Attentional biases in addictive behaviours: An investigation employing the flicker induced change blindness paradigm and eye tracking.

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Author's Declaration

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

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Previously published work

Findings reported in Chapter 2 have previously been presented at the European Conference on Eye Movements, Marseille, France (2011) and subsequently published:

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[1] All work previous to this PhD has been published and presented under the name Jillian Hobson

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Abstract

Past research and theory has suggested that biased attention to substance related stimuli may be an important factor in the development, maintenance and relapse of addictive behaviours and therefore may be a fruitful target for interventions. The current understanding of the extent and roles of substance related attentional biases in addictive behaviours however remains limited primarily as a result of methodological limitations. This thesis examines the extent and roles of substance related attentional bias in social use and dependent use by employing the flicker change blindness paradigm whilst utilising eye tracking and further examines the validity of this methodological approach.

Experiment 1a explored alcohol related attentional biases in social users of alcohol. Results demonstrated that a bias in the initial orienting of attention was associated with levels of subjective craving. Additionally analysis indicated that such biases were only evident over multiple trials and when real world scene stimuli were viewed. Experiment 1b examined smoking related attentional biases in dependent smokers and non-smokers and showed that dependent smokers compared to non-smokers demonstrated a smoking related attentional bias in both grid and real world scene stimuli. However when dependent smokers were analysed by themselves, only a relationship between maintained attention on smoking related stimuli and levels of cigarette use was implicated. Again this later finding was only demonstrated over multiple trials when viewing real world scenes. Whilst experiments 1a and 1b provide evidence demonstrating that sub-components of substance related attentional biases may play differing roles in substance use, they also highlighted the impact of the types of stimuli and number of trials employed when utilising such methodology.

Experiments 2a and 2b based on Gilchrist and Harvey (2006) went on to explore the possibility that when using the flicker change blindness paradigm the structure of the stimuli may encourage strategic scanning and so limit the validity of the paradigm as a measure of attentional bias. The results of experiment 2a and 2b demonstrated that when employing the flicker change blindness paradigm, participants display a strategic component in their scan paths from the very first trial, irrespective of the structure of the stimuli. Furthermore, over multiple trials the extent of strategic scanning of both social users of alcohol (experiment 2a) and smokers (experiment 2b) was strongest when viewing the most spatially structured stimuli. However the results were limited in their ability to fully evaluate the relationship between the degree of structure of the stimuli, the extent of strategic scanning and the attentional biases evidenced, possibly as a result of the stimuli composition.

Experiments 3a and 3b therefore reanalysed experiments 1a and 1b in order to examine the extent of strategic scanning between perfectly structured grids and complex real world scenes. The results clearly demonstrated that even when real world scene stimuli are utilised when employing the flicker ICB participants still employ strategic scanning, however both experiments demonstrated that it was to a lesser degree than when viewing perfectly structured stimuli. The results of experiments 2a-3b and with the consideration of the pattern of attentional bias results in experiments 1a and 1b outline the effects of the stimuli type on the validity of the flicker ICB task to measure attentional biases and as a result have important implications for future research.

Chapter 1

1.1 **The problem of addiction and misuse of legal substances**

Legal substance misuse and addiction are an on-going major concern, particularly in relation to the associated economic, health and social problems. For example, in Europe, both tobacco and alcohol are in the top three leading risk factors for disease and mortality (World Health Organisation, 2009). With particular reference to Scotland, recent figures estimate that treating smoking related diseases costs the National Health Service of Scotland £409m per year (The Scottish Government, 2011). In addition, recent figures estimate the overall societal cost of alcohol misuse and addiction in Scotland, taking into account; healthcare, social care, crime, productive capacity of the Scottish economy and wider social costs to be between £2.5bn and £4.6bn (York Health Economics Consortium, 2010).

As a result of the negative consequences of tobacco and alcohol use, reducing consumption of these legal substances has become a key goal for governments. Indeed, the Scottish government has spent £155m since 2008 to tackle alcohol misuse (The Scottish Government, 2012) as well as introducing plans in 2008 for Scotland to become a smoke free nation within the next two decades (The Scottish government, 2008). Although the governments' objectives involve tackling the initiation of tobacco use and the promotion of responsible alcohol use, a main priority is in relation to effective treatments for current smokers and hazardous drinkers. The most recent figures estimate that in 2011, 23% of all adults (aged 16+ years) in Scotland were current smokers and 21% of adults were categorized as hazardous or harmful drinkers (men drinking more than 21units per week and women drinking more than 14) (The Scottish Government, 2012). Discouragingly, however, twelve month relapse rates following alcohol and tobacco cessation attempts (with and without help) generally range from 80-95% (Brandon, Vidrine & Litvin, 2007). As highlighted from the prevalence and relapse rates, despite considerable research, our understanding of the mechanisms of the development, maintenance and relapse of addictive behaviours remain limited. Therefore, continuing research into these mechanisms is vital, as it may provide further understanding which could allow for more effective treatments to be developed and implemented.

1.2 Attentional processing: A target for interventions?

Biased attentional processing of substance related stimuli is thought to play an important role in the development, maintenance and relapse of addictive behaviours (Field & Cox, 2008). As such there has been a recent surge in research to develop and assess the effectiveness of training paradigms aimed at directly influencing attentional mechanisms (Fadardi & Cox, 2009; Field, Duka, Tyler & Schoenmakers, 2009; Schoenmakers, Weirs, Jones, Bruce & Jansen, 2006; Schoenmakers, de Bruin, Lux, Goertz, Van Kerhof & Weirs, 2010; Weirs, Gladman, Hoffman, Salemink & Ridderinkhof, in press). The attentional retraining paradigms to date however have been somewhat disappointing in their ability to reduce relapse rates.

The remainder of this chapter will discuss the theoretical and thus implied clinical importance of substance related attentional biases in addictive behaviours and provide an overview of substance related attentional bias research to date. In doing so this chapter will provide a critical analysis of the methodology employed in such research and present the argument that current research methodology potentially has limited validity and as such has limited the development of our knowledge and understanding of the roles of attentional biases in addictive behaviours. As a result, the methodology employed in the attentional retraining paradigms to date may not be appropriate, possibly explaining their disappointing ability to reduce relapse rates (see section 1.6 for a full discussion).

1.3. The theoretical importance of attentional bias in addictive behaviours

1.3.1 Attentional bias

Attention is the mechanism by which the complex and large volumes of information that is received from the environment is reduced. Selective attention is one component of this mechanism which allows us to focus and process relevant information, as guided by ones goals and motivations and ignore masses of irrelevant information (Klinger, 1996; Panskepp, 1998). Indeed research has demonstrated that the likelihood of stimuli to capture attention is linked to the relevance of such stimuli to the current goals of the individual (Folk, Remington, and Johnston, 1992).

Attentional bias is said to be a manifestation of selective attention and is said to be present when a particular category of stimuli has more impact on attentional processes to the detriment of competing stimuli. In the context of addiction, a substance related attentional bias would be evident if experienced users of a substance show a tendency to selectively attend to substance related information to the detriment of other categories of information (Bruce & Jones, 2004).

1.3.2 Theoretical perspectives

There are several theoretical perspectives which predict the presence of substance related attentional biases such as; the elaborated intrusion of desire theory (Kavanagh, Andrade & May, 2005), the theory of current concerns (Cox & Klinger,1988; Cox & Klinger 2004), negative reinforcement models (Baker, Brandon and Chassin, 2004) and incentive sensitisation models (Franken, 2002; Robinson & Berridge, 1993).

The elaborated intrusion of desire theory (Kavanagh et al., 2005) posits that subjective desires such as alcohol or nicotine craving can be triggered by internal states (e.g. withdrawal states) or external stimuli (e.g. a bottle of beer or someone holding a lighted cigarette). Once these subjective desires have been elicited they are then 'elaborated on' as individuals will ruminate on their desired substance and as a result will focus their attention on substance related stimuli. The cognitive elaboration then increases the strength of desire which then increases the elaboration on the substance related stimuli and so on, resulting in a positive feedback loop which promotes substance seeking and consumption.

According to the theory of current concerns (Cox & Klinger, 1988) a current concern is the motivational state of an individual once they have decided to pursue a particular goal until they either achieve the goal or decide to abandon its pursuit. Throughout this motivational state, cognitive processes are biased to goal related stimuli which keeps the individual directed toward attaining the goal. Therefore in terms of addiction it is theorised that substance users have a goal of using a substance and as a result will demonstrate an attentional bias for substance related stimuli which will promote the attainment of the goal, i.e. consumption of the substance (Cox & Klinger, 2004).

Negative reinforcement models such as that put forward by Baker, Brandon and Chassin, (2004) suggest that substance use is maintained as it relieves aversive withdrawal symptoms or other negative affective states. Baker et al., (2004) argues that as negative affect increases the motivational value of substance related cues increases. This model therefore implies that when negative affect increases, reducing negative affect becomes the primary motivation of the individual and as a result individuals will bias their attention and response selection processes to options that have reduced negative affect in the past i.e. substance use.

Lastly, incentive sensitisation models (Franken, 2003; Robinson & Berridge, 1993) argue that substance use is maintained due to incentive motivational properties of substance related stimuli, which are acquired through processes of classical conditioning. These models suggest that substance related stimuli through repeated pairings with consumption of the substance become associated with the positive reinforcing properties of the substances and as a result the cues acquire conditioned incentive motivational properties. Due to these incentive motivational properties, the substance related stimuli will capture and hold the attention of the user making the substance become 'wanted' therefore promoting substance seeking and consumption.

As reviewed briefly above, several theoretical perspectives predict the presence of substance related stimuli in addictive behaviours. The elaborated intrusion of desire theory, the theory of current concerns and the negative reinforcement models are all based on the substance user's general motivational state and how this influences substance seeking and consumption, whereby biased attention to substance related stimuli play a role. These models however provide limited explanations as to how substance seeking and substance related stimuli become motivational targets, with Kavanagh et al., (2005) simply referring to the mechanisms set out by the incentive sensitisation models. The incentive sensitisation model however provides a more encompassing model with clearly testable predictions in terms of the development of attentional biases and the role in which they play in substance use. Unsurprisingly, the incentive sensitisation models are the most popular (Field & Cox, 2008), however such popularity has been further reinforced by a considerable amount of empirical support throughout the literature, from a combination of both behavioural and neurobiological research (discussed in section 1.2.3). As a result of such testable predictions and empirical support, the incentive sensitisation models will provide the theoretical framework to this thesis and will now be reviewed in more depth.

1.3.3 Incentive Sensitisation models of addiction

The incentive sensitisation theory (IST) was originally proposed by Robinson & Berridge (1993) and as stated above in section 1.3.2, it is based on processes of classical conditioning whereby substance related stimuli through repeated pairings with substance consumption will come to acquire incentive motivational properties. More specifically the IST posits that consumption of a substance produces a dopaminergic response in the ventral striatum, a response which is well established to be associated with reward (Bromberg-Martin et al., 2010). Through repeated consumption this dopaminergic response becomes sensitised (i.e. progressively larger) to every subsequent administration. In line with the IST, research has shown that all drugs of abuse, including tobacco and alcohol induce the release of dopamine in the ventral striatum (Hart & Ksir, 2002; Imperato and Di chiara, 1986; Wise, 1996). In addition research has also demonstrated that substance related stimuli through the processes of classical conditioning also induce dopamine release in the ventral striatum, (Duvauchelle, Ikegami & Castaneda, 2000; Kiyatkin & Stein, 1996).

Furthermore, as this dopaminergic mechanism is associated with reward, it is argued to be involved in the attribution of incentive salience to associated stimuli. Robinson & Berridge (1993) hypothesize that this attribution of incentive salience transforms the neural representations of otherwise neutral stimuli into salient motivational incentives, which are able to capture attention making them become 'attractive' and 'wanted.' Indeed dopamine has been implicated in attentional processing, especially selective attention (Clark, Geffen & Geffen, 1987; Franken, Booij, van der Brink, 2005) and has been postulated to play a key role in the signalling of reward (Shultz, 1998; Robinson & Berridge, 1993). Moreover, Vollstadt-Klein et al., (2011) in line with the predictions of IST demonstrated that cue induced activation of the mesocorticolimbic reward system triggers focussing attention on alcohol related stimuli in alcohol dependents.

In summary, the IST postulates that as the neurological system becomes increasingly sensitised by every substance administration, the system increasingly attributes incentive salience to the perception and representation of the substance and substance related stimuli. As a consequence, this process results in the substance and related stimuli becoming highly salient due to their motivational properties and therefore will capture attention, as a result self-administration of the substance becomes an important goal and strong subjective cravings for the substance develop promoting consumption.

Research has primarily utilised tobacco addiction, however, there is a growing body of evidence demonstrating, in line with the predictions of IST, that neutral stimuli repeatedly associated with tobacco can be conditioned to elicit tobacco related attentional bias, subjective tobacco craving, increased physiological responses and approach behaviours (Austin & Duka, 2012; Field & Duka, 2001; Hogarth, Dickinson & Duka, 2003; Thewissen, Havermans, Geschwind, van den Hout & Jansen, 2007; Waters, Carter, Robinson, Wetter, Lam, Kerst., et al., 2009; Winkler, Weyers, Mucha, Stippekohl, Stark & Pauli, 2011). In addition, cues paired with a low dose of alcohol have also been shown to elicit an alcohol attentional bias, subjective craving and physiological responses in social users of alcohol (Field & Duka, 2002).

Important to note however, that although the IST suggests that attentional bias and subjective craving are associated, they are assumed to both exist as distinct emotional and cognitive outputs of the process which promotes substance seeking and consumption. Therefore although the IST suggests that subjective craving and attentional bias reflect the same underlying processes which promote substance seeking and consumption, Robinson and Berridge (1993) also posit that the incentive-motivational properties of substance-related cues can drive substance-seeking behavior in the absence of conscious awareness, therefore implying that subjective craving and attentional bias can be decoupled in some circumstances.

The IST proposed by Robinson & Berridge (1993) has more recently been extended by Franken (2003), and although the extension is consistent with the ISTs explanation of the development of substance related attentional biases, Franken's (2003) model differentiates from Robinson & Berridge (1993) as he argues that attentional bias and subjective craving have mutual excitatory relationships. Therefore, when substance related cues become the focus of attention, through processes of classical conditioning, subjective craving increases which in turn increases the attention capturing properties of substance related stimuli, which increases subjective craving and so on, therefore producing a positive feedback loop which promotes substance seeking and consumption.

From the limited number of studies which have examined the relationship between subjective craving and substance related attentional biases there have been reports of a positive correlation in both tobacco and alcohol users (Field, Mogg & Bradley, 2004, Field, Mogg & Bradley, 2005, Field, Field, Duka, Eastwood, Child, Santarcangelo, & Gayton, 2007; Mogg & Bradley, 2002, Mogg, Bradley, Field & Dehower, 2003, Mogg, Field & Bradley, 2005; Sayette et al., 1994) however others have failed to replicate such a finding (Ehrman et al., 2002, Lubman et al., 2000; Wertz & Sayette, 2001). In a meta-analysis of the studies which did measure craving, a significant, albeit weak association between attentional bias and craving in substance abuse was found (Field, Munafo and Franken, 2009). In terms of IST models this weak relationship seems problematic for Franken's (2003) theory in that craving and attentional bias are mutually excitatory however it is more supportive of Robinson & Berridges' (1993) theory which suggests the two can be decoupled.

The weak relationship between attentional bias and craving in substance use reported by Field et al. (2009) however must be considered with caution considering the limited number of studies examining the relationship between the two factors and the possible methodological and task limitations of the research (which will be discussed in section 1.3). As such the empirical evidence in terms of explaining the relationship between subjective craving and substance related attentional biases remains inconclusive, this will be discussed further in section 1.4.

1.3.4 Why are attentional biases important?

In summary, a compilation of both behavioural and neurobiological research has provided considerable support for IST models of addictive behaviours (Franken, 2003; Robinson & Berridge, 1993). These models suggest that alcohol and drug users should not only demonstrate a bias towards their respective substances but that the attention directed towards such stimuli will increase motivation to seek out and consume their substance of choice. Franken (2003) suggests that substance related attentional biases may contribute to the development, maintenance and relapse of addictive behaviours in three ways. Firstly, addictive behaviours may continue due to the increased likelihood to detect and thus become aware of the substance related stimuli in the environment. Secondly, once substance related stimuli have been detected it is then difficult for the user to draw their attention away from the stimulus and as a result this may contribute to increased subjective craving. Lastly, due to the limited capacity of attention, the preferential processing of substance related stimuli will result in reduced processing of competitive stimuli. As a result substance related attentional biases are thought to directly impact on the development, maintenance and relapse of addictive behaviours and thus be of clinical importance and a possible target for treatments.

1.4 An overview of attentional biases in tobacco and alcohol users

Research has attempted to examine the extent and role of substance related attentional biases. Despite their acknowledged limitations, the modified Stroop and visual probe task have primarily been utilised to examine attentional biases in substance users (Ataya et al., 2012; field & Christiansen, 2012; Spiegelhalder, Jahne, Kyle, Beil, Doll & Feige, 2011). Other paradigms have emerged, the most promising being the flicker induced change blindness paradigm (flicker ICB), which has been argued to overcome many of the limitations of the modified Stroop and visual probe tasks (Jones, Jones, Blundell & Bruce, 2002; Jones, Jones, Smith & Copley, 2003). Overall, the research employing each of these paradigms has yielded inconsistent findings, stymying our understanding of the extent and role of substance related attentional bias in addictive behaviours. The present section is devoted to reviewing the relevant findings in terms of alcohol and tobacco related attentional biases in relation to each experimental paradigm as well as discussing their associated potential limitations.

1.4.1 The modified Stroop task

The original Stroop task (Stroop, 1935) was developed as means to examine basic information processing biases and has since been modified to use disorder related stimuli in order to test if the appropriate disorder related stimuli are more salient to individuals with that disorder. As a result the modified Stroop has been utilised to measure attentional biases in anxiety disorder, depression, panic disorder, post-traumatic stress disorder, obsessive compulsive disorder and eating disorders as well as in addictive behaviours (Williams, Matthews, McLeod, 1996).

The modified Stroop task requires participants to respond to the colour of a word whilst ignoring the meaning of the word. Individuals are assumed to be slower to colour name words related to their current concerns compared to neutral words. In terms of examining attentional biases to substance related stimuli, the modified Stroop task infers substance related attentional bias from the difference between participants mean colour naming reaction time on substance related words compared to neutral words. For example, it is assumed that heavy alcohol users and smokers will take longer to respond to their respective substance related stimuli compared to neutral stimuli as they are more salient to the individuals and so will selectively attend to the semantic meaning of the substance related word even though it should be ignored during the task.

1.4.1.1 Evidence of alcohol and smoking related attentional biases using the modified Stroop task

Using the modified version of the Stroop task several studies have demonstrated that dependent smokers and alcohol dependent individuals are slower to colour name words related to their respective substance relative to neutral words and that they are slower to colour name words related to their respective substance of dependence compared to control groups of non-users and social users (for example: Drobes, Elibero & Evans, 2006;Johnsen, Laberg, Cox, Vaksdal & Hugdahl, 1994;Munafo, Mogg, Roberts, Bradley &Murphy, 2003; Stetter, Ackerman, Bizer, Straube & Mann,1995; Stormack, Laberg, Nordby & Hughdal, 2000).

In addition the modified Stroop task has also demonstrated the existence of an alcohol related attentional bias amongst social users of alcohol (a person who consumes alcohol in moderation in socially acceptable circumstances). Bauer and Cox, (1998) and Lusher, Chandler and Ball (2004) both found that alcohol related words were distracting for both alcoholics and social drinkers demonstrating that all users of alcohol demonstrate a level of alcohol related attentional bias. Furthermore, research has demonstrated that heavy social drinkers demonstrate increased distraction from alcohol related pictures compared to light social drinkers using a pictorial version of the modified Stroop task (Bruce & Jones, 2004). A pictorial version of the Stroop task involves participants being presented with substance related images and neutral images in different colours and the participants are asked to ignore the content of the stimuli and to press the appropriate button to indicate the colour of the image. Attentional bias using the pictorial Stroop is inferred from the time taken to colour name a substance related image compared to a neutral image.

In summary, research employing the modified Stroop task has provided evidence that substance related attentional biases are evident across users of tobacco and alcohol (dependent and social) and also the latter studies in relation to alcohol use have been argued to suggest that substance related attentional biases exist on a graded continuum relative to consumption level (Bruce & Jones, 2004), as would be predicted by incentive sensitisation theories of addiction (Franken, 2003; Robinson & Berridge, 1993).

Although from these studies the existence of attentional biases in tobacco and alcohol use may appear robust, several studies using the modified Stroop task have failed to demonstrate a difference in alcohol related attentional bias across dependent, social and non-drinkers (Bauer & Cox, 1998; Duka, Townshend, Collier & Stephens, 2002; Ryan, 2002; Stetter, Chaluppa, Ackerman & Straube, 1994). Furthermore, several studies using the modified Stroop task have failed to demonstrate differential smoking related attentional biases between smokers and non-smokers and between smokers varying in levels of consumption and dependence (Fehr, Weidenmann & Herrmann, 2006; Johnsen, Thayer, Laberge & Asbjornsen, 1997; Waters, Shiffman, Sayette, Paty, Gwaltney & Balabanis, 2003).

1.4.1.2 Methodological limitations of research using the modified Stroop task

As reviewed in the previous section, research employing the modified Stroop task to examine alcohol and tobacco related attentional biases have been somewhat inconsistent in their findings. Several potential methodological and task limitations have been put forward within the literature to explain such contradictory findings and will now be discussed.

In order to ensure that the differences between substance related stimuli and neutral stimuli are a result of the salience of the substance related stimuli several linguistic factors would have to be controlled during testing when using the modified Stroop task. For example, word length and frequency have been shown to affect the Stroop interference effect, with longer words and words that appear more frequently causing greater distraction (Burt, 2002; Kahan & Hely, 2008). Also words which are semantically related to each other are thought to increase inter- trial priming of associated concepts and this is thought to interfere with the Stroop effect and so have also been suggested to be important to control (Cox et al., 2003; Cox, Fadardi & Pothos, 2006). Despite the effects of such linguistic factors on the modified Stroop task, many studies as reviewed by Cox et al. (2006) have failed to control for such basic confounds. For example, Stetter et al. (1995) controlled for word frequency, length and semantic relatedness whilst Bauer & Cox (1998) controlled for word length, frequency and number of syllables. Therefore, the difference between studies regarding the control of linguistic factors may have contributed to such contradictory findings as reviewed previously.

Another methodological limitation that arises when using the modified Stroop task to measure attentional bias is that the sequence of trials may interfere with the degree of attentional bias demonstrated (Cox et al., 2006; Holle, Neely & Heimberg, 1997; Sharma, Albery & Cook, 2001; Waters & Feyeraband, 2000). Trials can be presented either in a blocked or unblocked format. The blocked format being when all of the smoking trials are presented in one block and all the neutral trials in another and the unblocked format being when the smoking and neutral trials are intermixed. Waters and Feyerabend (2000) found that smokers showed greater interference on smoking related trials compared to neutral trials when a blocked format was used but demonstrated no such finding in the unblocked format. Waters, Sayette and Wertz (2003) suggested that this finding may be due to a carryover effect occurring in the unblocked format. They found that smokers were slower to colour name neutral words occurring after smoking related words than neutral words occurring after neutral words. They suggest that this is because carry over effects from the substance related words will slow down colour naming times on the following neutral words. This may possibly be as a result of the motivationally incentive properties of the substance related stimuli holding the attention of the substance users and as a result they have difficulty disengaging from the substance related stimuli, producing a carryover effect when the following neutral word is presented. The different formats have been used interchangeably within the literature and as a result may also have contributed to the contradictory findings as reviewed previously.

Furthermore, it has been suggested that single word representations are relatively impoverished compared to images of substance related stimuli, as images of substance related stimuli are thought to be more indicative of real life experiences which are thought to give rise to substance related attentional biases (Bruce & Jones, 2004). Until more recently when Bruce & Jones (2004) adopted a pictorial version of the Stroop task, the majority of research using the modified Stroop task has relied on single word representations which are thought to possibly be limited in their ability to generate attentional bias. Therefore, methodological limitations pertaining to the type of stimuli used may also have contributed to the inconsistent findings as reviewed previously.

1.4.1.3 Limitations of the modified Stroop Task

Although methodological limitations may play a role in the inconsistent findings within the literature, the modified Stroop task itself has received considerable criticism in its ability to effectively measure attentional bias. Despite the Stroop task being utilised in research since 1935 it is still unclear as to what mechanism Stroop interference actually represents. For example, Waters et al. (2003) argue that it is unclear whether the modified Stroop task reflects the emotional salience of the stimuli, the familiarity of the stimuli, or the ability of the stimuli to induce involuntary cognitions which disrupt processing. Also, there have been several theoretical explanations put forward to explain the basic Stroop interference effect such as the connectionist model (Cohen, Dunbar & McClelland, 1990) and the “not just another model of Stroop” model (Lovett, 2002), suggesting that there remains no agreed theoretical explanation of the mechanisms underlying the basic Stroop interference effect which as a result clouds the interpretation of the findings of research employing the task.

In addition to the interpretation issues, Field, Mogg, Zettler and Bradley (2004) have argued that the Stroop task takes an over-simplified view of selective attention as it ignores important distinctions that have been made in terms of the sub-components, such as the initial orienting of attention and the maintenance of attention. As highlighted in section 1.3.1 selective attention allows us to process relevant information and inhibit less relevant information. However, selective attention is not a unitary construct; instead it consists of different components such as the initial orienting of attention and the maintenance of attention (Franken, 2003). It has been suggested that the initial orienting of attention to stimuli and maintained attention on stimuli may play differential roles in the control of behaviour (Pearce & Hall, 1980; Hogarth, Dickinson, Austin, Brown & Duka, 2008; Hogarth, Dickinson & Duka, 2009). Furthermore it has been suggested that separate neural subsystems underlie these different sub-components of selective attention, (LaBerge 1995). The implication of this in terms of addiction is that not all components of attentional bias may have a role in behavioural control or indeed they may play differential roles. Therefore to understand the extent and role of attentional biases in addictive behaviours, research should look to examine the different components of attention in order to determine which are clinically relevant (Mogg, Bradley, Field & De houwer, 2003).

Therefore, considering the unclear understanding of what the Stroop interference actually represents and its argued over simplistic examination of attentional bias, the effectiveness of the modified Stroop task to examine substance related attentional bias is potentially limited. In addition, recent research has demonstrated that the modified Stroop task when utilised to examine substance related attentional biases demonstrates low internal reliability, which is essential for a task to be considered valid (Ataya, et al., 2012).

1.4.2 The visual probe task

The visual probe task was developed by MacLeod, Matthews & Tata (1986) and was originally designed to measure the allocation of attention in emotional disorders. Lubman, Peters, Mogg and Bradley (2001) were the first to employ it in addiction research in order to examine attentional bias to substance related stimuli (opiates). The task involves a pair of stimuli (one neutral image and one substance related image) being presented simultaneously on different sides of a computer screen followed immediately by a visual probe, such as an arrow or “X”, which replaces one of the stimuli. Participants have to respond to the visual probe as quickly as possible by pressing a button to indicate whether it appeared at the left or right hand side of the screen. MacLeod et al. (1986) argue that response latencies to detect the probe can be measured as indicating the allocation of attention to the stimuli which it replaces. Therefore it is assumed for example, that smoking related stimuli will hold the attention of a smoker, therefore, if the probe replaces the neutral stimuli, smokers should be slower to react to the probe compared to if it replaced the smoking stimuli where they would be quicker to react.

The visual probe task could be argued to overcome some of the highlighted limitations of the Stroop task. For example pictorial images are used, which as discussed in section 1.4.1.2 are thought to be more ecologically valid as they may be more representative of real life experiences which give rise to attentional biases. In addition the visual probe task has been argued to be more effective than the modified Stroop task as by manipulating the image display time the extent and roles of different attentional components can be examined which as highlighted above will be an important development in research in terms of understanding which specific attentional processes are involved in substance use (Mogg et al., 2003), an issue discussed further in sections 1.4.2.1 and 1.4.2.2.

1.4.2.1 Evidence of alcohol and smoking related attentional biases using the visual probe task.

Using the visual probe task, Townshend and Duka (2001) using both a pictorial version and a word version of the visual probe task demonstrated that heavy social drinkers compared to light social drinkers showed a greater alcohol related attentional bias, however this effect was only apparent in the pictorial version of the task. As indicated above, researchers have attempted to examine the different sub-components of attention when using the visual probe task in order to overcome measurement limitations of the Stroop task by manipulating the display timings of the stimuli. Whereby shorter presentation times of pictorial stimuli prior to probe onset, such as 200ms are assumed to reflect initial orienting of attention and longer presentation times such as 2000ms are assumed to reflect maintained attention.

Field, Mogg, Zettler and Bradley (2004) have presented research which claims to support and extend the findings of Townshend and Duka (2001). Field et al., (2004) demonstrated that heavy social drinkers as compared to light social drinkers show a greater alcohol related attentional bias when the stimuli are presented at 500ms and 2000ms but not at 200ms, with subjective craving being positively correlated with attentional bias at 2000ms. These findings have also been replicated in relation to smoking related attentional biases, with smokers demonstrating a greater smoking related attentional bias compared to non-smokers when the stimuli is presented for 500ms and 2000ms (Erhman et al., 2002; Bradley, Mogg, Wright & Field, 2003, Bradley, Field, Mogg, & De Houwer, 2004; Bradley, Field., Healy, & Mogg, 2008). Bradley et al., (2003) failed to demonstrate a difference in smoking related attentional bias between smokers and non-smokers when stimuli were displayed for 500ms. They did however show that smokers were quicker to detect probes replacing smoking related stimuli compared to neutral stimuli at 2000ms whereas this was not found in non-smokers.

The series of results above were argued by the authors to demonstrate that an alcohol related attentional bias in social drinkers and a smoking related attentional bias in smokers operates with regard to maintained attention and not related to the initial orienting of attention, as the longer stimulus exposure times (500ms and 2000ms) are thought to measure maintained attention, whilst shorter durations (200ms) are thought to represent initial orienting of attention (Field et al., 2004). However, as can be seen from the results there were inconsistent findings in terms of producing such a bias at 500ms (Bradley et al., 2003).

Field, Mogg and Bradley (2005) inconsistent with the arguments above in terms of which display timings reflect which sub-components of attention, the significance of which will be discussed in section1.4.2.2, argued that stimuli presented for 500ms was indicative of initial orienting not maintained attention and stimuli presented for 2000ms was indicative of maintained attention. They demonstrated that high alcohol cravers demonstrated a greater alcohol related attentional bias compared to low alcohol cravers overall but they failed to demonstrate group differences within the stimulus exposure durations.

1.4.2.2 Limitations of the visual probe task

Although studies using the visual probe have been consistent in demonstrating an attentional bias towards alcohol related cues in social drinkers and smoking related cues in smokers, conclusions regarding the possible differential roles of initial orienting and maintained attention remain unclear. The visual probe task measures only a snapshot of attention and infers bias after the offset of the stimuli and so the roles of initial orienting and maintained attention are inferred by manipulating the stimulus exposure duration, with shorter durations assumed to reflect initial orienting and longer durations maintained attention. However, the manipulating of stimuli exposure durations is merely a crude measure of the different components of attention, which is made all the more salient by the conflicting results and contrasting opinions within the literature on whether 500ms is indicative of initial orienting or maintained attention (Bradley et al., 2003; Field et al., 2004; Field et al., 2005). Indeed, it has been argued that the attentional mechanisms underlying biases found when the stimuli exposure duration is 500ms may be unclear as a 500ms window is sufficient time to allow for multiple shifts of attention (Fox, Russo, Bowles & Dutton, 2001; Posner & Peterson, 1990).

Furthermore the visual probe task itself is subject to one potentially major limitation which was demonstrated by Bradley, Mogg & Miller (2000). By monitoring the eye movements of participants whilst they completed a visual probe task they demonstrated that when using the visual probe task some participants showed a tendency to ignore all of the stimuli displayed on the screen and initiate their search only when the probe appeared. This finding indicates that on occasions the basic presumptions of how attentional bias is inferred from the visual probe task may be invalid.

1.4.2.3 The visual probe task and eye tracking

In order to overcome the interpretation problems related to inferring the roles of initial orienting and maintained attention from indirect measures as discussed above, researchers have monitored participants eye movements whilst completing the visual probe task in order to directly measure biases in visuo-spatial attention in substance use. The monitoring of eye movements improves upon previous measures of attentional bias which have relied on indirect measures of attention as it allows directly observable measures of attentional allocation (Field et al., 2006). Therefore through the monitoring of eye movements researchers are able to directly parse out the initial orienting of attention and maintenance of attention. For example the location and speed of initial fixations indicate initial orientating of attention and the proportion of fixations on substance related stimuli compared to neutral stimuli and the duration of fixations on substance related stimuli can be used to indicate maintained attention.

Mogg, Bradley, Field and De Houwer (2003) were the first to adopt eye tracking whilst using the visual probe task in order to examine the role of attentional biases in addictive behaviours. The stimuli were presented for 2000ms and based on reaction time data they found that smokers were significantly faster to respond to probes replacing the smoking images compared to the neutral images whereas non-smokers showed no such bias. Additionally, eye movement analysis examining the direction and duration of initial fixations only, demonstrated that smokers showed a bias in both orienting towards and fixating for longer on smoking related stimuli compared to neutral stimuli and that quicker initial orienting and longer fixation times were associated with higher levels of subjective craving, however non-smokers demonstrated no such biases. Mogg et al., (2003) only examined the initial fixation within trials and demonstrated that smokers demonstrate biased attentional orienting to smoking related stimuli which is related to the degree of subjective craving, consistent IST models of addictive behaviours (Franken, 2003; Robinson & Berridge, 1993).

Mogg, Field and Bradley (2005) followed up this work employing eye tracking in a visual probe task with a 2000ms stimulus exposure duration where they examined both initial orienting and maintained attention. However this was in low dependent and moderately dependent smokers only and did not include a non-smoking control group. The authors demonstrated from reaction time data that although both moderately dependent smokers and low dependent smokers showed a smoking related attentional bias there was no difference between the groups. Eye movement data however demonstrated that low dependent smokers but not moderately dependent smokers showed a bias to initially fixate on smoking related stimuli as compared to neutral stimuli. In addition the authors analysed the duration of fixations on smoking and neutral stimuli throughout the full duration of each trial and demonstrated that both moderate and low dependent smokers fixated longer on smoking compared to neutral stimuli but low dependent smokers fixated significantly longer than moderately dependent smokers on smoking compared to neutral stimuli. Mogg et al., (2005) posited to be the first to directly examine multiple components of attention and their roles in addictive behaviours but their findings were partly at odds with the IST models of addiction (Franken, 2003; Robinson & Berridge, 1993). The IST models would expect attentional bias to be greater in those with heavier dependence compared to those of lower dependence.

In contrast, Miller and Fillmore (2010) monitored the eye movements of social drinkers whilst they completed the visual probe task in order to directly measure alcohol related attentional bias. They used both simple stimuli (e.g. presenting an image of one bottle of beer and one bottle of juice simultaneously) and complex stimuli (e.g. presenting a bar scene and a kitchen scene simultaneously) and presented them for 1000ms. Reaction time data demonstrated that social drinkers demonstrated an alcohol related attentional bias in simple stimuli but not complex stimuli. Eye movement analyses indicated that for simple stimuli only, social drinkers demonstrated longer fixation times on alcohol compared to neutral stimuli, the degree of which was related to the participant's level of use, which the researchers argued to be representative of a bias in maintained attention.

1.4.2.4 Limitations of research using the visual probe task employing eye tracking

Although the studies described in section 1.4.2.3, have employed eye tracking in order to directly measure the allocation of attention in an attempt to examine the extent and roles of initial orienting and maintained attention in addictive behaviours, the development of our understanding remains somewhat limited. The studies, limited in number, are inconsistent in the measures which they propose to have used. For example, Mogg et al., (2003) examined initial orienting only, Miller & Fillmore (2010) examined maintained attention only and Mogg et al., (2005) examined both. In addition the research above arguing to have directly measured maintained attention did so using the duration of fixations in trials with stimulus presentation times of 1000ms (Miller & Fillmore, 2010) and 2000ms (Mogg et al., (2005) which could be considered as considerably short durations to allow for the measurement of maintained attention and therefore may not be accurate representations of maintained attention. Furthermore, due to the inconsistent timings between the studies comparisons between the studies are limited in generating any clear conclusions.

The stimuli employed within these studies also possibly cloud the conclusions which can be drawn. All studies employed relatively simple stimuli which most often depicted a single object on a neutral background. These simple stimuli however may be impoverished compared to the real life scenes which may actually give rise to attentional biases, as context has been shown to differentially influence cue reactivity (Nees, et al., 2012). The biases in attentional processing evidenced by these studies may therefore be attenuated compared to if stimuli depicting real world scenes were utilised. Miller & Fillmore (2010) did however also employ complex stimuli in addition to simple stimuli but yet were only able to demonstrate an alcohol related attentional bias in simple stimuli not the complex stimuli, which would have been assumed to be more representative of the environments which may give rise to attentional biases. The complex stimuli used by Miller & Fillmore (2010) however are subject to several possible limitations. For example, the complex stimuli used consisted of two scenes of people taking part in consumption related activities. The examples given by the researchers were people drinking in a bar for the alcohol scene and eating food for the neutral scene. Food related stimuli however cannot be assumed to be neutral as attentional biases have been demonstrated for food related stimuli when competing for attention with neutral stimuli (e.g Newman, O'connor & Conner, 2008). Therefore, the complex neutral stimuli employed by Miller and Fillmore (2010) may also contain stimuli which competes with the substance related stimuli for attention and thus influences the reliability of their results.

In addition to the potential methodological limitations of these studies there remain inherent limitations of the visual probe task itself that even when employing eye tracking as a direct measure of attentional processes, may still undermine the use of the task to effectively measure attentional bias. The visual probe task involves presenting one substance related image and one neutral image side by side simultaneously on a screen and inferring attentional bias from these two competing images. The researchers then interpret the findings in order to explain the extent and role of attentional biases to substance related stimuli in addictive behaviours and by doing so extrapolate their findings to explain attentional biases which occur in real world environments which are far richer and more complex. Therefore in order to demonstrate greater ecological validity, attentional bias to substance related stimuli would need to be measured within one single visual scene representing a more naturalistic environment which may actually give rise to attentional biases in addictive behaviours (e.g Nees et al., 2012), rather than being inferred from two competing visual scenes.

Furthermore, recent research has demonstrated that the visual probe task when utilised to measure substance related attentional biases, whether utilising word or pictorial stimuli or even when employing eye tracking demonstrate low internal reliability, a criterion considered essential for a task to be valid (Ataya et al., 2012; Field & Christiansen, 2012; Schmukle, 2005).

1.4.3 The flicker induced change blindness task (flicker ICB)

The Flicker ICB task was developed by Rensink, O'Regan and Clark, (1997) and was first adopted to examine substance related attentional bias in addictive behaviours by Jones et al., (2002) and has since been argued to be a more sensitive and ecologically valid paradigm overcoming some of the limitations of the Stroop task and visual probe task (Jones et al., 2003). The flicker ICB is essentially a "spot the difference" task, where by an original image repeatedly alternates with a modified image (original image except contains one or two changes) with a brief blank field being displayed between the image presentations. Participants freely view the flickering display and press a button when they have detected a change.

The disruption between the flickering images by the blank field makes the change surprisingly difficult to spot, compared to when the flickering images are presented immediately one after the other without the disruption, as using the latter approach the change to the object itself would be able to capture attention (see Rensink, 2002, for a review). Instead with the inclusion of the blank field Rensink et al., (1997) argues that for detection of the change to occur, direct attention must be paid to and maintained on the changing object. Furthermore, if the changed object is considered interesting to the participant they are likely to detect the change more quickly. Importantly, with the flicker ICB the measurement of attentional bias to particular stimuli is captured within one single visual scene. Therefore, the flicker ICB task allows researchers to use complex stimuli which would be more consistent with real world environments. This allows researchers to present multiple stimuli within the same context and ultimately measure the ability of particular object within a single scene to capture and maintain attention. Therefore the flicker ICB could be argued to effectively measure attentional bias in terms of incentive sensitisation theories of addiction (Franken, 2003; Robinson & Berridge, 1993). As highlighted above, these theories suggest that through the processes of classical conditioning, stimuli associated with substance use will come to acquire incentive salience and as a result, within an individual's environment, will capture and maintain attention making the substance become wanted and so promote consumption.

1.4.3.1 Evidence of alcohol and smoking related attentional biases using the Flicker ICB

Using the flicker ICB and employing bi-laterally grouped stimuli (e.g. alcohol related objects to the left and neutral objects to the right) Jones et al., (2002) found that heavier social drinkers were significantly more likely to detect the alcohol related change relative to the neutral change compared to lighter users when both an alcohol and neutral change were competing for detection. Jones et al. (2003) found that heavy social drinkers given an alcohol related change to detect do so more quickly compared to heavy social drinkers given a neutral change to detect whereas lighter drinkers show no difference between the latency to detect alcohol changes and neutral changes. Furthermore, in line with incentive sensitisation theories of addiction (Franken, 2003; Robinson & Berridge, 1993), Jones et al., (2003) demonstrated that attentional bias to alcohol related stimuli correlated to level of consumption. Jones et al. (2006) examined both problem drinkers and social drinkers and demonstrated that problem drinkers were quicker to detect alcohol related changes compared to social drinkers and that there was correlation between alcohol related attentional bias and severity of alcohol use in problem drinkers. However, they failed to find a correlation between attentional bias and alcohol consumption in social drinkers. The researchers however, argued that this was possibly due to the small variation in consumption of the group of social drinkers compared to the social drinkers used in Jones et al. (2003). None the less, Jones and colleagues have argued that substance related attentional biases exist on a graded continuum relative to consumption level, which would be predicted by incentive sensitisation theories of addiction (Franken, 2003; Robinson & Berridge, 2003).

In addition Yaxley and Zwaan (2005) adopted the flicker ICB task to examine smoking related attentional biases and reported that, smokers demonstrate an attentional bias for smoking related stimuli compared to non-smokers. They demonstrated that when given a smoking related change to detect smokers detected the change more quickly than non-smokers and when given a neutral change to detect, smokers were slower than non-smokers to detect the change when smoking stimuli were present in the line-up of stimuli.

1.4.3.2 Limitations of research employing the flicker ICB to measure substance related attentional bias

The flicker ICB has been put forward as a more effective tool to measure attentional bias as it is argued to measure the ability of a stimulus to capture and hold attention within one single visual scene (Jones et al. 2003). Existing research using the flicker ICB however are reliant on indirect measures of attentional bias such as the type of change detected and time taken to detect the change, therefore arguably they take an oversimplified view of attentional bias as they remain unable to parse out the sub-components of selective attention (field et al., 2004). As discussed previously, the initial orienting of attention and the maintenance of attention may play differing roles in the control of behaviour (Hogarth, et al., 2008; Hogarth, et al., 2009). Therefore in order to develop our understanding of the extent and role of attentional biases in substance use, research should examine the different components of attention in order to determine which are clinically relevant (Mogg et al., 2003).

In addition, existing research employing the flicker ICB task has relied on relatively impoverished stimuli. For example, the stimuli used by Jones et al (2006) consisted of scenes which depicted individual bottles of alcohol related and matched neutral stimuli arranged on a grid. Jones et al., (2002) and Jones et al., (2003) used scenes which depicted neutral and substance related stimuli bi- laterally grouped on a white surface and Yaxley & Zwaan (2005) used scenes which depicted 8 objects arranged on a white surface. Therefore despite the flicker ICB allowing researchers to examine the ability of substance related stimuli to capture attention within one single scene, they have neglected to adopt scenes which are more likely to depict real life environments. Real life scenes would more closely match the environment in which the results are being extrapolated and therefore would have arguably more ecological validity, especially as context, as highlighted previously, has been shown to influence cue reactivity (Nees et al. 2012).

Furthermore, Jones et al., (2006) hypothesised that if more than one trial is used participants may employ search strategies such as sequentially searching each section of the matrix and that this would therefore limit the ability of the flicker ICB task to measure attentional bias, although this assertion remains to be empirically tested. As a result the studies conducted by Jones and colleagues are potentially limited in power as they have relied on only one trial per participant. Yaxley and Zwaan (2005) however employed the flicker ICB with multiple trials per participant and yet still demonstrated that smokers showed a greater attentional bias for smoking related stimuli compared to non-smokers. Comparisons between the studies are therefore limited as it remains unclear if substance related attentional biases measured over one trial are equivalent to those measured over multiple trials when utilising the flicker ICB.

The flicker ICB task is thought to overcome many of the limitations of the Stroop and visual probe tasks in terms of ability to measure substance related attentional biases within one single visual scene. Research employing the flicker ICB task although limited, has demonstrated an attentional bias to alcohol and smoking related stimuli in social users and dependent individuals. However, our understanding of the extent and roles of initial orienting and maintained attention remain limited due to potential methodological limitations of previous research utilising this task as highlighted above.

1.5 General limitation of attentional bias research

Subjective craving is regarded by almost all theories of addiction as a key factor which maintains substance seeking behaviour and can increase the risk of relapse in users attempting to quit (Field, Schoenmakers & Weir, 2008). Furthermore, the IST models amongst other models (as highlighted in section 1.3.2) posit a relationship between subjective craving and substance related attentional biases. These models differ in their explanations of such relationships; whether they are mutually excitatory factors (Cox & Klinger, 1988; Franken, 2003; Kavanagh, 2005) or exist as distinct but related outputs (Robinson & Berridge, 1993) which promote substance seeking and consumption. However, it can nonetheless be assumed that in order to effectively examine the extent and roles of substance related attentional biases in addictive behaviours their relationship to craving must be examined and understood.

Despite this, the majority of studies outlined above employing the Stroop task and visual probe task as well as all of the studies employing the flicker ICB task have neglected to examine subjective craving (Field & Cox, 2008). As a result our knowledge of the roles of substance related attentional bias in addictive behaviours remains unclear, limiting our understanding of the clinical importance of substance related attentional biases.

Therefore, in addition to the potential task limitations and their respective methodological limitations as discussed previously in this chapter, the neglect to measure craving, despite its theoretical and clinical importance is a major limitation of existing research, and limits our understanding of the extent and role of attentional biases in addictive behaviours and thus how to potentially target them for treatment.

1.6 Attentional re-training paradigms to date

Due to the theoretical importance of substance related attentional biases in the development, maintenance and relapse of addictive behaviours (see section 1.3) it is clear to see why researchers have attempted to devise attentional retraining paradigms in order to treat addictive behaviours. Attentional retraining paradigms have been developed and tested on social alcohol drinkers (Schoenmakers et al., 2006), dependent alcohol users (Fadardi & Cox, 2009; Schoenmakers, et al., 2010) and dependent smokers (Field et al., 2009).

Findings from both Schoenmakers et al., (2006) and Field et al.,(2009) revealed that attentional retraining paradigm's were insufficient to reduce substance use, whilst Fadardi and Cox (2009) and Schoenmakers et al., (2010) findings indicated that attentional retraining paradigms may have clinically relevant effects.

Therefore the support relating to the efficacy of attentional retraining interventions remains mixed, indicating a clear need further research.

In terms of the possible clinically relevant effects, Fadardi & Cox (2009) found that the attentional retraining paradigm reduced alcohol related attentional bias in dependent alcoholics which was accompanied by a reduction in drinking levels. However caution has to be asserted when interpreting the robustness of such a finding considering a lack of control group. Schoenmakers et al., (2010) demonstrated that compared to a control group, dependent alcohol users who had received the attentional retraining paradigm had been discharged on average one month earlier from the treatment facility. However the researchers were unable to conduct follow up analysis, therefore limiting any conclusions which can be made regarding the efficacy of such retraining.

Considering the potential limitations of both the modified Stroop task and visual probe task as discussed in section 1.5, the conclusions which can be drawn from such attentional retraining studies are further hindered as the research incorporated either a modified pictorial Stroop task (Fadardi & Cox, 1009) or a visual probe task (Field et al., 2009; Schoenmakers et al., 2006; Schoenmakers et al., 2010) in order to both retrain attention as well as test attentional bias. Furthermore as can be seen from the overview of research provided in section 1.5, the current understanding of the extent and roles of attentional biases in addictive behaviours remains limited, therefore such efforts may have been premature. Therefore, before future research attempts to develop attentional retraining paradigms to reduce substance use and relapse, advancement in the understanding of the extent and roles of substance related attentional biases and the use of effective tools to measure attentional bias must be established.

1.7 Organisation of the thesis

Following on from this general introduction, chapters 2, 3 and 4 present a series of six experiments, each addressing research questions pertinent to furthering our understanding of the extent and roles of substance related attentional biases in addictive behaviours. A general discussion and conclusion to this thesis is then provided in chapter 5.

In chapter 2, the first known studies to incorporate eye tracking technology whilst using the flicker ICB task in order to directly measure biases in the initial orienting of attention to, and maintained attention on substance related stimuli are presented. The aim of these studies was to explore the associations between such biases in attention with levels of subjective craving and levels of consumption across different levels of use (social and dependent). In order to clarify previous findings and provide recommendations for future research these studies also aimed to assess the influence of the type of stimuli employed (simple grid and real world scenes) as well as the number of trials employed when utilising the flicker ICB task.

In order to address and account for the inconsistencies within the literature and the findings presented in chapter 2 the studies presented in chapters 3 and 4 were designed to explore the influence of the structure of stimuli on the extent and time course of strategic scanning when using the flicker ICB task to measure attentional biases. The aim of these studies were therefore to examine the validity of the flicker ICB task as a tool to measure attentional biases and provide recommendations for future research.

A general discussion is provided in chapter 5. This chapter provides a summary of the research findings of this thesis and explores the ramifications of these findings for future research. This chapter also highlights possible methodological limitations as well as directions for future research.

Chapter 2: Employing the flicker ICB whilst utilising eye tracking: An investigation of attentional biases in addiction

2.1 Experiment 1a- An examination of alcohol related attentional biases in social drinkers using the flicker ICB employing eye tracking.

Substance related attentional biases as predicted by theoretical models of addictive behaviours are thought to be of key importance in the development, maintenance and relapse of addictive behaviours (Field & Cox, 2008). However as discussed in the previous chapter, our understanding of the extent and roles of such biases in addictive behaviours remain limited, possibly as a result of methodological limitations of previous research.

The Incentive sensitisation models (Franken, 2003; Robinson & Berridge, 1993) are considered the most popular theoretical models (Field & Cox, 2008) and importantly have received extensive support throughout the literature (see section 1.2.3). These models posit that through repeated administration of a substance (alcohol, nicotine, cocaine, heroin, cannabis etc.) the mesocorticolimbic reward system becomes increasingly sensitised. As a result this system increasingly attributes incentive salience to the perception and representation of the substance and substance related stimuli. As a consequence, this process results in the substance and related stimuli becoming highly salient due to their motivational properties and therefore will increase the likelihood of capturing attention relative to competing stimuli. As a result self-administration of the substance becomes an important goal and strong subjective cravings for the substance develop promoting substance seeking and consumption. Robinson & Berridge (1993) further suggested that although subjective craving and attentional bias are related constructs they can be decoupled in some instances to drive substance seeking behaviour in the absence of conscious awareness. Franken (2003) however suggests that substance related attentional biases and subjective craving have a mutual excitatory relationship. Therefore, when substance related cues become the focus of attention, subjective craving increases this in turn increases the attention capturing properties of substance related stimuli which increases subjective craving and so on, producing a positive feedback loop promoting substance seeking and consumption. These models both agree in terms of how substance related attentional biases develop but they differ in terms of their explanation of the relationship between subjective craving and substance related attentional biases. Both perspectives nonetheless conceptualise subjective craving and substance related attentional biases as related constructs which play a role in the maintenance and relapse of addictive behaviours.

As discussed in section (1.5), a large proportion of previous research has neglected to measure subjective craving and the results of the limited number of studies which have examined the relationship have been inconsistent, with some detecting a relationship between attentional bias and subjective craving and others failing to do so (for example: Ehrman et al., 2002; Field et al, 2004; Field et al., 2005; Field, et al., 2007; Lubman et al., 2000; Mogg & Bradley, 2002; Mogg, et al., 2003; Mogg et al., 2005; Sayette et al., 1994; Wertz & Sayette, 2001). In addition, a meta-analysis of the studies which have measured subjective craving demonstrated only a weak association between subjective craving and substance related attentional biases (Field, et al. 2009). However these findings must be considered with caution as the studies and meta- analysis highlighted above consisted of research employing both the Stroop task and the visual probe task, which as discussed in chapter 1 are subject to several criticisms which may possibly limit their validity as tools to measure substance related attentional biases. As a result our knowledge of the roles of substance related attentional bias in addictive behaviours remains unclear as the relationship between attentional biases and subjective craving remain to be established, limiting our understanding of the clinical importance of substance related attentional biases.

The flicker ICB task however as adopted by Jones et al., (2002) has since been argued to be a more sensitive and ecologically valid paradigm compared to the Stroop task and the visual probe task as it allows researchers to measure the ability of a stimulus to capture and hold attention within one single visual scene (Jones et al., 2003). Using this task substance related attentional biases have been demonstrated in dependent alcohol and nicotine users (Jones et al., 2006; Yaxley & Zwaan, 2005) as well as social users of alcohol (Jones et al., 2002; Jones et al., 2003). With such findings by Jones and colleagues (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006) being argued as evidence of substance related attentional biases existing on a graded continuum relative to consumption level, which would be predicted by incentive sensitisation theories of addiction (Franken, 2003; Robinson & Berridge, 2003). The studies by Jones and colleagues however have not been consistent, with Jones et al., (2006) failing to demonstrate a relationship between alcohol related attentional bias and consumption level in social users of alcohol. The researchers have however argued that this may be due to the variation in consumption level of the social users of alcohol in that study. However, despite these studies adopting the flicker ICB task, an arguably more ecologically valid task compared to the Stroop task and the visual probe task, no study to date employing the flicker ICB task has measured subjective craving.

The studies above employing the flicker ICB task are also subject to several of the same possible methodological limitations which plagued previous research employing the Stroop task and the visual probe task. Studies employing the flicker ICB task, similar to those which have employed the Stroop task to measure substance related attentional biases have taken an indirect and arguably simplified view of attentional bias as they have conceptualised attentional bias as a unitary construct and measured it through reaction times or type of change detected, whether substance related or neutral (see section 1.4.1.3 for full discussion). Attentional bias however consists of distinct sub-components such as the initial orienting of attention and the maintenance of attention (Franken, 2003) which have been suggested to possibly play different roles in the control of behaviour (Hogarth, et al., 2008; Hogarth, et al., 2009; La Berge, 1995; Pearce & Hall, 1980). Therefore the sub-components of attentional bias may play differing roles in addictive behaviours.

As discussed in section (1.4.2) research employing the visual probe task initially attempted to examine these sub-components by manipulating stimulus display times. This approach meant that the sub-components of attention were measured indirectly and with inconsistencies between the researchers in terms of which timings were are argued to reflect which components of attention limited any conclusions which could be drawn (for example: Bradley et al., 2003; Field et al., 2004; Field et al., 2005). To overcome this, researchers have adopted eye tracking technology in order to directly measure the sub-components of attentional bias when utilising the visual probe task (Miller & Fillmore, 2010; Mogg et al., 2003; Mogg et al., 2005). However even when employing eye tracking in order to directly measure the sub-components of attentional bias these studies still suffer from the shortcomings inherent to the visual probe task itself. The visual probe task involves presenting two competing images, one substance related image and one neutral image side by side simultaneously on a screen and infers attentional bias from these two competing images. Researchers then extrapolate their findings to explain attentional biases which occur in real world environments which are far richer and more complex and importantly consist of competing stimuli within one single visual scene. Therefore in order to demonstrate ecological validity, sub-components of attentional bias to substance related stimuli should be directly measured within one single visual scene representing a more naturalistic environment. This also highlights a further possible weakness of the research to date which has employed the flicker ICB task.

Although the flicker ICB task is argued to allow researchers to measure the ability of a stimulus to capture and hold attention within one single visual scene, research to date has employed relatively simple stimuli, a potential weakness which has also limited studies employing the Stroop task and visual probe task (see sections 1.4.1.2 and 1.4.2.4) . Studies utilising the flicker ICB task have employed stimuli such as; substance related and neutral objects being bi-laterally grouped on a table top (Jones et al., 2002; Jones et al., 2003), substance related stimuli and neutral stimuli being bi-laterally arranged on a white grid (Jones et al., 2006) and substance related and neutral stimuli being presented in a straight line with a white back ground (Yaxley & Zwaan, 2005). Therefore the research to date has neglected to adopt scenes which are more likely to depict real life environments. Real life scenes would more closely match the environment in which the results are being extrapolated to, therefore would have more ecological validity. Especially as context, as highlighted previously, has been shown to influence cue reactivity (Nees et al. 2012). Therefore although the simplistic stimuli utilised in previous research has demonstrated substance related attentional biases, such effects may be attenuated compared to those evidenced when using stimuli arguably more representative of real life environments.

In addition, although research adopting the flicker ICB task maintains that it overcomes some of the limitations of previous tasks, this research has also highlighted a possible methodological issue which may influence the validity of the flicker ICB task as a tool to measure substance related stimuli under certain circumstances. Jones et al., (2006) hypothesised that if more than one trial is used participants may employ search strategies such as sequentially searching each section of the stimulus and thus possibly limiting the validity of the flicker ICB as a tool to measure attentional bias. As a result the studies conducted by Jones and colleagues are potentially limited in power as they have relied on only one trial per participant (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006). Yaxley and Zwaan (2005) however employed the flicker ICB with multiple trials per participant and still demonstrated that smokers showed a greater attentional bias for smoking related stimuli compared to non-smokers. Comparisons between studies adopting the flicker ICB task are therefore limited as it remains unclear if substance related attentional biases measured over one trial are equivalent to when measured over multiple trials when utilising the flicker ICB which will be important to consider when trying to reach conclusions on the role of attentional biases in addictive behaviours. This therefore remains an important issue to examine in order to clarify existing research and examine the validity of the flicker ICB task to provide recommendations for future research.

Given the theoretical prominence and implied clinical importance of substance related attentional biases in addictive behaviours, the purpose of this experiment was to attempt to overcome several limitations of previous research, as argued both above and in chapter 1. Furthermore this experiment also sought to examine possible methodological issues when using this approach. The present study therefore aims to extend the current literature by monitoring participants' eye movements whilst they complete the flicker ICB task. The monitoring of eye movements improves upon previous measures of attentional bias which have relied on indirect measures of attention as it allows directly observable measures of attentional allocation (Field et al., 2006). This approach will therefore allow for a direct examination of the extent and roles of the sub-components of attentional bias within one single visual scene by examining the initial orienting of attention to, and the maintained attention on substance related stimuli. In addition, given the neglect of research to date to examine the relationship between attentional bias and subjective craving, despite its theoretical importance, the present study will examine the relationship of both the initial orienting of attention and maintenance of attention on alcohol related stimuli with both levels of alcohol consumption and levels of subjective alcohol craving.

Furthermore this experiment aimed to both attempt to overcome and assess possible methodological issues which may influence the validity of the flicker ICB. This study therefore also sought to replicate previous research by using simple grid stimuli such as that used by Jones et al., (2006) as well as extend previous research which has utilised the flicker ICB task by using stimuli depicting real world scenes, thought to be more representative of the environments which may actually give rise to attentional biases (e.g Nees et al., 2012). In addition, multiple trials were incorporated within this experiment however all participants received the same stimuli on the first trial in order to allow for the examination of attentional biases as measured over one trial compared to many trials. This will allow for both the clarification of previous results as well as recommendations for future research.

The main research question that this experiment sought to address was:

1) To what extent are both the initial orienting of attention to alcohol related stimuli and maintained attention on alcohol related stimuli related to levels of alcohol consumption and levels alcohol craving in social drinkers?

Additionally, the study also sought to address the following questions in relation to methodological aspects of measuring attentional bias:

2) Is the extent of alcohol related attentional bias demonstrated modulated by the types of stimuli used (simple compared to complex real world scenes) when employing the flicker ICB?

3) Are the measures of attentional bias as examined in the first trial only comparable to attentional bias as measured over multiple trials when using the flicker ICB?

2.2Method

2.2.1 Participants

The sample consisted of 58 undergraduate and postgraduate students (24 male and 34 female, mean age 24.54, S.D. =7.00). Participants were advised that the aim of the study was to investigate attention and so were naïve to the true purpose of the study. This was done as Yaxley and Zwann (2005) demonstrated that if you specifically advertise for smokers and non-smokers to examine smoking related attentional bias the non-smokers demonstrate the same level of smoking related attentional bias as the smokers however when participants are recruited naïve to the study the smokers demonstrated a greater attentional bias compared to non-smokers. The eligibility criteria for inclusion in the study were a) participants should have normal or corrected to normal vision b) be over the age of 18 years and c) have no current or previous substance dependence other than nicotine. This study was conducted under ethical approval, granted by the University of Strathclyde Psychology Departmental Ethics Committee.

2.2.2 Stimuli

Two different types of stimuli were employed in the study: grid stimuli (Appendix A) and complex real world scene stimuli (Appendix B). The complex scene stimuli consisted of 16 pairs (original image and changed image) of full colour 1280 × 1024 pixel images of unstructured real world scenes (Figure 2.1). Each image pair included both an alcohol related change and a neutral change. The alcohol and neutral changes were matched for physical properties such as; colour, shape, height and width. The changes were arranged on two levels of laterality; alcohol related changes on the left with the neutral change on the right and the alcohol related change on the right with the neutral change on the left.

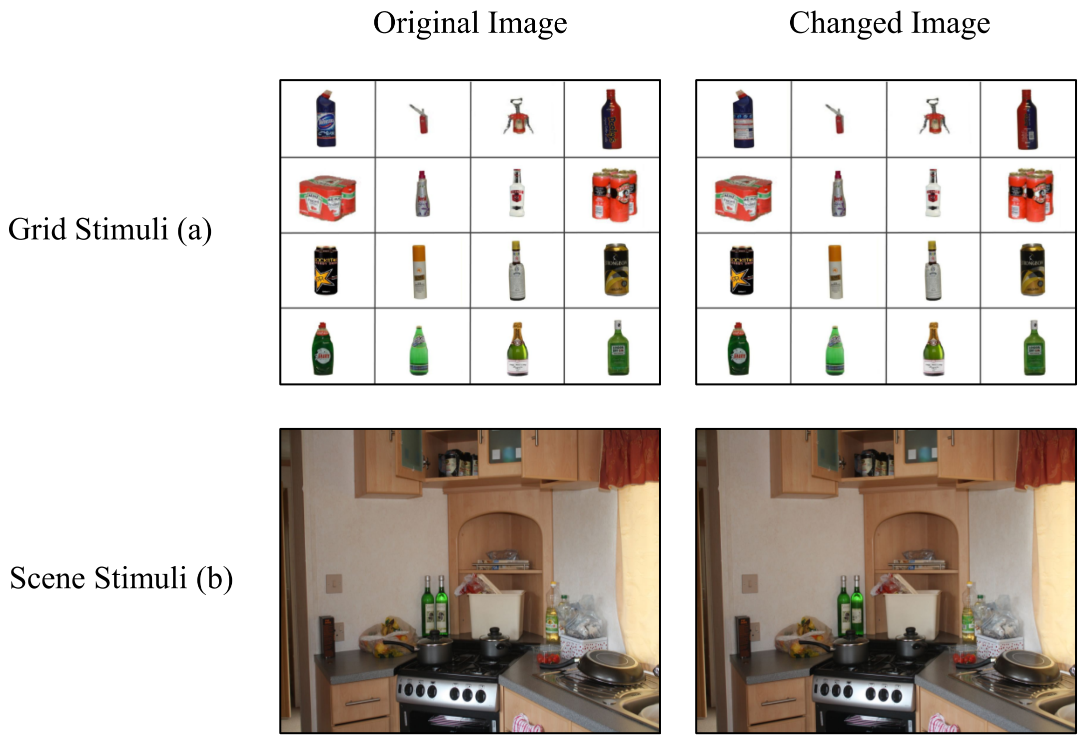

Figure 2.1: Example stimulus pairs for flicker ICB(a) A simple grid example is shown, the top left and top right stimuli have been rotated. (b) A real world scene example is shown, one of the bottles of wine and one of the bottles of oil have been rotated.

The grid stimuli consisted of 16 pairs (original image and changed image) of full colour 1280 x 1024 pixel images composed of 4 x 4 matrices of 8 pairs of alcohol related objects and neutral objects (see figure 2.1). The pairs of alcohol and neutral objects were matched for physical properties such as; colour, shape, height and width. The stimuli were arranged in a 4 x 4 matrix with items of each matched pair occupying corresponding positions on the matrix. The matrices were arranged in terms of 4 levels of laterality; alcohol related objects grouped on the right and neutral grouped on the left, alcohol related objects grouped on the left and neutral grouped on the right, alcohol related objects grouped on the top and neutral grouped on the bottom and alcohol related objects grouped on the bottom with neutral objects grouped on the top. Over the 16 grid trials each object was repeated 4 times, therefore the four repetitions appear only once in each level of laterality and so were never displayed at the same position more than once. Furthermore the matrices were arranged in an order such that a matched neutral change and alcohol related change occurred at each of the 16 matrix positions only twice.

2.2.3 Measures

Desire for Alcohol Questionnaire

To measure subjective craving the Desires for Alcohol Questionnaire (DAQ; Love, James & Willner, 1998) was used (appendix C). The questionnaire consists of 22 statements and the participant has to rate how much they agree or disagree with each statement. Examples of statements include "drinking would make me feel good" and "I have an urge to drink now." Scores range from 22 (low craving) to 110 (high craving) and the authors have reported a Cronbachs α of 0.97.

Severity of Alcohol Dependence Questionnaire

The Severity of Alcohol Dependence Questionnaire (SADQ; Stockwell, Hodgson, Edwards, Taylor & Rankin, 1979) is a measure of dependence severity experienced by alcohol users (appendix D) and has been shown to have high internal reliability, Cronbachs α 0.98 (Stockwell, Sitharthan, McGrath & Lang, 1994). Participants are required to rate on a 4 point scale from "almost never" to "nearly always" on 20 items corresponding to physical symptoms, moods, consumption and withdrawal. Scores range from 0 to 60, with scores of 0-15 indicating no dependence, 16 -29 indicating mild to moderate dependence and scores of 30 and above as indicating severe dependence. This measure was used in order to determine if any participants were hazardous drinkers, in order to exclude them from analysis.

Alcohol Timeline Follow Back

The alcohol timeline follow back (TLFB; Sobell & Sobell, 1992) was used to measure levels of consumption (appendix E). The TLFB presents participants with a calendar layout for the last 7 days and asks participants to provide a retrospective estimate of their daily drinking over this time period including how many drinks, type and brand. In line with Jones et al. (2003), units of alcohol were measured rather than number of drinks due to alcoholic drinks varying in their units of alcohol.[2]

2.2.4 Apparatus and Procedure

The stimuli were presented centrally on a 19 inch Viewsonic monitor with 1280 x1024 pixel resolution and an 85 Hz refresh rate. Eye movements were recorded with an SR EyeLink II eye tracking device (SR Research, Ontario, Canada) using the centre of the pupil to define pupil position. Eye movements were recorded at a 500 Hz sample rate at a spatial resolution, typically, of 0.01°. Saccade onset was defined as a change in eye position with a minimum velocity of 22°/s or a minimum acceleration of 8000°/s.

The participants were all tested individually in a dimly lit room. First, participants provided informed written consent. Participants were then seated with their head positioned on a chin rest so that the distance between the screen and the participants eyes was 57cm. Participants were then fitted with the SR Eyelink II lightweight headset. Although both eyes viewed the stimuli only the eye with the

[2] For example a UK unit of alcohol contains 8g of ethyl alcohol, which is equivalent to half a pint of 4.5% lager, a single shot of spirits or a 125ml glass of 11% wine. Therefore measuring units of alcohol rather than number of drinks is more accurate measure of alcohol consumption.

best spatial accuracy, as determined by the calibration and validation procedure was analysed. The 9 point grid calibration and validation procedure involved participants' saccading to a fixation dot which appeared randomly at 9 points on a 3 x 3 grid. Once successful validation was obtained the task instructions appeared on the screen. Once the participant fully understood the instructions of the task they pressed any button on the control pad to begin, which was centrally located in front of the chin rest. The instructions did not state how many changes there were, only that once a change was detected to press the button and verbally state the nature of the change. All participants received the same grid stimuli on their first trial for which the laterality of the stimuli presented in the first trial was controlled (with half of the sample being shown the stimuli with alcohol objects grouped on the right and neutral on the left and the remaining half with alcohol objects on the left and neutral on the right).

Each trial started with a central fixation dot, once the participant was stably fixated on the dot (manually assessed), the original image was presented for 250ms, followed by a mask (a plain white screen) for 80ms, then the changed image for 250ms and then the mask for 80ms. This stimulus- mask series was continuously presented for 60s or until the participant detected the change by pressing any button on the control pad. Participants also had to verbally state the change so as the researcher could record whether the participant was correct and record whether an alcohol related or neutral change was detected. There were 32 trials in total, 16 grid trials and 16 real world scene trials, with no practice trials. After completing the flicker ICB task, participants were immediately required to complete the DAQ, SADQ and TLFB. Participants were then fully debriefed as to the true aims of the study.

2.3 Results

2.3.1 Eye movement and response errors

In line with previous research trials were removed from analysis in which the participant failed to detect a difference (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006), anticipated the stimulus appearance by making a saccade with a reaction time shorter than 80ms (Machado & Rafal, 2000), or were improperly fixated on the central fixation point (a deviation larger than 1°) at the start of the trial (Mogg et al., 2003; Mogg et al., 2005). These criteria resulted in 12.80% trials being excluded from subsequent analysis.

2.3.2 Group characteristics

As per the SADQ no participants were considered as dependent alcohol drinkers, therefore given that all participants were representative of the intended group (social drinkers), and in line with Field (2009), outlier analysis was not conducted on the consumption and craving data as it is therefore assumed that the sample is representative of the group we wish to examine, social drinkers. In order to examine the relationship of the sub-components of attentional bias (initial orienting and maintained attention) with both levels of alcohol consumption and levels of subjective craving participants were allocated to both a consumption group and craving group[3]. In line with Bruce & Jones (2004) a median split was conducted based on questionnaire responses. A median split was conducted on the reported

[3] Consumption and reaction time data were skewed, as such all scores were log transformed to reduce skewness. Following transformation there were no differences between analyses therefore data is reported non-transformed for ease of presentation and interpretation.

number of units consumed within the previous week as measured by the TLFB (light drinkers (n=29, 7 male) and heavy drinkers (n=29, 16 male)) as well as on the level of subjective craving as measured by the DAQ (low craving (n= 29, 10 male) and high craving (n=29, 13male)). Table 2.1 presents demographic information for each group.

Table 2.1: Consumption and craving group characteristics

	Consumption			**Craving**		
	Heavy (n=29)	Light (n=29)		High (n=29)	Low (n=29)	
	M (SD)	M (SD)	Sig.	M (SD)	M (SD)	Sig.
Age	24.86 (9.21)	24.48 (4.17)	0.008	25.90 (9.22)	23.45 (3.75)	> 0.05
Consumption	37.66 (15.60)	10.73 (5.01)	< 0.001	26.76 (17.04)	21.62 (18.43)	> 0.05
DAQ	43.14 (13.10)	38.38 (11.30)	> 0.05	50.97 (8.29)	30.55 (5.14)	< 0.001

When split by consumption level, chi-square analysis indicated a significant difference in gender ratio between the light consumption group (7 male, 13 female) and the heavy consumption group (16 male, 13 female) , X^2 (1, n = 58) = 7.11, p = 0.008. Independent t-test analysis indicated that heavier social drinkers consumed more units per week than lighter social drinkers, t (33.72) = -8.85, p <0.001, however the groups did not significantly differ in levels of craving t(56) = -1.48, p = 0.14. When split by craving, higher cravers reported significantly higher levels of craving than lower cravers, t (56) = -11.27, p <0.001, however they did not significantly differ in levels of alcohol consumption t (56) = -1.40, p = 0.29. There were no other significant differences.

2.3.3 Analyses of Attentional bias

In order to analyse the extent and role of alcohol related attentional bias both indirect and direct measures will be reported separately in relation to levels of consumption and levels of craving. Furthermore analyses will be reported separately for grids and scenes for both heavy and light social drinkers as well as for high and low alcohol cravers.

As a result multiple comparisons were conducted, however comparisons were deemed significant at the standard $p < 0.05$ level. Bonferroni corrections are most commonly applied when multiple comparisons are used in order to reduce the likelihood of making a type 1 error, however these corrections have been deemed overly conservative and likely to increase the chances of making a type 2 error (Perneger,1998). A multivariate approach may possibly have been utilised as a multivariate analysis of variance (MANOVA) is thought to reduce the likelihood of making a type 1 error (Field, 2009). However if the aim of the research project is to establish if the groups differ on each variable and there is no interest in a composite of the outcome variables, as was the case in this study, then a MANOVA is not appropriate and multiple comparison approach should be conducted (Huberty & Morris, 1989). Analyses in this experiment were exploratory in nature therefore, due to the issues regarding bonferroni corrections and multivariate approaches, significance levels were left uncorrected.

The following indirect parameters were analysed.

- *Behavioural attentional bias* was assessed by calculating for each participant, the proportion of alcohol changes detected compared to neutral changes detected separately for trials consisting of grid stimuli and real world scene stimuli.
- *Alcohol related change detection latency* was assessed by calculating the mean time per trial, averaged for each participant, to detect an alcohol related change separately for trials consisting of grid stimuli and real world scene stimuli, when alcohol changes were detected.

Eye movements were measured in relation to saccades to, and fixations on alcohol and neutral stimuli, therefore interest areas had to be defined on the stimuli using Dataviewer (SR Research, Ontario, Canada) in order to accurately measure eye movements in relation to the stimuli of interest. In real world scenes interest areas were defined around the neutral and alcohol related stimuli which changed. As a result interest areas were defined differently on each trial, with the interest area being the smallest area to cover the largest target object. The same size area was then used to mark the interest area of the other object. Therefore interest areas varied across scenes but were the same within each trial for both objects. As between groups analysis would be conducted this posed no issue. Areas of interest were defined in grids as the stimuli and the surrounding area of each cell of the 4 x 4 matrix. Therefore all interest areas in the grids were exactly the same size.

The following direct parameters were analysed:

- *Proportion of first saccades to alcohol related stimuli*

  This was assessed by calculating the proportion of first saccades to an alcohol related stimulus compared to a neutral stimulus separately for trials consisting of grid stimuli and real world scene stimuli, per participant.

- *Time to initially fixate on alcohol related stimuli*

  This was calculated by the mean time per trial to initially fixate on an alcohol related stimulus averaged for each participant separately for trials consisting of grid stimuli and real world scene stimuli.

- *Proportion of fixations on alcohol related stimuli*

  This was assessed by calculating the total number of fixations on alcohol related stimuli compared to neutral stimuli for each participant for each trial. These were then averaged for each participant separately for trials consisting of grid stimuli and real world scene stimuli. This procedure was used in order to control for the different number of fixations generated in different trials.

- *Fixation durations on alcohol related stimuli*

  This was assessed by calculating a running total of fixation time by attributing neutral fixations as negative and alcohol fixations as positive for each sequential fixation in each trial, which were then averaged per participant, separately for trials consisting of grid stimuli and real world scene stimuli. Therefore more time spent on alcohol related stimuli was reflected as a positive value and more time spent on neutral stimuli as a negative value.

2.3.3.1 Indirect measures of attentional bias

Indirect measures of attentional bias are presented in table 2.2 for both heavy and light social drinkers and high and low alcohol cravers.

Table 2.2: Indirect measures of attentional bias: social users of alcohol

	Consumption			Craving		
	Heavier (n=29)	Lighter (n=29)		Higher (n=29)	Lower (n=29)	
	M (SD)	M (SD)	Sig.	M (SD)	M (SD)	Sig.
Grids						
Proportion of alcohol changes detected	0.45 (0.14)	0.43 (0.10)	> 0.05	0.45 (0.13)	0.43 (0.12)	> 0.05
Mean RT of alcohol related change detected (ms)	6047.95 (1771.07)	6765.93 (2957.62)	> 0.05	6425.66 (2656.59)	6388.22 (2256.76)	> 0.05
Scenes						
Proportion of alcohol changes detected	0.72 (0.11)	0.64 (0.15)	0.03	0.72 (0.15)	0.64 (0.12)	0.04
Mean RT of alcohol related change detected (ms)	5514.95 (2004.42)	6165.97 (2274.04)	> 0.05	5810.76 (2268.72)	5870.16 (2063.86)	> 0.05

Indirect measures of attentional bias in relation to consumption

Independent t-tests were used to assess if there were any significant differences in alcohol related attentional bias as measured by the proportion of alcohol changes detected and the time taken to detect alcohol related changes between heavy social drinkers and light social drinkers. Analysis was conducted separately for trials using grid stimuli and trials using real world stimuli. Analysis demonstrated that heavier social drinkers detected a higher proportion of alcohol related changes compared to lighter social drinkers in real world stimuli, t(56) = -2.28, *p*=0.03, d = 0.60. There were no other significant group differences.

Indirect measures of attentional bias in relation to craving

Independent t-tests were used to assess if there were any significant differences in alcohol related attentional bias as measured by the proportion of alcohol related changes detected and the time taken to detect alcohol related changes between high alcohol cravers and low alcohol cravers. Analysis demonstrated that higher alcohol cravers detected a higher proportion of alcohol related changes compared to lower alcohol cravers again in real world stimuli only, t(56) = -2.93, *p*=0.04, d = 0.56. There were no other significant group differences.

2.3.3.2 Direct measures of attentional bias

Direct measures of attentional bias are presented in table 2.3 for both heavy and light social drinkers and high and low alcohol cravers. In order to assess the different attentional components, initial orienting of attention was measured by the proportion of first saccades to alcohol related stimuli relative to neutral stimuli, and the time taken to initially fixate on alcohol related stimuli. Maintained attention was measured by the proportion of fixations on alcohol stimuli relative to neutral stimuli, and the duration of fixations on alcohol related stimuli relative to neutral stimuli.

Direct measures of attentional bias in relation to consumption

Comparisons by way of independent t-tests demonstrated no significant differences in the initial orienting of attention to alcohol related stimuli or maintained attention on alcohol related stimuli for either simple grid stimuli or real world scenes between heavy social drinkers and light social drinkers.

Direct Measures of attentional bias in relation to craving

Independent t-tests were used to assess any differences between high alcohol cravers and low alcohol cravers in terms of initial orienting of attention to alcohol related stimuli and maintained attention on alcohol related stimuli. Analysis demonstrated that higher alcohol cravers were significantly faster to initially saccade to alcohol related stimuli in real world scenes compared to lower cravers, $t(56) = 2.60$, $p=0.01$, $d = 0.69$. There were no other significant group differences.

Table 2.3: Direct measures of attentional bias: social users of alcohol

	Consumption			Craving		
	Heavier (n=29)	Lighter (n=29)		Higher (n=29)	Lower (n=29)	
	M (SD)	M (SD)	Sig.	M (SD)	M (SD)	Sig.
Grids						
Proportion of 1st saccades to alcohol related stimuli	0.47 (0.02)	0.51 (0.02)	> 0.05	0.47 (0.11)	0.52 (0.10)	> 0.05
Mean time to initially saccade to alcohol related stimuli (ms)	2301.58 (409.42)	2357.77 (616.46)	> 0.05	2299.74 (428.18)	2359.60 (603.40)	> 0.05
Proportion of fixations on alcohol related stimuli	0.46 (0.09)	0.45 (0.06)	> 0.05	0.45 (0.09)	0.46 (0.06)	> 0.05
Duration of fixations on alcohol related stimuli (ms)	-300.96 (607.23)	-290.44 (470.65)	> 0.05	-307.33 (592.00)	-284.06 (489.44)	> 0.05
Scenes						
Proportion of 1st saccades to alcohol related stimuli	0.29 (0.43)	0.25 (0.43)	> 0.05	0.32 (0.47)	0.32 (0.46)	> 0.05
Mean time to initially saccade to alcohol related stimuli (ms)	5159.91 (2925.19)	5470.02 (3128.13)	> 0.05	4338.61 (2329.45)	6291.32 (3315.22)	0.01
Proportion of fixations on alcohol related stimuli	0.53 (0.02)	0.51 (0.02)	> 0.05	0.50 (0.14)	0.54 (0.13)	> 0.05
Duration of fixations on alcohol related stimuli (ms)	376.65 (41.77)	319.02 (60.09)	> 0.05	363.90 (270.04)	331.76 (289.14)	> 0.05

2.3.4 First trial only analysis

In order to directly compare to, and extend previous research by Jones and colleagues (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006) who employed only one trial per participant, both indirect and direct measures of attentional bias were also calculated for the first trial only. In direct comparison to Jones et al., (2006) all participants viewed a simple grid stimulus on the first trial.

Indirect measure of attentional bias

Chi square analysis was conducted to compare the number of alcohol related changes detected on the first trial only between heavy social drinkers (63%) and light social drinkers (61 %), χ^2 (1) =0.03, p = 0.86 and between high alcohol cravers (68%) and low alcohol cravers (55%) , χ^2 (1) =0.88, p = 0.35. As can be seen from the analysis there were no significant group differences. The change detection latency was not assessed as it was not deemed to be meaningful to look at the difference between the heavy and light social drinkers who detected the alcohol related change and the high and low alcohol cravers who detected the alcohol related change. This decision was made as there were no group differences in terms of whether an alcohol related change was detected in the first trial and the group sizes which would be analysed due to the number of those in each group who actually detected the alcohol change would be markedly reduced.

Direct measures of attentional bias

Initial orienting of attention was assessed by whether the participant's first saccade was to an alcohol related stimulus in the first trial as well as the time taken to initially fixate on alcohol related stimuli in the first trial. Maintained attention was measured by the proportion of fixations on alcohol related stimuli relative to neutral stimuli, and the duration of fixations on alcohol related stimuli in the first trial only. See table 2.4 for descriptive statistics.

Table 2.4: First trial only descriptive statistics: social users of alcohol

	Consumption			Craving		
	Heavier (n=29)	Lighter (n=29)		Higher (n=29)	Lower (n=29)	
	M (SD)	M (SD)	Sig.	M (SD)	M (SD)	Sig.
Proportion of 1st saccades to alcohol related stimuli	48%	50%	> 0.05	41%	57%	> 0.05
Mean time to initially saccade to alcohol related stimuli (ms)	1194.40 (1133.47)	1872.00 (2955.75)	> 0.05	1651.17 (2124.15)	1424.31 (2381.84)	> 0.05
Proportion of fixations on alcohol related stimuli	0.37 (0.19)	0.39 (0.18)	> 0.05	0.40 (0.17)	0.37 (0.20)	> 0.05
Duration of fixations on alcohol related stimuli (ms)	-892.44 (2462.70)	-708.64 (2928.20)	> 0.05	-730.83 (2405.05)	-866.86 (2922.63)	> 0.05

A chi square analysis was used to assess group differences between heavy social drinkers and light social drinkers as well as between high alcohol cravers and low alcohol cravers in terms of the first saccade being to alcohol related stimuli. Independent t tests were used to assess all other group differences in the remaining direct measures of attention. Analysis demonstrated no significant group differences in alcohol related attentional bias on any of the direct measures between heavy social drinkers and light social drinkers or between high alcohol cravers and low alcohol cravers.

2.4 Discussion

The main aim of this experiment was to examine to what extent initial orienting of attention to and maintained attention on alcohol related stimuli were related to levels of alcohol consumption and levels of subjective alcohol craving in social drinkers. The experiment also sought to examine methodological aspects which may influence the measurement of attentional bias such as the effect of the type of stimuli used and the number of trials employed. Several key findings emerged from the analysis.

When assessing alcohol related attentional bias using indirect measures of visual attention across multiple trials, but only when real world scenes were viewed, a greater proportion of alcohol related changes were detected by heavier drinkers and higher cravers compared to lighter drinkers and low cravers, as would be predicted by IST models of addiction (Franken, 2003 Robinson & Berridge, 1993). As highlighted previously however, indirect measures have been argued by Mogg et al., (2004)to take an over simplistic view of attention as they fail to distinguish between different sub-components which are thought to play possibly differential roles in the control of behaviour (Hogarth et al., 2008; Pearce & Hall, 1980). When using direct measures of visual attention however, only subjective craving appeared to be associated with an alcohol related attentional bias but only in the form of initial orienting of attention, as alcohol related stimuli captured the attention of high cravers more quickly than low cravers when viewing real world scenes. Interestingly, levels of alcohol consumption were not associated with either initial orienting of attention to or maintained attention on alcohol related stimuli. Additionally, there were no differences between consumption groups and between craving groups on any direct or indirect measures of attentional bias when simple grid stimuli were employed or when the first trial only was assessed.

The present study directly examined the relationships between the sub-components of attentional bias as argued by the IST models of addictive behaviours (Franken, 2003; Robinson & Berridge, 1993) with both levels of subjective craving and levels of consumption by analysing the initial orienting of attention to alcohol related stimuli and maintained attention on alcohol related stimuli using eye tracking. Importantly, the present study measured such biases within one single visual scene, incorporating stimuli arguably more representative of the environments which may actually give rise to attentional biases (Nees et al., 2012). As a result, the present study overcame many of the possible methodological and measurement limitations of previous research, as discussed in chapter 1 and section (2.1).

The results of the present study however are only partially consistent with IST models of addiction (Franken, 2003; Robinson & Berridge, 1993), demonstrating that subjective craving is associated with the ability of an alcohol related cue to capture attention but not the ability of the cue to hold attention. Interestingly, however the present study demonstrated that alcohol related attentional biases were not related to levels of alcohol consumption in social drinkers, contrary to what both IST models would have predicted and research using indirect measures of attention, including from the present study would have suggested (Jones et al., 2002; Jones et al., 2003). This finding therefore suggests that Jones and colleagues due to the reliance on indirect measures of attentional bias may have been premature to suggest that substance related attentional biases exist on a graded continuum relative to consumption level (Bruce & Jones, 2004) and further highlights the importance of employing direct measures of attention in future research.

Research to date has largely neglected to examine the relationship between attentional bias and subjective craving (Field & Cox, 2008) making comparisons to previous research difficult. Findings of the limited number of studies which have examined the relationship however are contradictory and a meta-analysis of these studies has demonstrated only a weak relationship between subjective craving and substance related attentional bias (Field et al., 2009). As highlighted previously (section 2.1) these studies are constrained by the shortcomings of employing either the Stroop task or Visual probe task as a measure of substance related attentional biases limiting any conclusions which can be drawn.

Field et al., (2005) although subject to the limitations of the visual probe task and the reliance on indirect measures of attention has however also demonstrated in line with the findings of the present study that in social drinkers, attentional bias was associated with subjective craving but not levels of alcohol consumption. These findings appear to pose potential conceptual problems for IST models of addictive behaviours as it would be expected that alcohol related stimuli should capture attention due to its motivational salience, but that it should then become the focus of attention, meaning that a bias in maintained attention should be evident, increasing wanting and thus make self-administration of the substance a key goal. Therefore, suggesting that there should also be an association between subjective craving and maintained attention and a relationship between the sub-components of attentional biases and levels of alcohol consumption. However, there are several possible explanations as to why in the present study alcohol related attentional biases were only found to be associated with levels of subjective craving in the form of a bias in the initial orienting of attention.

One possible explanation is that the relationship between subjective craving and subsequent consumption may not be as simple as the IST models of addictive behaviours would predict for social users of a substance as other factors may influence this relationship. For example, in social users of alcohol different social factors and alcohol outcome expectancies, particularly positive expectancies, have been shown to predict variability in levels social alcohol consumption (Lee, Greely & Oei, 1999).

Another possible explanation relates to levels of impulsivity. Impulsivity has not only been shown to predict variability in levels of consumption between social substance users and dependent substance users, with heavier use being associated with higher levels of impulsivity (de Wit, 2009) but it has also been related to attentional processes. There is debate regarding the definition of impulsivity but it is conceptualised as a multi-factorial construct and there are two relatively independent factors, which have been implicated as being important in addictive behaviours. Firstly deficits in inhibitory control and secondly impulsive decision making, such that individuals will consistently choose immediate rewards despite the future negative consequences of the reward (Olmstead et al., 2006; Reynolds, Ortengren, Richards & De wit, 2006). Although the relationship between impulsivity and substance related attentional biases has received little attention within the literature (Lui, et al., 2011), researchers have argued that individuals who are less impulsive may be less affected by the motivational properties of the stimuli and with high inhibitory control are able to inhibit such motivational stimuli (Fadardi and Cox, 2006; Murphy & Garavan, 2007; Papachristou, Nederkoorn, Havermans , van der Horst & Jansen , 2012). The present study and that of Field et al., (2005) were conducted on social users of alcohol for whom lower levels of impulsivity have been associated, relative to dependent users (de Wit, 2009). It may therefore be suggested that due to the associated higher level of inhibitory control and the reduced effects of the motivational properties of the stimuli associated with lower levels of impulsivity, that the participants in the present study may have been more able to inhibit the alcohol related stimuli compared to dependent users who are associated with higher levels of impulsivity. Therefore due to the increased likelihood of inhibiting the substance related stimuli, biases in maintained attention, whether in relation to subjective craving or levels of consumption may not be evident in levels of social use. As a consequence, levels of impulsivity may mediate the relationship between attentional bias, subjective craving and levels of use, suggesting that sub-components of attentional bias may play differing roles across levels of use. This however remains to be empirically tested.

Although this may indeed be the case, it is however possible that the non-significant findings in relation to maintained attention were due to task demands. Rensink et al., (1997) argues that participants would have had to have been focused on the changing stimulus in order to detect the change. However, once the change was detected by the participants the trial ended which may possibly limit the ability of maintaining attention on the target stimulus. Therefore it may be possible that maintained attention is associated with subjective craving and underlies the variability in consumption levels even at social use, but due to possible task limitations the present study has been unable to demonstrate it.

In addition to examining the extent and roles of the sub-components of attentional biases in social drinkers the present experiment also sought to examine methodological aspects which may influence the measurement of attentional bias, such as the type of stimuli used and the number of trials employed. Previous research employing the flicker ICB task to measure attentional bias in alcohol users have used only one trial per participant as they argued that after one trial participants may employ search strategies in order to detect the change (Jones et al., 2002; Jones et al., 2003 and Jones et al; 2006). These studies however demonstrated inconsistent findings as although Jones et al., (2002) and Jones et al., (2003) were able to demonstrate a greater alcohol related attentional bias in heavier social drinkers, Jones et al., (2006) failed to replicate such a finding. The first trial in the present study in which all participants viewed a simple grid stimulus, was analysed using both indirect measures of attention equivalent to previous research and direct measures of attention. Interestingly the results supported those of Jones et al., (2006) as there was no evidence of a relationship between alcohol related attentional bias and levels of alcohol consumption or subjective craving.

Jones et al., (2006) had previously suggested that their inconsistent results may have been due to the differences in the variation of alcohol use across the studies. Jones et al., (2006) reported that the variation in alcohol use in their study (Median =7.3, semi-interquartile range = 2.2) was much smaller than the variation in their earlier study (Jones et al., 2003; Median = 12.9, semi interquartile range =7.1, which did demonstrate a relationship between alcohol related attentional bias and level of social alcohol use. The variation in alcohol use of the social drinkers in the present study however, (Median = 19.75, semi-interquartile range = 11.15) was larger than Jones et al., (2003) and still failed to detect any difference between heavy and light social drinkers or high and low alcohol cravers, even when employing direct measures of attention when assessing the first trial only. Additionally however, the present study also analysed alcohol related attentional biases over multiple trials when viewing grid stimuli and real world scene stimuli. Results showed that when attentional biases were measured over multiple trials their remained no attentional bias when viewing grid stimuli but an alcohol related attentional bias was evident when viewing real world scenes.

It has to be acknowledged however that the present study on account of the design meant that all participants were shown a simple grid stimulus on their first trial. As a result alcohol related attentional biases when viewing real world scenes could only be measured over multiple trials, therefore it is unclear if such biases would be evident or comparable to when viewing a real world scene stimulus on the first trial. Although this pattern of results limits any conclusions which can be drawn in terms of whether attentional biases as measured using only one trial or multiple trials are equivalent they nonetheless highlight the possibility that the type of stimuli employed may possibly modulate the alcohol related attentional biases which are evidenced, possibly helping to explain current inconsistent findings within the literature.

The present study utilised both simple grid stimuli and complex real world stimuli, however interestingly alcohol related attentional biases were only evident in trials displaying complex real world stimuli. Jones and colleagues research utilised both simple grid stimuli similar to that in the present study (Jones et al., 2006) and stimuli consisting of objects bi-laterally grouped on a table top representing “clutter”

(Jones et al., 2002; Jones et al., 2003). Upon consideration of the findings in terms of which stimuli was used, it would appear that when simple grid stimuli are employed social drinkers do not demonstrate alcohol related attentional biases (the present study and Jones et al., 2006), however when real world scene stimuli (the present study) or bi-laterally grouped stimuli are employed (Jones et al., 2002; Jones et al., 2003), alcohol related attentional biases are evident in social drinkers. When taken together, this pattern of results highlights the possibility that the type of stimuli used may impact the sensitivity of the flicker ICB to measure attentional bias.

One possible explanation is that real world scenes used in the present study may be more ecologically valid especially as context has been shown to influence cue reactivity (Nees et al., 2012). Therefore these stimuli may more accurately represent the environments which may give rise to attentional bias and therefore more reliably evidence attentional biases, compared to when simple grid stimuli is used. The stimuli employed by Jones et al., (2002) and Jones et al., (2003) could be suggested to be more ecologically valid compared to the simple grid stimuli (Jones et al., 2006) as the stimuli in these studies although bi-laterally grouped are presented as "clutter" on a table top which may be argued to be more indicative of a real life scenario compared to individual objects being presented on a white background in a grid formation.

Another possibility however is that the simple grid stimuli such as that used in the present study and Jones et al., (2006) which failed to demonstrate any differential attentional bias between social drinkers, may encourage the use of search strategies in order to detect the changing object. This is due to their perfect spatial structure compared to that of the bi-laterally grouped stimuli and the real world scene stimuli. Research has indeed, demonstrated that participants show a systematic component in their scan paths during a visual search task and that the extent is modulated by the degree of structure of the stimuli (Gilchrist & Harvey, 2006). Gilchrist and Harvey (2006) defined strategic scanning as starting at one place in a display and working your way systematically through sections of the display. They measured this strategic scanning in terms of a bias in saccade direction, on the basis that there is often a bias in the direction of saccades in visual search and that this bias reflects a systematic process rather than a random process (Williams, 1966). Gilchrist and Harvey (2006) showed that strategic scanning was strongest in perfectly structured grids and reduced as the degree of structure of the stimuli reduced. Therefore if this is the case and strategic scanning is employed when utilising the flicker ICB, this may then limit the effectiveness of measuring attentional bias to substance related stimuli, although this may be dependent on the structure of the stimuli employed.

It has to be noted however that although Jones et al., (2006) using perfectly structured grid stimuli failed to demonstrate an alcohol related attentional bias in social users of alcohol they did demonstrate an alcohol related attentional bias in problem drinkers using simple grid stimuli, whereby, the degree of attentional bias was associated with problem severity. In addition, Yaxley and Zwaan (2005) demonstrated using a scene depicting 8 objects presented in a perfectly spatially structured line, a smoking related attentional bias in dependent smokers compared to non-smokers, however this was over multiple trials. As substance related attentional biases have been demonstrated when using perfect spatially structured stimuli in dependent substance users and not social users, it may be that the incentive motivation that alcohol related stimuli acquire in social users may not be strong enough to override the task demands of visual search (i.e. strategic scanning). However, when using such perfectly structured stimuli, the motivational salience of the stimuli is strong enough in problem/dependent users. Nonetheless, the present pattern of results suggest that the types of stimuli used when employing the flicker ICB may influence the sensitivity of the flicker ICB to measure substance related attentional bias which not only helps to explain the inconsistent results but will be an important aspect of methodology for future research to consider.

In conclusion of experiment 1a, by directly measuring the attention of social drinkers as they completed the flicker ICB task utilising both simple grid stimuli and real world scene stimuli, results revealed in line with IST models of addictive behaviours that alcohol related attentional bias, in terms of the ability of alcohol related cues to capture attention is associated with subjective craving. Inconsistent with the IST models of addictive behaviours however, the present study was unable to demonstrate an association between maintained attention and subjective craving as well as any association between levels of consumption and measures of attentional bias in social users of alcohol. In addition the present study highlighted possible methodological limitations when employing the flicker ICB in terms of the type of stimuli used and the number of trials employed. The findings from the present study highlight potential conceptual issues for IST models as well as raise possible methodological issues in terms of the effectiveness of the flicker ICB to measure attentional bias. The conclusions which can be drawn from this study however are limited in that they may be a result of examining social users of an addictive substance. Therefore research examining dependent users merits further examination.

2.5 Experiment 1b- An examination of smoking related attentional biases in smokers and non - smokers using the flicker ICB employing eye tracking.

As discussed in Chapter 1, conclusions that can be drawn from research to date examining the extent and roles of substance related attentional biases in addictive behaviours remain unclear. This is most likely due to the limitations of the tasks employed to measure attentional bias, such as the Stroop task and Visual probe task. However even when the flicker ICB task, an arguably more sensitive task to measure attentional bias is used, potential methodological limitations in terms of neglecting to examine the relationship between attentional biases and subjective craving, the type of stimuli used and a reliance on indirect measures of attention still cloud our understanding.

Experiment 1a aimed to improve upon previous research by examining alcohol related attentional bias in social drinkers by monitoring participants eye movements whilst they completed the flicker ICB task utilising both simple grid like stimuli similar to previous research (Jones et al., 2006) and real world scene stimuli. In addition the study aimed to examine not only the relationship between different components of attentional bias and alcohol consumption but also the relationship between the different components of attentional bias and subjective alcohol craving.

The findings from experiment 1a however only provided partial support for the predictions of IST models of addictive behaviours (Franken, 2003; Robinson & Berridge 1993). The results demonstrated that although alcohol related attentional bias in terms of initial orienting of attention was associated with levels of subjective craving, there was no association with maintained attention or any association with the different components of attentional bias and levels of alcohol consumption. I postulated earlier that these findings may be as a result of examining social users of an addictive substance rather than dependent users, therefore suggesting that the extent and roles of components of attentional bias at the various stages of consumption may differ possibly as a result of levels of impulsivity. However I also postulated that they may be due to the task demands of the flicker ICB which may possibly limit its ability to effectively measure maintained attention. Research conducted using the flicker ICB task to measure alcohol and smoking related attentional biases in dependent users however have several shortcomings and so limit any conclusions which can be drawn (Jones et al., 2006; Yaxley & Zwann, 2005). Both studies relied on indirect measures of attention and so fail to make the important distinction between different components of attention, which may play differing roles in the control of behaviour (Pearce & Hall, 1980; Hogarth et al., 2008). Furthermore, Jones et al., (2006) neglected to examine the role of craving and Yaxley and Zwann (2005) neglected to consider the relationships between smoking related attentional bias and levels of use, subjective craving and dependence.

In addition the alcohol related attentional bias as measured indirectly or directly by eye movements in experiment 1a were only evident in stimuli depicting real world scenes. As highlighted earlier this may be due to the scenes being more representative of the environments which may give rise to attentional biases or alternatively it may be due to the structure of the grids encouraging the use of strategic scanning (Gilchrist &Harvey, 2006) or a combination of both. However, Jones et al., (2006) used perfectly structured grids similar to experiment 1a and Yaxley and Zwann (2005) using a spatially structured line up of 8 objects were able to demonstrate an attentional bias in dependent users. Therefore as suggested previously it is possible that the incentive motivation that alcohol related stimuli acquire in social drinkers may not be strong enough to override the task demands (strategic scanning) of visual search when using perfectly structured stimuli in the flicker ICB, however it may be strong enough in dependent users. Therefore although the types of stimuli used may influence the sensitivity of the flicker ICB to measure substance related attentional bias it may only be when examining social users of an addictive substance.

The aim of experiment 2b is to therefore examine substance related attentional biases employing the same methodology as experiment 1a with the exception of testing dependent users of an addictive substance. As such experiment 2b sought to examine smoking related attentional bias between smokers and non-smokers and further assess smoking related attentional biases in relation to levels of subjective craving, levels of consumption and levels of dependence. The present study also sought to examine the influence of stimuli type and the number of trials on the sensitivity of the flicker ICB to measure substance related attentional bias.

The research questions that this study sought to address were:

1) Do smokers compared to non-smokers demonstrate a smoking related attentional bias in both simple grid stimuli and real world scene stimuli?
2) To what extent are initial orienting of attention to smoking related stimuli and maintained attention on smoking related stimuli related to levels of cigarette use, nicotine craving and nicotine dependence when employing both simple grid stimuli and real world scene stimuli?

3) Are the measures of smoking related attentional bias as examined in the first trial only comparable to smoking related attentional bias as measured over multiple trials?

2.6 Method

2.6.1 Participants

In total, 294 participants completed the CABQ (see section 2.6.3) in order to screen participants for smokers and non- smokers. Of these participants 80 undergraduate and postgraduate students (38 male and 42 female, mean age 23.78, S.D. = 6.19) took part in the experimental phase. Again, participants were advised that the aim of the study was to investigate attention and so were naïve to the true purpose of the study. This was done to ensure that participants were not primed to look for smoking related changes in the flicker ICB task (Yaxley & Zwaan, 2005). The eligibility criteria for inclusion in the study were the same as Experiment 1a. This study was conducted under ethical approval, granted by the University of Strathclyde Psychology Departmental Ethics Committee.

2.6.2 Stimuli

The stimuli consisted of grid stimuli and real world scene stimuli and were created in an identical fashion to those in experiment 1a (section 2.2.2), with the exception that it was matched smoking and neutral stimuli that were incorporated instead of alcohol related stimuli.

2.6.3 Measures

Questionnaire of Smoking Urges

The brief version of the Questionnaire of Smoking Urges (QSU-Brief; Cox, Tiffany & Christen, 2001) (Appendix F) is a 10 item self-report measure of cigarette craving covering both positive and negative subscales such as "a cigarette would taste good now" and "smoking would make me less depressed." Participants are asked to rate each of the 10 items on a scale of 0 to 100 and scores are calculated by averaging the item scores, with higher scores indicating higher craving. The QSU- Brief has good construct reliability and validity with reported Cronbachs α ranging between 0.84 - 0.93 (Doran, Cook, McChargue & Spring, 2009)

Fagerstrom Test for Nicotine Dependence

The Fagerstrom Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker & Fagerstrom, 1991) (Appendix G) is a 6 item self-report measure of nicotine dependence designed to correlate with physiological measures of nicotine tolerance. Scores can range from 0-10 with higher scores indicating greater levels of nicotine dependence. The FTND has shown reliable internal consistency with a Cronbachs α 0.64 and test – retest reliability of 0.88 (Pomerleau, Solange, Carton, Lutzk, Flessland & Pomerleau, 1994)

Smoking Timeline Follow Back (STLFB)

The smoking timeline follow back is based on the alcohol TLFB developed by Sobell & Sobell, (1992) (Appendix H). The STLFB presents participants with a calendar layout for the last 7 days and asks participants to provide a retrospective estimate of the number of cigarettes smoked over this time period including brand. In addition the questionnaire collects details on gender, age, and time of last cigarette.

College Activities and Behaviours Questionnaire (CABQ)

The College Activities and Behaviours Questionnaire (CABQ; Pennebaker, Colder, & Sharp, 1990) (Appendix I) is a general inventory of objective behaviours and activities commonly performed by students. As participants were being recruited naïve to the study smokers could not be specifically targeted. As such the number of smokers and non-smokers taking part in the experiment were unequal. In order to counteract this, an online version of the CABQ was used to screen participants, with those reporting smoking in the previous week being invited to take part in the experiment. The CABQ asks participants to rate how many times in the previous week they have done particular activities and behaviours. There are 22 items, primarily reflecting social activity and health-related behaviours. For example; "talked on the phone to old friends who are not at your college", "number of times had difficulty falling asleep" as well as asking how many times in the last week they have consumed any of the following; alcohol, cigarettes, coffee, prescribed drugs, non- prescribed drugs, sugary snacks, pain relievers or vitamins. As the CABQ pertains to a variety of activities and behaviours, its use to screen participants for smokers remains concealed and participants remained naïve to the true purpose of the study.

2.6.4 Apparatus and Procedure

The apparatus and procedure were identical to experiment 1a (section 2.2.4) with the following exceptions (i) As smokers and non-smokers were not specifically recruited to the study in order to keep them naïve to the true purpose of the study, participants first had to complete the CABQ in order to screen for equal numbers of smokers and non-smokers (ii) participants completed smoking related questionnaires to measure craving, consumption and dependence on completion of the flicker ICB task.

2.7 Results

2.7.1 Eye movement and response errors

In line with previous research, trials were removed from analysis in which the participant failed to detect a difference, anticipated the stimulus appearance by making a saccade with a reaction time shorter than 80ms or were improperly fixated on the central fixation point (a deviation larger than 1°) at the start of the trial. These criteria resulted in 9.81% trials being excluded from subsequent analysis.

2.7.2 Group Characteristics

In total 80 participants took part in the project however 3 participants were removed from the analysis as they reported being former smokers (recruited prior to the introduction of the CABQ) and one participant was removed from analysis as they reported an allergy to cigarettes. The non-smoking group consisted of 40 participants (19 male, 21 female), mean age of 22.85 (SD = 4.83) years who had reported having never smoked cigarettes regularly. The smoking group consisted of 36 participants (18 male and 18 female) with a mean age of 24.92 (SD = 6.37) years who reported smoking on average 9.06 (SD = 6.74) cigarettes per day. The smokers had a mean FTND score of 2.28 (SD= 2.46) which indicates low dependence and a mean craving score of 22.07 (SD= 22.05) which indicates low craving. The groups did not differ in gender ratios χ^2 (1, n= 79) = 0.05, $p = 0.83$ or age, t (74) = 1.60, $p = 0.11$.

2.7.3 Analysis of Attentional bias

The calculation of both indirect and direct measures of smoking related attentional bias, were calculated in line with the procedures adopted in experiment 1a, as outlined in section (2.3.3).

2.7.3.1 Indirect measures of smoking related attentional bias

The descriptive statistics for the indirect measures of smoking related attentional bias of smokers and non- smokers are presented in table 2.5.

Table 2.5: Indirect measures of attentional bias: Smokers and non- smokers

	Smoker (n=36)	Non-smoker (n=40)	
	M (SD)	M (SD)	Sig.
Grids			
Proportion of smoking relates changes detected	0.46 (0.13)	0.46 (0.13)	> 0.05
Mean reaction time to detect smoking related changes (ms)	5431.00 (2053.84)	6473.63 (2325.33)	0.03
Scenes			
Proportion of smoking relates changes detected	0.62 (0.15)	0.56 (0.13)	0.04
Mean reaction time to detect smoking related changes (ms)	5292.39 (2755.06)	5828.03 (2516.87)	> 0.05

Independent t-tests were used to assess if there were any significant differences in smoking related attentional bias as measured by the proportion of smoking changes detected and the time taken to detect smoking related changes between smokers and non-smokers. In line with experiment 1a, analysis was conducted separately for trials using grid stimuli and trials using real world scene stimuli. Analysis demonstrated that smokers detected a higher proportion of smoking related changes compared to non-smokers in real world stimuli, $t(74) = 1.79$, $p=0.04$, d = 0.43 and that smokers were quicker than non-smokers to detect smoking related changes in grid stimuli, $t(74) = -2.24$, $p=0.03$, $d = 0.47$ There were no other significant group differences.

2.7.3.2 Direct measures of smoking related attentional bias

In line with experiment 1a, in order to assess the different attentional components, initial orienting of attention was measured by the proportion of first saccades to smoking related stimuli relative to neutral stimuli, and the time taken to initially fixate on smoking related stimuli. Maintained attention was measured by the proportion of fixations on smoking related stimuli relative to neutral stimuli, and the duration of fixations on smoking related stimuli.

Descriptive statistics for the direct measures of smoking related attentional bias for smokers and non-smokers are presented in table 2.6. Independent t-tests were used to assess if there were any significant differences in smoking related attentional bias as measured directly by the monitoring of eye movements. In line with experiment 1a, analysis was conducted separately for trials using grid stimuli and trials using real world scene stimuli.

Table 2.6: Direct measures of attentional bias: Smokers and non- smokers

	Smokers (n=36)	Non- Smokers (n=40)	
	M (SD)	M (SD)	Sig.
Grids			
Proportion of 1st saccades to smoking related stimuli	0.50 (0.11)	0.47 (0.13)	> 0.05
Mean time taken to initially saccade to smoking related stimuli (ms)	750.64 (170.79)	876.74 (302.13)	0.03
Proportion of fixations on smoking related stimuli	0.48 (0.07)	0.47 (0.07)	> 0.05
Mean duration of fixations on smoking related stimuli (ms)	-152.08 (500.86)	-61.40 (548.83)	> 0.05
Scenes			
Proportion of 1st saccades to smoking related stimuli	0.38 (0.48)	0.35 (0.48)	> 0.05
Mean time taken to initially saccade to smoking related stimuli	2531.31 (1731.97)	3652.99 (2579.33)	0.03
Proportion of fixations on smoking related stimuli	0.46 (0.14)	0.40 (0.14)	0.06
Mean duration of fixations on smoking related stimuli (ms)	209.02 (277.97)	159.30 (238.41)	> 0.05

In terms of initial orienting of attention, analysis demonstrated that smokers where quicker than non-smokers to initially saccade to smoking related stimuli in both grids, t (62.78) = -2.27, p=0.03, d = 0.51 and scenes, t (68.66) = -2.25, p = 0.03, d = 0.51. In terms of maintained attention, there was a trend towards significance indicating that smokers demonstrated a greater proportion of fixations on smoking related stimuli compared to non-smokers in real world scene stimuli, $t(74) = 1.88$, p = 0.06, d = 0.43 . There were no other significant group differences in direct measures of attention.

2.7.3.3 Relationships between smoking related variables

Pearson correlations were conducted between the smoking-related variables: average number of cigarettes smoked per day (STLFB), craving (QSU) nicotine dependence (FTND) and time since last cigarette. Higher levels of cigarettes on average smoked per day was significantly associated with higher levels of craving, r (36) = 0.46, p <0.01 and higher rates of nicotine dependence, r (36) = 0.68, p<0.001, with a shorter time since last cigarette approaching significance r (36) = -0.32, p = 0.06. Higher levels of craving were significantly associated with higher levels of dependence, r (36) = 0.58, p <0.001 however neither levels of craving or dependence were associated with time since last cigarette (p >0.5).

2.7.3.4 Relationships between smoking variables and indirect measures of attentional bias

Pearson correlations were conducted separately for grids and scenes between the smoking variables: average number of cigarettes smoked per day (STLFB), craving (QSU) and nicotine dependence (FTND): proportion of smoking related changes detected and the time taken to detect smoking related changes. Higher levels of cigarettes on average smoked per day was significantly associated with detecting a higher proportion of smoke related changes in grids, r (36) = 0.35, p = 0.04. Approaching significance were relationships between higher levels of cigarettes smoked on average per day and higher rates of nicotine dependence with shorter reaction times to detect smoking related changes in scenes, r (36) = -.033, p = 0.05 and , r (36) = -.033, p = 0.05, respectively. There were no other significant correlations.

2.7.3.5 Relationships between smoking variables and direct measures of attentional bias

Pearson correlations were conducted separately for grids and scenes between the smoking variables: average number of cigarettes smoked per day (STLFB), craving (QSU) and nicotine dependence (FTND): the proportion of first saccades to smoking related stimuli relative to neutral stimuli, the time taken to initially fixate on smoking related stimuli, the proportion of fixations on smoking related stimuli relative to neutral stimuli, and the duration of fixations on smoking related stimuli. Analysis indicated a possible relationship between a higher number of cigarettes on average smoked per day with both a longer duration of fixation on smoking related stimuli in real world scenes, r (36) =0.29, p=0.07 and a higher proportion of fixations on smoking related stimuli in real world scene stimuli, r (36) = 0.29, p = 0.09, although they did not quite reach statistical significance.

2.7.4 First trial only analysis

In order to directly compare to the analysis in experiment 1a and previous research by Jones and colleagues (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006) who employed only one trial per participant, both indirect and direct measures of attentional bias were calculated for the first trial only.

Indirect measure of attentional bias

Chi square analysis was conducted to compare the number of smoking related changes detected on the first trial only between smokers (60%) and non-smokers (45%), χ^2 (1) =1.68, p = 0.20. The change detection latency was not assessed as it was not deemed to be meaningful to look at the difference between the smokers and non-smokers who detected the smoking related change considering the reduced group sizes and the fact that there were no group differences in terms of whether a smoking related change was detected in the first trial. Analysis therefore demonstrated no significant group differences in smoking related attentional bias between smokers and non-smokers in the first trial.

Direct measures of attentional bias

Initial orienting of attention was assessed by whether the participants first saccade was to a smoking related stimulus in the first trial as well as the time taken to initially fixate on smoking related stimuli in the first trial. Maintained attention was measured by the proportion of fixations on smoking related stimuli relative to neutral stimuli, and the duration of fixations on smoking related stimuli in the first trial only. See table 2.7 for descriptive statistics.

Table 2.7: First trial only descriptive statistics for smokers and non-smokers

	Smoker (n=36)	Non-smoker (n=40)	
	M (SD)	M (SD)	Sig.
1st saccade to smoking related stimuli	40%	60%	> 0.05
Time taken to saccade to smoking related stimuli (ms)	637.76 (878.94)	454.56 (807.40)	> 0.05
Proportion of fixations on smoking related stimuli	0.53 (0.18)	0.46 (0.22)	> 0.05
Duration of fixations on smoking related stimuli (ms)	-736.68 (2683.22)	-750.95 (3208.65)	> 0.05

A chi square analysis was used to assess group differences between smokers and non-smokers in terms of the first saccade being to smoking related stimuli. Independent t tests were used to assess all other group differences in the remaining direct measures of attention. Analysis demonstrated no significant group differences in smoking related attentional bias on any of the direct measures between smokers and non- smokers.

In summary, analysis of the present study revealed that when inferring attentional bias from indirect measures, smokers detected a greater proportion of smoking related changes compared to non-smokers however this was only for real world scene stimuli. Smokers did however detect smoking related changes more quickly than non-smokers in grid stimuli. When inferring attentional bias from direct measures of attention smoking related stimuli captured the attention of smokers more quickly than non-smokers in both grids and real world scenes. In addition, there was a trend for smokers to demonstrate a bias in maintained attention on smoking related stimuli in real world scenes.

The associations between smoking related attentional bias and levels of consumption, subjective craving and dependence in smokers were also examined. When inferring attentional bias indirectly results demonstrated that heavier smokers detected a greater proportion of smoking related stimuli in grids and that there was a trend indicating that higher levels of cigarette use and dependence were associated with quicker smoking related change detection times in real world scenes. When inferring attentional bias from direct measures there were no significant findings, however there was a trend in the results suggesting that higher levels of cigarette use was associated with a greater maintenance of attention on smoking related stimuli in real world scenes only. Furthermore, the analysis indicated that when analysing the first trial only there were no differences between smokers and non-smokers in any of the indirect or direct measures of attention.

2.8 Discussion

Previous research employing the flicker ICB to examine substance related attentional biases in dependent substance users have demonstrated through indirect measures of attention that smokers display a greater attentional bias for smoking related stimuli compared to non-smokers over multiple trials (Yaxley & Zwann, 2005). In addition, previous research on problem drinkers showed that alcohol related attentional bias increases with problem severity as measured during one trial only (Jones et al., 2006). As argued in chapter 1 and above in section 2.1, these studies suffer from several potential weaknesses; a reliance on indirect measures of attention, the use of relatively simple and highly structured stimuli and the neglect to examine associations between substance related attentional biases and subjective craving (Jones et al., 2006; Yaxley & Zwann, 2005), level of use, and level of dependence (Yaxley & Zwann, 2005). The present study due to a) the introduction of eye tracking to directly monitor attention and allow for direct measurement of different sub-components of selective attention b) the use of both simple grid stimuli and stimuli depicting real world scenes and c) an examination of the associations between attentional bias and levels of use, subjective craving and dependence, aimed to extend previous research by attempting to overcome such potential limitations.

Yaxley and Zwaan (2005) is the only study to date which has examined smoking related attentional biases employing the flicker ICB task. In their study attentional bias was inferred from indirect measures of attention (reaction time) over multiple trials and participants were either given a smoking related change to detect or a neutral change to detect (only 1 change per trial compared to 2 competing changes in the present study). Supporting the findings of Yaxley and Zwaan (2005) the present study also demonstrated that smokers show a greater attentional bias for smoking related stimuli compared to non-smokers over multiple trials when attentional bias is indirectly inferred (type of change detected and reaction time). As the results showed that smokers were quicker compared to non-smokers to detect smoking related changes in grids but only in real world scenes did they actually detect a greater proportion of smoking related changes compared to non- smokers. The present study however further demonstrated through direct measures of attention that smoking related stimuli captured the attention of smokers more quickly than non- smokers in both grids and real world scenes. Results from direct measures of attention also suggested that only in real world scenes did smokers show evidence of a bias in maintained attention on smoking related stimuli, as demonstrated by a trend indicating that heavier use was associated with a higher proportion of fixations and longer duration of fixations on smoking related stimuli. In addition, in comparison to Jones et al., (2006) in terms of analysing attentional bias from the first trial only, the present findings support those of experiment 1a. The results demonstrated no differences in any indirect or direct measures of smoking related attentional bias between smokers and non- smokers when the first trial only was analysed. This pattern of findings highlights several points in relation to both the type of stimuli employed and the number of trials used when measuring attentional bias.

In relation to the types of stimuli employed, I had previously postulated based on the research of Gilchrist and Harvey (2006) and the findings of experiment 1a and Jones et al., (2006), that when using perfectly structured grid stimuli social users of a substance may adopt search strategies in order to detect the change (i.e. systematically scan the display). As a result this may limit the effectiveness of the flicker ICB task to measure attentional bias when using such stimuli. However previous research in dependent users had demonstrated, both an alcohol related attentional bias in problem drinkers using perfectly structured grid stimuli similar to the present experiment and experiment 1a (Jones et al., 2006) and a smoking related attentional bias in dependent smokers using stimuli depicting a perfectly structured line up of stimuli (Yaxley & Zwann, 2005). As a result I further suggested that the stronger incentive salience of the substance related cues may override the task demands of visual search (i.e. strategic scanning) in dependent users compared to social users. As a result substance related attentional biases may be evident in dependent users when employing perfectly structured grid stimuli.

On first look, the results of the present study seem to be consistent with my suggestion as smokers compared to non-smokers evidenced a smoking related attentional bias when viewing the simple grid stimuli when measured by both indirect (reaction time) and direct measurements (initial orienting of attention). On closer inspection of both grid stimuli and real world stimuli however when inspecting the direct measures of attentional bias, a different pattern of smoking related attentional bias emerges depending on the type of stimuli being analysed. With smokers relative to non-smokers showing a bias only in the initial orienting of attention to smoking related stimuli being implicated in grid stimuli (as measured by time taken to initially saccade to smoking related stimuli) but both a bias in the initial orienting of attention (as measured by time taken to initially saccade to smoking related stimuli) and maintained attention (as measured by the proportion of fixations on smoking related stimuli) in real world scene stimuli. In addition, when smokers were analysed themselves direct measures of attention further implicated a bias in maintained attention in real world scenes as the results indicated a trend showing that heavier cigarette use was associated with a higher proportion of fixations and longer duration of fixations on smoking related stimuli, however, there was no evidence of substance related attentional biases when viewing grid stimuli.

This pattern of results however may not be consistent with my previous postulation. As according to Gilchrist and Harvey (2006) the potential consequence of strategically scanning a display is that it will limit refixations to objects. Therefore maintained attention as measured by the proportion and duration of fixations on smoking related stimuli would be assumed to be effected by strategic scanning, however where participants look first (i.e. initial orienting of attention) would not be effected. The present study therefore provides evidence that the type of stimuli used modulated the attentional biases evidenced and further suggests that this may be as a result of the perfect structure of the grid stimuli encouraging strategic scanning compared to the complex structure of the real world scenes. As biases in the initial orienting of attention were implicated in both simple grid stimuli and real world scene stimuli but yet biases in maintained attention were only implicated in real world scene stimuli. This study therefore highlights that the type of stimuli employed should be considered in future research employing the flicker ICB task as it may have considerable influence on the findings and thus consequent conclusions, as such this issue is further examined in chapters three and four.

As highlighted above, the present pattern of results when comparing smokers and non-smokers also raises additional points in terms of the number of trials used in order to measure attentional bias. In contrast to the studies of Jones and colleagues (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006) but in support of experiment 1a, smoking related attentional biases between smokers and non-smokers were not evident on the first trial. As a consequence of the experiment design the first trial for all participants consisted of simple grid stimuli. The present experiment however further showed that when analysing simple grid stimuli over multiple trials, smoking related attentional biases emerged, as indicated by a bias in the initial orienting of attention which is consistent with Yaxley and Zwaan (2005). Jones et al., (2006) argued that their reasoning for employing only one trial per participant was because during pilot testing participants quickly reported developing search strategies. However, strategic scanning is only thought to impede on measurements of maintained attention (Gilchrist & Harvey, 2006), not measures of initial orienting of attention. The results therefore highlight that measuring attentional biases with one trial and measuring attentional biases over multiple trials are not comparable, and further suggest that utilising only one trial per participant may limit the power necessary to detect such biases. The extent and time course of strategic scanning when employing the flicker ICB task however remains to be empirically tested, an issue examined further in chapters 3 and 4.

Although by comparing smoking related attentional biases between smokers and non- smokers we can provide evidence of a smoking related attentional bias in smokers it does not provide us with any understanding of the extent or roles of attentional biases in addictive behaviours. This is because it is unclear how the attentional biases shown by dependent smokers manifests in terms of the relationship between these biases in the sub-components of attention, subjective craving and levels of use. The present study therefore further assessed smoking related attentional biases in smokers only, examining associations between smoking related attentional biases and levels of cigarette use, subjective nicotine craving and nicotine dependence.

Indirect measures of attention highlighted associations between higher levels of cigarette use and a greater proportion of changes detected when viewing grid stimuli as well as being suggestive of an association between higher levels of use and dependence with a faster latency to detect smoking related changes in scenes. These results appear to be at odds with the findings above when comparing smokers and non-smokers in that there was no difference in the proportion of smoking related changes detected between non-smokers and smokers in grid stimuli and that there was no difference in the time taken to detect smoking related changes between smokers and non-smokers when viewing real world scenes. However, as highlighted previously indirect measures have been argued (Mogg et al., 2004) take an over simplistic view of attention and do not distinguish between different attentional components and as a result are limited in their explanation of the roles of attentional bias in addictive behaviours.

In the present study however, direct measures of attention did not reveal any significant associations between smoking related attentional biases and levels of cigarette use, subjective craving or dependence. Although not significant, the results were however suggestive of an association between levels of cigarette use and maintained attention in that heavier smokers fixated longer and more often on smoking related stimuli in real world scenes, which would be predicted by IST models of addictive behaviours (Franken, 2003; Robinson & Berridge, 1993).

IST models however would also have predicted that smoking related attentional biases should also have been evident in terms of a bias in the initial orienting of attention. As through repeated pairings with consumption, substance related stimuli should become motivationally salient and should thus capture attention. The results of experiment 1a suggested attentional bias in terms of initial orienting of attention was associated with levels of subjective craving, with alcohol related stimuli capturing the attention of high cravers more quickly than low cravers in real world scenes. This finding would also have been expected in dependent users as previous research employing eye tracking when utilising the visual probe task has demonstrated that a bias in initial orienting of attention to smoking related stimuli in smokers is associated with levels of subjective craving (Mogg et al., 2003).

The failure of the present study to demonstrate this may be due to the characteristics of the smokers. For example the smokers in the present study were relatively light smokers of low dependence and reported relatively low levels of craving, therefore the limited variation within the smokers themselves particularly in terms of craving may have contributed to the null findings. Another contributing factor may have been a methodological bi-product as a result of keeping participants naïve to the purposes of the study. By recruiting participants naïve to the purpose of the study in order not to prime participants attention to smoking related stimuli, it meant that the time since participants smoked their last cigarette before taking part in the experiment was not controlled and as such may have influenced subjective craving and as a consequence affected the results. Analysis however indicated that craving was not associated to time since last cigarette. So although the present results did not show a relationship between initial orienting of attention and craving, which is most probably as a result of the characteristics of the smoking group and/or a bi-product of not controlling for abstinence, the present study does highlight the possibility that maintained attention underpins the variability in levels of consumption in dependent users. The results were only trending towards significance, again possibly as a result of the smoking group characteristics and as there were no significant associations between any direct measures of attentional bias with levels of subjective nicotine craving or nicotine dependence the results are limited in their capacity to draw any clear conclusions.

Nonetheless, although only nearing significance, the present study highlights that maintained attention may indeed be associated with the variability in consumption at the level of dependence. In experiment 1a I had previously postulated that the lack of an association between maintained attention on alcohol related stimuli and levels of subjective craving and consumption in social drinkers could have been due to two reasons. Firstly, that it may have been due to task demands, as Rensink et al., (1997) argues that participants would have to maintain attention on the target stimuli in order to detect the change but once the change was detected the trial subsequently ended, therefore possibly limiting the ability to maintain attention on the target stimuli. However, as maintained attention on smoking related stimuli was implicated when examining substance related attentional biases at the level of dependent use in the present study (both in smokers only analysis and in smokers compared to non-smokers analysis) it would suggest that when using direct measures of attention the flicker ICB is indeed sensitive enough to measure biases in maintained attention.

Secondly, it was suggested that different components of attention might play different roles depending on the level of substance use, whether social or dependent. As highlighted in experiment 1a, impulsivity has been implicated as a possible mediator of the roles of attentional bias in substance use. Interestingly impulsivity has also been linked to substance related attentional biases, not because attentional biases are a function of an individuals poor inhibitory control but because those highly impulsive may be more susceptible to the motivational properties of the substance related stimuli and with poor inhibitory control are less able to inhibit substance related stimuli (Fadardi and Cox, 2006). Therefore as high impulsivity is associated with higher levels of dependence (de Wit, 2009) it may possibly explain why maintained attention was only implicated in levels of dependence and not levels of social use, as the dependent participants may have been less able to inhibit the substance related stimuli. The relationship between impulsivity and substance related attentional biases however, has received little attention within the literature (Lui, et al., 2011). Nonetheless, the combined findings of experiment 1a and the present study suggest that components of attention may have specific roles depending on level of use and as speculated from previous research this may possibly be as a function of levels of impulsivity. As such impulsivity may be vital to understanding the differential roles of initial orienting to and maintained attention on substance related stimuli and their roles in addictive behaviours. Future research should therefore seek to examine the possible effects of impulsivity on the relationships between initial orienting of attention to substance related stimuli and maintained attention on substance related stimuli with subjective craving and levels of consumption and dependence.

In conclusion of experiment 1b, by directly monitoring the attention of smokers and non- smokers as they completed the flicker ICB task utilising both simple grid stimuli and real world scene stimuli, results revealed that smokers do indeed demonstrate a smoking related attentional bias compared to non- smokers. Furthermore, in line with IST models of addictive behaviours (Franken, 2003; Robinson & Berridge, 1993) the results suggested that the ability of the cue to hold attention was associated with heavier use. Inconsistent with the model however there were no relationships between attentional biases and levels of subjective craving or dependence, although these findings may have been as a result of the smoking group characteristics. In addition the results further highlight possible methodological considerations worthy of further examination which may influence the effectiveness of the flicker ICB to measure substance related attentional biases such as the type of stimuli used and the number of trials employed.

Chapter 3

3.1 Strategic Scanning employed during the flicker change blindness task: Implications for the measurement of attentional bias

Given the theoretical prominence of substance related attentional biases in addictive behaviours and their perceived clinical utility it is vital that the methods adopted by researchers are adequate in their ability to effectively measure such biases. As highlighted previously in chapter 1, there has been considerable research attempting to examine the extent and roles of attentional biases in addictive behaviours however as discussed in chapter 1, potential methodological and task limitations may have impacted on developing a clearer understanding.

The two main tasks used to measure attentional bias in addictive behaviours have been the modified Stroop task and visual probe task, both of which have produced inconsistent findings (for a full discussion see chapter 1). Despite being the most prominently used tasks to examine substance related attentional bias, research employing such tasks have received heavy criticism within the literature. Such criticism has been in relation to both the methodology employed using the tasks as well as the effectiveness, validity and reliability of the tasks themselves. As such there has been a recent call in the literature to examine the effectiveness of attentional bias measures (Ataya, et al., 2012; Field & Christiansen, 2012).

As discussed previously, the flicker induced change blindness task (flicker ICB) was argued to overcome some of the limitations of the modified Stroop task and the visual probe task, as it has been argued to measure the power of changed components to capture and hold attention within one single scene (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006). Therefore, the flicker ICB task has been argued to be in line with IST models of addictive behaviours (Franken, 2003; Robinson & Berridge, 1993) as it measures attentional bias in terms of the ability of the incentive motivational salience of the substance related stimulus to capture and hold attention (Bruce & Jones, 2004). Previous research utilising this task however remain subject to several possible limitations such as; the neglect to examine associations with subjective craving, a reliance on indirect measures of attention, the use of simplistic stimuli and employing differing numbers of trials which may possibly cloud interpretations (Jones et al., 2002; Jones et al., 2003; Jones et al., 2005; Yaxley & Zwaan, 2005).

Experiments 1a and 1b in the present thesis (chapter 2) set out to extend previous research and attempt to overcome these limitations in order to assess alcohol related attentional biases in social drinkers and smoking related attentional biases in dependent smokers. As such the experiments a) measured subjective craving as well as levels of use b) utilised eye tracking in order to directly measure sub-components of attention c) employed both simplistic grid stimuli and real world scene stimuli and d) evaluated attentional biases on the first trial and over many trials. Utilising this approach, the results of experiments 1a and 1b in the present thesis suggested that methodological factors such as the type of stimuli used and the number of trials employed may influence the validity of the flicker ICB task as an effective measure of attentional bias.

Firstly, experiments 1a and 1b provided clear evidence through the direct measures of attention that the substance related attentional biases evidenced differed depending on the type of stimuli employed. Experiment 1a examined alcohol related attentional biases in social users of alcohol. When considering direct measures of attention, alcohol related attentional biases were only evident when participants viewed real world scene stimuli (initial orienting of attention). No attentional biases were evident when participants viewed simple grid stimuli, such as that used in previous research (Jones et al., 2006). Experiment 1b examined smoking related attentional biases in smokers compared to non-smokers and within smokers themselves. When examining smokers compared to non-smokers the results demonstrated evidence of a smoking related attentional bias in both simple grid stimuli and real world scene stimuli, however the pattern of biases differed depending on the type of stimuli viewed. For example a bias in only the initial orienting of attention was implicated in simple grid stimuli (time taken to initially saccade to smoking related stimuli) both the initial orienting of attention (time taken to initially saccade to substance related stimuli) and the maintenance of attention were implicated when viewing real world scene stimuli (proportion of fixations on smoking related stimuli). In addition, when analysing the performance of smokers themselves, comparing measures of attentional bias with levels of use, craving and dependence a different pattern of smoking related attentional bias emerged again depending on the type of stimuli being analysed. No attentional biases were evidenced when simple grid stimuli were viewed but again when real world scenes were viewed maintained attention was implicated by a trend for heavier smokers to demonstrate a greater proportion of fixations and longer duration of fixations on smoking related stimuli.

As can be seen, these experiments differ in terms of the attentional biases evidenced within social users (initial orienting of attention) and within dependent users (maintained attention) of addictive substances. As discussed in chapter 2, although the initial orienting of attention was not implicated within smokers in experiment 1b the result may have been due to the group characteristics of the smokers in terms of their limited variation in levels of use, dependence and subjective craving. In addition it was also suggested that maintained attention was only implicated in dependent use and not social use as the sub-components of attention may play differing roles within different levels of use such that maintained attention may only underpin levels of consumption in dependent use not social use (see chapter 2 and chapter 5 for a full discussion). It has to be acknowledged however that biases in maintained attention in experiment 1b were only nearing significance however, the limited variation in the smokers characteristics may have impacted the strength of these findings.

In addition the pattern of results from experiments 1a and 1b, highlighted above, also suggest that when utilising the flicker ICB task that the substance related attentional biases evidenced differed depending on the types of stimuli employed (simplistic grids vs. real world scene). It was previously postulated in chapter 2, that the inconsistent findings between the types of stimuli may be due to several possible reasons. Firstly, real world scenes used in experiments 1a and 1b may be more representative of the environments which give rise to attentional biases (Nees et al., 2012) and as a result be more ecologically valid compared to the simple grid stimuli used in experiments 1a and 1b. Another possibility however is that the perfect spatial structure of the simple grid stimuli such as that used in experiments 1a and 1b may encourage the use of search strategies in order to detect the changing object compared to the complex structure of the real world scene stimuli. Or indeed it may be a combination of both ecological validity and structure.

As highlighted in chapter 2, Gilchrist and Harvey (2006) defined strategic scanning as starting at one place in a display and then searching systematically through sections of the display. Early research has shown that there is often a bias in the direction of saccades in visual search and that this bias reflects a systematic process rather than a random process (Williams, 1966). Gilchrist and Harvey (2006) therefore measured strategic scanning in terms of a bias in saccade direction and showed that strategic scanning was strongest in perfect spatially structured grids and reduced as the degree of the spatial structure of the stimuli reduced. Gilchrist and Harvey (2006) further argued that a potential consequence of strategically scanning a display is that it will limit refixations to objects (i.e. maintained attention). Therefore as maintained attention was measured in experiments 1a and 1b by the proportion and duration of fixations on substance related stimuli they would be assumed to be effected by strategic scanning, however where participants look first (i.e. initial orienting of attention) would not be effected. Therefore the differing degree of spatial structure of the perfect spatially structured grid stimuli and the complex structure of the real world scene stimuli employed in experiments 1a and 1b, may account for the inconsistent findings between the types of stimuli. In that the results of experiments 1a and 1b demonstrated that biases in initial orienting of attention were implicated in both perfect spatially structured grid stimuli (experiment 1b) and real world scene stimuli (experiments 1a and 1b) however maintained attention was only implicated in real world scene stimuli (experiment 1b). If strategic scanning is employed by participants when utilising the flicker ICB task, the validity of the flicker ICB as a measure of attentional bias when employing such perfect spatially structured stimuli may be limited.

The task employed by Gilchrist & Harvey (2006) however involved participants searching for an upside down triangle amongst correctly orientated triangles, therefore it did not involve stimuli which is assumed to be motivationally salient to some participants which should thus capture and hold attention (Franken, 2003; Robinson & Berridge, 1993). As a result, the extent of strategic scanning employed by participants when using a visual search task such as the flicker ICB to measure attentional biases to motivationally salient stimuli remains unknown. This will be important to understand in order to determine the validity of the flicker ICB task to measure substance related attentional biases.

Furthermore, experiments 1a and 1b also highlighted that the number of trials employed to measure substance related attentional biases may influence the validity of the flicker ICB task as a measure of attentional biases. The results of experiments 1a and 1b demonstrated that substance related attentional biases as measured over one trial, the approach utilised by Jones and colleagues (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006) is not comparable to substance related attentional biases as measured over multiple trials, the approach used by Yaxley and Zwaan, (2005). As in both experiments 1a and 1b attentional biases were only evident when analysed over multiple trials. No substance related attentional biases were evidenced when measuring attentional bias from the first trial only. As such the results suggested that utilising only one trial per participant may limit the power necessary to detect such attentional biases. However the first trial in both experiments 1a and 1b consisted of a perfect spatially structured grid stimulus being shown to participants. Therefore considering the possible influence of the spatial structure of the stimuli on the validity of measuring attentional bias, it is unclear if substance related attentional biases would be evident from the first trial when employing stimuli with reduced or more complex spatial structures compared to the perfect spatially structured grid stimuli.

Indeed, the studies by Jones and colleagues used different types of stimuli and conveyed inconsistent findings between the types of stimuli, when utilising only one trial per participant. For example Jones et al., (2006) used perfect spatially structured grid stimuli such as that used in experiments 1a and 1b yet Jones et al., (2002) and Jones et al., (2003) used stimuli bi-laterally grouped on a table top, representative of "clutter". Jones et al., (2002) and Jones et al., (2003) consistently evidenced substance related attentional biases in social users of alcohol and cannabis. The results of Jones et al., (2006) however were inconsistent, with alcohol related attentional biases being evident in problem users but not in social users. The authors argued that the inconsistent finding may have been due to the smaller variation of alcohol use of their social drinkers in the study compared to earlier studies.

Experiment 1a however had a higher distribution of alcohol consumption within participants than Jones et al., (2003) and Jones et al., (2006) (the variation of alcohol consumption in Jones et al., 2002 was not reported) yet still failed to find evidence of an alcohol related attentional bias in social users of alcohol on the first trial. In addition experiment 1b examining dependent smokers also failed to demonstrate evidence of a smoking related attentional bias when measured on the first trial only. The first trial in experiments 1a and 1b consisted of a perfect spatially structured grid stimulus similar to that of Jones et al., (2006). The inconsistencies within the literature in terms of attentional bias as measured over one trial only therefore may not be in relation to levels of consumption of participants as Jones et al., (2006) have argued, but are instead possibly a result of the types of stimuli employed. When attentional biases are measured on the basis of one trial only, employing spatially structured grid stimuli, attentional biases have been inconsistently demonstrated, with the majority failing to evidence substance related attentional biases. Yet when bi-laterally grouped stimuli, representative of "clutter" on table top which will be less spatially structured compared to the grids are used, attentional biases have been consistently evidenced from only one trial, although such biases have been demonstrated using indirect measures of attention.

Jones et al., (2006) argued that their reasoning for employing only one trial per participant was because during pilot studies participants reported that they quickly developed search strategies and this would limit the validity of the flicker ICB task as a measure of attentional bias. However as highlighted above the degree of strategic scanning evidenced when utilising the flicker ICB task may be dependent on the spatial structure of the stimuli (Gilchrist & Harvey, 2006). So although participants may employ search strategies from the first trial, the extent may be dependent on the structure of the stimuli used. This is a vital issue to understand as it may influence the validity of the flicker ICB task as a measure of attentional bias.

It is imperative that researchers employ tasks and methodology which allow substance related attentional biases to be measured effectively in order to develop as full an understanding as possible of their roles in addictive behaviours. The flicker ICB task has been argued to be a more robust measure compared to the Stroop task and visual probe task (Jones et al., 2002; Jones et al., 2003). Yet as highlighted above both the spatial structure of the stimuli and number of trials employed when using the flicker ICB task may encourage strategic scanning which would limit the effectiveness of the task to measure attentional bias. The influence of these factors on the validity of the flicker ICB task however remain to be empirically tested.

Experiments 2a and 2b therefore sought to examine both the extent and time course of strategic scanning when employing the flicker ICB task, using stimuli varying in degree of spatial structure between non-drinkers and social drinkers in experiment 2a and between non-smokers and smokers in experiment 2b. Additionally the studies also aimed to examine substance related attentional biases when using such stimuli and look at possible relationships between the extent of strategic scanning and the substance related attentional biases evidenced in stimuli varying in levels of structure.

3.2 Experiment 2a: the extent of strategic scanning when employing the flicker ICB to measure alcohol related attentional bias: An investigation between non-drinkers and social drinkers

The purpose of the present study was to examine the extent and time course of strategic scanning as well as examine alcohol related attentional biases in non-drinkers and social drinkers when using the flicker ICB task with stimuli which varied in their degree of spatial structure. The following hypotheses were predicted

1) In line with Gilchrist & Harvey (2006) even when using stimuli assumed to be motivationally salient to only the social users of alcohol, all participants will demonstrate a strategic component in their scan paths, evidenced by a bias in the frequency of horizontal saccades compared to saccades made in any other direction when completing the flicker ICB.

2) The extent of strategic scanning will be modulated by the degree of structure, with it being strongest in the most structured stimuli and reduce as the degree of structure decreases.
3) There will be no difference in the extent of strategic scanning between non-drinkers, light social drinkers and heavy social drinkers in the perfect spatially structured stimuli. However, group differences may become apparent as the stimuli reduce in levels of spatial structure.
4) Strategic scanning will be evident from the first trial when the most structured stimuli is presented however may not be present when less spatially structured stimuli are presented on the first trial.
5) In terms of alcohol related attentional bias, biases between groups in terms of the initial orienting of attention to alcohol related stimuli may be evident in all three conditions of spatial structure. However it is predicted that biases in maintained attention may not be evident considering that in experiments 1a and 1b maintained attention was only evident in dependent users of a substance.

3.3 Method

3.3.1 Participants

In line with experiments 1a and 1b the experiment was advertised as "investigating attention" therefore all participants were naïve to the purpose of the study in relation to the involvement of alcohol and participant exclusion criteria were identical to Experiments 1a and 1b (see section 2.2.1). In total 78 participants (39 male, 39 female) with a mean age of 24.67 years (SD= 5.86) took part and all participants gave informed written consent. All procedures were approved by the University of Strathclyde ethics committee.

3.3.2 Stimuli

The pictorial stimuli consisted of 48 pairs of full colour 1280 x 1024 images, with 16 pairs of images in each of the three conditions. Each pair consisted of an original image and a changed image, which was the same as the original image except contained both an alcohol and neutral change to a matched pair of stimuli. In every trial in each of the three conditions, 16 items; 8 alcohol related and 8 neutral were used. As in experiments 1a and 1b the 8 pairs of alcohol and neutral stimuli each occupied corresponding positions on the matrices and were matched for physical properties such as; colour, shape, height and width in each matrix and were grouped in four levels of laterality.

In condition 1 the 16 items were placed in an imaginary 4 x 4 grid resulting in a spatially regular display (see Appendix J). In condition 2 the same stimuli used in the images from condition 1 were placed on an imaginary 6 x 6 grid, leaving 20 randomly selected locations blank in each trial (see Appendix K) and in condition 3, the same items were placed on an 8 x 8 imaginary grid, leaving 48 randomly selected locations blank in each trial (see Appendix L). Across all 3 conditions the overall display size and size of the alcohol and neutral stimuli were kept constant .Therefore, as a result condition 1 was most structured and condition 3 was least structured. Example displays can be seen in figure 3.1.

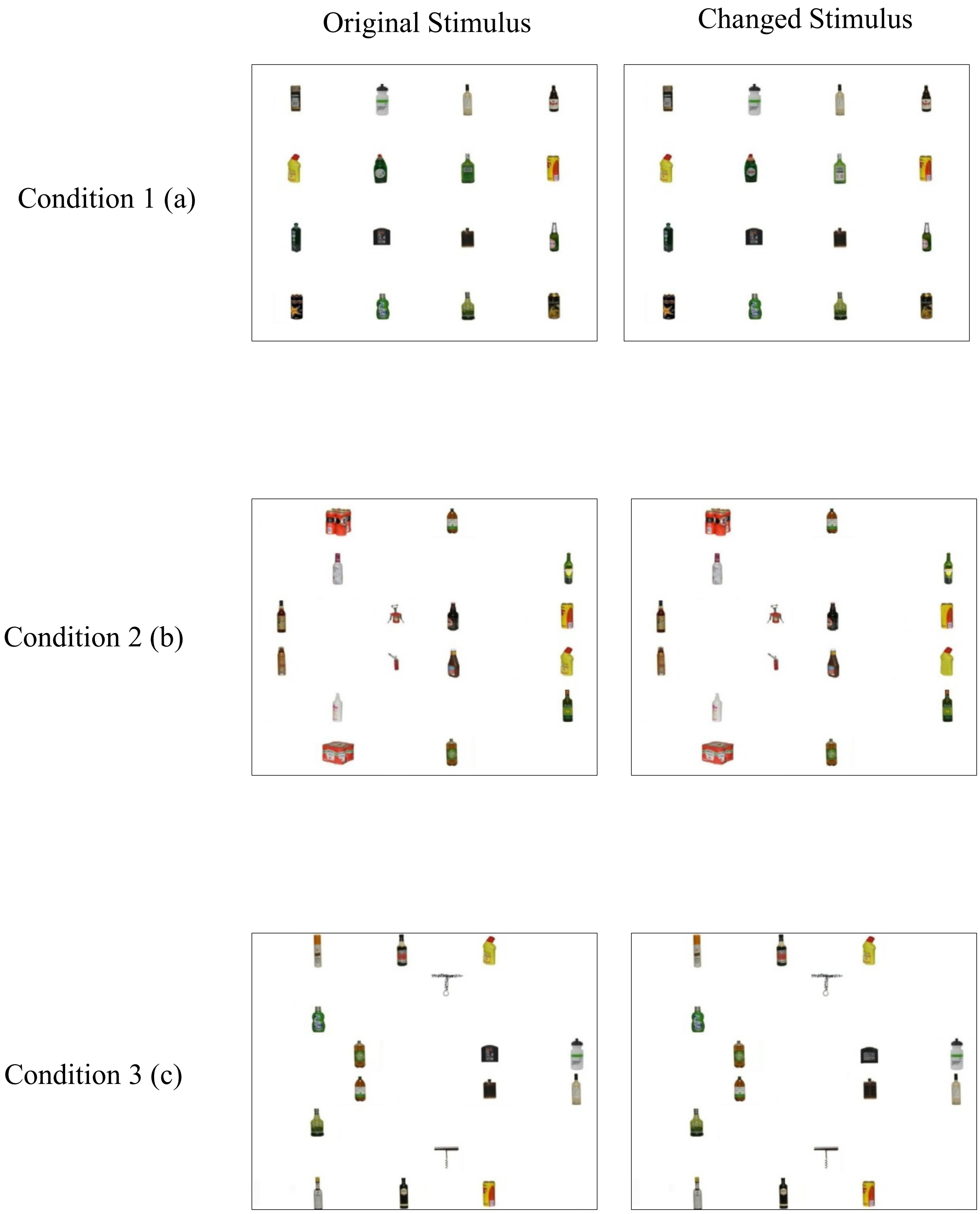

Figure 3.1: Example stimuli pairs for each condition of structure. a) example stimuli from condition1, the fairy liquid bottle and gin bottle have been rotated b) example stimuli from condition 2, the logos from the tennents can and bleach bottle have been removed c) example stimuli from condition 3, the Nintendo game and hipflask have been rotated.

3.3.3 Measures

As in experiment 1a the TLFB was used to assess levels of alcohol consumption, the DAQ to measure levels of alcohol craving and the SADQ to ensure participants were indeed social drinkers. For a full description see section 2.2.3.

3.3.4 Apparatus and Procedure

The procedure was identical to experiment 1a (see section 2.2.4) with the following exceptions i) There were three conditions of stimuli structure and as such each of the three conditions were presented in a separate block, with approximately a break of 2 minutes between each block. ii) The order of condition presentation was counterbalanced across the participants.

3.4 Results

3.4.1 Eye movement and response errors

In line with previous research, trials were removed from analysis in which the participant failed to detect a difference, anticipated the stimulus appearance by making a saccade with a reaction time shorter than 80ms or were improperly fixated on the central fixation point (a deviation larger than 1°) at the start of the trial. These criteria resulted in 5.37% trials being excluded from attentional bias analysis. The criteria for removal of trials was not employed in the strategic scanning analysis as they were not thought to impact on the measurement of frequency of saccades per direction, as such no trials were removed from this analysis.

3.4.2 Group characteristics

Participants were identified as non-drinkers or social drinkers on the basis of the TLFB responses and no participants were removed on the basis of SADQ scores. Twenty four participants indicated that they were non-drinkers (13 male, 11 female).

The remainder of the participants were allocated to a heavy social drinking group (n = 27; 17 male, 10 female) or light social drinking group (n = 27; 9 male, 18 female) on the basis of a median split from the TLFB responses. Independent t-test analysis indicated that heavier social drinkers consumed more units per week (M= 19.42, SD = 7.36) than lighter social drinkers (M = 5.91, SD = 3.15), t (52) = -8.76, p <0.001. However subjective craving scores did not significantly differ between heavy social drinkers (M= 43.30, SD = 7.36) and light social drinkers (M=37.59, SD = 9.05), t (52) = -1.88, p = 0.07, although this was approaching significance.

3.4.3 Strategic scanning analysis

Foulsham & Kingstone (2010) and Gilchrist & Harvey (2006) suggest that a strategic component in scan paths is evidenced by significantly more saccades in a horizontal direction compared to any other. In line with previous research (see Foulsham & Kingston, 2010) after removing all saccades with an amplitude of less than 1°, in order to exclude corrective and micro saccades, the saccades were organised into four symmetrical bins covering eye movements in the horizontal, vertical, 45° and 135° axes. For example, the horizontal (0°) axis contained all leftward (0° ± 22.5°) and rightward (180° ± 22.5°) eye movements. The frequency of saccades within each of the four direction bins was then computed for each participant in each of the three conditions of structure.

All Trials

To examine the extent of strategic scanning across all trials, the frequency of saccades in each direction were analysed using a 3 (consumption group) x 3 (structural condition) x 4 (saccade direction) mixed ANOVA. On the basis of the

ANOVA results, planned contrasts were then used to examine the hypotheses[4]. By employing this procedure the probability of a type 1 error is reduced compared to conducting the planned contrasts regardless of the significance of the ANOVA (Rutherford, 2011). Where sphericity was violated the Huyn -Feldt correction was applied.

The mixed ANOVA revealed a significant main effect of direction, $f\,(2.07, 155.76) = 351.20$, $p<0.001$, $\eta_p^2 = 0.95$ due to more horizontal saccades across all conditions. More importantly there was a significant structure by direction interaction, $f\,(3.84, 287.93) = 48.08$, $p<0.001$, $\eta_p^2 = .74$. No other main effects or interactions were significant. Therefore highlighting that there were no group differences between non- drinkers, light social drinkers or heavy social drinkers. Stepwise planned contrasts were then used to compare the mean frequency of horizontal saccades compared to vertical saccades in each condition, as it can be assumed that if these are significantly different the remaining comparisons will also be significant (Rutherford, 2011). Stepwise planned contrasts were used to assess hypothesis 1 as they tend to be more powerful than single step procedures as they control for type 1 error (Rutherford, 2011). The mean frequencies of saccades in each direction in each condition are presented in figure 3.2

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[4] Planned comparisons were left uncorrected as Keppel (1991) argues that the most widely used strategy to evaluate planned comparisons is to do so at the usual p <0.05 level and to only exercise control when conducting post hoc analysis, given that the number of comparisons are restricted to meaningful and theoretically focussed questions. Although others may advocate the use of corrections such as bonferroni corrections also known as Dunns procedure, this correction is overly- conservative and unnecessary as when predefined multiple tests are needed to show several effects multiple comparisons can be justified without the need for adjustment (Perneger, 1998).

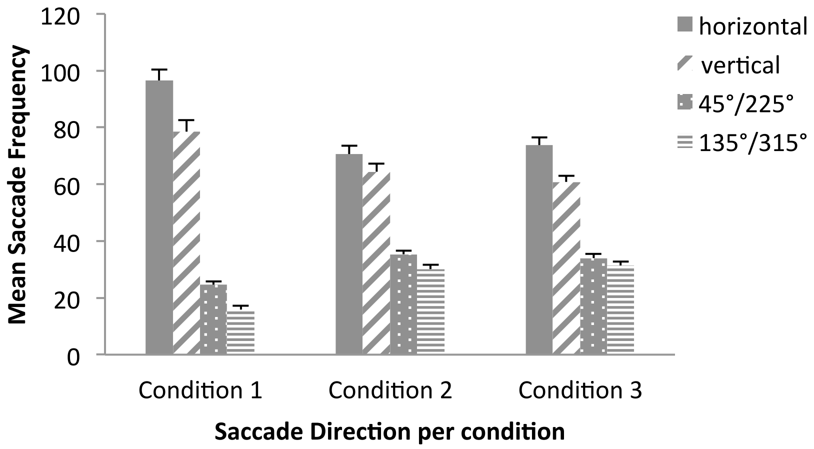

Figure 3.2. Mean saccade frequency in each direction per structural condition

Analysis revealed that there were more horizontal saccades being made compared to any other direction in condition 1, $f\,(1,290.33) = 40.09$, $p < 0.01$, $d = 0.51$; condition 2, $f\,(1,290.33) = 4.60$, $p < 0.05$, $d = 0.23$ and condition 3, $f\,(1,290.33) = 20.53$, $p < 0.001$, $d = 0.57$, which is evidence of a systematic component in scan paths in each of the three conditions of structure. In order to examine if the extent of this strategic scanning was modulated by the degree of structure planned comparisons compared the frequency of horizontal saccades in each of the three conditions. Analysis demonstrated that that there were more horizontal saccades generated in condition 1 compared to condition 2, f(1,290.33) = 84.30, $p<0.001$, $d = 0.89$ and condition 3, f(1,290.33) =64.76, $p<0.001$, $d = 0.82$, however there was no reliable difference between condition 2 and condition 3, suggesting that systematic scanning was strongest for the most structured condition.

First Trial Only

In order to examine the extent of strategic scanning in the first trial the frequency of saccades within each of the four direction bins described above was computed for each participant for their first trial only. Similar to the analysis strategy above a 3 (structural condition) x 4 (saccade direction) mixed ANOVA was conducted, if significant planned comparisons would then be conducted. As the order of structural condition presentation was counterbalanced across the participants this reduced the number of participants in each condition to 26, it was therefore not statistically viable to assess group differences within the levels of structure between non-drinkers, light social drinkers and heavy social drinkers due to low and uneven numbers as groups were assigned post-hoc. The mean frequencies of saccades in each direction in each condition for the first trial only are presented in figure 3.3.

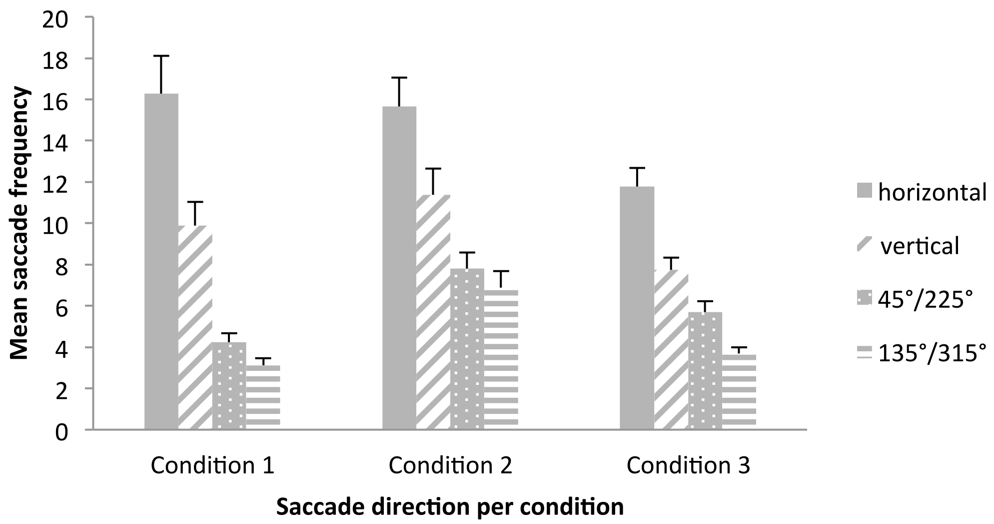

Figure3.3: Mean frequency of saccades in the first trial only

The mixed ANOVA revealed a significant main effect of saccade direction, $f\,(1.68, 74)$ =37.90, p <0.001, η_p^2 = 0.34, due to more horizontal saccades being made across all conditions however there was no significant interaction, $f\,(3.35, 75)$ =1.28, p= 0.28 or main effect of structural condition, $f\,(2, 75)$ = 1.01 , p = 0.37. The results therefore provide evidence of a bias in saccade direction indicating strategic scanning but that the levels of strategic scanning do not differ per structural condition.

3.4.4 Alcohol related attentional bias analysis

The calculation of both indirect and direct measures of alcohol related attentional bias[5], were calculated in line with the procedures adopted in experiment 1a, as outlined in section (2.3.3) for each participant in each of the three conditions of structure.

Indirect measures of alcohol related attentional bias

The descriptive statistics for indirect measures of alcohol related attentional bias for each structural condition are presented in table 3.1. An Independent 3 (level of structure: condition 1, condition 2 and condition 3) x3 (alcohol consumption: heavy social drinkers, light social drinkers and non-drinkers) mixed model ANOVA was conducted on the proportion of alcohol changes detected and alcohol related change detection latencies. The analysis revealed no significant main effects or interactions suggesting that heavy social drinkers, light social drinkers and non-drinkers do not differ in their attention to alcohol related stimuli when measured indirectly by the proportion of alcohol changes detected or the time taken to detect alcohol related changes in any of the conditions of structure.

[5] Measures of alcohol related attentional bias were skewed, as such all scores were log transformed to reduce skewness. Following transformation there were no differences between analyses therefore data is reported non-transformed for ease of interpretation.

Table 3.1: Descriptive statistics for indirect measures of alcohol attentional bias

	Heavy Social Drinkers	Light Social Drinkers	Non-Drinkers
	M (SD)	M(SD)	M(SD)
Structural Condition 1			
Proportion of alcohol changes detected	0.46 (0.12)	0.43 (0.10)	0.44 (0.12)
Mean RT of alcohol related change detected (ms)	6547.85 (2652.58)	5839.58 (1887.72)	5924.56 (1222.56)
Structural Condition 2			
Proportion of alcohol changes detected	0.42 (0.11)	0.43 (0.11)	0.40 (0.12)
Mean RT of alcohol related change detected (ms)	6075.64 (2306.95)	5909.42 (2011.21)	5097.26 (1755.89)
Structural Condition 3			
Proportion of alcohol related changes detected	0.42 (0.11)	0.43 (0.12)	0.41 (0.11)
Mean RT of alcohol related change detected (ms)	5527.52 (2547.64)	5999.98 (2196.46)	5817.1 (1929.86)

Direct measures of alcohol related attentional bias

As in Experiments 1a and 1b both the initial orienting of attention to alcohol related stimuli and maintained attention on alcohol related stimuli were analysed in each condition, see Table 3.2 for descriptive statistics. Where sphericity is violated the Greenhouse - Geisser correction was applied.

Table 3.2: Descriptive statistics for direct measures of alcohol attentional bias

	Heavy Drinkers	Light Drinkers	Non- Drinkers
	M (SD)	M (SD)	M (SD)
Structural Condition 1			
Proportion of 1st Saccades to alcohol related stimuli	0.45 (0.20)	0.42 (0.13)	0.49 (0.14)
Mean time to initially saccade to alcohol related stimuli (ms)	1065.14 (334.70)	968.28 (332.86)	897.14 (293.94)
Proportion of fixations on alcohol related stimuli	0.46 (0.08)	0.47 (0.07)	0.45 (0.07)
Duration of fixations on alcohol related stimuli (ms)	-127.82 (669.59)	-194.08 (487.01)	-231.68 (625.86)
Structural Condition 2			
Proportion of 1st Saccades to alcohol related stimuli	0.50 (0.21)	0.47 (0.15)	0.52 (0.15)
Mean time to initially saccade to alcohol related stimuli (ms)	922.83 (356.86)	891.36 (287.31)	840.18 (305.28)
Proportion of fixations on alcohol related stimuli	0.47 (0.06)	0.47 (0.07)	0.45 (0.06)
Duration of fixations on alcohol related stimuli (ms)	-202.16 (363.92)	-139.81 (508.15)	-213.54 (498.06)
Structural Condition 3			
Proportion of 1st Saccades to alcohol related stimuli	0.42 (0.14)	0.42 (0.11)	0.45 (0.12)
Mean time to initially saccade to alcohol related stimuli (ms)	935.02 (333.82)	906.83 (283.05)	883.92 (321.47)
Proportion of fixations on alcohol related stimuli	0.47 (0.06)	0.48 (0.07)	0.47 (0.06)
Duration of fixations on alcohol related stimuli (ms)	-359.56 (508.47)	-104.38 (469.58)	-151.33 (507.12)

Independent 3 (level of structure: condition 1, condition 2 and condition 3) x3 (alcohol consumption: heavy social drinkers, light social drinkers and non-drinkers) mixed model ANOVA's were conducted for each direct measure. In terms of proportions of first saccades to alcohol related stimuli there was a main effect of structural condition , $f(1.84,138.25)= 3.65$, $p=0.03$, with further analyses indicating a higher proportion of first saccades to alcohol in condition 2 (M=0.50) compared to condition 3 (M= 0.43). There were no other significant main effects or interactions. Although the results indicate differences in alcohol related attentional bias between the conditions in terms of a greater proportion of first saccades being made to alcohol related stimuli in condition 2 compared to condition 3, importantly there were no reliable differences between heavy social drinkers, light social drinkers and non-drinkers.

3.5 Discussion

The present study demonstrated clear evidence of strategic scanning being employed by participants when using the flicker ICB task. In support of hypotheses (1) and in line with the findings of Gilchrist & Harvey (2006), across multiple trials the participants demonstrated strategic scanning in all three conditions as evidenced by a bias in the frequency of horizontal saccades made compared to saccades in any other direction. Also consistent with Gilchrist and Harvey (2006) and hypothesis (2) the extent of strategic scanning was modulated by the degree of structure of the stimuli with the effect of strategic scanning being strongest in the perfectly structured grid condition compared to the stimuli conditions whereby the degree of spatial structure had been reduced. As the biases in saccade direction differed across conditions, the bias in saccade direction would not appear to reflect low level oculomotor biases (for example muscles may lead to biases in the number of saccades in each direction). If they were due to such biases, the biases in saccade direction would be expected to be the same across the conditions (Gilchrist & Harvey, 2006), however this was not the case.

The present results further those of Gilchrist and Harvey (2006) by using motivationally incentive stimuli, which according to IST models of addiction, through processes of classical conditioning, should come to acquire motivational salience and should therefore capture and hold attention in social drinkers (Franken, 2002 and Robson & Berridge, 1993). Therefore as a result of such incentive salience, when such stimuli are included in a visual search task they should, if motivational to the participant possibly come to disrupt search strategies. However contrary to hypothesis 3, the present study was unable to demonstrate any differences in the extent of strategic scanning between heavy social drinkers, light social drinkers and non-drinkers in any of the conditions of spatial structure. Therefore this experiment provides strong evidence of systematic scanning when using the flicker ICB task to measure substance related attentional bias.

Gilchrist and Harvey (2006) argued that the consequence of strategically scanning a display is that it will limit refixations to objects. As such it was suggested previously that strategic scanning would therefore possibly influence the ability to measure maintained attention but not the initial orienting of attention. It was therefore hypothesised (hypothesis 5) that biases between groups in terms of the initial orienting of attention to alcohol related stimuli may be evident in all three conditions of spatial structure. Inconsistent with the hypothesis however, there were no differences in the initial orienting of attention to alcohol related stimuli between non-drinkers, light social drinkers and heavy social drinkers in any of the conditions of spatial structure. One possible explanation for this is that in experiment 1a, the bias in the initial orienting of attention to alcohol related stimuli was associated with levels of subjective craving not levels of consumption. In the present study however the heavy and light social drinkers, although approaching significance, did not differ in levels of subjective craving, which may possibly explain this finding. In addition in experiment 1a biases in the initial orienting of attention were only demonstrated in real world scenes, not in the perfectly structured grids.

Hypothesis 5 further predicted in line with experiment 1a and 1b that as a bias in maintained attention was only implicated in dependent users (experiment 1b) not social users (experiment 1a), that biases in maintained attention might not be evident in any condition of spatial structure. Consistent with this hypothesis there were no differences in the maintenance of attention on alcohol related stimuli between non- drinkers, light social drinkers and heavy social drinkers in any of the conditions of spatial structure. This finding supports experiment 1a, in that biases in maintained attention were not evidenced in social users of alcohol. As discussed in chapter 2, there may be several reasons for this. One possibility is that the incentive salience of the alcohol related stimuli may not be strong enough in social users compared to dependent users to override task demands (strategic scanning) when using the flicker ICB task, although this may be dependent on the spatial structure of the stimuli. However in experiment 1a, even when viewing complexly structured real world scene stimuli whereby the extent of strategic scanning would be assumed to be reduced, biases in maintained attention were not evidenced in social users of alcohol. The extent of strategic scanning when viewing such stimuli however remains to be tested and is the focus of investigation in chapter 4. Another possibility highlighted previously however is that it may be possible that the sub-components of attention may play differing roles at different levels of use. Nonetheless, future research is therefore required with dependent users of a substance in order to assess any possible relationships between the extent of strategic scanning and the substance related attentional biases evidenced in stimuli varying in levels of spatial structure (experiment 2b).

The findings reported above however relate to strategic scanning as measured across multiple trials and Jones et al. (2006) argued that in pilot studies, participants reported quickly developing search strategies when given multiple trials. As a result they suggested that it would be more powerful to use only one trial per participant. As such the extent of strategic scanning was also examined in the first trial in the present study. The pattern of results are partially consistent with hypothesis (4), suggesting that strategic scanning is indeed evident from the first trial, as evidenced by a greater frequency of horizontal saccades being made compared to saccades in any other direction. However, as there was no significant effect of structural condition, in that the frequency of horizontal saccades did not differ between the conditions of stimuli structure, strategic scanning was implicated across all conditions and not just the most structured. The results therefore highlight that even when the stimuli are not perfectly structured strategic scanning is still employed from the first trial. These results however have to be considered with caution as the examination of strategic scanning in the first trial only was a secondary aim. The order in which conditions were presented to participants was counterbalanced, therefore as groups were defined post hoc there were low and uneven group numbers of non - drinkers, light and heavy drinkers in each condition. As a result the present study did not allow for any between groups examination of the extent of strategic scanning or an examination of alcohol related attentional biases in the first trial only. Therefore although from this analysis we can demonstrate that there are no group differences across multiple trials in the extent of strategic scanning between groups, the results are unable to ascertain if there are indeed group differences apparent from the first trial. Therefore it is possible that the time course of strategic scanning between consumption groups may indeed differ, an issue examined in chapter 4. However Jones et al., (2006) and both experiments from chapter 2 were unable to demonstrate any differences in substance related attentional biases between social users of alcohol or between non-smokers and smokers on the first trial. These studies did however use perfect spatially structured grid stimuli, which as the present study has shown encourage the strongest degree of strategic scanning over multiple trials. It may therefore be a possibility that when using stimuli with a disrupted spatial structure that strategic scanning may not be evident from the first trial and instead may develop over multiple trials. As using bi-laterally grouped stimuli representing "clutter" on a table top, Jones et al., (2002) and Jones et al., (2003) demonstrated alcohol related attentional biases using only one trial, however this was inferred by indirect measures of attention only and thus conclusions are limited are we are unable to parse out the sub-components of selective attention from such measurements.

In conclusion, the present study has provided strong evidence of strategic scanning when using the flicker ICB task to measure alcohol related attentional biases in non-drinkers and social drinkers and that the extent of which is modulated by the degree of spatial structure of the stimuli. In addition the present study suggests that such strategic scanning may be evident from the very first trial. The current study was however conducted in social users of alcohol and thus the effects of strategic scanning on measuring attentional bias remains to be examined in dependent users before conclusions regarding the validity of the flicker ICB task can be drawn and recommendations for future research can be made.

3.6 Experiment 2b: The extent of strategic scanning when employing the flicker ICB to measure smoking related attentional bias: An investigation between non-smokers and smokers

Study 3a provided strong evidence that both non-drinkers and social drinkers demonstrate strategic scanning when using the flicker ICB task to measure alcohol related attentional biases and that the extent of strategic scanning is modulated by the degree of spatial structure of the stimuli. Strategic scanning however is only thought to impact on the measurement of maintained attention as Gilchrist and Harvey (2006) argued that a potential consequence of strategically scanning a display is that it will limit refixations to objects (i.e. maintained attention). From the studies presented in chapter 2 however, maintained attention was only implicated when measuring dependent smokers (experiment 1b) no such bias was evidenced in social users of alcohol (experiment 1a) and it was suggested that the sub-components of attention may play differing roles at different levels of use. Therefore in order to further assess the validity of the flicker ICB task as a measure of attentional bias, the extent of strategic scanning and its impact on the measurement of substance related attentional biases in stimuli varying in levels of spatial structure should be investigated in dependent substance users.

The purpose of the present study was therefore to examine the extent and time course of strategic scanning as well as examine smoking related attentional biases in non- smokers and dependent smokers when using the flicker ICB task with stimuli which varied in their degree of structure. The following hypotheses were predicted

1) All participants will demonstrate a strategic component in their scan paths when completing the flicker ICB.
2) The extent of strategic scanning will be modulated by the degree of spatial structure, with it being strongest in the most structured stimuli.
3) Smokers and non-smokers will not differ in their extent of strategic scanning in the most structured grids however group differences may become apparent as the stimuli reduces in the degree of spatial structure.
4) In line with experiment 2a strategic scanning will be evident from the first trial across all conditions.
5) In terms of smoking related attentional bias, biases between groups in terms of the initial orienting of attention to alcohol related stimuli may be evident in all three conditions of spatial structure. However it is predicted that biases in maintained attention may only appear when in conditions whereby the degree of strategic scanning has been reduced.

3.7 Method

3.7.1 Participants

In line with experiment 2a the experiment was advertised as “investigating attention” therefore all participants were naïve to the purpose of the study, in relation to the involvement of smoking. The participant exclusion criteria were identical to previous experiments (see section 2.2.1). In total 40 participants (18 male, 22 female) with a mean age of 21.90 years (SD= 2.67) took part and all participants gave informed written consent. All procedures were approved by the University of Strathclyde ethics committee.

3.7.2 Stimuli

The stimuli were created in an identical fashion to those in experiment 2a (section 3.3.2), with the exception that it was matched smoking and neutral stimuli that were incorporated instead of alcohol related stimuli.

3.7.3 Measures

As in experiment 1b the STLFB was used to assess levels of cigarette use, the QSU to measure levels of nicotine craving, the FTND to measure nicotine dependence and the CABQ to screen for non-smokers and smokers. For a full description of the measures see section 2.6.3.

3.7.4 Apparatus and Procedure

The apparatus and procedure were identical to experiment 2a (section 3.2.4) with the following exceptions (i) As smokers and non-smokers were not specifically recruited to the study in order to keep them naïve to the true purpose of the study, participants were assigned to a smoking or non-smoking group post hoc. Therefore as in experiment 1b a screening measure (CABQ) was employed in order to create equal group sizes. Therefore, once participants had demonstrated an interest in taking part in the experiment they were initially asked to complete an online version of the CABQ to ensure that similar numbers of non- smokers and smokers were being tested. (ii) participants completed smoking related questionnaires to measure craving, consumption and dependence on completion of the flicker ICB task.

3.8 Results

3.8.1 Eye movement and response errors

In line with the criteria outlined in section (3.3.1), 12.34% trials were excluded from attentional bias analysis. Similar to Experiment 2a these trials were not removed from strategic scanning analysis as they were not thought to impact on levels of strategic scanning.

3.8.2 Group Characteristics

The non-smoking group consisted of 20 participants (7 male, 13 female), mean age of 21.55 (SD = 2.72) years who had reported having never smoked cigarettes regularly. The smoking group consisted of 20 participants (11 male and 9 female) with a mean age of 22.25 (SD = 2.63) years who reported smoking on average 9.70 (SD = 4.71) cigarettes per day. The smokers had a mean FTND score of 3.10 (SD= 1.94) which indicates low dependence and a mean craving score of 38.53 (SD= 27.70) which indicates low craving.

3.8.3 Strategic scanning analyses

All trials

Strategic scanning analysis was conducted in an identical fashion to experiment 2a as outlined in section (3.3.3). To examine the extent of strategic scanning across all trials, the frequency of saccades in each direction were analysed using a 2 (smoking status) x 3 (structural condition) x 4 (saccade direction) mixed ANOVA. The mixed ANOVA revealed a significant main effect of direction, $f(1.40, 52.96) = 137.56$, $p < 0.001$, $\eta_p^2 = .94$, due to more horizontal saccades across all conditions. In addition there was a significant 2 way interaction of condition by direction, $f(3.63, 137.79) = 28.59$, $p < 0.001$, $\eta_p^2 = .86$. More importantly there was a significant 3 way interaction, $f(3.62, 38) = 5.49$, $p < 0.01$, $\eta_p^2 = .34$. The 3 way interaction was further examined by planned comparisons in order to examine the hypotheses described in section 3.5. The mean frequencies of saccades made in each direction for each condition are displayed in figure 3.4.

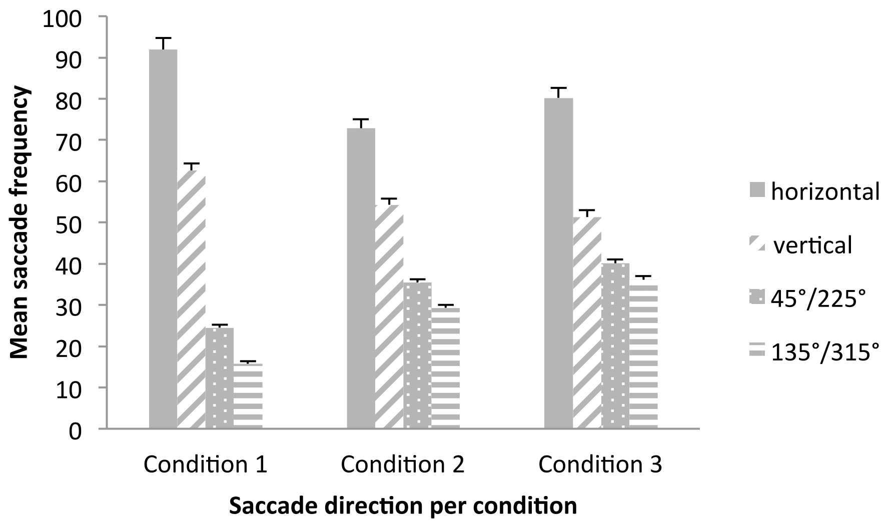

Figure 3.4: Mean frequency of saccades in each direction per condition

Firstly, in order to examine if strategic scanning was employed by smokers and non - smokers in each of the three conditions stepwise planned comparisons as described in section (3.4) assessed the mean frequency of horizontal saccades compared to the mean frequency of vertical saccades in each condition, separately for smokers and non- smokers, the mean frequency of saccades in each direction per condition for smokers and non- smokers are presented in figures 3.5 and 3.6, respectively.

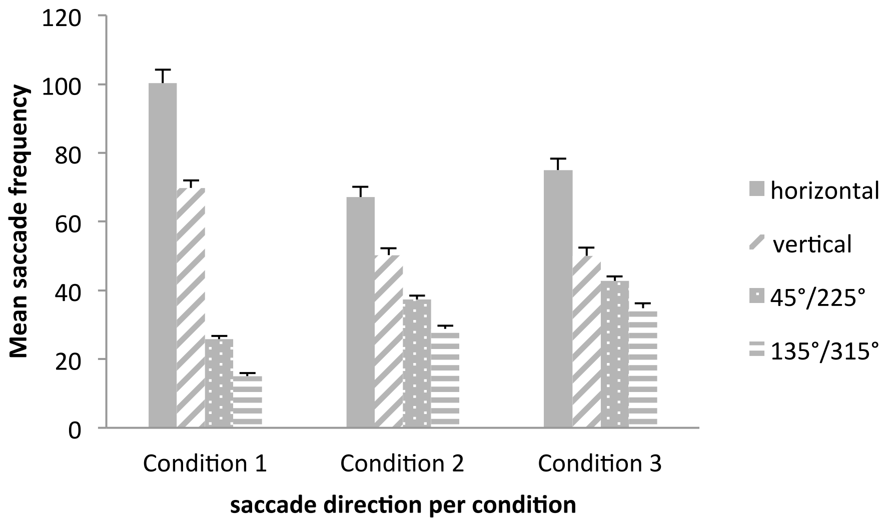

Figure 3.5: Frequency of saccades per direction for each condition made by smokers

The analysis indicates that smokers made more horizontal saccades compared vertical saccades and thereby saccades in any other direction in condition 1, *f* (1,28.08) = 38.6, $p < 0.001$, $d = 1.58$, condition 2, *f* (1, 28.08) = 11.87, $p < 0.01$, $d = 1.36$ and condition 3 *f* (1, 28.08)= 25.86, $p < 0.001$, $d = 1.84$, suggesting that smokers demonstrated a strategic component in their scan paths in all the three conditions.

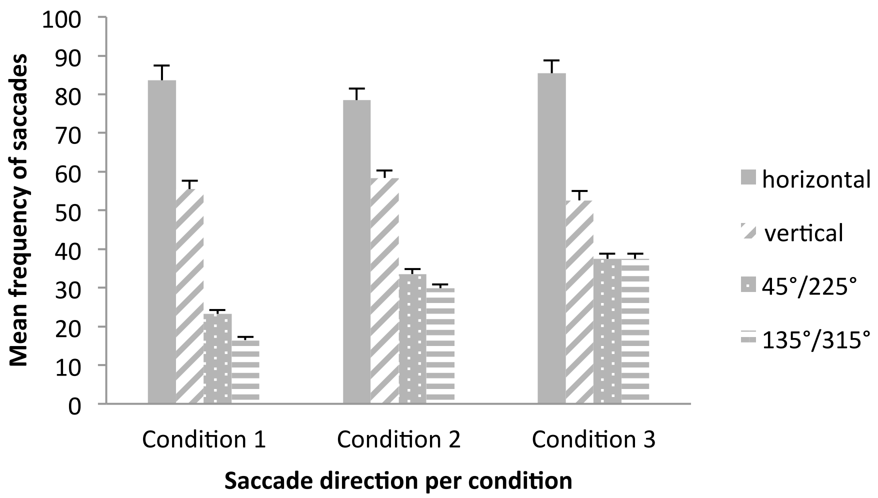

Figure 3.6: Frequency of saccades per direction for each condition made by non-smokers

Analysis also demonstrated that non- smokers made more horizontal saccades compared to saccades in any other direction in condition 1, $f(1, 25.50) = 35.36$, $p < 0.001$, $d = 1.37$, condition 2, $f(1,25.50) = 18.10$, $p < 0.001$, $d = 1.05$ and condition 3, $f(1, 25.50) = 48.34$, $p < 0.001$, $d = 1.49$, suggesting that non- smokers also demonstrated a strategic component in their scan paths in all the three conditions.

Secondly, in order to examine if the degree of strategic scanning evidenced by smokers and non - smokers was modulated by the degree of structure of the stimuli planned comparisons were conducted to assess the difference between the mean frequency of horizontal saccades between each of the three conditions, separately for smokers and non- smokers. Analysis demonstrated that smokers demonstrated a greater degree of strategic scanning in condition 1 compared to condition 2, $f(1, 37.65) = 45.70$, $p < 0.001$, $d = 1.68$ and condition 3, $f(1, 37.65) = 26.59$, $p < 0.001$, $d = 1.27$ however there was no difference between condition 2 and condition 3, $f(1, 37.68) = 2.56$, $p > 0.05$. Therefore strategic scanning was strongest in the most structured condition. The degree of strategic scanning demonstrated by non – smokers did not differ between condition 1 and condition 2, $f(1, 37.14) = 1.16$, $p>0.05$, condition 1 and condition 3, $f(1, 37.14) = 0.15$, $p > 0.05$ or between condition 2 and condition 3 $f(1, 37.14) =2.13$, $p > 0.05$. Therefore, indicating that the degree of strategic scanning demonstrated by non-smokers did not differ between conditions.

Lastly, in order to examine whether the extent of strategic scanning differed between non-smokers and smokers in each condition planned comparisons were conducted to assess if the mean frequency of horizontal saccades made in each condition differed between smokers and non-smokers. In condition 1, smokers demonstrated a greater degree of strategic scanning compared to non- smokers $f(1, 40) = 9.06$, $p < 0.01$, $d = 0.68$. However non- smokers demonstrated a greater degree of strategic scanning compared to smokers in both condition 2, $f(1, 40) = 4.18$, $p < 0.05$, $d = 0.60$ and condition 3, $f(1,40) = 3.56$, $p < 0.05$, $d = 0.50$.

First trial only

In order to examine the extent of strategic scanning in the first trial the frequency of saccades within each of the four direction bins described above was computed for each participant for their first trial only (see figure 3.7). Similar to the analysis strategy above a 3 (structural condition) x 4 (saccade direction) mixed ANOVA was conducted, if significant planned comparisons would then be conducted. As the order of structural condition presentation was counterbalanced across the participants this reduced the number of participants in each condition to 13 in condition 1, 13 in condition 2 and 14 in condition 3, it was therefore not statistically viable to assess group differences within the levels of structure between smokers and non-smokers due to such low numbers.

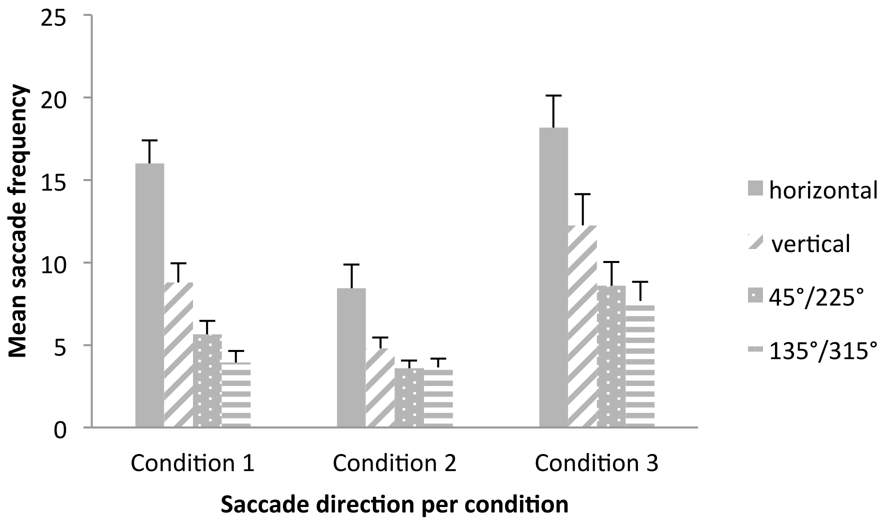

Figure 3.7: The mean frequency of saccades made in each direction for each condition for the first trial only.

The mixed ANOVA revealed a significant main effect of saccade direction, $f(3, 79.99) = 33.80$, $p < 0.001$, $\eta_p^2 = 0.48$, due to more horizontal saccades across all conditions however there was no significant interaction, $f(4.32, 37) = 1.94$, $p = 0.11$ or main effect of structural condition, $f(2, 37) = 2.32$, $p = 0.12$. The results therefore provide evidence of a bias in saccade direction indicating strategic scanning but that there was no effect of structural condition.

3.8.4 Smoking related attentional bias

The calculation of both indirect and direct measures of alcohol related attentional bias[6] were calculated in line with the procedures adopted in the previous experiments as outlined in section (2.3.3).

Indirect measures of smoking related attentional bias

The descriptive statistics for indirect measures of smoking related attentional bias for each structural condition are presented in table 3.3. Independent 3 (level of structure: condition 1, condition 2 and condition 3) x 2 (smoking status: smoker and non-smoker) mixed model ANOVAs were conducted for both indirect measures. Analysis revealed no significant differences suggesting that when measured indirectly smokers do not show a smoking related attentional bias in terms of the proportion of smoking related changes detected or the time taken to detect smoking related changes.

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[6] Measures of smoking related attentional bias were skewed, as such all scores were log transformed to reduce skewness. Following transformation there were no differences between analyses therefore data is reported non transformed for ease of interpretation.

Table 3.3: Descriptive statistics of indirect measures of smoking related attentional bias

	Smokers	Non- smokers	
	M (SD)	M(SD)	Sig.
Structural Condition 1			
Proportion of smoking related changes detected	0.45 (0.07)	0.40 (0.10)	> 0.05
Mean RT of smoking related change detected (ms)	5649.30 (2144.87)	4285.79 (1676.32)	> 0.05
Structural Condition 2			
Proportion of smoking related changes detected	0.45 (0.13)	0.43 (0.07)	> 0.05
Mean RT of smoking related change detected (ms)	4069.41 (917.10)	4590.71 (1232.69)	> 0.05
Structural Condition 3			
Proportion of smoking related changes detected	0.42 (0.12)	0.44 (0.11)	> 0.05
Mean RT of smoking related change detected (ms)	5247.09 (1972.51)	5626.88 (3248.05)	> 0.05

Direct measures of smoking related attentional bias

As in the previous experiments both the initial orienting of attention to smoking related stimuli and maintained attention on smoking related stimuli were analysed in each condition, see Table 3.4 for descriptive statistics. Independent 3 (level of structure: condition 1, condition 2 and condition 3) x 2 (smoking status: smoker and non- smoker) mixed model ANOVA's were conducted for each direct measure of attention. Analysis revealed no significant differences suggesting that when measured directly smokers and non-smokers do not differ in any measure of smoking related attentional bias regardless of the degree of structure of the stimuli.

Table 3.4: Descriptive statistics for direct measures of smoking related attentional bias

	Smokers	Non - Smokers	
	M (SD)	M (SD)	Sig.
Structural Condition 1			
Proportion 1st Saccades to smoking related stimuli	0.55 (0.11)	0.48 (0.25)	> 0.05
Mean time to initially saccade to smoking related stimuli (ms)	825.91 (387.71)	821.39 (558.84)	> 0.05
Proportion of fixations on smoking related stimuli	0.49 (0.07)	0.48 (0.09)	> 0.05
Duration of fixations on smoking related stimuli (ms)	9.42 (459.21)	-136.14 (377.97)	> 0.05
Structural Condition 2			
Proportion 1st Saccades to smoking related stimuli	0.56 (0.19)	0.54 (0.14)	> 0.05
Mean time to initially saccade to smoking related stimuli (ms)	773.80 (212.80)	708.02 (186.00)	> 0.05
Proportion of fixations on smoking related stimuli	0.46 (0.07)	0.48 (0.07)	> 0.05
Duration of fixations on smoking related stimuli (ms)	-102.36 (377.97)	-145.32 (318.51)	> 0.05
Structural Condition 3			
Proportion 1st Saccades to smoking related stimuli	0.57 (0.14)	0.47 (0.18)	> 0.05
Mean time to initially saccade to smoking related stimuli (ms)	685.89 (231.50)	810.72 (222.34)	> 0.05
Proportion of fixations on smoking related stimuli	0.48 (0.05)	0.49 (0.07)	> 0.05
Duration of fixations on smoking related stimuli (ms)	19.09 (438.12)	-137.45 (346.41)	> 0.05

3.9 Discussion

In line with Harvey and Gilchrist (2006) and the findings of experiment 2a when measured across multiple trials, both smokers and non-smokers demonstrated strategic scanning in all three conditions as evidenced by a horizontal bias in saccade direction as predicted by hypothesis (1). However only for smokers was the extent of strategic scanning modulated by the degree of structure of the stimuli, with the effect being strongest in the most spatially structured stimuli as evidenced by a higher frequency of horizontal saccades being made in the most structured condition compared to the conditions whereby the degree of structure had been reduced. Conversely, non - smokers showed no difference in the extent of strategic scanning between conditions therefore findings only partially support experiment 2a and hypothesis (2). In addition, and partially consistent with hypothesis (3), when comparing levels of strategic scanning between smokers and non- smokers the results demonstrated that smokers displayed a greater degree of strategic scanning compared to non- smokers in perfectly structured stimuli, however in conditions two and three where the degree of structure had been disrupted non- smokers demonstrated a greater degree of strategic scanning compared to smokers. In line with experiment 2a and hypothesis 4, strategic scanning was evident from the first trial across all conditions. However, contrary to hypothesis 5, there were no differences in any measures of smoking related attentional biases between smokers and non-smokers in any of the three conditions of stimuli structure.

The present study furthers the findings of experiment 2a by assessing the extent of strategic scanning and substance related attentional biases in non- users and dependent users of a substance. In assessing non- users and social users of a substance in experiment 2a, strategic scanning was evidenced in all three conditions but there were no differences in the extent of strategic scanning or alcohol related attentional biases between non- drinkers, light social drinkers or heavy social drinkers. The results of the present study however suggest that although strategic scanning is evidenced by both smokers and non-smokers in all three degrees of structure, only for smokers is the extent of strategic scanning modulated by the degree of structure of the stimuli.

The extent of strategic scanning however is not thought to impact on where participants look first. Indeed in experiment 1b smokers demonstrated biases in the initial orienting of attention in both spatially perfect grid stimuli and real world scene stimuli. The present study however did not find any differences between smokers and non-smokers in the initial orienting of attention to smoking related stimuli in any of the conditions of stimuli structure. This result however may be a consequence of the reduced number of participants in the present study compared to that of experiment 1b.

Gilchrist and Harvey (2006) argued however that the consequence of strategically scanning a display is that it will limit refixations to objects, therefore it would be assumed to effect the maintenance of attention on stimuli. Therefore as smokers demonstrated less strategic scanning than non-smokers when the stimuli structure had been disrupted, biases in maintained attention as evidenced by the proportion or duration of fixations on smoking related stimuli would have been predicted. However no biases in the maintenance of attention were demonstrated in any of the conditions of stimuli structure. A possible explanation for this finding is that although strategic scanning was reduced in smokers compared to non-smokers when stimuli were not perfectly structured, strategic scanning was indeed still evident as indicated by a horizontal bias in saccade direction in each of the three conditions of spatial structure. Therefore the degree of strategic scanning may still have been too strong for maintained attention to be effectively measured. Therefore if the spatial regularity of the stimuli was further reduced the presence of strategic scanning may further reduce or disappear allowing for the sensitivity of the flicker ICB task whilst employing eye tracking to measure biases in maintained attention, particularly when one considers that experiment 1b implicated biases in maintained attention but only in complexly structured real world scenes, an issue which is further examined in chapter 4. Nonetheless, by demonstrating that dependent smokers show a greater horizontal bias in saccade direction in the most spatially structured condition compared to the conditions in which the spatial structure had been reduced, the present study provides clear evidence that when using the flicker ICB task the spatial structure of the stimuli modulates the degree of strategic scanning in dependent substance users. This will have important implications for future research, however further study is required with more complex real world stimuli (chapter 4) before clearer recommendations can be provided.

Although smokers showed a reduction in levels of strategic scanning compared to non-smokers in conditions whereby the degree of spatial structure had been reduced, they actually demonstrated a greater degree of strategic scanning compared to non- smokers in the perfect spatially structured grids. This point however merely strengthens the argument that when using such perfectly structured stimuli, the task demands in terms of strategic scanning overrides the ability to effectively measure substance related attentional biases even in dependent users of a substance as they demonstrated a greater degree of strategic scanning compared to non-smokers in such stimuli. As a result, the effectiveness and validity of the flicker ICB in such instances to measure attentional bias is limited.

It has to be acknowledged however that in the present study the degree of strategic scanning demonstrated by non-smokers did not differ across the different structural conditions. Also both in the present experiment (smokers only) and experiment 2a (all participants), although strategic scanning was demonstrated to be strongest in the most structured stimuli condition there was no difference in the extent of strategic scanning between the two conditions in which the degree of structure had been disrupted. These findings are contrary to that of Gilchrist & Harvey (2006) who demonstrated that when using non-motivational stimuli that the degree of strategic scanning gradually reduces as the degree of spatial structure of the stimuli reduce. A possible reason for these contrasting findings may be in relation to the stimuli design differences between Gilchrist & Harvey (2006) and the experiments presented in this chapter. Gilchrist and Harvey (2006) used triangles with the target stimulus being an upside down triangle. These triangles were randomly placed on the imaginary grid displays to create the three conditions of structure as detailed in (section 3.3.2). In the present experiment and experiment 2a, pairs of substance related stimuli and neutral stimuli were used. In line with experiments 1a and 1b, the pairs of substance related stimuli and neutral stimuli were matched for colour, shape and size and although placed randomly on the imaginary grid displays, the matched pairs occupied corresponding positions on the grids. This was done in order to control for any possible low level factors such as colour, shape and size of the stimuli and thus the positioning of such stimuli, which may have influenced attentional processes (Theeuwes, 1992). As a result of this additional control however, the structure of the stimuli conditions in experiment 2a and 2b may not be equivalent to that of the randomly placed stimuli of Gilchrist & Harvey (2006). Therefore if the spatial regularity of the stimuli was to be reduced further the presence of a graduated reduction in the degree of strategic scanning may be evident.

The findings discussed above however relate to strategic scanning as measured across multiple trials and Jones et al. (2006) argued that in pilot studies, participants reported quickly developing search strategies when given multiple trials, and so suggested that it would be more powerful to use only one trial per participant. In line with the findings of experiment 2a, the present study also demonstrated that strategic scanning was evident in the first trial and again there was no difference in the extent of strategic scanning across the three conditions of stimuli structure. The strength of these results however have to be considered with caution as examining the extent of strategic scanning in the first trial was secondary to the main aim of the study. Therefore due to counterbalancing the condition shown in the first trial, both low numbers and the inability to examine group differences limit the conclusions that can be drawn.

In conclusion, the present study has provided strong evidence of strategic scanning when using the flicker ICB task to measure smoking related attentional biases in non-smokers and dependent smokers, the extent of which in dependent smokers is modulated by the degree of spatial structure of the stimuli. In addition the present results demonstrated no smoking related attentional biases between smokers and non-smokers. This is an important finding, suggesting that even when the spatial structure of the stimuli is not perfect participants employ strategic scanning and thus the sensitivity of the flicker ICB to effectively measure the ability of a cue to hold attention may be limited. The disruption to the structure of the stimuli both in the present experiment and experiment 1a however may not have been adequate enough to reduce to strategic scanning to a degree where biases in maintained attention could be evidenced. As differential substance related attentional biases have been implicated when using the flicker ICB task employing real world stimuli with a complex spatial structure (experiment 1b). Therefore in order to further examine the validity of the flicker ICB and provide methodological recommendations for future research an examination of levels of strategic scanning in such stimuli are warranted and as such are the focus of investigation in chapter 4.

Chapter 4

4.1 Strategic Scanning employed during the flicker change blindness task: A comparison of perfectly structured grid stimuli and real world scene stimuli

In experiments 1a and 1b (chapter 2) substance related attentional biases were assessed using both perfectly structured grid stimuli and stimuli representative of real world scenes. The results demonstrated that the pattern of substance related attentional biases evidenced by social users and dependent users differed depending on the type of stimuli used. In study 1a, alcohol related attentional biases in social users of alcohol were only evident when analysis was conducted on stimuli representative of real world environments, no such biases were demonstrated when grid stimuli were used. In experiment 1b, although smoking related attentional biases were demonstrated in smokers compared to non-smokers in both grids and scenes, the pattern of results differed depending on the type of stimuli. In that a bias in the initial orienting of attention was demonstrated in both grids and scenes however a bias in maintained attention was only implicated in scenes. In addition, when examining smoking related attentional biases within smokers only, smoking related attentional biases were again only suggested to be evident when analysing real world scene stimuli, in the form of maintained attention.

As discussed previously in chapter 2, there are several possible explanations for such findings. One possibility is that the perfect spatial structure of the grid stimuli encourages strategic scanning which limits the sensitivity of the flicker ICB task when using such stimuli to measure attentional biases compared to when complexly structured real world scene stimuli are employed. Another possibility is that the real world scene stimuli compared to the grid stimuli are more ecologically valid as they are more representative of the environments which may actually give rise to attentional biases (Nees, et al., 2012). Or indeed it may be a combination of both.

Gilchrist and Harvey (2006) defined strategic scanning as starting in one place in a display and then searching systematically through sections of the display. They argued that the consequence of strategically scanning a display is that it will limit refixations to objects. As a result strategic scanning would be assumed to influence the measurement of maintained attention and not the initial orienting of attention. Gilchrist and Harvey (2006) demonstrated that during a visual search task the degree of strategic scanning is modulated by the degree of structure of the stimuli, with the effect of strategic scanning being strongest in the most spatially structured stimuli. The study however used non-motivational stimuli such as triangles with upside down triangles as targets. Therefore chapter 3 of this thesis sought to examine the extent of strategic scanning when employing the flicker ICB task to measure attentional biases to motivationally incentive stimuli using stimuli varying in the degree of spatial structure. These experiments were important because if strategic scanning is employed by participants when completing a flicker ICB task, the task may be limited in its validity as a measure of substance related attentional bias. Although, this may be dependent on the spatial structure of the stimuli used and as such have important ramifications for future research employing this task.

Experiments 2a and 2b (chapter 3) using stimuli which varied in the degree of structure demonstrated that even when employing objects within the stimuli which are assumed to be motivationally salient to some participants and should thus capture and hold attention (Franken, 2003; Robinson & Berridge, 1993), strategic scanning was still employed and further demonstrated that the effect was strongest in the most spatially structured displays. These studies provide strong evidence of strategic scanning when using the flicker ICB task and demonstrate that the extent of strategic scanning is modulated by the degree of structure of the stimuli.

In both experiments 2a and 2b however, even when the stimuli were not perfectly structured and there were reduced levels of strategic scanning, substance related attentional biases were still not evident. As discussed in section 3.8, the design of the stimuli in experiments 2a and 2b may have been subject to limitations. As by attempting to control for possible low level influences on attentional processes, the reduction in the degree of spatial structure between the conditions may have been limited. As a result, the stimuli although assumed to vary in the degree of spatial structure may not have had their degree of spatial structure reduced to a level at which strategic scanning would be further reduced or possibly eradicated in order for the flicker ICB to be sensitive enough to detect biases in maintained attention. Therefore the findings from experiments 2a and 2b suggest that the flicker ICB task may have limited validity as a measure of attentional bias when using heavily structured stimuli. However further research is required employing heavily structured stimuli and real world scene stimuli in order to further examine the relationships between stimuli structure, strategic scanning and any biases in attention that are evidenced.

Indeed, the results of experiment 1b indicated that dependent smokers demonstrated a bias in maintained attention when viewing real world scene stimuli but not when viewing perfect spatially structured grid stimuli. The extent of strategic scanning has been shown to be modulated by the degree of spatial structure of the stimuli (Experiments 2a, 2b, Gilchrist & Harvey, 2006), therefore due to the complex spatial structure of real world scenes, strategic scanning may not present or may be reduced when viewing such stimuli. Therefore as strategic scanning is thought to influence the ability to measure maintained attention it may be that the degree of strategic scanning is reduced to a level when viewing such complex real world scene stimuli to allow for the measurement of biases in maintained attention. This is an important point because if this is the case, this would provide an explanation for the previous inconsistent findings between the grid stimuli and the real world scene stimuli in terms of the attentional biases evidenced and raise important methodological considerations for future research when using the flicker ICB task to measure attentional bias.

Although the difference in the degree of strategic scanning employed when viewing grid stimuli and real world scene stimuli may provide an explanation for the inconsistent results between attentional biases evidenced when viewing grid stimuli compared to real world scene stimuli, research has demonstrated that when viewing real world scene stimuli, several additional factors may modulate where attention and eye movements are directed due to the context of the scene. Therefore the real world scene stimuli may also be subject to additional factors which may influence the degree of strategic scanning demonstrated when using such stimuli. For example, it is well known that viewers do not fixate on every part of a scene and instead only fixate on what is deemed to be informative and interesting (Rayner, 2009). In addition in real world scenes the semantic content of the scene and the general co-occurrence of particular objects within a scene also modulate where attention and eye movements are directed (Torralba, Oliva, Castelhano & Henderson, 2003). For example, real world scenes are relatively stable in that they consist of sets of objects that co-occur with each other in known and predictable ways. For example a kitchen is likely to contain a cooker and the placement of the cooker will be constrained within semantic knowledge of the world (i.e. a cooker cannot float in mid-air). Therefore the scene context provides information that can be used to guide attention to behaviourally relevant stimuli (Brockmole & Henderson, 2006; Chun, 2000; Henderson, 2003; Neider & Zelinsky, 2006). Perfect spatially structured grids lack context and as highlighted above the context of real world scenes may guide eye movements and attention when viewing such stimuli. Therefore real world scene stimuli may be less conducive to strategic scanning due to the more complex structure and context of the scene and as a result be more sensitive compared to grid stimuli when used in the flicker ICB task to measure maintained attention.

However, the context of real world scene stimuli may also improve the sensitivity of the flicker ICB due to its influence on cue reactivity. Research paradigms which expose individuals to substance related stimuli in vivo (e.g. watching someone drink alcohol), through imagery (e.g. using script guided imagery of a previous substance taking episode), by dynamic video, (e.g. watching a film of someone lighting a cigarette) or pictorial images (viewing images of substance related stimuli) have shown that individuals who use the respective substances demonstrate cue reactivity in the face of such paradigms by eliciting subjective, physiological and cognitive reactions which promote drug seeking and consumption (see Conklin, 2006 for a review).

Although research has provided strong evidence of cue reactivity in substance users, research has also demonstrated that the degree of such cue reactivity elicited can be influenced by context. In order to demonstrate this, researchers have utilised a discriminative classical conditioning task whereby smokers entered two different contexts; one context predicted the future occurrence of smoking (e.g. one puff of a cigarette) and one context predicted the non-occurrence of smoking and in both contexts smokers were exposed to smoking cues (e.g. cigarettes and lighter). These studies demonstrated that smoking cues elicited less craving in the non-smoking context than in the smoking context (Dols, Willems, Van den hout, & Bittoun, 2000; Dols , van den Hout, Kindt & Willems, 2002; Thewissen, van den hout, Havermans & Jansen, 2004). In addition Nees et al, (2012) showing pictures of alcohol related stimuli in different contexts, for example in an alcohol related environment, a neutral environment or a social environment showed that different contexts differentially influenced cue reactivity in that both social and pub-related contexts elicited the most appetitive and arousing responses. Considering these findings stimuli depicting real world environments may be more representative of the environments which may give rise to such attentional biases and so may be more sensitive to detecting substance related attentional biases when used in the flicker ICB compared to that of the grid stimuli.

It is pertinent to the advancement of developing a clearer understanding of the extent and roles of substance related attentional biases that the methods employed to measure such phenomenon are valid. Research presented in this thesis (chapter 3) has already highlighted that the validity of the flicker ICB task as a measurement of attentional bias is limited when using heavily structured stimuli. The aim of the present chapter is to therefore examine the extent of strategic scanning in both perfectly structured grid stimuli compared to real world scene stimuli. This will allow for a further examination of the validity of the flicker ICB task in order to provide methodological recommendations for future research as well as attempt to clarify the reason for the inconsistent findings between the different types of stimuli used (grids and real world scenes) when employing the flicker ICB task.

4.2 Experiment 3a: The extent of strategic scanning employed during the flicker change blindness task when using simple grid stimuli and real world scene stimuli: A comparison between social users of alcohol

In light of the differences between substance related attentional biases as measured using perfect spatially structured grid stimuli and real world scene stimuli a reanalysis of experiment 1a was conducted in order to examine the extent of strategic scanning in both types of stimuli.

The following hypotheses were predicted:

1) In line with Experiment 2a and 2b strategic scanning will be evident in perfect spatially structured grid stimuli by all participants over multiple trials
2) Due to the more complex structure and the context of the scene, strategic scanning may not be evident in real world scene stimuli
3) However, if strategic scanning is evident in both perfect spatially structured grids and real world scenes, the effect is predicted to be significantly stronger in perfect spatially structured grids
4) As there were no differences in alcohol related attentional biases between heavy and light social drinkers in experiment 1a and in light of the findings that non-users and social users of alcohol did not differ in their degree of strategic scanning demonstrated in experiment 2a, it is predicted that there

will be no differences in the extent of strategic scanning between heavy and light social drinkers in either grid stimuli or real world scene stimuli[7].

5) As perfectly structured stimuli was presented for the first trial for all participants it is expected that in line with experiments 2a and 2b that strategic scanning will be evident from the first trial

6) Since heavy social drinkers and light social drinkers demonstrated no differential alcohol related attentional biases on the first trial in experiment 1a it is predicted that there will be no group differences in the extent of strategic scanning within the first trial.

4.3 Method

The participants, apparatus, measures and procedures adopted are described in chapter 2 section 2.2.

4.4 Results

All trials

Strategic scanning analysis was conducted in an identical fashion to experiment 2a as outlined in section (3.4.3). To examine the extent of strategic scanning across all trials, the frequency of saccades in each direction were analysed using a 2 (drinking group: heavy and light social drinkers) x 2 (condition: grid stimuli and real world scene stimuli) x 4 (saccade direction) mixed ANOVA. The mixed ANOVA revealed a significant main effect of direction, $f\,(1.61, 88.53) = 364.24$, $p < 0.001$, $\eta_p^2 = .92$, due

[7] Although in experiment 1a no differences in alcohol related attentional biases were demonstrated between heavy and light social drinkers, there were differences between high alcohol cravers and low alcohol cravers however in order to compare to previous research employing the flicker ICB by Jones and colleagues, only data in terms of levels of consumption are presented. Note however that analysis has been conducted on levels of alcohol craving and there were no differences between levels of strategic scanning between high and low alcohol cravers.

to more horizontal saccades being made compared to saccades in any other direction across all conditions. Analysis also revealed a significant main effect of condition, f (1,55) = 5.68, p =0.02, η_p^2 = 0.09 due to more saccades being made overall when viewing real world scene stimuli (M= 62.20, SE 3.01) compared to when viewing grid stimuli (M=55.35, SE = 2.05). In addition there was a significant 2 way interaction of condition by direction, f (1.90, 104.94) = 60.64, p <0.001, η_p^2=.84. No other main effects or interactions were significant, therefore highlighting that there were no group differences between light social drinkers or heavy social drinkers.

In line with experiment 2a in order to further examine the significant condition by direction interaction stepwise planned contrasts were used to compare the mean frequency of horizontal saccades compared to vertical saccades in each condition. Planned contrasts were then used to compare the frequency of horizontal saccades made in each condition. The mean frequency of saccades in each direction in each condition are presented in figure 4.1.

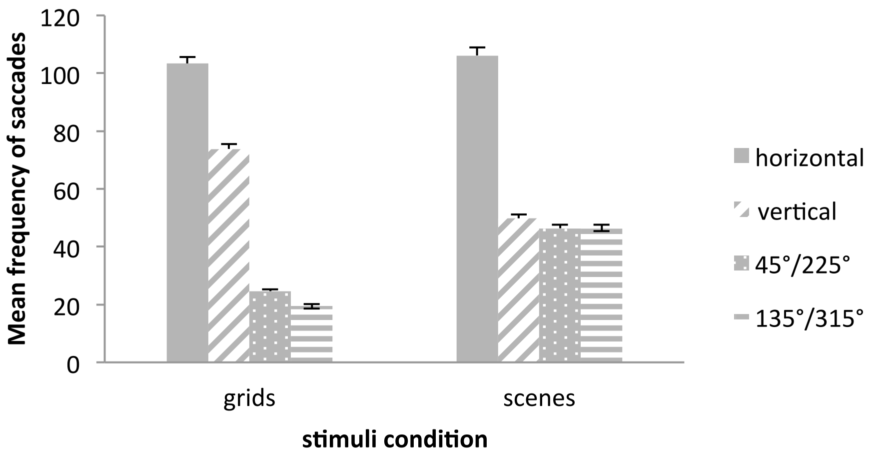

Figure 4.1: Mean frequency of saccades in each direction for both grid and real world scene stimuli.

Comparing the mean frequency of saccades made in a horizontal direction compared to vertical direction within each stimulus condition, analysis revealed that there were more horizontal saccades made compared to vertical saccades and thereby any other saccade direction in grid stimuli, $f(1,107.48) = 64.61$, $p < 0.001$, $d = 1.4$ and real world scene stimuli, $f(1,107.48) = 235.65$, $p < 0.001$, $d = 2.43$, which is evidence of a systematic component in scan paths in both types of stimuli.

In order to examine if the extent of strategic scanning differed between grids and real world scene stimuli, a planned comparison was conducted to compare the frequency of horizontal saccades made in each condition. Analysis however was non-significant suggesting that there was no difference in the extent of strategic scanning between grid stimuli and real world scene stimuli. This analysis however was conducted in line with previous research (Foulsham and Kingstone, 2010; Gilchrist & Harvey, 2006; experiments 2a and 2b) and as such compared the mean frequency of saccades made in a horizontal direction between each stimuli condition. This type of analysis however may not be suitable in this particular instance because as highlighted above there was a significant main effect of condition, meaning that overall there were more saccades made when viewing real world scene stimuli compared to grid stimuli. In order to provide a thorough and more adequate analytic approach in this instance, the proportion of horizontal saccades made compared to saccades in any other direction in both grids and real world scenes were also computed. A 2 (drinking group: heavy and light social drinkers) x 2 (condition: grid stimuli and real world scene stimuli) repeated measures ANOVA was conducted with the proportion of horizontal saccades made as the dependent variable. Utilising this approach therefore overcomes the issues regarding the different number of saccades made in each condition.

The analysis indicated a main effect of stimulus condition, $f(1,55) = 13.28$, $p<0.001$, $\eta_p^2 = 0.19$, demonstrating that there was a higher proportion of saccades made in a horizontal direction compared to any other direction when viewing grid stimuli (M= 0.47, SE =0.01) compared to when viewing scene stimuli (M= 0.43, SE = 0.01). Therefore utilising this statistical approach, the extent of strategic scanning is found to be stronger when viewing grid stimuli compared to when viewing real world scene stimuli. The interaction between drinking group and stimulus condition however was non-significant, $f(1, 55) = 1.47$, $p=0.23$, suggesting that there was no difference in the extent of strategic scanning between heavy and light social drinkers across the different types of stimuli.

First trial only

In order to examine the extent of strategic scanning demonstrated in the first trial the frequency of saccades within each of the four direction bins were computed for each participant for their first trial only. As the first trial for all participants consisted of a grid stimulus a 2 (social drinking group) x 4 (saccade direction) mixed ANOVA was conducted, if significant planned comparisons would then be conducted. The mean frequency of saccades made in each direction for each group in the first trial are presented in figure 4.2.

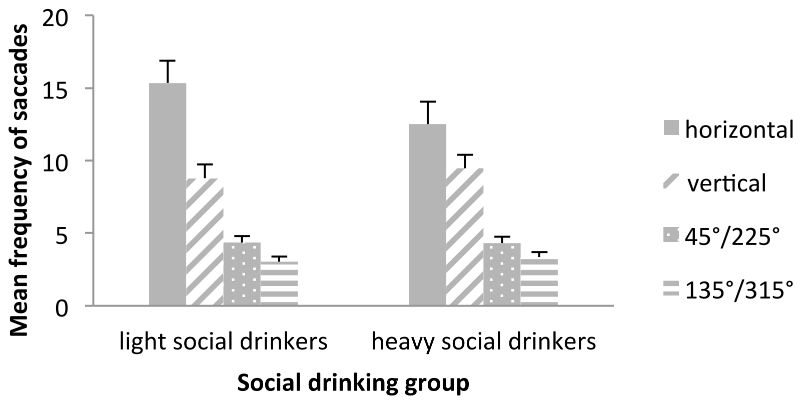

Figure 4.2: Mean frequency of saccades made in each direction for light and heavy social drinkers in the first trial only

The mixed ANOVA revealed a significant main effect of saccade direction, *f* (1.58, 83.35) =29.38, p <0.001, η_p^2= 0.35, due to more horizontal saccades across all conditions however there was no main effect of social drinking group and no significant interaction between social drinking group and direction. The results therefore provide evidence of a bias in saccade direction indicating strategic scanning but that the levels of strategic scanning do not differ between heavy and light social drinkers.

4.5 Discussion

The aim of the present experiment was to examine the extent of strategic scanning employed when using perfectly structured grid stimuli and real world scene stimuli whilst employing the flicker ICB to measure alcohol related attentional biases in social users of alcohol. In line with experiments 2a and 2b, strategic scanning was evidenced in the perfectly structured grids as predicted by hypothesis 1, however contrary to hypothesis 2 strategic scanning was also evident in real world scene stimuli. However if strategic scanning was evidenced in real world scene stimuli it was further predicted in hypothesis 3 that it would be to a lesser extent compared to strategic scanning evidenced when viewing perfect spatially structured grid stimuli. Indeed the extent of strategic scanning was found to be stronger when viewing perfect spatially structured grid stimuli compared to when viewing real world scene stimuli.

In experiment 1a there were no differences between heavy and light social drinkers in relation to any measures of alcohol related attentional biases, contrary to what would have been predicted by IST models of addiction (Franken, 2002; Robinson & Berridge, 2003). This issue was discussed in depth in Chapter 2, whereby possible explanations were put forward to explain such findings. Such as; the possibility that the sub-components of attention may play differing roles in different levels of substance use as well as the possibility that the incentive motivation that alcohol related stimuli acquires in social users may not be strong enough to override the task demands of visual search tasks such as the flicker ICB task. As such, as a result of this null finding plus the finding that non-users and social users of alcohol did not differ in their degree of strategic scanning demonstrated in experiment 2a it was hypothesised (hypothesis 4) in the present study that there would be no difference in the extent of strategic scanning between heavy and light social drinkers. Although the results of the present study support hypothesis 4, further research is needed in dependent users of a substance before clearer conclusions can be drawn regarding the relationship between stimuli type, strategic scanning and attentional biases evidenced. As in experiment 1b, biases in maintained attention were indicated by dependent smokers when viewing real world scene stimuli and in experiment 2b dependent smokers demonstrated strategic scanning to a lesser degree compared to non- smokers when the structure of the stimuli had been disrupted. Therefore in order to more fully evaluate the relationship between types of stimuli (grid and real world scenes), strategic scanning and attentional biases evidenced additional research is required using dependent substance users.

It has to be acknowledged that the analysis in this experiment indicated that overall there were a higher mean number of saccades made when viewing real world scene stimuli compared to when viewing perfect spatially structured grid stimuli. This was problematic, as the dependent variable which had been used in previous experiments in order to measure strategic scanning had been the mean frequency of saccades in a horizontal direction (Foulsham & Kingstone, 2010; Gilchrist & Harvey, 2006; experiments 2a and 2b). Therefore a comparison between the grid stimuli and real world scene stimuli in terms of the mean frequency of saccades would not have been adequate due to the stimuli conditions differing in the mean number of saccades made overall. However by using the proportion of horizontal saccades made compared to saccades made in any other direction, a comparison of the extent of strategic scanning between grid stimuli and real world scene stimuli could be made.

The difference in the mean number of saccades made when viewing real world scene stimuli compared to grid stimuli may signal that the flicker ICB task is more difficult when using real world scene stimuli compared to when using spatially structured grid stimuli. This may be for a variety of reasons such as the possible increased complexity of the stimuli or the reduction in strategic scanning which may possibly be me the most optimal search strategy. If the increased number of saccades are related to increased difficulty when trying to detect the changing object within real world scene stimuli it would be predicted that the time taken to detect a change would be slower in real world scene stimuli compared to in perfect spatially structured grid stimuli. In order to further investigate this possibility I examined the mean time taken to detect a changing stimulus, irrespective of whether it was neutral or alcohol related, between the grid stimuli and real world scene stimuli. The results suggested that participants were slower to detect changes in real world scenes (M = 6629.02 ms, SD = 7733.59 ms) compared to changes in perfect spatially structured grid stimuli (M=6076.74 ms, SD 5005.95ms), however this was only approaching significance (p=0.06). Although only approaching significance, the results indicate that the increased number of saccades made when viewing real world scenes compared to when viewing perfect spatially structured grids may be due to increased difficulty of detecting the change in the real world scene stimuli. This however would bear no influence on the measuring of the initial orienting of attention (i.e. where the eyes look first) but it must also be noted that this would not be thought to influence measures of maintained attention. As maintained attention, measured either by proportion of fixations or durations of fixations on alcohol related stimuli are made relative to the proportion of fixations and duration of fixations on neutral stimuli within each condition.

The above results are in relation to strategic scanning across multiple trials. As discussed previously Jones et al (2006) argued that participants reported quickly developing search strategies over multiple trials and so they argued that using only one trial per participant was a more robust measure of substance related attentional bias when using the flicker ICB task. Experiment 2a and 2b however demonstrated that strategic scanning was evident from the first trial, even when the stimuli were not perfectly structured. Both studies demonstrated that strategic scanning was evident from the first trial in all three conditions of stimuli structure and further showed that the extent of strategic scanning did not differ between the stimuli structural conditions. The analysis however was unable due to low and uneven group numbers per structural condition to compare the extent of strategic scanning between consumption groups. Analysis of the present study did however overcome this limitation to a degree as all participants received the same simple grid stimulus on their first trial, allowing for group comparisons to be made. In line with hypothesis 5 strategic scanning was demonstrated in the first trial, in that there were more horizontal saccades made compared to saccades made in any other direction. This supports the findings of experiments 2a and 2b. Additionally however, the results of the present study demonstrated that there was no difference in the extent of strategic scanning demonstrated in the first trial between heavy and light social drinkers, supporting hypothesis 6. This finding was expected considering the null findings in terms of a differential alcohol related attentional bias in social drinkers as measured from one trial in Jones et al., (2006) and experiment 1a. Therefore as strategic scanning was shown to be evident in all participants from the first trial it is assumed that it would limit the ability of the flicker ICB to measure attentional bias and thus its sensitivity to detect group differences when using perfect spatially structured stimuli. Therefore even when only utilising one trial per participant the effectiveness of the flicker ICB task is limited as a measure of attentional bias in social users of a substance when using such heavily structured stimuli. Jones et al., (2006) using only one trial per participant however did evidence an alcohol related attentional bias in dependent alcohol users, using perfect spatially structured grid stimuli, although this bias was inferred through indirect measures of attention. Yet experiment 1b incorporating both indirect and direct measures of attention failed to evidence any differential smoking related attentional bias between non-smokers and dependent smokers on the first trial only which incorporated perfect spatially structured grid stimuli. As such a further examination of the extent of strategic scanning demonstrated in the first trial by dependent users of a substance is required to provide clearer conclusions.

The conclusions in relation to the extent of strategic scanning in the first trial however can only be made in relation to when perfect spatially structured grid stimuli are employed when using the flicker ICB, as all participants received a grid stimulus on their first trial in the present study. Therefore no such analysis can be carried out on the real world scene stimuli. Therefore although strategic scanning was evidenced in real world scene stimuli over multiple trials in the current study it may be that strategic scanning may develop in such stimuli as a result of the task demands. Therefore it is possible that strategic scanning may be reduced or possibly not be present when using one trial only, when incorporating real world scene stimuli or bi-laterally grouped stimuli. As Jones et al., (2002) and Jones et al., (2003) evidenced an alcohol related attentional bias in social drinkers using only one trial with bi-laterally grouped stimuli, however such biases were inferred from indirect measures of attention.

In conclusion of experiment 3a, it is clear that strategic scanning is evident when viewing both grid stimuli and real world scene stimuli during the flicker ICB task and that the degree of strategic scanning is stronger when viewing grid stimuli compared to when viewing real world scene stimuli. Additionally the present experiment also demonstrates strong evidence that when using grid stimuli, strategic scanning is evident from the first trial. Furthermore the present study also shows that there is no difference in the extent of strategic scanning between heavy and light social drinkers when viewing either perfect spatially structured grid stimuli or real world scene stimuli over multiple trials or on the first trial when a perfect spatially structured grid stimulus is used. Further research however is required to examine the extent of strategic scanning between the types of stimuli with dependent users, as from the experiments presented in this thesis, a bias in maintained attention has only been implicated in dependent users (experiment 1b) not social users (experiment 1a). and strategic scanning is thought to impact only on the measurement of maintained attention (Gilchrist & Harvey, 2006), not the initial orienting of attention. Therefore in order to explain previous findings and more fully examine the validity of the flicker ICB task in order to provide recommendations for future research, an examination of the time course and extent of strategic scanning demonstrated by dependent users when viewing spatially structured grid stimuli compared to real world scene stimuli is warranted.

4.6 Experiment 3b: The extent of strategic scanning employed during the flicker change blindness task when using simple grid stimuli and real world scene stimuli: A comparison between non-smokers and dependent smokers

In order to attempt to explain the inconsistent findings in relation to substance related attentional biases depending on the type of stimuli employed when using the flicker ICB task as discussed above, experiment 3a consisted of a reanalysis of experiment 1a in order to examine the extent of strategic scanning of heavy and light social drinkers in both perfectly structured grid stimuli and real world scene stimuli. The findings however demonstrated that strategic scanning was evident when participants viewed both perfectly structured stimuli and real world stimuli and that the extent of strategic scanning is stronger in perfect spatially structured grid stimuli compared to real world scene stimuli. However as there were no differences in alcohol related attentional biases between heavy and light social drinkers, the relationship between stimuli structure, the degree of strategic scanning and its influence on measures of maintained attention remain limited.

As such the present experiment provides a reanalysis of experiment 1b, aiming to examine the extent of strategic scanning in perfectly structured grids and real world scene stimuli between non-smokers and dependent smokers. Employing both perfectly structured grid stimuli and real world scene stimuli to measure smoking related attentional biases in dependent smokers and non- smokers, experiment 1b demonstrated that smoking related attentional biases were demonstrated in smokers compared to non-smokers in both grids and scenes however the pattern of results differed depending on the type of stimuli. The results demonstrated that smokers compared to non-smokers were quicker to initially orient their attention to smoking related stimuli in both grids and scenes. There was also a trend suggesting that smokers also showed a bias in maintaining attention on smoking related stimuli in terms of the proportion of fixations on smoking related stimuli however this was in real world scenes only. Also when examining smoking related attentional biases within smokers themselves, smoking related attentional biases were suggested to only be evident in real world scene stimuli, again in terms of a bias in maintained attention. These findings in relation to maintained attention were only suggestive as they were only approaching significance but as discussed in chapter 2 this is possibly as a result of the characteristics of the smokers due to low levels of dependence, use and craving. Nonetheless, examining the extent of strategic scanning employed by non-smokers and dependent smokers in experiment 1b will allow for an examination of the relationship between the types of stimuli (perfect spatially structured grid and real world scene), the degree of strategic scanning and the attentional biases evidenced.

The following hypotheses were predicted:

1) In line with previous experiments in this thesis (experiments 2a, 2b and 3a) strategic scanning will be evident in perfectly structured stimuli by all participants over multiple trials.

2) In line with experiment 3a, strategic scanning will be evident in real world scenes.

3) In line with experiment 3a, the extent of strategic scanning will be stronger in perfectly structured grids compared to real world scene stimuli.

4) In experiment 1b there was a trend indicating that smokers demonstrated a bias in maintained attention on smoking related stimuli compared to non-smokers but only in real world scenes, no such biases were evident in perfect spatially structured grid stimuli. In addition in experiment 2b, the degree of strategic scanning demonstrated by smokers was modulated by the degree of structure of the stimuli, however non-smokers demonstrated no difference in the degree of strategic scanning across stimuli structural conditions. As such it is predicted that smokers will demonstrate a lesser degree of strategic scanning in real world scene stimuli compared to non- smokers but that there will be no difference in the extent of strategic scanning between smokers and non-smokers when viewing perfect spatially structured grid stimuli.

5) As perfectly structured stimuli was presented for the first trial for all participants it is expected that in line with previous experiments (experiments 2a, 2b and 3a) that strategic scanning will be evident from the first trial for both smokers and non-smokers

6) As there were no differential smoking related attentional biases between non-smokers and smokers on the first trial in experiment 1b it is further predicted that strategic scanning will not differ between non- smokers and smokers within the first trial

4.7 Method

The participants, apparatus, measures and procedures adopted are described in chapter 2, section 2.6.

4.8 Results

All trials

Strategic scanning analysis was conducted in an identical fashion to previous experiments as outlined in section (3.4.3). To examine the extent of strategic scanning across all trials, the frequency of saccades in each direction were analysed using a 2 (smoking group: non-smokers and smokers) x 2 (condition: grid stimuli and real world scene stimuli) x 4 (saccade direction) mixed ANOVA. The mixed ANOVA revealed a significant main effect of direction, $f(1.43, 105.96) = 180.51$, $p < 0.001$, $\eta_p^2 = .71$, due to more horizontal saccades across all conditions. In addition there was a significant 2 way interaction of condition by direction, $f(1.66,123.12) = 82.29$, $p < 0.001$, $\eta_p^2 = .53$. No other main effects or interactions were significant, therefore highlighting that there were no group differences between non- smokers and smokers.

In line with previous experiments in order to further examine the significant condition by direction interaction firstly stepwise planned contrasts were used to compare the mean frequency of horizontal saccades compared to vertical saccades in each condition and planned contrasts were then used to compare the frequency of horizontal saccades made in each condition. The mean frequency of saccades in each direction in each condition are presented in figure 4.3.

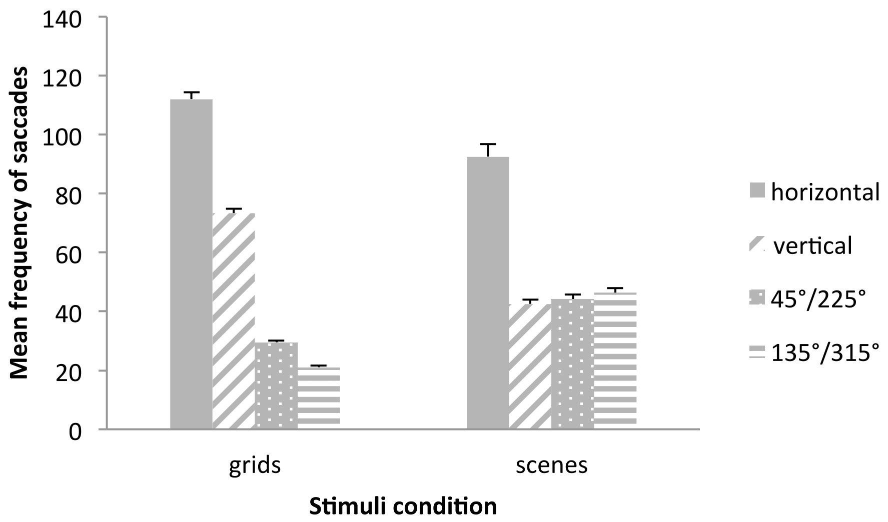

Figure 4.3: the mean frequency of saccades in each direction for grid and real world scene stimuli

Analysis revealed that there were more horizontal saccades made compared to saccades made in any other direction in grid stimuli, $f(1,123.41) = 94.54$, $p < 0.001$, $d = 1.6$ and real world scene stimuli, $f(1,123.41) = 157.84$, $p < 0.001$, $d = 1.29$, which is evidence of a systematic component in scan paths in both types of stimuli. As such in order to examine if the extent of strategic scanning differed between grids and real world scene stimuli a planned comparison was conducted to compare the frequency of horizontal saccades in each condition, $f(1,123.41) = 24.13$, $p < 0.001$, $d = 0.46$, demonstrating that strategic scanning was strongest in the grid stimuli.

In order to provide a thorough analysis to allow for both a direct comparison to experiment 3a and to corroborate the statistical approach taken in experiment 3a, the proportion of horizontal saccades made compared to saccades in any other direction between perfect spatially structured grid stimuli and real world scene stimuli were also analysed.

A 2 (smoking status: smoker and non-smoker) x 2 (condition: grid stimuli and real world scene stimuli) repeated measures ANOVA was conducted with the proportion of horizontal saccades made as the dependent variable. The analysis indicated a main effect of stimulus condition, $f(1,74) = 72.62$, $p<0.001$, $\eta_p^2 = 0.50$, demonstrating that there was a higher proportion of saccades made in a horizontal direction compared to any other direction when viewing grid stimuli (M= 0.47, SE =0.01) compared to when viewing scene stimuli (M= 0.40, SE = 0.01). The interaction between smoking status and stimulus condition however was non-significant, $f(1, 74) = 0.01$, $p=0.93$, suggesting that there was no difference in the extent of strategic scanning between non-smokers and smokers. Therefore, utilising the statistical approach incorporated in experiment 3a, using the proportion of horizontal saccades made as the dependent variable, the results are consistent with the analysis using the mean frequency of saccades made in a horizontal direction as has been used in previous experiments (Foulsham & Kingstone, 2010; Gilchrist & Harvey, 2006; Experiments 2a and 3b).

First trial only

In order to examine the extent of strategic scanning in the first trial the frequency of saccades within each of the four direction bins described above were computed for each participant for their first trial only. As the first trial for all participants consisted of a grid stimulus a 2 (smoking group) x 4 (saccade direction) mixed ANOVA was conducted, if significant planned comparisons would then be conducted in line with the reasons outlined in chapter 3. The mean frequency of saccades made in each direction for each group in the first trial are presented in figure 4.4.

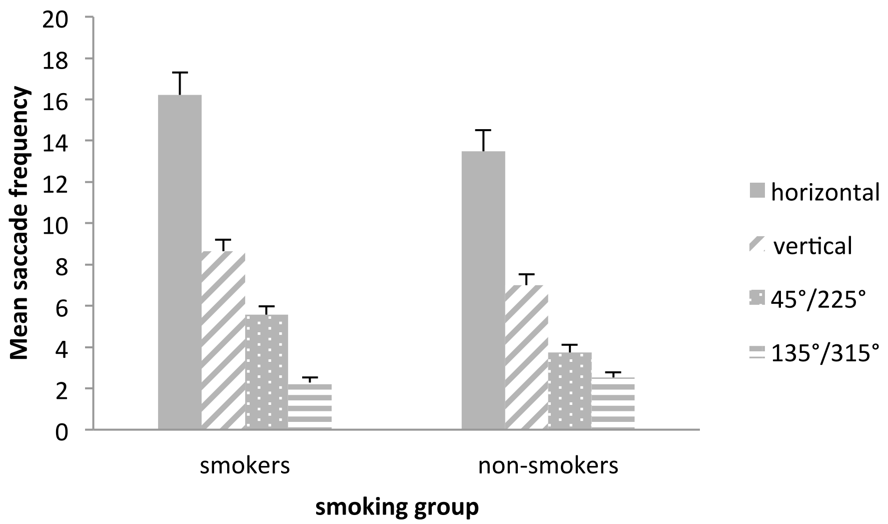

Figure 4.4: Mean frequency of saccades in each direction for smokers and non-smokers in the first trial only

The mixed ANOVA revealed a significant main effect of saccade direction, *f* (1.54, 113.70) = 61.77, p <0.001, η_p^2 = 0.46, due to more horizontal saccades however there was no main effect of smoking group and no significant interaction between smoking group and direction. The results therefore provide evidence of a bias in saccade direction indicating strategic scanning but that the levels of strategic scanning do not differ between smokers and non-smokers.

4.9 Discussion

The aim of the present study was to investigate the extent of strategic scanning employed by non-smokers and dependent smokers when viewing perfect spatially structured grid stimuli and real world scene stimuli during the flicker ICB task. In line with hypotheses 1-3, strategic scanning was evidenced when participants viewed both grid stimuli and real world scene stimuli but importantly the degree of strategic scanning was shown to be strongest when viewing the grid stimuli compared to when viewing the real world scene stimuli. This was evidenced by a larger mean frequency of saccades being made in a horizontal direction in perfect spatially structured grids compared to real world scenes (the statistical approach used by Foulsham & Kingstone, 2010, Gilchrist & Harvey, 2006; Experiments 3a and 3b). However in experiment 3a, due to there being a difference in the mean number of saccades made when viewing the perfect spatially structured stimuli compared to the real world scene stimuli a different statistical approach had to be adopted. Therefore in order to directly compare to experiment 3a the proportion of saccades made in a horizontal direction in perfect spatially structured grids compared to real world scenes were also analysed. This analysis was consistent with the above analysis and demonstrated that strategic scanning was stronger when viewing perfect spatially structured grid stimuli compared to when viewing real world scene stimuli, therefore corroborates the statistical approach and findings of experiment 3a.

These findings are line with previous research which has shown that strategic scanning is strongest in the most spatially structured stimuli (Gilchrist & Harvey, 2006; experiments 2a and 2b). Importantly, the present study and experiment 3a further demonstrate that even when using real world scene stimuli which are complexly structured, strategic scanning remains present, although the effect is to a lesser degree than is demonstrated in perfect spatially structured grid stimuli. This finding may not be solely dependent of the difference in structure as highlighted previously, additional factors such as context has also been shown to modulate attention and eye movements in real world stimuli (Brockmole & Henderson, 2006; Chun, 2000; Henderson, 2003; Neider & Zelinsky, 2006; Rayner, 2009; Torralba, 2003). Nonetheless, these studies provide strong evidence that the degree of strategic scanning demonstrated by participants when completing the flicker ICB task is modulated by the types of stimuli employed, in that the degree of strategic scanning is strongest when viewing perfect spatially structured stimuli compared to stimuli with reduced spatial structures.

Gilchrist and Harvey (2006) argue that during visual search that the lack of refixations to objects would reflect the consequence of strategically scanning a display in terms of following a predictable route. Therefore maintained attention as measured by the proportion and duration of fixations on smoking related stimuli would be assumed to be effected by strategic scanning as the strategic scanning in terms of following a predictable route through a display would be expected to override the incentive salience of the stimuli and therefore limit refixating on the smoking related stimuli. In experiment 1b in terms of maintained attention on smoking related stimuli as indicated by the proportion and duration of fixations on smoking related stimuli, there were no differences between smokers and non-smokers or between smokers themselves when viewing perfectly structured grid stimuli. However when viewing real world scene stimuli, results where suggestive of a trend indicating that smokers demonstrated a greater proportion of fixations on smoking related stimuli compared to non-smokers. Also when analysing attentional biases within smokers themselves there was a trend indicating that heavier smoking was associated with a greater proportion and duration of fixations on smoking related stimuli, indicating a bias in maintained attention but only when viewing real world scene stimuli. In terms of the present reanalysis of experiment 1b, strategic scanning was found to be stronger when viewing perfectly structured grid stimuli compared to real world scenes. Therefore the lack of findings in terms of between groups differences in maintaining attention on smoking related stimuli when viewing perfectly structured grid stimuli may be a consequence of the strong degree of strategic scanning employed when viewing such stimuli limiting re-fixations on smoking related stimuli.

When viewing real world scene stimuli the degree of strategic scanning was reduced relative to the grid stimuli in the present study, as indicated by a lower frequency of saccades being made in a horizontal direction, however there was no difference in the frequency of horizontal saccades made between non-smokers and smokers. The findings from experiment 1b evidenced trends which indicated biases in maintained attention, but as these measures of maintained attention did not quite reach significance it may explain why there were still no differences in the extent of strategic scanning when viewing such stimuli between smokers and non-smokers. As highlighted in Chapter 2, there was limited variability in terms of the characteristics of the smokers in their levels of use and craving which may have impacted on the findings, explaining why the maintained attention measures were only nearing significance and thus why there were no differences in the extent of strategic scanning when viewing such stimuli. Therefore although the results are suggestive in that the reduction in strategic scanning when viewing complexly structured real world scenes may allow for biases in maintained attention to be measured, future research is still required in order to confirm such predictions.

It has to be acknowledged that contrary to experiment 3a, the mean frequency of saccades made did not differ between the perfect spatially structured grid stimuli and the real world scene stimuli. However nor did the time taken to detect a change, regardless of whether it was alcohol related or neutral related , between the types of stimuli ($p=0.98$). Therefore change detection only appeared to be of increased difficulty in real world scene stimuli compared to perfect spatially structured grids in experiment 3a. The real world stimuli used in both the present experiment and experiment 3a were different. Therefore as they did not consist of the same scenes with the exception of whether alcohol or smoking related stimuli were present the scenes may have differed in degrees of difficulty as the number of objects and layout of objects within the scene were not controlled across the studies. As argued throughout this thesis, context is important in cue reactivity and different scenes were used across the studies reflecting contexts relevant to smoking related stimuli and alcohol related stimuli. However as a particular context is not necessarily conducive to both alcohol and smoking related stimuli different scenes were used. In order to control for this in future research, it may be more appropriate to use computer generated scenes in order to control for factors which may influence change detection difficulty such as the number of objects and layout of objects within the scene, allowing for direct comparisons.

In line with previous experiments within this thesis, analyses examining the extent of strategic scanning on the first trial only were also conducted. In support of hypothesis 5, strategic scanning was indeed evident from the first trial, which is in line with the findings of experiments 2a, 2b and 3a. In that both non-smokers and smokers demonstrated a higher frequency of saccades being made in a horizontal direction compared to saccades made in any other direction. Additionally, the findings also supported hypothesis 6 as there was no difference in the extent of strategic scanning on the first trial only between dependent smokers and non-smokers. This finding supports that of experiment 3a which demonstrated that there was no difference in the degree of strategic scanning demonstrated on the first trial between heavy and light social drinkers. Indeed, these findings were expected as the first trial analysis refers only to strategic scanning in perfect spatially structured stimuli and throughout the experiments of this thesis strategic scanning has consistently been shown to be strongest in perfectly structured grid stimuli (experiments 2a, 2b, 3a and 3b). As a result of the study design incorporating a grid stimulus as the first trial for all participants in order to provide a direct comparison to Jones et al., (2006) it remains unclear as to whether strategic scanning is evident from the first trial when viewing real world scenes or if strategic scanning later develops over multiple trials.

In summary, the findings presented in this study further strengthen the argument put forward in experiment 3a and chapter 3 of the present thesis that grid stimuli such as that used by Jones et al., (2006) and incorporated in experiments 1a and 1b can due to their perfect spatial structure, encourage the use of strategic scanning. As the extent of strategic scanning is strongest in such stimuli this overrides the ability to measure maintained attention on substance related stimuli when using such stimuli, even when incorporating only one trial and as a result such stimuli are limited in their sensitivity to measure attentional biases within this paradigm. The studies presented in this chapter also suggest that even though strategic scanning was demonstrated when viewing real world scene stimuli during the flicker ICB task over multiple trials, it is to a reduced level compared to perfectly spatially structured stimuli. As attentional biases in terms of maintained attention do seem to be indicated when using real world scene stimuli (experiment 1b), it is suggested that even though a strategic component in participants scan paths are at play when using such stimuli, the motivational salience of the substance related stimuli may be able to disrupt such processes to allow refixations and so an increased number of fixations and longer fixations on such stimuli can be observed, indicating maintained attention, although further research is required to assess this. As a result the inconsistent findings between previous research by Jones and colleagues (Jones et al., 2002; 2003; 2006) and the inconsistent findings within experiments 1a and 1b in terms of the attentional biases evidenced may indeed be due to the type of stimuli employed. As the extent of strategic scanning employed when viewing the different types of stimuli may influence the sensitivity of the flicker ICB task to measure maintained attention on substance related stimuli.

Considering the theoretical importance and implied clinical importance of substance related attentional biases in addictive behaviours it is extremely important that researchers are utilising effective tasks and methodologies in order to effectively measure attentional bias before a thorough examination of the extent and roles of substance related attentional biases can take place. The studies presented in this chapter further highlight the limited validity of the flicker ICB task as a tool to measure substance related attentional biases when using heavily spatially structured stimuli due to such structure promoting strategic scanning. Although the results suggest that the flicker ICB task may be a valid tool when incorporating complexly structured real world scene stimuli however, further research is required.

Chapter 5: General Discussion

5.1 Thesis summary

Substance related attentional biases have been suggested to play a vital role in the development, maintenance and relapse of addictive behaviours, however, our understanding of the extent and roles of such biases remain limited due to a number of possible methodological limitations. Previous research primarily utilised the Stroop and visual probe tasks but as discussed in chapter 1 these tasks have been subject to criticisms throughout the literature in terms of both methodological limitations and task validity. The flicker ICB task was however argued to overcome many previous limitations as it was argued to allow researchers to measure the ability of a cue to capture and hold attention within one single visual scene (Jones et al., 2002). As discussed in chapter 1, even when adopting this task, the conclusions which could be drawn in terms of the extent and roles of substance related attentional biases in addictive behaviours remained limited due to a number of potential methodological limitations (Jones et al., 2002; Jones et al., 2003, Jones et al., 2006; Yaxley & Zwann, 2005). For example, attentional bias was measured indirectly during these studies through the type of change detected (substance or neutral) or the time taken to detect the change and as a result adopted an arguably simplistic measurement of attention as they failed to measure the extent and roles of the sub-components of selective attention (Mogg et al., 2004). In addition, despite the flicker ICB task allowing researchers to measure the ability of a cue to capture and maintain attention within one single visual scene, this research adopted largely simplistic stimuli by utilising either simple grid stimuli, bi-laterally grouped stimuli or a line up of stimuli. They therefore failed to utilise potentially more ecologically valid stimuli, which may more accurately represent the environments which may give rise to attentional bias (Nees et al., 2012). Another potential methodological limitation previously highlighted relates to the differing number of trials which were utilised across the studies, limiting the capacity to directly compare findings. As Jones and colleagues adopted only one trial per participant, which may be limited in power yet Yaxley & Zwann (2005) adopted multiple trials, which Jones et al., (2006) argued may have been subject to participants developing search strategies and as such limit the validity of the findings evidenced. Additionally, this research also neglected to consider relationships between substance related attentional bias and subjective craving, despite it being of key theoretical importance (Franken, 2003; Robinson & Berridge, 1993).

This thesis sought to overcome such limitations by using the flicker ICB task whilst employing eye-tracking technology in order to directly measure the allocation of attention within one single visual scene. Utilising this approach the aims of this thesis were to examine the relationships between different sub- components of substance related attentional biases, levels of subjective craving, levels of consumption and levels of dependence. In addition this thesis also sought to assess the validity of such an approach to measure attentional biases and examine the influence of the type of stimuli and number of trials employed.

The first experiment (experiment 1a) examined alcohol related attentional biases in social users of alcohol. The findings demonstrated that an alcohol related attentional bias was evident but only in the form of a relationship between subjective craving and the initial orienting of attention to alcohol related stimuli, when viewing real world scene stimuli over multiple trials. As such there was no relationship between measures of alcohol related attentional bias and levels of alcohol consumption, which would have been predicted by IST models of addiction (Franken, 2003; Robinson & Berridge, 2003). Additionally, contrary to Jones and colleagues findings (Jones et al., 2002; Jones et al., 2003; Jones et al., 2006), biases could not be determined from the first trial, even when adopting direct measures of attention in addition to the indirect measures used previously.

Experiment 1b examined smoking related attentional biases in dependent smokers compared to non-smokers, and within smokers themselves with regards to levels of subjective craving, consumption and dependence. Results demonstrated that smokers evidenced smoking related attentional biases compared to non-smokers in both grid (initial orienting of attention) and real world scene stimuli (initial orienting of attention and maintained attention) but only over multiple trials. In contrast to experiment 1a however, when analysing smokers themselves, a smoking related attentional bias was implicated in the form of an association between maintained attention on smoking related stimuli and levels of consumption but only from analysis of real world scene stimuli. No associations were found between measures of smoking related attentional biases and levels of subjective craving and again biases were not evident when analysing the first trial only. The results of experiments 1a and 1b, presented in chapter 2 not only have theoretical ramifications in terms of the extent and roles of substance related attentional biases but also highlight methodological factors which may influence the utility of the flicker ICB task as a measure of attentional bias such as the number of trials and type of stimuli employed (discussed below in sections 5.2 and 5.3).

The remainder of the thesis moved on from further examining the extent and roles of substance related attentional biases in addictive behaviours to instead focusing on examining factors which arose from chapter 2 which may impact on the validity of the flicker ICB task, such as the types of stimuli (simple spatially structured stimuli and real world scene stimuli) and number of trials employed (one versus multiple). This approach was taken as in order to develop an understanding of the extent and roles of substance related attentional biases in addictive behaviours, researchers have to ensure that they are utilising tasks and methodology that are effective and valid. Therefore the work presented in subsequent chapters attempted to both clarify inconsistent findings from previous research as well as provide recommendations for future research employing the flicker ICB task.

Research was then reviewed in chapter 3 which related to the stance that participants may employ strategic scanning (i.e. starting at one place in a display and working your way systematically through sections of the display), when completing the flicker ICB task which may limit the effectiveness of the task to measure substance related attentional biases. On the basis of Gilchrist & Harvey (2006) it was suggested that the when completing a visual search task such as the flicker ICB task, participants may employ search strategies but that the extent of such behaviour may be dependent on the structure of the stimuli used, with it being strongest in the most spatially structured displays (Gilchrist & Harvey, 2006). According to Gilchrist and Harvey (2006) the potential consequence of strategically scanning a display is that it will limit refixations to objects. Therefore maintained attention as measured by the proportion and duration of fixations on substance related stimuli would be assumed to be effected by strategic scanning but where participants look first (initial orienting of attention) would not be effected. As a result it was suggested that the differing degrees of spatial structure of the perfect spatially structured grid stimuli and the complex structure of the real world scene stimuli employed in experiments 1a and 1b may account for the inconsistent attentional bias findings between the types of stimuli. The results of experiments 1a and 1b demonstrated that biases in initial orienting of attention were implicated in both perfect spatially structured grid stimuli (experiment 1b) and real world scene stimuli (experiments 1a and 1b) however maintained attention was only implicated in real world scene stimuli (experiment 1b).

Experiments 2a and 2b, which were presented in chapter 3, evaluated the extent and time course of strategic scanning as well as the extent to which it may be modulated by the degree of structure of the stimuli when employing the flicker ICB task. Additionally the studies aimed to evaluate the possible relationships between the structure of the stimuli, the extent of strategic scanning and the substance related attentional biases evidenced. The results of experiment 2a and 2b demonstrated that when employing the flicker ICB task, participants do indeed display a strategic component in their scan paths from the very first trial, as indicated by a bias in horizontal saccades being made compared to saccades in any other direction, with such a bias being demonstrated irrespective of the structure of the stimuli. Over multiple trials however the extent of strategic scanning of both social users of alcohol (experiment 2a) and dependent smokers (experiment 2b) was strongest when viewing the most spatially structured stimuli. As there were no differential substance related attentional biases between groups in either study, results were limited in their ability to evaluate the relationship between the degree of structure of the stimuli, the extent of strategic scanning and the attentional biases evidenced. As discussed in chapter 3, this however may have been a result of the stimuli composition, due to the additional control exercised over object positioning compared to that of Gilchrist & Harvey (2006). Meaning that although the stimuli differed in their degree of spatial structure, the reduction may not have been sufficient enough to reduce strategic scanning to the extent at which biases in maintained attention could be measured due to the additional controls exercised over stimuli positioning. Therefore it was suggested that if the spatial regularity of the stimuli was further reduced the presence of strategic scanning may further reduce or disappear allowing for the sensitivity to measure biases in maintained attention.

Chapter four thus extended the findings of chapter 3 by reanalysing experiments 1a and 1b (originally presented in chapter 2) in order to examine the extent of strategic scanning between perfectly structured grids and complexly structured real world scenes and further examined the possibility of between group differences in the extent of strategic scanning in the first trial. The findings from this chapter clearly demonstrate that even when real world scene stimuli are utilised when employing the flicker ICB task, participants still employ strategic scanning but to a lesser degree than when viewing perfectly structured stimuli. Experiments 3a and 3b, in line with the findings from chapter 3, additionally demonstrated that strategic scanning was evident from the first trial but further showed there were no between group differences in the extent of strategic scanning on the first trial. The findings detailed in both chapters three and four in terms of strategic scanning, and with the consideration of the pattern of results in chapter 2 in terms of the different pattern of attentional biases evidenced when viewing the simple grid stimuli compared to when viewing real world scene stimuli, outline the effects of the stimuli type on the validity of the flicker ICB task to measure attentional biases and as a result have implications for future research (discussed in section 5.3). Taken together, the findings from all empirical chapters have a number of both theoretical and methodological implications.

5.2 The extent and roles of substance related attentional biases in addictive behaviours

Attention is not a unitary construct; instead it is comprised of multiple components which researchers have argued may actually play different roles over the control of behaviour (Austin et al., 2008; Hogarth et al., 2009; Pearce & Hall, 1980). In the case of addictive behaviours, Hogarth et al., (2009) suggests that both the detection of substance related stimuli and the maintenance of attention on substance related stimuli may have dissociable roles in enabling substance related stimuli to influence substance seeking and consumption and research is required to establish which are clinically relevant. Indeed contemporary models of addiction which predict the presence of substance related attentional biases such as the IST models (Franken, 2003; Robinson & Berridge, 1993) make distinctions between components of attention, referring to the ability of a cue to capture (initial orienting of attention) and hold (maintained attention) attention. As reviewed in chapter 1, despite the theoretical importance of conceptualising attentional bias in terms of sub-components, research to date has inadequately addressed such distinctions and has largely measured attentional bias as a unitary construct.

To complicate the picture further, previous research is also guilty of largely neglecting to examine the relationship between attentional biases and subjective craving, despite the fact that such a relationship is predicted by most contemporary theories of addiction (Cox & Klinger, 1998; Franken, 2003; Kavanagh et al., 2005; Robinson & Berridge, 1993).The few studies which have assessed the relationship between subjective craving and attentional bias have however utilised either the Stroop task or visual probe task, thus the conclusions which can be drawn are limited due to the methodological shortcomings which have been highlighted throughout the literature (see chapter 1 for a full discussion).

The experiments in chapter 2 were the first to my knowledge to directly examine the ability of substance related stimuli to capture and hold attention within one single visual scene by utilising the flicker ICB task by measuring directly, through the use of eye tracking, both the initial orienting of attention and the maintenance of attention on substance related stimuli. Additionally the experiments sought to examine the relationships of such components to both subjective craving and levels of use. The findings of these two studies (experiments 1a and 1b) have several important ramifications.

5.2.1 The importance of distinct components

According to IST models of addiction (Franken 2003; Robinson & Berridge, 1993) previously neutral stimuli through repeated pairings with substance use and the associated dopaminergic responses described within the model cause the substance related stimuli to acquire strong motivational properties. Due to these motivational properties substance related stimuli will capture the attention of the substance users and as a result, subjective craving increases which in turn increases the attention capturing properties of substance related stimuli which increases subjective craving and so on, therefore, producing a positive feedback loop which promotes substance seeking and consumption.

Previous studies employing the flicker ICB task have relied on indirect measures of attention, and as a result drew conclusions regarding the relationship between attentional bias and consumption from conceptualisations of attentional bias as a unitary construct. From doing so these studies have, in line with IST models of addictive behaviours, suggested that substance related attentional biases exist on a graded continuum relative to consumption level (Jones et al., 2002; 2003; 2006), demonstrating that greater substance related attentional bias is associated with higher levels of consumption. The indirect measures of attentional bias from experiments 1a and 1b are in line with such conclusions by Jones and colleagues and therefore the general predictions of the IST models. In experiment 1a alcohol related attentional bias was associated with higher levels of alcohol use in social drinkers. Additionally, experiment 1b supported this finding by demonstrating that smoking related attentional bias was associated with heavier levels of use. In addition experiment 1a further demonstrated that such indirect measures of attentional bias were associated with higher levels of subjective craving.

The application of eye tracking in experiment 1a and 1b however allowed for the direct measurement of the sub-components of attentional bias indicated within the IST models of addictive behaviours; the initial orienting of attention and maintenance of attention. In reference to direct measures of attentional bias however, experiment 1a demonstrated that the initial orienting of attention to alcohol related stimuli was associated only to levels of subjective craving in social users of alcohol and experiment 1b demonstrated that in dependent smokers, heavier use of cigarettes was associated with a bias in maintaining attention on smoking related stimuli, albeit only approaching significance. The findings taken from the direct measures of attention in experiments 1a and 1b illustrate the over-simplicity in measuring attentional bias as a unitary construct and suggest that the conclusions drawn by Jones and colleagues (Jones et al., 2002; 2003; 2006) may have been premature.

The disparity between the findings evidenced from indirect and direct measures of attention also highlight interpretation issues when relying on indirect measures of attention when using the flicker ICB task. Jones and colleagues utilised indirect measures of attentional bias in terms of examining the type of change detected (substance related or neutral) or the time taken to detect such changes. Rensink et al., (2007) suggest that for a change to be detected direct attention must be paid to and maintained on the changing object. As such Jones and colleagues have argued that the flicker change blindness task therefore allows researchers to measure the ability of a stimulus to capture and hold attention within one single visual scene (Jones et al., 2006). As such it would have been assumed in the studies of the present thesis that if differences in terms of indirect measures of substance related attentional biases were evident between groups, then such differences would manifest in the eye movement data. For example in experiment 1a group differences were demonstrated in terms of the proportion of alcohol changes detected. As such it would have been assumed that as Rensink et al., (1997), argues that direct attention must be paid to the changing object, then group differences in terms of maintained attention on alcohol related stimuli would also have been evident. This however was not the case, as no group differences were demonstrated in terms of maintained attention on alcohol related stimuli as measured by the proportion or duration of fixations.

Simons (2001) however argues that the underlying mechanisms of change detection remain undetermined and as such question the argument put forward by Rensink et al., (1997). Indeed there is conflicting research relating to this field, for example some researchers suggest that the majority of changes during the flicker ICB task are detected when the target object is directly fixated, whilst others suggest that this is not the case and even when participants are directly fixated on the target object the change is not necessarily detected (Hollingworth, Schrock & Henderson, 2001; Triesch, Ballard, Hayhoe & Sullivan, 2003). The disparate findings between the indirect and direct measures of attention in both experiment 1a and 1b therefore also add to the controversy regarding the mechanisms of change detection, further highlighting interpretation issues when relying on indirect measures of attentional bias such as the proportion of substance related changes detected when utilising the flicker ICB task. The experiments in the present thesis therefore both highlights, through the disparity between indirect and direct measures of attentional biases evidenced, and overcomes such potential interpretation issues by additionally measuring directly the allocation of visual attention in terms of the initial orienting of attention to substance related stimuli and maintained attention on substance related stimuli through the use of eye tracking in order to infer attentional bias.

Experiments 1a and 1b are the first known studies to directly examine different components of attentional bias within one single visual scene through the novel application of eye tracking technology, which allowed the analyses of the sub-components of attentional bias. The findings emphasise not only the utility in adopting eye tracking technology whilst employing the flicker ICB in order to directly measure attentional bias but also the importance of measuring the individual sub-components of attentional bias. As utilising this arguably more valid approach, experiments 1a and 1b suggest that different components of attention may operate and / or play differing roles depending on the level of use.

5.2.2 Attentional biases and subjective craving

As highlighted in chapter 1, IST models (Franken, 2003; Robinson & Berridge, 1993) amongst other models (Baker, et al., 2004; Cox & Klinger,1988; Cox & Klinger 2004 Kavanagh et al., 2005) predict that substance related stimuli should capture the attention of the substance user, and so once detected in the environment such stimuli should then become the focus of attention, resulting in an increase in subjective craving and thus an increase in the attention capturing properties of the stimuli. Therefore subjective craving would have been assumed to have been associated with both the initial orienting of attention and maintained attention. Experiment 1a however indicated that although subjective craving was associated with a quicker time to detect alcohol related stimuli, there was no relationship between maintained attention and subjective craving. Experiment 1b however failed to support this as it was unable to demonstrate any relationship between attentional biases and subjective craving. As discussed in chapter 2, the restrictions of Experiment 1b in terms of the characteristics of the smoking group may have contributed to these null findings in terms of any relationship between subjective craving and measures of attentional bias. As previous research, although subject to the limitations of the visual probe task as highlighted throughout the literature (see chapter 1 for full discussion), when employing eye tracking and examining the direction and duration of initial fixations has suggested in line with experiment 1a that subjective craving is associated with a bias in initial orienting of attention in dependent smokers (Mogg et al., 2003).

As highlighted above, Experiments 1a and 1b are the first known studies to directly examine different components of attentional bias within one single visual scene through the novel application of eye tracking technology whilst using the flicker ICB. Utilising this approach allows for the analyses of the sub-components of attentional bias and their relationship with levels of subjective craving and consumption. In addition Experiments 1a and 1b were the first studies utilising the flicker ICB task to employ complex real world scene stimuli which could be considered more representative of the real world environments which may actually give rise to attentional biases (Nees et al., 2012). Therefore the methodological approach taken in chapter 2 attempted to overcome many of the limitations of previous research, as highlighted within the literature. Yet utilising this arguably more valid approach the finding that subjective craving was only associated with a bias in the initial orienting of attention is however only partially consistent with the predictions of IST models of addiction in terms of the relationship between subjective craving and attentional biases (Franken, 2003; Robinson & Berridge, 1993). The models would predict that once the substance related stimuli captures attention, subjective craving would increase and in turn this would increase the attention capturing properties of the stimulus. Therefore an association with maintained attention and subjective craving would also have been predicted. Contrary to the findings of experiments 1a and 1b however, Mogg et al., (2005) did demonstrate that subjective craving in smokers was associated with longer dwell times on smoking related stimuli. This study, although it employed eye tracking to directly measure attention remains subject to the limitations of the visual probe task as highlighted throughout the literature (discussed in depth in chapter 1), which may indeed account for the inconsistent findings.

The findings presented in chapter 2 of this thesis suggest an association between a bias in the initial orienting of attention to substance related stimuli and subjective craving. In doing so this thesis has taken the first steps to highlight both the importance of assessing subjective craving when trying to evaluate the roles of substance related attentional biases in addictive behaviours, especially considering the neglect to do so in research to date, as well as further highlighting the importance of examining the different sub-components of attentional bias. Further research is however required in order to fully understand the causal relationship between subjective craving and attentional bias as the present research was subject to some potential limitations.

The research presented in chapter 2 recruited participants naïve to the nature of the experiments. This approach meant that baseline measures of craving were not taken in either study, and in relation to experiment 1b neither the time since last cigarette nor deprivation were controlled, therefore subjective craving was not controlled or manipulated in either study. By not controlling or manipulating these factors the present thesis therefore did not allow for an examination of the causal relationship between subjective craving and attentional biases. This method of recruitment was however chosen as Yaxley and Zwann (2005) and Yan, Jian, Wang, Den, He and Weng (2009) have both demonstrated that if participants are aware of the nature of the study they develop a short-term context dependent attentional bias. Such a potential confound would result in for example, non-smokers when recruited aware of the nature of the experiment in relation to the involvement of smoking, demonstrating smoking related attentional biases comparable to smokers, yet non-smokers recruited unaware would show no such biases. Therefore administering measures of craving before completion of the task or by manipulating time since last cigarette or deprivation may have primed and thus modulated the attentional biases demonstrated. Naturally, it is imperative that future research should attempt to systematically disentangle the casual relationship between subjective craving and attentional biases however they should consider such methodological aspects when doing so. Additionally the factors relating specifically to experiment 1b, in terms of the characteristics of the smoking group in relation to their limited variation in levels of subjective craving, cigarette use and nicotine dependence may also have contributed to the null findings in terms of a relationship between subjective craving and smoking related attentional biases, limiting the conclusions which could be drawn.

5.2.3 Attentional biases and levels of substance use

The results of experiment 1b suggested that a heavier level of use in dependent smokers is associated with a bias in maintaining attention on smoking related stimuli. This finding was however only approaching significance, most probably as a result of the characteristics of the smoking group as discussed in chapter 2. Contentiously perhaps, in experiment 1a whereby the social users of alcohol reported considerable variation in their levels of alcohol use (which were infact larger than the variation reported for the studies by Jones and colleagues (Jones et al., 2006; see chapter 2)), no association was found between levels of alcohol use and either sub-component of attentional bias, failing to support experiment 1b. This finding is somewhat contradictory to what has been found previously when employing the visual probe task as Miller and Fillmore (2010) reported that in social users of alcohol a bias in maintained attention was associated with levels of alcohol use. However in addition to the limitations of the visual probe task discussed in chapter 1, the stimuli in Miller and Fillmore (2010) were presented for only 1000ms and therefore may not actually be representative of a bias in maintained attention considering the bias was measured over only 1000ms a relatively short display time.

The research presented in chapter 2 as highlighted in section 5.2.2, utilised an arguably more valid methodological approach in order to measure the extent and roles of attentional bias compared to previous research. The findings from chapter 2 in relation to attentional biases and levels of use tentatively suggest a possibility that substance related attentional biases may play differing roles depending on the level of use of the user, in that the maintenance of attention may only underpin levels of consumption in dependent users and not social users. As such, additional factors may be implicated in accounting for this disparity between levels of use and as a result should be considered for future advancements in theory and research.

Impulsivity has been highlighted as a risk factor for addiction (Verdejo-García, Lawrence & Clark ,2008). Although there is debate regarding the definition of impulsivity, two relatively independent processes have been implicated as being important in addictive behaviours; deficits in inhibitory control and impulsive decision making, such that individuals will consistently choose immediate rewards despite the future negative consequences of the reward (Olmstead et al., 2006; Reynolds, Ortengren, Richards & De wit, 2006). Research has shown that substance users higher in impulsivity demonstrate higher levels of subjective craving and physiological responses to substance related stimuli, and so highly impulsive individuals have been argued to be more sensitive to the motivational incentive properties of substance related stimuli and so are more cue reactive (Doran, Spring & McHargue, 2007; Doran, McHargue, Spring, 2007). In terms of the association between impulsivity and attentional bias, Dawe, gullo & Loxton, (2004) have proposed a possible synergistic relationship between the incentive salience of the substance related stimuli and deficits in inhibitory control, whereby highly impulsive substance users with poor inhibitory control might be more sensitive to the attention capturing properties of the substance related stimuli compared to others. It has to be noted however that attentional bias however is not simply a function of poor inhibitory control, as by statistically controlling for poor inhibitory control alcohol abusers still show an alcohol related attentional bias (Fadardi & Cox, 2006).

Therefore as impulsivity is associated with higher levels of dependence (de Wit, 2009), it may therefore be suggested that the extent and roles of components of attentional bias at the various stages of consumption may differ due to the influence of impulsivity and inhibitory control. The relationship between impulsivity, poor inhibitory control, subjective craving and substance related attentional biases have received little attention within the literature (Lui, et al., 2011). The studies which have are however limited due to their methods of measurement of attentional bias by using either the Stroop task or visual probe task or due to their reliance on self-report measures of impulsivity (E.g Field, Christiansen, Gould & Goudie, 2007 and Lui et al., 2011). As such impulsivity and inhibitory control may be a fruitful avenue to pursue in order to understand the extent and roles of initial orienting to and maintained attention on substance related stimuli and their subsequent roles in addictive behaviours. Therefore it seems that research combining attentional bias, subjective craving and impulsivity in the future may provide a more coherent understanding of the roles of these factors in substance use which will be important for developing possible interventions.

5.3 The validity of the Flicker ICB as a measure of Attentional bias

Consistent findings reported throughout this thesis have highlighted factors which may impact the validity of the flicker ICB task as a tool to measure substance related attentional biases. The studies presented in chapter 2 employed both simple grid stimuli comparable to previous research (Jones et al., 2006) and the novel use of real world scene stimuli. However, it became apparent that the attentional biases evidenced differed depending on the type of stimuli being analysed, with only a bias in the initial orienting of attention being evident in simple grid stimuli (experiment 1b) but a bias in both the initial orienting of attention and maintenance of attention being evident in real world scene stimuli (experiment 1a and 1b). Furthermore such biases were only evident over multiple trials, no substance related attentional biases were evident when the first trial only was analysed, which was the approach was taken by Jones and colleagues (Jones et al., 2002; 2003; 2006). However as the first trial consisted of viewing a simple grid stimulus this finding may have been the result of the type of stimuli rather than the number of trials employed as argued in chapters 3 and 4. Therefore the findings of chapter 2 highlighted that the type of stimuli employed when utilising the flicker ICB task may influence the attentional biases evidenced and so have important ramifications for future research employing this task.

Research was reviewed in chapters 2 and 3 highlighting three possible reasons for the inconsistent findings between the types of stimuli when employing the flicker ICB task. Firstly, considering that context has been shown to modulate cue reactivity (Dols, et al., 2000; Dols et al., 2002; Nees et al., 2012; Thewissen, 2004) it may be that the real world stimuli are more representative of the environments which actually give rise to attentional biases. Secondly, it was suggested that the perfect spatial structure of the grid stimuli may have encouraged the use of search strategies (Gilchrist & Harvey, 2006) and as a result the task demands (strategic scanning) may possibly over-ride the utility of the flicker ICB to accurately measure the ability to maintain attention in such instances. Or lastly it may be a combination of both context and strategic scanning. The studies presented in chapters 3 and 4 are novel in that they are the first to examine the extent and time course of strategic scanning when utilising the flicker ICB to measure attentional biases to motivationally salient stimuli. In doing so this thesis provides the first report of the impact of such task demands of the flicker ICB task on the validity of its use as a measurement of attentional bias and provides clear recommendations for future research.

Throughout chapters 2 and 3 when viewing spatially structured grid stimuli social users of alcohol and dependent smokers consistently failed to demonstrate substance related attentional biases in terms of a relationship with levels of subjective craving (DAQ and QSU) or consumption (timeline follow back) (experiments 1a, 1b, 2a and 2b). In conjunction with such attentional bias findings, strategic scanning was consistently found to be strongest when viewing perfect spatially structured stimuli compared to stimuli with reduced spatial regularity (experiments 2a, 2b, 3a and 3b). It should be noted however that in chapter 2 smokers compared to non- smokers did show a bias in the initial orienting of attention to smoking related stimuli when viewing grids. It was argued however that the measurement of strategic scanning adopted within this thesis would have little impact on measures of attentional capture as defined by the proportion of first saccades to substance related stimuli and the time taken to initially saccade to substance related stimuli, as strategic scanning was inferred in relation to the mean frequency of saccades made in each direction across trials. Therefore the argument put forward in this thesis, in line with Gilchrist and Harvey (2006) is that measures of maintained attention would be affected by strategic scanning as following a predictable route through a display would be expected to override the incentive salience of the stimuli and therefore limit refixations on the substance related stimuli. Therefore the findings of the present thesis highlighted above suggests that the flicker ICB task when employing spatially regular stimuli has poor validity as a measure of attentional bias, as the strategic scanning overrides the ability to effectively measure maintained attention.

The findings of chapter 4 further reported evidence that strategic scanning is also demonstrated when viewing complexly structured real world scene stimuli, however, in both experiments 3a and 3b the extent of such strategic scanning was to a lesser degree than when viewing the perfectly structured grid stimuli. In conjunction with this finding, when viewing perfectly structured grid stimuli dependent smokers evidenced no biases in maintained attention. However, when viewing real world scenes there was a trend indicating that dependent smokers when compared to non-smokers and also when analysed on their own in relation to levels of cigarette use, demonstrated a bias in maintaining attention on smoking related stimuli. These findings however were only approaching significance, most likely as a result of the limitations of the group characteristics of the smokers in terms of the limited variation in levels of subjective craving, use and dependence. Nonetheless taken together these findings suggest possibly that although strategic scanning is evident when viewing real world scene stimuli it is to a lesser degree allowing the motivational salience of the substance related stimuli to disrupt such processes to allow refixations on such stimuli (maintained attention), however further research is required in order to clarify such suggestions. It has to be noted that although experiment 3a demonstrated that strategic scanning was employed to a lesser extent when viewing real world scene stimuli compared to spatially regular grid stimuli, biases in maintained attention were not evident. However as discussed previously this may be a result of examining social users of a substance as the sub-components of attentional bias may play differing roles in varying levels of use.

By showing the impact of the types of stimuli employed when using the flicker ICB task these findings have important ramifications as not only do they help to explain the inconsistency within the literature in terms of the attentional biases evidenced when viewing different types of stimuli (Jones et al., 2002; 2003; 2006 and chapter 2), they also provide recommendations for future research. As although the validity of the flicker ICB task may be limited when employing heavily structured stimuli, when complex real world scenes are employed the flicker ICB task when employing eye tracking technology may possibly have validity as a tool to measure attentional biases. These recommendations have been put forward based on the findings relating to strategic scanning, but it has to be conceded that the context of the real world scene stimuli in its ability to influence cue reactivity of the participants was not evaluated and may indeed add to the validity of using such stimuli, as such future research should also look to assess this in order to further clarify the validity of complexly structured real world scene stimuli.

The results and recommendations discussed above relate to measuring attentional biases over multiple trials. Indeed Jones et al., (2006) reported that when multiple trials were used participants reported quickly developing search strategies and as such argued that employing one trial per participant was therefore a more robust measure of attentional bias (Jones et al., 2002; 2003; 2006). The empirical findings from chapters 3 and 4 however are inconsistent with Jones and colleague's observation, as the findings of chapter 3 showed that strategic scanning was evident from the first trial when viewing perfectly structured grid stimuli as well as in stimuli not perfectly structured. Chapter 4 supported these findings by again showing that participants evidenced strategic scanning when viewing perfectly structured grids but additionally demonstrated that there was no difference in the extent of strategic scanning employed by participants differing in levels of use. In conjunction with these strategic scanning results, no attentional biases were evidenced when the first trial only was analysed in any of the studies presented in this thesis. One limitation of these findings however is that real world scenes were never presented on the first trial for participants and so it is unclear if strategic scanning is evident from the first trial when using such stimuli or if strategic scanning develops over time. This thesis nonetheless presents evidence showing that strategic scanning is evident from the first trial and so even when utilising one trial per participant when incorporating heavily structured stimuli such as in Jones et al., (2006) the validity of the flicker ICB task is limited.

5.4 General methodological issues

With regards to the generalizability of the findings the present research only examined current users and non-users of a substance and as such the substance using participants who took part in the research in the present study were not in treatment or seeking treatment to reduce their use or to remain abstinent. It has been suggested there might be important, but as yet unidentified differences in the roles of attentional bias among different users and that such differences may be dependent on their current concerns, for example whether their goal is to use the substance or remain abstinent (Cox & Klinger, 2004; Field & Cox, 2008). Research has been conducted in such substance users but has employed either the Stroop task or the visual probe task to do so (e.g. Klein, 2007; Noel et al., 2006; Townshend & Duka, 2007). As a result the conclusions which can be drawn in relation to the extent and roles of attentional biases in such users remain unclear due to the limitations of the tasks as discussed in chapter 1. As argued within this thesis the flicker ICB task whilst employing eye tracking overcomes many of the limitations of the Stroop task and visual probe task and is a potentially valid tool, depending on the type of stimuli and number of trials employed. Therefore, in order to provide a greater understanding of the extent and roles of substance related attentional biases, future research should examine the possibly different roles they may play in the maintenance of use as well as in abstinence and relapse. By adopting the flicker ICB task whilst utilising eye tracking technology as well as consideration of the recommendations put forward in this thesis with regards to the stimuli employed, a clearer understanding could be developed and used to guide possible interventions.

In the present thesis generalised alcohol related attention biases were measured in alcohol users (experiments 1a and 2a) and generalised smoking related attentional biases were measured in dependent smokers (experiments 1b and 2b). As such these studies incorporated two categories of stimuli in each experiment; one in relation to the respective substance (including a variety of brands and types of substance) and the other neutral. Individuals partaking in the use of addictive substances however show preferences in their use. For example smokers will have preferences as to whether they prefer cigarettes or tobacco and have brand preferences within these types. In relation to alcohol, users will have preferences in relation to the type of alcohol e.g. whether beer or vodka and even preferences for particular brands within these types of alcohol. Therefore it may be possible that if individualised stimuli based on each individuals preferences were utilised throughout these studies an alternative pattern of results may have been produced as the generalised stimuli may not have been sufficient to generate substance related attentional biases or they may have produced a less representative pattern of substance related attentional biases compared to if individualised stimuli were used. Recently however, Fridrici, Leichsenring-Dreissen, Driessen, Wingenfield, Kremer and Beblo, (2013) have demonstrated that there is no effect on alcohol related attentional bias demonstrated when personally relevant alcohol related stimuli are used compared to when general alcohol related stimuli was used. Therefore these findings suggest that the impact of employing generalised stimuli in the present thesis may not have had an impact on the pattern of results. Fridrici et al., (2013) utilised the Stroop task and evaluated personally relevant alcohol words, which are however over simplistic compared to images of the actual stimuli therefore further clarification of this matter may be required.

5.5 Concluding remarks

This thesis illustrates the utility of the flicker ICB paradigm as a measure of attentional bias and provides methodological recommendations for its use in future research. The conclusions from this thesis advocate the use of complexly structured stimuli representative of real world environments and the additional use of eye tracking whilst utilising the flicker ICB paradigm to examine attentional biases. Attentional biases have been implicated in the maintenance of a number of psychopathologies such as anxiety and depressive disorders (Williams, Matthews & MacLeod, 1996). So although the validity of the flicker ICB task when employing eye tracking has been examined in terms of its ability as a measure of substance related attentional biases in addictive behaviours within the present thesis, these recommendations may also have implications for use in other psychopathological conditions.

Understanding the extent and roles of attentional biases to substance related stimuli in addictive behaviours may serve to guide the development of treatment and intervention strategies. Whilst further research is required before a complete understanding is achieved, the present thesis contributes to efforts to disentangle the complicated relationship between attentional biases and substance use and suggests avenues for future research in terms of assessing the possibly different roles which attentional biases may play at different levels of use and factors which may influence such roles, in particularly impulsivity.

Although further research is required to fully understand the extent and roles of substance related attentional biases in addictive behaviours the present thesis does demonstrate that users of tobacco and alcohol demonstrate attentional biases to their respective substances and that such biases are associated with levels of craving and levels of consumption. As such the findings of this thesis also have implications for government policy in relation to the display of tobacco and alcohol products for sale as well as the advertisement of such products and the use of tobacco and alcohol related stimuli in health promotion materials.

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Appendix A: Example grid stimuli from Experiment 1a

Original image

Changed image - Top left ant top right stimuli have been rotated

Appendix B: Example real world scene stimuli from experiment 1a

Original image

Changed image – The wine bottle and oil bottle have been rotated

Appendix C: Desire for Alcohol Questionnaire (DAQ)

Please answer, by placing "**X**" in the box for how strongly you agree or disagree with each of the following statements, as honestly as you can.

1. **Drinking now would make the good things in my life appear even better**

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

2. **I am missing having a drink now**

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

3. **It would feel as if the bad things in my life had completely disappeared if I drank now**

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

4. I need a drink now

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

5. My desire to drink now seems overwhelming

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

6. Even major problems in my life would not bother me now if I drank

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

7. Drinking now would make me feel on top of the world

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

8. Drinking now would make me feel less tense

Strongly agree ☐

Agree ☐

Undecided ☐

Disagree ☐

Strongly Disagree ☐

9. I would do almost anything to have a drink now

Strongly agree ☐

Agree ☐

Undecided ☐

Disagree ☐

Strongly Disagree ☐

10. Drinking now would make the bad things in my life seem less bad

Strongly agree ☐

Agree ☐

Undecided ☐

Disagree ☐

Strongly Disagree ☐

11. I crave a drink now

Strongly agree ☐

Agree ☐

Undecided ☐

Disagree ☐

Strongly Disagree ☐

12. Drinking would make me feel good

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

13. If I drank now the small daily hassles would feel less important

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

14. I have an urge to drink now

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

15. I want a drink so much I can almost taste it

Strongly agree ☐
Agree ☐
Undecided ☐
Disagree ☐
Strongly Disagree ☐

16. I would probably feel less worried about my daily problems if I drank now

- Strongly agree ☐
- Agree ☐
- Undecided ☐
- Disagree ☐
- Strongly Disagree ☐

17. I am thinking of ways to get alcohol

- Strongly agree ☐
- Agree ☐
- Undecided ☐
- Disagree ☐
- Strongly Disagree ☐

18. Drinking would make me feel less stressed

- Strongly agree ☐
- Agree ☐
- Undecided ☐
- Disagree ☐
- Strongly Disagree ☐

19. I will have a drink now whatever gets in the way

- Strongly agree ☐
- Agree ☐
- Undecided ☐
- Disagree ☐
- Strongly Disagree ☐

20. Drinking now would make things seem just perfect

- Strongly agree ☐
- Agree ☐
- Undecided ☐
- Disagree ☐
- Strongly Disagree ☐

21. I am going to drink as soon as I possibly can

- Strongly agree ☐
- Agree ☐
- Undecided ☐
- Disagree ☐
- Strongly Disagree ☐

22. All my tension would completely disappear if I drank now

- Strongly agree ☐
- Agree ☐
- Undecided ☐
- Disagree ☐
- Strongly Disagree ☐

Appendix D: Severity of Alcohol Dependence Questionnaire

NAME____AGE___________No.___

DATE:______________

Please recall a typical period of heavy drinking in the last 6 months.

When was this? Month:………………………………. Year……………………………..

Please answer all the following questions about your drinking by circling your most appropriate response.

During that period of heavy drinking

1. The day after drinking alcohol, I woke up feeling sweaty.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

2. The day after drinking alcohol, my hands shook first thing in the morning.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

3. The day after drinking alcohol, my whole body shook violently first thing in the morning
if I didn't have a drink.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

4. The day after drinking alcohol, I woke up absolutely drenched in sweat.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

5. The day after drinking alcohol, I dread waking up in the morning.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

6. The day after drinking alcohol, I was frightened of meeting people first thing in the morning.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

7. The day after drinking alcohol, I felt at the edge of despair when I awoke.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

8. The day after drinking alcohol, I felt very frightened when I awoke.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

9. The day after drinking alcohol, I liked to have an alcoholic drink in the morning.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

10. The day after drinking alcohol, I always gulped my first few alcoholic drinks down as
quickly as possible.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

11. The day after drinking alcohol, I drank more alcohol to get rid of the shakes.

ALMOST NEVER SOMETIMES OFTEN NEARLY ALWAYS

12. The day after drinking alcohol, I had a very strong craving for a drink when I awoke.

ALMOST NEVER SOMETIMES OFTEN ALMOST ALWAYS

13. I drank more than a quarter of a bottle of spirits in a day (OR 1 bottle of wine OR 7 beers).

ALMOST NEVER SOMETIMES OFTEN ALMOST ALWAYS

14. I drank more than half a bottle of spirits per day (OR 2 bottles of wine OR 15 beers).

ALMOST NEVER SOMETIMES OFTEN ALMOST ALWAYS

15. I drank more than one bottle of spirits per day (OR 4 bottles of wine OR 30 beers).

ALMOST NEVER SOMETIMES OFTEN ALMOST ALWAYS

16. I drank more than two bottles of spirits per day (OR 8 bottles of wine OR 60 beers)

ALMOST NEVER SOMETIMES OFTEN ALMOST ALWAYS

Imagine the following situation:

1. You have been **completely off drink for a few weeks**
2. You then drink **very heavily** for **two days**

How would you feel the **morning after** those two days of drinking?

17. I would start to sweat.

NOT AT ALL SLIGHTLY MODERATELY QUITE A LOT

18. My hands would shake.

NOT AT ALL SLIGHTLY MODERATELY QUITE A LOT

19. My body would shake.

NOT AT ALL SLIGHTLY MODERATELY QUITE A LOT

20. I would be craving for a drink.

NOT AT ALL SLIGHTLY MODERATELY QUITE A LOT

Appendix E: Alcohol Timeline Follow Back

PARTICIPANT DETAILS

SECTION 1 PERSONAL DETAILS

sex female ☐ male ☐ | age | have you ever sought help for an alcohol-related problem ? yes ☐ no ☐

SECTION 2

WHAT ALCOHOLIC DRINKS HAVE YOU CONSUMED DURING THE LAST WEEK ? PLEASE FILL IN EACH DAY'S DETAILS BELOW.

today
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

yesterday
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

2 days ago
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

3 days ago
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

4 days ago
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

5 days ago
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

6 days ago
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

7 days ago
how many drinks ? write number in the box ☐ | where ? | what were the drinks ? (type, number, brand name, size)

WAS THIS A TYPICAL WEEK'S CONSUMPTION? yes ☐ no ☐

SECTION 3 ADDITIONAL INFORMATION

Does any of the following
(i) have (or have had) a drink problem
(ii) for which help was sought ?

	[i]	[ii]
parent	☐	☐
brother or sister	☐	☐
aunt or uncle	☐	☐
cousin	☐	☐

Have you ever worked in any of the folowing places and if so for how long?

bar	☐	a week ☐	a month ☐	3 months ☐	a year ☐	more ☐
licenced restaurant	☐	a week ☐	a month ☐	3 months ☐	a year ☐	more ☐
off-licence	☐	a week ☐	a month ☐	3 months ☐	a year ☐	more ☐

How often do you go into bars or pubs?
never ☐ less than once a month ☐ once a month ☐ once a week ☐ twice a week ☐ more ☐ daily ☐

please do not write below this line please do not write below this line please do not write below this line please do not write below this line please do not write below this line please do not write below this line

Pno
Exp
Cond

notes

date
time
place

Appendix F- Questionnaire of Smoking Urges

Please respond to each of the items below using a 100-point scale in which

0 represents "I strongly disagree" and 100 represents "I strongly agree."

Write in a number 0-100

1. I have a desire for a cigarette right now. ……….
2. Nothing would be better than smoking a cigarette right now. ……….
3. If it were possible, I would probably smoke a cigarette now. ……….
4. I could control things better right now if I could smoke. ……….
5. All I want right now is a cigarette. ……….
6. I have an urge for a cigarette. ……….
7. A cigarette would taste good now. ……….
8. I would do almost anything for a cigarette now. ……….
9. Smoking would make me less depressed. ……….
10. I am going to smoke as soon as possible. ……….

Please check that you have answered each of the 10 items.

Thanks.

Appendix G: Fagerstrom Test of Nicotine Dependence

If you do not smoke please put an x in the box and do not complete the remainder of the questionnaire ☐

If you do smoke please read the following statements carefully and circle the answer which is most appropriate to yourself.

1. How soon after you wake up do you smoke your first cigarette?

♦ After 60 minutes ♦ 31-60 minutes

♦ 6-30 minutes ♦ Within 5 minutes

2. Do you find it difficult to refrain from smoking in places where it is forbidden?

♦ No ♦ Yes

3. Which cigarette would you hate most to give up?

♦ The first in the morning ♦ Any other

4. How many cigarettes per day do you smoke?

♦ 10 or less ♦ 11-20

♦ 21-30 ♦ 31 or more

5. Do you smoke more frequently during the first hours after awakening than during the rest of the day?

♦ No ♦ Yes

6. Do you smoke even if you are so ill that you are in bed most of the day?

♦ No ♦ Yes

Appendix H: Smoking Timeline Follow Back

PERSONAL DETAILS

SEX: MALE ☐ FEMALE ☐ AGE __________

SMOKING STATUS : NON SMOKER ☐ (PLEASE RETURN QUESTIONNAIRE TO RESEARCHER)

FORMER SMOKER ☐ (PLEASE ANSWER FOLLOWING QUESTION ONLY ON THIS QUESTIONNAIRE AND COMPLETE THE NEXT QUESTIONNAIRE ONLY)

- HOW MANY _____YEARS _____MONTHS____ DAYS SINCE YOUR LAST CIGARETTE

SMOKER ☐ (PLEASE COMPLETE THE QUESTIONNAIRE)

How many cigarettes have you smoked in the past week? Please fill in each days details

TODAY

HOW MANY CIGARETTES: _______

TIME SINCE LAST CIGARETTE: _______

BRAND:_________________________

4 DAYS AGO

HOW MANY CIGARETTES: _______

BRAND: _________________________

YESTERDAY

HOW MANY CIGARETTES: _______

BRAND: _________________________

5 DAYS AGO

HOW MANY CIGARETTES: _______

BRAND: _________________________

2 DAYS AGO

HOW MANY CIGARETTES: _______

BRAND: _________________________

6 DAYS AGO

HOW MANY CIGARETTES: _______

BRAND: _________________________

3 DAYS AGO

HOW MANY CIGARETTES: _______

BRAND: _________________________

7 DAYS AGO

HOW MANY CIGARETTES: _______

BRAND: _________________________

Appendix I : College Activities and Behaviors Questionnaire

Within the last week, how **MANY TIMES** have you done each of the following:

1. Number of times exercised strenuously ____

2. Number of times had difficulty falling asleep ____

3. Talked on the phone to one or both parents ____

4. Talked on the phone to old friends who are not at your college ____

5. Visited a physician or the student health center for illness ____

6. Ate far too much at one meal ____

7. Had a heart-to-heart talk with someone here at college ____

8. Attended a meeting of an organization (e.g., church, fraternity) ____

9. Studied _____

10. Thought about dropping out of college ____

11. Talked or corresponded with an old girlfriend or boyfriend ____

12. Made a new friend ____

13. Received a traffic ticket (including parking violation) ____

14. Written down your deepest thoughts and feelings _____

In the last week, how many of the following have you consumed:

15. Alcoholic beverages ____ 16. Doses of prescribed drugs____

17. Cigarettes ____ 18. Doses of nonprescribed drugs___

19. Cups of coffee _____ 20. Snacks with sugar____

21. Aspirin or other pain reliever ____ 22. Vitamins ____

Sex ________ Age ________ Year in College_________

Marital status _________ Number of hours currently taking______

Appendix J: Example of condition 1 stimuli from experiment 2a

Original image

Changed image – The Strongbow can and Rockstar can have been changed.

Appendix K: Example of condition 2 stimuli from experiment 2

Original Image

Changed image- The bottle of sun cream and angostura bitters have been rotated

Appendix L: Example condition 3 stimuli from experiment 2a

Original Image

Changed image – The CD and box of Chambord has been rotated