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An investigation into the relationship between attentional bias and the perceived pleasantness of smoking-related stimuli

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ABSTRACT

The first aim of the literature review is to explore current theories of addiction which consider the relationship between drug-related stimuli and drug use. The second aim of this review is to consider the relevant empirical research and, in particular, focus on the potential role of attentional bias and valence towards drug-related cues. The majority of the literature suggests that drug-related cues are perceived as pleasant and attract attention (Mogg, Bradley, Field & De Houwer, 2003); however, some drug-related cues can also be perceived as unpleasant (Mucha, Geier & Pauli, 1999). Therefore, there may be a dissociation between attentional bias and valence (Robinson & Berridge, 1993; 2001). The role of attentional bias and the perceived pleasantness of drug-related cues is one area which could further develop psychologists' understanding of the mechanisms through which drug-related cues influence behaviour and inform clinical practice.

The empirical paper investigates whether the perceived pleasantness of different types of smoking-related cues influence smokers' attentional bias towards drug-related cues. Results of the study show that smoking-related cues hold attention (at 2000 ms, not 200 ms in a visual probe task) and elicit approach behaviours (stimulus response compatibility task), irrespective of their valence (neutral, unpleasant or pleasant). These findings are consistent with Robinson and Berridge's (1993; 2001) incentive-sensitisation theory of addiction, which suggests that there is a dissociation between 'wanting' and 'liking', in which attentional and approach biases for drug-related cues are independent of cue valence.

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The relationship between drug-related stimuli and drug use: the role of attentional bias and the perceived pleasantness of drug-related cues

Literature review

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LITERATURE REVIEW ABSTRACT

The first aim of this review is to explore current theories of addiction which consider the relationship between drug-related stimuli and drug use. The second aim of this review is to explore the relevant empirical research and, in particular, focus on the potential role of attentional bias and valence towards drug-related cues.

The literature review critically discusses the relevant theories of addiction; from this discussion various questions arise, including what is the role of valence and attentional bias towards drug-related stimuli? The majority of the literature suggests that the drug-related cues are perceived as pleasant and attract attention (Mogg, Bradley, Field & De Houwer, 2003); however, some drug-related cues can also be perceived as unpleasant (Mucha, Geier & Pauli, 1999). Therefore, there may be a dissociation between attentional bias and valence (Robinson & Berridge, 1993; 2001).

The role of attentional bias and the perceived pleasantness of drug-related cues is one area which could further develop psychologists' understanding of the mechanisms through which drug-related cues influence behaviour and inform clinical practice.

INTRODUCTION

The Diagnostic and Statistical Manual-IV (DSM-IV: American Psychiatric Association, 1994) describes addiction as a maladaptive pattern of substance use leading to clinically significant impairment or distress as manifested by a combination of several factors, including a persistent desire or unsuccessful efforts to cut down or control substance misuse. Addiction has been identified as an extensive clinical problem for clinical psychologists (Cottler, 1993; Rounsaville et al., 1993); therefore there is a need to develop new and effective treatment approaches and in particular those with a firm scientific basis.

It has been well documented in the literature that addiction typically involves initial exposure to a stimulus in the environment followed by behaviours to repeat the experience, subsequently the stimuli can become associated with drug use and act as cues to maintain and reinitiate (relapse) drug use (West, 2001). Consequently, cue exposure has the potential to be an effective treatment for nicotine and other addictive substance misuse. Cue exposure typically involves repeated, unreinforced exposure to stimuli associated with drug use in an attempt to extinguish an addict's conditioned response to such cues (e.g. craving). However, thus far, while cue exposure has become a method of key importance in the treatment of phobic and obsessive disorders, its effectiveness has not been conclusively demonstrated in the addictions field (Conklin & Tiffany, 2002). This may be partly due to the lack of clarity surrounding the mechanism through which drug cues affect behaviour.

The first part of this review considers some of the most prominent theories which have been put forward to explain the mechanism through which drug cues affect behaviour: conditioning theories (e.g. Wikler, 1948); cognitive theories (e.g. Tiffany, 1990); incentive-sensitisation motivational theories (Franken, 2003; Robinson &

Berridge, 1993; 2001). In addition, the potential for the application of recent theories of emotion (e.g. Lang, Davis & Ohman, 2000) in the field of addiction is considered. Each theory purports a different mechanism and it appears that there is currently no one accepted model. Finally, discussion is made of the link between addiction theory and clinical practice.

The second part of the review considers the relevant empirical research surrounding five of the main questions which arise from these theories of addiction: Do drug-related cues elicit craving, drug-seeking and drug-taking behaviour? Are drug-related stimuli associated with the activation of dopamine transmissions? Do addicts have an attentional bias for drug-related cues? Do addicts have an attentional bias for drug-related cues at a preconscious level? Are drug-related stimuli appetitive? The last part of the review focuses on exploring, in more depth, the last of these questions: are drug cues appetitive?

A limitation of addiction theories is that there is a lack of clear predictions about the role of the valence and attentional bias towards drug-related stimuli in drug-taking behaviour (e.g. Tiffany, 1990). Recently, Franken (2003) proposes an incentive-sensitisation theory, which suggests that all drug-related stimuli are appetitive (i.e. perceived as pleasant) and subsequently have attention-grabbing properties. The majority of the empirical evidence thus far is consistent with this theory, as drug-related cues have been found to be perceived as 'pleasant' and attract attention (e.g. Bradley, Field, Mogg, & De Houwer, 2004). However, one study by Mucha, Geier and Pauli (1999) suggests that some drug-related cues are also perceived as unpleasant. If some drug-related stimuli are perceived as unpleasant and still attract attention this would be more consistent with the interpretation of Robinson and Berridge's (1993; 2001) theory, in which drug-related cues could be perceived as either pleasant or unpleasant and still attract attention (i.e. valence and attentional bias are dissociated). The review focuses on exploring the empirical research evaluating these theories. In the final part of the

literature review conclusions are drawn regarding the role of attentional bias and valence in the development of theories of addiction.

ADDICTION THEORIES

There are many theories of addiction, which are too numerous to discuss fully within the scope of this review. Therefore the main theories are considered. Traditionally, conditioning theories can be divided into two camps: those that predict that addicts are motivated to take drugs to avoid the unpleasant consequences of withdrawal (e.g. Wikler, 1948); or for the pleasure these drugs produce (i.e. incentive-based models, e.g. Stewart, de Wit & Eikelboom, 1984). There is also a third group of theories which can be classified as cognitive models (e.g. cognitive processing model: Tiffany, 1990).

1. Withdrawal theories

Withdrawal-based models hypothesise that stimuli frequently associated with drug use become conditioned stimuli that elicit conditioned withdrawal-like effects (e.g. Seigel, 1975; Melchior & Tabakoff, 1984). Wikler (1948) proposed that drug-related stimuli elicit the autonomic and affective components of drug withdrawal, triggering craving; subsequently, drug use is reinforced negatively through alleviation of discomfort of unpleasant withdrawal symptoms. However, Wikler (1948) does not adequately explain why people use drugs before they experience withdrawal, why people develop a drug addiction in the first instance or why addicts often relapse into taking drugs even when they are free from withdrawal (Hunt, Barnett & Branch, 1971; Marlatt & Gordon,

1985). Therefore there must be another mechanism other than withdrawal motivating behaviour in the drug dependent individual.

Two-sided hedonic theory is another withdrawal-based explanation for why drug-related stimuli act as cues to drug dependent individuals. There are a variety of names for this theory: pleasure-pain; positive-negative reinforcement; opponent processes; hedonic homeostasis; hedonic dysregulation; reward allostasis (e.g. Koob, Caine, Parsons, Markou & Weiss, 1997; Seigel, 1989). The two-sided hedonic theory proposes that, at first, drugs are taken because they are pleasant, but with repeated drug use homeostatic neuroadaptations lead to tolerance and dependence, such that unpleasant withdrawal symptoms ensue upon the cessation of use (e.g. Koob et al., 1997; Seigel, 1989). To avoid the unpleasant withdrawal symptoms, drugs are used compulsively. Therefore, this model is similar to Wikler's (1948) as it is predicted that the addict takes more of the drug to overcome the negative hedonic state, but it also has the additional component of positive incentive processes.

A wide variety of studies using animals and humans have confirmed the proposal from withdrawal theories that drug-related cues elicit withdrawal reactions (see review by O'Brien, Childress, Erhman, & Robbins, 1998). However, there are methodological difficulties with some of these studies, such as no control groups and the applicability of animal studies to humans. In addition, most of these studies used the cue-reactivity paradigm; difficulties with this are discussed later in the review under the empirical research section. Further consideration is now given to the positive incentive processes, suggested by the two-sided hedonic theories.

2. Incentive – based theories

Several theories of addiction contain the concept of an incentive motivational process (Bindra, 1992; Cox & Klinger, 1988; Franken, 2003; Robinson & Berridge, 2000;

Stewart et al., 1984; Toates, 1994). In this approach it is hypothesised that drug-related stimuli become conditioned incentives that activate a central motivational state. This central state can be best understood if consideration is first made of theories of emotion and the way in which it is proposed that organisms process affective stimuli.

Theories of emotion

Emotions theorists propose that neural networks underlying emotion include direct connections to the brain's primary motivational systems (e.g. Davidson, 1998; Gray, 1987; Lang, Bradley & Cuthburt, 1990; Lang, Davis & Ohman, 2000). These systems are neural circuits developed early in our evolutionary past, which mediate behaviours basic to survival through specific autonomic (e.g. heart rate change) and somatic reflexes (e.g. startle change). Emotion theorists propose that there are two distinct motivational circuits which are activated by unconditioned appetitive and aversive stimuli: unpleasant emotions are associated with a defensive system, which mediates withdrawal, escape or defensive behaviour in response to aversive or harmful stimuli; pleasant emotions are associated with an appetitive system, mediating approach, hunger, sexual and nurturant behaviour to stimuli with rewarding or life sustaining potential. Through this conditioned incentive motivational process, in order to survive, an organism learns to approach cues associated with (unconditioned) pleasant stimuli such as food and water, and to avoid cues associated with (unconditioned) unpleasant stimuli such as extreme heat, by means of associative (classical) conditioning. In terms of survival, it has been important that organisms are able to determine whether a stimulus is pleasant or unpleasant without engaging in intentional, goal directed, conscious or capacity demanding processing of the (evaluative attributes) stimulus (De Houwer, Crombez, Baeyens & Hermans, 2001).

It has also been suggested that a selective attention mechanism increases the likelihood that the most appropriate stimuli will control behaviour (Hallond & Gallagher, 1999). A bias in selective attention (i.e. attentional bias/selective processing bias) refers to the tendency for information processing resources to be allocated disproportionately towards certain categories of stimuli, such as appetitive or aversive stimuli relevant to survival. It is proposed that stimuli with high affective valence, whether pleasant or unpleasant, are more likely to attract attention than stimuli with moderate affective valence.

There is a variety of research to support emotion theories in negative emotions; Lang et al. (2000) state that their theory is supported by evidence which shows that fear reactions are automatic and that physiological responses in fear are often independent of slower, language based appraisal processes (e.g. Ohman & Soares, 1994). There is also evidence that anxious individuals have an attentional bias towards highly affective stimuli whether pleasant or unpleasant (e.g. Bradley, Mogg & Millar, 2000). This literature is considered in the second section of this review. As yet, emotion theory has not been used in the field of addiction. However, as it is proposed that valence is correlated with attentional bias, it should follow from this theory, that drug-related cues that are highly pleasant or unpleasant should both command attention, whether the person is a drug user or not. However, the incentive motivational framework has been adapted by addiction theorists (e.g. Robinson & Berridge, 1993; 2001), considered next.

Incentive-based addiction models

Within the incentive motivational framework, incentive-based theorists have made specific predictions about its role in the field of addiction. Overall, they see craving (similar to food cravings and sexual desires) as a conditioned appetitive motivational response (Bindra, 1992; Cox & Klinger, 1988; Franken, 2003; Robinson & Berridge,

2000; Stewart et al., 1984; Toates, 1994). Common neuronal pathways are probably shared by these different appetitive processes; the generation of a central motivational state, in turn, further enhances the salience of incentive related stimuli, which in the case of drug use can lead to craving, drug use behaviour and autonomic responses. Stewart et al. (1984) were the first to propose that drug cues become associated with the drug's pleasurable effects and that this positive reinforcement is what motivates drug users to use drugs repeatedly. Therefore, drug cues were assumed to promote drug intake because they were appetitive.

In support of Stewart et al.'s theory (1984), and other incentive-based models, findings from behavioural and neuropharmacological studies suggest that stimulant drugs act on common neurochemical systems of the brain to generate positive appetitive states that maintain drug-taking behaviour (e.g. Davies & Smith, 1987; de Wit & Stewart, 1981,1983). There is further research to support incentive-based theories, but as with the evidence to support withdrawal models, there are methodological difficulties which are discussed later in the review under empirical research. Another limitation of the incentive-based models discussed thus far (e.g. Stewart et al., 1984), is the presumption that there is a link between craving states and drug use; the evidence does not suggest that this is the case (Tiffany & Conklin, 2000). Glautier and Remington (1995) point out that drug use does not necessarily arise from an appetitive (or aversive) hedonic conditioned craving state. It has been shown that over time drug-taking increases with dependence, but the subjective pleasure induced is not reported to increase; drug-taking can continue in the absence of pleasurable effects (e.g. Fischman & Fotlin, 1992). Therefore, another explanation is needed.

Incentive-sensitisation theory, Robinson and Berridge (1993; 2001)

To explain why subjective pleasure does not increase with dependence Robinson and Berridge (1993; 2000; 2001) put forward an incentive-sensitisation motivation theory. They propose that there are two different neural and psychological brain reward systems involved in incentive motivation for drugs. Firstly, there is a system involved in mediating the pleasurable or euphoric effects of drugs (drug 'liking'). Secondly, there is a system involved in incentive salience attribution (drug 'wanting' or craving). In the latter system, drug-related stimuli and their representations (including pictures) become conditioned to drug-taking and are associated with the activation of mesotelencephalic dopamine transmissions. It is thought that dopamine directs attention towards appetitive conditioned stimuli (Wickelgren, 1997). This process is necessary so that the person's attention is directed towards the relevant cues, reducing the probability that they will be ignored. Subsequently, addicts attribute attractive salience to drug-related stimuli, which become especially 'wanted' (craved) and grab attention. The neural systems that are sensitised appear to be only those involved in incentive salience attribution (i.e. drug-wanting/craving). This can help explain why there can be a dissociation between how much they are 'wanted' and how much they are 'liked'. Drugs can become pathologically 'wanted' (craved), which can occur even if drugs are 'liked' less and less. Robinson and Berridge (2001) hypothesised that, when sensitised, the incentive motivational process produces compulsive patterns of drug-seeking. The persistence of neural sensitisation is thought to leave addicts susceptible to relapse even long after discontinuation of drug use. An indicator of susceptibility to sensitisation may be the degree to which attention is drawn to the drug-related stimuli.

A cognitive psychopharmacological model, Franken (2003)

More recently, Franken (2003) proposed a cognitive psychopharmacological model, which has some similar features to those of Robinson and Berridge's (2001) theory. According to Franken's (2003) model, addictive behaviour is the result when the brain's approach mechanism is hypersensitised. Franken (2003) proposed that craving is an emotional state that is produced by conditioned stimuli that are associated with the reward effects of substances or behaviour. It is suggested that, for research purposes, craving could be interpreted as a continuous, measurable state that can also be present in non-addicted subjects. Franken (2003) draws from emotion theories (e.g. Lang et al., 2000) and hypothesises that desire, or drug craving, could be regarded as the emotion which accompanies approach behaviour, in the same way that fear is the emotion that accompanies avoidance behaviour. Franken (2003) suggests that conditioned drug cues produce an increase in dopamine levels in the corticostriatal circuit, in particular the anterirocingulate gyrus, amygdala, and nucleus accumbens, which in turn draws attention towards the drug cue. This process results in motor preparation and a hyperattentive state towards drug-related cues, which in turn leads to further craving and relapse.

Franken's (2003) theory is different from that of Robinson and Berridge's (1993; 2001) because the former argues that attentional bias for drug cues may lead to future episodes of drug use, whereas the latter argue that attentional bias is an index of the underlying processes that cause drug use and that attentional bias in itself should not actually lead to drug use. Another difference between the two theories occurs in relation to their explanations of the role of valence and attentional bias in addiction. Franken (2003) suggests that all drug-related stimuli are appetitive and subsequently have attention-grabbing properties. However, Robinson and Berridge (1993; 2001) propose that drug-related cues grab attention and elicit approach behaviours, independent of

drug 'liking' (i.e. drug 'liking' system); this may mean that attentional and approach biases are independent of cue valence. If this aspect of the theory is accurate the valence of drug-related cues would be irrelevant to measures of 'incentive salience'; all drug-related cues, whether pleasant or unpleasant, would have 'incentive salience' in drug users, but not in non-users.

Research conducted in both animal and human studies (e.g. Bradley, Mogg, Wright & Field, 2003; Stewart & Badiani, 1993) provides some support for Robinson and Berridge's (1993; 2001) and Franken's (2003) incentive-sensitisation theories. This research will be considered later in the review in empirical research, which also includes a discussion of the research on the valence of drug-related stimuli. However, before exploring this issue, consideration will be made of cognitive theories of addiction; thus far only those from a behavioural perspective have been reviewed.

3. Cognitive theories

There are several theories which explain the process of addiction from a mainly cognitive perspective (Dual affect model: Baker, Morse & Sherman, 1987; Dynamic regulatory model: Niaura et al., 1988). Cognitive Social Learning Theory (CSLT: Marlatt & Gordon, 1985) suggests that high 'positive outcome expectancies' for taking drugs, together with low 'negative expectancies' about ones ability to cope without drugs, maintains addictive behaviour. This review is to consider another influential cognitive model, the cognitive processing model (Tiffany, 1990).

Cognitive processing model (Tiffany, 1990)

Tiffany's (1990) cognitive processing model of addiction proposes that drug use is an automatic process, carried out without conscious awareness or effort most of the time.

This process is through automised action schemata, which are elicited by specific stimulus configurations, occurring automatically without awareness. Therefore, craving will not occur during a typical drug sequence. However, if these behaviours are interrupted, for example, access to the drug denied, then more effortful, intensive, resource demanding processes are recruited to overcome the obstacle. In this model this is where craving occurs; if the drug is not available the person will experience increased drug urges and an associated attentional bias for drug cues.

There is a variety of literature to support this theory, which is critically evaluated in the next section (e.g. Sayette & Hufford, 1994). However, in general, the theory is limited as, although it explains how drug-seeking behaviour can become automatic, it does not explain why the habitual nature of drug-seeking behaviour should be viewed as a key factor in the acquisition of drug use. In addition, it does not consider the role of the valence of drug-related cues and associated attentional bias. This is unlike the previously discussed incentive sensitisation theories (Robinson & Berridge, 1993; 2001). These and other unanswered issues are considered in the next section of the review. First the application of addiction theory to clinical practice is discussed.

LINKING THEORY TO PRACTICE

Thus far the various theories surrounding addiction have been discussed (e.g. Robinson & Berridge, 2001; Tiffany, 1990). It is commonly agreed that drug-related stimuli can lead to various (cue) reactions, including drug use and relapse (West, 2001). However, the precise mechanism through which drug cues affect behaviour is still being established. Consequently, thus far, treatments that are available can only produce short term cessation in the majority of motivated smokers; no treatment reliably produces

long term change (e.g. Zelman, Brandon, Jorenby & Baker, 1992). If the mechanism through which drug cues affect behaviour was made explicit, in particular, cue exposure could have the potential to be an effective treatment for nicotine dependence and other addictions.

Cue exposure treatment has been successfully applied to the understanding and treatment of other human behavioural disorders such as obsessive compulsive disorder and phobic anxiety (e.g. Foa & Kozack, 1986; Rachman & Hodgson, 1980). This technique has been utilised in a variety of different addictions including alcohol (Drummond & Glautier, 1994) and cocaine (O'Brien, Childress, McLellan & Ehrman, 1990) dependence. However, there is only little evidence for the efficacy of cue exposure treatment in addiction, including nicotine dependence (Conklin & Tiffany, 2002). To improve cue exposure, in clinical practice it has been combined with a variety of other approaches such as social skills training (Cooney, Baker & Pomerleau, 1983) and Cognitive Social Learning Theory (CSLT: Marlatt & Gordon, 1985), which enables individuals to mobilise coping strategies when most at risk of using drugs (Marlatt & Gordon, 1985). However, as Conklin and Tiffany (2002) suggest, it may be premature to be attempting to identify effective supplements to cue-exposure therapy and it may be of more benefit to improve theoretical understanding about the process of how drug cues affect behaviour, including evaluating the role of attentional bias and valence.

Firstly, in relation to attentional bias, it has been suggested that allocation of attention to drug-related stimuli can determine post-treatment drinking when individuals are faced with a high risk situation (Marlatt & Gordon, 1985; Rohsenow et al., 1994). Sayette et al. (1994) found that the presence of cues disrupted an alcoholic's skill in refusing a drink and suggested that if attentional resources are automatically drawn to drug-related cues then fewer resources are available for coping with the offer of a drink. Further investigation of attentional bias is needed to determine if it predicts

susceptibility to relapse in smokers and to help develop strategies to overcome the effects of having attentional resources taken by drug-related material.

Secondly, the motivational or affective valence of drug-related cues could also inform cue exposure treatments. As discussed, there is an assumption in incentive based models that drug cues are appetitive (Robinson & Berridge, 2000). It may be that, thus far, only appetitive or what could be described as pleasant cues have been used in treatment. Studies are not always clear about the valence of the cues used. For example, Niaura et al. (1999) mention that participants were exposed to their favourite brand of cigarette (clearly a pleasant cue), but also to any cues which they could imagine would increase their desire to smoke; these cues could potentially have been unpleasant or pleasant. If addicts are not exposed to unpleasant drug-related cues, they would not desensitise to this type of stimuli and could, therefore, still be at risk of relapse. This may help explain why cue exposure as a treatment has not been as effective in the field of addiction thus far (Conklin & Tiffany, 2002). However, further investigations are needed to establish the motivational salience of drug-related stimuli and associated drug cue responses before treatment approaches can be developed. The issue of whether drug-related stimuli are appetitive is considered at the end of the next section; first the empirical research evaluating theories of addiction is discussed.

EMPIRICAL RESEARCH

Thus far the most pertinent theories of addiction have been discussed. However, there has been little discussion of the empirical research which exists to evaluate these theories. Reviews and meta-analyses have concluded that, in general, the literature in cue-reactivity (the main methodological paradigm used by researchers in this area)

supports incentive models rather than withdrawal models (Carter & Tiffany, 1999; Niaura, et al., 1988). The cue-reactivity paradigm in research into nicotine addiction refers to the cognitive, behavioural and physiological responses that are elicited when smokers are presented with the environmental cues associated with smoking (Field & Duka, 2001). Cue-reactivity designs have been found to elicit increases in both self-report of craving and physiological reactions in smokers, reflecting a positive-incentive state (Carter & Tiffany, 1999). The physiological cue-reactivity effects to smoking were characterised by an increase in heart rate and sweat gland activity, and decreases in skin temperature (Carter & Tiffany, 1999). Other physiological responses to smoking cues can include frontal EEG responses and facial muscle reactivity (e.g. Abrams et al., 1998; Niaura, Abrams, Pedraza, Monti & Rohsenow, 1992). However, Carter and Tiffany (1999) found that there were significantly larger effect sizes for self-report of craving rather than physiological responding. They propose that this may be due to physiological indices being derived from general measures of physiological responses, of which only a small amount may be reflective of cue manipulations, whereas craving reports relate very focused information about participants' levels of drug desire in relation to the cues. Researchers also state that there are a number of other problems in interpreting results obtained from studies using the cue-reactivity paradigm (Carter & Tiffany, 1999; Niaura et al., 1988). These difficulties will be considered next.

A more detailed discussion will then be made of the empirical research, with particular reference to the studies related to: cognitive process models (Tiffany, 1990); incentive-sensitisation models (Franken, 2003; Robinson & Berridge, 2001); and theories of emotion (Lang et al., 2000). The research related to the most pertinent questions posed by these models is covered: Do drug-related cues elicit craving, drug-seeking and drug-taking behaviour? Are drug-related stimuli associated with the activation of dopamine transmissions? Do addicts have an attentional bias for drug-

related cues? Do addicts have an attentional bias for drug-related cues at a preconscious level? Are drug-related stimuli appetitive?

Cue-reactivity paradigm

As discussed earlier, there are a number of problems in interpreting results obtained from studies using the cue-reactivity paradigm (Drummond, Tiffany, Glautier & Remington, 1995). Firstly, there are many different ways in which cues can represent a drug stimulus (e.g. picture, word, image etc.) and there is an assumption that these laboratory cues reflect the nature of the stimuli comprising the drug stimulus. Secondly, cue-reactivity, as measured in the laboratory setting, may simply reflect the test situation and the response repertoire of the subject (e.g. mood and cognition). Thirdly, participants' expectations of what they can expect during the experiment can affect outcome (e.g. Mucha, 1991; Schupp, Mucha & Pauli, 1996). For example, Drougnas, Ehram, Chuildress and O'Brien (1995) found that cravings elicited by smoking cues were influenced by expectations regarding the opportunity to smoke.

Lastly, there is a lack of standardised measures for craving. Consequently, as Carter and Tiffany (1999) point out, results cannot be generalised across studies. According to Drummond et al. (1995) there are three ways in which responses to cues can be measured, each with their own limitations: subjective individual responses; physiological reactivity; behavioural reactivity. Firstly, subjective responses are problematic as there is a lack of standardised measures and constructs such as craving are difficult to define (discussed in the next section). Subjective responses are also reliant on self-report, which may be influenced by such factors as what participants feel the researchers want to hear and on them being able to access their memory (Cooney, Gillespie, Baker & Kaplan, 1987). Secondly, measures of physiological reactivity may be more objective, but they are still problematic, as they can be idiosyncratic;

individuals can have unpredictable and variable reactions to stimuli. Thirdly, some studies have examined behavioural reactivity to drug cues; for example, operant responding for drug cues after cue exposure (Payne, Etscheidt & Corrigan, 1990), or latency to reach for cigarettes during cue exposure (Herman, 1974). Difficulties with observed cue-induced increases in behaviour are that participants may be conforming to the perceived demands of the experimental situation (Robins & Ehrman, 1992). However, as Drummond (2000) points out in their review, little attention has been paid to behavioural cue-reactivity, which could provide a more valid measure of actual smoking behaviour rather than making inferences (e.g. from observed physiological responses) concerning likely behavioural outcomes.

Despite its limitations, thus far, the cue-reactivity paradigm appears to provide the most useful way of investigating the link between drug cues and cue reactions. One way in which the cue-reactivity paradigm has been popular is investigating the link between drug cues, drug craving and drug use; this is discussed next.

1. Do drug-related cues elicit craving, drug-seeking and drug-taking behaviour?

Researchers have investigated proposals in cognitive processing models and incentive-sensitisation theories that drug cravings, drug-seeking and drug-taking increase in response to drug cues (Franken, 2003, Robinson & Berridge, 2001; Tiffany, 1990). In a cue-reactivity paradigm, it should follow that cues trigger craving and subsequent drug-seeking behaviour and drug use. Indeed, in the field of addiction, it has been shown in the laboratory that smoking images and paraphernalia, or arbitrarily conditioned stimuli paired with smoking, increase drug-seeking and smoking behaviour (e.g. Droungas et al., 1995; Field & Duka, 2001; Herman, 1974; Mucha , Pauli & Angrilli, 1998; Niaura et al., 1992; Perkins, Epstein, Grobe & Fonte, 1994).

Carter and Tiffany (1999) also indicate, in their meta-analysis, that drug cues reliably produce increases in self-reported subjective craving. Researchers have found that exposure to smoking scenes (imaginary or in-vivo) increases desire to smoke relative to neutral scenes (e.g. Cepeda-Benito & Tiffany, 1996; Drobes & Tiffany, 1997; Droungas et al., 1995; Field & Duka, 2001; McDermut & Hugga, 1998; Tiffany & Drobes 1990). However, the results of these studies need to be interpreted with caution. As discussed earlier, the cue-reactivity paradigm is fraught with difficulties. There are problems with the measurement of drug craving (e.g. unreliability of self-report data). In addition, considered next, there are a number of factors which have led to researchers having difficulty in unpacking and assessing the construct of 'craving' (e.g. Tiffany & Carter, 1998).

Firstly, investigations into the concept of craving are limited due to the lack of clarity surrounding its definition. In general, craving (the desire for drugs) is often conceptualised as an abnormal, subjective, motivational state that is the result of dependency. However, the term 'craving' has been used to mean many different things, including liking, wanting, urges, desires, need, intention or compulsion to use (Kozlowski & Wilkinson, 1987; Drummond, Lowman, Litten, & Hunt, 2000). Several reviews have been published investigating craving in addiction and it is clear that there is little consensus on the concept (Altman et al., 1996; Drummond et al., 2000). As discussed earlier, some addiction theorists view it as a conscious cognitive process measured by self-report (Tiffany, 1990; Marlatt & Gordon, 1985). Other theorists view it as a preconscious state (Robinson & Berridge, 2001). On one hand craving has been thought of as the basic motivational process responsible for ongoing drug use and serves as a necessary trigger for relapse, yet on the other hand it is considered a redundant epiphenomenon, neither necessary nor sufficient for relapse to occur (Drummond et. al, 2000; Lowman, Hunt, Litten & Drummond, 2000). Drummond et al. (2000) stated that

given such mixed views it is questionable if researchers are measuring different aspects of the same or a different phenomenon.

Secondly, investigations into craving are limited because self-report is confounded by voluntary or involuntary cognitive strategies and depends heavily on people's ability to reflect on their internal motivational state (Berridge, 1996). There may also be other factors modulating and confounding a person's self-report of craving, including information processing mechanisms such as selective attention and social desirability. These limitations would seem to suggest, that the research (mentioned previously) indicating that drug cues elicit craving should be interpreted with caution. The research does not necessarily indicate a causal relationship between craving, drug use or relapse. Tiffany and Carter (1998) did not find strong correlations between craving and subsequent drug use. Research has also found that addicts do not typically identify urges and cravings as an important component of their relapse (Bradley, Phillips, Green, & Gossop, 1989; Miller & Gold, 1994; Shiffman, 1986). Despite these limitations, clinicians and patients still perceive craving as clinically relevant (Tiffany & Carter, 1998). Clearly, further research in this area is needed.

Another way in which the cue-reactivity paradigm has been popular is investigating the link between drug cues and dopamine release.

2. Are drug-related stimuli associated with the activation of dopamine transmissions?

The preceding discussion provides some support for the proposal of both Tiffany (1990) and Robinson and Berridge (1993; 2001) that drug craving, drug-seeking and drug-taking increase in response to drug cues; however, the empirical research evaluating the process through which this occurs needs to be discussed. Incentive-based models suggest that craving is produced by conditioned drug-related stimuli, which are associated with the activation of mesotelencephalic dopamine transmissions; through

repeated drug administrations the brain reward system becomes sensitised to drug-related stimuli (Franken, 2003; Robinson & Berridge, 2001). In support of this proposal a number of studies have been conducted, mainly with animals (see review by Robinson & Berridge, 2000). Firstly, all drugs of abuse have been found to release dopamine in the mesolimbic dopamine reward system (in particular the nucleus accumbens) (see review by Wise, 1996). Secondly, it has been found that, through the mechanism of classical conditioning, drug-related stimuli can release dopamine in the mesolimbic region (e.g. Duvauchelle, Ikegami & Castaneda, 2000). Thirdly, there are a number of studies which show that repeated administrations of drugs can produce sensitisation (see review Robinson & Berridge, 2000; Segal, Geyer & Schuckit, 1981; Stewart & Badiani, 1993). Most of the studies investigating the latter proposal involve measures of the psychomotor activating effects of drugs, such as increased locomotor activity, or stereotyped motor patterns; psychomotor activating effects of drugs are thought to be the same or at least overlap with the neural substrate responsible for the rewarding effects of drugs (i.e. the dopamine system) (Wise & Bozarth, 1987).

Although animal studies are informative about the nature of addiction they do not provide information about the nature of craving, as researchers do not have access to animals' thoughts and feelings. Few studies address the role of dopamine in motivated behaviour of humans; this may be due to constraints posed by ethics. There is some limited research to suggest that dopamine antagonists reduce craving/wanting in drug users, although the majority has shown negative or mixed results (Smelson, Roy & Roy, 1997). Strakowski, Sax, Setters & Keck (1996) and Strakowski and Sax (1998) have shown that repeated exposure to amphetamine produces psychomotor sensitisation in humans. However, it is difficult to quantify behavioural sensitisation using measures of locomotor activity (in humans and animals) and it is unclear whether these do, indeed, reflect neural sensitisation (Robinson & Berridge, 2001). More research needs to be conducted with humans before firm conclusions can be drawn. Although the role of

dopamine cannot easily be assessed in humans, one variable which can is attentional bias. This area of research is considered in the next section.

3. Do addicts have an attentional bias for drug-related cues?

As discussed, one way in which incentive based models represent the process though which drug-related stimuli affect drug-craving and drug-taking is that drug-cues become associated with the activation of dopamine transmissions. In addition, incentive based models suggest that these dopamine transmissions trigger the brain's attention towards the appetitive conditioned drug-related stimuli (Franken, 2003). Tiffany (1990) also suggests that addicts have an attentional bias for drug cues and that this is determined, in part, by drug urges. A discussion is now made of the attentional bias investigations in the field of addiction. There are four main types of paradigms used by researchers in this area: the modified Stroop; auditory probe; visual probe; and, eye-movements. These are each considered in turn.

The modified Stroop paradigm

The modified Stroop task is a commonly used paradigm designed to investigate attentional bias. In this task words are presented in different colours and participants are asked to name the colour of the word whilst ignoring the content, requiring participants to suppress task-irrelevant information. The amount of cognitive capacity that is used by processing of the words (i.e. task irrelevant information) is assessed by recording performance decrements on the colour naming task. The more capacity that is being consumed by the secondary task, the longer the latency of reaction time to the primary task.

In support of cognitive processing models and incentive-sensitisation theories (Franken, 2003, Robinson & Berridge, 2001; Tiffany, 1990), modified Stroop studies

have shown that smokers are slower to colour name smoking-related words than control words (Gross, Jarvik & Rosenblatt, 1993; Waters & Feyeraband, 2000; Zack, Belsito, Scher, Eissenberg & Corrigall, 2001; Mogg & Bradley, 2002). The opiate and alcohol literature has found similar results (e.g. Johnsen, Laberg, Cox, Vaksdal & Hugdahl, 1994; Lubman, Peters, Mogg, Bradley & Deakin, 2000). However, Johnsen, Thayer, Laberg and Asbjornsen (1997) found mixed results. They compared smokers, ex-smokers and non-smokers on the modified Stroop task and failed to show any significant difference between smokers and non-smokers for an attentional bias towards smoking words.

The colour naming interference effects assessed by the modified Stroop task do not necessarily reflect a selective attentional bias for drug-related cues. Colour naming interference effects may arise at both the input (encoding) stage of processing and during later aspects of processing such as response selection (Mogg & Bradley, 2002). Such interference effects may be caused by competition for processing resources from task-irrelevant processes (e.g. intrusive thoughts) triggered by the cues, or cognitive effort which is required to suppress the distracting information.

Auditory probe

The auditory probe paradigm is another, less common, paradigm used to assess attentional bias, for which participants are required to respond to a series of tones while being exposed to smoking-related and control stimuli. Researchers found that smokers were slower to respond to an auditory probe stimulus in the presence of smoking-related stimuli rather than control stimuli (Cepeda-Benito & Tiffany, 1996; Juliano & Brandon, 1998; Sayette & Hufford, 1994).

Visual probe paradigm

The visual probe is another, more common paradigm than the auditory probe, which may provide a more direct measure of attentional bias than the modified Stroop task (Mogg & Bradley, 1998). Visual probe tasks assess the deployment of visuo-spatial attention. In the task, on each trial, two pictures are presented beside each other simultaneously on a computer screen. In research into attentional biases in smokers, one picture is of a smoking scene and one is of a control scene. Immediately after the pictures disappear an arrow appears in the location of one of them and participants are required to press a key as quickly as possible in response to the arrow. The duration for which the pictures are displayed can vary, usually between 200 ms and 2000 ms to examine different components of attention such as initial orienting versus maintained attention (discussed in the next section). The rationale is that participants will respond more quickly to stimuli that appear in an attended, rather than unattended region, of visual display.

To support cognitive processing models and incentive-sensitisation theories (Franken, 2003, Robinson & Berridge, 2001; Tiffany, 1990) an attentional bias towards drug-related stimuli has been demonstrated using the visual probe paradigm in social drinkers (Townshend & Duka, 2001), cocaine addicts (Franken, Kroon & Hendricks, 2000) and opiate addicts (Lubman et al. 2000). Several studies have also demonstrated an attentional bias in smokers for smoking-related cues, relative to controls (Bradley et al., 2004; Bradley et al., 2003; Field, Mogg, Bradley, in press; Hogarth et al., 2003; Mogg & Bradley, 2002; Mogg, Bradley, Field & De Houwer, 2003). Studies consistently show that smokers, in general, have an attentional bias for smoking-related pictures at 2000 ms (Bradley et. al, 2003; Mogg et al., 2003); however, at durations of less than 2000 ms the research results were not so consistent.

Eye-movement paradigm

The eye-movement paradigm provides another measure of visual orienting and attentional bias, which is valid and reliable as participants commonly first look at the stimuli that they are attracted to and then closely follow this by guided shifts in attention (Kowler, 1995). This is a useful paradigm for researchers to investigate the proposal that the attentional system may not be unitary and that there may be important distinctions between the mechanisms involved in initial orienting versus maintenance of attention (Allport, 1989). A couple of studies have found that smokers have a bias in initial orienting to smoking pictures and maintain their gaze longer on smoking-related pictures than control pictures (Field et al., in press; Mogg et al., 2003).

Factors affecting attentional bias towards drug-related cues

It may be that there are various factors affecting bias in the shifting of attention to smoking-related cues, such as increased craving, number of attempts to quit smoking, severity of dependence and levels of deprivation from smoking (Bradley et al., 2003; Gross et al., 1993; Mogg & Bradley, 2002; Hogarth et al., 2003; Sayette & Hufford, 1994; Zack et al., 2001). LaBerge (1995) suggests that motivational effects are likely to operate more strongly in maintained attention and that separate neural subsystems may underlie different cognitive operations of attentional shifting and maintenance. In smokers, it has been found that maintained attention was likely to be demonstrated by longer durations (e.g. 2000 ms), when there was greater opportunity for attention to shift repeatedly between the pictures and initial shifts in attention were more likely to be demonstrated when picture pairs were shown briefly (e.g. 500 ms or less) (e.g. Mogg et al., 2003). As discussed earlier, smokers were more likely to have an attentional bias when picture pairs were shown for longer durations (e.g. 2000 ms) (Bradley et. al, 2003;

Mogg et al., 2003). However, at durations of less than 2000 ms smokers did not always demonstrate an attentional bias towards smoking-related cues (e.g. Bradley et al., 2003), which is consistent with LaBerge's (1995) suggestion that initial orienting may be less strongly influenced by motivational factors. The various factors are considered next. Firstly, the number of attempts to quit smoking may be affecting attentional bias towards smoking-related cues. Bradley et al. (2003) found that only smokers who had made repeated attempts to quit smoking showed an attentional bias to smoking-related cues at 500 ms. In line with the models of Tiffany (1990) and Robinson and Berridge (2001), Bradley et al. (2003) hypothesised that this increased level of vigilance to drug cues may make attempts at abstinence less likely to be successful, as processing resources are preferentially directed to smoking-related cues and away from ongoing daily activities.

Secondly, levels of deprivation from smoking may be affecting attentional bias towards smoking-related cues. Tiffany (1990) and Robinson and Berridge (1993; 2001) both suggest that attentional bias should be increased by higher levels of deprivation. Studies have found that deprived, rather than non-deprived, addicts show an attentional bias for drug-related cues (e.g. Gross et al., 1993; Sayette & Hufford, 1994; Zack et al., 2001).

Thirdly, levels of craving may be affecting attentional bias towards smoking-related cues. Cognitive processing models and incentive-sensitisation theories (Franken, 2003; Robinson & Berridge, 2001; Tiffany, 1990) suggest that attentional bias should be increased by increased levels of craving. Studies using the auditory probe and Stroop paradigm have found that craving is associated with an attentional bias for smoking-related stimuli (e.g. Gross et al., 1993; Sayette & Hufford, 1994). Mogg and Bradley (2002) also used the modified Stroop paradigm and found that there was a bias which was most strongly predicted by self-reported urge to smoke; however, their experiment using the visual probe paradigm showed no association of attentional bias with urge to

smoke at durations of 500 ms and 1500 ms. Mogg and Bradley (2002) suggest that perhaps one reason for the difference is that the two paradigms tap separate underlying mechanisms. The visual probe tasks may assess the distribution of attention to different regions of a visual display (visuo-spatial orienting) and the modified Stroop task may assess suppression of task-irrelevant information (inhibitory processes).

It may be that the eye-movement paradigm and duration of gaze is a particularly sensitive indicator of activation of motivational states, indicating maintenance or engagement of attention. Researchers have found that initial shifts in gaze and visual probe RT measures were less sensitive to changes in nicotine deprivation and craving, whereas a longer duration of gaze was associated with higher levels of deprivation and craving (Field et al., in press; Mogg et al., 2003). As discussed earlier, it may be that different attentional bias measures tap into different underlying attentional processes.

Clearly, further research is needed to investigate what factors (e.g. craving, deprivation) may be affecting the attentional bias process using different measures (i.e. eye-movement tasks; modified Stroop tasks; visual probe tasks) so that the theories of Robinson and Berridge (2001) and Tiffany (1990) can be evaluated.

4. Do addicts have an attentional bias for drug-related cues at a Preconscious level?

Robinson and Berridge (2000) and Tiffany (1999) both suggest that the processing of drug-related stimuli occurs at a preconscious level, although Franken (2003) suggests that this may not be the case. The role of awareness in the automatic processing of drug-related stimuli is scarcely addressed by the empirical literature. There is evidence in the field of emotion suggesting that anxious participants have a preconscious bias favouring anxiety related stimuli, which has come from research using a masked condition of the modified Stroop task (Mogg & Bradley, 1998; Morris, Ohman & Dolan, 1998). However, there is no clear evidence for nonconscious cognitive bias in processing

appetitive stimuli (e.g. Jansen, Huygens & Teeney, 1998). Mogg and Bradley (2002) also found no evidence of a preconscious bias for smoking cues in smokers. In addition, no evidence of a preconscious bias for masked heroin related words was found in opiate addiction (Franken et al., 2000). However, these studies employed the modified Stroop task; it may be that the masking conditions were too effective to allow sub-threshold effects to emerge. Bradley et al. (2004) employed a pictorial dot-probe task, which was more naturalistic, but still did not find a preconscious bias (17 ms) for smoking-related stimuli. Mogg and Bradley (1998) suggest that preconscious biases may operate specifically for fear relevant stimuli rather than appetitive stimuli, due to a specialised cognitive mechanism underlying the processing of threat-related information, which has adapted evolutionarily. However, the question of whether drug-related stimuli are indeed appetitive is considered in the next section.

5. Are drug-related stimuli appetitive?

The preceding discussion of research into evaluate cognitive processing and incentive-sensitisation theories (Franken, 2003, Robinson & Berridge, 2001; Tiffany, 1990), suggests that further research is needed to investigate which factors (i.e. craving, deprivation) may be affecting attentional bias towards drug-related cues. One factor not discussed in detail, thus far, which may also be affecting the attentional bias process, is the perceived attractiveness of drug cues. As considered earlier, there is a lack of clear predictions about the role of valence and attentional bias towards drug-related stimuli. Tiffany (1990) does not make specific predictions about the valence of drug-related cues and attentional bias. However, Franken (2003) does suggest that drug-related stimuli are appetitive and subsequently have attention-grabbing properties. In addition, Robinson and Berridge (1993; 2001) propose that drug-related cues can be perceived as either pleasant or unpleasant and still attract attention; i.e. 'liking' (as reflected by the

valence or subjective pleasantness of drug-related cues) and 'wanting' (as reflected by attentional bias or approach behaviours to drug-related cues) are dissociated. Furthermore, recent theories of emotion (e.g. Lang et al., 2000) provide another potential explanation for attentional bias and the role of cue valence in addiction, whereby attentional bias and valence are thought to be related. Next, a review is made of the empirical research which helps to evaluate these theories: firstly, the empirical research investigating attentional bias towards unpleasant stimuli is explored; secondly, the empirical research investigating attentional bias towards pleasant stimuli; thirdly, the literature which explores whether or not drug-related cues are appetitive or aversive; lastly, consideration is made of the relationship between attentional bias and the perceived attractiveness of drug-related cues.

Empirical research investigating attentional bias towards aversive and appetitive stimuli

To support the proposal of emotion theorists (e.g. Lang et al., 2000) that there is a motivational system activated by aversive stimuli, there is a large body of research which has investigated the process of attentional bias in negative emotions (i.e. anxiety and depression) (see review by Mogg & Bradley, 1998). It is not possible fully to explore this aspect of the literature within the scope of this review; however, it is of note that research has shown that anxious and depressed individuals have an attentional bias towards threat-related or negative stimuli (e.g. Bradley et al., 2000; Fox, 1993; Matthews, Ridgeway & Williamson, 1996; MacLeod & Matthews, 1988; MacLoed, Mathews & Tata, 1986; Mogg & Bradley, 1998; Mogg, Bradley & Hallowell, 1994; Mogg, Bradley & Williams, 1995).

To evaluate the proposal of emotion theorists (e.g. Lang et al., 2000) that there is a motivational system activated by appetitive stimuli, there has been some research into

attentional biases for positive stimuli in emotional disorders and into the appetitive state of hunger (there are fewer studies than those investigating aversive stimuli). Firstly, in emotional disorders, some studies have found that anxious and depressed individuals have a similar attentional bias for positive and negative words, indicating that individuals may be vigilant for emotional information in general (e.g. Gotlib, McLachlan & Katz, 1988; McCabe & Gotlib, 1995; Martin, Williams & Clark, 1991). Gotlib et al. (1988) and McCabe and Gotlib (1995) also found that non-depressed individuals showed a protective bias against the perception of negative stimuli by avoiding such material in favour of positive or neutral stimuli; therefore, they suggested that depressed individuals do not have an attentional bias towards negative stimuli, but fail to show protective bias. However, Bradley et al. (2000) found no evidence of an anxiety-related bias for happy faces in non-clinical individuals with high and medium anxiety. Nonetheless, Bradley, Mogg, White, Groom and de Bono (1999), in a study of clinical anxiety, did find a bias for both positive and negative faces; this study also provides some evidence to support the proposal of emotion theorists (e.g. Lang et al., 2000) that there is a greater attentional bias for stimuli with high affective valence. Clearly further research in this area is needed to establish the processes involved.

Secondly, research has been conducted into the appetitive state of hunger, which shows that individuals do have an attentional bias towards appetitive, food-related cues (Lavy & van den Hout, 1993). In a similar way to addiction, food cravings are thought to be a good predictor for attentional bias to food-related words; studies have found that colour naming of food-related words varied according to subjects' levels of self-reported hunger (Green, Elliman & Rodgers, 1996). In addition, in a similar way to addiction, levels of deprivation have been shown to increase attentional bias towards food-related words (Placanica, Faunce & Job, 2002; Mogg, Bradley, Hyare & Lee, 1998). However, Faunce (2002) conducted a review of the literature in attentional bias demonstrated by individuals with an eating disorder and pointed out that despite the

consistency of the findings there were methodological problems inherent in the design of the studies, such as that the majority employ the modified Stroop paradigm (difficulties discussed earlier). The amount of research in this area is very limited and more research needs to be conducted before firm conclusions can be drawn.

It can be seen from the preceding discussion that there is empirical support for an attentional bias for aversive stimuli (e.g. Mogg et al., 2000) and there are also some studies showing an attentional bias for appetitive stimuli (Green et al., 1996). This provides some support for theories of emotion (e.g. Lang et al., 2000). However, most of the studies made an assumption about the valence of the cues and only some explored, through subjective valence ratings, whether participants actually found the stimuli pleasant or unpleasant (e.g. Bradley et al., 2000). In addition, this research is not in the field of addiction. In the next section, research which has directly assessed the extent to which drug-related cues are evaluated as appetitive will be considered.

Empirical research investigating the valence of drug-related stimuli

Thus far, the research findings appear to suggest that smoking-related cues are appetitive; this is in support of Franken's (2003) theory that all drug cues are evaluated as pleasantly attractive. For example, a number of studies have found that pictures and videos of smoking (McDermut & Hugga, 1998; Bushnell et al., 2000), conditioned smoking cues (Mucha et. al, 1998; Lazev, Herzog, & Brandon, 1999) and actual smoking cues (Zinser, Fiore, Davidson & Baker, 1999), increased desire to smoke without being described as unpleasant. These studies suggest that smoking cues are appetitive, although they did not directly assess the valence of smoking cues. Mucha et al., (1999) directly investigated the valence of smoking cues and concluded that pre-smoking cues, such as the preparation and the start of smoking, were more likely to be seen as pleasant (i.e. positively valenced), increase the desire to smoke and be viewed as

relaxing. More recently, Mogg et al. (2003) and Field et al. (in press) also found that smokers rated smoking-related pictures more positively than control pictures. However, the pleasantness ratings given by participants in these studies were self-reported and therefore subjective.

There are other less subjective methods which may be used to assess the attractiveness of drug-related cues, which measure response times of participants to approach an appetitive cue. Behavioural approach tendencies have been found to be compatible with positively valenced stimuli, whereas behavioural avoidance tendencies have been found to be compatible with negatively valenced stimuli (De Houwer, 2003). Firstly, in an early investigation, Herman (1974) found that increasing the illumination of a container of cigarettes increased participants' speed to reach for the container, suggesting that smokers found these cues more pleasant. A second task used by researchers to assess motivational or affective valence is the Acoustic Startle Reflex (ASR). The ASR measures the reactivity of a facial muscle (orbicularis oculi) to a loud burst of sound, whereby the magnitude of the ASR is reduced for pleasant stimuli and potentiated for unpleasant stimuli. An appetitive cue approach effect has been demonstrated in: opiate users (Mucha, Volkovskis, & Kalant, 1981); individuals with alcoholic dependence (Mucha, Geier, Stuhlinger & Mundle, 2000); and, smokers (Geier et al., 2000; Mucha et al., 1999; Muller, Mucha & Pauli, 1998). A third paradigm is the Stimulus Response Compatibility task (SRC). In this task participants move a manikin figure either towards or away from a picture. The rationale is that participants will be faster to make approach then avoidance movements to pleasant stimuli; if the stimuli are negative the opposite pattern of results would be seen. De Houwer (2003) describes this task as a more direct measure of how attractive a subject finds a cue, as it is less confounded by response bias (e.g. a participant may believe that an experimenter wants them to rate the cues more positively). Researchers have found that participants from non-clinical populations were faster to approach pleasant rather than unpleasant stimuli,

if the appropriate categorisation response was congruent (e.g. Chen & Bargh, 1999; De Houwer et al., 2001; Neuman & Strack, 2000). In the field of addiction, Mogg et al. (2003) found that smokers subjectively rated smoking pictures more positively than non-smoking pictures and also showed faster approach tendencies for smoking-related cues on the SRC task.

Despite the research supporting the appetitive nature of drug-related stimuli, the research discussed thus far still does not provide conclusive evidence that all drug-related cues are appetitive. Consequently, Franken's (2003) theory that all drug cues are evaluated as pleasantly attractive and subsequently attract attention may not be supported. The studies in this area have mainly used pleasant, 'pre-smoking' (i.e. positively valenced) cues (Geier et al., 2000; Mucha et al., 1999). Pre-smoking cues mainly depict scenes, such as the preparation and the start of smoking, which are more likely to be considered 'pleasant' than cues which depict, what may be considered, 'unpleasant' scenes (e.g. a dirty ash tray). Mucha et al. (1999) did find that the pictures depicting the end of smoking (i.e. post smoking) produced little craving, were arousing (i.e. not relaxing) and were viewed as unpleasant (i.e. negatively valenced). No studies have attempted to replicate the findings of Mucha et al. (1999). If drug-related cues are perceived as unpleasant, this would be more in line with the interpretation of Robinson and Berridge's (1993; 2001) theory, that there is a dissociation between 'wanting' and 'liking', in which drug-related cues may be perceived as both pleasant and unpleasant. Next the relationship between the valence of cues and attentional bias is considered.

The relationship between attentional bias and the perceived attractiveness of drug-related cues

In emotion theory (e.g. Lang et al., 2000) it should follow that drug-related cues that are highly pleasant or unpleasant should both command attention, whether the person is a

drug user or not. However, studies have not found that smoking-related cues perceived as unpleasant elicit an attentional bias in non-smokers (e.g. Bradley et al., 2004; Mogg et al., 2003); these findings are more consistent with Robinson and Berridge's (1993; 2001) theory, which does not predict that non-smokers would have an attentional bias towards smoking-related cues.

Franken's (2003) theory that drug-related cues are perceived as pleasant and attract attention is also supported by a couple of other studies (Field et al., in press; Mogg et al., 2003). Mogg et al. (2003) found that a longer duration of gaze, smokers' positive ratings for smoking pictures, faster approach tendencies for smoking-related cues on the SRC task, and greater urge ratings were inter-correlated; Field et al. (in press) also found that longer fixations of gaze on smoking-related pictures were accompanied by a bias to rate the pictures more positively. Field et al. (in press) propose that attention, perceived attractiveness and craving are cognitive and motivational effects of smoking cues, which may be mediated by a common underlying mechanism influenced by deprivation, namely, an incentive-sensitisation system (Robinson & Berridge, 1993; 2001). However, again, the findings in both these studies may only be because 'pleasant' smoking cues were used. There appear to be no studies which have investigated the effects of unpleasant smoking-related stimuli on attentional bias in smokers. If further research demonstrated that some drug-related cues are perceived as unpleasant and still attracted attention, this would support the interpretation of Robinson and Berridge's (1993; 2001) theory that there is a dissociation between 'wanting' and 'liking', in which attentional biases are independent of cue valence.

CONCLUSION

This review considered some of the most prominent theories which have been put forward to explain the mechanism through which drug cues affect behaviour (e.g. Robinson & Berridge, 1993; 2001; Tiffany, 1990; Wikler, 1948). The empirical research which exists to investigate these theories of addiction and the main questions which arise from these were discussed. Research has done much to clarify the mechanism through which drug-related stimuli affect drug use and drug-seeking behaviour; however, further work in this area is still necessary (Weinstein, et al., 1998).

One area which this review focused on was the valence and attentional bias of drug-related cues. Recent theories of emotion (e.g. Lang et al., 2000) provide a potential explanation for attentional bias and the role of cue valence in addiction, whereby valence is correlated with attentional bias. Consideration of the relevant literature shows that, in individuals with emotional disorders, there is some support that attentional bias was related to the valence of unpleasant stimuli, although this relationship was less evident with pleasant stimuli (e.g. Bradley et al., 2000). If emotion theory is applied to the field of addiction it should follow that drug-related cues that are highly pleasant or unpleasant should both command attention, whether the person is a drug user or not. However, it has been shown that non-smokers who were more likely to perceive the smoking-related cues as unpleasant did not have an attentional bias towards those cues (e.g. Mogg et al., 2003).

In the field of addiction, incentive-sensitisation theories (Franken, 2003; Robinson & Berridge, 1993; 2001) have attempted to propose the mechanism through which this occurs. Therefore, one research domain that could be developed is to assess the extent to which different types of drug-related cues are appetitive or aversive and

whether addicts do have an attentional bias towards those cues. The research thus far seems to support Franken's (2003) theory that all drug-related cues are perceived as attractive and attract attention, even though the effects of drugs may not be liked (i.e. valence and attentional bias for drug-related cues are related) (Field et al., in press; Mogg et al., 2003). However, if further research demonstrated that some drug-related cues are perceived as unpleasant and still attracted attention, this would support the interpretation of Robinson and Berridge's (1993; 2001) theory that there is a dissociation between 'wanting' and 'liking', in which attentional biases are independent of cue valence.

It is evident that further research is needed to investigate the relationship between the motivational salience of drug-related stimuli and attentional bias for those cues, and such research is likely to be helpful in the future development of addiction theories.

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UNIVERSITY OF SOUTHAMPTON

An investigation into the relationship between attentional bias and the perceived pleasantness of smoking-related stimuli

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ABSTRACT

The aims of the present study were to investigate whether perceived pleasantness of different types of smoking-related cues would influence smokers' attentional bias towards those cues.

There were two groups: smokers ($n = 22$) and non-smokers ($n = 23$). The study used a visual probe task (with stimulus presentation times of 200 ms and 2000 ms) to assess attentional bias, a Stimulus Response Compatibility task (SRC) to measure approach tendencies and a pleasantness rating task to assess stimulus valence. Pleasant and unpleasant smoking-related pictures were presented in each task.

The results from the visual probe task showed that smokers, but not non-smokers, had an attentional bias for smoking-related cues when they were presented for 2000 ms, irrespective of their valence. Smokers rated the unpleasant smoking-related cues as significantly less pleasant (perceived as neutral/unpleasant) than the pleasant smoking-related cues, relative to non-smokers. Non-smokers found all smoking-related cues to be unpleasant, relative to control pictures. On the SRC task, participants were generally faster to approach, rather than avoid, smoking-related pictures and there was a trend, which approached significance, for this effect to be bigger in smokers compared to non-smokers.

Results show that smokers have an attentional bias for smoking-related cues and this bias was not significantly influenced by the perceived pleasantness (neutral, pleasant or unpleasant) of the smoking cues. In addition, smoking cues elicited approach behaviours irrespective of their valence. These findings seem to be consistent with Robinson and Berridge's (1993; 2001) incentive-sensitisation theory, that there is a dissociation between 'wanting' and 'liking', in which attentional and approach biases are independent of cue valence.

INTRODUCTION

According to recent theories of addiction, biases in selective attention and the attractiveness of drug-related stimuli are important factors in the development and maintenance of drug-taking behaviour (Robinson & Berridge, 1993; 2001).

Incentive-sensitisation theory, Robinson and Berridge (1993; 2001)

Robinson and Berridge (1993; 2001) put forward an incentive-sensitisation motivation theory of addiction. They propose that there are two different neural and psychological brain reward systems involved in incentive motivation for drugs. Firstly, there is a system involved in mediating the pleasurable or euphoric effects of drugs (drug 'liking'). Secondly, there is a system involved in incentive salience attribution (drug 'wanting' or craving), in which drug-related stimuli become conditioned to drug-taking and are associated with the activation of dopamine transmissions. Repeated administration of drugs results in the neural system becoming sensitised. Consequently, these drug-related stimuli are perceived as highly attractive, become especially 'wanted' (craved), grab attention, cannot be ignored and elicit approach behaviours. These processes are suggested to occur automatically and outside awareness.

This theory appears to generate predictions about the role of the valence of drug-related stimuli in drug-taking behaviour. One proposal Robinson and Berridge (1993; 2001) appear to make is that drug-related cues grab attention and elicit approach behaviours and this effect is mediated by the drug 'wanting' system, independent of the

drug 'liking' system. This may mean that attentional and approach biases are independent of cue valence (i.e. the extent to which the cues are perceived to be pleasant). If this interpretation of the theory is accurate the valence of smoking-related cues would be irrelevant to measures of 'incentive salience'. Thus, all smoking-related cues, whether pleasant or unpleasant, would have 'incentive salience' in smokers, but not in non-smokers.

Is there an attentional bias towards smoking-related cues?

Consistent with both of these theories, recent research has indicated that smokers do have an attentional bias towards smoking-related stimuli, compared to non-smokers, utilising a number of different paradigms (the modified Stroop; auditory probe; visual probe; eye-movement: Juliano & Brandon, 1998; Sayette & Hufford, 1994; Gross, Jarvik & Rosenblatt, 1993). Modified Stroop studies have shown that smokers are slower to colour-name smoking-related words than control words (e.g. Waters & Feyeraband, 2000; Zack, Belsito, Scher, Eissenberg & Corrigall, 2001; Mogg & Bradley, 2002). However, it is unclear if the modified Stroop is actually measuring biases in the allocation of attention. There may be colour-naming interference effects (e.g. cognitive effort required to suppress distracting information), which arise at both the input (encoding) stage of processing and later aspects of processing such as response selection (Mogg & Bradley, 2002). Visual probe tasks assess the deployment of visuo-spatial attention and may provide a more direct measure of attentional bias than the modified Stroop tasks (Mogg & Bradley, 1998), as the visual probe task does not rely on interference effects.

In the visual probe task, on each trial, two pictures are presented simultaneously. Immediately after the pictures disappear an arrow appears in the location of one of them and participants are required to press a key as quickly as possible in response to the arrow. The rationale is that participants will respond more quickly to stimuli that appear in an attended, rather than unattended region, of visual display. Therefore, reaction time to the probes provides an index of attentional deployment. Using this task, several studies have demonstrated an attentional bias in smokers for smoking-related cues, relative to controls (e.g. Bradley, Mogg, Wright & Field, 2003; Hogarth, Mogg, Bradley, Duka & Dickinson, 2003; Mogg & Bradley, 2002; Mogg, Bradley, Field & De Houwer, 2003). Investigations consistently show that smokers, in general, have an attentional bias for smoking-related pictures when the pictures were presented for 2000 ms (Bradley et al, 2003; Bradley, Field, Mogg & De Houwer, 2004; Mogg et al., 2003).

The eye-movement paradigm provides another measure of visual orienting and attentional bias. This is a useful paradigm for researchers to investigate the proposal that the attentional system is not unitary and that there may be important distinctions between the mechanisms involved in initial orienting versus maintenance of attention (Allport, 1989). In eye-movement studies, smoking-related and control pictures are presented simultaneously on a computer screen and the direction of initial fixation is measured, which should reflect initial orienting of attention. In addition, maintenance of attention is measured by the overall amount of time that gaze is directed towards the pictures. Smokers have been found to have biases to maintain their gaze on smoking-related cues (Mogg et al., 2003; Field, Mogg & Bradley, in press).

LaBerge (1995) suggests that motivational effects are likely to operate more strongly in maintained attention. As noted earlier, smokers show an attentional bias

when picture pairs were shown for relatively longer durations (e.g. 2000 ms), which may be sensitive to the maintenance of attention (e.g., Bradley et. al, 2003; Bradley, Field, Moss & de Houwer et al., 2004; Mogg et al., 2003). However, at durations of less than 2000 ms smokers did not always demonstrate an attentional bias towards smoking-related cues (e.g. Bradley et al., 2003), which is consistent with LaBerge's (1995) suggestion that initial orienting may be less strongly influenced by motivational factors.

Are smoking-related cues pleasantly attractive?

The majority of investigations have found that smoking-related stimuli are perceived as more pleasant by smokers, relative to non-smokers (e.g. Mogg, Bradley, Field & de Houwer et al., 2003). A number of studies have found that pictures and videos of smoking (McDermut & Hugga, 1998; Bushnell et al., 2000), conditioned smoking cues (Mucha, Pauli & Angrilli, 1998; Lazev, Herzog & Brandon, 1999) and actual smoking cues (Zinser, Fiore, Davidson, Baker 1999) increased desire to smoke without being described as unpleasant. These studies suggest that smoking cues are appetitive, although they did not directly assess the valence of smoking cues. Mucha, Geier and Pauli (1999) directly investigated the valence of smoking cues and concluded that pre-smoking cues, such as the preparation and the start of smoking, were more likely to be seen as pleasant (i.e. positively valenced), increased the desire to smoke and be viewed as relaxing. More recently, there have been a few studies which have also found that smokers rated smoking-related pictures more positively than control pictures (Mogg et al., 2003; Field, Mogg & Bradley et al., in press; Bradley et al., 2004). However, the

pleasantness ratings in the studies discussed thus far were self-reported and therefore subjective.

There are other less subjective methods used by a few studies to assess the attractiveness of drug-related cues. One such method is the Acoustic Startle Reflex (ASR). The ASR measures the reactivity of a facial muscle (orbicularis oculi) to a loud burst of sound, whereby the magnitude of the ASR is reduced for pleasant stimuli and potentiated for unpleasant stimuli. A reduced ASR effect has been demonstrated in smokers in response to smoking cues, which is consistent with their having positive valence (Geier, Mucha & Pauli, 2000; Mucha, et al., 1999; Muller, Mucha & Pauli, 1998). Another paradigm used to assess the attractiveness of drug-related cues is the Stimulus Response Compatibility task (SRC). In this task, participants move a manikin figure either towards or away from a picture. The rationale is that participants will be faster to make approach than avoidance movements to pleasant stimuli; if the stimuli are negative the opposite pattern of results would be seen (De Houwer, Crombez, Baeyens & Hermans, 2001). Behavioural approach tendencies have been found to be compatible with positively valenced stimuli, whereas behavioural avoidance tendencies have been found to be compatible with negatively valenced stimuli (e.g. De Houwer, 2003; Neumann & Strack, 2000). De Houwer (2003) describes the SRC task as a more direct measure of how attractive a subject finds a cue, as it is less confounded by response bias (e.g. a participant may believe that an experimenter wants them to rate the cues more positively). Recently, in the field of addiction, a couple of studies have found that smokers subjectively rated smoking pictures more positively than non-smoking pictures and also showed faster approach tendencies for smoking-related cues on the SRC task (Mogg et al., 2003; Bradley et al., 2004).

Are smoking-related cues unpleasant?

Although the majority of the research discussed thus far supports the appetitive nature of drug-related stimuli in smokers, the studies do not provide conclusive evidence that all drug-related cues are perceived as pleasant. The studies in this area have mainly used pleasant, 'pre-smoking' (i.e. positively valenced) cues (Geier et al., 2000; Mucha et al., 1999). Pre-smoking cues mainly depict scenes, such as the preparation and the start of smoking, which are more likely to be considered 'pleasant' than cues which depict, what may be considered, 'unpleasant' scenes (e.g. a dirty ash tray). Indeed, Mucha et al. (1999) did find that the pictures depicting the end of smoking (i.e. post smoking) produced little craving, were not relaxing and were viewed as unpleasant (i.e. negatively valenced) by smokers. There appear to be no studies which have replicated the findings of Mucha et al. (1999).

It has also been consistently found that non-smokers perceive smoking-related cues as unpleasant (Bradley et al., 2004; Mogg et al., 2003; Mucha et al., 1999); although these cues do not consistently elicit avoidance behaviours in non-smokers on the SRC task (e.g. Mogg et al., 2003). Again, it has to be taken into consideration that, thus far, the studies in this area have mainly used positively valenced smoking cues. If the smoking-related cues used by researchers were very unpleasant, they may elicit avoidance behaviours in both smokers and non-smokers.

Are attractiveness and attentional bias part of the same mechanism?

Previous research suggests that measures of stimulus valence, approach behaviours and attentional bias may be mediated by the same system. For example, Mogg et al. (2003) found that in smokers a longer duration of gaze, positive ratings for smoking pictures, faster approach tendencies for smoking-related cues on the SRC task and greater urge ratings were positively inter-correlated. Field et al. (in press) also found that longer fixations of gaze on smoking-related pictures were accompanied by a bias to rate the pictures more positively. Field et al. (in press) propose that attention, perceived attractiveness and craving are cognitive and motivational effects of smoking cues, which may be mediated by a common underlying mechanism influenced by deprivation, namely, an incentive-sensitisation system (Robinson & Berridge, 1993; 2001). However, again, these studies only used 'pleasant' smoking cues and so the generalisablity of the findings is unclear. There appear to be no studies which have investigated the effects of unpleasant smoking-related stimuli on attentional bias in smokers.

Are perceived attractiveness and attentional bias mediated by separate mechanisms?

The aims of the present study were to examine the perceived attractiveness of different types of smoking-related cues and to investigate whether smokers have attentional biases towards both pleasant and unpleasant smoking cues. Firstly, in line with previous research (e.g. Mucha et al., 1999) the present study predicted that different types of smoking-related cues would be perceived as having different degrees of pleasantness or unpleasantness by smokers, relative to non-smokers. Unlike other attentional studies

(e.g., Mogg et al., 2003), this investigation used two types of smoking-related pictures, which included those that were more likely to be considered unpleasant (e.g. a dirty ashtray), as well as pleasant pictures (e.g. person relaxing and smoking). The subjective valence for each smoking-related and control picture was rated by participants for perceived pleasantness. The SRC task was also employed as a behavioural approach measure of motivational or affective valence. It was predicted that if smokers rated smoking-related cues as more positive, they should be faster to make approach movements than avoidance movements to those pictures. Conversely, if smokers rated smoking-related cues as more unpleasant, the opposite pattern of results should be seen.

The second aim of this investigation was to examine the relationship of attentional bias and stimulus valence. If smokers did have an attentional bias towards unpleasant smoking-related cues, this would be more in line with the interpretation of Robinson and Berridge's (1993; 2001) theory, that there is a dissociation between 'wanting' and 'liking', in which attentional biases are independent of cue valence. Participants' attentional bias to smoking-related cues was assessed through the visual probe task which, as discussed earlier, may provide a more direct measure of attentional bias than the modified Stroop task (Mogg & Bradley, 1998). Previous research has found that smokers have an attentional bias towards smoking cues at stimulus presentations of 2000 ms, thought to be more reflective of maintenance of attention, and 200 ms, thought to be reflective of initial orienting of attention (Bradley et al., 2004). Therefore the present investigation used stimulus durations of 200 ms and 2000 ms. This study also investigated whether the attentional bias results were associated with the behavioural approach (SRC task) and rating (pleasantness ratings) measures of valence of the smoking-related stimuli.

In summary, this study made the following hypotheses: firstly, smokers will have more positive valence ratings for pleasant than unpleasant smoking-related cues, relative to non-smokers; secondly, smokers will have an attentional bias for smoking-related cues, relative to non-smokers, irrespective of the valence of the cues.

METHOD

Design

In the picture rating task: the dependent variable was the picture valence rating; the between-subjects factor was group (smokers versus non-smokers); the within-subject factor was picture type (pleasant smoking-related, unpleasant smoking-related, neutral control pictures). In the SRC task: the dependent variable was the response time; the between-subjects factor was group (smokers versus non-smokers); the main within-subject factor was assignment type (approach smoking cues versus avoid smoking cues); there was also an additional variable for smoking pictures only, which was valence (pleasant versus unpleasant). In the visual probe task: the dependent variable was the attentional bias index (see the Visual Probe Task section in the Results for how this was calculated); the between-subjects variable was group (smokers versus non-smokers); the within-subject variables were picture exposure duration (200 ms versus 2000 ms) and smoking picture valence (pleasant versus unpleasant).

Mixed design analyses of variance (ANOVA) were used to analyse data using the variables described above.

Participants

Participants were recruited from staff and students at the University of Southampton via poster advertisements and an online booking system. There were twenty-two participants in the smokers group, which consisted of 6 males and 16 females, with a mean age of 21.91 years (SD = 0.46). Participants were recruited if they smoked at least one cigarette per day. An additional criterion was that participants smoked filtered cigarettes and not roll-ups, so that attentional bias was not affected by presentation of filtered cigarettes in the pictures.

The control group consisted of twenty-three non-smokers, of whom 8 were male and 15 female, with a mean age of 21.96 years (SD = 3.64), who reported having never smoked regularly. Additional criteria were that all participants spoke fluent English and had visual acuity within normal limits.

Materials

Experimental tasks

All tasks were presented on a 333 Mhz Pentium II PC, with 15'' monitor, attached to a parallel-port, two-button response box and standard keyboard.

Pictorial stimuli

The pictorial stimuli consisted of eight photographs of smoking scenes that were intended to be pleasant (e.g. pictures of people about to smoke) and eight photographs of smoking scenes intended to be unpleasant (e.g. a dirty ashtray). These pictures were newly taken, specifically for this study. The pictures selected were the most pleasant and unpleasant rated by three judges, one non-smoker and two ex-smokers. These photographs were matched as closely as possible with 16 neutral control pictures of scenes, in respect of content (e.g. presence of person, outdoor scene), without any smoking-related cues. Eight pairs of photographs of neutral household stimuli were used for practice material and four pairs for practice and buffer trials.

Questionnaires

Fagerstom Test for Nicotine Dependence (FTND: Heatherton, Kozlowski, Frecker & Fagerstrom, 1991)

This is a 6-item questionnaire used to assess smokers' severity of dependence. Heatherton et al., (1991) found the FTND to have good internal consistency ($\alpha = .61$); the FTND is an updated version of the original Fagerstrom Tolerance Questionnaire (FTQ: Fagerstrom, 1978) and it was found that this modification improved predictive ability on biochemical indices of heaviness of smoking (e.g. carbon monoxide levels: $r^2 = 28.4, 23.9$, for the two questionnaires, respectively).

Attitudes Towards Smoking scale (ATS-18: Etter, Humair, Bergman and Perneger 2000)

This is an 18-item scale used to measure attitudes towards smoking in smokers. There are three subscales which measure: perceptions of adverse effects of smoking (10 items); psychoactive benefits (four items); pleasure of smoking (four items). Etter, Humair, Bergman and Perneger (2000) found that the ATS-18 was valid, as differences in attitude scores between smokers in the pre-contemplation and preparation stages of change were found (*SD* = 0.90, 0.75, 0.89, for the three sub-scales, respectively); they also found high test-retest reliability correlations (*r* = .90, .75, .89) and high internal consistency coefficients (α = .85, .88, .81, for the three subscales, respectively).

Self-Efficacy Questionnaire (SEQ-12: Etter, Bergman, Humair & Perneger, 2000)

This is a 12-item questionnaire used to measure the confidence of smokers to abstain from smoking in high-risk situations. There are two six-item sub-scales which are used to measure ability to refrain from smoking when facing internal stimuli (e.g. feeling depressed) and ability to refrain from smoking when facing external stimuli (e.g. being with other smokers). Etter, Bergman, Humair and Perneger (2000) found that the SEQ-12 was valid, as scores were higher in former smokers than in current smokers (*SD* = 1.62, *SD* = 1.47, $p<.001$, for the two scales, respectively), that it had high internal consistency (α = .95, .94, for the two scales, respectively) and high test-retest reliability (*r* = .95, .93, for two scales, respectively).

Questionnaire of Smoking Urges (QSU–Brief) (Cox, Tiffany & Christen, 2001)

This is a brief 10-item version of the long version of the Questionnaire of Smoking Urges (QSU: Tiffany & Drobes, 1991), which was used to provide a baseline for participants' urge to smoke and to see if this was correlated with the bias scores (i.e. attentional and valence). It has two factors: factor one items reflect a strong desire to smoke, with smoking perceived as rewarding for active smokers; factor two items represent an anticipation of relief from negative affect with an urgent desire to smoke. Cox et al. (2001) report that the QSU-Brief has high reliability as a measure of global craving in initial and follow up sessions (α = .89, .87, for the two factors, respectively).

Smokers Questionnaire (see Appendix A)

This is an unpublished 8-item questionnaire, used to obtain further information about smoking habits and to see what participants generally feel about smokers and cigarettes.

Supplementary questionnaire: Non-smokers' & smokers' versions (see Appendix B)

This is an unpublished questionnaire used to obtain information about participants' gender and age. The smokers' version also obtained additional information about smoking habits and history, which was used to see if they were correlated with the bias scores (i.e. attentional bias and valence).

Profile Of Mood States (POMS) (McNair, Lorr & Droppleman, 1992)

This is a shortened 36-item version, which has state and trait scales of tension-anxiety, depression and vigour. It was used to compare smokers' and non-smokers' baseline level of affect. McNair, Lorr et al. (1992) reported that the POMS had high internal consistency reliability (K-R 20 = .87 to .95) and good validity, correlating highly (r = .80) with the Manifest Anxiety Scale (Taylor, 1953).

Positive And Negative Affect Scale (PANAS) (Watson, Clark & Tellegen, 1988)

This is a 20-item scale also used to compare smokers' and non-smokers' scores on the dimensions of Positive Affect (PA: 10 items) and Negative Affect (NA: 10 items). Watson et al. (1988) reported that this scale had good internal consistency reliability (PA: α = .86 to .90; NA: α = .84 to .87) and good validity, the PA scale was highly correlated (r = .74) with the Hopkins Symptom Checklist (Derogatis, Lipman, Rickels, Uhlenhuth & Covi, 1974).

Stait Trait Anxiety Inventory Y1 (State) & Y2 (Trait) (STAI: Speilberger, Gorsuch, Lushene, Vagg & Jacobs, 1983)

This questionnaire was used to compare smokers' and non-smokers' levels of state and trait anxiety. Speilberger et al. (1983) found that it had good test retest reliability (r = .73

to .86) and good validity, the STAI was highly correlated (r = .75) with the IPAT Anxiety Scale (Cattell & Scheier, 1963).

Procedure

Ethics committee approval was first obtained from the School of Psychology Ethics Committee. To control for time abstinence participants were asked not to smoke for one hour before the experiment. Participants then met with the investigator for one session, which took approximately 60 minutes; testing took place in a small, dimly-lit room. Participants were seated at a desk, approximately one metre away from the monitor. There were three main tasks: attentional bias; pleasantness rating; SRC task. The visual probe task was conducted first, so that participants' attentional bias would not be affected by having already seen the pictures. The SRC and pleasantness tasks were then conducted, counterbalanced in order.

Participants were introduced to the study and any questions regarding the information sheet were answered. All participants were initially asked to complete a consent form (see Appendix C). Next, a sample of expired carbon monoxide (CO) was taken from those participants who smoke, to ensure that they really did smoke. In addition, participants' momentary state of craving was recorded using a visual analogue scale. This was a 10-point scale, ranging from no urge to smoke at all, to a very strong urge to smoke (see Appendix D). The median time elapsed since smoking their last cigarette was 7 hours.

Visual-probe task

In the visual-probe task, participants were presented with pairs of pictures side-by-side on the computer monitor. Before each trial, participants were asked to look at a central fixation cross, which appeared for 500 ms in the middle of the screen, followed immediately by a pair of pictures. Each picture was 100 mm high and 125 mm wide. The distance between the inner edges of the pictures was 60 mm. The distance between left and right probe positions was 185 mm. Length of picture presentation was either 200 ms or 2000 ms and was immediately followed by a probe. The probe was either an up or down arrow, approximately 5 mm high. Participants were instructed to press one of two keys, as quickly as possible, to indicate the direction of the arrow.

The tasks consisted of 8 practice trials and 2 buffer trials, followed by 256 main trials. In the main trials, each picture pair was presented 16 times, resulting from the combination of independent variables of: smoking picture location (left versus right); probe location (left versus right); picture presentation time (200 ms vs 2000 ms); probe type (up versus down arrows) (i.e. 2x2x2x2 = 16). Order of the trials and length of time-presentation were fully randomised. The computer automatically recorded response accuracies and latencies. After completing the tasks, participants' momentary state of craving was again recorded using a visual analogue scale.

The picture rating task

There were two practice trials, in which filler pictures were presented. There were then 32 test trials in which each smoking picture and control picture was presented one at a time, for 2000 ms, in random order. After a pause of 500 ms, a 7-point anchored rating scale for pleasantness (i.e. affective valence) was displayed on the screen. Participants were asked to press one of seven keys, which were correspondingly labelled from -3 to +3, to indicate how pleasant or unpleasant they found each picture. Momentary state of craving was recorded using a visual analogue scale, after completion of the task.

The Stimulus-Response Compatibility (SRC) task

There were two blocks. In each block, there were 144 trials (i.e. 16 practice and 128 'critical' trials). Practice consisted of four trials of each picture type (pleasant, unpleasant and control). On each trial, a picture was individually presented in the centre of the screen. A manikin figure was presented either above or below the picture. Critical trials were each of the 32 pictures four times each, with the manikin presented below each picture twice and above each picture twice. The trials were presented in a new random order for each participant, so that each picture and manikin position varied over trials. In the first assignment, participants were instructed to press up or down arrows to move the manikin toward the smoking picture and away from the non-smoking picture. In the second assignment participants were instructed to move the manikin away from the smoking pictures and toward the non-smoking pictures. The order of these two assignments was counterbalanced across participants. The measure of the SRC task was

recorded as the latency between each picture onset and the response. After completing the task, participants' momentary state of craving was recorded using a visual analogue scale.

After the experimental tasks, participants were asked to complete a questionnaire package. Smokers completed the: QSU-Brief; POMS; PANAS; STAI Y-1 and Y-2; FTND; ATS-18; SEQ-12; Supplementary questionnaire; Smokers Questionnaire; Debriefing Statement (see Appendix E). Non-smokers completed the: POMS; PANAS; STAI Y-1 and Y-2; Supplementary questionnaire; Debriefing Statement. After completing the questionnaires participants were thanked for their time and either received £5 or course credits (psychology students only).

RESULTS

Group characteristics

The smoker and control groups did not differ significantly in age $t(43) = .04, p > .05$, or in gender ratio $\chi^2 (1, N = 45) = .30, p > .05$. Table 1, on the next page, shows descriptive statistics and t-tests comparing the smoker and non-smoker groups in expired CO and measures of affect. The smoker and control groups did differ significantly on their expired CO. Smokers and non-smokers did not differ significantly on the POMS or the STAI Y-1 and Y-2. However, for the PANAS, smokers did have a significantly higher score on the negative affect scale than the non-smoker group.

On average, the participants in the smoker group smoked 9.23 cigarettes per day ($SD = 5.47$, range 3 - 25) and had been smoking for an average of 5.53 years ($SD = 7.88$, range 3 months to 40 years). Smokers' mean FTND was 3.09, $SD = 1.38$ (range 1.00 to 7.00). Their mean QSU-Brief score was 3.30 on a seven-point scale, $SD = 1.45$ (range 1.00 to 6.20). Their mean rating of urge to smoke on the ten-point visual analogue scales were: pre-experiment, $M = 4.32$, $SD = 2.40$; after first task $M = 5.18$, $SD = 2.56$; after second task $M = 5.41$, $SD = 2.84$; after third task $M = 5.41$, $SD = 2.91$. Smokers' mean scores on the ATS-18 five-point scale were: positive, $M = 3.80$, $SD = 0.63$; negative $M = 2.60$, $SD = 1.34$. Smokers' mean scores on the SEQ-12 five-point scale were: internal, $M = 3.83$, $SD = 0.62$; external, $M = 4.30$, $SD = 0.63$.

Table 1

Group characteristics

	Smokers		Non-smokers		*t*	*p*
	M	*SD*	*M*	*SD*		
Expired CO (parts per million)	7.63	8.12	1.57	1.08	3.55	.00*
POMS						
State anxiety	6.30	4.62	3.90	4.50	1.73	.09
State depression	3.18	3.90	1.68	2.34	1.57	.13
State vigour	7.38	4.92	9.48	4.98	1.40	.17
Trait anxiety	6.24	4.62	3.90	3.78	1.80	.08
Trait depression	3.84	4.38	2.52	3.00	1.17	.25
Trait vigour	13.08	4.08	14.88	4.80	1.33	.19
STAI – Y-1						
State	44.27	13.02	38.17	10.00	1.77	.08
STAI – Y-2						
Trait	44.81	10.87	41.91	10.87	0.81	.42
PANAS						
Positive affect	3.20	0.71	3.22	0 .71	0.08	.94
Negative affect	1.90	0.62	1.41	0 .40	3.14	.00*

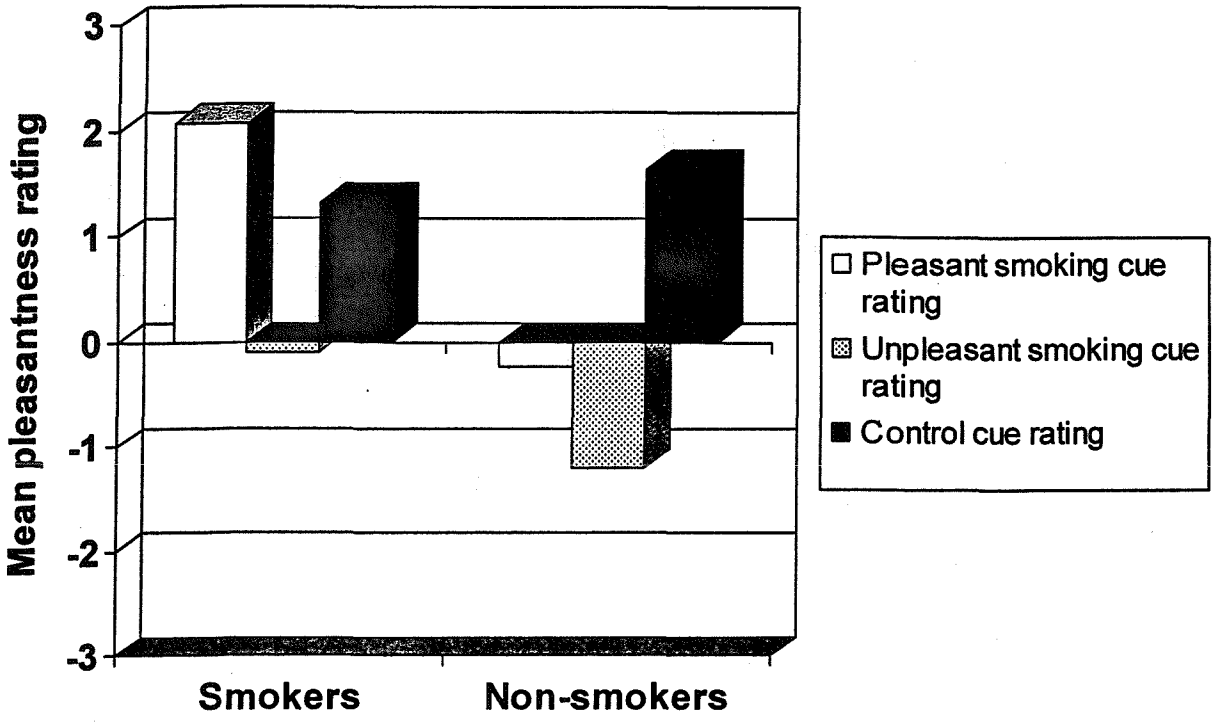
* $p < .01$

Picture valence

To analyse the data from the picture rating task a 2x3 mixed design ANOVA was carried out with group (smokers versus non-smokers) as a between-subjects variable and picture type (pleasant smoking-related, unpleasant smoking-related, and control) as a within-subjects variable. All main effects and interactions were significant, $Fs > 34.12$, $ps < .01$, including the two-way interaction, picture type x group, $F(2, 42) = 34.12$, $p < .01$.

To explore the picture type x group interaction, t-tests were conducted. Paired samples t-tests indicated that the rating scores for pleasant and unpleasant smoking and neutral control pictures, in both the smokers and non-smoker groups, were all significantly different from each other, $t > 14.82$, $ps < .01$. In smokers, pleasant smoking pictures were rated as more pleasant ($M = 2.07$, range 0.50 to 3.38, $SD = 0.86$, $Mdn = 2$) than the unpleasant smoking pictures ($M = -0.09$, range -1.37 to 1.75, $SD = 0.82$, $Mdn = 0$). The control pictures ($M = 1.33$, range 0.05 to 2.94, $SD = 0.33$, $Mdn = 1.38$) were rated as less pleasant than the pleasant smoking pictures and more pleasant than the unpleasant smoking pictures. In non-smokers, both pleasant and unpleasant smoking pictures ($M = -0.23$, range -1.62 to 0.88, $SD = 0.69$, $Mdn = 1.88$; $M = -1.19$, range -2 to 0.13, $SD = 0.53$, $Mdn = -1.12$, respectively) were rated as less pleasant than the control pictures ($M = 1.64$, range 0.94 to 3.13, $SD = 0.55$, $Mdn = 1.63$). Independent t-tests indicated that there was a significant difference between the smokers and non-smokers in their ratings for the pleasant smoking cues, $t(43) = 9.85$, $p < .01$ and the unpleasant smoking cues $t(43) = 5.36$, $p < .01$ and for control pictures $t(43) = 2.30$, $p < .05$. Figure 1, overleaf, illustrates these results.

Figure 1. Mean valence rating for smokers (n = 22) and non-smokers (n = 23), to pleasant and unpleasant smoking and control cues



Stimulus Response Compatibility task

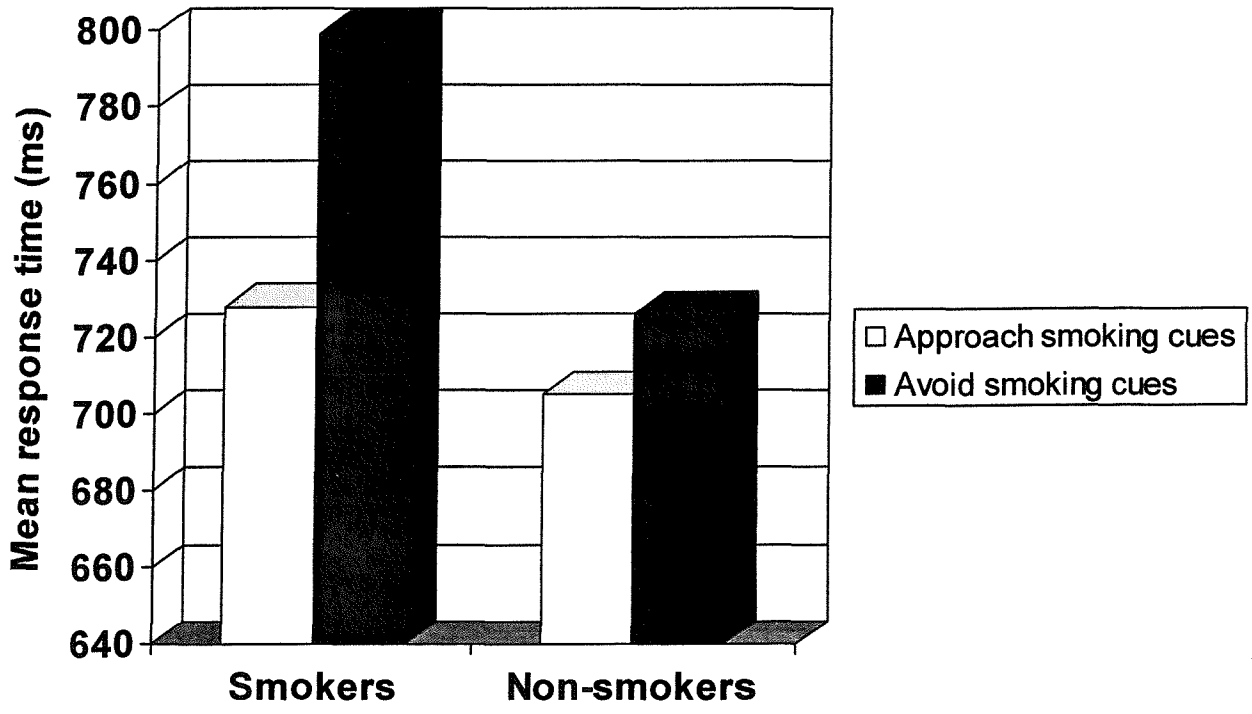
Data from one participant were missing due to technical difficulties. As in the Bradley et al. (2004) study, RT data from trials with errors were discarded (4% of data). A box and whisker plot revealed that one participant (from the smoker group) had an outlying high rate of errors (10.94%), so data from this participant were excluded from the analysis; for the remaining participants, the mean percentage of errors was 3.96%. To eliminate outliers, RTs were excluded if they were less than 200 ms or more than 3000 ms, and if they were more than 2 *SD* above the mean (4% of the data).

To analyse the data from the SRC task a 2x2 mixed design ANOVA was carried out of RTs with: group (smokers versus non-smokers) as a between-subjects variable

and assignment type [(1) approach smoking pictures versus (2) avoid smoking pictures] as a within-subject variable. This showed significant main effects of assignment type, F (1, 41) = 12.55, $p < .01$. There was no significant group x assignment interaction, but there was a trend which approached significance, F (1, 41) = 3.68, $p = .06$.

To explore further the trend for the near-significant group x assignment interaction, paired samples t-tests were conducted. The t-tests indicated that smokers were faster in assignment 1 (approach smoking cues, $M = 728$ ms) than in assignment 2 (avoid smoking cues, $M = 799$ ms), $t(20) = 2.99$, $p < .01$. However, in non-smokers, there was no significant difference between the mean approach and mean avoidance scores ($M = 705$ ms and 726 ms respectively), $t(21) = 1.84$, $p > .08$. The results are illustrated, below, in figure 2.

Figure 2. Mean SRC task response time (ms) for smokers ($n = 21$) and non-smokers ($n = 22$), to smoking cues



A separate 2x2x2 mixed design ANOVA of RTs to smoking pictures examined the effect of picture valence. This had group (smokers versus non-smokers) as a between-subjects variable and assignment type [(1) approach smoking pictures versus (2) avoid smoking pictures]; picture valence [(1) pleasant pictures versus (2) unpleasant pictures)] as within-subject variables. This analysis showed a significant main effect of valence, $F(1, 41) = 13.83, p < .01$ and assignment type $F(1, 41) = 24.51, p < .01$. There were no other significant effects, *ps* > .11.

Visual probe task

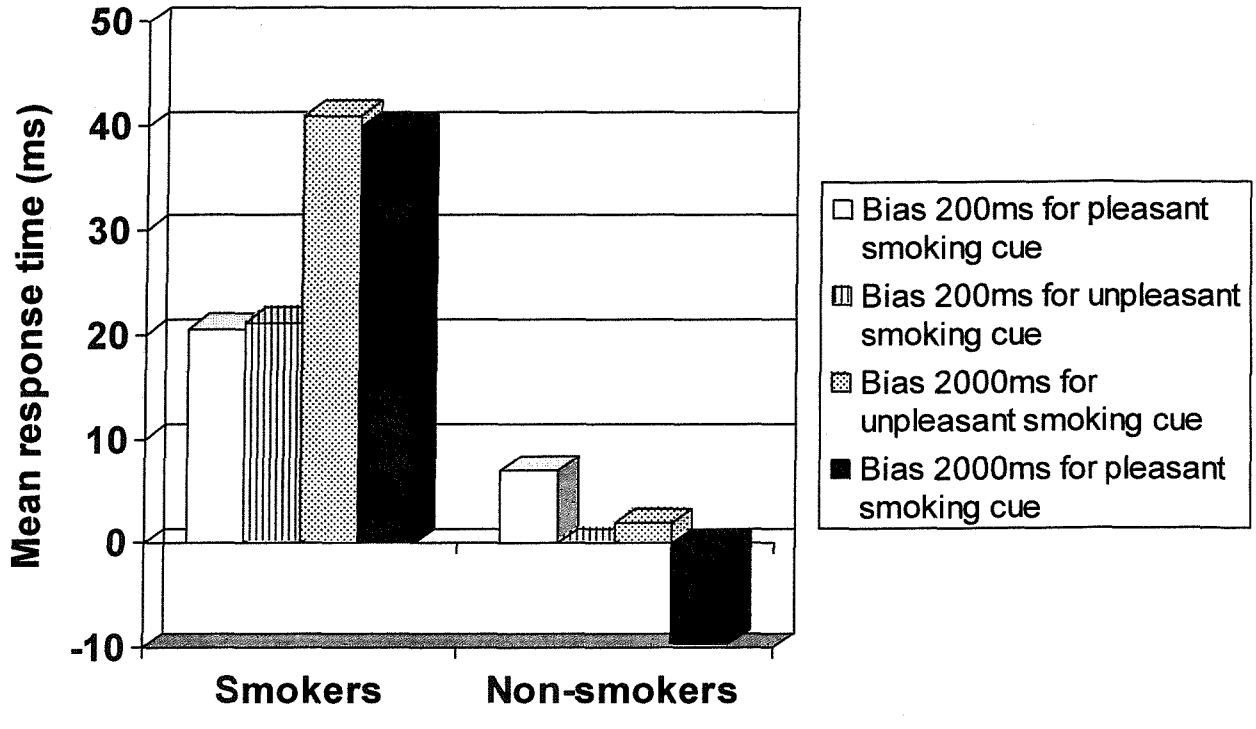
RT data from filler trials and from trials with errors were discarded (3% of the data). After errors were removed, to exclude outliers, RTs were excluded if less than 200 ms, more than 2000 ms and if they were 2 *SD*s above the mean (4% of the data). Box and whisker plots revealed that four participants (one from the smoker group and three from the non-smoking group) had an outlying high rate of errors (errors on 7 % or more of the trials) on the task, so data from these participants were not included in the analysis. For the remaining participants, errors were made on 2.5% of the trials.

To analyse the data from the visual-probe task, attentional bias scores were calculated. The mean RT to probes replacing smoking pictures was subtracted from the mean RT to probes replacing control pictures; therefore, positive values of the bias score reflected faster response times to probes that replaced smoking-related pictures, i.e. vigilance. Bias scores were calculated for each participant at both the 200 ms and 2000 ms exposure times, for pleasant and unpleasant, smoking pictures. These attentional bias scores were analysed using a 2x2x2 ANOVA with stimulus duration (200 ms versus

2000 ms) and cue valence (pleasant versus unpleasant) as within-subject variables and group (smokers versus non-smokers) as a between-subjects variable. There was a significant stimulus duration x group interaction, $F(1, 39) = 6.57, p < .01$. There were no other significant results, $ps > .21$.

To explore the stimulus duration x group interaction attentional bias scores were collapsed across stimulus valence. Paired samples t-tests indicated that there was a significant difference between the bias scores for 200 ms ($M = 20.88$) and 2000 ms ($M = 40.41$) for the smokers, $t(21) = 2.67, p < .05$, but not in non-smokers ($M = 3.54, -3.77$, respectively) $t(20) = .98, p > .30$. Independent t-tests indicated that there was a significant difference between the bias scores for smokers and non-smokers ($M = -3.78$) at 2000 ms only, $t(39) = 2.96, p < .01$, but not at 200 ms ($M = 20.88$) $t(39) = 1.40, p > .10$. Figure 3, below, illustrates these results.

Figure 3. Mean attentional bias scores for smokers ($n = 21$) and non-smokers ($n = 20$), to pleasant and unpleasant smoking cues, at 200ms and 2000ms exposure duration.



Correlations

Pearson correlations were used to examine the relationships between the bias measures (i.e. valence and attention). The bias measures were each calculated individually. Firstly, as discussed earlier, for the visual probe task the bias scores were collapsed across stimulus valence, because the ANOVAs revealed that valence had no influence on these results. Therefore, for smokers and non-smokers, mean bias scores were calculated separately for 200 ms and 2000 ms (SOAs). Secondly, for the SRC task, a mean approach bias score was calculated. The mean RT to avoid smoking pictures was subtracted from the mean RT to approach smoking pictures; subsequently, positive values of the bias score reflected greater approach tendencies for smoking-related pictures. Thirdly for the rating task, mean pleasantness rating bias scores were calculated for both the pleasant and unpleasant pictures. The mean rating scores for the smoking pictures were subtracted from that of control pictures, so that positive scores reflected a more positive evaluation of smoking pictures.

In the smoking group greater approach tendencies for smoking-related pictures on the SRC task were correlated positively with a greater attentional bias for smoking-related pictures at 200ms ($r = .57, p < .01$), but not at 2000ms ($r = .33, p > .05$). The rating for pleasant and unpleasant pictures did not relate to approach or attentional bias ($ps > .22$). All correlations in the non-smoking group were non-significant ($ps > .41$).

DISCUSSION

The results from the visual probe task showed that smokers, but not non-smokers, had an attentional bias for all smoking-related cues at 2000 ms, but not at 200 ms. With respect to the rating measure of valence, smokers rated the unpleasant smoking-related cues as significantly less pleasant than the pleasant smoking-related cues, relative to non-smokers. On the behavioural approach measure of valence, the SRC task, smokers showed a non-significant trend to be faster to approach than to avoid all smoking-related cues, relative to non-smokers. This approach bias in smokers was unaffected by the valence of the smoking cues. Each of these results will be discussed in turn.

Picture rating task

The first aim of this study was to examine the perceived attractiveness of different types of smoking-related cues. On the picture rating task the first hypothesis was supported, as smokers had more positive valence ratings for pleasant than unpleasant smoking-related cues, relative to non-smokers. These findings are in line with previous studies which have shown that smokers rate smoking pictures more positively than non-smoking pictures, relative to non-smokers (e.g. Mogg et al., 2003; Field et al., in press; Bradley et al., 2004). The results of this task indicate that the manipulation of the valence of the smoking cues was successful (i.e. smokers rated the pleasant cues more positively than the unpleasant cues). However, although, overall the unpleasant smoking-related cues were perceived as unpleasant, the mean score (M = -0.09) was actually very close to 0

and, although, some of the scores were in the unpleasant range (-1.37 to 1.75), some of the unpleasant pictures were in the pleasant range (i.e. above 0). Therefore it could be said that the unpleasant smoking cues were perceived as neutral by the smokers. There may be several reasons for this. Firstly, two of the original judges who scored the pleasantness of the cues were ex-smokers, but none were smokers. It may be that the cues were not unpleasant enough for smokers. Secondly, pleasantness was assessed using a bipolar, unitary rating task. Traditionally, it was thought that an affective scale would be bipolar (e.g. Guilford, 1954); however, early factor analytic work rarely confirmed this and ratings of positive and negative affect seemed largely independent (McNair & Lorr, 1964). Nonetheless, Russell (1979) then argued that bipolarity was suppressed in most studies of affect because of a series of measurement issues that created systematic error. Currently the literature is still divided, as to whether or not pleasant and unpleasant affect are independent dimensions (e.g. Watson, Clark & Tellegen, 1988) or opposite poles of a single dimension (e.g. Green, Goldman & Salovey, 1993). In the current study, if a binary task was used, in which each cue was assessed separately for pleasantness (0-3) and unpleasantness (-3 to 0), a different result may have been seen. This is because the cues could be perceived as both pleasant and unpleasant at the same time, accounting for why many of the cues were perceived, overall, as neutral.

SRC task

On the behavioural approach measure of valence (the SRC task), it was found that in general all participants were faster to approach than to avoid smoking-related pictures.

However, there was a trend that smokers were faster, than the non-smokers, to approach rather than to avoid all smoking-related cues; although this trend was still irrespective of valence.

Overall, previous research has found that smokers show significantly faster approach tendencies for 'pleasant' smoking-related cues on the SRC task, relative to non-smokers (Mogg et al., 2003; Bradley et al., 2004). Although, Mogg et al. (2003) also found that non-smokers were faster to approach smoking-related cues, but this was not to the same extent as smokers. The difference in the findings of this study from previous research may be due to a number of reasons; for example, previous studies used a different picture set, which may have been perceived as more pleasant than the pictures used in the present study and so subsequently participants were more likely to demonstrate behavioural approach tendencies to those cues. In addition, smokers in the present study may have been less nicotine dependent. In the current study the mean number of cigarettes smoked per day (i.e. 9.23) was fewer than that of previous studies (e.g. 16.2: Mogg et al., 2003). Therefore, participants may have been more dependent in preceding studies, felt more deprived and had higher cravings, which may subsequently have led them to demonstrate greater behavioural approach tendencies towards the smoking-related stimuli than the participants in the present study. Indeed, incentive sensitisation theories (Robinson & Berridge, 1993; 2001) suggest that higher levels of craving are related to greater approach tendencies towards drug-related cues.

A reason why the trend that smokers were faster, than the non-smokers, to approach rather than to avoid all smoking-related cues, was irrespective of valence, may have been due to the cues being mainly perceived as pleasant or neutral; as discussed earlier, unpleasant cues were perceived as relatively neutral (some pleasant). If the

unpleasant smoking cues were perceived, as more unpleasant, valence may have been related to approach bias. However, the findings of this study generally seem to be in line with the interpretation of Robinson and Berridge's (1993; 2001) theory that smoking-related cues elicit approach behaviours regardless of drug 'liking', as there was no evidence that the pleasantness of the smoking cues influenced approach behaviours. It may be that drug-related stimuli can be perceived as neutral or unpleasant, but as they were conditioned with pleasant emotions (i.e. dopamine release) they can still elicit approach behaviours. The original evidence that behavioural approach/avoidance tendencies are a reflection of subjective valence came from normal motivational states; for example Neumann and Strack (2000) examined the responses of university students to positive and negative word stimuli. The relationship of approach biases and valence may be different in addiction and become dissociated, as Robinson and Berridge (1993; 2001) suggest. The present study's findings that non-smokers were faster to approach smoking cues, irrespective of the subjective pleasantness of the smoking cues, would also appear to suggest that the SRC task is specifically measuring behavioural approach and not emotional valence. It may be that the SRC task always shows facilitated approach behaviours to drug cues, in all participants with addiction; however, again, this interpretation of the results needs to be taken with caution, as many of the unpleasant smoking-related cues were perceived as neutral (some as pleasant).

Visual probe task

The second aim of this study was to investigate whether smokers have an attentional bias towards unpleasant and pleasant smoking-related cues. The results from the visual

probe task showed that smokers, but not non-smokers, had an attentional bias for all smoking-related cues at 2000 ms; this finding supports the second hypothesis, which suggested that smokers would have an attentional bias for smoking-related cues, relative to non-smokers, irrespective of the valence of the cues. This result is also in line with the findings of previous studies, which have shown that smokers have a greater attentional bias for 'pleasant' smoking-related cues at 2000 ms (Bradley et al., 2003; Mogg et al., 2003). However, the present findings are different from that of previous investigations, in that the attentional bias was demonstrated towards all smoking-related stimuli, irrespective of the extent to which they were rated unpleasant/neutral or pleasant. These findings seem to be supportive of Robinson and Berridge's (1993; 2001) proposal that the valence of smoking-related cues is irrelevant to measures of incentive salience; however, this interpretation of the results needs to be taken with caution, as most of the unpleasant smoking-related cues were seen as neutral by the smokers, with some of the cues being perceived as positive, the unpleasant smoking-related cues may not have been unpleasant enough and therefore incentive salience may not be independent of valence.

The results from the visual probe task did not show that smokers had an attentional bias for smoking-related cues at 200 ms, only 2000 ms; this finding is unlike the previous investigation by Bradley et al. (2004), which did find an attentional bias for smoking-related cues at 200 ms in smokers. The difference in the findings of this study compared with Bradley et al. (2004), may again be due to similar reasons as to why they also found that smokers were more likely to demonstrate a greater approach bias to smoking-related cues. Firstly, as this study used a different picture set from Bradley et al. (2004), there may have been something in particular about their pictures which were

more likely to attract the attention of these smokers at 200 ms. Secondly, as mentioned before, because many of the unpleasant smoking-related cues were perceived as neutral, they may not have attracted the participants' attention to the same extent. Lastly, as before, the smokers in the current study may have been less nicotine dependent (they smoked fewer cigarettes per day, 9.2 versus 14.5; and for a fewer number of years, 5.5 versus 8.2), which resulted in them having less of an attentional bias towards smoking-related cues.

Limitations of study and possible future directions

This study did not find that attentional bias and behavioural approach tendencies were influenced by the pleasantness of the smoking cues. In addition, correlations revealed that, although, in the smoking group a greater attentional bias for smoking-related pictures at 200 ms was correlated positively with greater approach tendencies for the smoking-related pictures on the SRC task, pleasantness ratings were not related to either approach or attentional biases. Previous investigations have found that pleasantness ratings, approach and attentional biases (i.e. longer duration of gaze) are all intercorrelated (e.g. Mogg et al., 2003). There may be several reasons for the current studies findings.

Firstly, as discussed before, it may be that as some of the unpleasant smoking-related pictures were perceived as neutral, therefore, they did not attract attention or elicit approach behaviours. A suggestion for further research would be to conduct the study again, using a binary rather than a unitary measure of pleasantness (as discussed

earlier) and with pictures which may be even more likely to be perceived as unpleasant by smokers, to see what the results would be.

Secondly, previous studies (e.g. Field et al., in press) have used eye-movements and 'dwell time' (i.e. duration of gaze) as the attentional bias measure, rather than the manual reaction times used here. As discussed earlier, different attentional bias measures may tap into different underlying attentional processes. Indeed, previously researchers have found that visual probe RT measures were less sensitive to changes in nicotine deprivation and craving than a longer duration of gaze, which was associated with higher levels of deprivation and craving (Field et al. in press; Mogg et al., 2003). It may be that visual probe RT measures are also less sensitive to the effects of perceived attractiveness. As Mogg et al. (2003) point out, the visual probe task only reflects a small snap-shot of attentional processes (i.e. at the time of offset of the pictures), whereas eye-movement monitoring provides a more ecologically valid index of visual orienting. Therefore, a suggestion for future research may be to conduct the present investigation again, but using the eye-movement paradigm.

Thirdly, another possible reason why this study did not find that attentional bias and behavioural approach tendencies were influenced by the pleasantness of the smoking cues, may have been because the smokers were not as nicotine dependent and did not have as high an urge to smoke. Smokers were young (mean age 21.9 years) and not heavily dependent (9.2 cigarettes per day and had been smoking for an average of only 5.5 years); in addition, the study did not manipulate deprivation levels. A suggestion for further research may be to repeat the study with more heavily dependent individuals and to manipulate deprivation levels. Indeed, Field et al. (in press) did find that levels of

deprivation were related to subjective craving and perceived pleasantness of cues in participants who were more nicotine dependent than the participants in the present study.

Lastly, a reason why this study found that subjective pleasantness of cues did not significantly influence attentional bias and greater approach tendencies may be because, as discussed earlier, they are mediated by separate mechanisms and this is more supportive of the interpretation of Robinson and Berridge's (1993; 2001) theory, that there is a dissociation between 'wanting' and 'liking', in which attentional and approach biases are independent of cue valence. Clearly, further research is needed, using a variety of ecologically valid smoking-related stimuli, manipulating levels of deprivation and the urge to smoke, to establish what mechanisms are involved and whether or not subjective attractiveness is related to attentional bias and behavioural approach tendencies.

Clinical implications

The results of this study are potentially relevant to the further development of addiction theory and subsequent clinical practice. One such treatment approach is cue exposure, which typically involves repeated, unreinforced exposure to stimuli associated with drug use in an attempt to extinguish an addict's conditioned response to such cues (e.g. craving). Cue exposure has become a method of key importance in the treatment of phobic and obsessive disorders, but its effectiveness has not been conclusively demonstrated in the addictions field (Conklin & Tiffany, 2002). Its poor success may be partly due to the lack of clarity surrounding the mechanisms through which drug cues affect behaviour. Therefore, the results of this study could be of benefit in clarifying this

issue. It may be that, thus far, only what could be described as 'pleasant' cues have been used in treatment. Studies are not always clear about the valence of the cues used. For example Niaura et al. (1999) mention that participants were exposed to their favourite brand of cigarette (clearly a pleasant cue), but also to any cues which they could imagine would increase their desire to smoke; these cues could potentially have been unpleasant or pleasant. If addicts are not exposed to unpleasant drug-related cues, they would not desensitise to this type of stimuli and could therefore still be at risk of relapse. However, further investigations are needed to establish the motivational and affective valence of drug-related stimuli and associated drug cue responses before treatment approaches can be developed.

Summary

In summary, this study found that smoking-related cues hold attention, even when smokers found them neutral/unpleasant. The results of this study appear to be supportive of the interpretation of Robinson and Berridge's (1993; 2001) theory, that there is a dissociation between 'wanting' and 'liking', in which attentional and approach biases are independent of cue valence. The results of this study may be relevant to the further development of addiction theory and subsequent clinical practice.

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Appendix A

Smokers Questionnaire

Smokers questionnaire

Do you enjoy cigarette smoking?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

How much would you like to quit smoking?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

How likely is it that you will try to quit smoking within the next year?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

If you tried to quit smoking, how likely is it that you would be successful?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

This questionnaire is concerned with how you generally feel about smokers and cigarettes.

How irritating do you find cigarette smoke in public places (e.g. pubs, restaurants)?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

If you walk into a room how likely is it that you would notice someone smoking?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

How likely is it that you would avoid sitting next to someone who is smoking?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

In general how bothered or upset do you feel by other people smoking?

Not at all		Slightly		Moderately		Very		Extremely
0	1	2	3	4	5	6	7	8

Appendix B

Supplementary questionnaire: Non-smokers & smokers versions

Non smoker supplementary questionnaire

Participant number _____

1. Sex M/F

2. Age _____ years

3. How many cigarettes have you smoked in your life time _____

4. When did you have your last cigarette _____ ,

Subject Number_____

Supplementary Questionnaire

1. Sex: M / F

2. Age: _____years

3. How many cigarettes do you smoke per day, on average? _____

4. For how long have you been smoking regularly? _____

5. Have you ever attempted to give up smoking? Y / N
   -If so, on how many occasions? _____
   -For how long were you successful at abstaining? _____

6. How long ago did you have your last cigarette? ____hrs ____mins

7. How many cigarettes have you had in the last 6 hours? _____

8. Do you try to limit your daily cigarette intake?
   - Please circle a number along the following scale:

1_____2_____3_____4_____5

Not at all Moderately I severely limit my intake

Appendix C

Consent form

Cognitive performance in smokers
Consent form for participants

Information sheet

I am , a clinical psychology trainee. I am requesting your participation in a study regarding the relationship between cigarette smoking and various measures of mood and attention. You will need to attend the laboratory for a single, one hour session. During the session you will complete some questionnaires and some computer tasks. You will be asked to react to stimuli appearing on the screen and press various buttons on the computer keyboard. Personal information will not be released to or viewed by anyone other than researchers involved in this project. Results of this study will not include your name or any other identifying characteristics.

Your participation is voluntary and you may withdraw your participation at any time. [For students: If you choose not to participate there will be no consequences to your grade or to your treatment as a student in the psychology department.] If you have any questions please ask them now, or contact me, , by email

Signature Date

Name

Statement of consent

I_____have read the above informed consent form.

I understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. I understand that data collected as part of this research project will be treated confidentially, and that published results of this research project will maintain my confidentiality. In signing this consent letter, I am not waiving my legal claims, rights, or remedies. A copy of this consent letter will be offered to me.

(Circle Yes or No)
I give consent to the above study: Yes No

I understand that if I have any questions about my rights as a participant in this research, or if I feel that I have been placed at risk, I can contact the Chair of the Ethics Committee, Department of Psychology, University of Southampton, Southampton, SO17 1BJ.
Phone (023) 80593995

Signature Date

Name [Participants name]

Appendix D

Visual analogue scale

Please circle a number to indicate how strong your urge to smoke is right now:

0	1	2	3	4	5	6	7	8	9	10

No urge at all to smoke — slight — moderate — strong — very strong urge to smoke

Appendix E

Debriefing Statement

Cognitive performance in smokers
Debriefing statement *(written or verbal)*

Currently, addiction theory presumes that all smoking cues are perceived as pleasantly attractive by smokers and therefore grab their attention. The aim of this research is to show that not all smoking cues may be perceived as pleasant and yet could still grab the attention of smokers. Once again results of this study will not include your name or any other identifying characteristics. The experiment/research did not use deception. You may have a copy of this summary if you wish and a summary of the research findings once the project is completed.

If you have any further questions please contact me, , by email

Thank you for your participation in this research.

Signature_____ _____ Date _____

Name_____ _____

If you have any questions about your rights as a participant in this research, or if you feel that you have been placed at risk, you may contact the Chair of the Ethics Committee, Department of Psychology, University of Southampton, Southampton, SO17 1BJ.
Phone (023) 80593995