objects being reported in smokers compared to SATQ ($p < .05$) and never-smokers ($p < .001$, see Table 4-4). There was no significant difference in the number of smoking-related objects reported between SATQ and never-smokers ($p > .1$). There was no main effect of Time or interaction of Time x Group for the number of smoking objects reported ($Fs < .45$, $ps > .05$).

For the number of people smoking the ANOVA revealed a main effect of Group ($F(1, 38) = 5.21, p < .05$, partial $\eta^2 = .22$). There was an increase in the number of people smoking reported by smokers compared to non-smokers ($p < .01$). However, there were no significant differences in the number of people smoking reported by smokers compared with SATQ ($p > .1$, see Table 4.4) or by SATQ compared with never-smokers ($p > .1$). There was no significant main effect of Time ($F(2, 76) = 1.04, p > .1$, partial $\eta^2 = .03$) and no significant interaction of time x group ($F(4, 76) = 1.31, p > .1$, partial $\eta^2 = .07$).

For all smoking objects grouped together the ANOVA revealed a main effect of Time ($F(2, 76) = 7.79, p < .001$, partial $\eta^2 = .17$) and a main effect of Group ($F(1, 38) = 7.15, p < .005$). However, the interaction of Time x Group was not significant ($F(4, 76) = 1.76, p > .1$, partial $\eta^2 = .09$). For the main effect of Time post hoc analyses revealed significantly more smoking items reported at baseline compared to the 2-month follow-up ($p = .001$, see Table4-4). However, there were no significant differences in the number of smoking-related items reported between baseline and 1-month follow-up ($p > .05$) or between 1-month follow-up and 2-month follow-up ($p > .1$).

Table 4-2

Smoking-related behaviour and intentions at baseline in smokers and smokers attempting to quit

		Baseline	
		SM N=24	SATQ N=16
How long smoked for in		9.22 (5.14)	12.08 (11.24)
Fagerstrom score		9.83 (2.22)	9.50 (2.55)
Crave score		3.40 (.37)	1.92 (.41)
Intended/ intending to quit due to smoking ban		12 (50%)	8 (50%)
Number of quit attempts in previous during smoking career	Lasted over 6 months	1.83 (1.13)	2.00 (1.27)
	Total quit attempts	3.79 (2.36)	3.00 (2.28)

Values are Mean (SD) for How long smoked for, Fagerstrom, and craving; N (%) for quit related items

Table 4-3

Smoking-related behaviour and craving scores at 1-month and 2 month follow-up in smokers and smokers attempting to quit

	1-month follow-up		2-month follow-up	
	SM N=16	SATQ N=15	SM N=14	SATQ N=13
Crave Score	3.00 (.43)	1.75 (.48)	2.87 (.31)	1.75 (.35)
Fagerstrom Score*	10.50 (1.98)	-	9.83 (1.75)	-
Quit in previous month*	2 (12.5%)	-	1 (7.14%)	-
Quit because of smoking ban	2 (12.5%)	-	1 (7.14%)	-

*Responses regarding quitting and Fagerstrom questionnaire were not completed by SATQ at 1-month or 2-month follow-up as these had not changed since baseline. Values are Mean (SD) for How long smoked for, Fagerstrom, and craving; N (%) for quit related items

Table 4-4

Mean (SD) number of reported smoking items, friends, and household members who smoke for each group at each survey time-point

		Baseline				**1-month follow-up**				**2-month follow-up**			
		SM N=24	SATQ N=16	NS N=32	AP N=72	SM N=16	SATQ N=15	NS N=21	AP N=52	SM N=14	SATQ N=13	NS N=17	AP N=44
Number of smoking cues reported	Ban related	20.79 (12.19)	11.38 (10.16)	16.69 (11.70)	16.88 (11.90)	13.00 (11.84)	6.86 (4.94)	8.52 (8.47)	9.54 (9.20)	14.27 (12.82)	6.25 (4.22)	8.41 (10.23)	9.82 (10.40)
	Non-ban related	125.62 (31.33)	87.06 (42.38)	81.69 (34.85)	97.53 (40.40)	125.41 (36.27)	70.43 (29.22)	75.00 (28.52)	90.25 (39.56)	111.13 (37.99)	77.25 (31.26)	65.12 (42.55)	84.11 (42.47)
	People smoking	19.25 (5.08)	16.00 (6.46)	13.56 (6.78)	16.00 (6.59)	18.88 (4.11)	11.50 (8.00)	14.00 (7.04)	14.92 (7.06)	17.13 (5.22)	16.67 (6.03)	11.35 (8.11)	14.77 (7.09)
	Total	145.96 (40.03)	103.75 (49.97)	102.06 (42.45)	117.07 (47.51)	138.94 (41.42)	77.29 (29.51)	83.52 (27.07)	99.79 (42.34)	125.40 (47.50)	83.50 (27.07)	73.53 (49.27)	93.93 (49.75)
Friends who smoke		8.79 (4.75)	7.81 (5.36)	5.78 (4.78)	7.24 (5.02)	8.59 (5.34)	7.07 (5.15)	5.62 (4.32)	6.98 (4.97)	6.60 (4.19)	6.67 (4.33)	4.35 (3.97)	5.75 (4.20)
Household members who smoke		2.00 (.89)	1.50 (.73)	1.47 (1.11)	1.65 (.98)	1.94 (.97)	1.50 (.76)	1.67 (1.46)	1.71 (1.14)	2.07 (.88)	1.33 (.65)	1.59 (1.50)	1.68 (1.14)

All values are Mean (SD)

SM= smokers, SATQ= smokers attempting to quit, NS=non-smokers, AP=All participants

4.2.3 - Summary of Findings for Study 4

The survey conducted in Study 4 indicates that while intentions and the total number of smoking items changed over the period of the first two months of the smoking ban this appeared to have very little influence on smoking behaviour and the number of people smoking. Also, in smokers attempting to quit only two (out of 16) relapsed back to smoking behaviour. This is interesting given that only three people used interventions in the form of nicotine patches to aid their smoking cessation attempt, indicating that the remaining smoking quit attempts were successful over a 2 month period even though interventions were not used to aid cessation.

Whilst half of smokers indicated their intention to quit smoking in light of the smoking ban only three smokers out of the sample of smokers had attempted to quit during the time the survey was conducted. Indicating that intentions to quit may not lead to actual quitting behaviour in the short term. Furthermore, the findings also showed that number of friends and household members who had considered quitting in light of the smoking ban was relatively high during the initial introduction of the smoking ban but that this diminished after the first month of the smoking ban, returning to moderate levels two months after the smoking ban. It may be possible that if the intention to attempt to quit was not carried out in the early stages of the smoking ban then the intention to quit on subsequent period of time would be relatively low.

With respect to smoking items and the number of people smoking, there was no evidence of any changes in the number of smoking items unrelated to quitting and the smoking ban, or the number of people smoking over the period of the survey. This indicates that smoking was similarly prevalent across all three survey time-points. There was, however, evidence that the number of smoking ban related items and quit smoking items decreased over the period of the survey. This was possibly a result of the drive to advertise the smoking ban during its initial phase. Similarly, when all items were grouped together there was a decrease in smoking items from baseline to 2-month follow-up. This is important as it indicates that smoking may have been more salient during the introduction of the smoking ban, compared to two months after the smoking ban.

4.3 - General Discussion

Chapter 5 presents two studies, Study 3 and Study 4, which examine the effects of the England smoking ban on smoking attentional bias, the emotion associated with smoking-related stimuli and smoking-related behaviours. Specifically, Study 3 examined the effect of the smoking ban on attentional bias to smoking stimuli in smokers using the Stroop task and the visual probe task. In contrast, Study 4 examined smoking behaviour changes in smokers and smokers attempting to quit, and the effects of the smoking ban on the prevalence of smoking objects and number of people smoking using an online survey.

In line with predictions, the findings of Study 3 showed evidence of smoking attentional bias in smokers across both the Stroop task and the visual probe task, adding to the growing evidence that the attention of smokers is grabbed by smoking stimuli to a greater extent than to neutral stimuli. Furthermore, the findings showed that attentional bias to smoking stimuli changed over the follow-up sessions, 1-month and 2-months following the introduction of the smoking ban. In the Stroop task, attentional bias for smoking stimuli was shown at baseline and in the 1-month follow-up session. However, there was no significant difference in responses to smoking stimuli and neutral stimuli in the 2-month follow-up. In contrast in the visual probe task attentional bias was shown at baseline, but was not present in the 1-month follow-up. However, there was evidence of attentional bias toward smoking stimuli in the 2-month follow-up session.

Both Study 3 and Study 4 provided evidence that the smoking ban had little effect on smoking behaviour, with nicotine dependence, subjective craving, and BCO measures in Study 3 remaining relatively consistent across the test sessions. Furthermore, the smoking status of survey respondents and the number of friends and household members who smoked in Study 4 remained relatively unchanged across survey periods. There was also no association between the presence of smoking attentional bias and smoking-related behaviours in Study 3. Together these findings suggest that the presence of smoking attentional bias is independent of these smoking behaviour-related measures. This finding contradicts evidence from previous research and which has shown correlations between smoking urges, craving, nicotine dependence and smoking attentional bias (e.g. Cane et al., 2009; Mogg & Bradley, 2002). It also contradicts the findings of Study 2, which revealed negative correlations between

Fagerstrom scores, craving and the attention given to smoking images. However, such relationships are relatively inconsistent across research examining smoking attentional bias, with a number of studies showing no relationship between measures of smoking behaviour and smoking attentional bias (e.g. Bradley et al., 2008; Ehrman et al., 2002; Mogg & Bradley, 2002; see Chapter 2, section 2.2.1; Munafò et al., 2003; Munafò et al., 2005). Indeed this was the case in Study 1 where Fagerstrom scores and craving were unrelated to attentional bias to smoking images. One possible reason for these inconsistencies is that the measures adopted may not be tapping the same underlying mechanisms of smoking attentional bias. For instance, Klinger and Cox et al. (2004; see Chapter 1, section 1.3) suggest that attentional bias may index current concerns to which none of these measures are indicative of (e.g. the opportunity to smoke, the willingness to quit or continue smoking, health concerns related to smoking). These findings, along with the findings of Studies 1 and 2, also provide no evidence for the mutually excitatory link between attentional bias and craving as suggested by Field et al. (2008) and Franken et al. (2003).

The findings of Study 3 also indicate no relationship between the emotional content of smoking stimuli, state and trait anxiety and smoking attentional bias. Furthermore, Study 3 showed that smokers view smoking stimuli as relatively positive and these emotional ratings of smoking stimuli did not significantly differ across the test sessions. The finding that smokers rate smoking stimuli as positive replicates Studies 1 and 2 and also previous research examining the emotional content of stimuli in relation to attentional bias (e.g. Cane et al., 2009). Furthermore, the finding that emotional ratings of smoking stimuli were not associated with smoking attentional bias further replicates Cane et al. (2009) who only showed relationships between the emotional rating of smoking stimuli and smoking attentional bias in smokers attempting to quit, who rated the smoking stimuli as negative.

Based on the evidence from Study 3 it is unclear the exact effect that the smoking ban had on smoking attentional bias in the study as it was difficult to control for behaviour which occurred between the test sessions. Indeed, to identify the exact effects of the smoking ban the present study would have benefitted from examining attentional bias in a group who were unaffected by the smoking ban. However, based on the findings of Study 4 it may be possible that the prevalence of smoking cues may have affected the outcome of the attentional bias experiment. Indeed, Study 4 showed that there were significantly more smoking-related items reported during baseline measurements than at the 2-month follow-up. This increase in prevalence of smoking cues, be they smoking ban related or non-smoking ban related, could have possibly made smoking more salient to participants who participated in Study 3 increasing the presence of attentional bias in the baseline measures, as shown in the Stroop task and the visual probe task. Furthermore, the finding that there was a decrease in smoking attentional bias in the visual probe task in the 1-month follow-up and in the Stroop task in the 2-month follow-up mirrors the decrease in smoking objects reported over the same periods of time. Unfortunately, this is a speculative suggestion at this stage, and further research would be required to examine if the increase in smoking cues prior to experimental procedures affects the presence of smoking attentional bias.

In conclusion, Study 3 has provided evidence of smoking attentional bias in both the Stroop task and the visual probe task and has also shown changes in attentional bias after the introduction of the England smoking ban. Furthermore, both Studies 3 and 4 have shown that smoking behaviour is unlikely to change in light of a smoking ban even if the intention is to quit smoking as a result of the smoking ban. These studies also support previous research showing that smoking attentional bias is unrelated to smoking behaviour measures and that measures such as the Fagerstrom questionnaire and subjective craving may not tap the underlying mechanisms of smoking attentional bias (e.g. Bradley et al., 2008; Ehrman et al., 2002; Mogg & Bradley, 2002; Munafò et al., 2003; Munafò et al., 2005; see Chapter 2, section 2.2.1). One speculative reason for the change in attentional bias over the initial period of the England smoking ban is that smoking may have been less salient due to the decrease in smoking-related items in the months after the smoking ban. This possibility is examined further in Study 5, which attempts to manipulate the attention given to smoking-related stimuli through a technique named attentional retraining, and examines whether this manipulation affects the presence of smoking attentional bias.

Chapter 5: An examination of Attentional Retraining in smokers, smokers attempting to quit, and never-smokers

Chapter 5 presents the findings from Study 5. It examines the effectiveness of a technique called attentional retraining in manipulating smoking attentional bias across smokers, smokers attempting to quit and never-smokers. It also examines whether any manipulation of bias changes subsequent nicotine dependence and craving. Results indicated that attentional retraining was effective in reducing attentional bias in smokers, both when smokers were trained to attend away from smoking stimuli and when they were trained to attend towards smoking stimuli. However, contrary to predictions, the change in attentional bias did not affect subsequent nicotine dependence or cravings measured one week and one month after the experimental sessions. Importantly, the findings did generalise to novel stimuli and to a Stroop task following training.

Study 3 examined the effects of an external influence, the England smoking ban, on smoking attentional bias. It was shown that attentional bias may change as a result of the smoking ban but this was unrelated to smoking behaviour or the emotion assigned to smoking-related stimuli. Furthermore, there was some indication that changes in attentional bias might have been related to the number of smoking items present over the period examined in Studies 3 and 4. In addition, both the findings from Study 2 and Study 3 have indicated that smoking attentional bias can, to some extent, be manipulated. This was particularly evident in Study 2, in which it was shown that attention to smoking stimuli in latter stages of attentional processing could be controlled under explicit instructions to attend to neutral stimuli. Study 5 extends on these findings by examining whether a technique, commonly termed attentional retraining, is effective in manipulating the extent to which smoking attentional bias is shown across smokers, smokers attempting to quit and never-smokers.

As mentioned in Chapter 2, (section 2.3.2), research examining the manipulation of attentional bias is in its infancy. However, a number of studies have shown that the technique attentional retraining can be effective in both reducing and increasing attentional bias in relation to emotion, alcohol and smoking. Attentional retraining involves the adaption of the visual probe task so that probes either always replace critical stimuli (e.g. alcohol, smoking or emotion stimuli), or always replace neutral stimuli. In the version where probes always replace critical stimuli it has been shown that attentional bias towards these stimuli increases. This is thought to be because attention is trained to seek critical stimuli so that the probe can be responded to more quickly. In the version where the probe always replaces neutral stimuli, it has been shown that attentional bias to concern-related stimuli often decreases (for further details see Chapter 2, section 2.3.2).

Whilst this technique has been shown to be effective in relation to short-term changes in attentional bias, the effects have been shown to be limited to the attentional retraining task itself and do not generalise to novel stimuli or to other tasks measuring attentional bias (see Chapter 2, section 2.3.2). Furthermore, whilst AR has been proven to be somewhat effective in relation to the manipulation of smoking attentional bias (e.g. Field et al, 2009; Attwood et al. 2008; see Chapter 2, section 2.3.2), there are a number of limitations of this research. Firstly, previous studies examining attentional retraining in relation to smoking have used pictorial stimuli which, as previously discussed, may be too specific to yield generalisation effects to novel stimuli and an alternative attentional bias measure (see Chapter 1, section 2.1.1). Secondly, previous studies have not examined the effectiveness of attentional retraining in relation to smokers who are attempting to quit to whom attentional retraining may be most beneficial. Indeed, any intervention that proves effective in reducing attentional bias in quitting groups may have a great impact on improving smoking cessation success rates. Thirdly, whilst Field et al. (2009) include a control group whose attention is trained equally to smoking and neutral stimuli neither Field et al (2009) or Attwood et al. (2008) include a non-smoking control group. The inclusion of a non-smoking control group may prove beneficial as it would help identify whether attentional retraining affects attentional mechanisms specific to smoking groups or whether it is having a more global effect on attention unrelated to smoking status.

In light of these limitations, Study 5 aims to extend on previous findings by examining whether attentional retraining is similarly effective across smokers, smokers attempting to quit, and never-smokers, and whether effects of generalisation to a new task occur when word stimuli, instead of pictorial stimuli, are used.

Attentional retraining was delivered using the visual probe paradigm. In order to assess effects of generalisation to a novel task, the effect of AR on a different measure of bias were examined. This measure was the addiction Stroop task as used in Study 3. By using this version of the Stroop task the effects of attentional retraining on both the fast and slow effects of attention can be examined. Furthermore, research suggests that the Stroop task and the visual probe task may measure different components of attention (see Mogg & Bradley, 2002; Field, et al. 2007; Chapter 2, section 2.1.1: *visual probe task*), therefore it would be interesting to examine whether effects generalise across these two tasks with regards to smoking attentional bias.

As well as measuring effects of generalisation the present study aimed to examine whether smoking behaviour in the form of nicotine dependence is affected by AR. Attwood et al. (2008) showed a relationship between craving and changes in attentional bias to smoking-related cues as a result of AR. However, it is still unclear what effect AR may have on other smoking-related behaviours. The present study intends to examine this by measuring nicotine dependence and subjective craving at three time points; once at the time of the experiment, and then one-week and one-month after the experiment. By measuring nicotine dependence at these time points the present study assesses any changes in smoking behaviour which may have resulted from AR.

In addition to examining effects of generalisation and changes in smoking behaviour and craving which result from AR, Study 5 includes two important controls. It includes a 'control' condition in which dots replace smoking and neutral stimuli equally during training, thereby not biasing attention towards or away from smoking stimuli. It also includes a 'never-smoker' control group with which the effects of AR and the presence of attentional bias to smoking–related stimuli among smokers attempting to quit and smokers can be compared.

Based on previous studies it was hypothesised that among smokers and smokers attempting to quit smoking attentional bias would i) decrease when attention was trained away from smoking-related stimuli, ii) increase when attention was trained towards smoking-related stimuli, and iii) remain unchanged when attention was trained equally towards smoking-related and neutral stimuli. iv) In relation to generalisation, it was expected that generalisation to novel stimuli and also generalisation to the Stroop task following training would occur given that word stimuli, instead of pictorial stimuli, are being used . v) Finally, it was also hypothesised that increased smoking attentional biases would increase craving for smoking-related stimuli and decreased attentional bias would lead to reductions in craving and nicotine dependence following experimental procedures.

5.1 - Study 5

5.1.1 – Method

Participants

One hundred and five participants (32 males, 73 females; mean age=21.39, *SD*=3.67, age range = 17-35) were recruited through a research participation scheme at the University of Kent and through advertisements in the University of Kent Job Shop. Participants recruited through the research participation scheme were given 3 credits towards a module for their participation. Participants recruited through the university Job Shop were given £3 for their participation. All participants who took part were either native English speakers or fluent in spoken English. Participants were categorised into one of three conditions, i) active smokers, ii) smokers attempting to quit (SATQ), or iii) non-smokers. Participants were classed as active smokers if they had smoked a cigarette within the past 24 hours, SATQ if they were smokers who had abstained from smoking for over twenty-four hours and under two years and were actively attempting to quit, and non-smokers if they had never smoked or if they had abstained from smoking for over two years. Of those who took part 38 were classed as active smokers, 30 were classed as SATQ, and 37 were classed as non-smokers. All participants were treated in accordance with the ethical standards of the British Psychological Association. In addition, ethics approval was obtained from the University of Kent at Canterbury's Department of Psychology ethics committee before recruiting participants and proceeding with the experiment.

Design

Stroop task (before training and after training)

The Stroop task was a modified version of the smoking Stroop task used in Study 3. To detect attentional bias effects within the Stroop a 3x2x4 factorial mixed design with Group (smokers, SATQ and never-smokers) as the between participant factor and Word Sequence (smoking and neutral) and Position (1-4) as within participant factors was adopted.

Two Stroop tasks were used: one prior to training, to identify attentional bias effects before training and, one following training, to identify any effects of AR on Stroop attentional bias. Each Stroop task (before training and after training) was identical except for the particular set of smoking and neutral words used. Both Stroop tasks contained five sequences with each sequence containing a category specific word at position 1 (e.g. a smoking word or a neutral word) followed by three trials of neutral words (positions 2-4). The words in each sequence at position 1 remained at position 1 whenever the sequence was presented. However, words in positions 2-4 were counterbalanced using a Latin-Square design. Therefore, each of the five sequences of 4 trials was presented six times. In total there were 120 trials for each category (smoking and neutral), giving 240 trials overall in each Stroop task. Each sequence was displayed randomly within each Stroop task.

Visual probe task incorporating AR

A 3 x 3 x 2 mixed factorial design was adopted for the visual probe task with group (smokers, SATQ, and never-smokers) and training condition (avoid smoking, attend smoking, and control) as the between participant's factor and trial type (training trials and test trials) as the within group factor.

Each trial on the visual probe task involved the presentation of three items: a fixation signal, the word pairs and the probe. The initial fixation consisted of the words 'next trial' which were presented for 1000ms. The initial fixation served to alert the participant to the next trial and to ensure fixation of gaze on the centre of the screen. After the initial fixation the word pairs were presented for 500ms after which the probe (either one dot . or two dots ..) was presented and stayed on the screen until a selection was made. A blank screen was presented for 500ms between trials.

Stimuli consisted of 36 pairs of words (1 pair = 1 smoking word & 1 neutral word) split into two subsets. Only one subset of 18 pairs was shown in the training trials however both subsets were used in the test trials. In total the visual probe task involved 504 trials consisting of 72 test trials and 432 training trials. The 72 test trials comprised of 36 pairs of words (both subsets) repeated twice with the probe placed in the position of the neutral trials and in the position of the smoking trials an equal number of times.

The 432 training trials consisting of 18 pairs of words (only one subset) repeated 24 times. The position of the probe on each trial was dependent on the condition. In the 'attend smoking' condition the probes replaced the smoking-related words on all training trials, in the 'avoid smoking' condition the probes replaced the neutral related words on all training trials, and in the 'control' condition probes were placed in the position of the smoking words and the neutral words an equal number of times.

Stimuli

Stimuli used in the Stroop and visual probe tasks are shown in Appendix A3. Smoking words were largely taken from three studies that had assessed attentional biases in smokers (Waters, Shiffman, & Sayette, et al., 2003, Munafò et al., 2003; Cane, et al., 2009). Additional smoking words were adopted if they had any relation to smoking behaviour or smoking-related products. Neutral words were also taken from previous studies examining smoking attentional bias (Waters, Shiffman, & Sayette, et al., 2003, Munafò et al., 2003, Cane, et al, 2009) and additional neutral words were adopted if they had no relation to smoking-related behaviour or products. In the Stroop task the main neutral words shown in the neutral sequences at position 1 were chosen if they matched the frequency and word length of each of the five smoking stimuli. All other neutral words used in positions 2-4 were chosen if they matched the word length and frequency of the smoking or neutral words at position 1. To avoid effects of habituation confounding effects of AR in the Stroop tasks there were two sets of five smoking sequences and two sets of five neutral sequences used in the Stroop tasks. The experimental program randomly allocated one set of five smoking sequences and one set of five neutral sequences to the Stroop task prior to training and allocated the remaining set of five smoking sequences and set of five neutral sequences to the Stroop task following training. In addition stimuli used in the visual probe task were different to stimuli shown in the Stroop tasks. Pairs of words in the visual probe task were matched for word length and frequency. Words were matched for length and frequency using the Celex English Lexical Database, Release 2 (Baayen, Piepenbrock, & Gulikers, 1995). The stimuli for the Stroop task were 0.6cm high, 2cm wide and in one of four colours; red, green, blue or yellow on a black background and the words used in the visual probe task were also 0.6 cm high, 2cm wide but displayed in white on a black background. Participants sat approximately 60cm from the screen.

Apparatus

Task presentation and recording

The Stroop task, visual probe task and anxiety and depression scales were developed, run and the reaction times logged using E-prime computer program version 1.1. Stimuli were presented using a ATX p5/200 MMX computer connected to a 14in RM video monitor screen. Manual responses to the colour of stimuli for the Stroop task were collected using a response box utilising four buttons. Each of the buttons were labelled with the presented ink colours (RED, GREEN, BLUE, & YELLOW), these labels were written in black ink above each colour allocated button. For the Visual probe task participants made their selections using the buttons on a mouse, they pressed the left mouse button if they saw one dot and the right mouse button if they saw two dots. The left mouse button had one small circular sticker placed on it and the right mouse button had two circular stickers placed on it so that participants could remind themselves of the correct response button by feel if needed.

Measures

ASI, STAI, Fagerstrom questionnaires, and subjective craving scores were used as in Studies 1 and 2 and the word-relatedness measure was used as in Study 3. In addition, the Beck Depression Inventory (BDI) and the Positive and Negative Affect Scale (PANAS) were adopted for Study 5 to identify if depression or affective traits might be indexed by smoking attentional bias. Furthermore, computerised measures of depression and anxiety were taken during experimental trials to identify any immediate changes in light of experimental procedures. Details of the BDI, PANAS-X and computerised measures of anxiety and depression are given below.

The Beck Depression Inventory (BDI)

The Beck Depression Inventory (BDI) (Beck, Rial, & Rickets, 1974) measures attitudes and characteristics of depression using a 21 item self-report rating inventory. Participants select phrases which relate to how they have felt over the past few weeks across 21 specific aspects of depression. The rating of these items yields a score between 0 and 63 which indicates a level of depression with 5 – 9 'being ups and downs which are considered normal', 10 – 18 'being mild to moderate depression', 19 – 29 'being moderate to severe depression', and 30 – 63 'being severe depression'. Scores of below 4 are considered to be possible 'denial of depression'.

The Positive and Negative Affect Scale - extended form (PANAS-X)

To assess levels of mood in participants the study adopted the PANAS-X (Watson & Clark, 1994) . The PANAS-X is an expanded version of the Positive And Negative Affect Schedule. It measures the general factors of Positive Affect (PA) and Negative Affect (NA) as well as measuring 11 specific affects: Fear, Sadness, Guilt, Hostility, Shyness, Fatigue, Surprise, Joviality, Self-assurance, Attentiveness, and Serenity. It comprises of 60 items (emotion words) which participants rate from 1 (very slightly or not at all) to 5 (extremely) based on their feelings over the past few weeks. Therefore, higher scores on the PANAS-X equate to a greater amount of that feeling. By measuring both the general factors of PA and NA and the 11 specific affects the PANAS-X provides mood measurement at 2 different levels. Therefore, this measure yields two scores: one score for positive affect and one score for negative affect.

Computerised measures of anxiety and depression during experimental procedures

In addition to the STAI measure and BDI measure, on four occasions during the experiment participants were asked to rate how anxious they felt and how happy they felt. This was done in order to identify any changes in subjective ratings of anxiety and depression during experimental procedures. These measures were taken before the experiment began, after the initial Stroop task, after the visual probe task (AR training), and after the final Stroop task. Participants rated how anxious and happy they felt on a computerised version of the visual analogue scale. For anxiety the labels at the two extremes of the line were 'relaxed' and 'anxious' and for depression the labels at the two extremes of the line were 'happy' and 'depressed'. Also, as the participants moved the mouse over the line a number from 0-14 appeared, corresponding to the point on the line which the mouse pointer was at. Higher scores were related to greater anxiety or greater depression.

Procedure

On arrival participants completed the FTND questionnaire, the State-Trait Anxiety Inventory, the PANAS X, the ASI, the BDI and gave a BCO sample.

Participants were then assigned to a group (smoker, SATQ or never-smoker), training condition (attend smoking, attend neutral, or control) and visual probe subset (training subset 1 or training subset 2). Participants were unaware of group, condition, and visual probe subset allocation.

Participants then rated levels of anxiety and depression using the computerized scales and were introduced to the Stroop task in which they were told they would have to respond to the colour of words shown on the screen whilst ignoring the words themselves. Each participant indicated the colours of words using their index fingers and middle fingers of each hand placed on each of the four buttons. To begin with each participant was then given 60 practice trials using random strings of four letters (e.g. XXXX, CCCC, TTTT). This not only helped them to get used to doing a Stroop task but also allowed them to learn the position of the coloured buttons. Participants then began the Stroop task, and were tested on all 240 trials before reporting their levels of anxiety and depression again on the computer.

Participants were then introduced to the visual probe Task in which they completed all 504 trials indicating their responses on the mouse using the index and middle fingers of the right hand. After the visual probe task participants again reported their levels of anxiety and depression on the computer. Following these measures participants completed the second Stroop task and subsequent ratings of anxiety and depression.

Once all the computer tasks were completed participants completed the subjective rating of craving and the word-relatedness scale. Participants were fully debriefed, both verbally and via a debriefing sheet following experimental procedures.

Data analysis

Data from both Stroop tasks and the training trials in the Attentional Retraining task were analysed using mixed-design analyses of variance (ANOVAs). Any interactions were clarified by follow up ANOVAs and t-tests with Bonferroni where applicable. To analyse between group characteristics in data from questionnaires taken prior to training a series of 2-way between group ANOVAs were carried out. In addition, chi-square analyses were used to identify any between-condition variances in gender. Analyses conducted to identify effects of AR on craving and nicotine tolerance were conducted using a series of mixed measure ANOVAs.

5.1.2 - Results

Group Characteristics

Although it was not directly hypothesised, given that it was possible that the level of anxiety, mood, depression and smoking-related factors could have had an influence the effectiveness of attentional retraining , initial analyses were conducted to check whether reports of anxiety, mood, depression and smoking-related factors differed between the distribution of conditions and groups.

Table 5-1 shows a summary of measures taken at the beginning of the experiment separately for each group (smokers, SATQ and never-smokers) and for each training condition (avoid smoking, attend smoking and control). A series of 3x3 between subjects ANOVAs were used to identify any between group and between condition differences prior to training for each of the measures shown in table 1. These ANOVAs incorporated Group (smokers, SATQ and never-smokers) and Attend condition (avoid smoking, attend smoking, and control) as the independent variables and the pre-training measure scores as the dependent variables. These analyses revealed no significant differences in state or trait anxiety scores, BDI scores, or positive affect scores (taken from the PANAS measure) between training conditions and between groups (all $Fs < 1.43$, all $ps > .1$). The analyses did reveal a significant main effect of group for Negative affect scores taken from the PANAS measure ($F(2, 95) = 3.40, p < .05$, *partial* $\eta^2 = .07$), with smokers reporting significantly more negative affect (M=22.83, SE = 1.00) than never-smokers (M=19.43, SE = .97)($p < .05$). The analyses also revealed a significant main effect of Group for ASI scores ($F(2, 95) = 6.51, p < .005$, *partial* $\eta^2 = .12$) showing that smokers and SATQ had significantly greater levels of anxiety sensitivity (smokers: M=21.14, SE = 1.73, SATQ: M = 23.77, SE = .19) than never-smokers (M=14.70, SE = 1.78)($ps < .05$). .However, both anxiety sensitivity scores and negative affect did not significantly differ between the attend conditions within each group prior to training. Chi-squared analyses conducted on male and female counts revealed that the training conditions within each group also did not significantly differ in gender ratio (Never-smokers - X^2= 1.04, p>.1; Smokers - X^2= 1.42, p>.1; SATQ - X^2= .95, p>.1).

Table 5-1

Comparison of pre-training measure data by group and training condition

Group	Measure		Training Condition: Attend	Control	Avoid	Training Conditions Combined
Smokers	**Age**		21.92 (3.60)	22.54 (4.50)	22.23 (3.94)	22.24 (3.94)
	Sex	*Male*	5	4	7	16
		Female	7	9	6	22
	State Anxiety		39.83 (7.90)	40.54 (9.90)	38.62 (8.66)	38.36 (10.93)
	Trait Anxiety		43.75 (10.35)	44.08 (11.88)	42.54 (9.59)	43.45 (10.39)
	ASI		22.58 (11.41)	22.31 (12.89)	18.54 (11.59)	21.11 (11.82)
	BDI		10.83 (8.12)	7.46 (7.29)	7.31 (4.15)	8.47 (6.72)
	PANAS	*PA**	25.00 (6.61)	25.54 (7.29)	28.15 (8.90)	26.26 (7.60)
		*NA**	23.33 (2.53)	22.46 (6.62)	22.69 (7.08)	22.82 (5.70)
	No. of cigarettes smoked	*1-15*	11	9	11	31
		16-25	1	4	2	7
	Fagerstrom Scores		3.25 (1.42)	4.08 (2.18	4.38 (1.76)	3.92 (1.84)
	How long smoked for		4.37 (3.08)	7.04 (5.09)	5.54 (3.31)	5.68 (4.00)
	Hours since last		3.78 (5.42)	6.33 (13.03)	3.54 (4.25)	4.56 (8.4)
	BCO (ppm)		11.25 (7.16)	13.54 (8.33)	14.31 (8.58)	13.08 (7.96)
SATQ[a]	**Age**		22.80 (6.05)	20.60 (2.07)	20.70 (2.87)	21.37 (4.04)
	Sex	*Male*	4	3	2	9
		Female	6	7	8	21
	State Anxiety		39.80 (10.67)	37.80 (9.31)	40.20 (10.33)	39.27 (9.10)
	Trait Anxiety		46.70 (10.67)	43.20 (9.57)	41.70 (9.23)	43.87 (9.73)
	ASI		26.60 (12.08)	20.90 (5.55)	23.80 (12.74)	23.77 (10.53)
	BDI		4.6 (3.69)	7.50 (5.62)	6.50 (6.15)	6.20 (5.22)
	PANAS	*PA**	*30.80 (2.15)*	27.70 (4.74)	29.50 (4.55)	29.33 (5.42)
		*NA**	19.90 (2.23)	19.50 (4.79)	20.70 (5.44)	20.03 (5.66)
	No. of cigarettes smoked	*1-15*	5	7	6	18
		16-25	5	3	4	12
	Fagerstrom Scores		5.30 (2.87)	3.00 (1.41)	3.20 (2.25)	3.83 (2.42)
	How long smoked for		5.55 (5.39)	3.25 (1.55)	4.29 (2.44)	4.36 (3.54)
	Days since last		196.40 (290.91)	120.20 (227.68)	141.70 (238.63)	152.77
	BCO (ppm)		4.7 (1.34)	3.50 (1.72)	4.00 (1.24)	4.07 (1.48)
Never-smokers	**Age**		20.36 (1.91)	20.67(3.28)	26.64 (15.45)	22.84 (9.98)
	Sex	*Male*	1	3	3	7
		Female	10	9	11	30
	State Anxiety		36.64 (9.20)	34.92 (10.41)	43.00 (11.85)	39.66 (8.68)
	Trait Anxiety		40.09 (10.09)	43.92 (10.67)	46.31 (11.27)	43.61 (10.72)
	ASI		13.55 (8.93)	16.08 (9.42)	14.46 (8.54)	14.72 (8.76)
	BDI		7.00 (4.00)	9.67 (8.60)	12.92 (11.52)	10.03 (8.91)
	PANAS	*PA**	28.91 (9.04)	27.92 (5.50)	29.23 (5.21)	19.47 (6.04)
		*NA**	18.91 (5.80)	18.75 (5.17)	20.62 (7.17)	14.72 (8.76)
	BCO (ppm)		3.27 (.78)	3.33 (1.07)	2.38 (1.26)	2.97 (1.11)

*PA= Positive Affect, NA=Negative Affect [a] SATQ = smokers attempting to quit
NB. Data presented are Means (SD) apart from No. of cigarettes smoked per day and Sex variables which are counts for each group

To identify if there were any significant differences in scores on smoking-related factors between smokers and SATQ prior to training a similar series of 2x3 between subjects ANOVAs were conducted. The analyses used group (smokers and SATQ) and training condition (attend smoking, avoid smoking , and control) as the independent variables and BCO readings, craving scores, Fagerstrom scores, days since last cigarette and length of smoking career separately as the dependent variables. The analyses revealed a main effect of group for BCO readings ($F(1, 62) = 35.73, p < .001$), craving scores ($F(1, 61) = 25.36, p < .001$), and days since last cigarette ($F(1, 62) = 13.89, p < .001$). Smokers had significantly higher BCO readings ($M = 13.03$, $SE = .99$), craving scores ($M = 3.83$, $SE = .19$) and were reported to have smoked more recently ($M=.19$ days, $SE = 27.20$) than SATQ (BCO: $M=4.07$, $SE = 1.12$; Craving score: $M=2.40$, $SE = .21$; Days since last cigarette: $M=152.77$ days, $SE = 30.59$). Analyses also revealed a significant interaction of Group x Training Condition for Fagerstrom scores ($F(2, 62) = 4.55, p < .05$). However, post hoc analyses conducted revealed no significant differences after Bonferroni correction. There were no significant differences in the length of smoking career between smokers and SATQ ($p > .1$) and between attend training conditions in each group (all $ps>.05$).

Removal of Outliers

Initial analysis of RT data revealed that in both the Stroop task and the visual probe task less than 2% of all RTs were outside 300ms and 4000ms, the RTs outside of these limits were therefore treated as outliers and were removed from subsequent analyses. In addition, an initial analysis of the number of errors within each participant revealed that 3 participants (2 active smokers, 1 never-smoker) had over 15% of errors in the Stroop tasks and 1 participant had over 15% error rate in the visual probe task. These participants' data were removed from subsequent analyses. As a consequence the analyses of Stroop data were conducted for 36 smokers, 30 SATQ and 36 never-smokers, and the analyses for visual probe data were conducted for 37 active smokers, 30 SATQ and 37 never-smokers.

Analysis of Errors

To identify any effects of AR on the number of errors participants made in the Stroop task mean error rates for both Stroop tasks were subjected to a 2x2x4x3x3 mixed measure ANOVA. These analyses included Time (pre-training and post-training), Word Sequence (smoking and neutral) and Position (1-4) as the within group factors and Group (Smokers, SATQ, Never-smokers) and Attend Condition (attend smoking, avoid smoking, and attend control) as the between group factors. These analyses revealed a significant interaction of Position x Word x Group x Attend ($F(6, 198) = 2.70, p < .05$, *partial* $\eta^2 = .08$). Follow-up analysis for each group and each condition separately revealed a Position x Word interaction in the 'Attend Smoking' condition of the smoking group only ($F(3, 33) = 3.75, p < .05$, *partial* $\eta^2 = .25$). Subsequent t-tests revealed significantly more colour-naming errors were made in the neutral sequence (M=4.96%, SD=4.63%) compared to the smoking sequence (M=2.44%, SD=3.21%) at position 2 in the Stroop tasks ($t(11) = -2.86, p < .05$). The reason for this significant difference in errors in smokers at this specific position in the neutral sequence was unclear and was therefore considered to be a spurious result.

Mean error rates were also entered into a 2x3x3 repeated measures ANOVA for the visual probe task with position of probe (in vicinity of smoking word and in vicinity of neutral word) as the within subject factors and Group (Smokers, SATQ, Never-smokers) and Attend condition (attend smoking, avoid smoking, and attend both) as the between subject factors. However, this analysis revealed no significant main effects or interactions.

The frequency of errors for the Stroop task and visual probe task constituted no more than 5% of all trials on all sections of the experiment. Therefore, all error trials were removed from subsequent RT analyses.

Analysis of median correct reaction times

Stroop prior to training

It was hypothesised that attentional bias would be present at baseline in smokers and smokers attempting to quit, but not non-smokers. To examine the presence of smoking attentional bias at baseline, median correct reaction times for the Stroop prior to training were entered into a 2 x 4 x 3 x 3 mixed design ANOVA with Word Type (Smoking and Neutral) and Position (positions 1-4) as the within subjects factors and Group (Smokers, SATQ, and Never-Smokers) and Attend Condition (Attend Smoking, Avoid Smoking, Control) as the between subject factors. The analysis revealed a main effect of Position ($F(3, 273) = 5.01, p < .005$, *partial* $\eta^2 = .05$), which was indicative of significantly slower colour-naming of words at position 2 (M=802.15, SE = 14.17) compared to position 1 (M=780.03, SE = 13.18; $p < .005$). There were no other significant differences in colour-naming response latencies between positions (all ps>.05; position 3: M=792.07, SE = 13.21; Position 4: M=789.01, SE = 13.74). The analysis also revealed significant main effects of Word Type ($F(1, 91) = 6.38, p < .05$, *partial* η^2 = .07 and Group ($F(2, 91) = 6.98, p < .005$, *partial* η^2 = .13) which were qualified by a significant two-way interaction of Word Type x Group ($F(2, 91) = 3.22, p < .05$, *partial* η^2 = .07). Simple main effects analysis indicated that smokers were significantly slower to colour name smoking words (M=871.75, SE = 24.60) compared to neutral words (M=845.15, SE = 20.90; $F(1, 33) = 10.71, p < .005$, *partial* η^2 = .25). There were no significant differences in colour-naming latencies for smoking and neutral words in SATQ (smoking: M=755.36, SE = 22.05; neutral: M=745.26, SE = 20.46; $F(1, 33) = .03, p > .1$, *partial* η^2 = .01) or in never-smokers (smoking: M=763.12, SE = 24.47; neutral: M=764.27, SE = 22.64; $F(1, 25) = 1.11, p > .1$, *partial* η^2 = .04) (See figure 5-1). These results suggest that attentional bias at baseline is only evident in smokers.

Effects of attentional retraining on the visual probe task

It was hypothesised that attentional retraining would manipulate the presence of attentional bias. To examine the effects of Attentional Retraining during the visual probe task median correct reaction times from the test trials were subjected to a 2x2x3x3 repeated measures ANOVA with Word Type (probe in vicinity of smoking word, probe in vicinity of neutral word) and Word Set (words in training, words not in training) as the within subject factors and Group (smokers, SATQ, and never-smokers) and Attend Condition (attend smoking, avoid smoking, control) as the between subject factors. By including 'word set' as a factor, this allows an examination of whether effects generalise to novel words which were not used in training. Whereas, the more crucial 'word type' refers to differences in responses to smoking and neutral words. The analysis revealed a main effect of Word Set ($F(1, 96) = 5.32, p < .05$) and a significant interaction of Word Set x Attend Condition x Group ($F(4, 96) = 2.57, p < .05$, *partial* η^2 = .09). More importantly the analysis revealed a marginal interaction of Word Type x Attend Condition x Group ($F(4, 96) = 2.02, p = .098$).

For the significant Word Set x Attend Condition x Group interaction subsequent analyses conducted for each attend condition separately revealed a marginally significant interaction of Word Set x Group in the attend smoking condition ($F(2, 30) = 3.11$, $p = .06$, *partial* $\eta^2 = .17$). This interaction was not significant for the other attend conditions (all $Fs < .1.5$, $ps > .1$). Simple main effects analysis revealed a significant simple main effect of Word Set in smokers ($F(1, 11) = 6.87$, $p < .05$, *partial* $\eta^2 = .38$), indicating quicker responses to words that were in the training trials (M=532.17, SE = 19.16) compared to words that were not in the training trials (M=555.42, 14.73). This difference was not evident in SATQ (words in training trials: M=506.45, SE = 24.78; words not in training: M=498.28, SE = 21.71; $p > .05$) or never-smokers (words in training trials: M=495.25, SE = 19.58; words not in training: M=504.61, SE = 24.61; $p > .05$).

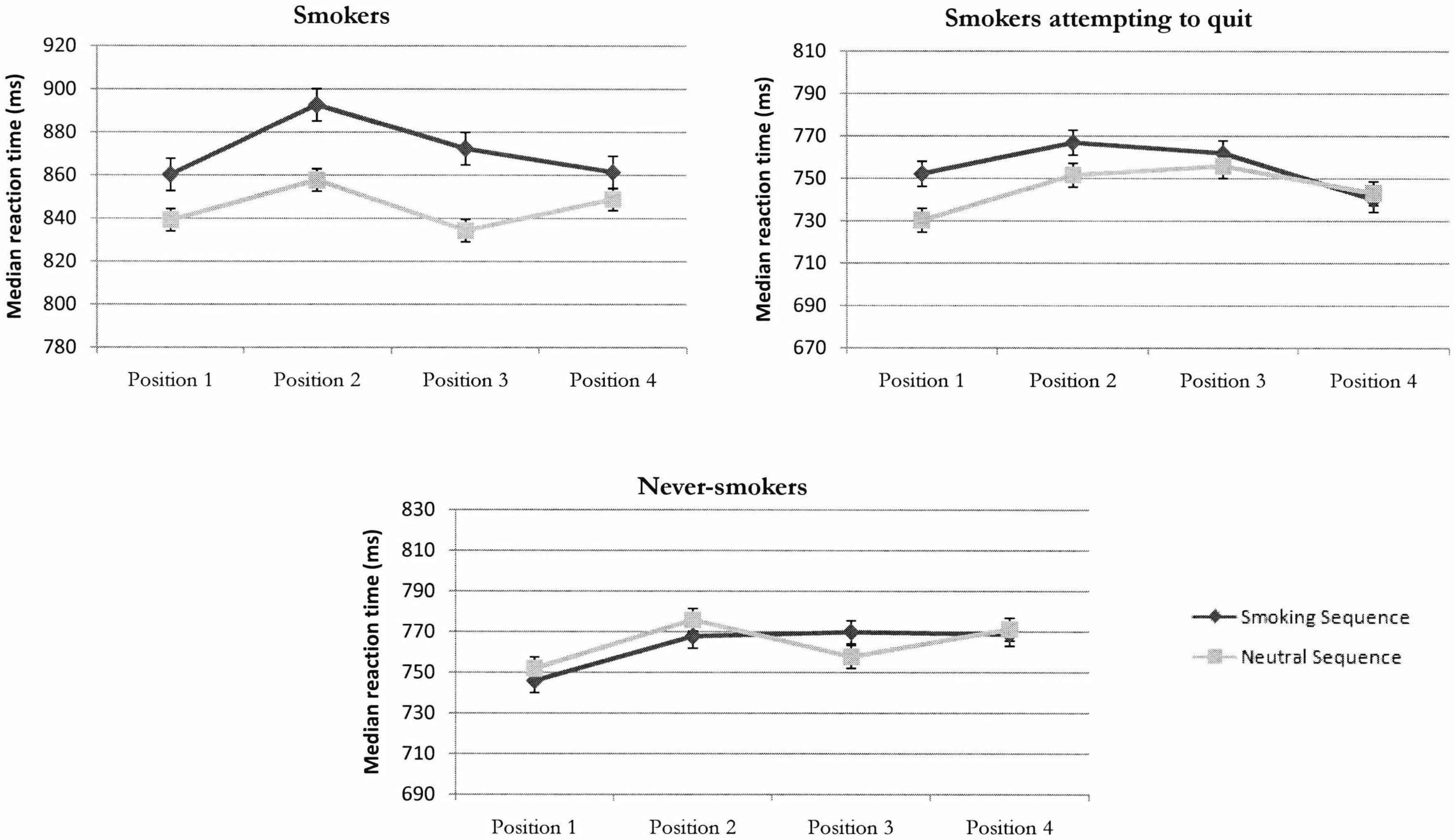

Figure 5-1 **-Median correct reaction times (ms) in the Stroop task prior to training by position and group**

For the marginally significant Word Type x Attend Condition x Group interaction ANOVAs conducted for each group separately revealed no significant interactions of Word Type x Attend Condition in SATQ or never-smokers (All *Fs* < 2.0, *ps*>.1). However, this interaction was marginally significant in smokers ($F(2, 35) = 3.00$, $p = .06$, *partial* $\eta^2 = .15$). Simple effects analysis revealed significantly quicker reaction times to probes replacing smoking stimuli than probes replacing neutral words in the control condition only (probes replacing smoking stimuli: M=528.58, SE = 58.21; probes replacing neutral stimuli: M=544.83, SE = 45.90; $F(1, 12) = 5.04$, $p < .05$, *partial* $\eta^2 = .30$). Interestingly, no significant differences in response latencies for smoking stimuli and neutral stimuli were shown in both the 'attend neutral' condition (probes replacing smoking stimuli: M=515.60, SD=20.55; probes replacing neutral stimuli: M=510.73, SE = 20.05; $p > .1$). and the 'attend smoking' condition (probes replacing smoking stimuli: M=548.15, SE = 17.52; probes replacing neutral stimuli: M=539.44, SE = 16.50; $p > .1$). This indicates that training in both the 'attend neutral' condition and the 'attend smoking' condition attenuated smoking attentional bias in smokers (see Figure 5-2).

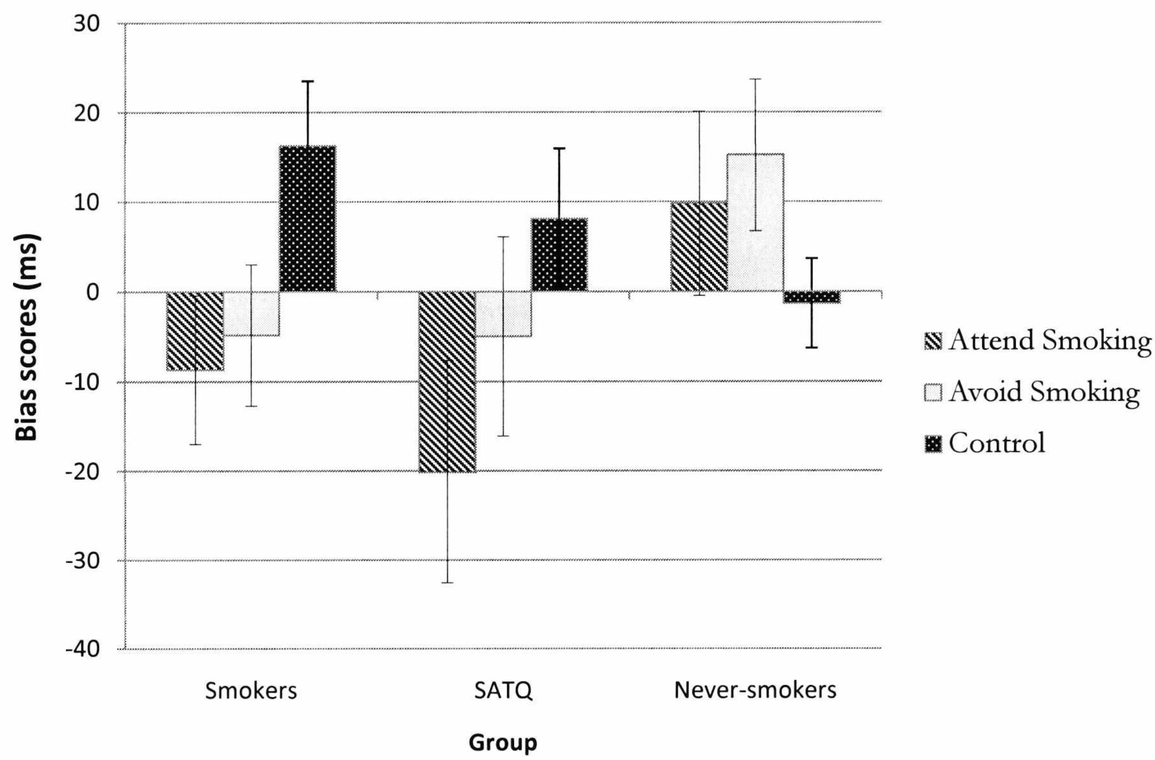

Figure 5-2 **- Visual probe task bias scores in each attend condition for each group**

These results provide support for the hypothesis that attentional retraining would manipulate the presence of attentional bias, but this effect was limited to smokers only: smoking attentional bias remained consistent in the control condition, but was attenuated in smokers in the 'attend smoking' condition and in the 'avoid smoking' condition.

Effects of attentional retraining on attentional bias in the Stroop task

It was hypothesised that the effects of training would generalise to responses on the Stroop task following training. To identify any effects of attentional retraining on the presence of attentional bias median correct reaction times on the Stroop task following training were entered into a 2 x 4 x 3 x 2 mixed measure ANOVA. This analysis included Word Type (smoking, neutral) and Position (positions 1-4) as the within subjects factors and Group (smokers, SATQ, never-Smokers) and Attend Condition (attend smoking, avoid smoking, control) as the between subject factors. This analysis revealed significant main effects of Word Type ($F(1, 91) = 10.22, p < .005$, *partial* $\eta^2 = .10$), Position ($F(3, 273) = 4.29, p < .01$, *partial* $\eta^2 = .05$), and Group ($F(1, 91) = 4.47, p < .05$, *partial* $\eta^2 = .09$). However, these were all qualified by a significant four-way interaction of Word x Position x Attend x Group ($F(12,273) = 1.92, p < .05$, *partial* $\eta^2 = .08$).

On visual inspection of Figures 5-3, 5-4, and 5-5, it appeared that any interaction effects may be most prominent in the control condition. To examine whether this was the case mixed measure ANOVAs were conducted separately for each attend condition. These ANOVAs included Word Type (smoking, neutral) and Position (positions 1-4) as the within subjects factors and Group (smokers, SATQ, never-smokers) as the between group factor. These analyses revealed no significant interactions for the attend smoking condition and the avoid smoking condition (all $Fs < 1.5, ps > .1$). However, a significant three-way interaction of Word x Position x Group was revealed in the control condition ($F(3, 93) = 2.25, p < .05$, *partial* $\eta^2 = .13$). Further analyses conducted for each Position indicated no significant Word x Group interactions at positions 1, 3, or 4 (all $Fs < 2.5, ps > .1$), but did indicate that the Word x Group interaction was significant at position 2 ($F(1, 31) = 3.33, p < .05$, *partial* $\eta^2 = .17$). Simple effects analysis revealed that there were no significant differences in the colour-naming of words in the smoking sequence at position 2 for SATQ or never smokers (all $Fs < 2.5$, $ps > .1$). However, smokers took significantly longer to colour name words in the smoking sequence compared to neutral words at this position ($F(1, 11) = 6.12$, $p < .05$, *partial* $\eta^2 = .36$). This provides evidence for slow effects of smoking attentional bias following training in smokers in the control condition.

Whilst large differences in colour-naming responses at positions 1 and 2 were also shown in never-smokers these did not yield significant results as the variance in responses at these positions were relatively large (SDs >92ms). It was hypothesised that the effects of training would generalise to responses on the Stroop task following training. The findings suggest that attentional retraining effects do generalise to the Stroop task following training, in particular attenuation of attentional bias was shown in the 'attend smoking' condition and the 'avoid smoking' condition.

Examination of differences in attentional bias effects across the Stroop tasks

In order to examine whether there were any significant differences in attentional bias to smoking stimuli between the baseline Stroop task and the Stroop task following training an ANOVA was conducted using bias scores. Bias scores for the Stroop task were calculated by subtracting reaction times to words in the neutral sequence from reaction times to words in the smoking sequence. This ANOVA incorporated Time (Baseline Stroop, Post-training Stroop), and Position (1-4) as the within subjects factors and Group (Smokers, SATQ, and Never-Smokers) and Attend Condition (attend smoking, avoid smoking, control) as the between group factors. However, these analyses revealed no significant main effects or interactions involving Time ($Fs < 1.6$, $ps > .1$).

Correlation analyses of Stroop bias and visual probe Bias

Although not central to the hypotheses, to identify any relationship between attentional bias in the Stroop task and attentional bias in the visual probe task correlation analyses were conducted for bias scores in the visual probe compared with bias scores in both of the Stroop tasks. Bias scores for the Visual probe task were calculated by subtracting reaction times for probes replacing smoking words from the reaction times for probes replacing neutral words. The correlation analyses were conducted separately for smokers and never-smokers in each of the training conditions.

These analyses only revealed a moderate negative correlation between attentional bias in the visual probe task and attentional bias in the Stroop task following training in the control condition of Smokers ($r = -.60$, $p < .05$). Indicating that a greater attentional bias for smoking cues in the visual probe task were related to decreased attentional bias for smoking cues in the Stroop task following training. No other correlations between the visual probe and Stroop task attentional bias were found.

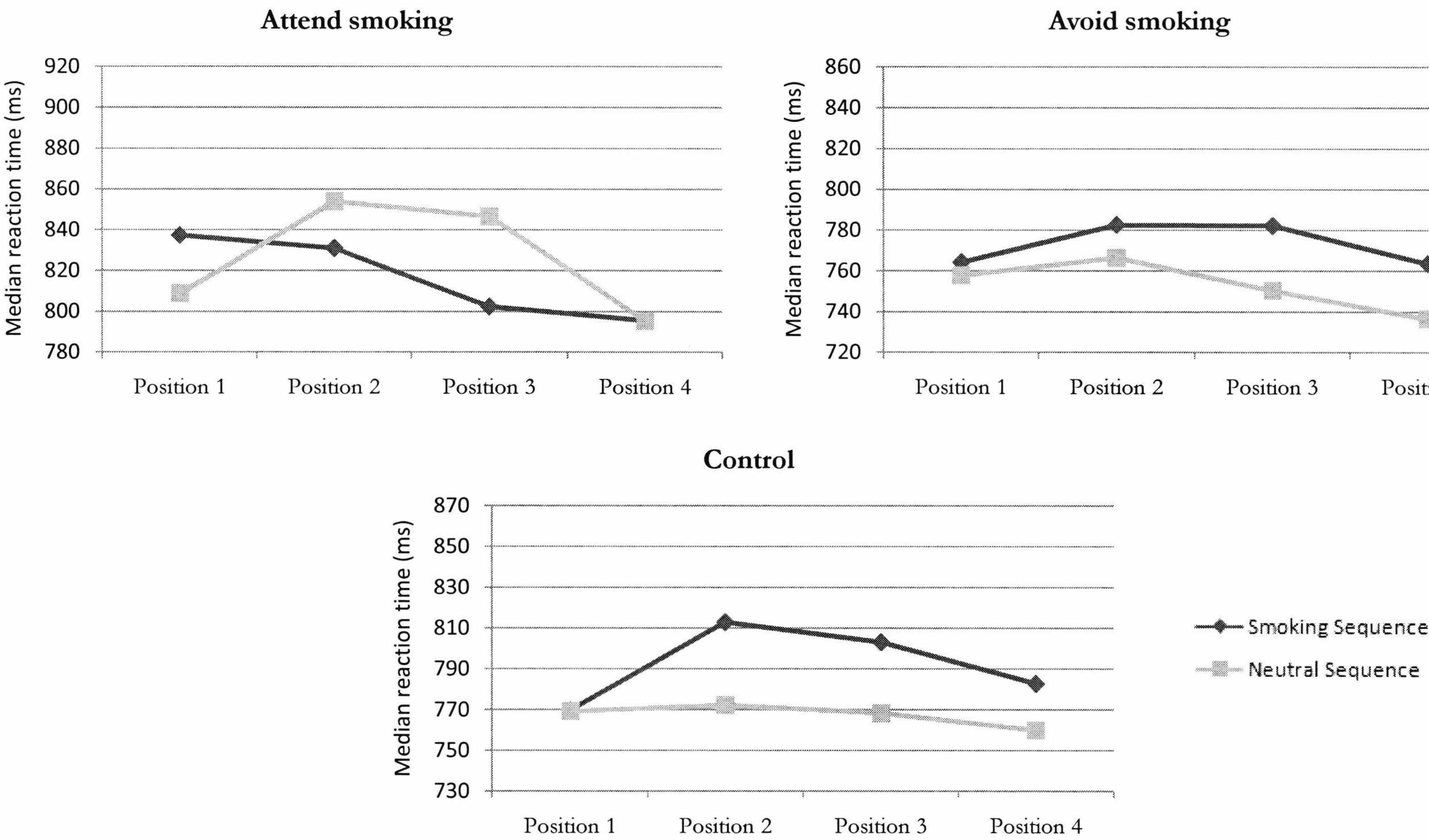

Figure 5-3 **- Median correct reaction times (ms) in the post training Stroop task by position for Smokers**

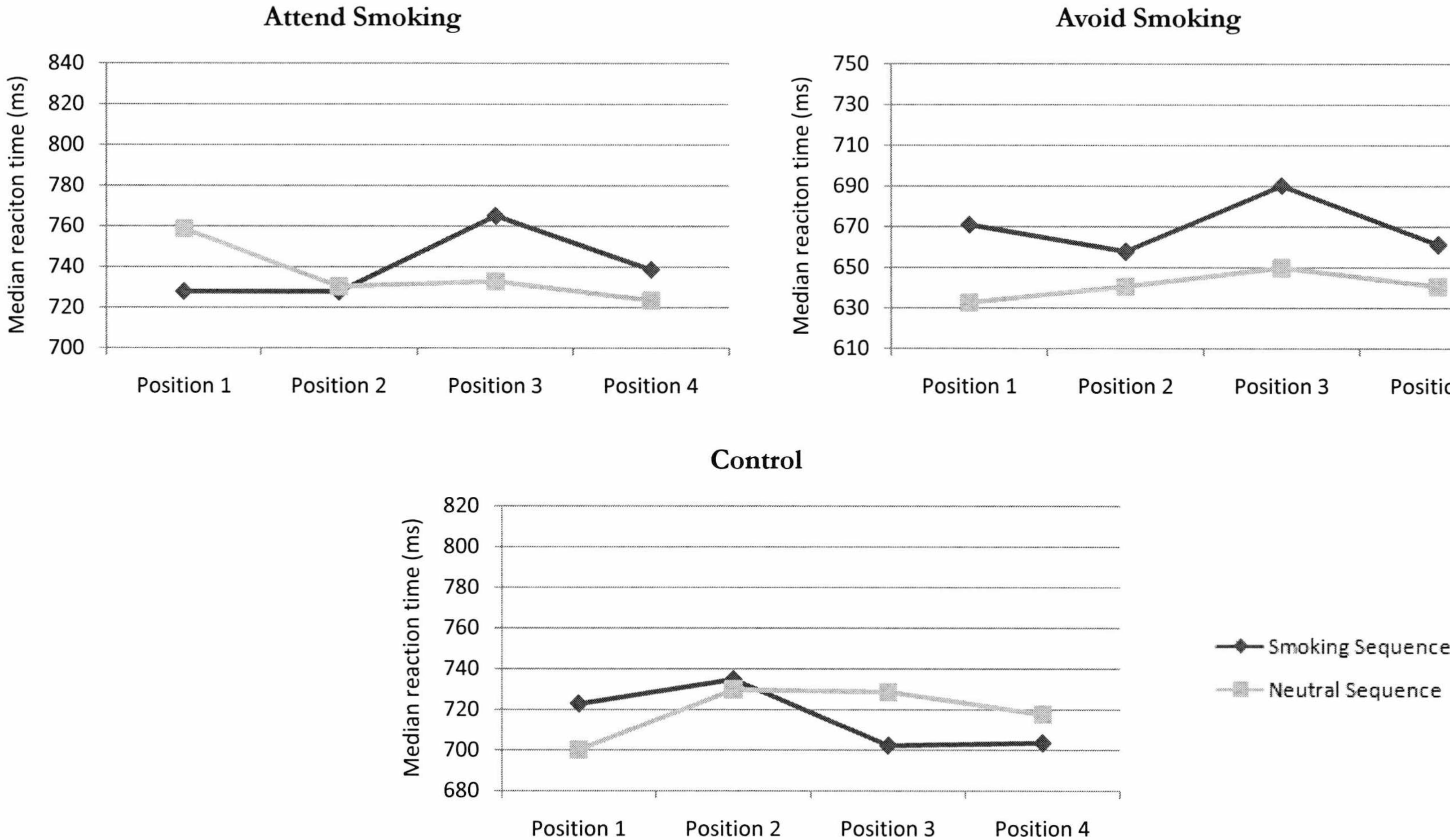

Figure 5-4 **- Median correct reaction times (ms) in the post training Stroop task by position for Smokers Attempting to Quit**

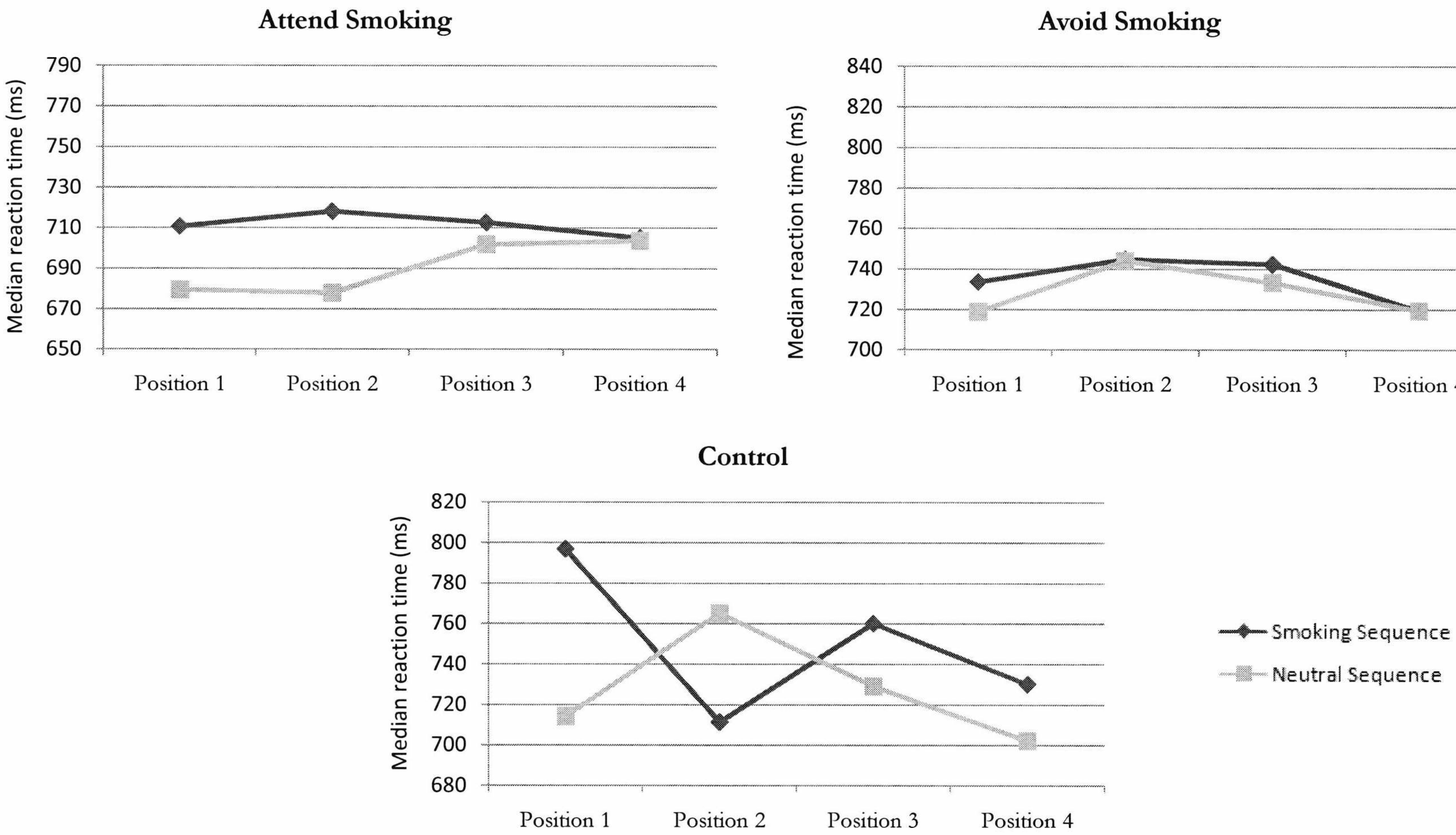

Figure 5-5 **- Median correct reaction times (ms) in the post training Stroop task by position for Never-Smokers**

Craving & Fagerstrom Scores

It was hypothesised that there would be changes in craving relative to changes in attentional bias following attentional retraining. To examine whether subjective craving and nicotine dependence immediately following the experiment and on one week and one month follow ups were specifically affected by the type of training given subjective craving scores and Fagerstrom scores were entered into a 3x3x3 repeated measures ANOVA. This ANOVA incorporated Time (immediately following experiment, 1 week follow-up, 1 month follow-up) as the within subject factor and Group (smokers, SATQ, and never-smokers) and Attend Condition (attend smoking, avoid smoking, control) as the between subject factor. This analysis revealed that levels of craving both immediately after the experiment and in the 1 week and 1 month follow ups were unaffected by the type of training condition given [all $Fs < .33$, $ps > .10$]. There was no effect of attentional retraining on either craving or nicotine dependence.

Additional analyses

Although not central to the hypotheses, the following analyses examined whether attentional retraining influenced anxiety, depression and the emotional association with smoking stimuli.

Computerised ratings of anxiety and depression

To identify whether subjective ratings of anxiety and depression taken during the experimental trials were affected by the type of training given scores were entered into two 4x3x3 repeated measures ANOVAs, one for anxiety scores and one for depression. Both ANOVAs used Time (before experimental trials, after baseline Stroop, after visual probe, after post-training Stroop) as the within subject factor and Group (smokers, SATQ, and never-smokers) and Attend condition (attend smoking, avoid smoking, control) as between subject factors. Results showed that both anxiety and depression during the experimental trials were unaffected by smoking status and the type of training given (F's less than 2 and $p > .1$).

Word Relatedness

To identify if the AR training conditions affected emotion ratings of smoking words and neutral words a 2x2x3 mixed measure ANOVA was conducted, with Word Type (smoking and neutral) as the within subject factors and Group (smokers, SATQ, never-smokers) and Training Condition (attend smoking, avoid smoking, control) as the between subjects factors. The dependent variable was emotional rating scores. The analysis revealed main effects of Word Type($F(1, 95) = 91.29, p < .001$, *partial* $\eta^2 = .49$) and Group ($F(2, 95) = 9.96, p < .005$, *partial* $\eta^2 = .12$). However, these were subsumed under a significant interaction of Word Type x Group ($F(2, 95) = 13.17, p < .001$, *partial* $\eta^2 = .26$). Analyses conducted for each group separately revealed a main effect of Word Type in never-smokers and SATQ, both rated smoking words significantly more negatively (SATQ: M=-.97, SE = .19; never-smokers: M=-1.09, SE = .18) than neutral words (SATQ: M=.54, SE = .12; never-smokers: M=.75, SE = .11) ($ps < .001$). No difference in emotion ratings between smoking and neutral words were shown in the smoking group who rated both word types slightly positively (smoking: M=.15, SE = .20; neutral: M=.38, SE = .09). No main effects or interactions involving training condition were revealed (all $Fs < 2.15, ps > .1$).

5.1.3 - Discussion

The findings of Study 5 indicate that the attentional re-training technique is somewhat effective in manipulating smoking attentional bias. In particular, prior to attentional retraining smokers in all three attend conditions showed consistent levels of attentional bias for smoking-related stimuli in the Stroop task. Attentional bias was also present in smokers in the visual probe task for the attend control condition during training. Importantly, AR was effective in manipulating smoking attentional bias in the visual probe task; the attentional bias decreased in both the 'avoid smoking' condition and the 'attend smoking' condition during training. These effects generalised to novel stimuli across all three attend conditions during the training task itself and appeared to generalize to the Stroop task, where attentional bias for smoking stimuli was shown in the Control condition but not in ‘attend smoking’ condition or the ‘avoid smoking’ condition. No effects of attentional bias were shown in smokers attempting to quit or never-smokers.

The finding that smoking attentional bias can be reduced by training attention away from smoking-related stimuli replicates the findings of Attwood et al. (2008). These effects are also comparable with attentional retraining studies of other pathologies which show similar reductions in attentional bias when training attention away from concern-related stimuli (e.g. alcohol: Field et al., 2005, 2007; Schoenmakers et al., 2006, and emotion: MacLeod et al., 2002). Importantly, this indicates that smoking attentional bias, shown to be a robust phenomenon across smoking groups, can be effectively manipulated and that it can be manipulated in a similar way to attentional biases of other pathologies.

The finding that attentional bias within the visual probe task can be reduced by training attention towards smoking-related stimuli is, to the authors' knowledge, novel. There are two possible reasons for the reduction in smoking attentional bias in the 'attend smoking' group. Firstly, participants may have been aware of the experimental contingencies to get them to always attend to smoking-related stimuli. This may have resulted in strategic attempts to avoid smoking stimuli. Another possible reason is that participants became habituated to smoking-related stimuli to the point that smoking-related stimuli no longer affected the control of attention. Indeed, research has shown that there is some evidence that the repetition of stimuli may lead to the habituation of attentional bias (Sharma, Albery, & Cook, 2001). However, as attentional bias was still shown in the 'control' condition, where participants were trained towards smoking-related stimuli and neutral stimuli equally, this indicates that it may not be mere exposure to smoking-related stimuli that leads to attenuation of attentional bias. Rather it is prolonged exposure, as in the experimental manipulation in the 'attend smoking' condition, that leads to this attenuation of smoking attentional bias. Smoking attentional bias was also reduced by attending to neutral stimuli. This indicates that AR may have more general benefits in improving attentional flexibility or attentional control. An alternative explanation is that AR (whether towards smoking or neutral stimuli) may result in strategic attempts to avoid all stimuli. If this was the case it might suggest longer latencies for the attend smoking and avoid smoking conditions compared to the control condition. However, as there was no main effect of Attend this seems unlikely.

The present study showed effects of generalisation to novel stimuli across all conditions in the training task. This partially replicates the findings of Field, et al. (2007) who showed generalisation to novel stimuli in the 'attend alcohol' condition in their study. The fact that generalisation was present across all conditions in the present study but only present in the 'attend alcohol' condition of Field et al.'s (2007) study may be due to the nature of stimuli used. In the study by Field et al. (2007) pictures were used whereas in the present study words were used. As discussed in the introduction, it may be easier to categorise words compared to pictures (see Chapter 2, 2.1.1: *The use of word* *and pictorial stimuli*). This relative ease of categorising words may have facilitated generalisation to novel stimuli and to the Stroop task following training.

The finding that effects generalized to another cognitive paradigm is again novel, as previous studies of AR has shown no generalisation effects across tasks (e.g. Field et al., 2007, Shoenmakers, et al., 2007). An explanation for the lack of generalisation on previous studies is put forward by Field, et al. (2007) who suggest that effects of AR may not generalise across tasks as different paradigms tap different components of attention. Indeed, findings from the present study and previous research have shown little or no evidence of correlations between indices of smoking attentional bias in the Stroop task and indices of smoking attentional bias in the visual probe task (Mogg and Bradley, 2002). Therefore, the findings of generalisation in the present study are unexpected. The most likely explanation for these findings, given that the procedure replicates that of previous studies, is that word stimuli are more easily generalised within and across tasks than pictorial stimuli as previously argued. It is, however, unclear how long such generalisation effects may last and whether they might persist beyond the experimental procedures used in the present study. The findings that nicotine dependence and craving were unaffected by the training procedure indicate that these attentional retraining effects may be relatively short-lived and may not affect subsequent behaviours. However, it is also possible that the smoking behaviour measures used were not sensitive enough to measure specific changes in smoking behaviour. Combining AR with other manipulations, such as motivational training, may be more successful in changing actual smoking behaviours. However, this argument requires further research (see Fadardi and Cox, 2007).

In addition to the effects shown for smokers, there was an indication that increased exposure to smoking-related stimuli may result in attentional bias for smoking-related stimuli in those who are non-nicotine dependent (i.e. never-smokers). Indeed, whilst there were no significant effects for never-smokers they did show an increased tendency to be biased towards smoking stimuli following training in the 'attend smoking' condition. Such a finding is interesting as it suggests that attentional bias in smoking is not only the product of the neurological changes caused by nicotine consumption, but also may be a product of the category of smoking becoming salient. However, the effects of attentional bias in never-smokers were only shown in the control condition, indicating that prolonged exposure in people who are not nicotine dependent may not produce the same effects. Also, the finding that these effects only appeared to be developing at position 1 indicate that the attentional re-training manipulation may only be effective in influencing the fast effect component of attentional bias in non-nicotine dependent groups. That is, attentional retraining appears more likely to influence the initial capture of attention of smoking stimuli rather than the maintenance of attention on smoking stimuli in non-nicotine dependent groups.

In conclusion, Study 5 provides further evidence for the effectiveness of AR as a method for manipulating attentional bias. It also indicates that attentional bias for smoking-related stimuli might develop in groups who are not nicotine dependent if smoking is made salient. Also, with regards to smokers the use of word stimuli appears to increase generalisation effects across cognitive tasks and novel smoking words. However, smoking behaviour appears to be relatively unaffected by AR. This suggests that AR needs further development before it might be effective in a clinical capacity. Study 6, builds on the findings from study 5 by examining whether manipulating cognitive control instead of visual attention to smoking stimuli, can also be effective in manipulating the presence of smoking attentional bias.

Chapter 6: Attentional retraining using Stroop methods

Chapter 6 presents findings from Study 6 which examines the manipulation of attentional bias by varying cognitive control. Cognitive control was manipulated by changing the number of incongruent trials in a classic Stroop task. In previous research, an increase in incongruent trials has been shown to increase focus on the colour-naming task and decrease the distraction from words (e.g. Botvinick et al., 2001; Tzelgov et al., 1992). Findings indicate that this manipulation, contrary to expectations, led to increases in smoking attentional bias rather than decreases in attentional bias, particularly in smokers attempting to quit.

Study 5 provided evidence to show that attentional retraining was somewhat effective in manipulating smoking attentional bias. Furthermore, Study 5 showed that the manipulations of attentional bias which stem from attentional retraining generalise to novel stimuli and to the Stroop task following training. Study 6 aims to build on these findings by examining if these effects can be replicated using a technique to manipulate cognitive control.

Previous attentional retraining manipulations have used the visual probe task to manipulate visual attention away from, or towards, concern-related stimuli (e.g. alcohol and emotion-related stimuli). There has however, been, research conducted with the classic Stroop task to suggest that attention can also be focused on a specific domain (e.g. colour-naming) whilst decreasing the distraction from other aspects of a stimulus (e.g. the word itself). This research stems from the Conflict Monitoring and Cognitive Control theory (Botvinick et al., 2001) which suggests that a system in the anterior cingulated cortex (ACC) monitors for conflicts in information processing and compensates for any conflicts found (see also Chapter 1, section 1.2). Using the Stroop task as an example they suggest that when there are conflicts between words and the colour of the words, as in incongruent trials, the Conflict Monitoring System compensates by encouraging the system to focus on colour-naming and avoiding word naming. By compensating the focus towards colour-naming, reaction times decrease and therefore lead to a reduction in interference.

Research conducted by Tzelgov, Henik, and Berger (1992) has supported such claims and has shown that interference in the classic Stroop task can be reduced by altering the frequency of incongruent trials (e.g. The word 'red' in the colour 'blue') in a Stroop task. To examine this phenomenon they subjected participants to a Stroop task in which they altered the proportions of neutral trials in comparison to the proportion of congruent and incongruent trials. They measured both interference and facilitation, where interference was quantified as the difference between neutral trials and incongruent trials and facilitation was quantified as the difference between neutral and congruent trials. Results showed that the more frequent the incongruent trials the less interference occurs, indicating that increased conflict led to increased focus on colour-naming and reduced the distraction of the colour words themselves (see Figure 6-1).

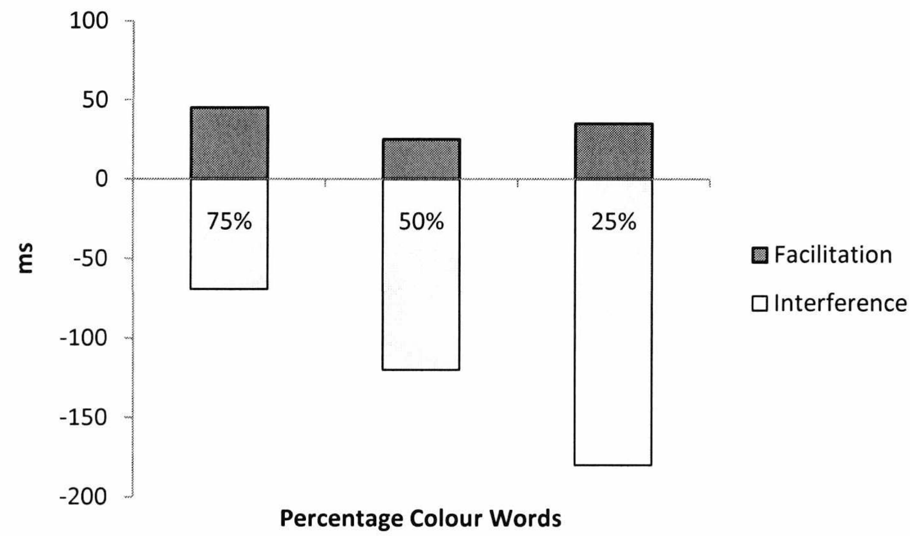

Figure 6-1 Interference and facilitation scores by percentage word condition as shown by Tzelgov (1992)

6.1 - Study 6

Study 6 exploits the manipulation used by Tzelgov et al. (1992) to examine whether increasing the focus on colour-naming, by increasing conflict, reduces the distraction from smoking-related words in smokers and smokers attempting to quit. Adopting a similar design to Study 5, Study 6 replaced the visual probe Attentional

Retraining task with the classic Stroop manipulation used by Tzelgov et al. (1992), but still measured the presence of smoking attentional bias using pre- and post-training smoking Stroop tasks. For the training task participants received either a high level of conflict trials or a low level of conflict trials. It is expected that both smokers, and smokers attempting to quit, would show an attentional bias for smoking stimuli in the Stroop task prior to training. However, smokers and smokers attempting to quit who are in the high conflict training condition should show greater decreases in smoking attentional bias post-training than those in the low conflict condition. This is because attention should be more focussed on colour-naming and less distracted by smoking words in the high conflict condition.

6.1.1 - Method

Participants

Seventy-six participants (17 males, 59 females; mean age=20.22, *SD*=2.82, age range = 18-32) were recruited through a research participation scheme at the University of Kent and through advertisements in the University of Kent Job Shop. Participants recruited through the research participation scheme were given 2 credits towards a module for their participation. Participants recruited through the university Job Shop were given £4 for their participation. All participants who took part were either native English speakers or fluent in spoken English. As with previous studies participants were categorised into one of three conditions, i) active smokers, ii) smokers attempting to quit (SATQ), or iii) never-smokers. Participants were classed as active smokers if they had smoked a cigarette within the past 24 hours, SATQ if they were smokers who had abstained from smoking for over twenty-four hours ago and under two years ago and were actively attempting to quit, and never-smokers if they had never smoked. Of those who took part 26 were classed as active smokers, 23 were classed as SATQ, and 27 were classed as never-smokers. All participants were treated in accordance with the ethical standards of the British Psychological Association. In addition, ethics approval was obtained from the University of Kent at Canterbury's Department of Psychology ethics committee before recruiting participants and proceeding with the experiment.

Design

Stroop task (before training and after training)

The Stroop task used before and after training was the same as the Stroop task used in Studies 3 and 5.

Stroop training

A 3x2x3 factorial design was used with Group (smokers, SATQ, and never-smokers) and percentage colour (25, & 75) as the between subjects factors and Stroop (incongruent, congruent, and baseline) as a within subject factors. Only colour words and neutral words were used in the training. Participants were either subjected to the 25 percent colour word condition (75 percent neutral words), or the 75 percent colour word condition (25 percent neutral words). Each consisted of 192 trials: for the 25 percent colour word condition this consisted of 48 colour words and 144 neutral words and in 75 percent colour word condition this consisted of 144 colour words and 48 neutral words.

Stimuli

Stimuli for the pre-training and post-training Stroop task were the same as those used in Study 5. For the training task 48 neutral stimuli were used and were taken from the neutral words used in the visual probe task of Study 5. All neutral words were unrelated to smoking or emotion. The colour words used in the training task were red, green, blue, and yellow.

Measures

State-Trait Anxiety Inventory, The Fagerstrom Test for Nicotine Dependence (FTND) Questionnaire, The Anxiety-Sensitivity Inventory (ASI), and the Word Relatedness Measures were administered. However, the Beck Depression Inventory (BDI) and PANAS scales were removed due to lack of findings on previous studies in relation to smoking attentional bias.

Apparatus

Task presentation and recording

Apparatus were the same as those used in Study 5 with the exception that the response box used in the Stroop task was used in the training task of Study 6.

Procedure

The procedure followed the procedure detailed in Study 5 with exception of the Stroop training task. The Stroop training task followed the initial Stroop task and participants completed all 192 trials before reporting levels of anxiety and depression on the computer. Following the Stroop training task participants completed the second Stroop task and subsequent ratings of anxiety and depression.

6.1.2 - Results

Group characteristics

Smoking-related, anxiety, and emotion rating measure scores for each group and each condition are shown in Table 6-1.

Although not of central interest in this study, to identify any between group and between condition differences in anxiety, anxiety sensitivity and emotional ratings that may have influenced the effects of the training, 3 x 2 between subjects ANOVAs were conducted separately for each of the measures administered (STAI, ASI, emotional ratings). These ANOVAs incorporated Group (smokers, SATQ and never-smokers) and Percentage Colour Words (25% colour words, & 75% colour words) as the independent variables and the pre-training measure scores as the dependent variables.

These analysis revealed main effects of Percentage Colour Words for the ASI measure ($F(1, 68) = 5.96, p < .05$, *partial* $\eta^2 = .08$) and state anxiety ($F(1, 68) = 5.41, p < .05$, *partial* $\eta^2 = .07$). In both cases scores were higher in the 75% colour word condition (ASI: M=42.51, SE = 1.62; State anxiety: M=44.94, SE = 1.63) compared to the 25% colour word condition (ASI: M=36.99, SE = 1.62; State anxiety: M=39.51, SE = 1.67). These indicated that state anxiety and anxiety sensitivity were greater in the high conflict condition (75% colour-word condition) compared to the low conflict condition (25%).

There were no between group differences in anxiety of anxiety sensitivity (all *Fs* < 1.0, *ps*>.05).

Analyses for emotion ratings of smoking and neutral words revealed a main effect of Group for the emotion ratings of smoking words ($F(2, 67) = 5.40, p < .05$, *partial* $\eta^2 = .14$). Never-smokers and SATQ rated smoking words significantly more negatively (never-smokers: $M = -.81$, $SE = .17$; SATQ: $M = -.90$, $SE = .19$) than smokers ($M = -.09$, $SE = .192$) (*ps* < .05). There were no between group or between condition differences in emotion ratings of neutral words.

Table 6-1

Smoking-related, anxiety and emotion rating measures for each group and condition

		Smokers (N = 26)		SATQ (N = 23)		Never-smokers (N = 27)	
		Colour word condition		Colour word condition		Colour word condition	
		25%	75%	25%	75%	25%	75%
Fagerstrom		9.69 (2.32)	8.45 (0.93)	9.38 (1.85)	7.92 (2.39)	-	-
Subjective Crave Score		3.54 (1.51)	2.91 (1.51)	2.10 (1.20)	2.25 (1.91)	-	-
Time since last cigarette		2.14 hours (3.40)	10.24 hours (2.97)	149.43 days (233.83)	113.48 days (126.56)	-	-
Smoked for (years)		5.73 (3.45)	3.45 (2.24)	4.10 (3.45)	3.71 (2.95)	-	-
State Anxiety		37.50 (7.88)	46.50 (7.42)	43.27 (10.85)	47.67 (14.87)	37.77 (7.87)	40.64 (9.44)
Trait Anxiety		44.75 (11.51)	46.92 (6.52)	44.28 (9.61)	45.08 (9.64)	40.62 (9.85)	45.00 (9.11)
ASI		36.83 (5.84)	42.75 (10.17)	39.82 (13.39)	41.00 (9.32)	34.31 (7.05)	43.79 (10.91)
Emotion ratings	Smoking	.22 (1.30)	-.40 (.94)	-.80 (.74)	-1.00 (.85)	-.58 (.75)	-1.03 (.83)
	Neutral	.45 (.64)	.63 (.41)	.27 (.33)	0.43 (.47)	.45 (.66)	.56 (.69)

Values are Mean (SD) SM=smokers SATQ=smokers attempting to quit

To identify any between group (smokers and smokers attempting to quit only) and between condition differences in smoking-related measures that may have influenced the effects of the training, 2 x 2 between subjects ANOVAs were conducted separately for each of the measures administered (Fagerstrom, length of smoking career, craving ratings). These ANOVAs incorporated Group (smokers, SATQ) and Percentage Colour Words (25% colour words, & 75% colour words) as the independent variables and the smoking measure scores as the dependent variables. These analyses revealed a significant main effect of Group for craving scores ($F(1, 42) = 5.10, p < .05$, *partial* $\eta^2 = .11$) with smokers reporting greater levels of craving ($M = 3.22$, $SE = .32$) than SATQ ($M = 2.18$, $SE = .34$) . In addition, analyses revealed a significant main effect of Percentage Colour Words for Fagerstrom scores ($F(1, 40) = 4.22, p < .05$, *partial* $\eta^2 = .10$). Fagerstrom scores were higher in the 25% Colour Word condition ($M = 9.53$, $SE = .45$) compared to the 75% Colour word condition ($M = 8.19$, $SE = .42$). There was no significant difference in Fagerstrom scores between smokers and smokers attempting to quit (all $Fs < .1$, $ps > .05$).

Removal of Outliers

Initial analysis of RT data revealed that in both the Stroop task and the visual probe task less than 2% of all RTs were outside 300ms and 4000ms, the RTs outside of these limits were therefore treated as outliers and were removed from subsequent analyses.

Analysis of Errors

To identify any effects of the conflict maniputlation on the number of errors participants made in the Stroop task mean error rates for both Stroop tasks were subjected to a 2x2x4x3x3 mixed measure ANOVA. These analyses included Time (pre-training and post-training), Word Sequence (smoking and neutral) and Position (1-4) as the within group factors and Group (Smokers, SATQ and Never-smokers) and Attend Condition (attend smoking, avoid smoking, and attend control) as the between group factors. These analyses revealed a significant main effect of Time ($F(1, 73) = 5.57, p < .05$, *partial* $\eta^2 = .07$) with participants making significantly less errors in the the pre-training Stroop task ($M = 3.21\%$, $SE = .03$) compared to the post-training Stroop task ($M = 3.62\%$, $SE = .03$, $p < .05$). This increase in errors between the two Stroop tasks is possibly the result of tiredness over the experimental procedures. No other significant main effects or interactions in relation to errors in the Stroop tasks were shown (all *F*s<2.0, *p*s>.05).

Mean error rates were also entered into a 3x3x2 repeated measures ANOVA for the Stroop training task (conflict manipultation) with Stimuli Type (congruent, incongruent, neutral) as the within subject factors and Group (Smokers, SATQ, Never-smokers) and Percentage Colour Words (25%, 75%) as the between subject factors. These analyses revealed only a significant main effect of Stimuli Type (F (2, 140) = 14.85, $p < .001$, *partial* $\eta^2 = .18$) with significantly more errors made on incongruent trials ($M = 6.45\%$, $SE = .07$) compared to congruent ($M = 3.22\%$, $SE = .05$) and neutral trials ($M = 3.31\%$, SE = .04, *p*s < .001). No other significant main effects or interactions with Group or Percentage Colour Words were shown (all *F*s<2.0, *p*s>.05).

The frequency of errors for the Stroop tasks prior to, and following, training and the Stroop training task itself constituted no more than 5% of all trials. Therefore, all error trials were removed from subsequent RT analyses.

Stroop prior to training

It was hypothesised that attentional bias would be present at baseline in smokers and smokers attempting to quit, but not non-smokers. Median correct reaction times for Stroop 1 were entered into a 2 x 4 x 3 mixed design ANOVA with Word (Smoking and Neutral) and Position (positions 1-4) as the within subjects factors and Group (Smokers, SATQ, and Never-Smokers) as the between subject factor. The analysis revealed a main effect of word ($F(1, 73) = 5.96$, $p < .05$, *partial* $\eta^2 = .08$) and a significant interaction of Word x Position x Group ($F(6, 219) = 2.40$, $p < .05$, *partial* $\eta^2 = .06$). To examine this interaction further separate ANOVAs were conducted for each group. These analyses revealed no significant Word x Position interaction in SATQ or never-smokers (all *Fs* < 2.0, *ps*>.1) but did reveal a significant Word x Position interaction in Smokers ($F(3, 75) = 2.79$, $p < .05$, *partial* $\eta^2 = .10$). Simple effects analysis revealed no significant difference between responses to smoking word sequences and responses to neutral word sequences at positions 1, 3, and 4 (all *Fs* < 2.0, *ps*>.1). However, there was significantly slower colour-naming responses to the smoking word sequence compared to the neutral word sequence at position 2 ($F(1, 25) = 19.47$, $p < .001$, *partial* $\eta^2 = .44$, Smoking: $M=800.06$, $SD=105.81$, Neutral: $M=758.29$, $SD=97.50$;

see Figure 6-2), indicating a slow effect of smoking attentional bias in smokers before training. These results suggest that attentional bias at baseline is only evident in smokers.

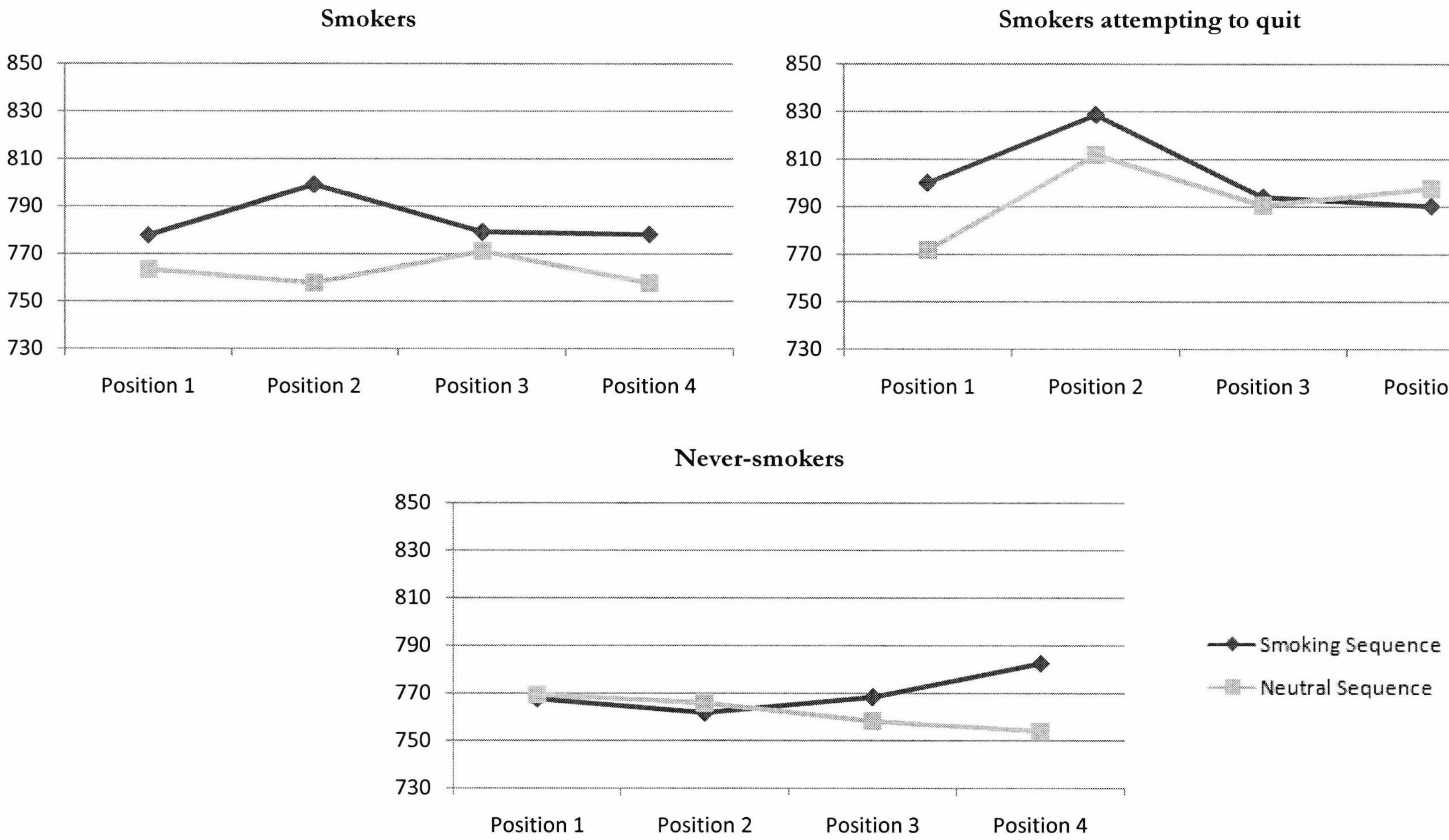

Figure 6-2 **- Median correct reaction times (ms) in the post training Stroop task by position for each group**

Training trials

It was hypothesised that, in the training trials, the high conflict would lead to decreased interference across all groups, thereby increasing focus on the colour-naming task. To examine any effects of the cognitive control manipulation, median correct reaction times were entered into a 3 x 3 x 2 mixed model ANOVA with Stroop Type (congruent, incongruent and neutral) as the within subject factor and Group (smokers, SATQ, and never-smokers) and Percentage Colour Words (25% colour words and 75% colour words) as the between subjects factors. This analysis revealed a main effect of Stroop Type ($F(2, 140) = 59.37, p < .001$, *partial* $\eta^2 = .46$) and significant two-way interactions of Stroop Type x Group ($F(4, 140) = 2.86, p < .05$, *partial* $\eta^2 = .06$) and Stroop Type x Percentage Colour Words ($F(2, 140) = 4.21, p < .05$, *partial* $\eta^2 = .06$). However, these were subsumed under a significant three-way interaction of Stroop Type x Group x Percentage Colour Words ($F(4, 140) = 2.92, p < .05$, *partial* $\eta^2 = .08$).

To identify the root of this interaction ANOVAs were conducted separately for each group. For smokers and never-smokers there was no significant interaction of Stroop Type x Percentage Colour Words (all $Fs < .5, p > .1$). However, for SATQ the interaction of Stroop Type x Percentage Colour Words was significant ($F(2, 42) = 5.86$, $p < .001$, *partial* $\eta^2 = .22$). Simple effect analysis using independent t-tests with Bonferroni correction were conducted between 75% colour word condition and the 25% colour word condition for each stimuli type separately (congruent, incongruent, and neutral) . These revealed no significant differences in response latencies between percentage colour word conditions for congruent and neutral stimuli (all $ts < .1, ps > .1$). However, there was a significant reduction in colour-naming latencies for incongruent stimuli in the 75% colour word condition (M=1027.91, SD=270.92) compared with the 25% colour word condition (M=849.58, SD=116.48; $t(21) = 2.02, p = .05$; see figure 6-3), indicating that interference is reduced when there is an increase of incongruent and congruent colour words among SATQ. The findings suggest that the conflict manipulation was only effective in smokers attempting to quit where decreased interference was shown in the high conflict condition, compared with the no conflict condition. Therefore the hypothesis received partial support.

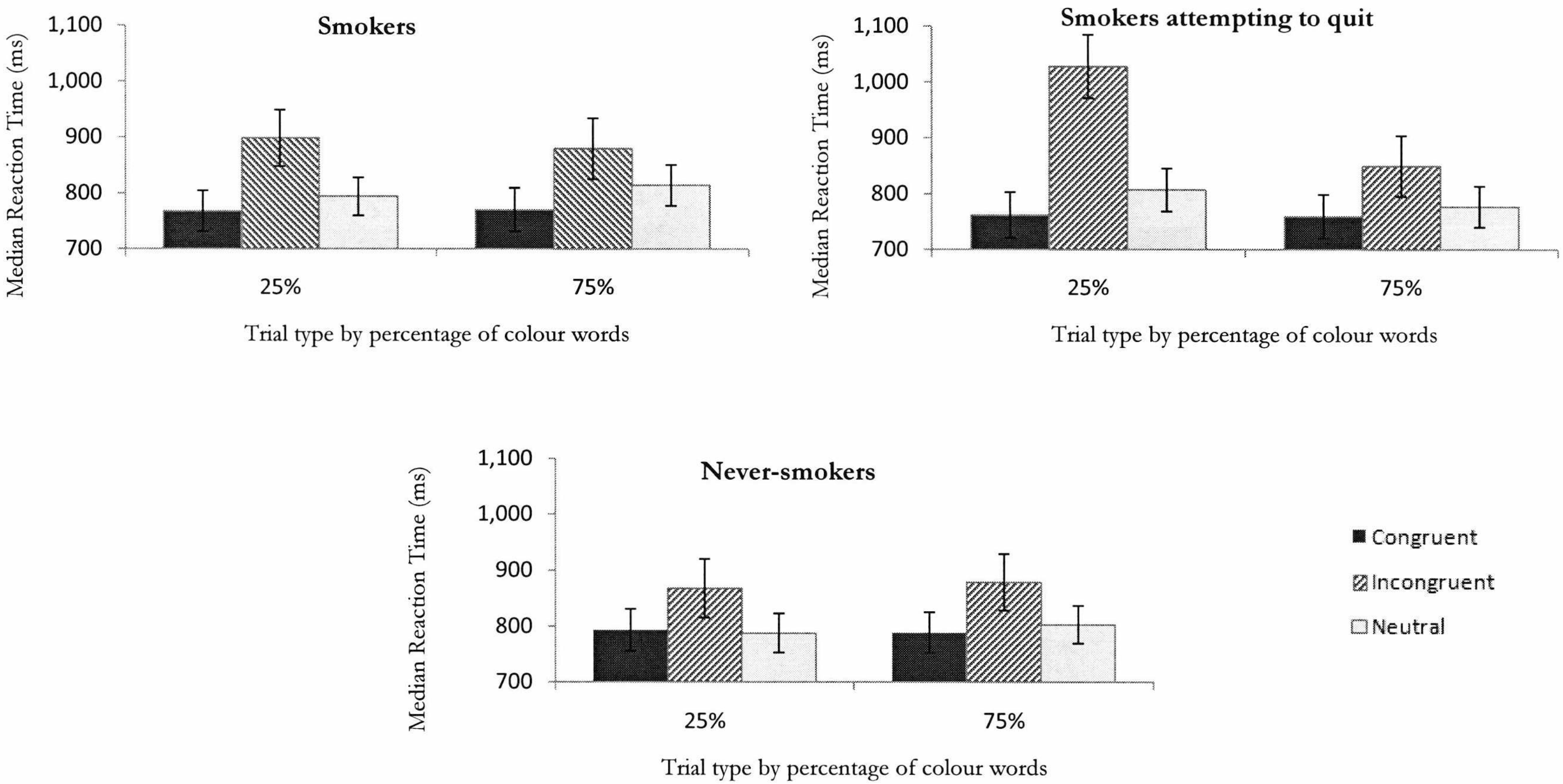

Figure 6-3 - Median reaction times for incongruent, congruent, and neutral trials for each condition in each group

Stroop task following training

It was hypothesised that attentional retraining would manipulate the presence of attentional bias. Specifically, it was predicted that decreased attentional bias would be shown in groups exposed to the high conflict condition. To examine this hypothesis, median correct reaction times were entered into a 2 x 4 x 3 x 2 mixed ANOVA to identify any effects of the cognitive control manipulation on the presence of attentional bias in the Stroop task. This analysis included Word (Smoking and Neutral) and Position (positions 1-4) as the within subjects factors and Group (Smokers, SATQ, and Never-Smokers) and Percentage Colour Words (25% colour words and 75% colour words) as the between subject factors. The analysis revealed a main effect of Word ($F(1, 70) = 8.76, p < .005$, *partial* $\eta^2 = .11$) an interaction of Word x Position ($F(3, 210) = 3.28, p < .05$, *partial* $\eta^2 = .05$) and a marginally significant four-way interaction of Word x Position x Group x Percentage Colour Words ($F(6, 210) = 2.03, p = .06$, *partial* $\eta^2 = .06$).

Subsequent ANOVAs conducted separately for each Percentage Colour Word condition revealed no significant interaction of Word x Position x Group in the 25% Colour Word condition ($F(3, 105) = .22, p > .1$, *partial* $\eta^2 = .03$). However. in the 75% colour word condition the Word x Position x Group interaction was significant ($F(3, 105) = 3.33, p = .005$, *partial* $\eta^2 = .16$). Similarly, separate ANOVAs conducted for each group within the 75% colour word condition revealed a significant interaction of Word x Position in SATQ ($F(3, 33) = 4.75, p < .01$, *partial* $\eta^2 = .30$), but only marginal Word x Position interactions in smokers ($F(3, 33) = 2.55, p = .07$, *partial* $\eta^2 = .19$) and never-smokers ($F(3, 39) = 2.59, p = .07$, *partial* $\eta^2 = .17$).

Simple main effects analysis conducted using paired sample t-tests for reaction times to words in the smoking sequence and words in the neutral sequence at each position separately revealed no significant difference in any of the groups for positions 1 and 4 ($ts < 2.0, ps > .1$) . At position 2 significantly slower colour-naming of words in the smoking sequence compared to words in the neutral sequence were shown in SATQ ($t(11) = -2.87, p = .02$) and smokers ($t(11) = -2.47, p = .03$). However, after Bonferroni correction the former became marginally significant and the latter became non-significant. There was no significant difference in responses at position 2 for Never-smokers. At position 3, however, never-smokers were slower to words in the smoking sequence compared to words in the neutral sequence ($t(13) = -2.46, p = .03$), after Bonferroni correction this difference became non-significant. There were no significant difference in responses to the different words sequences in smokers and SATQ at position 3 (*ts* < 2.0, *ps*>.1). Thus, these results indicate a marginal slow effect of attentional bias for smoking words in SATQ in the 75% word condition, and also that both smokers and never-smokers are showing a trend towards similar slow effects in the 75% colour word condition (see Figure 6-4).

These effects are inconsistent with the hypotheses that increased conflict in the training trials would lead to decreased attentional bias. Specifically, following training smokers attempting to quit in the high conflict condition showed a marginally significant slow effect of bias to smoking stimuli. Furthermore, trends in this direction were also shown in smokers and never smokers.

Smoking behaviour after training

It was hypothesised that there would be changes in smoking behaviour relative to changes in attentional bias following the conflict manipulation. Analyses were planned to identify if smoking behaviour changed as a result of the training task. However, Fagerstrom scores taken at baseline were identical to Fagerstrom scores taken one-week later (M=8.71, SD=2.07). Also, only 8 participants (10.5% of the original cohort of participants) responded to a request for reports on smoking behaviour 1–month later. This level of response was deemed to be too low to conduct effective ANOVA analyses for each condition. It was hypothesised that there would be changes in craving relative to changes in attentional bias following the conflict manipulation.

Additional analyses

Although not central to the hypotheses, the following analyses examined whether conflict manipulation influenced anxiety and the emotional association with smoking stimuli.

Correlation analyses for attentional bias with measures

Correlation analyses were conducted to examine possible relationships between anxiety-, emotion-, and smoking-related measures and attentional bias shown in the pre-training and post-training Stroop tasks. These correlation analyses incorporated anxiety-, emotion-, and smoking-related measure scores and bias scores for the pre-training and post-training Stroop tasks. The analyses revealed no significant correlations between the measures and attentional bias shown prior to training or post-training (all *ps*>.05).

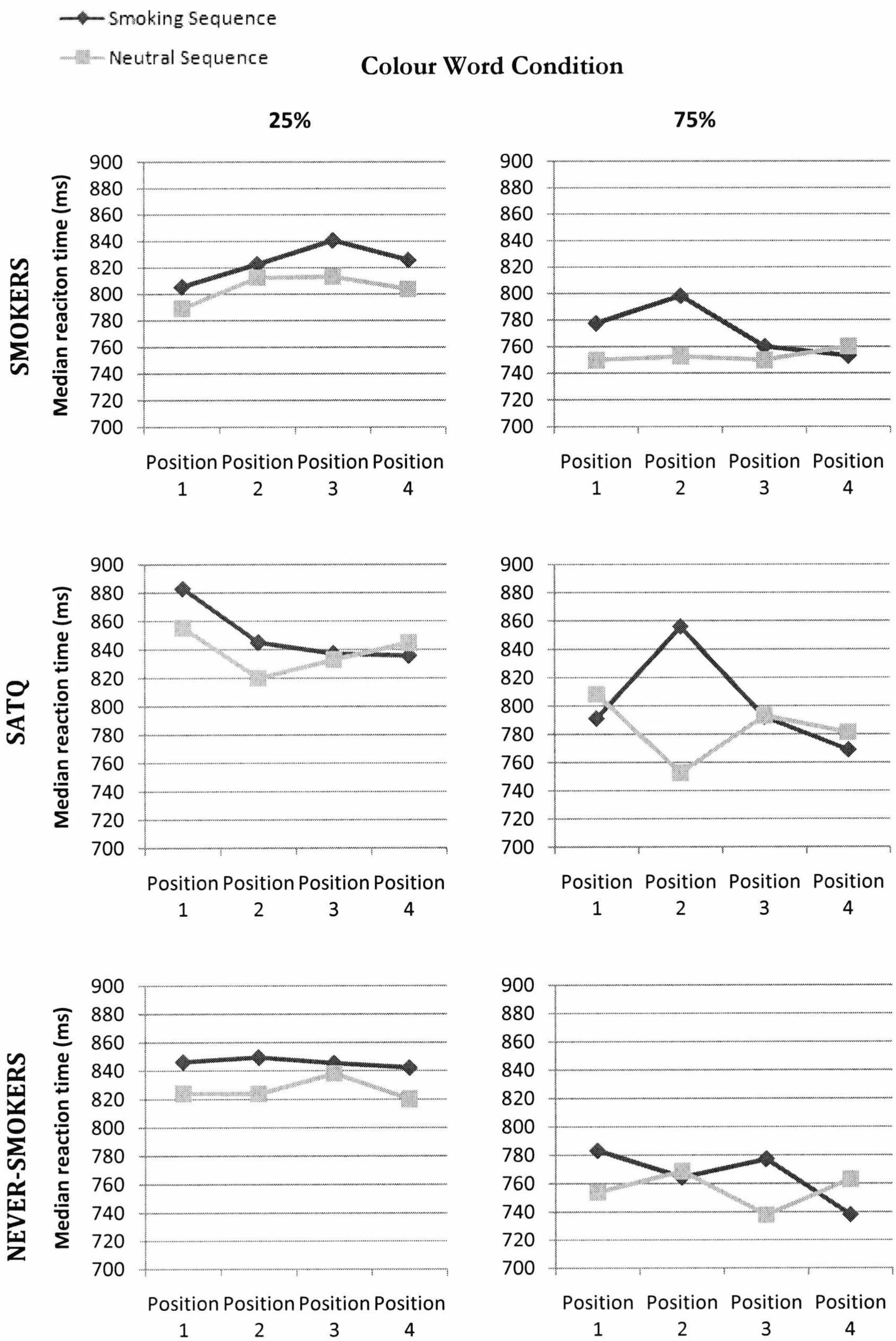

Figure 6-4 - Median reaction times for the Stroop task following training in each condition for each group

6.1.3 – Discussion

In partial support of predictions, attentional bias for smoking stimuli was shown to be present in smokers prior to training but not in smokers attempting to quit, replicating the findings of Study 5. Furthermore, the findings indicate that the conflict manipulation in the training task was only effective in smokers attempting to quit where decreased interference was shown in the high conflict condition (75% colour words) compared to the low conflict condition (25% colour words). Following training a marginally significant slow effect of bias to smoking stimuli was shown in smokers attempting to quit in the high conflict condition (75% colour words). Whilst there were no significant bias effects in smokers and never-smokers in the Stroop task following training both smokers and never-smokers also showed trends towards slow effects of smoking attentional bias in the high conflict condition.

The finding that smoking attentional bias was only present in smokers at baseline replicates the findings of Study 5. However, this contradicts previous research (e.g. Cane et al, 2009), which has shown that attentional bias is also found in smokers who are undergoing a quit attempt. Furthermore the findings also showed that the slow component of attention, rather than the fast component was present in the smoking group. Whilst Waters et al. (2005) have shown evidence of the slow effect in smokers, Cane et al. (2009) showed that the fast effect was only present in smokers, with the slow component being limited to smokers attempting to quit.

The Stroop conflict manipulation yielded expected effects only in smokers attempting to quit. It is unclear why this manipulation was more effective in smokers attempting to quit than smokers and never-smokers. One explanation for these effects is that never-smokers and smokers are more able to compensate for conflict than smokers attempting to quit, even under low conflict situations. Indeed the results provide evidence for such a suggestion, indicating that interference on incongruent trials was relatively low across both the high conflict and low conflict conditions in both smokers and never-smokers and that the interference shown was similar to the decreased interference shown in smokers attempting to quit in the high conflict condition. Furthermore, such a suggestion compliments previous research that has shown that following recent nicotine administration smokers have improved performance, which is similar to never-smokers, on cognitive tasks. Whereas under abstinence performance on these tasks deteriorates.

The Stroop conflict manipulation did have an impact on the presence of smoking attentional bias as shown in the Stroop task following training. In particular, no attentional bias effects were shown in participants who had received low conflict training across all groups, but attentional bias effects were marginally significant in smokers attempting to quit in the high conflict condition. Similarly there was a trend towards smoking attentional bias in both smokers and never-smokers in the high conflict condition. These effects were contrary to expectations, as it was expected that decreased attentional bias, rather than increased attentional bias, should be present in the high conflict condition.

There are a number of possible reasons for these findings. Firstly, the high conflict condition, compared to the low conflict condition, can be seen as more cognitively demanding and therefore participants in this condition may have suffered from fatigue on the Stroop following training. This may have affected the cognitive control mechanism making it more likely that smoking stimuli will be automatically attended to. However, assuming that response times reflect fatigue, the data provide evidence to the contrary, indicating that participants in the low conflict had slower response times in the Stroop task (M=830.45, SD=135.23) following training compared to participants in the high conflict condition (M=771.54, SD=82.76). This indicates that participants in the low conflict condition were more likely to be suffering from fatigue than the participants in the high conflict condition.

A second possibility is that smoking attentional bias emerged as a product of the increased anxiety sensitivity and state anxiety shown in participants in the high conflict condition. Indeed, previous research has shown increases in state anxiety to be related to increases in smoking attentional bias particularly in smokers attempting to quit (Cane et al, 2009). Furthermore, research in relation to emotional attentional bias has shown that increased anxiety leads to increases in attentional bias to negative stimuli (e.g. MacLeod et al., 1986). As smoking stimuli were rated as more negative in smokers attempting to quit and never-smokers the increased smoking attentional bias in the high conflict condition could be explained by the increases in anxiety. However, this does not explain the trend towards smoking attentional bias in smokers in this condition.

An extension of this possibility is that smoking words may have interrupted or 'reset' the cognitive control mechanism, leading to smoking stimuli once again distracting attention for the colour-naming task. Previous research in relation to emotion stimuli has shown similar effects, indicating that negative stimuli can interfere with cognitive control mechanisms counteracting the increased focus on colour-naming. However, to date such a suggestion is yet to be examined in direct relation to smoking stimuli.

In summary, Study 6 has shown that Stroop conflict manipulation has some impact on the presence of attentional bias to smoking stimuli. However, the effects were contrary to expectations, showing that increased conflict led to increased smoking attentional bias particularly in smokers attempting to quit. The most likely reason for this emergence of attentional bias is that the increased anxiety within the high conflict condition coupled with the negative emotion relatedness of these smoking stimuli led to these stimuli grabbing attention. Furthermore, it is possible that the emotion relatedness of these stimuli might have interrupted cognitive control mechanisms thus enabling smoking stimuli to grab attention. To investigate this suggestion further, Study 7 examines the direct influence of smoking-related stimuli has on cognitive control across smokers, smokers attempting to quit and never-smokers.

Chapter 7: An examination of the effects of smoking stimuli on cognitive control

Chapter 7 presents the findings from Study 7 which examines whether smoking attentional bias interrupts cognitive control. By interleaving smoking, negative, and neutral trials with incongruent and congruent trials the effects of the specific stimuli on cognitive control could be examined. Findings indicated that the context of the stimuli had little effect on cognitive control as measured through responses to incongruent trials. However, the results also indicated that smoking stimuli appeared to produce a general cognitive slow-down in comparison to neutral and negative stimuli.

In Study 6, it was shown that attentional bias to smoking stimuli had a tendency to emerge following a high conflict task, especially in smokers attempting to quit who rated smoking stimuli as negative. One possible reason for this was that smoking stimuli 'reset' cognitive control mechanisms allowing them to disrupt the focussed attention given to the colour-naming task. Study 7 builds on the findings of Study 6 by examining this proposition further. In particular, it examines the relationship between smoking and negative emotion stimuli and cognitive control mechanisms and examines whether this relationship differs depending on smoking status.

As mentioned in the previous chapter, the Conflict Monitoring and Cognitive Control theory (2001) proposes that conflicts in information processing are monitored, and compensated for, by a system within the ACC. These compensatory effects manifest themselves by focusing attention on the task specific responses and reducing the detrimental effects of task-irrelevant distracters, thus improving performance on tasks. More recently Wyble, Sharma, and Bowman (2005) have developed Botvinick et al.'s model to incorporate findings from studies using the emotional Stroop paradigm (see Chapter 1, section 1.2). Their development takes into account not only the Conflict Monitoring portion of the ACC but also an affective portion of the ACC, and shows how these two portions may work together to produce interference as seen in classic Stroop tasks and emotional Stroop tasks. The affective portion of the ACC they describe is particularly responsive to emotional cues and once activated inhibits the Conflict Monitoring system of the ACC, thus reducing the amount of cognitive control in a particular direction (e.g. towards colour-naming). Thus, Wyble et al.'s model predicts that if incongruent trials are increased but are interlaced with negative emotion words then this should counteract the activation of the conflict monitoring system and thus the interference-reducing effect on incongruent trials should be reversed.

Regarding smoking-related stimuli and the Stroop effect, the research of Botvinick et al. (2004) and Wyble et al. (2005) may have important implications. If smoking stimuli have no relation to negative emotion then it would be expected that changing the proportion of smoking words relative to congruent and incongruent trials would yield similar effects to those found by Tzelgov et al. (1992) with neutral words. Specifically, that decreasing the proportion of smoking words relative to incongruent trials should yield a decrease in interference on incongruent trials. However, if smoking-related words are related to negative emotions, as was shown in Study 6, then this may reverse the process of conflict monitoring thus reversing this decrease in interference on incongruent trials.

There is clear evidence from the previous studies presented in this thesis and from previous research (e.g. Cane et al., 2009; Carter & Tiffany, 2001), that smokers attempting to quit assign a greater amount of negative emotion to smoking stimuli than smokers. In relation to Wyble et al.'s (2005) model, this would mean that smoking stimuli should have a greater effect on the conflict monitoring system in smokers attempting to quit than in smokers. To examine whether this is the case, in Study 7 the Stroop conflict task used in Study 6 was adapted so that smoking words, negative words, and neutral words were interlaced with incongruent and congruent colour words across three separate blocks. The proportion of colour words relative to smoking, negative and neutral words were manipulated across participants, so that a high conflict condition and a low conflict condition were created for each block. Using this technique it is possible to examine whether smoking, negative, and neutral stimuli interrupt the conflict monitoring system and whether this changes depending on smoking status.

Based on the findings of Botvinick et al. (2001) and Wyble et al. (2005) it was hypothesised that:

i) if smoking stimuli are unrelated to negative emotion decreasing the proportion of these stimuli (smoking and neutral) relative to the proportion of congruent and incongruent trials will decrease the amount of interference shown on incongruent trials.

ii) if the stimuli (smoking, negative emotion, neutral) are related to negative emotions then stimuli should interfere with the conflict monitoring system leading to increased interference even when conflict is high.

iii) the above effects on the conflict monitoring system will be greater in smokers attempting to quit who have been previously shown to assign a greater amount of negative emotion to stimuli.

7.1 - Study 7

7.1.1 - Methods

Participants

Sixty three participants (15 male, 48 female; mean age=20.67, *SD*=3.67, age range = 18-36) were recruited through the University of Kent undergraduate research participation scheme and were given 2 credits towards a module for their participation. All participants who took part were either native English speakers or fluent in spoken English. Participants were categorised into one of three conditions, i) smokers, ii) smokers attempting to quit (SATQ), or iii) never-smokers. Participants were classed as active smokers if they had smoked a cigarette within the past 24 hours, SATQ if they were smokers who had abstained from smoking for over twenty-four hours and under two years and were actively attempting to quit, and never-smokers if they had never smoked. Of those who took part 21 were classed as smokers, 20 were classed as SATQ, and 22 were classed as never-smokers. The number of cigarettes smoked, Fagerstrom scores, time since last cigarette, and subjective craving are shown in Table 7-1. All participants were treated in accordance with the ethical standards of the British Psychological Association. In addition, ethics approval was obtained from the University of Kent at Canterbury's Department of Psychology ethics committee before recruiting participants and proceeding with the experiment.

Table 7-1

Number of cigarettes smoked, FTND scores, time since last cigarette and subjective craving scores for smokers and SATQ

	Number of cigarettes smoked		Fagerstrom score	Time since last cigarette	Subjective craving
	1-15	16-25			
Smokers (n=21)	90.5 %	9.5 %	4.00 (1.98)	6.22 hrs (11.04 hrs)	3.43 (1.21)
SATQ (n=20)	90 %	10 %	3.20 (1.70)	87.81 days (152.10 days)	2.55 (1.32)

Values are Mean (SD) for Fagerstrom, Time since last cigarette, Subjective craving

Apparatus

Stroop presentation and recording

Apparatus was identical to that used in experiment 6.

Stimuli

In total 48 smoking stimuli, 48 neutral stimuli and 48 negative emotion stimuli were used in this study (see Appendix A4). Smoking stimuli were stimuli previously used in Studies 3 and 5. Negative emotion stimuli were chosen from previous studies which had used the stimuli in a similar context (e.g. Cane et al. 2009). Neutral stimuli were lists of animal names. All stimuli were matched for frequency and word length using the Celex English Lexical Database, Release 2 (Baayen, Piepenbrock, & Gulikers, 1995). The colour words used were red, green, blue and yellow.

The stimuli were presented at a height of 0.6cm and a width of 2cm, in one of four colours; red, green, blue or yellow on a black background and participants sat approximately 60cm from the screen whilst the stimuli were presented.

Measures

Measures were the same as taken in Study 6.

Design

A 3 x 2 x 3 x 3 factorial design was used with Group (smokers, recently abstaining smokers, and non-smokers) and Percentage Colour (25 and 75) as the between subject factors and Context (smoking, negative, and neutral) and Stroop (incongruent, congruent, and baseline) as within subject factors.

Participants were either subjected to the 25 percent colour word condition (75 percent context-specific words; e.g. smoking, negative or neutral words), or the 75 percent colour word condition (25 percent context-specific words). For the Stroop task stimuli were arranged in three category blocks; a smoking-related block, a negative emotion block, and a neutral block. Each consisted of 192 trials: for the 25 percent colour word condition this consisted of 48 colour words and 144 context-specific words and in 75 percent colour word condition this consisted of 144 colour words and 48 context-specific words.

Procedure

On arrival participants completed the FTND questionnaire and gave a BCO sample. Participants were then assigned to a group (smoker, SATQ or never-smoker) and experiment version (category block order).

Participants were then introduced to the Stroop task in which they were told they would have to respond to the colour of words shown on the screen whilst ignoring the words themselves. Each participant indicated the colours of words using their index fingers and middle fingers of each hand placed on each of four buttons. To begin with each participant was given 200 practice trials using random country names. This not only helped them to get used to doing a Stroop task but also allowed them to learn the position of the coloured buttons.

Participants then began the Stroop task, and were tested on all 192 trials in a category block before proceeding onto the next category block. In total, participants completed 576 trials excluding the practice trials. In between each of the category blocks participants completed a filler task, so that any effects of stimuli (e.g. increased negative emotion or craving) and effects of habituation to the task could be reduced. The filler task was unrelated to the Stroop task and involved participants tracing a complex maze pattern through a sheet of white paper using a pencil for ninety seconds.

Following the filler task participants started on the next category block by pressing a button on the response box. Following the experimental trials participants completed the State-Trait Anxiety Inventory, the Fagerstrom Questionnaire, and the word-relatedness scale.

Throughout both the practice trials and the experiment trials the lights in the laboratory were turned off and the blinds closed to reduce reflections from the monitor screen and to ensure that participants focused on the words displayed. In addition, the experimenter left the room and viewed the experiment through a two-way mirror; this prevented any possible distractions caused by the experimenter. The experimenter only returned to the room on three occasions, once after the practice trials had finished and the other two times in between each category block whilst the filler task was being completed.

Following the experimental procedure participants were fully debriefed both verbally and via a debriefing sheet.

7.1.2 - Results

Group characteristics

To identify any between group and between condition differences in anxiety and anxiety sensitivity that may have influenced the effects of the training, 3 x 2 between subjects ANOVAs were conducted separately for each of the measures administered (state anxiety, trait anxiety, ASI). These ANOVAs incorporated Group (smokers, SATQ, never-smokers) and Percentage Colour Words (25% colour words, 75% colour words) as the independent variables and the anxiety measure scores as the dependent variables.

For state anxiety, a significant main effect of Group was revealed ($F(2, 62) = 5.38, p=.007$). Post hoc analysis revealed that smokers (M=41.57, SD=13.18) and SATQ (M=42.25, SD=10.89) showing significantly higher state anxiety than non-smokers (M=32.82, SD=6.46, $ps < .05$). Similarly, for trait anxiety a significant main effect of Group was revealed ($F(2, 62) = 5.69, p=.005$). As with state anxiety post hoc analyses revealed that both smokers (M=43.71, SD=10.36) and SATQ (M=46.50, SD=9.779) reported significantly greater trait anxiety than never-smokers (M=36.73, SD=9.019; ps

< .05). There were no significant main effects or interactions for anxiety sensitivity and no significant between condition differences in state anxiety, trait anxiety or anxiety sensitivity (all *Fs* < .1, *ps* < .05).

To identify any between group (smokers and smokers attempting to quit only) and between condition differences in smoking-related measures that may have influenced the effects of the training, 2 x 2 between subjects ANOVAs were conducted separately for each of the measures administered (Fagerstrom, length of smoking career, craving ratings). These ANOVAs incorporated Group (smokers, SATQ) and Percentage Colour Words (25% colour words, & 75% colour words) as the independent variables and the smoking measure scores as the dependent variables. These analyses revealed a significant main effect of Group for subjective craving scores only ($F(2, 62) = 4.966, p=.017$). Post hoc analysis revealed that smokers reported significantly greater levels of craving (*M*=3.43, *SD*=.1.207) than SATQ (*M*=2.55, *SD*=1.317, $p < .05$).

Valence ratings of stimuli

As it was expected that the emotional valence of context-specific stimuli (smoking, negative emotion, and neutral) might affect the levels of interference shown in the Stroop task a series of one-way ANOVAs were conducted to examine the extent to which context-specific word stimuli were related to emotion. These analyses used emotional ratings of context-specific stimuli (smoking, negative emotion, neutral) as the dependent variable and Group (smokers, SATQ, and non-smokers) as the independent variable.

These analyses revealed a significant difference in the emotional ratings of the smoking stimuli ($F(2, 62) = 14.99, p < .001$). Post hoc analyses revealed that both SATQ and non-smokers rated smoking stimuli significantly more negatively (SATQ *M*=-.89, *SD*=.66; non-smokers *M*=-.89, *SD*=.96) than smokers, who rated smoking stimuli as slightly positive (*M*=.23, *SD*=.61, all *ps* < .001).

The analysis did not reveal any differences in the emotion rating of negative emotion stimuli and neutral stimuli (all *Fs* < 1.6, all *ps* < .05). With all groups rating the negative emotion stimuli as negative (smokers *M*=-2.42, *SD*=.65; SATQ *M*=-2.54, *SD*=.18; non-smokers *M*=-2.12, *SD*=.93) and all groups rating neutral stimuli as only slightly positive (smokers *M*=.11, *SD*=.50; SATQ *M*=.39, *SD*=.62; non-smokers *M*=.45, *SD*=.93).

Analysis of Errors

Initially, mean error rates were entered into a 3 x 3 x 3 x 2 repeated measures ANOVA with Context (smoking, negative, and neutral) and Stroop (baseline, congruent, incongruent) as the within group factors and Group (Smokers, SATQ, Never-smokers) and Percentage Colour Words (75% and 25% colour words) as the between group factors. This analysis revealed only a significant main effect of Stroop ($F(2, 114) = 19.10, p < .001$). Subsequent post hoc analyses on this main effect showed a greater amount of errors in incongruent trials (M=.06, SD=.38) than congruent trials (M=.04, SD=.03), ($t(62) = -4.94, p < .001$) and also a greater amount of errors in incongruent trials compared to baseline trials (M=.04, SD=.03), ($t(62) = -5.42, p < .001$). However, these initial analyses also indicated that overall error rates were less than 6% across all trials. Therefore, these error trials were removed from subsequent analyses.

Analysis of median correct reaction times (RTs)

Median correct reaction times were entered into a 3 x 3 x 3 x 2 repeated measures ANOVA with Context (smoking, negative, neutral) and Stroop (baseline, congruent, incongruent) as the within subject factors and Group (Smokers, SATQ, Never-smokers) and Percentage Colour (75% and 25% colour words) as the between subject factors.

The analyses revealed a significant main effect of Context ($F(2, 114) = 11.02, p < .001$, *partial* $\eta^2 = .16$), and a main effect of Stroop ($F(2, 114) = 44.65, p < .001$, *partial* $\eta^2 = .44$). The latter was subsumed under a significant interaction of Stroop x Percentage Colour ($F(2, 114) = 7.30$, p.001, *partial* $\eta^2 = .11$; see Figure 7.1).

For the main effect of Context, post hoc analyses with Bonferroni correction revealed significantly longer colour-naming reaction times to stimuli in the smoking-related block (M=769.33, SD=21.07) compared to the negative emotion block (M=713.38, SD=17.17; $p < .001$), and significantly longer colour-naming reaction times to stimuli in the neutral word block (M=743.44, SD=16.59) compared to the negative emotion block ($p < .05$). However, there were no significant differences in colour-naming response times to stimuli in the smoking and neutral block ($p < .1$).

For the significant two-way interaction of Stroop x Percentage Colour a further two independent t-tests were conducted. The first t-test included Percentage Colour (25, 75) as the independent variable and interference RTs as the dependent variable, where interference RTs were calculated as the difference between incongruent trials and baseline trials. This analysis revealed significantly greater interference in participants shown 25 percent colour words (M=109.02, SE = 140.13) compared to those shown 75 percent colour words (M=30.24, SD=36.13, $t(38) = 3.16, p < .005$[6]). The second analysis included Percentage Colour (25, 75) as the independent variable and facilitation RTs as the dependent variable, where facilitation was calculated as the difference between congruent trials and baseline trials. This analysis revealed significantly greater facilitation in the75 percent colour words condition (M=41.09, SE = 32.68) compared to the 25 percent colour word condition (M=23.26, SE = 29.81) ($t(61) = -2.26, p < .05$; see Figure 7-2).

Correlation analyses to examine slower colour naming responses in smoking block

To examine if anxiety, emotional ratings of stimuli and smoking related variables (e.g. nicotine dependence, time since last cigarette, craving) influenced the extent to which interference in the Stroop task were found a series of correlation analyses were conducted. These correlation analyses used interference scores (calculated by subtracting response times to incongruent stimuli from response times to congruent stimuli) alongside measure scores. The correlation analyses were conducted for each group (smokers, SATQ, never-smokers) and each condition (25% colour word condition, 75% colour word condition) separately.

These analyses revealed significant correlations for SATQ only (all other correlations were non-significant $rs < .3, ps > .05$). In both conditions (75% colour word condition and 25% colour word condition) significant positive correlations were shown between interference in the smoking related block and Fagerstrom scores (75%: $r = .97, p < .001$; 25%: $r = .53, p < .05$) and length of smoking career (75%: $r = .84, p < .005$; 25%: $r = .76, p < .01$). These findings indicate that greater previous nicotine

[6] Levene's test indicated a significant difference in variance between groups therefore adjusted t-test was used to take account for this difference in variance between groups

dependence and longer smoking career in SATQ was associated with increased interference of incongruent colour words on the colour-naming task.

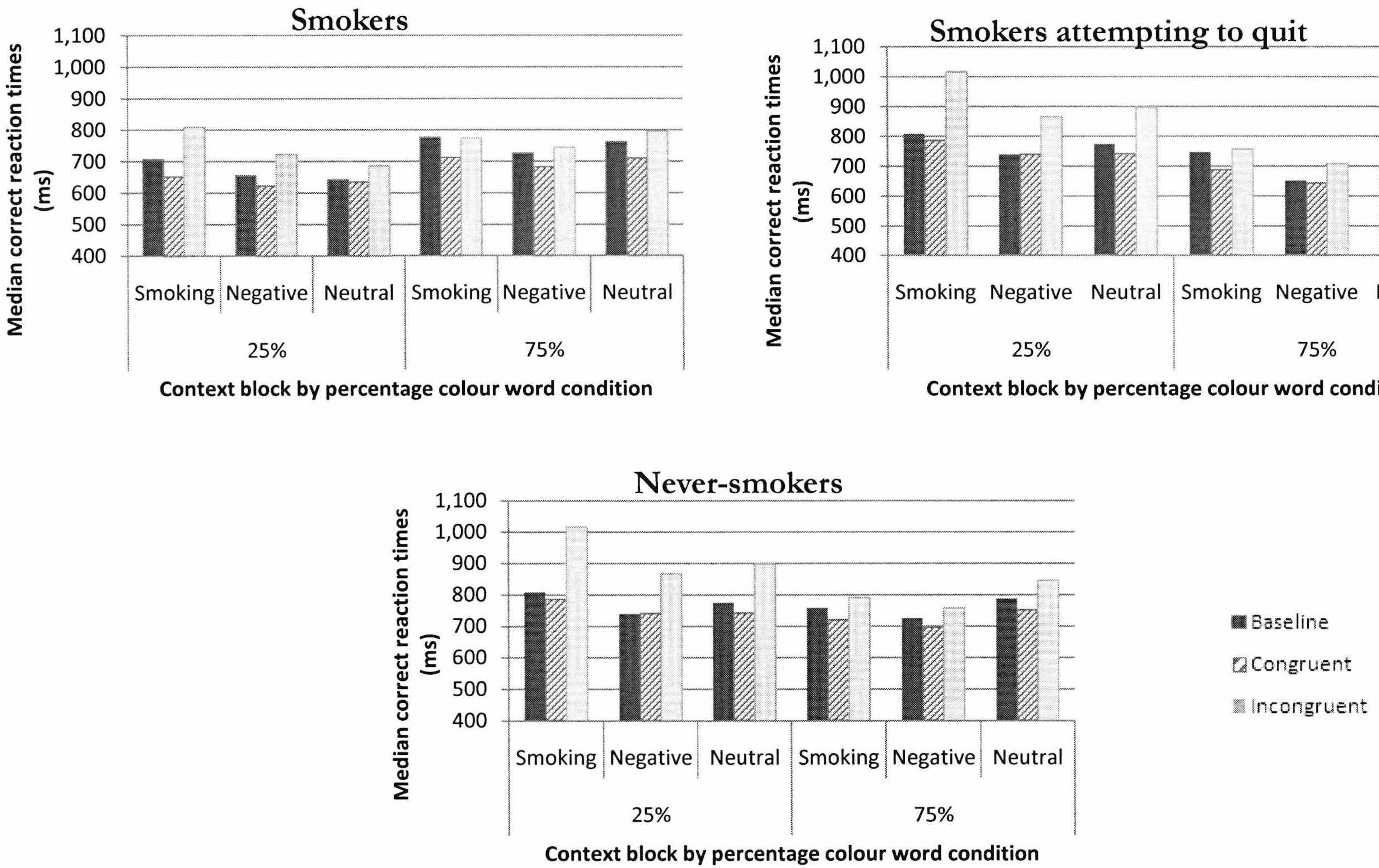

Figure 7-1 - **Median correct reaction times (ms) for each context block (smoking, negative and neutral) by percentage word condition for each group**

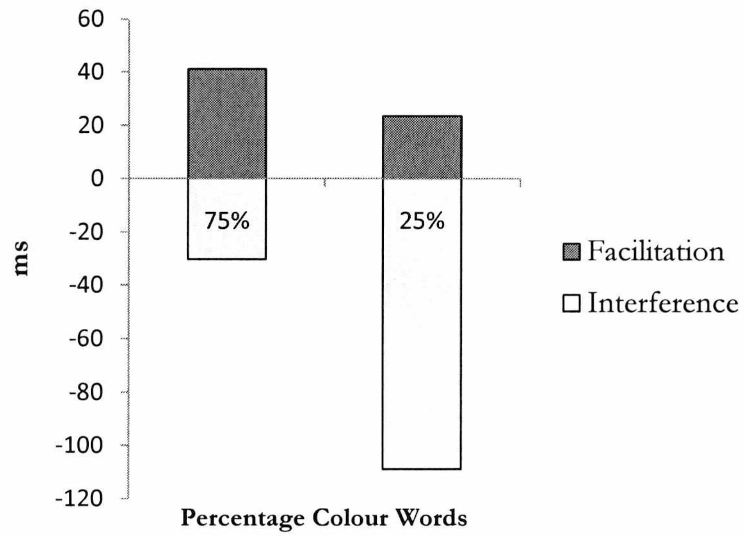

Figure7-2 - Facilitation and interference scores by percentage word type collapsed across all participants and contexts

7.1.3 - Discussion

In support of the first hypothesis the results show that increasing the proportion of non-colour words (smoking, negative emotion and neutral) relative to colour-words increased Stroop interference shown on incongruent trials. In addition, the results showed that this manipulation did not affect the amount of facilitation shown on congruent trials. This finding is a direct replication of the findings of Tzelgov et al. (1992) who showed that decreasing the proportion of incongruent trials (therefore increasing the number of neutral trials) yielded an increase in the level of Stroop interference on incongruent trials. As such, the findings of this study provide further evidence for Botvinick et al.'s (2004) model of conflict monitoring, which argues that a system exists in the ACC which monitors and adjusts for conflicts in cognitive processes.

In contrast, the finding that negative stimuli and smoking stimuli did not affect these changes in Stroop effects is unexpected. Based on Wyble et al.'s (2005) model it would be expected that stimuli associated with negative emotion should counteract the changes in interference effects seen as a possible result of conflict monitoring. Ratings of stimuli indicated that negative emotion stimuli were rated as negative across all groups and the smoking-related stimuli were rated as negative in the SATQ and the never-smokers. Therefore, it would be expected that differences in effects should be seen in all groups in the negative emotion block compared to the neutral block and in the smoking block compared to the neutral block in SATQ and non-smokers. However, this was not the case: the negative emotion block and smoking-related block affected the Stroop effect to a similar degree as the neutral stimuli across all groups and across both percentage colour word conditions. This shows that the context of words or their emotional relatedness does not affect the extent to which Stroop interference is found.

Although the results indicate that context does not affect the levels to which interference is shown, there was an indication that the context of smoking elicits a general slowing down effect across the smoking block as a whole (over congruent, incongruent, and smoking baseline trials). It must be noted however, that whilst there was slower colour naming in the smoking block compared to the other blocks, reactions times were not significantly different from reaction times in the neutral block (response times were significantly different from the negative emotion block). Although previous research has shown that smoking stimuli can have effects on attention at the time of stimulus presentation and on the trial immediately following smoking stimulus presentation (Cane et al., 2009; Waters et al., 2005), the finding that a general slow-down can occur across all trials within a smoking block (mixed with stimuli unrelated to smoking) is, to the author's knowledge, novel.

Although this is a novel finding in relation to smoking stimuli, the general slowing of reaction times in cognitive tasks has been shown previously in conjunction with emotional content. Algom, Chajut, and Lev (2004) have argued that the slowing of cognitive processes in general is a result of the increased anxiety caused by negative emotion stimuli in tasks such as the Stroop task. Field (2006) proposes a similar suggestion with regards to addiction-related stimuli and craving. In particular he suggests that addiction stimuli may produce feelings such as craving which could elicit similar general slowing down of cognitive processes as suggested by Algom et al. (2004; see Chapter 2, section 2.1.1). Whilst the present research showed no evidence of a relationship between increased response times and subjective craving, there was evidence of positive correlations in the smoking block between Stroop interference and previous nicotine dependence and length of smoking career in SATQ. These findings indicate that individuals who have quit but who were previously highly nicotine dependent have decreased cognitive performance when faced with smoking-related stimuli. This suggestion indicates that conscious control over automatic processes during a quit attempt may be attenuated if an individual was previously highly nicotine dependent.

The reason for general slow-down in smokers and never-smokers is less clear. Indeed, there were no significant correlations between Stroop interference and anxiety, smoking and emotion-rating measures in these group, indicating that the affective association of smoking stimuli or smoking behaviours did not influence effects on cognitive control.

It is possible that the slow-down shown in smokers is related to other smoking-related behaviours or cognitions that are not tapped by the smoking-related measures used in the present research. For never-smokers it may be possible that responses to smoking stimuli may stem from the implicit, rather than explicit affective relationships with the stimuli. However, at present these are tentative suggestions which need to be examined in future research.

One of the main limitations of this study is that the results are only directly relevant to effects found in the classical Stroop and effects which may be found in the emotional Stroop can only be surmised in light of these results. However, these results do show some important information on Stroop effects in general; specifically with regards to the lack of influence of the context of smoking and negative emotion on these effects and also the general influence of smoking stimuli in causing general slowing down on cognitive tasks.

In conclusion, the results of this study show that interference on the Stroop task can be affected by changing the proportions of incongruent trials relative to non-incongruent trials. However, these changes in interference are unaffected by the context of non-colour word trials. The results have shown evidence for a general cognitive slow-down in relation to smoking stimuli, and, whilst this appears to be unrelated to smoking status this may have resulted from the relationship between previous nicotine dependence in smokers attempting to quit. However, the reason for the slowing-down effects shown in smokers and never-smokers is less clear.

Chapter 8: General Discussion

The aim of the current research was to develop our understanding of smoking attentional bias and examine three factors in relation to smoking attentional bias: affect, automaticity and cognitive control. It did so by adapting techniques used in previous research examining attentional bias in addictions and attentional bias in relation to emotion. A summary of the chapters and main findings are provided below:

8.1 Summary of chapters

Chapter 1 outlined a number of theoretical perspectives that have been put forward to explain how attentional biases in addictions develop, the roles of automatic and non-automatic processes in attentional bias, and theoretical perspectives on the relationships between attentional bias and smoking behaviour and craving. The chapter also explored theories that examine the role of cognitive control in relation to attentional processes and how these might explain attentional bias.

Chapter 2 described some of the methodological approaches that have been adopted to examine attentional bias in relation to addiction and critically evaluated the effectiveness of these methodological approaches in measuring attentional bias. It also examined the empirical findings of previous research in relation to smoking attentional bias, focusing on the effects of abstinence, emotion, automaticity and cognitive control.

Chapter 3 presented the findings from Studies 1 and 2. These studies examined shifts in visual attention to smoking, negative, and neutral images across smokers, smokers attempting to quit and never-smokers using eye-tracking techniques. In Study 1, shifts in visual attention were examined when participants were free to examine image pairs (smoking-neutral, negative-neutral, and control-neutral) in any order. It was found that under these conditions initial shifts in visual attention were quicker to negative stimuli, compared to smoking and neutral stimuli and gaze was maintained for longer on both smoking and negative stimuli. However, these shifts in visual attention were unrelated to emotion ratings of stimuli, smoking status, smoking behaviour, and craving. Study 2 built on the findings of Study 1 by examining whether shifts in attention to smoking and negative stimuli were automatic, occurring when there was explicit instructions to keep gaze on a simultaneously presented neutral stimulus. Findings indicated that there were exogenous shifts in attention to smoking and negative stimuli in the early stages of attentional processing but these were not evident in later stages of attentional processing. Again, these shifts were unrelated to smoking status, smoking behaviour, craving and emotion ratings of stimuli.

Chapter 4 presented the findings from Studies 3 and 4. These studies examined the effects of the England smoking ban on smoking attentional bias, the emotional rating of smoking stimuli and smoking behaviours. Study 3 measured attentional bias using a Stroop task and visual probe task on three occasions over a two-month period: immediately prior to the smoking ban, one month after the introduction of the ban and two months after introduction of the ban. Findings indicated that attentional bias decreased across both measures following the introduction of the ban. However, there were no changes in smoking behaviour, craving or the emotional rating of smoking stimuli over this time. Study 4 was conducted to put the findings of study 3 in a wider context by examining changes in smoking behaviour and smoking environments over the same two-month period through an online survey. The survey revealed that smoking behaviours did not change even if there was some intention to quit in light of the smoking ban. Furthermore, Study 4 revealed a decrease in the number of smoking items reported by participants, indicating that smoking may have been less salient in the months after the smoking ban. It is suggested that this may have lead to the decrease in attentional bias in Study 3.

Chapter 5 presented the findings from Study 5, which examined the effectiveness of a technique called attentional retraining in manipulating smoking attentional bias across smokers, smokers attempting to quit and never-smokers. It also examined whether any manipulation of smoking attentional bias changes subsequent nicotine dependence and craving. Results indicated that attentional retraining was effective in reducing smoking attentional bias in smokers, both when smokers were trained to attend away from smoking stimuli and when they were trained to attend towards smoking stimuli. However, contrary to predictions, the change in attentional bias did not affect subsequent nicotine dependence or cravings measured one week and one month after the experimental sessions. Importantly, the findings did generalise to novel stimuli and to a Stroop task following training.

Chapter 6 presents findings from Study 6 which also examined the manipulation of attentional bias by varying cognitive control. Cognitive control was manipulated by changing the number of incongruent trials in a classic Stroop task. In previous research, an increase in incongruent trials has been shown to increase focus on the colour-naming task and decrease the distraction from words (e.g. Botvinick et al., 2001; Tzelgov et al., 1992). Findings indicate that this manipulation, contrary to expectations, led to increases in smoking attentional bias rather than decreases in attentional bias, particularly in smokers attempting to quit.

Chapter 7 presented the findings from Study 7 which builds on the findings of Study 6 by examining whether smoking attentional bias interrupts cognitive control. By interleaving smoking, negative, and neutral trials with incongruent and congruent trials the effects of the specific stimuli on cognitive control could be examined. Findings indicated that the context of the stimuli had little effect on cognitive control as measured through responses to incongruent trials. However, the results also indicated that smoking stimuli appeared to produce a general cognitive slow-down in comparison to neutral and negative stimuli.

The key findings of the empirical research are discussed in relation to previous research and theoretical approaches below.

8.2 Key findings of the present research

The overall aim of this thesis was to examine the presence and role of affect, automaticity and cognitive control in relation to attentional biases in smoking. By doing so, the thesis has broken new ground in the study of addictions in general, smoking and the development of smoking cessation programmes.

The findings indicate that smoking attentional bias is a robust phenomenon in smokers and that smoking stimuli can indeed have negative affective associations in smokers attempting to quit. However, these associations appear to have little impact on the presence of smoking attentional bias. This suggests that even if attempts are made to manipulate the emotional component of smoking stimuli, this may not impact on implicit smoking behaviours. This finding suggests that even if stimuli have an emotional component, attention is not necessarily grabbed by them. Future research should focus on indentifying additional factors that drive this attentional bias. Furthermore, this finding highlights the importance of testing the relationship between negative emotions and addiction-related stimuli for other types of addiction. The non-significant relationship between the emotional component of smoking stimuli and attentiona bias also has implications for smoking cessation programmes as it suggests programmes that focus on manipulating the affective associations of smoking stimuli are likely to be unsuccessful in changing implicit smoking behaviours.

Interestingly, smoking attentional bias was present in non-smokers and smokers attempting to quit under certain conditions (where there was explicit awareness of the presence of smoking stimuli, where exposure to stimuli is relatively long and in conditions that yield greater anxiety). This has far-reaching implications for the study of lapse episodes and possibly the uptake of smoking and other addictions. With regards to lapse episodes therapies which are able to decrease anxiety and decrese exposure to smoking stimuli could reduce the chances of smoking attentional bias which could lead to a lapse episode. With regards to uptake of smoking, the finding that non-smokers can also show attentional bias under these conditions may indicate that the uptake of smoking is influenced by attentional biases, commonly only associated with those who have smoked.

Another key finding is that smoking attentional bias can be manipulated in smokers through attentional retraining. However, in its current form it has limited application in changing smoking behaviour. Further research into this using extended training over multiple sessions may improve the effectiveness of the manipulation shown in this thesis. Also, attentional retraining may prove to be more effective if combined with motivational instruction. This could lead to the development of a home-based intervention to aide smoking cessation.

The main thrust of the thesis was to expand on Baker's (2004) theory by testing the relationship between smoking stimuli, which may have negative associations, and smoking attentional bias and by examining the relationship between negative associations of smoking stimuli and cognitive control and automaticity. As predicted, smokers attempting to quit associated smoking stimuli with negative affect. However, the negative affective association of smoking stimuli was unrelated to smoking attentional bias. This suggests that while smoking stimuli do have a negative emotional component, they do not grab attention because of this association. Rather, it seems that the stimuli are attended to because of their relationship with smoking. Furthermore, there was no relationship found between either cognitive control or automaticity and the affective component of smoking stimuli. These findings indicate that the association of stimuli with negative emotions is unrelated to smoking attentional bias and suggest that Baker's model is specific to the relationship between negative affective states that people experience and attentional bias in addictions.

8.2.1 Presence of smoking attentional bias and the relationship with smoking status

The present research has provided further evidence that smoking attentional bias for smoking stimuli exists in smoking groups. Specifically, in the current research smoking attentional bias was shown among smokers across all of the studies presented, and using different techniques (the Stroop task, visual probe and eye-movements). This finding is consistent with that of previous studies which, using a number of different measures, have shown smoking attentional bias to be a robust phenomenon in current smokers (e.g. Baxter & Hinson, 2001; Bradley et al., 2008; Cane et al., 2009; Ehrman et al., 2002; Johnsen et al., 1997; Mogg & Bradley, 2002; Sayette et al., 2001; Waters, Shiffman, Bradley et al., 2003). In this way, the present research provides further evidence that incentive-salience of stimuli stems from continued nicotine use and furthermore that smoking attentional bias is a fundamental component of smoking that may be central to the maintenance of smoking behaviours.

In contrast, the picture is less clear for smokers attempting to quit. Contrary to predictions, smokers attempting to quit only showed evidence of smoking attentional bias in eye-movement measures and in one condition of the Stroop attentional training study. This result conflicts with the findings of Cane et al. (2009), who showed smoking attentional bias to be present across a group of smokers attempting to quit. However, it replicates the findings of a number of studies that have shown decreased attentional bias in cessation periods (e.g. Ehrman et al., 2002; Johnsen et al., 1997; Littel & Franken, 2007; Waters, Shiffman, Bradley et al., 2003).

A number of possible explanations have been proposed for such decreases in attentional bias during cessation. For instance, it has been argued that through cessation treatment, smokers may be able to suppress smoking-related thoughts (Johnson et al, 1997). Indeed, even without specific training from smoking cessation services, smokers attempting to quit might be more aware of their own smoking-related thoughts and thus may be able to control them more effectively. This argument is supported by research in relation to alcohol where it has been shown that attentional avoidance of alcohol stimuli can occur during abstinence. For instance, alcoholics in treatment have been shown to exhibit attentional avoidance of alcohol related stimuli across the Stroop task during latter stages of treatment (e.g. Cox et al., 2002). Whilst in the present research none of the smokers attempting to quit in the experimental sessions indicated that they were using smoking cessation services, it is possible that they were still more active in suppressing smoking-related thoughts than current smokers. Indeed, the suppression of smoking-related thoughts could decrease the chances of interacting with smoking stimuli and decrease the likelihood of relapse.

Another explanation for the decreased presence of attentional bias in smokers attempting to quit is derived from the Incentive-Sensitization theory (Robinson and Berridge,1993; see chapter 1, section 1.1). According to this argument, the sensitisation of dopaminergic pathway are most likely semi-permanent (Munafò et al., 2003). This would mean that these neuroadaptations could be somewhat desensitized after extended periods where nicotine consumption had not taken place, leading to decreases in attentional bias for smoking stimuli among smokers attempting to quit. Similar responses between smokers attempting to quit and never-smokers across Studies 3 to 7 provides evidence for the desensitisation of these incentive-salience neuroadaptations.

The finding that attentional bias is reduced among smokers undergoing cessation is promising as it indicates that attentional bias may not be a factor of concern during a quit attempt. However, the present research has also shown that smoking attentional bias can persist among smokers attempting to quit under certain circumstances and also among never smokers. Attentional bias to smoking stimuli in smokers attempting to quit was present to a greater extent when participants were explicitly aware the task involved smoking stimuli (e.g. in Study 2), when the exposure of stimuli was relatively long (e.g. in Studies 1 & 2 where stimulus exposure was 3 seconds), and also in conditions which yielded greater anxiety (Study 6 in the high conflict condition). These effects were mirrored in the attentional bias exhibited by never-smokers, who also showed attentional bias to smoking stimuli under these conditions (Studies 1,2 and 6). This indicates that smoking attentional bias can be present even when there is no prior nicotine dependence or when current nicotine dependence is low (i.e. during a quit attempt). This finding suggests that smoking attentional bias may still be detrimental to quit attempts in specific situations, for instance if smokers attempting to quit were made explicitly aware of smoking by treatment, through prolonged exposure to smoking stimuli and in situations when they feel greater anxiety (e.g. before a driving test). These results also provide further evidence for the suggestion that low-level processing of stimuli is similar for ex-smokers and non-smokers (Littel & Franken, 2007).

In summary, the findings support the Incentive-Sensitization theory, as attentional bias was consistently found in smokers across all of the attentional bias measures and was, in the majority of studies, not prevalent in smokers attempting to quit and never-smokers. This is consistent with the majority of previous research and suggests that attentional bias is intrinsically related to current smoking behaviour and is reduced once a quit attempt is underway. The findings also indicate that attentional bias may be present in smokers during a quit attempt and in non-nicotine dependent individuals when they are explicitly aware they will be exposed to smoking stimuli, when exposure to smoking stimuli is relatively long, and possibly in conditions which yield greater anxiety. These findings have important implications for smoking cessation treatment which will be discussed further in the latter part of this chapter.

8.2.2 - The role of smoking behaviour and craving

As predicted, the present research found that strength of smoking attentional bias varied depending on smoking status (i.e. smoking attentional bias was stronger among smokers). However there was limited evidence of a relationship between smoking behaviours (as indicated by measures of nicotine dependence, BCO, time since last cigarette, length of smoking career) and craving with smoking attentional bias. Indeed, across the majority of studies presented in this thesis there was no indication that smoking behaviour measures were associated with the presence of smoking attentional bias. Where there was an indication of a relationship between smoking-related measures and smoking attentional bias this was in the opposite direction to the one expected (e.g. that nicotine dependence lead to decreased smoking attentional bias, see Study 2).

Whilst these findings appear to be counter-intuitive, they are somewhat in line with previous research which has shown an inconsistent relationship between smoking attentional bias and craving and smoking behaviour (Waters & Sayette, 2006). Indeed, a number of previous studies in this field have found a limited or non-significant relationship between smoking attentional bias and smoking behaviour (e.g. Bradley et al., 2008; Munafò et al., 2003; Munafò et al., 2005; Waters, Shiffman, Bradley et al., 2003). Furthermore, it has been shown that manipulations of smoking attentional bias do not lead to changes in craving (e.g. Field et al., 2009). However, some studies have also shown significant relationships between smoking attentional bias and nicotine dependence (Cane et al., 2009; Mogg & Bradley, 2002), craving (Field, Rush, Cole, & Goudie, 2007), and smoking urges (Mogg & Bradley, 2002; Mogg et al., 2003; Zack et al., 2001). The findings of the present research provide further evidence that smoking attentional bias does not robustly index explicit reports of smoking behaviour and craving.

There are a number of possible explanations for this non-significant relationship between smoking behaviour and craving with smoking attentional bias: i) the links between craving and smoking behaviour with smoking attentional bias are more inconsistent in relation to smoking, compared to other addictions, ii) the use of smokers who had been smoking for some time may have influenced the lack of evidence of these relationships, and iii) different measures of attentional bias tap different underlying mechanisms which may relate differentially towards smoking behaviours. These possible explanations will now be outlined in more detail.

i) *The link between craving and smoking behaviour with smoking attentional bias is more inconsistent in relation to smoking, compared to other addictions.*

It has been proposed that drug-use behaviours are involved in the development of attentional bias (see the Incentive-Sensitization theory, Robinson & Berridge, 1993, Chapter 1, section 1.1) and also that a mutually excitatory link exists between smoking attentional bias and craving (e.g. Field & Cox, 2008; Franken, 2003). Since the present research did not employ a long-term longitudinal design and used smokers who had been smoking for a number of years, it is difficult to examine the causal relationship between smoking behaviour and smoking attentional bias and test the causal predictions of the Incentive-Sensitization Theory. However, the present research has shown evidence that craving and smoking behaviours are independent of smoking attentional bias. This was particularly apparent in Study 5, in which it was shown that the manipulation of attentional bias did not influence ratings of craving. This suggests that there is no link between smoking attentional bias, craving and smoking behaviours. Therefore, the findings are inconsistent with the mutually excitatory link proposed by Field and Cox (2008) and Franken (2003). It should be noted, however, that in their meta-analytic review, Field, Munafò, and Franken (2009) concluded that the relationship between craving and attentional bias is not as strong in relation to smoking and alcohol studies, compared to other addictions such as studies of cocaine, cannabis, heroin and caffeine. Indeed, the review indicated that across 37 tobacco related studies the positive correlation between attentional bias and craving was weak ($r = .16$). Field and colleagues suggest that the reason for the difference in relationship between craving and attentional bias across different types of drug use is unclear at present and further research is needed before the reason for this difference can be identified (Field et al., 2009). However, the non-significant relationship between smoking attentional bias and craving shown in the present research is relatively consistent with the findings of Field et al..

ii) *The use of smokers who had been smoking for some time may have influenced the lack of evidence of these relationships*

The non-significant relationship between smoking behaviour and craving with smoking attentional bias can also be understood with reference to Chiara's (2000) suggestion that in the early stages of smoking, smoking behaviour is largely controlled by incentive-learning and through consumption of nicotine. However, in later stages smoking behaviours and responses to smoking stimuli are more reliant on habitual responses and less reliant on incentive motivation processes. The findings of the current research are consistent with this idea. Even though attentional bias was evident, the shifts in attention were independent of, or negatively correlated with, smoking behaviour and craving in smokers who had been nicotine-dependent for some time. It is possible that a significant association between smoking behaviour and craving with smoking attentional bias would be detected among smokers who have recently begun to smoke.

iii) *Different measures of attentional bias tap different underlying mechanisms which may relate differentially towards smoking behaviours.*

It has been suggested that inconsistent relationships between explicit drug use behaviours and the presence of attentional bias may stem from different measures of attentional bias tapping different components of this phenomenon (Field and Cox, 2008). However, the current research used a number of measures of smoking attentional bias, and a non-significant relationship between smoking behaviour and craving with smoking attentional bias was evident regardless of the attentional bias measure used. Therefore, it is unlikely that this explanation can explain the findings in the current research.

The lack of a relationship between smoking attentional bias with smoking behaviour and craving does not mean, however, that measures of smoking attentional bias are not clinically relevant especially given that previous studies have shown associations between attentional bias and smoking cessation outcomes (e.g. Waters, Shiffman, Sayette et al., 2003). Indeed it is possible that attentional bias is simply a better indicator of the propensity to relapse than an index of previous and current smoking behaviour. However, further research similar to the work of Waters et al. (2003) needs to be carried out before the predictive nature of attentional bias can be fully understood.

In summary, contrary to the relevant theories of addiction described above and in Chapter 1 (Field & Cox, 2008; and Franken, 2003; Robinson and Berridge, 1993), the present research has shown *limited* evidence that smoking attentional bias is related to explicit reports of smoking behaviour and craving. The majority of the findings are, however, consistent with the majority of previous research in relation to smoking, that smoking behaviour and craving are unrelated to smoking attentional bias. The most plausible explanations for this finding are that: i) in the latter stages of smoking addiction, attentional bias is more reliant on habitual responses than smoking behaviour and ii) that smoking attentional bias is a better predictor of future, rather than current or previous, smoking behaviour. Furthermore, these findings indicate that previous theoretical models that have proposed a mutually excitatory link between attentional bias and craving may not be applicable to smoking.

8.2.3 Relationship between smoking attentional bias and affect

Affective ratings of stimuli

Contrary to hypotheses, there was a non-significant relationship between smoking attentional bias and affect: there was no correlation between emotional rating of stimuli and the presence of smoking attentional bias. This finding was consistent across all studies, across all smoking status groups, and across a number of measures of attentional bias. Most notably, the hypothesis that smokers attempting to quit would assign increased negative emotion to smoking stimuli, leading to increased attentional bias was not supported - although smokers attempting to quit did show a greater propensity to rate smoking stimuli as negative this did not result in increased attentional bias. This was found across Studies 1,2 5,6 and 7 suggesting that smoking attentional bias is due to the smoking-relatedness of the stimuli, and not the affective associations of the stimuli. However, in Study 6 it was found that when anxiety was increased, attentional bias to smoking cues emerged in smokers attempting to quit and never smokers who rated smoking stimuli as negative. This suggests that attentional bias resulting from the negative rating of stimuli may be slightly more prevalent when anxiety is increased. However, this is a tentative proposition at present given that no significant correlations were found between negative emotion ratings, anxiety and the presence of smoking attentional bias.

The lack of a significant relationship between affect and smoking attentional bias is inconsistent with a number of theories that have suggested that the attention given to drug-related stimuli stems from the relationship that drug stimuli have with emotion (e.g. Baker et al., 1987; Stewart et al., 1984). According to these approaches, stimuli that have greater affective associations (i.e. positive or negative) will draw one's attention, therefore smoking stimuli would be attended to more readily if they have strong affective associations. However, neither the slightly positive ratings shown in smokers nor the negative ratings shown in smokers attempting to quit and never-smokers were related to attentional bias. Thus, the present research provides little evidence to support either positive or negative reinforcement models (e.g. Baker et al., 2004; Stewart et al., 1984). These findings are, however, consistent with previous research which has shown that the maintenance of attention to smoking-related stimuli is related to the drug-relevance of the stimuli rather than the affective association of the stimuli (e.g. Bradley et al., 2008). Importantly, in the current research, the non-significant relationship between smoking attentional bias and emotion was demonstrated using a number of measures of attentional bias, therefore this finding is quite robust. However, additional measures of attentional bias (e.g. dual-task paradigms, flicker task) need to be explored as these may tap the emotional component of drug-related stimuli.

Although affective ratings of stimuli were unrelated to attentional bias, there was consistent evidence that, as expected, affective ratings varied according to smoking status: smoking stimuli were rated more positively by smokers, compared with never smokers and smokers attempting to quit, who rated the stimuli negatively. These findings are consistent with previous research examining automatic affective responses to smoking-stimuli (e.g. Payne, McClernon & Dobbins, 2007). Payne et al. (2007) argued that when examining affective ratings of smoking stimuli, participants' motivation to smoke and withdrawal must be taken into account. They examined automatic affective associations of smoking stimuli across smokers at different stages of withdrawal. They found that smokers under withdrawal when there was a motivation to smoke responded to smoking stimuli as positive. However, under withdrawal with *no* motivation to smoke, as would be the case during a quit attempt, smoking stimuli were responded to negatively. Payne et al. (2007) also found that the group under withdrawal with no motivation to smoke had similar responses to a non-smoking control group. Responses in the current research could also be understood in this way. During the experiment smokers are under withdrawal but have a motivation to smoke, therefore they rate the smoking stimuli positively. Meanwhile, the smokers attempting to quit are under withdrawal and have no motivation to smoke, so they rate the smoking stimuli negatively. Finally, as in Payne et al (2007) the never-smokers responses were comparable with smokers attempting to quit. However, as described above, given that the emotional ratings of stimuli did not relate directly to the presence of attentional bias this indicates that smoking attentional bias does not reflect negative-affect processing as has been previously suggested (see Drobes et al., 2006).

Attentional bias to negative emotion stimuli

Another way to test whether smoking attentional bias is driven by the affective component of the stimuli is to test attentional bias to emotional stimuli and compare this with smoking attentional bias. If smoking attentional bias is driven by the negative affective component then a positive correlation between negative emotion attentional bias and smoking attentional bias would be expected. In contrast to responses to smoking stimuli, attentional bias was detected towards negative stimuli (Studies 1 and 2). This was found across all groups (Studies 1 and 2). However, previous research has found that response biases towards negative stimuli are more pronounced in smoking groups compared to non-smoking groups (see Cane et al., 2009; Drobes et al., 2006). This may result from smokers' inability to deal effectively with negative emotion stimuli as a result of increased anxiety which often accompanies abstinence of smoking behaviour (Parrot, 1994, 1998; Cane et al., 2009). The smokers in the present study did not directly consume nicotine during experimental procedures and thus were abstinent from nicotine during the period experimental trials were administered. Therefore, the attentional bias towards negative emotion stimuli could have been due to heightened anxiety. This suggestion is further corroborated by research showing that, during nicotine consumption, attentional bias to negative stimuli is decreased compared to periods of abstinence (e.g. Rzetelny et al., 2008). Therefore, Parrot's explanation could account for our findings among smokers and smokers attempting to quit and the current findings are consistent with the suggestion that abstinence from nicotine, even in the short term, attenuates the attentional control leading to the inability to deal effectively with negative stimuli.

These suggestions are also comparable to the theoretical propositions of Moss and Albery (2009), that the control of automatic responses can become muted under certain circumstances. In their model they suggest that alcohol consumption can suppress propositional reasoning leading to the increased chance that automatically activated alcohol-related representations will determine behaviour. Similarly, the abstinence experienced during experimental procedures could have muted control over the automatic responses to negative emotion stimuli leading to increased visuo-spatial attention being given to these stimuli.

However, this argument does not explain the negative attentional bias observed among never smokers. One possible explanation for the similarity in responses to negative stimuli across smoking groups in the present study is that the groups did not differ in their anxiety levels: smokers, smokers attempting to quit and never smokers reported similar anxiety levels (Study 1 and 2). As argued above, negative attentional bias may be dependent on anxiety level (e.g. Cane et al., 2009). This means that since anxiety levels were similar across groups, negative attentional bias was also comparable across groups. However, this explanation is unlikely given the lack of evidence of a correlation between anxiety and attentional bias. A more plausible explanation is that responses to negative stimuli resulted from explicit instructions that participants should compare the emotion relatedness of stimuli. Such a suggestion is confirmed by the fact that when participants had not received specific instructions regarding negative stimuli, attentional bias to negative stimuli was not present in any of the groups (see Study 7).

Relationship between smoking attentional bias and negative emotion attentional bias

Whilst there was no evidence of a relationship between emotional rating of stimuli and smoking attentional bias, there was a significant relationship between eye-movement responses for smoking stimuli and eye-movement responses for negative stimuli in smokers attempting to quit and never-smokers (Study 1). In particular, this relationship was shown to be prevalent in the early attentional processes in smokers attempting to quit and latter stages in never-smokers. This finding among smokers attempting to quit is consistent with previous research which has found a positive correlation between responses to smoking stimuli and responses to negative stimuli in smokers attempting to quit (Cane et al., 2009) and smokers (e.g. Drobes et al., 2006; Rzetelny et al., 2008). Rzetelny et al. (2008) suggest that one interpretation of these positive correlations is that smoking attentional bias and negative emotion attentional bias reflect a single underlying mechanism. However, in the current research there was a non-significant relationship between emotion attentional bias and smoking attentional bias in smokers, and a non-significant relationship was observed across all groups in Study 2. Therefore, this explanation cannot account for all of the findings. The correlation observed in Study 1 may be a by-product of the experimental instructions. In Study 1 participants were asked to explicitly compare the emotional content of pictures. This may have made the implicit affective associations of smoking stimuli more salient. The implicit affective associations across the smoking groups may be similar to the explicit affective ratings, that is smokers rate smoking stimuli as positive whereas smokers attempting to quit and never smokers rate them as negative. These implicit affective associations and the explicit ratings need not necessarily be related. Increasing the implicit affective associations may lead to increased attention towards smoking stimuli because of their implicit affective associations to a similar extent as negative emotional stimuli. This would bring smoking attentional bias and negative emotion attentional bias into line among smokers attempting to quit and never smokers. Furthermore, in Studies 1 and 2 there was a non-significant relationship between explicit affective ratings of stimuli and emotion attentional bias, indicating that implicit responses and explicit ratings are independent of each other.

In summary, the current research has shown that attentional shifts to smoking stimuli occur irrespective of their explicit affective ratings. These results imply that smoking attentional bias may manifest as a result of smoking-relatedness rather than emotion relatedness. There was, however, consistent evidence that smokers attempting to quit and never-smokers view smoking stimuli as negative which is comparable with previous research. Furthermore, smoking attentional bias and negative emotion attentional bias were significantly correlated among smokers attempting to quit and never smokers. It is possible that among these groups the implicit affective association was heightened by explicit instructions leading to smoking stimuli being attended to because of their negative implicit affective associations. This implies that implicit affective associations may be more relevant for smoking attentional bias than explicit emotional ratings. It is, however, unclear from these results to what extent the affective relationship of stimuli plays a role in the development of attentional bias in the early stages of smoking behaviour given that the smokers and smokers attempting to quit sampled had been smoking for some time.

8.2.4 The role of automaticity

In line with expectations, the present research has provided evidence that attentional bias for smoking stimuli is automatic and can occur even when explicit instructions are given to attend to alternative stimuli. Indeed, in Study 2 findings indicated that exogenous shifts in attention toward smoking stimuli were present in the early stages of attentional processing. Given that these shifts occurred under specific instruction to attend away from smoking stimuli suggests that they are automatic. However, these exogenous shifts in attention to smoking and negative stimuli were not present at later stages of attentional processing where attention was directed to stimuli in line with instructions given.

Previous research has shown evidence for shifts in attention to smoking-related stimuli in the early stages of attentional processing (see chapter 2, section 2.3.3). However, in the visual probe task, attention to stimuli presented for periods of 500ms or less has rarely been detected (e.g. Bradley et al., 2003b; Ehrman et al., 2002; Field et al., 2009). Meanwhile in eye-tracking studies, there is evidence that individuals are more likely to maintain attention on smoking stimuli rather then make initial shifts in attention towards those stimuli (see Chapter 2, section 2.3.3). The findings of Study 2 build on this previous research by showing not only that shifts in attention to smoking stimuli occur during early stages of attentional processing but that they can occur even under explicit instructions to direct attention elsewhere. Furthermore, the finding that attentional shifts in later stages of stimulus presentation can be guided by explicit instruction indicates that the maintenance of attention on smoking stimuli is possibly under conscious control.

Interestingly, the exogenous shifts in attention to smoking stimuli shown in Study 2 were also present in the never-smoking group. This has implications for how shifts in smoking attentional bias are understood across all groups. It suggests that either the low-level properties of the stimuli led to early shifts in attention or that the instructions primed responses to stimuli. Given that a number of low-level features of the stimuli were controlled for in this study, this suggests that the latter suggestion is more applicable to these findings. The possibility that explicit instructions led to increased attentional shifts to stimuli indicates that under conditions were smoking is made salient there is increase probability of exogenous shifts in attention to these stimuli which may subsequently influence future smoking behaviour. This suggestion is in line with the model proposed by Moss and Albery (2009) who suggest that behavioural responses to stimuli are more likely to occur under situations which prime these responses. For instance, environments or situations containing alcohol cues prime representations which may lead to alcohol-related behaviours. In relation to the present research, there is an indication that instructions may have primed representations relating to smoking and negative emotions subsequently leading to behavioural responses towards smoking and negative stimuli (i.e. visual orientation to these stimuli). This idea of salience and priming is discussed in further detail later in this discussion (see section 8.2.7).

The present research also provided evidence of both fast effects (effects occurring during smoking stimulus presentation) and slow effects (effects on neutral trials following the smoking stimulus) on the Stroop task among smokers (Study 3). In Study 6, slow effects of attention were also apparent in smokers attempting to quit following training. It has been argued that fast effects are indicative of the relatively automatic attentional grabbing properties of stimuli, and slow effects are indicative of the maintenance of attention on smoking stimuli (see Cane et al., 2009). These results therefore provide further evidence of both the relatively immediate attention-grabbing effects of smoking stimuli and maintenance of attention on smoking stimuli among smokers. These findings are somewhat consistent with previous research, which has shown evidence of the fast effect in smokers and smokers attempting to quit (Cane et al., 2009). Previous findings regarding the slow effect are more mixed: Waters found evidence of the slow effect among smokers and Cane et al. (2009) found evidence of the slow effect only among smokers attempting to quit. The findings of the present research provide further evidence that the slow effect can be exhibited among smokers and smokers attempting to quit. Furthermore, Cane et al. (2009) suggested that the slow effect is possibly related to emotion and anxiety, which may accompany a quit attempt. However, the present findings contradict this argument as the slow effect was shown to be similar among smokers and smokers attempting to quit. Also, there was no evidence of a correlation between the presence of slow effects and the affective rating of stimuli.

Together the evidence of fast effects and the exogenous shifts in attention are consistent with the theoretical assumptions of Tiffany (1990; see Chapter 1, section 1.2) who suggest that drug related stimuli are processed and attended to automatically. The findings also suggest that conscious control dictates later stages of attentional shifts to stimuli suggesting a continuum from automatic to conscious shifts in attention to smoking stimuli, particularly in smokers. When exposed to smoking stimuli, smokers may initially automatically attend to these stimuli. However, following these automatic shifts, attention to these stimuli comes under conscious control allowing them to divert their attention elsewhere. In relation to the model proposed by Moss and Albery (2009) this suggests that propositional reasoning (the control over automatic representations determining behaviour) is less apparent during early stages of stimulus presentation. However, during latter stages of stimulus presentation propositional reasoning can effectively control automatic responses to stimuli. Therefore, this suggests a time-course over which propositional reasoning can become effective in controlling automatic processes and determining behavioural responses.

In summary, these findings indicate that attentional shifts to smoking cues can be both automatic and under conscious control. Furthermore, they suggest that in conditions where individuals are made explicitly aware of smoking stimuli this may lead to exogenous shifts in attention towards these stimuli. Given that these exogenous responses occurred even when participants were under explicit instructions to attend elsewhere, this indicates that they may be relatively robust even under attempts to manipulate them. This suggestion is examined further in section 8.2.6 of this discussion.

8.2.5 The role of cognitive control

The present research assessed the role of cognitive control in two specific ways: i) by examining whether manipulating cognitive control affected smoking attentional bias, and ii) by examining the effect that smoking attentional bias had on cognitive control. There was little evidence to support either of these predictions; although there was partial support for the hypothesis that manipulation of cognitive control can affect subsequent attentional bias. We attempted to manipulate cognitive control by increasing the number of incongruent trials in the Stroop task, which has previously shown to increase focus on the colour-naming task and reduce interference from the words presented. In Study 6, during training it was shown that this manipulation was only effective in smokers attempting to quit. Following training this manipulation led to increases in the slow effect of smoking attentional bias in smokers attempting to quit. That is, it *increased* smoking attentional bias. This is contrary to our predictions, as it was expected that the manipulation would lead to a *decrease* in attentional bias. Furthermore, both smokers and never-smokers also showed general, but not significant, trends in this direction. These findings indicate that, rather than increase cognitive control, the manipulation used decreased subsequent cognitive control when smoking stimuli were presented.

One possible explanation for this surprising finding is that anxiety was increased in the condition with an increased number of incongruent trials. Incongruent trials are more effortful and possibly anxiety-inducing, therefore it is likely that this condition led to heightened anxiety among participants. This was confirmed by responses on the state anxiety measures, which were administered immediately following the experimental trials: participants in the condition with increased number of incongruent trials reported higher levels of anxiety than other conditions. This increased anxiety in this condition may have led to the subsequent increase in attentional bias to smoking stimuli as discussed previously (see Chapter 1, section 1.1.2). However, this is a tentative explanation at present and further research is required to examine the relationship between cognitive control, anxiety and smoking attentional bias.

As stated above, there was little evidence that smoking attentional bias affected cognitive control. Study 7 showed that the presence of smoking stimuli did not affect the cognitive control manipulation. This finding did not support the idea that interleaving smoking words with incongruent words would reset the conflict monitoring system. However, smoking stimuli appeared to lead to a general cognitive slowdown. It is possible that this general cognitive slowdown may have been a result of slow effects within the smoking block. Stimuli in Study 7 were presented randomly and therefore slow effects of smoking stimuli may have led to increased response times on subsequent trials whether they be incongruent, congruent or another smoking trial.

The finding in Study 7 that there was decreased interference on incongruent trials when the number of incongruent trials increased is consistent with previous research of Tzelgov et al. (1992) and in line with the theoretical assumptions of Botvinick et al. (2001). However, given that there was no change in response times to other stimuli (e.g. smoking, neutral and congruent stimuli) indicates that the cognitive control manipulation is only effective in reducing response times in trials where conflict is particularly salient (i.e. during incongruent trials). Indeed, the smoking stimuli and neutral stimuli are not necessarily in conflict with colour-naming responses to the same extent as incongruent colour words. Therefore, it is possible that compensatory effects may not be evident in those trials. Thus, it appears that the conflict monitoring system and cognitive control mechanisms may only exert their effects where conflict is greatest.

The finding that smoking stimuli and negative stimuli have little effect on the cognitive control manipulation is inconsistent with the theoretical assumptions of Wyble et al. (2008). They suggest that stimuli related to negative emotions would counteract the compensatory effects of the conflict monitoring system. Both smokers attempting to quit and never-smokers rated smoking stimuli as negative but this did not lead to the re-setting of cognitive control on incongruent trials. However, it was noted that there was no significant difference in response times between smoking, negative, and neutral stimuli trials. This indicates that the inclusion of colour word trials (congruent and incongruent) overrode the normal attentional bias responses that have been shown across the other studies shown in this thesis.

Therefore, there is little evidence that manipulating cognitive control affects smoking attentional bias or that smoking attentional bias has an effect on cognitive control. This indicates that responses to smoking stimuli are relatively independent of changes in cognitive control.

8.2.6 Manipulation of attentional bias

The present research tested a number of different means of manipulating attentional bias. Study 2 provided evidence that attentional bias to smoking stimuli in latter stages of attentional processing can be influenced by explicit instruction to attend to simultaneously presented neutral stimuli. In contrast, attentional bias shown in the early stages of attentional processing was relatively unaffected by the explicit instructions, indicating that early shifts in attention to smoking stimuli are relatively robust.

In addition, Study 5 showed that attentional bias in smokers can be manipulated through the attentional retraining technique. Specifically, Study 5 showed that when attention is trained away from smoking stimuli, attentional bias decreases. Also, when attention was trained towards smoking stimuli attentional bias also decreased. Whilst previous research has identified that smoking attentional bias can be manipulated through attentional retraining (see Attwood et al., 2008; Field et al., 2009; Chapter 2, section 2.3.2), previous research has not been able to identify conditions under which the manipulation of attention generalises to other cognitive paradigms and to novel stimuli (see Chapter 2, section 2.3.3 and Chapter 5). The present research has provided further evidence that smoking attentional bias can be manipulated and that these effects do generalise to a different cognitive paradigm and to novel stimuli.

It was also shown that attentional bias might be manipulated by external events whether they be the effects of the smoking ban or the reduction in salience of smoking in the smokers environments (See Study 3).

Whilst there is some indication that it is possible to manipulate attention by the methods suggested above these manipulations had little effect on nicotine dependence and craving, suggesting that they may have limited clinical application in their current formats. Cox et al. (2006) have suggested that attentional bias manipulations may be improved by linking them with motivational training to improve their effectiveness.

Overall, the research has identified a number of means of successfully manipulating attentional bias. However, the research suggests that effects on subsequent smoking behaviours are limited. This may be due to the short-term manipulations used in the studies presented. Future research could further examine effects on smoking behaviour through the implementation of a longer term attentional retraining intervention, regularly implementing training and examining effects on subsequent behaviours. The manipulations shown in the present study may have some use in their current form. Indeed, the development of methods of manipulating attentional bias has methodological importance as they can be used to manipulate attentional bias experimentally in order to study the causal relationship between attentional bias and potential correlates. This is particularly the case for attentional retraining.

8.2.7 The role of saliency in smoking attentional bias

The current research examined the relationship between affect, automaticity, cognitive control, smoking behaviour and craving with smoking attentional bias. Another factor which may be related to smoking attentional bias, and which could explain the present findings, is the saliency of smoking. Smoking is more salient among smokers since they are more likely to interact with smoking-related objects on a day-to-day basis. In contrast, non-smokers and smokers attempting to quit would be less likely to come across, or interact with, smoking stimuli and would therefore be less likely to harbour smoking-related thoughts at the time of testing. It is possible that these differences led to attentional bias in smokers but not in smokers attempting to quit and never-smokers, as found in the current research. Previous research has found that individuals who are not addicted to alcohol, but who are familiar with it, and work in an alcohol addiction treatment centre, exhibit attentional bias for alcohol stimuli, similar to those of problem drinkers, presumably because alcohol is more salient in their everyday lives (Ryan, 2002). Likewise, smokers attempting to quit and never smokers are unlikely to interact with smoking-related stimuli on a day-to-day basis, however it is possible that never smokers and smokers attempting to quit could exhibit smoking attentional bias if smoking is made more salient to them. These suggestions are in line with theoretical propositions that behavioural responses to stimuli are more likely to occur under situations which prime these responses (Moss and Albery, 2009). Indeed, it could be predicted that when given instructions relating to the presence of smoking stimuli, this could increase the salience of smoking, leading to smoking attentional bias. This was evident in the current research: when smokers attempting to quit and never smokers were given explicit instructions relating to the presence of smoking stimuli (e.g. the instructions given in Study 2) then smoking attentional bias became evident across all groups. This theory could also explain the rather mixed findings regarding the relationships between smoking attentional bias and smoking behaviour. Some methodologies could lead to heightened salience of smoking. For instance, measures of nicotine dependence identify how often someone smokes, and how often they are in situations where they may smoke, therefore increased nicotine dependence would more than likely, to some extent, be related to increased smoking saliency. Similarly, craving and urges may be related to how salient smoking is in that increased saliency may lead to increases in craving. Given its implications for the findings of previous research it is important that this proposition is examined in future research.

8.3 Limitations and implications of the present research

Limitations: A number of limitations of the current research have been identified. Firstly, control and emotional stimulus conditions were not used in Study 3. Regarding the exclusion of the control condition, this meant that the attenuation of the attentional bias effects shown in the smoking group studied could not be solely attributed to the smoking ban. Meanwhile, removing the emotional stimulus conditions meant that comparisons relating to affect could only be based on the explicit affective ratings of the smoking stimuli.

Secondly, Studies 1 and 2 relied mostly on eye-movement measures to support the claim that stimuli engaged attention automatically. Whilst it could be argued that these effects are indicative of automatic shifts in attention to smoking stimuli further research is needed using different methodologies to corroborate such effects.

Thirdly, with regards to Studies 1 and 2, the choice of eye movement measures, which were based on previous research (Nummenmaa et al., 2006), meant that it was difficult to dissociate between early, mid and late attentional processes. The late attentional process described was based on the total time spent within one image. As such this measure included time spent on stimuli during early, and mid allocation of attention also. Future research should aim to identify a more reliable and distinct measure of late attentional processing so that differences in temporal shifts in attention can be more reliably defined and identified.

Implications: The present research has shown further evidence that smoking attentional bias is comparatively different between smokers and smokers attempting to quit. In particular, in smokers there was robust evidence of smoking attentional bias across measures and in smokers attempting to quit smoking attentional bias was only evident under particular conditions: where they were made explicitly aware of the presence of smoking stimuli, where exposure to smoking stimuli was relatively long and in conditions which might yield greater anxiety. Understanding the conditions under which smoking attentional bias occurs across both of these groups is important. For smokers, it is important as it helps gain understanding of the role of smoking attentional bias in the maintenance of smoking behaviour. For smokers attempting to quit, it is important as it can help infer about the role of attentional bias roles in relapse and the conditions when attentional bias, which might lead to subsequent smoking behaviour, are more likely to occur.

Whilst the present research has examined components of attentional bias across these two groups, one other important facet that needs to be understood and, which has so far been neglected by previous research, is the role of smoking attentional bias in the early stages of smoking. Understanding the role of attentional bias in relation to early stages of smoking can help identify how attentional bias develops, and the influences it has on development of habitual smoking behaviour. As mentioned previously (see Chapter 1, section 1.2), it has been suggested that attentional bias in the early stages of a smoking career may be more dependent on smoking behaviours and emotional effects whereas latter stages of smoking behaviour are possibly more reliant on habitual behaviours. The findings of the present research provides evidence for this, showing that attentional bias is unrelated to smoking behaviour, craving and affect in smokers who have been smoking for over a year. However, this transient change between smokers at the start of their smoking career and smokers who have been smoking for some time is i) yet to be reflected in much of the research examining smoking attentional bias, and ii) not accounted for in theoretical models of attentional bias. Therefore, future research should seek to directly compare attentional bias effects and correlates in the early stages of smoking with effects and correlates in latter stages of a smoking career and during quit attempts.

This approach would help to provide further understanding of the differences in attentional bias that occur between the development of smoking addiction, the maintenance of smoking behaviour and the abstinence from smoking during a quit attempt. Such an approach is important as theoretically it would help gain understanding of the nature and underlying mechanisms of attentional bias in relation to different stages of smoking behaviour and practically it would help identify what treatment interventions in relation to attentional bias would be most effective for each of these stages.

The present research has also highlighted that smoking attentional bias may not be related to smoking behaviour and craving as has been suggested in previous theoretical models (e.g. Field & Cox, 2008; Franken, 2003; Robinson & Berridge, 1993). There are number of possible reasons for this. Firstly, these relationships may only be apparent in the early development of smoking attentional bias but not in later stages as was measured in the present research. Approaches which examine differences that occur at different stages of a smoking career, as mentioned in the previous paragraph, would help clarify whether this were the case. Secondly, other factors such as saliency of smoking may moderate the relationship between explicit reports of smoking behaviour and attentional bias. To examine this proposition research should aim to identify mutual correlates of both smoking behaviour and smoking attentional bias. Thirdly, it is possible that correlates of smoking attentional bias differ from those of correlates of attentional bias in relation to other addictions. This is particularly true of the correlations between attentional bias and craving which have been shown to be less apparent in relation to smoking and alcohol compared to other drug-related addictions (Field et al., 2009). This suggests that contemporary models of attentional bias in addictions cannot sufficiently explain the processes relating to attentional bias which are specific to smoking. Therefore, future research should aim to provide a model which is specific to attentional bias processes in relation to smoking. Based on the present research this model should take into account the changes in attentional bias and associated correlates that occur during different stages of a smoking career.

In relation to affect, no relationship was shown between explicit affective ratings of smoking stimuli and attentional bias. However, even though this relationship was not examined directly in this thesis there was some indication that attentional bias may have been associated with implicit affective associations and anxiety (see Chapter 7, Study 7). Currently, there is limited research in the relationship between implicit affective associations and the presence of smoking attentional bias. Therefore, future research should examine this proposition in particular relation to smokers attempting to quit to whom the indication of influences of affect and anxiety on attentional bias were greatest.

The present research has also indicated that making smoking more salient may increase the presence of attentional bias (See Chapter 3, Study 2). This suggestion has important implications, especially given that quit-smoking campaigns often increase the salience of smoking. This may have the undesired effect of potentiating attentional bias which might lead to smoking behaviour. Future research should therefore examine the impact that making smoking salient has on smoking attentional bias.

In relation to the manipulation of attentional bias, the findings indicated that manipulation of cognitive control had little effect on attentional bias and that explicit instructions had little effect on the exogenous shifts in attention to smoking stimuli in the early stages of attentional processing. These findings indicate that smoking attentional bias effects are relatively robust even when there is controlled focus on a task (i.e. increased focus on colour-naming or responding in line with explicit instructions). This suggests that even where there may be some conscious effort to ignore smoking stimuli or a manipulation to focus attention on an alternative task automatic responses to stimuli may still be present.

However, not all the attempted manipulations of attentional bias were unsuccessful. Indeed, one of the most important findings of this thesis is that attentional bias can be manipulated by the attentional retraining technique and that effects of attentional retraining can generalise to novel stimuli and to other attentional bias measures. This latter finding is novel in relation to previous attentional retraining literature and indicates that word stimuli may generalise better that image stimuli used in previous studies.

In its current form, however, attentional retraining has been shown to have no effect on craving and subsequent smoking behaviour (i.e. nicotine dependence) and therefore maybe limited in its clinical utility at present. One possible reason for this is that a single attentional retraining session is not sufficient enough to change smoking attentional bias which may have stemmed from the repeated administration of nicotine over a number of years. Future research should examine the impact of extended training through a longitudinal design to identify if multiple training sessions have a greater impact on the subsequent smoking behaviour and the longevity of attentional bias manipulation effects.

The attentional retraining technique may also prove beneficial as a tool for identifying causal relationships between attentional bias and correlates of attentional bias. If a causal relationship is hypothesised then this could be tested by manipulating attentional bias and examining subsequent changes in the correlate. In this way attentional retraining may not have a clinical utility but may be an important experimental tool.

8.4 General conclusions

The aim of the present research was to develop our understanding of smoking attentional bias by examining three factors in relation to smoking attentional bias; affect, automaticity and cognitive control. Overall, the present research has shown i) that smoking attentional bias is a robust phenomenon across smokers and can be present in smokers attempting to quit under certain conditions: where they were made explicitly aware of the presence of smoking stimuli, where exposure to smoking stimuli was relatively long and in conditions which might yield greater anxiety, ii) that smoking attentional bias is not related to the affective association of stimuli, particularly in latter stages of a smoking career, but that attentional bias during a quit attempt may be influenced by implicit affective associations and anxiety. Furthermore, it has an inconsistent relationship with smoking behaviour and craving which is not fully supported by current theories of attentional bias. iii) that automaticity is evident in smoking attentional bias but that this is relatively unchanged by conscious control and the manipulation of cognitive control. iv) that smoking attentional bias can be manipulated through attentional retraining and whilst this may have limited clinical utility at present it may be useful in identifying the causal relationships of correlates of attentional bias.

In relation to future research, these findings indicate the necessity to examine the implicit affective associations and salience of smoking stimuli in relation to smoking attentional bias. More importantly, it has identified the need to examine potential differences in the presence and correlates of attentional bias across different stages of the smoking career, and the need to develop a model of attentional bias specific to smoking incorporating these different stages of the smoking career. In relation to smoking cessation treatments, the findings indicate that merely quitting reduces the occurrence of attentional bias. Furthermore, they suggest that interventions which decrease the salience of smoking, decrease the exposure to smoking stimuli, and decrease situations which may lead to anxiety will be more effective in reducing the chances of smoking attentional bias occurring during a quit attempt.

Whilst our understanding of attentional bias in relation to smoking has developed relatively rapidly over the past decade there is still some way to go before the mechanisms and impact of smoking attentional bias on smoking behaviour can be fully understood. However, the findings of the present research go some way in aiding our understanding of the mechanisms and effects of smoking attentional bias and potentiating future research in this area.

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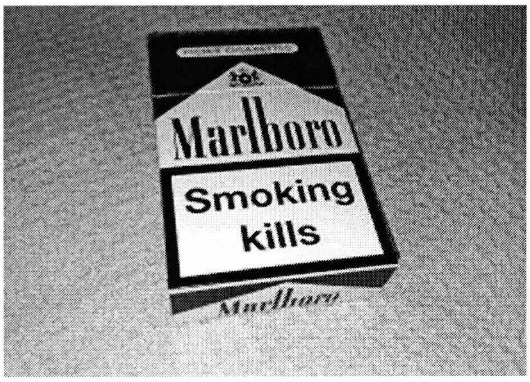
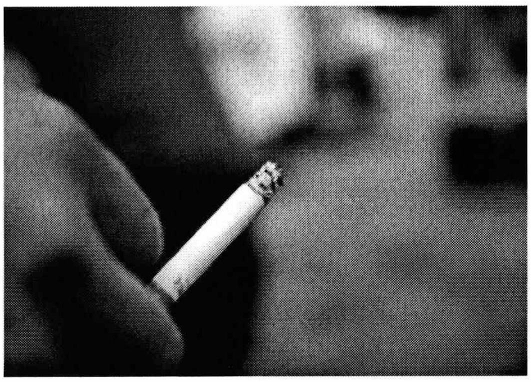
APPENDIX A

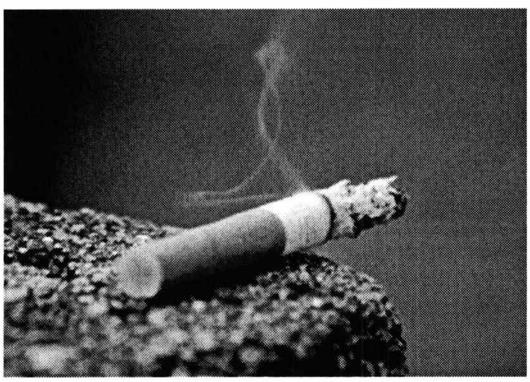
STIMULI

APPENDIX A1: Smoking image stimuli used in Studies 1 & 2


Marlboro
Smoking
kills




NO SMOKING



APPENDIX A2: Stimuli lists for the smoking ban Studies 3 & 4

Five smoking words and associated matched neutral words were selected at random as keywords for positions 1 in the Stroop task. The remaining smoking stimuli and neutral stimuli were used in the visual probe task

Smoking stimuli	Matched neutral stimuli
cigarette	permanent
smoke	china
puff	chef
nicotine	boutique
ash	net
fag	imp
butt	bath
marlboro	bungalow
benson	arrows
rollie	bamboo
zippo	apron
habit	novel
rizla	frock
stub	bran
skins	brush
crave	clogs
weed	bulb
cigar	lemon
smoking	bottles
ashtray	sausage
drag	cord
lighter	package
tobacco	curtain
embassy	athlete
smokers	buffalo

APPENDIX A2 continued.

The matched neutral words to be used at positions 2-4 in the smoking sequences and neutral sequences were chosen from the lists below.

Matched neutral for smoking sequences	Matched neutral for neutral sequences
officials	september
store	april
hose	crow
oncoming	omlette
aim	sum
sag	zip
bulb	chip
sailboat	knitting
sensor	pastry
toggle	dancer
piano	boxer
track	cross
flume	pearl
swig	fern
flint	jeans
drape	drill
cord	drum
cakes	canal
farming	overall
booklet	forearm
atom	lion
actress	concert
blanket	journal
weekend	algeria
lettuce	cologne
household	partment
share	goods
dove	mane
molasses	firework
egg	cat
elk	fir
dole	bolt
workbook	motorway
bloats	rocket
splice	dragon
lipid	badge
route	roman
house	puppy

Matched neutral for smoking sequences	Matched neutral for neutral sequences
chew	frog
pairs	thigh
elate	chick
bike	knot
tooth	spoon
display	pulling
collect	flannel
beam	dock
trading	fiction
circles	priests
offices	berries
bubbles	diploma
elsewhere	furniture
plain	notes
duel	loft
trainees	trophies
gap	box
bow	hem
rags	cart
marinate	disguise
toucan	runway
dilate	jewels
moped	lorry
loose	clock
weans	quote
kilt	sikh
spine	coats
carve	earth
robe	slab
creek	rally
wedding	lessons
brushes	reflect
stem	horn
unaware	penalty
painter	horizon
opening	pyjamas
carrots	gateway

APPENDIX A3: Visual Probe word pairs used in Study 5

Visual Probe Word Pairs
addiction, vibration
ash, aim
benson, sensor
butt, bulb
buzz, brim
cigar, cakes
cigarette, officials
cough, cable
coughing, elephant
crave, drape
fag, sag
filter, seller
habit, track
inhalation, practician
inhale, cobble
marlboro, sailboat
match, sweet
nicotine, oncoming
pack, trap
patch, scope
pipe, rose
puff, hose
quit, skip
rizla, flume
rollie, toggle
silkcut, sidecar
skins, badge
smoke, store
stains, onions
stink, stair
stub, swig
tar, eel
weed, cart
zippo, piano

APPENDIX A3 continued.

Key words (smoking and neutral shown at position 1) and matched neutral words (shown at positions 2-4) used in the pre-training and post-training Stroop tasks in studies 5 & 6

KEYWORDS (position 1)
smoking
ashtray
drag
lighter
tobacco
embassy
smokers
lung
passive
matches
welcome
sausage
cord
package
curtain
promise
furnace
echo
posture
content

Matched neutral words in sets of six. During the experiment 3 matched neutral words were assigned to one of the keywords and the remaining key words were assigned to the other keyword. (Continues on following 2 pages)

Matched Neutral Words (positions 2-4)	Keywords matched with
farming	smoking and embassy
display	
wedding	
weekend	
offices	
opening	
booklet	ashtray and smokers
collect	
brushes	
lettuce	
bubbles	
carrots	

Matched Neutral Words (positions 2-4)	**Keywords matched with**
atom	drag and lung
tins	
bald	
tidy	
beam	
stem	
actress	lighter and passive
amateur	
unaware	
charity	
posture	
trading	
blanket	tobacco and matches
circles	
ringing	
pockets	
painter	
engines	
overall	welcome and promise
nowhere	
pulling	
lessons	
bottles	
cutting	
marches	sausage and furnace
forearm"	
defined"	
textile"	
flannel"	
reflect	
lion	cord and echo
dock	
lime	
fans	
horn	
flag	
penalty	package and posture
joining	
fiction	
nursing	
lifting	
concert	
heading	curtain and content
gravity	
horizon	

Matched Neutral Words (positions 2-4)	Keywords matched with
journal	
masters	
priests	

APPENDIX A4: Word stimuli used in Study 7

Smoking	Negative Emotion	Animal
tobacco	cancer	panda
ashtray	maim	beaver
cigarette	betray	camel
smoke	grief	eagle
puff	abuse	goose
smoking	gloom	cattle
inhalation	killer	snake
drag	morgue	turtle
inhale	misery	badger
nicotine	cruel	donkey
ash	hatred	falcon
fag	afraid	magpie
lighter	upset	oyster
butt	prison	parrot
filter	stress	whale
lung	trauma	horse
heart	demon	zebra
cough	detest	crane
marlboro	lonely	spider
benson	victim	otter
silkcut	devil	monkey
rollie	loser	pigeon
zippo	crash	hyena
buzz	anger	cat
relax	cry	bird
smell	agony	rabbit
passive	guilty	shark
tar	annoy	leopard
pack	horror	hound
cool	crime	turkey
match	bored	sheep
money	panic	tiger
matches	hate	lion
habit	suffer	chicken
quit	anxiety	penguin
stink	defeat	fly
addiction	dreaded	seal
rizla	fail	duck
stub	disgust	fish
pipe	tragedy	cow
skins	fearful	bear
crave	outrage	fish
filthy	agony	squirrel
stains	die	stork
cigar	scream	pig
thin	kill	wolf
breathe	hurt	huski
cancer	pain	dog

APPENDIX B

Questionnaire and survey measures

APPENDIX B1: Adapted Fagerstrom Nicotine Dependence Questionnaire

Tick or circle the answer that is most appropriate to you.

Do you currently smoke Yes / No
If you gave up recently, or still smoke, when did you last have a cigarette?______________
How long have you smoked / did you smoke for?____________________________

If you have **never** smoked you do not need to answer anymore questions on this questionnaire.

______1. How soon after you awake do you/ did you smoke your first cigarette?

0. After 30 minutes
1. Within 30 minutes

______2. Do you / did you find it difficult to refrain from smoking in places where it is forbidden, such as the library, theatre, or doctors' office?

0. No
1. Yes

______3. Which of all the cigarettes you smoke in a day is / was the most satisfying?

0. Any other than the first one in the morning
1. The first one in the morning

______4. How many cigarettes a day do you / did you smoke?

0. 1-15
1. 16-25
2. More than 26

______5. Do you / did you smoke more during the morning than during the rest of the day?

0. No
1. Yes

______6. Do you smoke when you are so ill that you are in bed most of the day?

0. No
1. Yes

______7. Does the / did the brand you smoke have a low, medium, or high nicotine content?

0. Low
1. Medium
2. High

______8. How often do you / did you inhale the smoke from your cigarette?

0. Never
1. Sometimes
2. Always

______9. If you have recently given up which of the following aids have you used most to help you give up?

0. Nicotine patches, strength ______(please state)
1. Therapy / counselling
2. Support group
3. None

______10. In your estimation do you crave cigarettes…(please circle)

Never			Sometimes			Always
0	1	2	3	4	5	6

Adapted from: Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., Fagerstrom, K. O. (1991). The Fagerstrom Test for Nicotine Dependence: A revision of the Fagerstrom Tolerance Questionnaire. *British Journal of Addictions, 86,* 1119-1127.

If you require any further information on giving up smoking or smoking in general please contact the NHS Smoking Helpline on 0800 169 0 169

APPENDIX B2: Example of Stimulus Rating Questionnaire (word-relatedness / image relatedness - NB. for image stimuli used in Studies 1 & 2 images replaced the words in the right hand column

Word Rating Questionnaire

Below is a list of words for you to rate. For each word write down how much you think the word is:

a) **Related to smoking**

Not related to smoking Highly related to smoking

0 1 2 3 4 5

b) **Related to emotion**

Highly negative emotion No emotion Highly positive emotion

-4 -3 -2 -1 0 1 2 3 4

	a) Smoking related	b) Emotion related
Tobacco	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Ashtray	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Danger	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Maim	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Disgust	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Cigarette	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Chicken	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Smoke	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Puff	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Grief	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Dog	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Abuse	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Gloom	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Turkey	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**
Drag	**0 1 2 3 4 5**	**-4 -3 -2 -1 0 1 2 3 4**

APPENDIX B3: Study 2 - Smoking survey items

Time 1

Section 1:

Age:
Sex:

1. Which country do you currently live in?

2. Which of the following statements BEST describes you? *(respondents were given definitions of each option)*

Smoker
Smoker attempting to quit
Never-smoker

Section 2:

1. When did you last have a cigarette?(give answer to closest hour, day, or year) eg. 1 hour ago... 2 years ago etc.

2. How long have you smoked for / did you smoke for? (to nearest day, or year - eg. 3 years, or 4 days etc.)

Fagerstrom and craving questions (see Appendix B1 for full layout)

3. How soon after you have woken up do you / did you smoke you first cigarette?
4. Do you / did you find it difficult to refrain from smoking in places where it is forbidden, such as the library, theatre, or doctors' office?
5. Which of all the cigarettes you smoke in a day is / was the most satisfying?
6. How many cigarettes do you / did you smoke in a normal day?
7. Do you / did you smoke more during the morning than during the rest of the day?
8. Do you / Did you smoke when you are so ill that you are in bed most of the day?
9. Does the / did the brand you smoke have a low, medium, or high nicotine content?
10. How often do you / did you inhale the smoke from your cigarette?
11. If you have recently given up which of the following aids have you used most to help you give up?

NRT
Therapy
Support Group
None

12. In your estimation to what extent do you crave cigarettes now?

13. Please indicate how many unsuccessful quit attempts you have had whilst smoking? (Please include only quit attempts where you have made a concerted effort to quit in your answer)

14. Please indicate the number of times have you attempted to quit and not smoked for over 6 months as a result of the quit attempt?

15. Please indicate where the MOST LIKELY place was for you to start smoking during a quit attempt.

<u>Section 3:</u>

1. Are you intending to quit or have you quit in light of the England smoking ban?

2. If you were to attempt to quit, or if you have quit, do you think that the England smoking ban will help?

<u>Section 4:</u>

1. How many members of your household currenly smoke?

2. How many of your friends currently smoke?

3. Do you work in a place where smoking was common before the smoking ban (e.g. a pub, a nightclub, etc.)?

4. In the past two weeks how many times have you been to places were smoking was common (e.g. pubs, nighclubs, restaurants)?

5. How many places where you normally go out socially have areas where smoking may still be permitted after the smoking ban (e.g. a garden, patio area)

6. In your estimation how many of the people you have indicated in questions 20 and 21 are considering attempting to quit in light of the England smoking ban?

7. In your estimation how many of the people you have indicated in the question above are intending to get help quitting by using smoking cessation services (e.g. smoking quit groups)?

8.How many of the following items have you come across in the past two weeks:

cigarette lighters
cigarettes
cigars
cigarette butts
cigarette packets

no smoking signs
signs or leaflets about the smoking ban
adverts about the smoking ban
people smoking
adverts for services to help you quit (quitlines, etc)
adverts for nicotine patches
ashtrays

<u>Additional items used at 1-month follow-up and 2-month follow-up</u>

1. Did you give up smoking before or after you completed the first part of this survey at the beginning of July?

2. Did you give up smoking because of the England smoking ban?
Yes / No

3. Do you think the England smoking ban has helped you give up smoking?

4. If you have attempted to quit since the last time you completed the survey do you think that the England smoking ban has helped?

5. In the past two weeks how many times have you been to places were smoking was common before the smoking ban (e.g. pubs, nighclubs, restaurants)?

6. How many of the places where you normally go out to socially have areas where smoking is still permitted following the smoking ban (e.g. a garden, patio area)

7. In your estimation how many of your friends or family have quit smoking since you took the last part of this survey?

8. In your estimation how many of the people you have indicated in the question above have got help quitting by using smoking cessation services (e.g. smoking quit groups)?