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An Investigation into the Relationship Between Wanting and Liking for Alcohol

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ABSTRACT

FACULTY OF MEDICINE, HEALTH AND LIFE SCIENCES

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AN INVESTIGATION INTO THE RELATIONSHIP BETWEEN WANTING AND LIKING FOR ALCOHOL

By Malcolm Hobbs

The Incentive-Sensitisation Theory (IST) posits that reward is composed of distinct systems of 'wanting' and 'liking' that are mediated by separate neurobiological systems. The IST therefore claims that under certain conditions wanting and liking can become dissociated. One of these conditions is repeated drug use. The IST claims that drug use results in a progressive and selective sensitisation of wanting but not liking. The current research sought to explore this dissociation between wanting and liking in humans using alcohol. Seven experiments tested the proposed dissociation using three methods of investigation. Method one (Experiments one and two) compared liking (facial electromyography (EMG), subjective ratings) for alcohol in groups of drinkers (heavy/light) that differed in wanting for alcohol. Method two (Experiments three to five) used a priming dose of alcohol to increase wanting (consumption, choice) independently of liking (facial EMG, subjective ratings) for alcohol. Method three (Experiments six and seven) decreased liking (ratings) independently of wanting (consumption) for alcohol by adulterating drinks with Tween. The results indicated a dissociation between wanting and liking for alcohol using all three methods. Liking could not explain the differences in wanting between light and heavy drinkers. Priming with alcohol resulted in increases in wanting but not liking for alcohol. Finally, adulterating an alcoholic beverage was found to decrease liking but not wanting for that alcoholic beverage. The results therefore provided support for the IST.

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CHAPTER ONE: THE INCENTIVE-SENSITISATION THEORY OF DRUG USE

1.1 Introduction

'Wine maketh glad the heart of man' (Psalms 104:15) the bible says and alcohol has been long portrayed, not as a 'hard' drug, but as a social lubricant that calms people down and enriches social gatherings. However, despite some reputed health benefits of drinking in moderation, alcohol is still a drug that can have considerable negative consequences. It 'can floor a full-grown man in half an hour; kills and maims thousands on the roads every year; induces addiction, violence, suicide and disease.....and yet is freely available and freely advertised' (Tyler 1995). Alcohol, along with tobacco, is responsible for more deaths than any other drug, legal, or otherwise. Glautier and Drummond (1994) cited alcohol consumption data for the UK with 77% of men and 60% of women consuming alcohol in the past week. Out of these 23% of males and 8% of females had consumed above the weekly-recommended volume (21 units for men, 14 for women). This is often taken as an indication of heavy drinking. Sarafino (1994) provided a review of the health risks of heavy alcohol consumption. Long-term problems include liver cirrhosis and links to some forms of cancer, high blood pressure, heart disease and brain damage. People are also more likely to have fatal accidents when under the influence of alcohol. For example, Tyler (1995) noted that there are approximately 20 000 drunk driving automobile accidents in the US per year and that there were 660 alcohol related road deaths in the UK in 1991. Heavy alcohol consumption will eventually lead to some degree of dependency, characterised by tolerance, craving, and withdrawal symptoms. The withdrawal symptoms of alcohol can be as serious as any other drug (see Tyler 1995 for an overview). The first symptoms are typically shaking, sweating, jumpiness, agitation, and impaired motor skills. Mild paranoia and hallucinations (usually distorted shapes, snatches of music or shouted remarks) can also accompany the shakes. At its most extreme withdrawal can result in the condition delirium tremens

It is this widespread use and the serious health consequences that make alcohol an especially important drug to study. On the one hand it is a drug that is taken for pleasure and for enhancing social situations but on the other, with continued use, can lead to the serious negative consequences outlined above without that person

refraining from continued alcohol consumption. Despite a wealth of research, a model that successfully explains the motivation behind alcohol use, abuse, and drug dependence has been hard to formulate. There are a large number of theories that seek to explain why people take drugs despite all the negative consequences but the current research will focus on the Incentive-Sensitisation Theory (IST) of addiction. The IST will first be compared with traditional theories of incentive-motivation and positive reinforcement theories of addiction. Berridge (2000a) has already made a comparison of the IST with several older theories, including those of Bindra and Toates that are described below.

1.2 Theoretical Precursors of Incentive-Sensitisation Theory: Drug Use Motivated by Pleasure

1.2.1 Bindra: Incentive Motivation

An incentive stimulus refers to objects, events, and situations that are reinforcing for an organism. These include such things as food, water, taste, a sexual partner, and drugs. Bindra (1974) classed incentive stimuli as either 'hedonically potent' or 'hedonically neutral'. Hedonically potent stimuli can be either positive or negative and are associated with appetitive and aversive reactions, respectively. According to Bindra, these external incentive stimuli interact with internal 'drive' or 'organismic' (physiological) states to determine motivation. Incentive stimuli (e.g. smell/sight of food, drugs) and physiological states (e.g. energy level, withdrawal) interact with each other to produce a 'central motivational state' (CMS). Bindra (1974) defined this central motivational state as a 'hypothetical set of neural processes that promotes goal-directed actions in relation to particular classes of incentive stimuli'. Bindra (1968) considered these motivational states to be associated with the level of excitation of particular neural circuits. A high level of excitation was suggested to be equivalent to a high level of motivation and a low level of motivation corresponds to a low level of excitation. Physiological states modulate the effectiveness of an incentive input by exciting a motivational circuit. Thus, stimuli arising from an appetitive incentive object (e.g. smell of food) will produce an appetitive motivational state when physiological state is appropriate (e.g. low energy levels/hunger). An appetitive CMS will result in an increased tendency to approach

the incentive object and interact with that object in an appropriate manner (e.g. eat the food). Likewise, stimuli from an aversive object will (when physiological state is appropriate) result in an aversive CMS. This will act to make the organism avoid or reject the aversive incentive stimulus. Figure 1.1 shows Bindra's model. In Figure 1.1 feeding is used as an example. The CMS for eating is generated by the combined influence of physiological state (e.g. hunger resulting from an empty stomach, low sugar blood levels) and a central representation of the food (e.g. the sight, smell and taste of food) derived from sensory perception of the food. A low internal energy state might therefore increase the hedonic value of the food stimulus leading the animal to respond to the food stimulus. Indeed, some studies (Steiner 1974; Cabanac 1971; 1979) have shown that hedonic report for food can change according to salt and energy levels in the body. In essence, alteration of the CMS should alter the hedonic value of rewards.

Bindra considered the response an animal makes to incentive stimuli to consist of three classes of response: regulatory (e.g. salivation), consummatory acts (e.g. consumption/rejection) and instrumental (e.g. locomotion) actions. Bindra held that the CMS influences these different classes of response and allows an organism to select the appropriate response and direct itself to the incentive stimuli. Bindra also held that the CMS has a general excitatory or 'priming' effect on those sensory motor co-ordinations that are involved in appetitive behaviour and other specific influences.

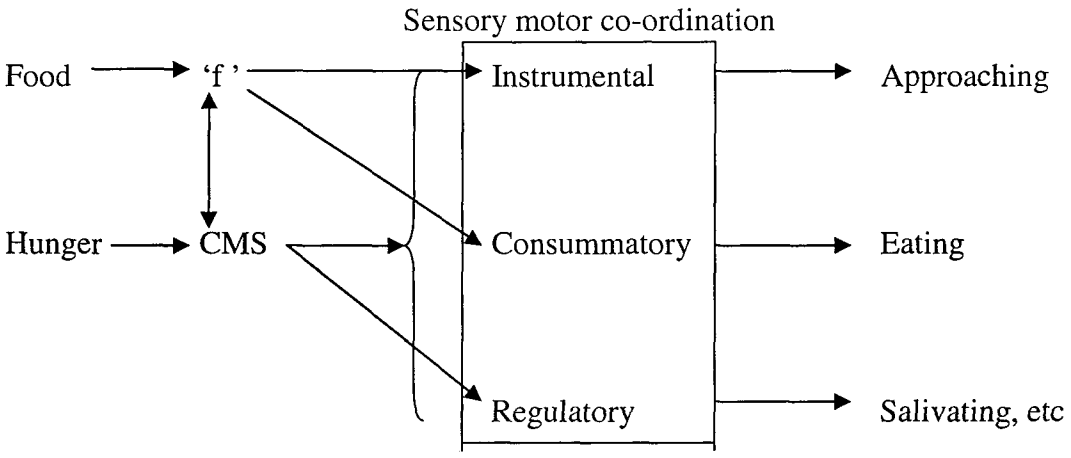


Figure 1.1 Bindra's model of incentive motivation. In this case the example is motivation for food. Note. 'f ' = central representation of food. CMS = central motivational state. Model and example taken from Bindra (1974).

One specific influence is to activate the regulatory sensory motor co-ordinations, producing responses such as salivation. Secondly, via a reciprocal association with the central representation of food (f), the CMS excites 'f ' further. This results in the activation of the sensory motor co-ordinations of instrumental and transactional acts. In this manner a stimulus can become steadily more salient so that the animal is more likely to respond to that stimuli and not other (neutral) stimuli.

Bindra (1974) also linked this model to learning theory. In Bindra's model, the role of a conditioned stimulus is to evoke a CMS appropriate to the stimuli. Thus, animals learn to pursue hedonically positive stimuli associated with primary rewards. Take, for example, a pigeon trained to associate a light with the presentation of food. In this conditioning procedure a light predicts the delivery of food for the pigeon. At the beginning of the procedure the light has no incentive value and will not influence the motivational performance of the pigeon but the presentation of the food will arouse a central motivational state for feeding. During conditioning a link is formed between the central representation of the light and the central representation of the food ('f'). After conditioning the light can therefore excite 'f' which in turn arouses the CMS for feeding. Thus, with experience previously neutral stimuli can take on some of the specific motivational properties of the food itself and become conditioned incentives. Therefore the conditioned stimulus can attract the animal, elicit goal directed behaviour and even consumption. In this manner a conditioned stimulus can become an incentive in itself for an animal.

Bindra's framework is a large and complex theory that explains how an organism is directed towards incentives. However, the central proposition of Bindra's model relevant for the present purpose is that internal states and external incentive stimuli determine the central motivational state of an organism. If the physiological state is appropriate then the incentive stimuli will result in a positive CMS and increase physiological responses, goal-directed behaviour, and interaction with the incentive stimuli.

In relation to drug use, Bindra's model would suggest that drug related incentive stimuli (e.g. beer can, syringe, etc) have the power to excite neural circuits resulting in a positive (drug) central motivational state. Therefore this should motivate people to seek out and use drugs. Similarly, it might be conceived that motivation for drug use might arise from an interaction between an internal drug-related state of withdrawal and external drug related incentive stimuli. Essentially these should result

in the addict attempting to reduce the negative drug CMS associated with withdrawal. Thus, Bindra's model sees drug-use as motivated by pleasure and the achievement of positive motivational states provided by the drug.

Toates (1986) levelled a number of criticisms at Bindra's model. Toates cited studies by Gallistel (1978) and Wong (1978). In these studies salt-injected rats found salt aversive and rejected it when salt was encountered for the first time. However, they still learned the location of the salt despite being in a state inappropriate for salt ingestion. If animals only pursue stimuli that give pleasure as Bindra suggested that should not have happened, as the rats would not have learned that the salt resulted in a positive CMS. Toates (1986) suggested that the model could be modified so that at the time the incentive is first encountered it need not be hedonically positive for information about the incentive to be assimilated. Toates also criticised the division of stimuli into potent and neutral as being useful only up until a certain point. He pointed out that any novel stimuli are likely to arouse exploration even if it lacks any obvious hedonic value. Epstein (1982 as cited in Toates 1986) commented that it is not always certain what the external incentive is in a given situation, suggesting that the model needed to be expanded to cover a broader range of situations.

1.2.2 Toates: Conditioned Incentive Motivation

Drawing heavily on Bindra's work, Toates (1986) formulated a modified model of incentive motivation. Toates adopted the framework of Bindra, with some qualifications and expansion of the surrounding theory. Toates' (1986) model is shown in Figure 1.2. Like Bindra (1974), Toates (1994) proposed that the hedonic value of incentive stimuli is not fixed and that motivation is determined by an interaction between internal physiological states and external incentive stimuli (unconditioned/conditioned stimuli). Incentive stimuli form both the target of behaviour and can arouse motivation. Again, incentives were held to be stimuli that give pleasure such as food, water, sex, social rewards and conditioned incentives such as a location associated with food. Toates also counted drugs as incentives but argued that all drug incentives are conditional, as behaviour is never directed at the chemical itself. However, he noted that there are numerous similarities between drug motivated behaviour and behaviour motivated by incentives such as food and water.

Toates (1986) argued that 'in the presence of incentives motivational states are aroused'. Internal states serve to either increase (e.g. low energy levels) or decrease (e.g. conditioned taste aversion) the power of incoming signals. For example, if energy state is low then the motivational state aroused by a food incentive might be relatively high. This effect has been found in several studies. Cabanac (1979; 1992) found that human subjects gave higher subjective ratings of liking for a sugar solution when they were hungry compared to when they were satiated. Schulkin (1991 as cited in Berridge 2000b) found the same effect with depleted salt levels.

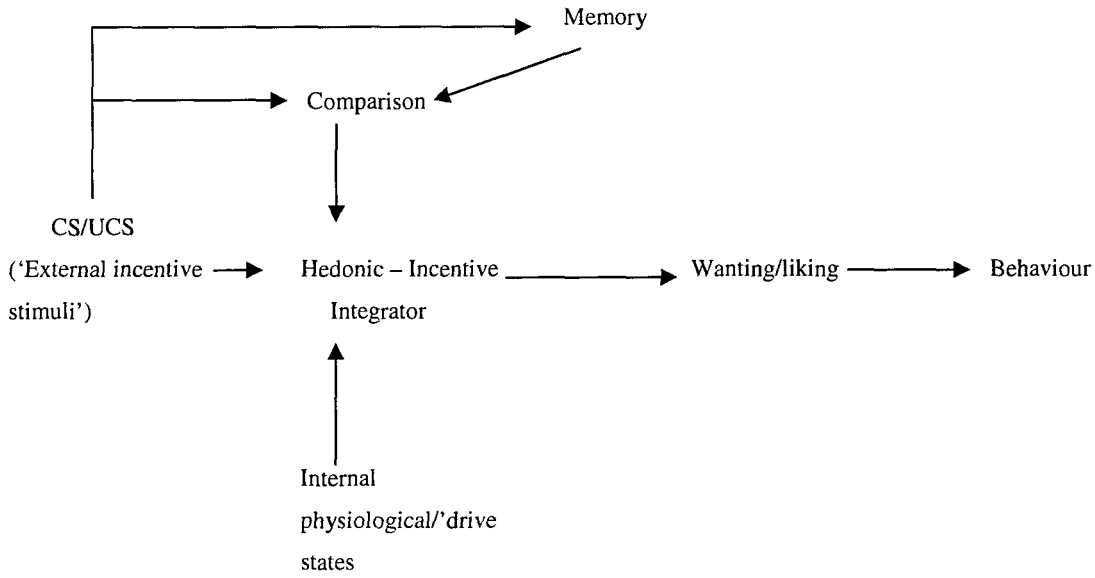


Figure 1.2 Toates' model of incentive motivation. Motivation is determined by an interaction between external incentive stimuli (conditioned or unconditioned) and physiological state. In addition, memory processes and past experience of a stimulus will influence its incentive value. Integration of this information determines the degree to which the incentive stimulus is wanted and liked. The organism then engages in an appropriate behaviour in the same manner described by Bindra Constructed from Toates (1986) and Berridge (2000a).

Even if energy state is not low then a food incentive may arouse a motivational state, if it is highly palatable. Therefore, the interaction between incentive stimuli and internal drives can also work in reverse. Incentive stimuli can increase internal 'drive', just as 'drive' can make an incentive more attractive. For example, Cornell, Rodin and Weingarten (1989) investigated the consumption of pizza or ice cream (desirable foods for the participants involved) in satiated participants. Participants received either a 'priming' portion of pizza or ice cream or no priming food. Participants were then allowed to eat as much as they liked of either

food. Primed participants consumed more of the food that they had been primed with compared to the non-primed participants.

Drug-related experiments have also shown this effect. De Wit *et al* (de Wit et al 1987; de Wit and Chutuape 1993; de Wit 2000) have observed the effects of priming in drug-related experiments. For example, de Wit and Chutuape (1993) gave normal social drinkers a priming dose of alcohol (0.25 or 0.5g/kg) or placebo. They reported that the drinkers primed with alcohol chose more alcohol in a subsequent series of choice tests (three choice tests), compared to social drinkers given a placebo-priming dose. Similarly, Meyer (2000) reviewed evidence that low doses of alcohol can prime alcohol craving and consumption, in a similar manner to the de Wit studies. Toates actually went one step further and claimed that 'drive cues' and incentive stimuli are both necessary to form a motivational state. If one or the other is totally missing then the other will have little effect on motivation and behaviour.

Toates' also held that learning plays a role in the incentive-drive interaction in the same manner specified by Bindra. Conditioned stimuli for incentives acquire some of the incentive properties of the primary incentive themselves, via pavlovian associations. For example, Weingarten and Martin (1989) found that the presentation of an auditory conditioned stimulus paired with food was enough to motivate satiated rats to begin eating again. Stewart, de Wit and Eikelboom (1984) have also shown that cues paired with opiate drugs can acquire some of the motivational properties of the drug itself.

Toates argued that the ability of an incentive stimulus to control behaviour is dependent on its consequences. He also held that if the incentive has been encountered before then sensory stimuli revive a memory. If the memory is of positive consequences, then it will increase the likelihood of interaction with the incentive stimulus in the future. However, if the memory is of aversive consequences, then it will decrease the likelihood of further interaction. In this manner Toates saw the power of incentives as directing behaviour via feedback systems. For example, as a palatable food stimulus can increase motivation to engage in eating then this demonstrates positive feedback. However, after consumption motivation will be reduced by 'the delayed effects of feedback' (i.e. satiety).

Toates' model is a general theory of motivation and has been applied to hunger, thirst, sex, fear, aggression and other behaviours. The theory has also been applied to drug use. Stewart, de Wit and Eikelboom (1984) argued that drugs act on

the central nervous system to produce affective motivational states. The principles outlined above should also apply to alcohol consumption. A given dose of alcohol is not fixed in its hedonic value and may shift predictably according to physiological states. This also works the other way in that drive states can be altered by exposure to either a relevant incentive or a conditioned stimulus for that incentive. For example, the sight of a beer might be a potent trigger of alcohol consumption, just as the sight of food might arouse appetite. Lastly, Toates suggested that the outcome of the interaction between external incentive stimuli and internal physiological cues is not only sufficient but also necessary to produce substantial motivation. Thus, motivation arises from a necessary interplay between incentive stimuli and drive cues, if one is totally absent then motivation is unlikely to occur.

The core claims of the Bindra and Toates theories of incentive motivation are exactly the same. That is, motivation for stimuli is determined by interactions between internal states and external stimuli and that the pursuit of incentive stimuli (including drugs) is motivated by pleasure. Where Bindra and Toates differ is how it is that incentives come to direct behaviour. For example, Toates places more emphasis on cognitive (e.g. memory processes) and feedback systems compared to Bindra. However, when applied to drug use both theories predict that drugs are used because of their ability to produce pleasure.

1.2.3 Positive Reinforcement as an Explanation of Drug Use

The Bindra and Toates models are general theories of motivation that have been applied to drug use. Some theories of drug use, most notably positive reinforcement theories, also see the ability of drugs to produce pleasure as the reason for the maintenance of drug use. Positive reinforcement theories posit that drugs are used because of their ability to act as positive reinforcers. Stewart, de Wit and Eikelboom (1984) outlined one of these theories. As this theory has had some influence from the Bindra/Toates model of incentive motivation it will be discussed further. Researchers (O'Brien 1975; Stewart, de Wit and Eikelboom 1984; Wise and Bozarth 1987) have claimed that the underlying reason for the positive reinforcing properties of drugs is their ability to produce 'positively affective motivational states' that result in drug seeking behaviour. That is, people continue to take drugs because they produce pleasure. These positive affective states can be considered similar to the

idea of a CMS. These affective states are also held to be associated with an underlying neural system, such as the dopamine system.

According to this theory, the ability of 'conventional' reinforcers (e.g. food) to result in consumption depends on internal deprivation ('drive') states (e.g. hunger) in the same manner as described by Bindra and Toates. The corresponding 'drive' for drugs has been suggested to be physical dependence and withdrawal. However, Stewart, de Wit and Eikelboom argued that there is no corresponding drive for drugs and that drug use can be maintained in the absence of withdrawal or physical dependence. Instead they claimed that the presence of a drug in the body is more important in motivating drug use, than its absence. They suggested that small amounts of a drug act to 'prime' an organism by activating the 'appetitive motivational mechanisms', including an increase in drug-related thoughts and an increase in the salience of drug stimuli to the organism. Evidence for this has been provided by the effectiveness of priming doses of a drug to reinstate drug taking in abstinent animals and humans (see Shaham *et al* 2003 for review). For example, de Wit and Stewart (1983) trained rats to self-administer heroin by pressing a lever. After lever responding had been extinguished they then demonstrated that priming injections of heroin could reinstate lever responding for heroin. In humans, Shiffman (1986) reported that exposure to smoking in social situations was one of the main causes of relapse, as reported by smokers using a relapse prevention hotline.

With experience stimuli associated with drug use become conditioned stimuli that act to prime organisms, in the place of the actual drug. Stewart, de Wit and Eikelboom (1984) claimed that conditioned stimuli associated with drug pleasure are 'able to elicit....a neural state similar to that elicited by the drug itself'. That is, the conditioned stimulus takes on some of the affective properties of the drug. For example, Stewart and de Wit (1981) allowed rats to press a lever to obtain cocaine. One group had a tone specifically paired with each drug infusion and another experienced a tone that was not presented during actual drug infusion. After allowing the self-administration behaviour to extinguish (by not allowing cocaine infusions when the lever was pressed) they then presented the rats with the tone alone, a priming injection of cocaine or no event. They found that in both groups of rats the priming injection of cocaine reinstated lever responding (for more cocaine). However, they found that in the rats that had the tone paired with drug infusion the tone initiated lever responding in the same manner as the priming injection. Similarly, O'Brien

(1975) noted that injections of a placebo could produce pleasure in human drug users, if they had expected the drug to be present.

Furthermore, the role of these conditioned stimuli in priming drug responding is seen as separable from the physiological effects (e.g. increased heart rate) of drugs that may also become conditioned to drug stimuli. Stewart, de Wit and Eikelboom suggested that some of these responses might modulate the affective value of a drug in a similar manner as hunger affects the hedonic value of food (see 1.2.1 and 1.2.2). For example, they cited literature (e.g. Deutsch 1974) that demonstrated stimuli associated with sweet foods can lower blood glucose levels and that this may be mediated by a conditioned secretion of insulin (consumption of sweet substances causes a secretion of insulin).

1.2.4 The Problem with Drug Use Motivated by Pleasure: When Pleasure is not Enough

The models discussed above focus on behaviour motivated by pleasure. Organisms are attracted to and learn to pursue objects in their environment that they derive pleasure from and avoid those that harm them or are not pleasurable. Therefore a positive CMS or affective state will direct an animal towards an incentive that it both wants and likes. They make no distinction between liking an incentive on one hand and wanting it on the other hand, the two are part of the same unitary process. Thus, the fundamental claim is that drug use is motivated by pleasure. However, there are a number of problems with this idea. If this were the case then it would be expected that the more pleasurable the drug is, the higher will be the motivation to take it, but this is not always observed. Nicotine, for example, is held to be a highly addictive drug but it's addictive potential seems to far outweigh its pleasure giving abilities.

For example, Kozlowski (1989 as cited in Warburton 1994) compared pleasure derived from cigarettes to pleasure derived from other drugs, using self-report measures. Problem users compared smoking with their own problem drug. Only 13.8% of alcoholics and 2.7% of cocaine users rated smoking as giving more pleasure than alcohol or cocaine respectively. Warburton (1994) compared the 'pleasurable stimulating' and 'pleasurable relaxing' effects of several drugs and activities. They stated that 'alcohol, amphetamines, cocaine, heroin, marijuana and

sex were significantly more stimulating than tobacco', whereas chocolate and coffee were not found to be statistically different from the tobacco. The participants also rated alcohol as more relaxing than tobacco but again they reported no difference in the relaxing properties between tobacco and chocolate. Remarkably, tobacco (which is considered a highly addictive drug) was not rated significantly different on many subjective pleasurable effects from chocolate, suggesting that pleasure is not the primary motivation for tobacco use. Robinson and Pritchard (1992) also pointed out that nicotine use does not produce euphoria, yet is an addictive drug.

Robinson and Berridge (1993; 2003) provided several criticisms of theories that see drug use as motivated solely by drug pleasure. They made the same point as the researchers above that there is no clear relationship between the ability of drugs to produce euphoria and their addictive potential. They also cited the case of nicotine, which, although addictive, does not produce 'marked euphoria' or other 'strong hedonic states'. They also noted that many addictive drugs can have strong dysphoric effects. For example, Oswald (1969) and a colleague reported an attempt to become addicted to heroin (themselves), in order to provide a laboratory account of the heroin experience. However, instead of a series of pleasurable drug-induced experiences, they reported a very negative reaction. They reported that heroin made them feel very ill and in particular they stated that heroin 'brings no joy, no pleasure'. Prolonged drug use also has many negative consequences, in terms of loss of health, family, job, etc. Robinson and Berridge (1993) argued that these negative consequences 'often far outweigh the magnitude of drug pleasure or the memory of drug pleasure'. For example, Satel, Southwick and Gawin (1991) reported that 76% of the cocaine users interviewed in their study suffering from cocaine-induced paranoia reported that paranoid ideation would last for hours. This far exceeded the amount of time they would experience the pleasurable cocaine high, which they estimated at minutes. However, these users would still administer cocaine. If prolonged drug-use has such negative consequences, and does not necessarily produce large amounts of pleasure, why do people continue to be motivated to take drugs?

Robinson and Berridge (1993) have also argued that some of the strongest evidence that drug-use is not motivated by the subjective pleasure provided by drugs comes from studies that show the self-administration of drugs in the absence of subjective pleasure. For example, in a study by Fischman (1989), subjects with a history of cocaine and (other drug use) were given the option of choosing between

two intravenous infusions – either saline or different doses of cocaine (4, 8, 16 or 32mg) in a series of sessions. The study took place over two weeks with daily experimental sessions lasting several hours. The participants were told that these solutions would be active or inactive drug and that the right-hand response button and light were associated with one solution and the left-hand button and light with a second solution. The participants had to press the button between 10 and 200 times in order to gain an injection. The solutions were the same over each daily session but changed from day to day. Subjective and physiological measures were taken on each day. Participants reliably selected all doses of cocaine over saline and the higher dose of cocaine over the lower doses. At the 16 and 32mg doses, the participants reported increases in their positive mood scores (i.e. the drug produced pleasurable effects). However, at the lowest dose (4mg) self-administration appeared to continue in the absence of any subjective effects. At this dose participants reported that they had only received saline and that the solution contained no cocaine. In addition, no cardiovascular responses to the drug were observed. However, according to the cumulative record of button pressing the addicts continued to self-administer the cocaine over the saline. Fischman and Foltin (1992) stated:

> "subjects.....tell me that they were not choosing cocaine over placebo. They often insist they that they were sampling equally from each of the two choice options and both were placebo. On the other hand if you look at the data from that session, you see that they were choosing the low dose or the dose with no measurable effect. Subjects...choose...cocaine over placebo repeatedly, despite the fact that I can measure no cardiovascular or subjective effects of that dose. I do not believe that subjective effects provides us with the information about 'what' is maintaining their cocaine-taking."

Although the participants did not consciously like the drug, and were even unaware of self-administering it, Berridge (1999) argued that on some unconscious level they perhaps "wanted" the cocaine solution more as they worked for it and 'selectively strove to gain it'. Furthermore, in another study Fischman and Foltin (1992) noted within-session tolerance to the cardiovascular and subjective effects of cocaine. However, throughout the session self-administration behaviour did not change, to the point where some doses had to be withheld because of medical

concerns (high blood pressure or heart rate). The implication is that something other than the subjective effects of the drug was maintaining the drug administration. Katz and Goldberg (1988) also reported that under certain conditions cocaine administration could be maintained in the absence of any subjective report of the drug effects. They concluded that although subjective report often overlaps with, it is not always a good predictor of whether a drug will act as a reinforcer.

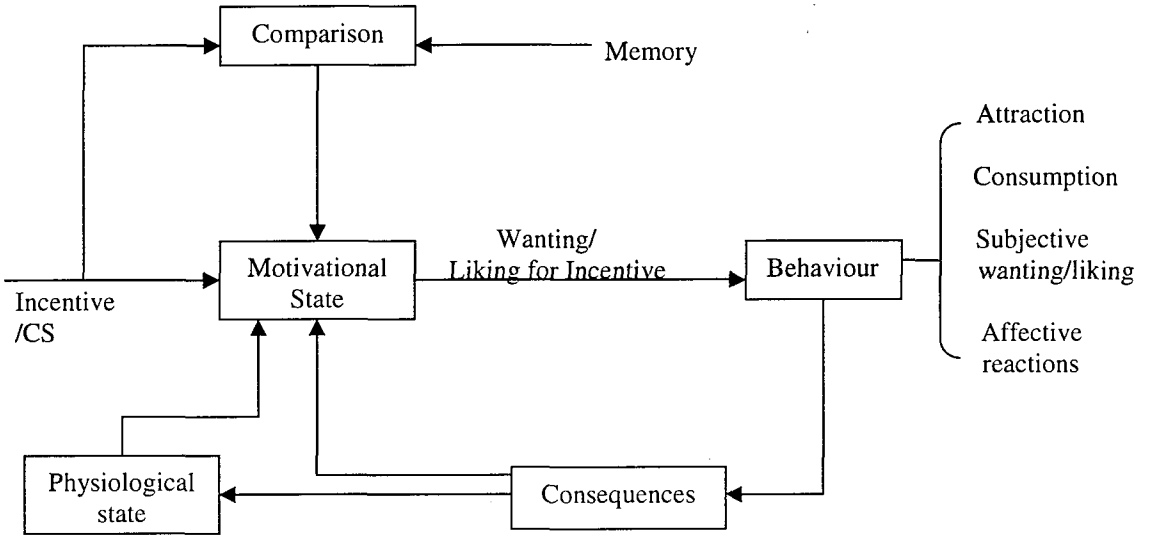
A similar study by Lamb *et al* (1991) used five heroin addicts who could press a lever to obtain injections of morphine. The addicts were seated in front of two levers. The left lever started the session and the right lever could result in an injection of morphine. During each experimental session the addicts were free to respond on the right lever over the course of one hour. They were told that when a red light came on and stayed on they would be given an injection. Injections were available under a second-order schedule of responding on the right lever. Each response on the right lever resulted in a brief flash of white light and the 100^{th} press turned on a red light for one second (fixed ratio: 100). The 30^{th} completion of the fixed ratio requirement turned the red light on for 15 minutes and participants received an injection: either 3.75, 7.5, 15 and 30mg of morphine or inactive saline. Each dose condition was in effect for a week, after which it switched to a different dose. During each experimental session physiological (heart rate, blood pressure, pupil diameter, temperature) and subjective (drug liking, detection, identification, addiction research centre inventory) measures were taken. The 7.5, 15 and 30mg morphine injections maintained responding in all five subjects and were described favourably in their subjective reports. In contrast the saline solution did not maintain responding. The lowest dose of morphine was described as equivalent to saline ("worthless" and "empty"). However, this low dose of morphine still managed to maintain lever pressing in 4/5 participants despite being described as equivalent to saline. They had worked as hard for it as the other morphine doses despite an absence of subjective pleasure.

The studies above suggest that drug-use can be motivated by mechanisms other than drug pleasure. Drawing on the work by Bindra and Toates, Robinson and Berridge (1993; 2000; 2001; 2003) have formulated a modified model of incentive motivation to explain these phenomena, which they have directly applied to drug use, including alcohol. They have named this model the incentive-sensitisation theory.

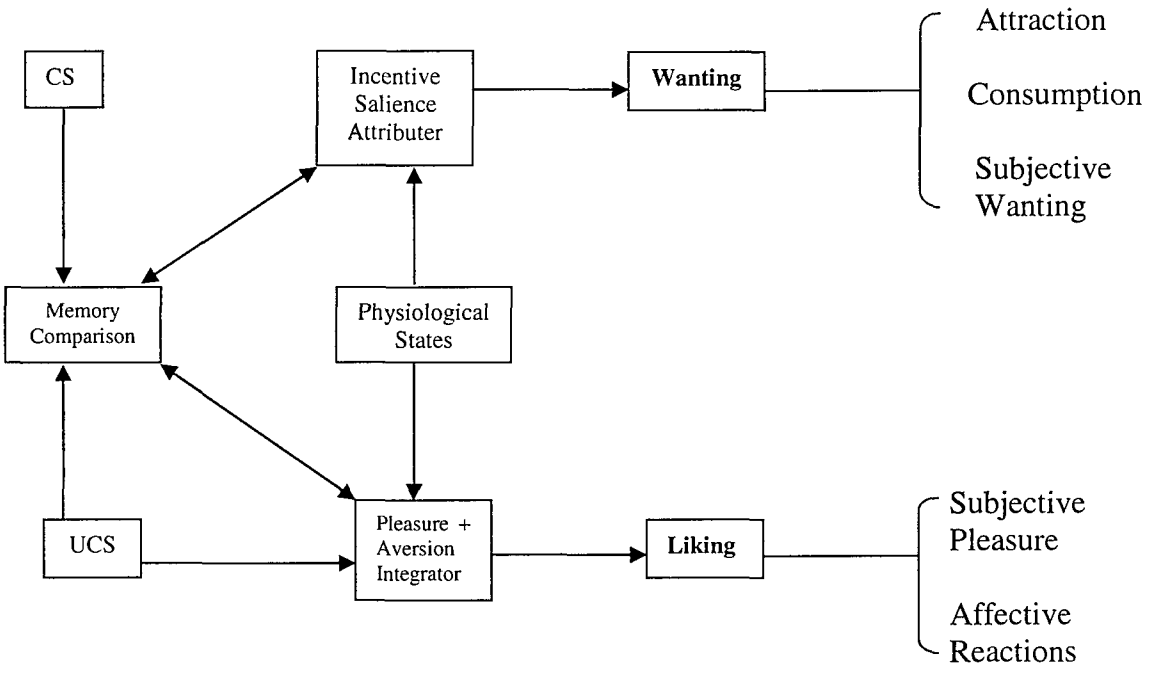
1.2.5 Overview of the Incentive-Sensitisation Theory

The incentive-sensitisation model is illustrated in Figure 1.3 and compared with Toates' (1986) model of incentive motivation. In the Toates model the external incentive stimuli and internal physiological 'drive' states interact to produce motivation towards an incentive. This motivation results in animals interacting with objects/events that they both want and like. In this model wanting and liking are treated as being part of the same underlying unitary process. Thus, if something is liked, it must also be wanted, and vice-versa.

Berridge and Robinson's model is different in that it sees reward as consisting of separate processes of wanting and liking. Over time stimuli go through a conditioning process whereby they are attributed with incentive salience, which can be best understood as 'wanting'. This is different from hedonic pleasure or aversion caused by the stimuli, best understood as 'liking'. In most cases liking and wanting cohere together. However, although 'liking' plays its part and has complex interactions with 'wanting' (including usually triggering wanting), it is the 'wanting' system that is important for understanding some important aspects of alcoholism and addiction. According to the theory the 'wanting' system (and not the 'liking' system) in the brain, strongly associated with mesotelencephalic dopamine systems (see Berridge and Robinson 1998 for review), is progressively 'sensitised' after repeated drug taking. Thus when presented with a drug or associated cues the neurones become 'hyper-active' causing activation of this motivational 'wanting' system. This results in the compulsive drug taking observed in addiction. Evidence for actual neural-sensitisation has mostly come from studies on sensitisation to the psychomotor-activating effects of addictive drugs, including alcohol (see Robinson and Berridge 1993 for a review). Other studies have demonstrated sensitisation to the incentive motivational effects of drugs and actual sensitisation at the cellular level. Furthermore, it is posited (Berridge 1999; Berridge and Winkielman 2003) that these processes can be unconscious, requiring no subjective awareness to motivate goal-directed behaviour, although it may manifest itself subjectively as desire or craving. In addiction sensitisation has reached such a level as to produce intense craving independent of whether a drug is 'liked'. Most of the evidence for the theory comes from animal studies, although there is some literature in humans.



A. Bindra/Toates' model of incentive motivation where wanting and liking are one underlying core process. Therefore attraction, consumption, affective reactions, subjective pleasure and wanting all measure the same reward process.



B. Berridge and Robinson's incentive salience and neural sensitisation model. Wanting and liking are separate components of an overall reward process. Therefore measures of wanting and liking are measuring separate underlying core processes and cannot be used interchangeably. Drug-taking results in the progressive neural-sensitisation of the wanting system but not the liking system. Therefore in the presence of drug or drug-related cues an individual will experience an increased desire to for the drug but not necessarily increased liking for the drug.

Figure 1.3 A. Toates' model of conditioned incentive motivation. B. The incentive-sensitisation model. Note. Taken from Berridge (2000a) and Toates (2001).

To summarise Berridge and Robinson make several important claims:

- Reward can be broken down into separate components of wanting and liking.
- Subjective experience of wanting and liking can further be dissociated from unconscious core emotional processes.
- Wanting and liking are mediated by separate underlying neurobiological systems.
- Through a process of neural-sensitisation it is the wanting system that can explain many forms of addiction and drug use.
- Sensitisation results in the neurones of the wanting system becoming hypersensitive to drugs and their associated cues, leading to an increase in wanting behaviour.

Berridge and Robinson's theory is not merely a theory of drug addiction but encompasses a theory of motivation also. Drugs and other rewards such as food and sex are known to act on some of the same reward systems and a central claim of the theory is that there are common systems associated with all rewards. Thus, when discussing the theory it is common to refer to wanting and liking in relation to other so-called 'natural' rewards, which can help shed light on drug-related reward. Although there are several aspects of incentive-sensitisation theory (see above) the current research is focussed upon the possibility that wanting and liking are based upon separate dissociable systems and that wanting becomes sensitised during addiction. Therefore the literature review of this chapter will focus upon the topics of sensitisation and the distinction between wanting and liking.

1.3 Evidence for Sensitisation in Animals

Many drug effects change after a drug has been administered repeatedly. Some effects decrease and this is known as tolerance. However, some effects are also known to increase after repeated drug administration. This is known as sensitisation and can eventually lead an organism to become hypersensitive to an effect of a drug. Strakowski *et al* (1996) defined behavioural sensitisation as 'the process whereby intermittent exposure produces a time-dependent, enduring, and progressively greater or more rapid behavioural response'. Stewart and Badiani (1993) defined sensitisation as 'the phenomenon of increased responsiveness to the same or lower doses that follows repeated drug administration'.

Manley and Little (1997) stated that, although different types of drugs have different physiological targets, there is now increasing evidence that a wide variety of drugs can cause changes in a common neural system. This common system (see Figure 1.4) is the mesolimbic dopamine system (especially the ventral-tegmental area and projections to the nucleus accumbens and prefrontal cortex), which has been posited by Robinson and Berridge to be associated with wanting for drugs. Berridge and Robinson also maintained that progressive sensitisation should occur with repeated drug experiences.

Evidence for the occurrence of sensitisation in animals comes from three lines of research, which have been reviewed by Robinson and Berridge (1993; 2000; 2001). The bulk of these studies are those that have investigated sensitisation to the psychomotor activating effects of drugs. These have explored the phenomenon of increased psychomotor activity after the repeated administration of drugs. These demonstrate that sensitisation can occur to drug effects and are mediated by the same (or overlapping) brain systems posited to be involved in wanting. The second type has investigated sensitisation to the incentive-motivational effects of drugs. That is the ability of experience (or pretreatment) with drugs to increase the likelihood of later drug self-administration or conditioned place preferences. These provide evidence that prior drug experiences can sensitise a motivational process for drugs, leading to an increase in drug use. These two lines of evidence infer neural-sensitisation from behavioural sensitisation but do not provide direct evidence that neural-sensitisation occurs. The third line of evidence comes from those studies that show that drugs cause cellular changes in brain systems associated with reward. These provide direct evidence that sensitisation occurs at a biological level.

1.3.1 Animal Studies of Psychomotor Sensitisation

Most of the studies that have provided evidence that drugs can lead to neural-sensitisation of the wanting system have investigated sensitisation to the psychomotor activating effects of drugs. Robinson and Berridge (2001) claimed that these studies are relevant to drug addiction because it is assumed that the 'neural substrate that mediates these [psychomotor] effects is either the same as, or at least overlaps with,

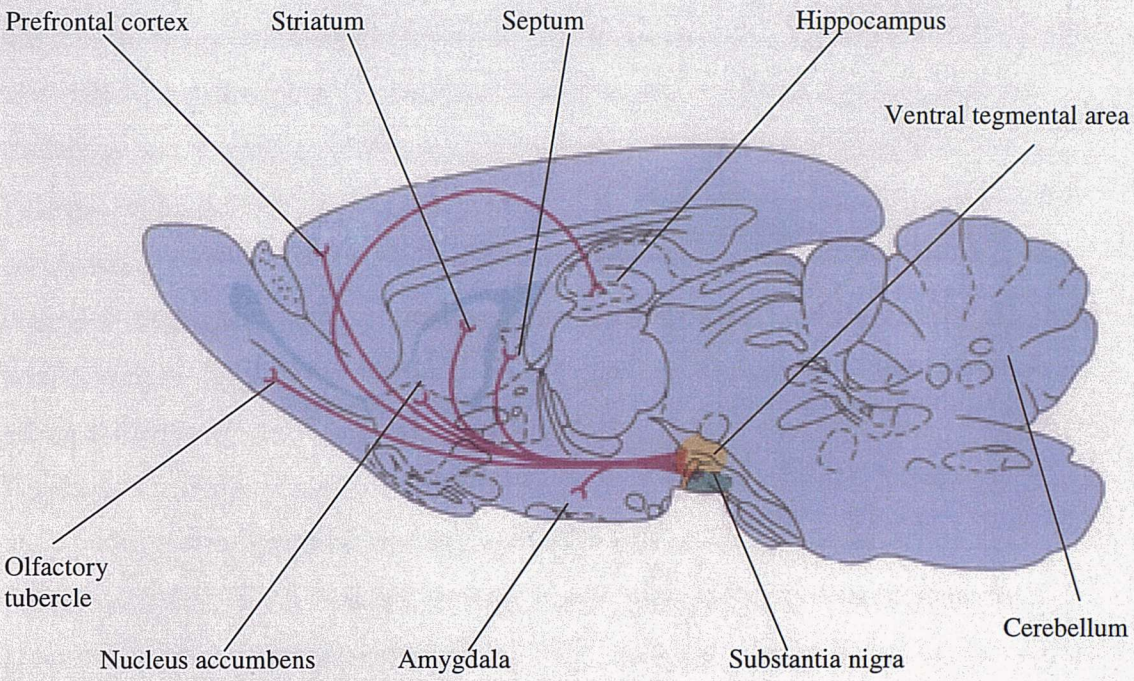


Figure 1.4 The mesotelencephalic dopamine system in the rat brain, posited as the candidate for the 'wanting' system. The most closely associated areas are the projections from the ventral tegmental area (VTA) to the nucleus accumbens (NA), known as the mesolimbic dopamine pathway (which also runs via the amygdala). It is also claimed that this system mediates the psychomotor effects of drugs. Figure derived from Toates (2001).

the neural substrate responsible for the rewarding effects of drugs'. This system is posited to be the mesolimbic dopamine system (see Figure 1.4), which is strongly associated with the rewarding effects of drugs (Stewart 1992; Wise and Bozarth 1987; Wise 1994; Nestby *et al* 1997). Therefore, it is reasonable to assume that if sensitisation to the psychomotor effects of drugs occurs then sensitisation of the wanting system might also occur. Thus, neural-sensitisation is often inferred from behavioural sensitisation.

A large number of studies over the past 20 years have shown that repeated administration of drugs can lead to a progressive increase in their psychomotor activating effects. Psychomotor responses include locomotor activity (also known as ambulation), rotational behaviour (vigorous turning) or stereotyped behaviour patterns (also know as stereotypy). Sensitised stereotyped behaviour patterns include sniffing and head/limb movements. Some stereotyped patterns do not become sensitised, such as licking and biting behaviours. Robinson (1988) suggested that this is because these stereotyped behaviour patterns are mediated by the nigrostriatal dopamine system (as opposed to the mesolimbic dopamine system), which may not become sensitised by

drugs. The drugs that have been shown to produce sensitisation include nicotine (Ksir *et al* 1985), amphetamine (Robinson 1984; Piazza *et al* 1990), cocaine (Badiani, Browman and Robinson 1995), morphine (Stewart 1992) and alcohol (Lessov and Phillips 1998), amongst others. For example, Paulson, Camp and Robinson (1991) pretreated rats with an escalating dose of amphetamine with a series of "runs" and "crashes" to mimic use observed in human amphetamine users. They found that two weeks after amphetamine use had been ended (and after withdrawal symptoms had disappeared) these rats showed increased stereotyped behaviour patterns to a challenge injection of amphetamine, compared to control rats.

Of greater relevance are the studies that have shown that sensitisation can occur to ethanol. Some researchers have argued that dopamine systems are not a critical reward system for alcohol. Koob (1996) argued that while dopamine systems are associated with drug reward they are 'only critical for psychostimulant reward' and that other neurobiological systems are more important for mediating reward for alcohol and heroin. While most of the research on sensitisation has focussed on psychostimulant drugs rather than alcohol, a number of studies do suggest that the repeated administration of alcohol can lead to sensitisation to its psychomotor effects. Furthermore, other studies have supported the claim that ethanol interacts with the mesolimbic dopamine system. For example, El-Ghundi *et al* (1998) and Risinger *et al* (2000; 2001) have reported that mice genetically deficient in dopamine receptors showed reduced ethanol self-administration.

Phillips, Roberts and Lessov (1997) provided a short review of the evidence for sensitisation by ethanol. They suggested that there is less research on alcohol because ethanol sensitisation is easier to demonstrate in the mouse than the rat (the usual animal for demonstrating sensitisation to drugs). They noted that a study by Masur and Boerngen (1980) was one of the first studies to provide evidence for ethanol sensitisation. Masur and Boerngen carried out a series of experiments on the effect of ethanol on locomotor activity in mice. They administered ethanol to female mice (1.0, 2.5 or 3.5g/kg) for 30 days, periodically measuring locomotor activity (Days 1, 15 and 30). The 1.0g/kg dose was ineffective in producing any change. Initially the 2.5g/kg produced excitation and 3.5g/kg produced a depressant effect. However, over the 30 days the 2.5g/kg dose produced a progressive increase in locomotor activity. Although the 3.5g/kg dose produced a depressant effect on day one, by day 30 the mice were displaying increased locomotor activity. A progressive

increase in locomotor activity was also observed in male mice given a 2.0g/kg dose over the course of 45 days. No tolerance to this excitatory effect of ethanol was observed. This would appear to suggest that the mice became sensitised to the locomotor effects of the ethanol. However, it might also be argued that instead the mice became tolerant to the depressant effects of ethanol and that this 'unmasked' the locomotor activating effects. However, the 2.5g/kg dose was not observed to produce any initial depressant effect but still there was a progressive increase in locomotor activity. Still, it is possible that the depressant effects at this dose were masked by the excitatory component. However, studies (e.g. see Itzhak and Martin 1999 next paragraph for more detail) have demonstrated sensitisation to challenge injections of ethanol that were presented 7-10 days after the end of ethanol pretreatment. Itzhak (personal communication) suggested that tolerance would not have been evident after this period, and in any case the mice showed no evidence of a depressant effect. A later experiment by Masur and Santos (1988) also showed that chronic exposure to ethanol sensitised certain strains of mice to the locomotor activating effects of ethanol.

Crabbe *et* al (1982) found that a certain strain of mice treated with two daily injections of ethanol for 10 days showed increased locomotor activity after a challenge injection of ethanol on the 11^{th} day, compared to control mice treated with saline. More recently, Itzhak and Martin (1999) pretreated mice with ethanol injections for five days (2.0g/kg per day). After a 10-day ethanol free period they were then given a challenge injection of ethanol. The mice pretreated with ethanol (compared to saline pretreated mice) showed increased locomotor activity to the challenge injection. In a follow-up, study Itzhak and Martin (2000) also showed that administration of ethanol (1.5g/kg) for seven days resulted in the same effect. Broadbent and Harless (1999) and Lessov and Philips (1998) have also reported similar results.

Although the literature covering sensitisation to the psychomotor effects of ethanol is not as large as those covering other drugs these studies suggest that sensitisation to some of the psychomotor stimulating effects of alcohol can occur. However, by itself psychomotor sensitisation cannot demonstrate directly that sensitisation to the wanting system occurs. Nevertheless, a number of studies have been carried out that suggest that sensitisation can occur to the incentive motivational

effects of drugs and in some cases that this is accompanied by psychomotor sensitisation.

1.3.2 Sensitisation to the Incentive Motivational Effects of Drugs

The second line of evidence has demonstrated that prior exposure to a drug can increase the likelihood of the development of a later drug self-administration habit. Woolverton *et al* (1984 as cited in Robinson and Berridge 1993) reported that rhesus monkeys would only develop a methamphetamine self-administration habit after undergoing pre-treatment with the drug. Robinson and Berridge (1993) suggested that pretreatment had the effect of 'lowering the threshold dose necessary to sustain self-administration'. In another study Piazza *et al* (1989) pre-treated one group of rats with four injections of *d*-amphetamine (spaced by three day intervals) and another with saline. They found that the group pre-treated with amphetamine were more likely to develop an amphetamine self-administration habit started four days after pre-treatment had finished. In a follow-up study, Deroche, Le Moal and Piazza (1999) compared rats allowed to self-administer cocaine (for six or 29 sessions) on their self-administration habit and three tests, designed to test the reinforcing and incentive effects of cocaine. The tests were cocaine-induced reinstatement of the cocaine self-administration habit, place conditioning and runway tests. They found that those rats that had completed 29 sessions (more experienced rats) self-administered a greater amount of cocaine than those that only completed six sessions. After extinction of the self-administration habit the more experienced rats' (29 sessions) habit was also reinstated by a lower 'priming' dose, than the less experienced rats (six sessions). Lower doses of cocaine were also more able to maintain running on the runway tests in the more experienced rats, compared to the less experienced rats. Both sets of rats also showed a place conditioning preference for the environment paired with previous cocaine administration but there was no significant difference between the two groups. Aside for the lack of a difference in the place preference test, these results suggest that the more experience with cocaine, the more sensitive the rats became to the incentive-motivational properties of the drug. That is, after drug pretreatment, lower doses of cocaine were needed to induce and maintain the motivation to engage in drug-taking behaviour. Also, De Vries *et al* (1998) allowed rats to self-administer heroin (for 14 days), cocaine (for 10 days) or

saline. Extinction of the self-administration habits then took place over the course of three weeks. Reinstatement of the self-administration habits was then tested using 'priming' injections. Priming injections of heroin and cocaine successfully reinstated self-administration of each drug respectively. Furthermore, these effects were observed to coincide with sensitisation to the locomotor effects of cocaine and heroin.

Other studies have shown that drug pretreatment can enhance the acquisition of a conditioned place preference. In these studies, a distinctive environment is paired with drug administration. After repeated pairings animals become to prefer the environment which was paired with the drug, compared to a neutral environment. This is measured by the amount of time an animal spends in each environment. Several studies have demonstrated that prior exposure to drugs can increase the effectiveness of this place conditioning procedure. For example, Shippenburg and Heidbreder (1995) found that rats pretreated with cocaine were faster to acquire cocaine-induced conditioned place preferences and acquired them at lower doses, compared to saline pretreated rats. Lett (1989) found similar findings with rats pre-exposed to amphetamine, cocaine and morphine, compared to non-pretreated rats. Cunningham and Noble (1992) demonstrated a similar effect with ethanol. In this experiment, one group of mice received four pairings of ethanol with a textured floor. A control group received pairings of saline with the textured floor. The group that received the ethanol showed a preference for the textured floor compared to a normal floor, whereas the control group did not. The ethanol treated mice also showed more locomotor activity on their preferred floor stimulus than the saline treated mice. Risinger and Oakes (1996) also showed that mice preferred a tactile stimulus that had been previously paired with ethanol presentation.

1.3.3 Sensitisation of Brain Systems Associated with Drug Reward

Finally, further evidence that sensitisation can occur to the incentive motivational effects of drugs also comes from studies that show sensitisation occurs in brain systems that are associated with drug reward. These neurobiological studies have shown that repeated drug use results in changes in brain systems associated with the rewarding effects of drugs. The key problem with this evidence is that they have focussed on stimulant drugs (notably amphetamine and cocaine) with comparatively few studies using alcohol. The incentive-sensitisation theory claims that drugs

sensitise a common neural system associated with 'wanting'. This is posited to be certain brain dopamine systems (see Berridge and Robinson 1998 for review). The evidence that dopamine systems are associated with 'wanting' is considered in 1.4. However, there are several studies that show that neurons associated with dopamine systems undergo neuro-adaptations after sensitisation by drugs has occurred. These adaptations include changes in the sensitivity of neurons to drugs and specific structural changes in the neurons themselves. Richtand *et al* (2001) noted that there are considerable gaps in the knowledge as to the exact role that these neuro-adaptations play in behavioural sensitisation. However, these studies do provide direct evidence that sensitisation occurs at the cellular level. Kalivas and Stewart (1991) and Pierce and Kalivas (1997) provided reviews of the neural adaptations undergone during sensitisation and their relations to behavioural sensitisation. These reviews and those by Robinson and Berridge (2000; 2001) classed these neuroadaptations as either presynaptic or postsynaptic adaptations.

The reviews above, all cited increases in the release of dopamine (*in vitro* and *in vivo*) as an example of a presynaptic adaptation. Robinson and Becker (1986) noted that long-term use of amphetamine is neurotoxic, resulting in brain damage. However, if repeated amphetamine administration is intermittent then sensitisation can occur. They noted that there is strong evidence that behavioural sensitisation produced by amphetamine is accompanied by an enhancement in the release of dopamine. For example, Robinson and Becker (1982) took neural tissue from rats that had demonstrated behavioural sensitisation to amphetamine and amphetamine naïve rats. They found that amphetamine increased dopamine release *in vitro* significantly more in the tissue from the sensitised rats, compared to the naïve rats. More recent studies such as Vanderschuren *et al* (1999) and Kantor, Hewlett and Gnegy (1999) have also supported these findings. They both reported that amphetamine pre-treatment results in enhanced dopamine release *in vitro*. Rosetti, Hmaidan and Gessa (1992) found that rats that had been subjected to chronic ethanol consumption showed a reduction in dopamine concentration in the ventral striatum after withdrawal from the ethanol. Weiss *et al* (1996) produced similar findings when they compared ethanol dependent rats to nondependent control rats. They measured a reduction in dopamine transmission in the dependent rats when ethanol availability was withdrawn, whereas ethanol consumption increased dopamine transmission in the control rats.

Postsynaptic neuroadaptations refer to changes in the sensitivity of certain receptors after drug administration. For example Henry and White (1991) have shown that repeated cocaine administration causes an increase in D1 dopamine receptor sensitivity in the nucleus accumbens of rats, the same system involved in the psychomotor stimulating effects of cocaine. Rats were injected twice daily with cocaine for two weeks. Using single cell electrophysiological recording techniques they demonstrated that cocaine administration led to increases in the sensitivity of dopamine neurons to cocaine. This sensitisation was still apparent two months after withdrawal from cocaine administration. In a similar study, White *et al* (1995) gave rats daily injections of amphetamine or cocaine for five days. They found that the responsiveness of dopamine neurons in these rats was significantly increased.

Robinson *et al* (Robinson and Berridge 2000; 2001; Kolb, Gibb and Robinson 2003) cited two studies that have shown that sensitisation is accompanied by structural modifications in the neurones of the nucleus accumbens and prefrontal cortex. Robinson and Kolb (1997) showed that an amphetamine regimen known to produce 'robust and persistent behavioural sensitisation' produced structural modifications in neurons of the nervous system. Specifically, one month after amphetamine treatment they found an increase in dendritic surface and dendritic spines on neurons located in the nucleus accumbens and prefrontal cortex. Dendritic surface is directly associated with the number of synapses on a neuron and the dendritic spines are involved in excitatory signalling. Therefore this study suggested that repeated exposure to amphetamine produced alterations in the number of synaptic connections, which the authors claimed might indicate an increase in sensitivity. In a follow-up study, Robinson and Kolb (1999) replicated their previous results with a lower dose of amphetamine and with cocaine. Both drugs increased the number and density of dendritic spines on neurons in the nucleus accumbens and prefrontal cortex.

1.3.4 Influences on and Characteristics of Sensitisation

The literature outlined above provided evidence that the repeated administration of many different drugs, including alcohol, results in both behavioural and incentive sensitisation and some studies have begun to identify the cellular basis of these effects. However, sensitisation is not an inevitable outcome of drug administration and there is a large literature exploring the conditions and influences

on whether sensitisation occurs. These studies serve both to highlight that sensitisation can be a complex phenomenon and provide further evidence that drugs result in the sensitisation of a common neural system. Some of these conditions and influences will be briefly considered. These include single dose sensitisation, the duration of sensitisation, modulation of sensitisation by learning, cross-sensitisation and individual differences.

1.3.4.1 Dose regime and duration of sensitisation

Sensitisation is a progressive process and so is enhanced by repeated drug doses. However, sensitisation can occur after even a single low dose of a drug (see Robinson 1988 for review). For example, Glick and Hinds (1984) gave rats single injections of cocaine or saline and measured rotational behaviour. They reported that the single injection of cocaine sensitised female rats to a challenge injection administered one to seven days later (they showed increased rotational behaviour compared to controls). Robinson (1988) also noted that sensitisation may depend upon the administration regime. Animals only show amphetamine sensitisation after being withdrawn from the drug for a few days and injections of amphetamine that are spaced over time are more effective at producing sensitisation than those massed together. For example, Samaha, Li and Robinson (2002) investigated the effect of rate of cocaine administration on psychomotor sensitisation (rotational behaviour) in two experiments. In one experiment they found that rats pretreated with 1.0mg/kg of cocaine delivered intravenously between three and 16 seconds displayed sensitisation to a challenge injection of cocaine. However, if the cocaine was delivered at 34 seconds the increase in rotational behaviour to the challenge injection was not statistically significant. In the second experiment they investigated the effects of cocaine doses (0.5mg/kg – 2.0mg/kg) administered between five and 100 seconds on rotational behaviour. At the higher delivery rates, sensitisation was induced. However, sensitisation was only induced at rates over 25 seconds when the highest dose was used.

Animals that have undergone sensitisation can remain hypersensitive for months or even years after drug administration has ended. Paulson, Camp and Robinson (1991) observed that sensitisation to amphetamine in rats remained undiminished a year after discontinuation of amphetamine administration.. More

recently, Bailey *et al* (2000) reported that mice that had undergone chronic ethanol consumption showed changes in dopamine function two months after the ending of ethanol consumption. Some studies have also shown that sensitisation may not be permanent. For example, Ksir *et al*'s (1985) study demonstrated that rats could be sensitised to the locomotor stimulating effects of nicotine. However, 21 days after the last exposure to nicotine the locomotor response to nicotine appeared to have returned to normal. Glick and Hinds (1984) also reported that, in their rats, sensitivity to cocaine induced rotational behaviour returned to normal 14 days after the initial dose.

1.3.4.2 Modulation of sensitisation by environment and learning

Sensitisation is also held to be dependent on the environment and learning. Robinson and Berridge (2001) noted that 'the ability of drugs to induce or express sensitisation is powerfully modulated by learning and the circumstances surrounding drug administration'. This area of the theory follows on from the Bindra/Toates models, with the role of external stimuli being to trigger wanting for drugs. Robinson and Berridge (2000; 2001) have argued that there are two ways in which sensitisation can be modulated by the environment and learning.

The first is whether sensitisation that has already occurred is expressed in a given situation. This has primarily involved studies that have investigated context-specific sensitisation. That is, instances in which sensitisation is only expressed in certain environments or by cues that have been associated with drug taking. Anagnostaras and Robinson (1996) examined the role of contextual stimuli on the expression of amphetamine sensitisation. Specifically, they measured rotational behaviour in rats with lesions of the dopamine system. All the rats developed sensitisation to the amphetamine. Amphetamine or saline was administered to the rats in group-specific environments (home cages, rotometers or a 'third world' environment). Challenge injections of amphetamine were administered in the rotometers (used for measuring rotational behaviour). Sensitisation was found to be context-specific. That is, the rats that received the amphetamine in the rotometers displayed sensitisation. However, when the rats that received the amphetamine in the home or third world environment were tested in the rotometers (a novel environment) they only showed a similar level of rotational behaviour to saline treated animals.

Anagnostaras, Schallert and Robinson (2002) have since replicated these findings in a more recent study.

Environment and learning factors may also affect whether sensitisation actually occurs with initial drug experience. Badiani, Browman and Robinson (1995) tested the effect of environment on sensitisation to amphetamine, using rotational behaviour. One group of rats received injections of amphetamine in their home environment. Another group received injections of amphetamine in a novel environment. They reported that the rats that received the amphetamine in the novel environment displayed greater sensitisation than those that received it in the home environment. In the same study the same effect was reported using cocaine. Robinson and Berridge (2000; 2001) have argued that unsignalled drug administration may actually result in a failure to induce sensitisation. For example, Badiani, Camp and Robinson (1997 as cited in Berridge 2000a) reported amphetamine (0.375 – 1.0 mg/kg) administered using an intravenous catheter (in a home environment) failed to induce sensitisation. However, if the same doses were signalled (given in a novel test environment) then sensitisation did occur. Berridge (2000a) noted that this method does not necessarily 'preclude sensitisation but moves the dose-curve for the induction of sensitisation. When high enough doses of either amphetamine or cocaine are administered sensitisation seems to occur regardless of environmental factors'.

Even in animals that do not express it, sensitisation may still occur. The occurrence of sensitisation has been demonstrated in circumstances that have claimed to eliminate the influence of environmental cues. Robinson and Berridge (2000) have cited two examples of this. One example of this is by administering drugs to anaesthetised animals. The second is sensitisation using tissue slices *in vitro*. Castenda, Becker and Robinson (1988) reported that *in vitro* striatal brain tissue from rats pretreated with amphetamine, showed increased DA release compared to controls. Other studies (Nestby *et al* 1997; Vanderschuren *et al* 1999; Henry and White 1991) discussed above have also demonstrated that sensitisation can occur *in vitro*, including after pretreatment with ethanol. These have shown that sensitisation can be induced non-associatively but the expression of sensitisation can be affected by learning factors. The theory resembles cue reactivity models in that environmental cues can activate a sensitised brain system. In the case of drug abuse and addiction the theory posits that this system is the 'wanting' system. Thus, this process can lead cues to elicit craving and drug-seeking behaviour. In this manner, stimuli associated with

drug use can become powerful incentives themselves in the terms described by Bindra. Robinson and Berridge (2000) have also used the influence of cues to explain relapse. The they state that the 'ability of drug-related environments and cues to modulate sensitisation could interact with craving as a classically conditioned response, combining to provide very strong contextual control over both craving and relapse'.

1.3.4.3 Cross-sensitisation

Evidence that a common motivational neural system is sensitised by many different drugs comes from studies demonstrating cross-sensitisation between drugs. Different drugs initially bind at different receptor sites in the brain but may affect common systems. If cross-sensitisation occurs then that suggests that drugs affect a common neural system. These studies have demonstrated cross-sensitisation to both psychomotor sensitisation and the incentive motivational effects. The implication being that addictive drugs sensitise the wanting system, as predicted by the incentive-sensitisation theory.

Exposure to one drug can result in sensitisation to another drug, despite that drug not being experienced before. Several studies have shown that exposure to alcohol can result in sensitisation to the effects of other drugs. Manley and Little (1997) showed that chronic ethanol administration can enhance locomotor activity in response to amphetamine and cocaine. They forced mice to become ethanol dependent over a 3-week period (ethanol was administered as a liquid diet). Daily challenge injections of cocaine or amphetamine were then administered for several days and locomotor activity was measured. The ethanol dependent mice showed increased locomotor activity to the challenge injections of amphetamine compared to non-ethanol dependent mice. This was apparent after the first and subsequent doses. Similar results were found by Nestby *et al* (1997) who found that rats pretreated with ethanol showed an increased locomotor response to a challenge injection of morphine. However, these rats did not show behavioural sensitisation to ethanol. Therefore the authors concluded that 'an acute locomotor effect does not seem to be required for a drug to induce behavioural sensitisation'. Itzhak and Martin (1999) examined cross-sensitisation between cocaine, nicotine, dizocipline and alcohol in mice. However, only cross-sensitisation between cocaine and ethanol was found. Specifically, five

daily injections of ethanol were found to increase locomotor activity in response to a challenge injection of cocaine 10 days later and vice versa (compared to saline treated mice). The researchers also found an increased number of dopamine binding sites in the sensitised mice.

Prior exposure to drugs, other than alcohol, has also been shown to sensitise animals to the effects of alcohol. For example, Fahlke *et al* (1994) observed that amphetamine sensitised rats consumed significantly more ethanol than control rats (pretreated with saline) after a three month drug-free interval.

In addition to cross-sensitisation from other drugs it has also been suggested that this can occur from non-pharmacological stimuli. Shaham, Erb and Stewart (2000) noted that 'relapse to alcohol and drug use is more likely to occur in individuals exposed to high levels of life stress'. They reported studies that had shown that stress, in the form of footshock, reinstated drug seeking for cocaine, heroin, alcohol and nicotine. In fact, footshock was even more successful in initiating relapse than oral alcohol itself. Despite this, the exact nature of this relationship is unclear. Robinson (1988) pointed out that one factor might be that the repeated exposure to environmental stress activates dopamine systems and can cause 'sensitisation-like changes in the brain, behaviour and the hypothalamic-pituitary-adrenal axis'. Kalivas and Stewart (1991) and Shaham, Erb and Stewart (2000) have also reviewed evidence that stress induces sensitisation-like changes in brain dopamine systems. There is evidence that cross-sensitisation between stress and drugs can occur. Antelman *et al* (1979; 1983 as cited in Antelman *et al* 1991) reported that exposure to stress (footshock, tail-pinch) increased stereotyped behaviour in response to a subsequent challenge injection of amphetamine. Antelman *et al* (1991) reported that rats showed increased catalepsy (rigid posture) in response to haloperidol, if they had been exposed to stress (i.e. needle jab) two weeks previously. Piazza *et al* (1990) found that chronic tail pinch increased the locomotor response to a single injection of amphetamine and increased their vulnerability to acquire a self-administration amphetamine habit. Other studies have found similar results with regards to cocaine-induced stereotypy, amphetamine induced locomotion and rotational behaviour (see Robinson 1988 for review). Cross-sensitisation from drugs to stress may also occur. Robinson and Berridge (1993) argued that 'animals previously exposed to amphetamine, cocaine and morphine are later hyper-responsive to stress'. Robinson and Berridge (1993) suggested that cross-sensitisation between drugs and stress may

induce relapse because addictive drugs and stress both appear to sensitise dopamine systems, which they posit to mediate incentive motivation. They also speculated that stress may predispose individuals to drug addiction by sensitising the neural systems related to the wanting system before a drug is experienced. Thus, they claimed that initial drug experiences maybe enhanced in these individuals so that they are more likely to engage in subsequent drug seeking and taking.

1.3.4.4 Individual variation in susceptibility to sensitisation: genetics, age, hormones and gender

There has been reported to be a large degree of individual variation in susceptibility to sensitisation. In a review Robinson (1988) discussed several factors that can influence sensitisation. There is a large literature on the genetic variation of sensitisation in rats and mice (see Phillips, Roberts and Lessov 1997 for review). For example, Leith and Kuczenski (1982) compared amphetamine sensitisation in 10 strains of rats. They reported strain differences in the duration of amphetamine induced stereotyped behaviour and also in 'post-stereotypy hyperactivity'.

Fujiwara *et al* (1987) reported data that age may influence whether sensitisation is induced. They found that methamphetamine enhances motor activity in all rats from 2 – 31 days of age. However, prior exposure to methamphetamine did not produce sensitisation to a challenge injection (given when the rats were 35 days of age) in rats pretreated between two and 21 days. However, rats pretreated when they were at least 22 days old did display sensitisation. The authors suggested that this difference maybe due to the development of dopamine receptors, which occurs after rats are 20 days old.

Gender may also be a factor that influences sensitisation. Robinson (1984) and Camp and Robinson (1988) have both reported that female rats produce more 'robust sensitisation' to amphetamine than male rats. Glick and Hinds (1984) have reported similar findings for cocaine. In this study only the females, and not the males, developed sensitisation to the rotational behaviour induced by cocaine. Masur and Boerngen (1980) have also reported that male mice required less ethanol to produce an excitatory response than females. Robinson, Becker and Presty (1982) found that sensitised rotational behaviour to a single d-amphetamine dose only occurred in female and not male rats. In his review, Robinson suggested three possible

explanations for this gender difference. Firstly, Camp and Robinson (1988) reported that male rats could be split into two groups: one was easily sensitised and the other was more resistant. The male rats that became more easily sensitised had greater amounts of striatal dihydroxyphenylacetic acid than males that were more resistant to sensitisation but the females did not differ in this manner. A second reason is suggested to be male hormones. Robinson, Becker and Presty (1982) found that removing endogenous gonadal hormones in adult rats significantly enhanced sensitisation to amphetamine. However no effect was found if female ovarian hormones were removed. Other studies have found similar results (see Robinson 1988 for review). The data suggests that the presence of a testicular hormone suppresses sensitisation. A possible explanation for this is given that these hormones have a suppressive effect on the 'hypothalamo-pituitary-adrenal axis, which overlaps with the areas of the brain posited to become sensitised'.

1.4 Animal Studies of Wanting and Liking

The incentive-sensitisation theory posits that the incentive motivation processes outlined by Bindra and Toates can be subdivided into at least two components – 'wanting' and 'liking'. That is, the psychological process and neural substrate responsible for determining incentive value (wanting) is separate from the psychological process and neural substrate that mediates pleasure (liking). To fully understand this idea it is necessary to provide a more detailed definition of what wanting and liking mean in the context of the incentive-sensitisation theory.

The wanting system is best understood as a system for attributing 'incentive salience'. Robinson and Berridge (1993) defined incentive salience as 'the attractiveness of external stimuli, events, places and their mental representations; their ability to capture attention'. Incentive salience is attributed to objects and events as a result of past association with activation of this neural incentive salience system (the mesotelencephalic dopamine systems). Robinson and Berridge (1993) claimed that the degree of incentive salience attributed to a stimulus is not fixed and will change according to the same interactions between internal physiological states and external stimuli, outlined by Bindra and Toates. They also claimed that the attribution of incentive salience is preconscious and that it is the result of incentive attribution that is experienced as subjective wanting or craving. In contrast, Robinson and Berridge

(1993) defined liking as 'the subjective experience of a sensation as pleasurable or hedonic and the underlying evaluative and neural processes that directly produce this subjective experience'. As with wanting they maintained that the evaluation of a stimulus as pleasurable or aversive is preconscious and that it is the result of this process that is experienced as subjective pleasure.

According to the incentive-sensitisation theory incentive salience attribution is normally 'triggered by a pleasurable experience'. However, under certain conditions wanting and liking can become dissociated when artificial incentives 'bypass sensory receptors and activate the neural system of incentive salience more directly'. One of these conditions is drug use. In drug use, the neurones associated with the wanting system (but not the liking system) are directly sensitised by the drugs, leading to a greater attribution of incentive salience to drugs and their cues, compared to other non-drug stimuli. This results in an increase in wanting in the presence of drugs and their cues. In drug addiction, the incentive-sensitisation theory posits that drug use results in an excessive degree of incentive salience being attributed to drugs and their related cues, leading to craving and compulsive drug-use. It is this process that can lead to a dissociation between wanting and liking.

1.4.1 Measuring Wanting and Liking in Animals: The Taste Reactivity Test

Most of the evidence for the distinction between wanting and liking comes from comparing wanting and liking in animals. Originally consumption, preference testing, and goal-directed behaviour (e.g. bar pressing) were considered measures of both liking and wanting as they were seen as a unitary process. However, these methods do not measure liking directly as they measure the outcome behaviour. That is, they are measures of the actual decision that an organism makes. Robinson and Berridge (Robinson and Berridge 1993; 2001; Berridge 1996; 2000a) therefore claimed that these behaviours are measures of wanting, as they do not directly measure the organism's evaluation of the pleasure experienced. Therefore liking can only be inferred from measures of consumption and preference. Thus, Berridge (1996) claimed that consumption and preference tests only measure wanting.

Instead, it has been suggested that liking can be measured using the analysis of affective reactions. Steiner *et al* (2001) defined affective reactions as 'distinctive, species-typical patterns of responses that have been claimed to reflect emotional

responses'. Although largely ignored at the time, Darwin (1872) was one of the first researchers to claim that affective reactions in animals and humans reflect emotional impact. More recent researchers (Steiner 1974; Grill and Berridge 1985; Berridge 1996) have argued that affective reactions primarily reflect liking or palatability. In animals this has meant the application of the taste reactivity test (see Figure 1.5) originally developed by Grill and Norgren (1978). This involves placing the animal,

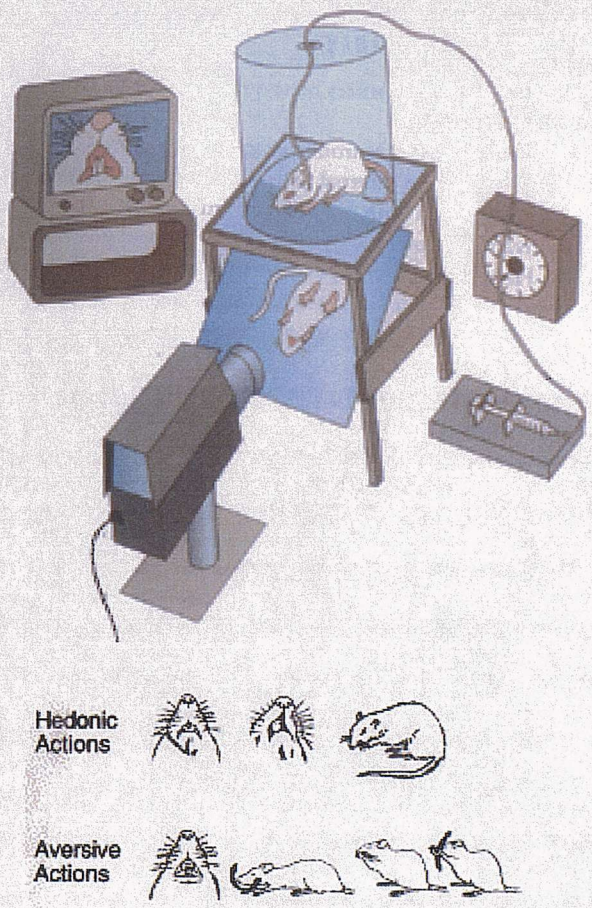


Figure 1.5 The taste reactivity test. Hedonic responses displayed are (from left to right) tongue protrusions, lateral tongue protrusions and paw licks. Aversive response displayed are (from left to right) gapes, headshakes, face wipes and forelimb flails. Taken from Toates (2001) and Berridge (1996).

usually a rat, on a glass base with a mirror underneath and videotaping the facial and bodily responses of the rat to solutions administered either intracranially or orally. Ingestive (tongue protrusions, mouth movements) and aversive (gapes, head shakes, passive drips, fluid expulsions, etc) responses are then observed frame by frame. Ingestive responses serve to move fluid to the back of the mouth to be swallowed and

aversive responses serve to expel fluid. Thus, by categorising and quantifying a rat's affective reactions into ingestive and aversive responses, a measure of how much a solution is liked can be assessed, independently of how much it is wanted. These ingestive and aversive responses correspond to positive and negative liking responses respectively.

1.4.2 Changing Wanting and Liking in Animals

Liking and wanting for rewards can be altered by manipulations of the brain. These essentially fall into three categories – administration of drugs that disrupt brain processes, surgical manipulation and electrical stimulation. Using brain manipulations and comparing their effects on affective reactions and measures of wanting it has been shown that liking and wanting can be changed independently. Furthermore, an indication of which neurobiological systems mediate each process have been obtained.

In many cases wanting and liking are changed together. One well know example of changing wanting and liking are brain lesions that cause "aphagia", that is they abolish normal feeding. Teitelbaum and Epstein (1962) reviewed literature that showed that damage to the lateral hypothalamus results in animals refusing to eat. This is so powerful that an individual will starve to death unless artificially fed. Cromwell and Berridge (1993) conducted a taste reactivity analysis in rats with lesions of the lateral hypothalamus. Normal rats respond with positive taste reactivity responses to sucrose. However, the rats with the lesions did not want the sucrose (it was not consumed when presented) and disliked the sucrose (ingestive responses decreased). Thus, damage to the lateral hypothalamus changed both wanting and liking for a normally wanted and liked food.

1.4.3 Dissociating Wanting and Liking in Animals

The examples above show that wanting and liking can be changed at the same time but the core evidence for Berridge and Robinson's theory comes from studies that change either wanting or liking independently of each other. There are a number of studies that have shown that wanting (consumption, goal directed behaviour) can be changed independently of liking (affective reactions) and vice versa.

Changes in wanting but not liking have been most successfully shown by manipulations that act upon dopamine/nucleus accumbens systems (see Figure 1.6) in the brain. Wise (see Wise 1985; 1994 for reviews) argued that drugs that block dopamine receptors disrupt the motivational effectiveness of rewards even though the drugs induce a certain amount of sensori-motor impairment, which was previously held to be solely responsible for the reduction in motivation for drugs. High doses of neuroleptics lead to decreases in psychomotor stimulant (cocaine, amphetamine) self-administration. However, Wise reported that low doses of neuroleptics actually lead to increases in stimulant self-administration. This indicated that motor impairment was not a sufficient explantion for the effects of neuroleptics as 'the animals respond more, not less, than usual'. Similarly, neuroleptics that lead to decreases in lever pressing for food rewards follow a pattern that cannot be fully explained as motor impairment. Wise reported studies in which neuroleptics were administered to rats trained to press a lever for food reward. The same doses of neuroleptic were administered to the rats over a period of days. After neuroleptic treatment, lever pressing progressively decreased until the response was extinct. However, for the first day responding was normal. If the reduction in responding was due solely to motor impairment, responding should have decreased on the first day as the same dose was used each day. Therefore it would have been expected that the same degree of impaired lever pressing would have been evident after each dose. Therefore, Wise argued that the neuroleptics were disrupting the rewarding properties of the food, leading to extinction of lever pressing as a result. Thus, indicating not just an affect on a motor system but also on a motivational system. Similar findings were reported with brain stimulation and other drugs of abuse.

Similarly, other manipulations of dopamine systems should disrupt the motivational effectiveness of rewards. Wise further suggested in his 'anhedonia hypothesis' that this was because dopamine systems mediate the subjective pleasurable effects of rewards. He held that drugs that block dopamine cause anhedonia, which is a 'reduction in the capacity for sensory pleasure'. Thus, animals stop working for a reward because it ceases to give pleasure. The anhedonia hypothesis is very similar to the Bindra/Toates models of incentive motivation. Using the terms of Toates' model it might be said to reduce the hedonic incentive value of rewards resulting in the reward being both less wanted and less liked. The view that dopamine mediates subjective pleasure has continued to be endorsed by other

researchers such as Koob (1996) and Di Chiara and Tanda (1997). It should be noted that Wise (1994) has since conceded that the anhedonia hypothesis was incorrect and opted for a distinction between wanting and liking. If dopamine does mediate the pleasurable effects of rewards then both measures of wanting and liking would correlate closely after manipulations on dopamine systems. However, a number of studies show that manipulations that act on the dopamine/nucleus accumbens system affect wanting but not liking. As mentioned previously these studies can be split into three categories and will be dealt with in the following order: drugs that manipulate dopamine transmission, destruction of dopamine neurons and electrical stimulation.

1.4.3.1 Dissociations by drugs that interfere with dopamine systems

The studies discussed below have used dopamine agonists and antagonists and observed their effect on the taste reactivity responses and wanting. In a number of reviews Berridge and Robinson (Berridge 1996; 1999; 2000a; Robinson and Berridge 1998) have cited the following studies as evidence for the dissociation between wanting and liking.

Treit and Berridge (1990) used the taste reactivity test to measure the responses of 20 rats to sucrose and quinine. As expected the sucrose elicited primarily ingestive responses and the quinine aversive responses. The rats were also tested after receiving drugs that act as dopamine agonists or antagonists (apomorphine, haloperidol and amphetamine) and the benzodiazepine agonist diazepam. They reported that the dopamine agonists/antagonists did not suppress hedonic reactions or increase aversive reactions to either sucrose or quinine. However, when diazepam was administered hedonic reactions increased and aversive reactions were decreased in response to sucrose. This suggested that although a large number of studies have shown that drugs that interfere with dopamine systems result in a reduction in consumption they do not necessarily enhance pleasure or reduce aversion for a reward.

Parker and Lopez (1990) reported the results of a study that appeared to show that dopamine manipulations could shift affective reactions under some conditions. Using the taste reactivity test, they reported that rats pretreated with pimozide (a dopamine antagonist) showed increased aversive reactions to five-minute oral infusions of a highly concentrated quinine solution, compared to control rats.

However, pimozide did not affect taste reactivity responses to low/moderate concentrations of quinine solution. Furthermore, affective reactions in response to a saccharin solution made unpalatable by pairing it with lithium induced illness, were not affected by pimozide. Leeb, Parker and Eikelboom (1991) found that pimozide had no effect on taste reactivity responses to a 10-minute infusion of sucrose on an initial taste reactivity trial. However, they reported that if there were more trials over a period of days then pimozide appeared to have some effect on the affective responses. On the third day, it was reported that during the first minute of the trial tongue protrusions were increased but then suppressed by the end of the 10-minute trial. They suggested that pimozide affects taste reactivity responses 'with repetition and over a prolonged exposure'. Using this explanation, they suggested that 'delayed suppression' of liking could account for Treit and Berridge's (1990) findings. The authors claimed that these results supported the anhedonia hypothesis and that delayed suppression of liking can account for the studies showing that dopamine mediates wanting and not liking.

Berridge (1996; Berridge and Robinson 1998) argued that this is not the case for two reasons. One reason, Berridge argued, is that pimozide can reduce responding to conditioned stimuli before the hedonic reward is experienced. Therefore, wanting behaviour can be reduced before pleasure from that reward has been experienced. Berridge argued that if wanting and liking were a unitary process then delayed suppression could not account for this because the reward 'would not yet have been experienced when the effect was observed'. Berridge claimed that the incentive-sensitisation theory can account for this in terms of pimozide interfering 'with the attribution of incentive salience' to both the incentive and the conditioned incentive. Secondly, Berridge (1996) noted that the literature supporting the anhedonia hypothesis has explained extinction of wanting (instrumental) behaviour by dopamine antagonists as being due to (the dopamine antagonists resulting in) an immediate suppression of liking. That is the extinction of wanting behaviour is due to the animal learning that the reward no longer gives pleasure. However, if pimozide produces delayed hedonic suppression then there should not be an immediate reduction in measures of wanting.

In a collaborative study Pecina, Berridge and Parker (1997) attempted to address the discrepancy. They reanalysed the Parker and Lopez data and revealed that the enhancement of aversive reactions was due to motor suppression caused by the

pimozide. The pimozide treated rats spent more time in front of the camera, resulting in inflated aversion scores. When this was corrected for the finding of enhanced aversive reactions was eliminated. In a new set of set of experiments they also provided evidence that these drugs reduced motivational effectiveness because they suppressed wanting but not liking (sensory pleasure). They assessed the ability of the pimozide to modify liking for sucrose and quinine in rats using the taste reactivity test. The experiments were conducted in two laboratories. After two adaptation trials, the rats received three trials in which taste reactivity responses to sucrose or quinine solution were compared after injections of Pimozide or a drug free solution. Pimozide was found to produce a general sensorimotor suppression of the capacity to emit taste reactivity responses (so affective reactions did sometimes appear to be altered) but after correcting the data for this the liking of the solutions were still not shifted by the pimozide. The authors concluded that pimozide suppresses wanting but not liking and was supportive of the incentive-sensitisation literature. They also suggested that previous studies might have been misled into believing that pimozide produced a reduction in liking (anhedonia) because of the sensory motor impairment. It might be argued that motor impairment is also one reason for the reduction in the wanting behaviours (lever pressing, etc). This is something the authors above have not discussed.

More recently, Kaczmarek and Keifer (2000) reported the effects of injections into the nucleus accumbens of *d*-amphetamine (a dopamine agonist), raclopride (a dopamine antagonist) or saline on taste reactivity and consumption for a 10% ethanol solution. They found that both the *d*-amphetamine and the raclopride reduced consumption of ethanol but had no effect on taste reactivity responses. The authors noted that the *d*-amphetamine decreased consumption, when it was predicted to increase consumption. They suggested that this might have been for two reasons. One is that the *d*-amphetamine was administered systemically (as opposed to microinjections directly into brain structures). They noted that previous research has shown that whereas microinjections cause increases in self-administration, some studies have reported that systemic presentations of dopamine agonists can reduce self-administration. Secondly, they suggested that the dose of *d*-amphetamine might have caused a ceiling effect. That is, the dose may have raised dopamine levels so high that the 'reinforcement was maximal and could not be advanced by further alcohol consumption'. So the rats drank less because doing so did not 'advance their

reinforcement experience'. In any case, even though *d*-amphetamine was predicted to result in an increase in ethanol consumption, a dissociation between wanting (consumption) and liking (taste reactivity responses) was found.

Wyvell and Berridge (2000) used a pure conditioned incentive paradigm, designed to rule out the role of reinforcement, in order to investigate the role of dopamine function in wanting. They studied the effect of amphetamine (a dopamine agonist) injections to the shell of the Nucleus accumbens on cue-elicited (light) lever responding for a sucrose solution. They found that amphetamine increased lever responding when no cues were present which was attributed to sensorimotor arousal. However, when the cue was presented, lever pressing increased far in excess of this general increase in responding. After the cue was withdrawn, responding decreased again. In a second experiment, they administered this same amphetamine treatment to rats, while they underwent the taste reactivity test. They found that the amphetamine failed to make the sucrose solution more palatable. This indicated that liking for the sucrose was not increased although the same amphetamine treatment increased lever pressing (wanting) for the sucrose. In a follow-up study, Wyvell and Berridge (2001) demonstrated that amphetamine pretreatment resulted in increased responding to cues (associated with sucrose as in the previous study) when the rats were in a drug-free state.

1.4.3.2 Dissociations caused by lesions

Similar dissociations between wanting and liking have been shown in studies that selectively cause lesions of dopamine/nucleus accumbens systems. For example, Berridge, Venier and Robinson (1989) found that the destruction of certain dopamine neurons with 6-hydroxdopamine (6-OHDA) lesions that cause aphagia (failure to eat) and adipsia (failure to drink) failed to change affective taste reactivity patterns. Eleven rats with 6-OHDA lesions were compared on their consumption and taste reactivity responses to sucrose, NaCl, HCl and quinine solutions. Although the rats refused to consume the solutions, their liking, as measured by the taste reactivity test, was not reduced. However, in this study flaws were noted concerning the lack of full dopamine depletion (only 85% was achieved) and dopamine depletion was not measured in all the relevant brain structures (not measured in nucleus accumbens). Berridge and Robinson (1996 as cited in Berridge 1996) addressed these issues in a

series of follow-up studies. In these studies the lesions caused 98-99% depletion of dopamine in the nucleus accumbens and neostriatum. The results confirmed the earlier study. Unconditioned taste reactivity responses elicited by quinine and sucrose remained unchanged in the rats after surgery, despite the almost complete depletion of dopamine. Furthermore, they demonstrated that dopamine depletion did not interfere with the rat's ability to learned conditioned taste aversions, indicating that liking could be altered irrespective of dopamine depletion. They tested 95% dopamine depleted rats in response to a saccharin solution and again after three pairings with lithium induced illness. All the rats displayed positive taste reactivity responses on their first encounter with the saccharin, in the same manner as normal rats. However, after pairing with the illness, both dopamine depleted and control rats, displayed aversive reactions to the same saccharin solution. Their positive hedonic taste reactivity patterns could also be enhanced by administration of diazepam (a benzodiazepam agonist). The results demonstrated that despite elimination of wanting, liking was still present and could actually be increased or suppressed without changes in wanting. Thus, Berridge stated that the difference between normal rats and dopamine-depleted rats 'appears to be solely a difference in food wanting' and not liking.

Lesions of other neurotransmitter systems and brain areas have also been shown to dissociate wanting and liking in some cases. One other brain area is the central nucleus of the amygdala. Lesions in this area do not produce aphagia but do disrupt some aspects of feeding. For example, Berridge (1996) noted that they are associated with loss of neophobia and block increased salt solution intake in salt depleted rats. Galaverna *et al* (1993) investigated further the consequences of amygdala lesions for salt appetite in sodium-depleted rats. The lesions blocked the post-sodium depletion intake as normal, so the rats were assumed not to 'want' the solution. Normally, after sodium depletion hedonic responses increase (normally they are aversive) in response to the salt solution. However, a shift in affective reaction patterns was also observed in the rats with the amygdala lesions. So although the taste reactivity test showed that rats with the lesions 'liked' the salt solution more after sodium depletion they did not appear to 'want' the sodium solution. However, unlike the dopamine manipulations the amygdala lesion did not result in a general reduction in wanting for food, as the rats continued to eat and drink normally. Instead the reduction in wanting seemed to be specific to the sodium depletion test.

1.4.3.3 Dissociations using electrical stimulation

Berridge (1996; 1999) noted that electrical stimulation (ES) of the lateral hypothalamus can motivate animals to engage in rewarding behaviours, such as eating, and can be rewarding in it's own right. One explanation for why ES increases eating is that it makes the food more palatable for the animal, perhaps by evoking pleasurable taste sensations that prime the animal by acting as 'appetisers'. The Bindra/Toates models might explain this in terms of the electrical stimulation eliciting a positive CMS. However, Berridge and Valenstien (1991) found that ES initiated eating in rats but this was not accompanied by an overall increase in hedonic taste reactivity responses. In fact, the rats responded with an enhancement of aversive reactions. They used the taste reactivity test to measure affective reactions during eating with periodic stimulation of the lateral hypothalamus. ES did not increase positive reactions in 5/6 tastes. The only exception was for a taste that was normally very unpalatable (quinine). However, in response to a normally palatable food (sucrose) aversive responses were actually increased. Berridge and Zajonc (1991) also found that the same phenomena could be observed using cooling of the hypothalamus.

1.4.4 Neurobiological Systems Associated with Liking

Whereas wanting has been associated with dopamine systems, liking has been associated with other systems. To date there is less research in this area and as a result it is unclear exactly what brain systems mediate liking. Berridge (1996; 2000a; 2003) has suggested a number of brain systems but has specifically highlighted the opioid system and Benzodiazepine drugs that affect the neurotransmitter GABA (γ-amino-butyric-acid). Robinson and Berridge have maintained that although wanting and liking can be dissociated they usually have a complex interaction. They have argued that usually liking can act as a trigger for wanting. Therefore, the studies that have been used to indicate those systems associated with the liking system are those that have observed interventions that increase taste reactivity responses but also often show increases in measures of wanting (e.g. consumption).

One system suggested is the opioid system. Berridge (2000) suggested that this system mediates 'positive hedonic palatability'. When injected into some brain structures (nucleus accumbens shell, hypothalamus, amygdala and tegmentum) opioid

agonists, such as morphine can induce feeding. For example, Bakshi and Kelley (1993) measured feeding and drinking after infusing morphine into the nucleus accumbens and striatum. They found that the morphine increased feeding but not drinking. However, studies of this type do not indicate that opioid systems are actually related to liking as they only rely on measures of wanting such as consumption rather than the taste reactivity test. Therefore, only studies that use taste reactivity measures can properly investigate this question. A number of taste reactivity studies have shown that opioid administration results in an increase in liking as measured by the taste reactivity test. Doyle, Berridge and Gosnell (1993) and Parker *et al* (1992) have reported that morphine suppresses aversive reactions to quinine and increases ingestive responses to sucrose, as measured by the taste reactivity test. Pecina and Berridge (1995; 2000) have also reported that morphine-induced increases in wanting for sucrose were accompanied by an increase in ingestive taste reactivity responses.

Berridge and Pecina (1995) provided a review of the literature and noted the ability of high doses of benzodiazepine agonists (BZD) to increase food and fluid consumption. The fact that they trigger feeding might at first appear to suggest an increase in wanting. However, they reported that BZDs selectively increased the consumption of more palatable food and drink. For example, they cited a study by Cooper and Yerbury (1988) who found that clonazepam selectively increased 0.05% saccharin solution consumption compared to water or 0.01% saccharin solution. They suggested that BZDs selectively 'multiply the pre-existing hedonic palatability' of the saccharin but not the water. Thus, they influenced the consumption of the palatable solution but consumption of water was not affected. Berridge and Treit (1986) investigated this further using the taste reactivity test. They gave rats infusions of sweet sucrose, sour HCl or bitter quinine after an injection of the BZD agonist chlordiazepoxide. They found that ingestive taste reactivity responses were increased but that aversive responses were not affected (except a slight decrease in response to the HCl). The authors concluded that the BZD agonist had enhanced the "positive evaluation of palatability". A second study (Treit, Berridge and Schultz 1987) showed that a BZD antagonist prevented the enhancement of ingestive responses by a BZD agonist and Berridge (1988) replicated these findings. Berridge (Berridge and Pecina 1995; Berridge 1999) suggested that the finding that BZD agonists selectively enhance ingestive responses and not aversive responses has led to the suggestion that

not only can wanting and liking be dissociated but that liking can be further subdivided into dissociable components of 'positive hedonic evaluation and aversive evaluation'.

1.5 Evidence for Incentive-Sensitisation Theory in Humans

1.5.1 Sensitisation in Humans

There is considerably less research on sensitisation in humans compared to animals. The focus has mainly been on studying animals because of the difficulties of studying sensitisation in humans. There are few direct studies of psychomotor sensitisation in humans and instead the evidence cited has focussed on studies that show sensitisation to the negative subjective effects of drugs (e.g.paranoia, psychosis), most notably studies of amphetamine and cocaine psychosis. These studies suggest that sensitisation to some drug effects can occur in humans. In addition, studies on the priming effects of drugs and reactivity to drug cues suggest that sensitisation can occur to the incentive motivational effects of drugs.

1.5.1.1 Psychomotor sensitisation and sensitisation to the negative subjective effects of drugs

Strakowski *et al* (1996) cited a number of studies that suggested that sensitisation occurs in humans. For example, Bell (1973) administered methamphetamine to 14 amphetamine addicts of which 12 developed amphetamine psychosis. The other two users were later found not to have used amphetamine above 'therapeutic doses'. Amphetamine psychosis is characterised by hallucinations, obsessional behaviour and paranoia. Bell concluded that previous experience with amphetamine reduces 'the threshold for future psychotic reactions to stimulants'. Sato *et al* (1983) found that amphetamine psychosis could be induced in ex-amphetamine addicts using very small doses of methamphetamine. Similarly, Satel, Southwick and Gawin (1991), in interviews with 50 cocaine users, reported that cocaine psychosis/paranoia had a more rapid onset after drug ingestion over time and became worse with continued cocaine use, even in three patients who reduced their cocaine doses. Brady *et al* (1991) reported that, in cocaine addicts, cocaine psychosis was also

more frequent and required less of the drug over time. Furthermore, Sax and Strakowski (2001) noted that clinical observations suggest that the dosing pattern associated with sensitisation to stimulants in animals is very similar to that seen in the early stages of stimulant abuse. That is, intermittent use, followed by an increase in frequency of use over time.

A few other studies have shown evidence that sensitisation can occur in humans. Bartlett *et al* (1997) interviewed 40 cocaine dependent patients. Many patients reported that repeated use resulted in increases in cocaine effects. The highest reported increases were for unease/paranoia (65%), Jitteriness (47%) and delusions (27%) although some patients also reported increases in libido. They then classed the patients as 'sensitised' or 'non-sensitised' based on whether paranoia occurred at low doses or worsened with repeated cocaine use. They noted that the sensitised patients showed longer regular cocaine use and lower dose escalation over time. Bartlett *et al* also noted that sensitised patients appeared more prone to relapse. They found that there were a larger number of rehospitalisations among the 'sensitised' patients compared to the 'non-sensitised' patients. Szechtman *et al* (1988) gave 12 apomorphine injections, every two weeks to 5 normal volunteers. After repeated injections onset of yawning, in response to the apomorphine, was more rapid and the time of peak activity was consistent with a sensitised response. However, other drug effects such as nausea and hyperthermia showed tolerance. Tenuous evidence also comes from Nyberg *et al* (1993). They found that the birth places (seven hospitals) of 200 opiate and amphetamine addicts in Stockholm was highly uneven with far more addicts being born in some hospitals compared to others. There was no difference in the babies according to residential area. However, the local hospitals did differ in their practices of administering anaesthetic and analgesic drugs during labour. The authors cited evidence (Jacobson *et al* 1988; 1990) that some form of 'imprinting' can occur in newborn children during birth as a result of anaesthetic drugs. These results and the author's discussion of 'imprinting' resemble the theory of sensitisation. The results could therefore suggest that neural-sensitisation occurs in the child during labour. This might explain the higher incidence of drug addiction in these children in later life.

The studies above only provide evidence that suggests that sensitisation occurs in humans. Controlled studies of sensitisation in humans are very few. However, Robinson and Berridge (2000; 2001) cited two controlled studies that they argued

provide direct evidence for sensitisation in humans. Strakowski *et al* (1996) examined behavioural sensitisation to repeated *d*-amphetamine challenges in 11 normal volunteers with no history of stimulant use. They were given two doses of amphetamine, separated by 48 hours, alternated with two doses of matched placebo. It was found that the second dose of amphetamine elicited increased eye-blink rates and symptoms of amphetamine use (activity/energy level, mood, rate and amount of speech) compared to the first amphetamine dose. In a follow-up study Strakowski and Sax (1998) repeated the previous study but added a 3rd amphetamine dose and added a measurement of subjective drug effects and liking. They found that eye blink rate and increased activity/motor ratings progressively increased following all three amphetamine doses. However, a clear progression was not observed for elevated mood and drug effect. This difference was attributed to the small sample size and individual differences in susceptibility to sensitisation. Finally, in a more recent paper Sax and Strakowski (2001) reported the preliminary findings of a third similar study that are consistent with these two studies.

The studies discussed above provide provisional evidence that sensitisation occurs in humans. However, some researchers have also failed to find evidence for sensitisation in humans. Strakowski *et al* (1997b) repeated their previous studies but using patients hospitalised for their first psychotic episode. Each patient received two doses of amphetamine, separated by 48 hours. However, in contrast to their other studies no evidence of sensitisation was found, as indexed by eye-blink rates, speech, mood levels and activity levels. Similarly, Rothman *et al* (1994) studied sensitisation in humans using cocaine. They measured heart rate, respiratory rate, pupil diameter, hormones (prolactin and cortisol), EEG and subjective responses of drug effects in 25 cocaine users. Participants were administered a single set of cocaine injections on one day and a challenge injection on the following day. They found no evidence for behavioural sensitisation to the effects of cocaine. In a follow up study (Rothman *et al* 1996 in Gorelick and Rothman 1997) the study was repeated using four daily sensitisation administrations of cocaine. Again they found no evidence for sensitisation. The authors suggested that their lack of findings might have been because their participants (due to prior cocaine use) may have already undergone the maximum possible sensitisation they were susceptible to. In a reply to this study Strakowski *et al* (1997a) agreed with this explanation for both their negative findings and Rothman *et al*'s studies. They also argued that they would not have expected,

from animals studies, the physiological measures used in the Rothman *et al* study to be sensitised by cocaine use. Finally, Wachtel and De Wit (1999) attempted to replicate the study by Strakowski *et al* (1996). They examined the behavioural responses to two doses of oral *d*-amphetamine (20mg), alternated with placebo in 16 people. They found no evidence that behavioural sensitisation occurred. However, they suggested that the negative result might have been because they did not exclude participants that had a history of nicotine and caffeine use.

1.5.1.2 Sensitisation to the incentive motivational effects of drugs in humans

The literature also suggests that prior drug taking can sensitise humans to the incentive motivational effects of drugs. These studies have shown that prior drug use and the level of dependence can render drug-users more sensitive to drug- or cue-induced wanting behaviours (subjective wanting, attentional biases, consumption). For example, ingestion of small (priming) doses of a drug or exposure to cues associated with drug administration are recognised by researchers (Shiffman 1986; de Wit 1996; Shaham *et al* 2003) to be a major cause of relapse amongst drug abusers, even after long periods of abstinence. Several studies have shown that priming doses of drugs increase measures of wanting (e.g. Ludwig, Wikler and Stark 1974; Jaffe 1989; Rose and Duka 2003). These studies are discussed in sections 1.2.3 and 6.1 and so will not be covered in detail here. More importantly for this section, some priming studies have demonstrated that the effectiveness of priming in increasing wanting is related to the severity of dependence. Meyer (2000) noted that the 'priming efficacy' of low doses of alcohol is related to the severity of alcohol dependence. For example, Hodgson *et al* (1979) primed 20 moderately or severely dependent alcoholics with 15ml of vodka, 150ml of vodka and placebo (on different days). Three hours later the alcoholics were asked to drink at least one of five alcoholic test drinks. They found that a priming effect was only evident if dependence was taken into account. The severely dependent alcoholics consumed the test drink quicker after the high priming dose (150ml vodka) than after the low or placebo priming doses. However, the opposite was found with the moderately dependent alcoholics. They actually consumed the afternoon drink slower after the high dose compared to the low and placebo doses. A follow-up study was conducted by Stockwell *et al* (1982). This study again used 20 moderately or severely dependent alcoholics. They all took part

in four conditions that each took place on a different day. In two conditions, they were given a 60ml priming dose of vodka and told they had received alcohol and then on another day they received the same dose but were told they had received placebo. In the other two conditions they received placebo and were told they had received placebo and then in the other condition told they had received alcohol. At intervals up to 60 minutes, they took a number of behavioural and subjective measures. They found that the severely dependent drinkers were more inclined to drink alcohol after the alcohol dose than after placebo and that it was irrelevant as to whether they were told they had been given alcohol or placebo. The moderately dependent drinkers were more inclined to drink alcohol after receiving alcohol if they had been told that it did contain alcohol.

Similarly, the ability of drug related cues to elicit wanting is related to the level of dependence. For example, Monti *et al* (1993 as cited in Rohsenow *et al* 1994) reported that scores on an alcohol dependence questionnaire were related to cue induced subjective desire for alcohol. That is, the desire to drink after the cue was presented was higher in the more dependent drinkers. Glautier and Drummond (1994) reported the findings of a study in which alcohol dependent patients were asked to look at and smell an alcoholic beverage. They found that the higher the level of dependence, the higher was the desire to consume alcohol in response to the alcoholic beverage.

Research has also found that attentional bias to drug-related stimuli is related to the level of drug use. Studies (Waters and Colin 2000; Zack *et al* 2001) have shown that abstinent smokers show an increased attentional bias (as measured by a Stroop Task) to smoking related visual words, compared to nonabstinent smokers. More recently, Bradley *et al* (2003) demonstrated that attentional biases (as measured by a visual probe task) to smoking related visual cues was greater in smokers, compared to non-smokers. Attentional bias was also greater in those smokers that had made a greater number of quit attempts. Townshend and Duka (2001) reported that this is also the case with alcohol. They demonstrated that heavy social drinkers had an attentional bias towards alcohol related images, compared to occasional users.

In conclusion the evidence for sensitisation in humans is limited and far from conclusive, with some negative findings. However, the existing studies do suggest that sensitisation can occur in humans. It should also be noted that many of the

existing studies on sensitisation in humans focussed on stimulant drugs such as cocaine and amphetamine, rather than alcohol.

1.5.2 Dissociation of Wanting and Liking in Humans

As with the research on sensitisation, the human evidence for a dissociation of wanting and liking is less comprehensive than the animal research.

1.5.2.1 Selective sensitisation of wanting but not liking

Some of the studies investigating sensitisation in humans, discussed above, found evidence that liking was not sensitised although sensitisation occurred in other systems. Although the researchers did not draw the theoretical link to the dissociation of wanting and liking their data does suggest that wanting and liking are mediated by different brain systems. In the Strakowski and Sax (1998) study they found that although the participants showed psychomotor sensitisation to amphetamine the self-report ratings of drug liking did not show a significant difference between the amphetamine doses. This suggests that drug liking scores were not sensitised by repeated amphetamine administration while the psychomotor system was. In Bartlett *et al*'s (1997) interview study they found that only 12.5% of patients reported an increase in euphoria after repeated use of cocaine. This suggests that drug pleasure does not necessarily increase with repeated drug administration and thus suggests that drug liking is not sensitised.

1.5.2.2 Kahneman, utility and dissociations of wanting and liking

When discussing the dissociation of wanting and liking in humans, Berridge (1999) has drawn upon the work of Kahneman (Kahneman and Snell 1992; Kahneman, Wakker and Sarin 1997) and the concept of utility. Kahneman and colleagues have applied the term utility to describe qualitative outcomes. Kahneman (1994 as cited in Berridge 1999) distinguished between experienced utility and decision utility. Experienced utility is the hedonic value (likes) of an outcome and decision utility is the degree to which an outcome is wanted (or unwanted). For a coherent and rational mind you would expect these two types of utility to correlate

closely. That is if an event was pleasant, it should be desired again. This is similar to the Bindra/Toates notion that organisms pursue stimuli and events that are pleasurable and that the organism both likes and wants. However, under certain conditions Kahneman claims that these two types of utility diverge in real life and this is taken as an indication that on some measurable level wanting and liking are distinct. Kahneman *et al* (1993) noted that decisions are often controlled by hedonic predictions. That is, people will choose those events that lead to the most pleasure or the least displeasure. They also noted that these hedonic predictions rely on memories of past experiences. Therefore, it is expected that events will be liked if they are remembered as pleasant and disliked if they are remembered as unpleasant.

Kahneman *et al* (1993) reported a dissociation between decision utility (wanting) and remembered experienced utility (liking) for a painful procedure, whereby the result was that the participants showed a preference for a more painful procedure. Berridge (1999) claimed that this represented a dissociation between wanting and liking. Thirty-two participants were exposed to two aversive procedures – a short trial and a long trial. In the short trial the participants had to immerse their hands in tubs of cold water (14°C) for 60 seconds. In the long trial the participants again immersed their hands in cold water (14°C) for 60 seconds but then kept it there for a further 30 seconds in which period the temperature was increased to 15 °C. Throughout each trial the participants gave an 'online' measure of discomfort on a potentiometer with an array of 15 LEDs. By adjusting the potentiometer participants could control the number of LEDs lit and provide a measure of their discomfort. A computer sampled the potentiometer five times a second and calculated one second means. Participants were then asked at the end, which trial they would wish to repeat if given the option and which trial was most unpleasant. The online ratings of discomfort were the same in both trials when the water was at 14°C. The rating of discomfort dropped significantly when the temperature was increased to 15 °C but this temperature was still reported as distinctly unpleasant. If people acted to minimise pain then no participants would have chosen the long trial as it contained the same amount of pain as the short trial, plus an extra 30 seconds of slightly less aversive pain. However, when asked at the end of the experiment, 22/32 of participants said they would want to repeat the long trial and they found it less painful, even though they experienced more pain in that trial. Kahneman *et al* (1993) replicated these findings in a second study without the 'online' ratings and Redelmeier and Kahneman

(1996) found a similar effect with a painful medical procedure. Therefore it is claimed that a dissociation between wanting and liking occurred because the participants decided (wanted) to choose the more painful procedure even though they reported less pleasure. However, whether this can be accurately be described as a dissociation is dubious. The dissociation was dependent on a memory distortion. That is, they remembered the more painful procedure as less aversive, even though it was not. Therefore, it might be more accurate to describe these findings as a dissociation between 'online' liking and remembered liking. The memory that the long trial was less aversive appears to have influenced the decision (wanting) to choose the more painful procedure but only because they thought that the long trial was least aversive. Thus, the remembered pleasure (liking) was the same as the decision (wanting) for the long trial so this cannot be considered good evidence of a dissociation between wanting and liking.

1.5.2.3 Selective changes in wanting and liking by neurotransmitter agonist/antagonists

More convincing evidence comes from studies that have measured subjective ratings of liking (liking of drug effects, euphoria) along with measures of consumption and craving. Some of these studies have shown that wanting for drugs can diverge from the subjective pleasurable effects of drugs after the administration of drugs that block or facilitate neurotransmitter transmission. Opioid systems have been implicated as being involved in mediating liking but not wanting (see 1.4.4). Therefore, the administration of opioid antagonists would be expected to reduce liking but not wanting and vice versa for opioid agonists.

Several studies exist that are suggestive of this viewpoint. For example, Drewnowski *et al* (1992) injected 14 female binge eaters and 12 normal control women with an opiate antagonist (naloxone), opiate agonist (butorphanol tartrate) or saline solution. They then allowed the women to select and consume 20 samples of snack foods ('of varying sugar and fat content') and give liking ratings for each of them. They found that naloxone reduced liking ratings for all the participants. However, consumption of the snack foods was not significantly reduced in the normal women (although it was in the binge-eaters). In a follow-up study Drewnowski *et al* (1995) injected 41 women with the same solutions and measured liking ratings and

consumption practices. Twenty of the women were binge eaters and 21 non-binge eaters. During drug infusion the women tasted and rated 20 sweetened dairy products and eight snack foods. They found that naloxone suppressed the liking ratings in all participants but again consumption was not affected in the non-binge eaters (although it was still lowered in the binge eaters). Despite the hedonic shift, the consumption of sweet and high-fat food after naloxone did not necessarily change. These studies indicate that liking may not in some cases be as closely related to consumption (wanting) as the Bindra and Toates theories would predict.

Other studies by O'Brien, Stunkard, and Ternes (1982) and Cohen *et al* (1985) have reported that naloxone reduces consumption but not subjective ratings of wanting (hunger) for food. However, two studies by Yeomans *et al* (1990; Yeomans and Gray 1997) have attributed this reduction in consumption as due to a decrease in food liking. Yeomans *et al* (1990) found that nalmefene (a more potent derivative of naloxone) reduced consumption of food but did not affect subjective ratings of food wanting. Furthermore, this effect was more marked for highly palatable foods. In another study, Yeomans and Gray (1997) investigated the effect of naltrexone on food consumption, subjective liking ratings, and subjective appetite during a meal. They found that naltrexone reduced subjective liking for food and reduced overall food intake (between 18 - 28%, depending on food type) but did not affect ratings of appetite (wanting) measured immediately before the meal. The authors concluded, in both studies, that the reason for the reduction in intake was due to the reduction in the perceived pleasantness of the food.

The findings above suggest that under some conditions naltrexone can result in a dissociation between wanting and liking. However, Hetherington *et al* (1991) did not find that naltrexone had this effect. They gave male participants a test meal, after the administration of oral naltrexone or placebo. They reported that the naltrexone had no effect on ratings of food liking, hunger or consumption (although on this measure nausea was a confound). However, Hetherington *et al* did note opioid antagonists did not reduce food consumption by more than 20 - 38%. This suggests that the opioid system is not the primary system involved in wanting, even though the other studies suggest that they are successful in reducing liking.

As dopamine systems are thought to mediate wanting it would be expected that dopamine antagonists/agonists would affect wanting but not liking. Brauer and De Wit (1996) administered oral doses of *d*-amphetamine to ten participants

following pretreatment with the dopamine antagonist pimozide (1 or 2mg) or a placebo. They found that pimozide did not suppress subjective ratings of liking or wanting for the amphetamine but suggested that a higher dose of pimozide might have been needed. In a follow-up study Brauer and De Wit (1997) examined the effect of a higher dose of pimozide (8mg) on responses to d-amphetamine in 12 participants. Again the pimozide failed to suppress subjective liking for amphetamine. However, subjective ratings of wanting (for more doses of amphetamine) were suppressed by this dose of pimozide. In another study Brauer, Goudie and De Wit (1997) reported that dopamine antagonists suppressed subjective ratings of the euphoric effects of amphetamine in only two out 10 participants. Similarly, Ohuoha *et al* (1997) reported that subjective reports of the euphoric effects of cocaine are not affected by prior administration of dopamine antagonists. However, they also reported that dopamine antagonists did not affect craving for cocaine.

Berger *et al* (1996) measured dopamine levels in the brain and a subjective measure of craving (visual-analogue scale) in response to auditory and visual cues associated with cocaine. The experiment was carried out on 20 cocaine addicts. They found that exposure to cocaine related cues resulted in significant increases of subjective measures of craving compared to neutral cues. This was accompanied by increases in dopamine levels in response to the cocaine related cues. Furthermore, it was found that the administration of haloperidol, a dopamine antagonist, resulted in a reduction in craving in response to the cocaine related cues. This study suggests that wanting is related to dopamine but there was no concurrent measure of liking for the cues so it was not possible to ascertain if there were concurrent changes in liking. However, a study by Haney, Foltin and Fischman (1998) has shown that the administration of dopamine agonists can increase subjective wanting but not liking. They gave cocaine addicts the dopamine agonist Peroglide or a placebo and let them self-administer cocaine. Pretreatment with the agonist significantly decreased subjective reports of liking for the cocaine but at the same time increased subjective reports of wanting, compared to placebo.

Brauer *et al* (2001) investigated the effect of haloperidol on cigarette smoking. Twenty smokers were allowed to smoke nicotine or denicotinised cigarettes freely or under controlled conditions after receiving oral haloperidol or placebo. All participants took part in all conditions to control for individual smoking habits. They measured the number of cigarettes smoked and subjective ratings for the effects of

nicotine (including liking). They found that haloperidol did not have an effect on subjective ratings of liking for the cigarettes. However, the number of cigarette smoked by participants was reduced after receiving haloperidol showing a reduction in wanting.

There are few studies examining the effect of dopamine antagonists on wanting and liking for alcohol. Modell *et al* (1993) gave haloperidol or placebo to alcoholics, followed by 0.4 – 0.6g/kg ethanol as their preferred alcohol-containing beverage. They found that placebo treated alcoholics reported increases in subjective craving after drinking the alcohol and that alcoholics pretreated with haloperidol reported no increases in craving after drinking alcohol. These participants also consumed 25% less available alcohol. This suggests that dopamine antagonists might also reduce wanting for alcohol but as no measure of liking was included in this study it was not possible observe any dissociation between wanting and liking.

The studies above seem to be consistent with the findings from the animal literature. Drugs that interfere with dopamine transmission do appear to affect wanting but not necessarily subjective liking and those that affect opioid systems appear to affect subjective liking but have little or no effect on wanting. However, the studies above have not had the test of a dissociation between wanting and liking as their research aim and the authors have not commented on or followed-up any evidence of a dissociation between wanting and liking. Also there are only a small number of studies and they typically rely on small sample sizes (usually only between eight and 20 participants) and there were some discrepancies, such as the Ohuoha *et al* (1997) study. Furthermore, almost all of the animal and human studies that provide evidence of a dissociation have relied on some form of neural manipulation. These can therefore, be thought of as artificially induced dissociations, in that they have to be caused by a manipulation that the organism would not normally encounter in everyday life. How these might be generalised to dissociations between wanting and liking resulting from everyday drug use is not clear.

1.5.2.4 Human brain imaging studies: evidence for the neurobiological correlates of wanting and liking

Recent studies using brain-imaging techniques have also provided evidence that wanting and liking are associated with separate neurobiological systems (see

Figure 1.6). Although there are at present only a few studies, Robinson and Berridge (2000; 2001) have argued that the studies below show that wanting and liking are mediated by different brain systems by showing which brain areas are activated during wanting and/or liking for drugs. These studies provide some evidence to support the animal studies that different neurobiological systems mediate wanting and liking.

Breiter *et al* (1997) used functional magnetic resonance imaging (fMRI) to monitor increases and decreases in signals related to blood flow in the brain of cocaine addicts. They observed that the cocaine-induced euphoria/rush was correlated with increases in activity in the nucleus accumbens, the neostiatum, neocortical regions and the ventral tegmentum and decreases in the amygdala, temporal pole and medial frontal cortex. The structures where the increases occurred are the same structures implicated to be involved in wanting on the basis of the animal literature. This might suggest that these areas are involved in liking. However, Robinson and Berridge (2000) noted that 'there were more sustained changes in cerebral blood flow, which outlasted the euphoric effects and that correlated best with subjective craving reports for more cocaine'. Grant *et al* (1996) and Maas *et al* (1998) have reported that craving is correlated with increased glucose metabolism in the prefrontal cortex, amygdala and cerebellum. However, Wang *et al* (1999) found that cocaine related cues resulted in changes in PET signals in the orbitofrontal and left insular cortex.

Robinson and Berridge (2000) also cited studies that have shown increases in specific brain structures in response to drug related cues. Childress *et al* (1999) used PET scans on former cocaine addicts. They showed the former addicts and normal subjects videos of drug taking. They found that blood flow 'increased significantly in the amygdala and decreased in the caudate and lenticular nucleus' in response to watching the video. In comparison the normal subjects did not show any significant increases in blood flow in response to the drug related stimuli.

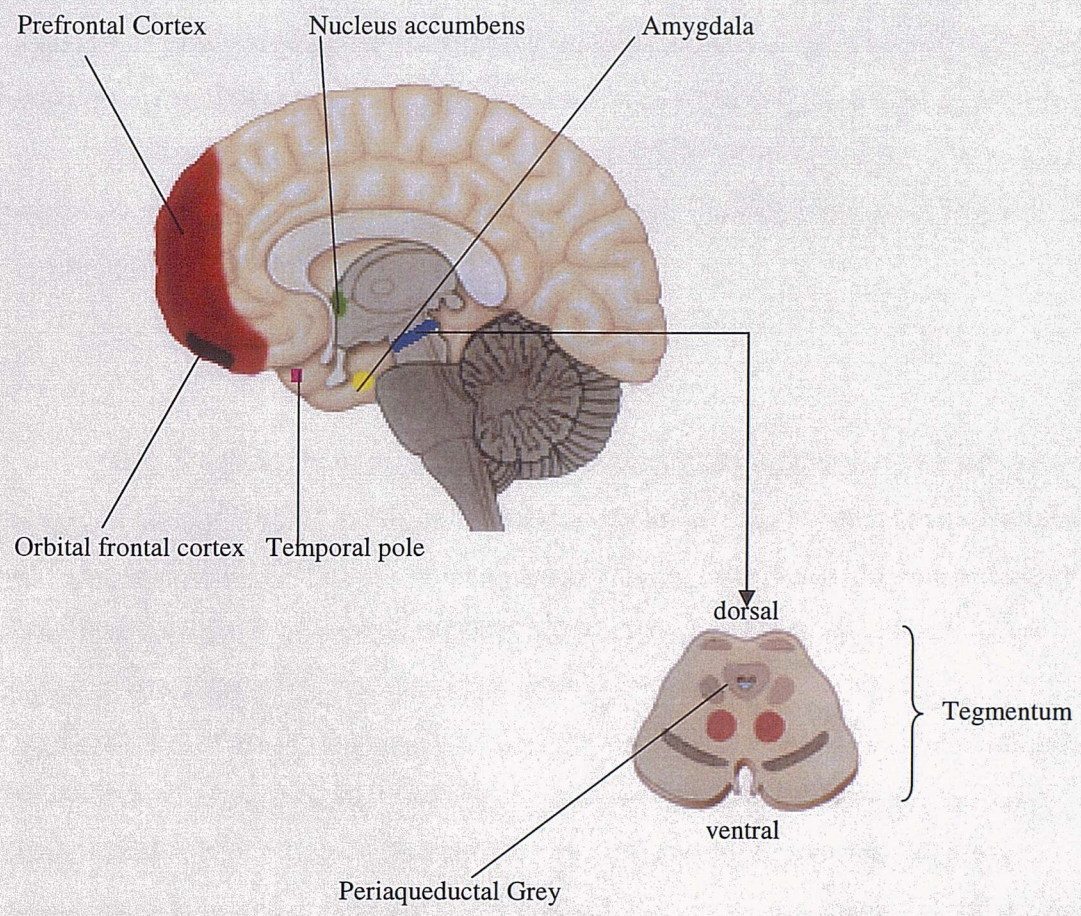


Figure 1.6 Brain regions associated with wanting and liking from human PET and fMRI studies. The regions labelled above all are part of or have connections to the mesotelencephalic dopamine system (see Figure 1.4). Constructed from Toates (2001) and Pinel (2003).

Similarly, Sell *et al* (1999) used PET scans to observe blood flow in heroin addicts in response to heroin itself or heroin related cues. After presentation of the cues and the heroin they observed increases in blood flow to the ventral tegmental area and the periaqueductal grey. Robinson and Berridge (2000) noted that the periaqueductal grey has many connections to the ventral tegmental area and is the 'origin of……dopamine projections to the nucleus accumbens and neocortex'. Brody *et al* (2002) took PET and fMRI scans in response to smoking-related cues (video and holding a cigarette). They reported that craving in heavy smokers was correlated with increased activity in the orbitofrontal cortex and prefrontal cortex. Due *et al* (2002) used fMRI to examine what brain structures were activated by the presentation of smoking related and neutral visual cues in (nicotine deprived) smokers and nonsmokers. In smokers there were greater signal increases in the mesolimbic

dopamine system after the presentation of smoking related cues. No differences were observed in nonsmokers following exposure to smoking related or neutral images.

Robinson and Berridge (2000) concluded that there are too few brain imaging studies to draw firm conclusions but they do appear to support the pattern predicted by the incentive-sensitisation theory.

1.6 Summary

This chapter discussed the incentive-sensitisation theory as an explanation of drug use. There have been a large number of studies that have provided evidence for the existence of sensitisation and some human studies have provided some support for this. There are also several animal studies have that demonstrated a dissociation between wanting and liking but these were been based on artificially induced neural manipulations and were focused on food, not drug reward. There are considerably fewer studies examining the dissociation between wanting and liking in humans. Although there are studies in the literature that appear to support the idea of a dissociation in humans, they have typically not had the investigation of a dissociation as their research aim. Therefore it is appropriate to carry out an investigation designed to directly test this hypothesis. Alcohol's wide use in society also provides an ideal position in which to investigate the claimed dissociation. If a dissociation could be demonstrated in drinkers, using stimuli that they would normally encounter in their everyday lives this would provide more convincing evidence of a dissociation. Thus, the aim of the current research was to extend the investigation of the dissociation between wanting and liking in humans, using alcohol.

CHAPTER TWO: MEASUREMENT OF WANTING AND LIKING IN HUMANS

As stated at the end of the previous chapter the main aim of the current research was to investigate the possibility of a dissociation between wanting and liking for alcohol in humans. Before this could be done it was necessary to consider how wanting and liking might best be measured in humans.

2.1 Measurement of Liking

Animal studies have used observation of affective reactions to measure liking, in taste reactivity tests. Two methods for the measurement of liking humans were used in the current research. One was a human version of the TRT. The other utilised subjective reports of liking.

2.1.1 A Human Taste Reactivity Test?

The TRT relies on observation of animal facial and bodily reactions in response to taste. A human analogue would use the measurement of human facial expression. Researchers, such as Panksepp, Knutson and Burgdorf (2002), have suggested the use of facial expression in the use of 'addiction related phenomena' and this has the advantage of being contiguous with the animal studies using the taste reactivity test. Indeed Wise (1994), although he contended that the taste reactivity test in rats only measures the consummatory responses of ingestion or rejection (and not liking), saw the study of human expression as more promising than those of animals. Wise suggested that human facial expressions, unlike the facial responses of rats, reflect much more than simply the components of ingestion or rejection. Therefore, they may be more likely to reflect liking. However, before the methods of measuring human facial expressions are examined it is necessary to consider if it is possible to generalise this method from animals to humans and if human facial expression is in fact a suitable analogue of animal taste reactivity.

Evidence suggests that although many affective reactions are species-specific, some affective responses are shared across rodents, primates and humans. Darwin (1872) was one of the first researchers to suggest that man *and* animals use facial and

bodily movements to express emotions. Furthermore, he suggested that emotions and their expression, like physical characteristics, are products of evolution. Darwin argued that emotions serve useful functions for an organism and showed how expression could be analysed in terms of adaptive behaviour patterns. For example, Darwin investigated the expression of disgust in humans. He noted that disgust is often experienced in the presence of tasting and eating. Thus, it is natural that its expression should primarily involve the movements around the mouth. These include opening the mouth, protruding the lips and making a sound that is similar to clearing the throat, to eject food from the mouth. He proposed that humans have inherited their expressions from their evolutionary ancestors and illustrated some of the similarities in expression between different species. Although Darwin was found to be wrong in some of his speculations, his claims are now largely accepted by modern theorists such as Ekman (1986).

More recent research has illustrated that some affective reactions are shared by several different species and can be placed on a theoretical 'evolutionary tree' of inherited affective responses. Thus, some affective reactions are held to be universal and shared by rodents, primates, and humans alike. For example, Brining, Belecky and Smith (1991) found that the taste reactivity responses of different species of rodents are related. They showed that hamsters share similar taste reactivity responses to rats, displaying similar positive reactions to sucrose (tongue protrusions) and aversive reactions (gapes, headshakes) to quinine. Steiner (1981 as cited in Ganchrow, Steiner and Dahner 1983) reported similar results by observing the gustofacial responses in newborn rabbits. Other studies (Steiner and Glaser 1984; 1995 in Berridge 2000b) have shown that primates emit facial reactions to the basic tastes in a very similar manner to humans, especially infant humans. These researchers even suggested that humans are more similar to great apes than great apes are to monkeys. Steiner *et al* (2001) stated that almost all primates emit facial reactions that are comparable to 'human-judged liking of the basic tastes'. Steiner *et al* (2001) compared the hedonic expressions of human infants to 11 non-human primates. They compared facial reactions to sucrose and quinine. They found that some are universal among all primates, such as gapes to bitter tastes. Other reactions are unique to only a few or one species, such as complex lip smacking in humans and great apes. They concluded that the degree of difference between facial reactions in primates is 'continuous and proportional to the phylogenetic distance between the species'.

One way that researchers have demonstrated evolutionary continuity in taste reactivity responses is by the use of allometric timing rules. That is, a timing rule dependent on size. Although reactions in different species might appear to be very different to the casual observer many differences are due to the speed at which responses are produced. Smaller species tend to produce faster taste reactivity responses than larger species and this is an example of the generation of allometric timing rules. Thus, despite differences in physical anatomy many taste reactivity components have been argued (Berridge 2000b; Steiner *et al* 2001) to be shared across species. For example, Steiner *et al* (2001) reported that the duration of a response is logarithmically scaled to species size (speed of response is indirectly proportional to body mass) and observed that the speed of tongue protrusions and gapes were closely related to species size across humans, apes and rats.

The foregoing suggests it may be possible to generalise the TRT across species and studies with human infants have supported this idea. Studies have shown that as with rats and primates, human infants also show innate, stereotyped responses to oral stimuli. Steiner (1974) examined the taste reactivity of newborn infants to the basic tastes. The infants were tested within a few hours of birth, before their first feeding, so they had no prior experience with any taste aside from amniotic fluid. All the infants displayed similar facial responses. It was demonstrated that the basic tastes of sweet and bitter elicited either negative or positive hedonic responses. Sweet sucrose elicited 'lip smacking, tongue protrusions and a relaxation of the muscles of the middle face and the occasional smile'. Bitter quinine elicited negative or 'aversive gapes, 'scrinching' of the eyebrows, retraction of the lips and wrinkling of the nose'. The salt, sour and other solutions elicited responses that appeared to lie in between the sweet/bitter extremes. These results have been replicated and expanded a number of times since with the same pattern of findings. For example, in a follow-up study Ganchrow, Steiner and Dahner (1983) showed that facial responses changed according to the concentration of oral stimuli (sucrose). Rosenstein and Oster (1988) examined the taste reactivity of infants to sodium chloride, citric acid, quinine and sucrose. Their results supported Steiner's findings that infants display differential facial expressions to different tastes.

Researchers (Izard 1971; Steiner 1974) have traditionally measured human adult facial responses using observational schemes and several well-validated methods, such as the Facial Action Encoding System (e.g. Katsikitas *et al* (1997) are

available. The observational technique involves observing, recording (on videotape) and coding huge numbers of patterns of facial motion. Hu, Luo and Hui (2000) noted that there are 25 detectable features involved in facial movement that need to be evaluated in terms of frequency and duration of movement. However, there are some problems associated with observational techniques of facial expressions. These techniques are very time consuming, requiring practice, and suffer from biases associated with inter-rater reliability. More recently, an alternative to using observational techniques has been suggested in the form of facial electromyography (EMG). The use of facial EMG was therefore considered for use in the current research.

2.1.2 Facial EMG as the Basis of a Human Taste Reactivity Test

EMG is a measure of muscle activity and so can be used to measure the responses of facial muscles. Fridlund and Cacioppo (1986) defined the EMG signal as 'a quasi-random train of motor unit action potentials discharged by the contraction of striate muscle tissue'. The signal can have a frequency range of several Hz to over 2kHz and amplitudes of micro Volts to several hundred micro Volts. EMG measures have a number of advantages over the observational method. Cacioppo *et al* (1986) and Vrana (1993) pointed out that they can sensitively assess covert activity of the facial muscles in a way that may not be visible to human observers. Fridlund and Izard (1983) have noted that EMG is not subject to the problems of reliability across observers associated with observation and the EMG signal is instantaneously detectable saving a lot of time. Thus, potentially EMG can provide a precise, sensitive, less biased measure of facial reactions.

A number of studies have shown that facial EMG can be used as a measure of liking in response to a variety of stimuli. These studies have been particularly successful in identifying the muscle groups associated with general positive and negative responses to stimuli. Increased activity in the zygomaticus major (cheek, used for smiling) region has been associated with positive responses and increased activity in the corrugator (brow, used for frowning) and levator labii (upper lip) regions has been associated with negative responses (see Figure 2.1 for location of facial muscle sites).

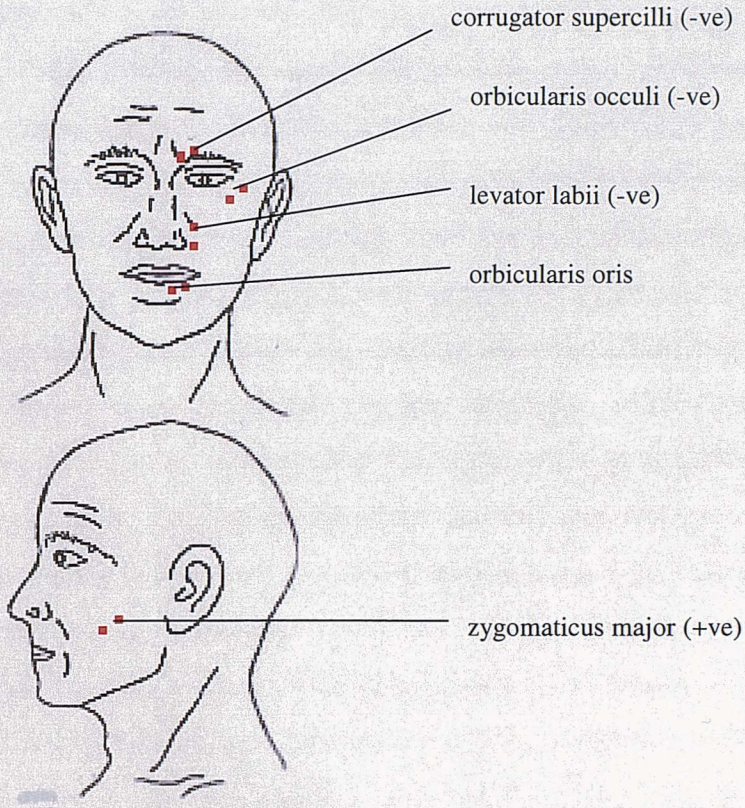


Figure 2.1 Electrode placement sites for recording facial EMG. Sites indicate location of facial muscles. '+ve' (positive) and '-ve' (negative) signs indicate whether that muscle region is associated with increased activity to either positive or negative affective stimuli in the literature. Derived from Fridlund and Cacioppo (1986).

2.1.2.1 Imagery studies

Facial EMG responses have primarily been studied in response to imagery. One of the first studies using EMG to measure facial response was a pilot by Izard (1971) using a 'graded anxiety-desensitisation imagery protocol'. A single female participant was presented with images ranging from those designed to evoke low through those designed to evoke high anxiety. It was found that corrugator EMG amplitude increased as the images became more anxiety provoking. Izard then proposed the use of EMG as a sensitive indicator of emotional states.

One of the researchers that has produced considerable evidence for the use of facial EMG as a measure of affect states is Ulf Dimberg. Dimberg (1982; 1987b) used imagery (happy and sad faces) to show differences in EMG facial patterns. Specifically, happy faces produced increased activity in the zygomatic region and sad and angry faces produced increased activity in the corrugator region. More recently, Sloan *et al* (2002) also showed that pictures of unhappy faces resulted in an increase in corrugator activity but happy faces resulted in an increase in zygomatic activity.

Dimberg (1986; 1987b) also used fear relevant slides (such as snakes) and fear irrelevant slides (such as flowers) as stimuli. He found that the fear relevant slides produced increased corrugator activity whereas the fear-irrelevant slides produced increased zygomatic activity. Dimberg and Ulrich (1990 as cited in Dimberg 1990) demonstrated that people respond with increased zygomatic activity to preferred natural landscape scenes. Zygomatic activity also significantly decreased when non-preferred scenes were presented. Finally, Dimberg (1987a) reported that pairing images with an aversive noise resulted in higher corrugator EMG responses to those images when they were presented alone and that this increase in responding was correlated with self-reports of fear. This indicated that EMG could index changes in the emotional impact of stimuli.

Vrana (1993; 1994) found that increases in corrugator activity were greater in anger and disgust imagery. Pleasure and joy imagery produced reductions in corrugator activity and increases in zygomatic activity. These studies found that disgust imagery resulted in increased activity in the corrugator region and large increases in the levator labii region. This is the region that lifts the upper lip and wrinkles the nose. The purpose of this being to close the nose and open the mouth in order to expel oral substances, as first observed by Darwin (1872). More recently Schienle, Stark and Vaitl (2001) reported disgusting pictures elicited higher levels of levator labii EMG activity compared to pleasant pictures. Arndt, Allen and Greenberg (2001) measured facial EMG in response to subliminal visual priming with either the word 'dead' or 'pain'. They reported increased corrugator during when the word 'dead' was presented.

Evidence from imagery studies shows that responses in the corrugator and levator labii regions are associated with negative images and responses in the zygomatic region are associated with positive images. These studies have also demonstrated that differences in affective responses to unpleasant and pleasant images can be measured reliably.

2.1.2.2 Auditory and painful stimuli

Differences in facial EMG levels have also been measured in response to auditory and painful stimuli. Dimberg (1987c; 1988 as cited in Dimberg 1990) measured facial EMG responses to auditory stimuli in the corrugator and zygomatic

regions. These were delivered via headphones as 75 decibels or 95 decibels. The results showed that the facial responses in the zygomatic and corrugator regions were differentially sensitive to auditory stimuli with different intensities. Specifically there was more activity in both regions at 95 decibels compared to 75 decibels but significantly more corrugator activity. The louder noise was held to be more unpleasant. Thus, this study supports the imagery studies, in that the more unpleasant noise elicited higher corrugator responses. Bolls, Lang and Potter (2001) allowed participants to listen to 60 second long radio advertisements and measured facial EMG responses. They reported that facial EMG can be used to assess the valence of adverts that differed in 'motional tone'.

Crombez, Baeyens and Eelen (1997) used painful heat stimuli (47 and 49 degrees Celsius) on the hand to elicit EMG responses in the corrugator and orbicularis occuli region (used in closing the eyelids). Both regions differentiated between low non-aversive heat and painful heat but the orbicularis region was sensitive to different levels of painful heat stimulation.

2.1.2.3 Taste Stimuli

More relevant to the current research are studies that show that facial EMG can be used to measure liking in response to taste. It appears that the only studies that have measured facial EMG in response to taste stimuli are a collection of studies carried out by Hu *et al* (Hu and McChesney 1999; Hu *et al* 1999; Hu, Luo and Hui 2000).

The Hu and McChesney (1999) study measured facial EMG and subjective ratings to water and pickle juice. The participants reported higher ratings of palatability to water than pickle juice. EMG activity in the levator labii region was higher during pickle juice than water and was higher generally than activity in the corrugator region. Tasting pickle juice was also found to produce higher responses in the zygomatic region compared to water. They concluded that facial EMG activity in the levator labii region was the most sensitive indicator of palatability.

The Hu *et al* (1999) study measured facial EMG and subjective liking ratings in response to a number of different tastes. It comprised of two experiments. In the first experiment responses to apple juice, water, soybean milk and pickle juice were measured. In the second experiment responses to sugar solution, salt solution and

water were measured. For each trial subjective ratings and EMG measures were obtained. Participants' showed positive ratings of liking for apple juice, water and sugar solution. Ratings of liking were negative for pickle juice, soybean milk and salt solution. Increased levator labii muscle activity was associated with the negative tastes while the positive tastes were associated with lower levels of levator labii activity. So responses to aversive tastes can be measured by increases in levator labii region activity.

Hu, Luo and Hui (2000) measured facial EMG (at the zygomatic, levator and corrugator regions) and subjective reports of liking in response to pickle juice and water. They found that there was a higher level of responding at the levator in response to water and pickle juice, compared to the zygomatic and corrugator. They concluded the levator labii was the most sensitive indicator of liking for taste.

The literature shows that EMG has been reliably associated with negative and positive emotional responses to a variety of different stimuli, including taste stimuli. Thus, facial EMG may provide a more convenient measure of taste reactivity compared to the observational techniques.

2.1.3 Subjective Measures as the Basis of a Human Taste Reactivity Test

The second option for measuring liking in humans is subjective report. Subjective measures often take the form of either single item questions or rating scales. These have been used very extensively in the literature and usually take the form of visual-analogue or numerical rating scales. For example, Zellner *et al* (1983) asked participants to provide liking ratings for the taste of drinks using a scale from –100 to 100, where –100 represented the 'most unpleasant imaginable' taste, and 100 represented the 'most pleasant imaginable' taste. Scales such as this have also been used to measure liking in drug experiments. Several studies (Wilkinson 1998; Watchel *et al* 2002; Justice and de Wit 2002) have used the Drug Effects Questionnaire (DEQ), which uses 100mm visual-analogue scales to measure dimensions such as 'liking for drug effect' and 'feeling of intoxication'.

Single item measures of liking provide an easy, convenient and nonintrusive measure of liking. However, several researchers have criticised the use of these measures and argued that more complex multi-item questionnaires (e.g. Cox, Tiffany and Christen 2001) are superior. For example, Tiffany, Carter and Singleton (2000)

noted that single item ratings might not be able to capture the precise semantic meaning of the phenomenon being investigated and highlighted concerns over the reliability and sensitivity of single item rating scales. Sayette *et al* (2000) reviewed evidence that showed that increasing the number of items could improve the sensitivity of the measure but also noted that the addition of too many items can interfere with the construct under investigation. They cited a study by Mark, Sinclair and Wellens (1991) who observed that participants' mood could be altered by the act of completing the Beck Depression Inventory. Despite these criticisms the use of rating scales may be acceptable in some cases. The above research was concerned mainly with the measurement of craving of which there is some disagreement over the exact definition (e.g. Sayette *et al* 2000). Thus, it is unsurprising that there would be difficulty selecting the words needed to capture the broad concept of craving on a single item rating scale. There is likely to be less confusion over the meaning of taste liking in the current research and so it should be easier to capture the exact meaning using a rating scale. There are also studies that have shown that rating scales can be sensitive to changes in an internal state. For example, de Graff (1993) reported that appetite ratings were highest before meal times, as would be expected and sensitive to changes in energy intake. There was also a good correlation between appetite ratings and food intake. It was concluded that subjective ratings could be a valid measure.

Although subjective report can be reliable, some researchers have suggested that subjective reports may not actually be accurate indicators of liking and can easily be distorted by other processes. Berridge (1996; 2003; Nesse and Berridge 1997; Berridge and Winkielman 2003) noted that subjective report might not be an accurate indicator of underlying motivational processes. According to Berridge conscious perception of pleasure 'is not a direct and faithful reproduction of an underlying core affective process' but rather is the 'product of an active reconstruction by cognitive mechanisms of sensory, affective, memory, etc processes'. Other researchers, such as Nisbett and Wilson (1977) and Cabanac (1979) have also argued that, although subjective report can sometimes be an accurate indicator of mental processes, people do not always report conscious experience accurately and people are often unaware of their responses and stimuli that affect their responses.

The idea that liking can be unconscious is a controversial point and the use of subjective report should certainly not be excluded. However, it is possible that a facial EMG measure of liking might be able to detect affective responses at a preconscious

level, which are not available to subjective report. Therefore, the current research aimed to use subjective report as a primary measure of liking. However, facial EMG was included as a supplement to the subjective report. Single item rating scales were chosen as they provided an easy, nonintrusive measurement to run alongside the EMG.

2.2 Measurement of Wanting

The wanting system is best understood as a system for attributing 'incentive salience'. Robinson and Berridge (1993) defined incentive salience as 'the attractiveness of external stimuli, events, places and their mental representations; their ability to capture attention'. Robinson and Berridge (Berridge 1996; Robinson and Berridge 2000a) claimed that wanting is indexed by measures of attraction, consumption and subjective wanting for an incentive stimulus (see Figure 1.3).

In animals these have taken the form of measures of consumption of a reward, choice/preference for a reward, or an operant task. Consumption and choice/preference testing have been used extensively in animal research. Very simply they measure the amount of reward (drug/food) consumed and if a choice/preference test, in comparison to another reward or control. For example, Keifer and Dopp (1989) presented rats with two bottles. They then measured the rats' consumption of water (in one bottle) compared to varying alcohol solutions (in the other bottle). This allows a comparison of wanting for the alcohol compared to the water. Similarly, other studies (e.g. Berridge and Valenstein 1991; Doyle, Berridge and Gosnell 1993) measured consumption by measuring the amount of food pellets scattered around the cages that were eaten. An example of an operant task to measure wanting is the study by Wyvell and Berridge (2001). It will be remembered (see 1.4.3.1) that they investigated the effect of amphetamine on the number of times rats pressed a lever to obtain a sucrose solution.

These methods of measuring wanting can be measured in humans in much the same manner as in the animal studies, with the addition that human measures can utilise verbal and subjective reports. Simple measures of actual (alcohol) laboratory consumption can obviously be measured in the same manner (e.g. Marlatt, Demming and Reid 1973; Modell *et al* 1993). In addition, self-report measures of consumption over days or weeks can be utilised in humans. For example, Fillmore and Vogel-

Sprott (1995) used a questionnaire in which participants reported the number of drinking occasions per week and the amount in of alcohol consumed in a typical drinking occasion. Furthermore, research suggests that self-report measures of drug consumption can be accurate indicators of actual drug use. For example, studies (Midanik 1988; O'Callaghan and Callan 1992; Grant *et al* 1997) have demonstrated that self-reported alcohol consumption can correlate well with other measures such as interviews, diaries and official statistics. Other studies have shown that self-report correlates well with laboratory measures of drug consumption. For example, Wish, Hoffman and Nemes (1997) found an association between cocaine use and cocaine concentration in the hair samples of cocaine addicts. Elman *et al* (2000) reported that self-reported cocaine and alcohol consumption in the past month was significantly correlated with cocaine concentration in hair samples and two proteins in the blood associated with alcohol intake.

Measurement of alcohol consumption can also be used as part of laboratory-based choice and preference tests. Typically, this involves allowing participants to choose between a drug and another substance or money. For example, Fischman and Foltin (1992) have used a form of preference testing whereby their participants could choose between cocaine solutions and a saline solution. Several other studies (e.g. Marlatt, Demming and Reid 1973; Cornell, Rodin and Weingarten 1989) have also measured consumption of alcohol and food. De Wit *et al* have used a choice testing procedure in several studies. For example, Chutuape *et al* (1993) gave participants a priming dose of ethanol and one hour later allowed participants to choose a selection of doses of either an alcoholic beverage or a placebo. If the alcoholic beverage was selected then participants were given the opportunity to change their choice to the placebo plus a negotiated sum of money. In a similar study, Chutuape, Mitchell and de Wit (1994) allowed participants to exchange points gained in a task for a beverage consumed at the start of the experiment, money or both. Kirk and de Wit (2000 as cited in de Wit 2000) also gave participants a priming dose of alcohol and then allowed them to choose either more alcohol or money. In all experiments, the choice procedure allowed the authors to gain a measure of the participants' preference for the alcoholic beverage compared to placebos and monetary incentives.

Several other options for measuring wanting in humans are also available. Operant tasks have also been used in humans (e.g. Schlund and Pace 2000). For example the Lamb *et al* (1991) used an operant task (lever pressing) to obtain

injections of morphine. Bigelow, Griffiths and Liebson (1977) required their participants to ride an exercise bike in order to obtain an alcoholic beverage. They found that the participants would consent to spend more time on the bike if they had received a priming dose of alcohol, compared to placebo. These operant tasks can be considered a form of drug seeking behaviour. They can provide a measure of quantifying how hard an individual is willing to work for a drug. Thus, this can demonstrate the degree to which the drug is wanted.

Measures of attentional bias can also measure wanting. Several researchers (e.g. Townshend and Duka 2001; Bradley *et al* 2003) have used visual probe tasks to measure the attraction of drug-related stimuli (pictures, words). In a visual probe task participants are require to stare at a 'fixation cross' on a screen. Two pictures are then flashed on the screen and after this a 'dot probe' appears on the screen where one of the pictures was. Participants press one of two buttons depending on whether the dot is on the left or right side of the screen. Participants' reaction times and number of correct responses are recorded. The level that participants are distracted by drug-related stimuli can thus be quantified. Consider, for example, if two pictures are flashed on the screen, one neutral and one drug-related. If the participants take longer to respond to the dot probe when it appears where the neutral picture was this is said to demonstrate a drug-related attentional bias because the drug-related picture distracted the participant. That is, the participant was not looking at the neutral picture when the dot probe appeared and so took longer to shift their attention to the other side of the screen and respond. Similarly, if responding is faster when the dot probe appears where the drug-related picture was this is said to demonstrate an attentional bias because the participant was looking at the drug-related picture. A variation on this method has been utilised by Mogg *et al* (2003) using equipment for measuring eye movements. The same method was used but a sophisticated camera measured exactly where participants were looking on the screen. These methods measure wanting as they quantify attraction to and salience of drug-related stimuli for the individual.

Of course it is also possible to utilise subjective reports of wanting in humans. These can range from simple visual analogue scales of desire for more alcohol (e.g. Justice and de Wit 2002) to questionnaires that several dimensions of wanting, such as the Alcohol Craving Questionnaire (e.g. Tiffany, Carter and Singleton 2000). As with the measurement liking, Robinson and Berridge, have claimed that wanting can also

be unconscious and that subjective report may not accurately reflect wanting. However, some theorists are critical of Robinson and Berridge's claims that wanting can be unconscious. For example, Tiffany and Carter (1998) noted that the proposal that wanting can operate at both unconscious and conscious levels present several problems. First, they warned that this general definition of craving (wanting) 'is prone to circularity'. They stated that 'if unconscious craving is to be measured by 'what people actually do', then how can craving cannot be 'indexed independently of compulsive drug use'. Secondly, they noted that these claims are not based upon a sophisticated theory of consciousness that 'permits testable predictions'. Specifically, they noted that there is no clear theory as to how incentive salience is transformed into conscious craving/wanting. Instead, Tiffany and Carter suggested that a cognitive theory of 'automatised performance' might better explain these behaviours. For example, drug use might become an 'automatic behaviour' that is not always available to awareness, much the same as practiced skilled behaviours (such as driving) come to be carried out with little awareness. Finally, they commented that this interpretation seems incompatible with how addicts describe their desires for drugs. That is, addicts seem to be aware of their craving and perfectly able to express it. Furthermore, self-report measures of craving appear to be highly sensitive to manipulations of various types.

As with the idea of unconscious liking, the claim of unconscious wanting is a controversial point. The argument suggests that where possible any subjective measures used should be supplemented by objective measures. It is easy to argue that measures such as consumption and choice tests take account of any unconscious process. As they measure the outcome of a psychological process they can be said to be the result of the full process of wanting, both conscious and unconscious. These measures also have the advantage of being the same as those that are used in animal studies. The current research used choice tests and consumption as measures of wanting. It was felt that these measures were the most convenient for recording alongside the measures of liking.

2.3 Aims and Predictions for Experiment One

The aim of Experiment one was to conduct an initial investigation of the dissociation between wanting and liking for alcohol in humans. Liking (subjective

ratings, facial EMG) was compared in two groups of drinkers (heavy and light) that, by definition, differed on a measure of wanting for alcohol (alcohol consumption in the last week). If the incentive-sensitisation theory's claim that differences in wanting, but not liking, are responsible for increased levels of drug use, it maybe that the heavy and light drinkers would not differ in their liking for alcohol. On the other hand, if liking and wanting were both measuring the same process it would be expected that heavy drinkers would show more liking for alcohol.

CHAPTER THREE: GENERAL METHODOLOGY FOR ALL EXPERIMENTS

Many aspects of the methodology were shared by all the experiments. To save repeating the same information, the aspects of the methodology that are shared by all or several experiments are presented below and should be referred back to if required. The chapter is organised into two parts. The first part (3.1) deals with the methodology that was shared by all of the experiments. This information can be assumed to the case for all experiments, unless otherwise stated. The second part (3.2) deals with the method relating to the EMG measures used in Experiments one to three.

3.1 Methodology for all Experiments

3.1.1 Participants

All participants were students at the University of Southampton. Most volunteered as part of a research participation scheme, to obtain course credits. Other participants took part for a small monetary payment (between £4.00 – £10.00). In every experiment participants were split into heavy and light drinkers, based on self-reported alcohol consumption. Researchers (e.g. Graham *et al* 1998) have observed gender differences in the effects of alcohol and drinking practices. Therefore it was appropriate to use different cut-off values for assigning heavy/light drinker status for males and females based on self-reported alcohol consumption (e.g. Cox, Yeates and Regan 1999; Glautier and Spencer 1999). This strategy avoided the heavy and light drinker categorisation producing a preponderance of males in the heavy drinker group. The participants were divided into males and females and a median split for units of alcohol consumed in the past week was done separately for each gender. The heavy females were then combined with the heavy males into an overall heavy drinker group. The same was done for the light drinkers.

3.1.2 Setting

The Psychology Department of Southampton University Ethics Committee approved all procedures. All the experiments were conducted in a laboratory consisting of a suite of three rooms, as shown in Figure 3.1. The preparation room was used to attach electrodes, fill in questionnaires, debrief participants and take breath alcohol levels. The other two rooms were used primarily for collecting the facial EMG data. When the facial EMG was being measured the participants were seated in the sound attenuated room. A table was positioned next to the participants for the presentation of solutions. The amplifiers were positioned behind the participants. A camera was positioned on the wall, near the ceiling, in front of the participant. This allowed the experimenter to view the participant from the observation room, which contained the computer equipment for viewing and analysing the EMG signals. The experimenter gave instructions to the participant from this room with a microphone.

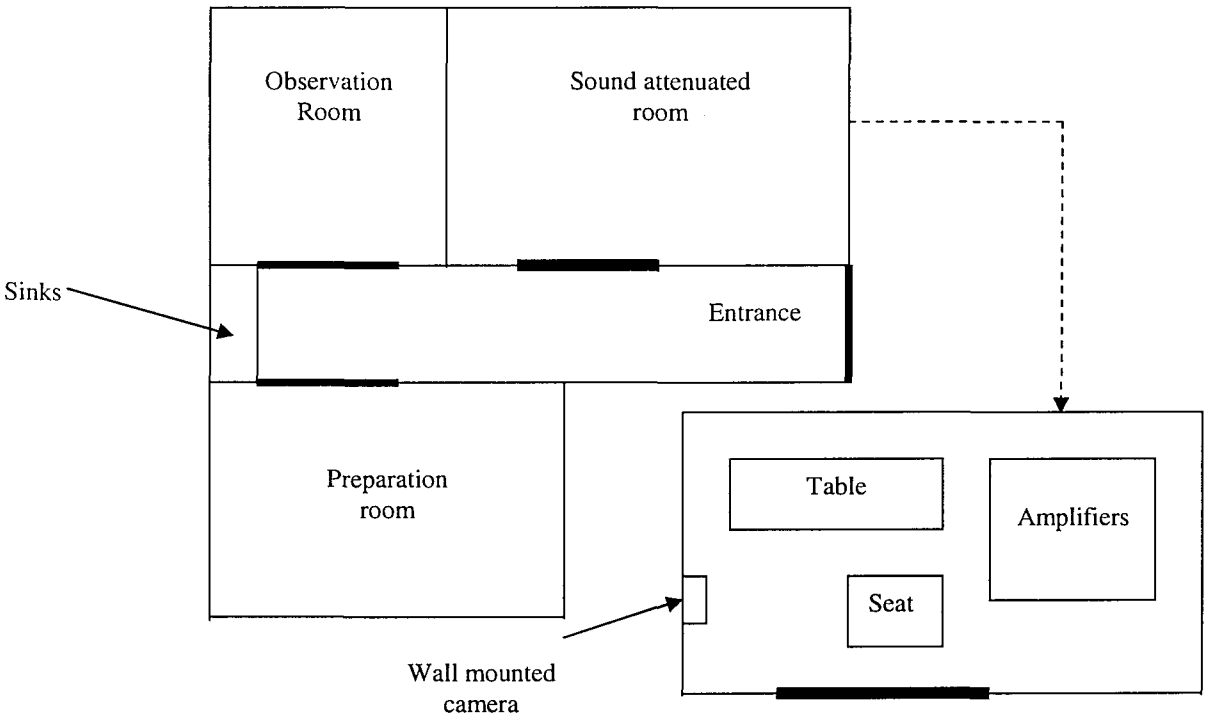


Figure 3.1 Layout of laboratory with close-up of sound attenuated room.

3.1.3 Procedure

At the start of each experiment all participants registered negative breath alcohol levels, read a description of the experiment, filled in any questionnaires and signed a consent form (see Appendix 1 for consent forms). At the end of each experiment participants were debriefed verbally or were provided with a debriefing statement (see Appendix 1 for debriefing forms) and were provided the opportunity to ask questions.

3.1.4 Materials

The subjective measure of liking used a simple numerical rating scale of 0-100, where 0 = extremely unpleasant, 50 = neutral and 100 = extremely pleasant (see Appendix 2.1 for example rating sheet). The alcohol consumption questionnaire (see Appendix 2.2) consisted of a grid in which the participants had to fill in the number and kind of drinks they consumed for the past week, starting with the previous night before the experiment. The number of UK standard units for each day and the entire week were then calculated (1 unit = 8gm ethanol). Participants were breathalysed using a Lion Alcometer S-D2.

3.1.5 Data Reduction and Analysis

All of the data was analysed using ANOVAs, except for Experiment 6A which only used t-tests. Sphericity was considered to have been violated if a significant value was obtained for Mauchley's test of sphericity. In this event guidelines set out by Winer, Brown and Michels (1991) were followed and Greenhouse-Geisser corrected degrees of freedom values were used instead for the ANOVA. Significant effects were followed-up with t-tests as appropriate.

3.2 EMG Methodology

3.2.1 Materials

The EMG measures were taken using 4mm diameter electrodes for the levator labii, corrugator supercilli and orbicularis oris and 8mm diameter electrodes for the zygomaticus major. The electrodes were placed according to guidelines set out by Fridlund and Cacioppo (1986) and Tassinary and Cacioppo (2000). The skin under the electrodes was prepared using Omni Prep in order to reduce impedance. The EMG was collected and digitalised using the Cambridge Electronic Design (CED) equipment and Spike2 program. The signal was amplified using CED 1902 amplifiers and passed through a low pass filter set at 1000Hz with a 50Hz notch. For Experiment 1C the sampling frequency was set at 555.6Hz. For all other experiments using EMG the sampling frequency was set at 1024Hz. The gain was set at 10 000 throughout. For all experiments the solutions were presented in clear 5ml sterile BD Plastipack disposable syringes.

3.2.2 Taste Reactivity Test Procedure

The syringes containing the solutions were laid out beside the participants on the table. Each trial used one syringe. At the start of each trial the experimenter instructed the participants to start timing on a stopwatch and the experimenter started the EMG recording. At certain points in time the participant infused the solution into their mouths and swallowed the solution. The trials were split into consecutive time periods that represented key segments of the EMG recording (see Figure 3.2). In Experiment 1C there were five time periods – baseline1 (15secs), taste1 (5secs), taste2 (5secs), baseline2 (20secs) and swallow (10secs), with an extra five seconds recorded to allow for adjustment due to small timing errors between experimenter and participant. In Experiments two and three, the data was broken down into exactly the same time periods but baseline2 was not recorded. At the end of each trial participants were allowed to rest for one or two minutes.

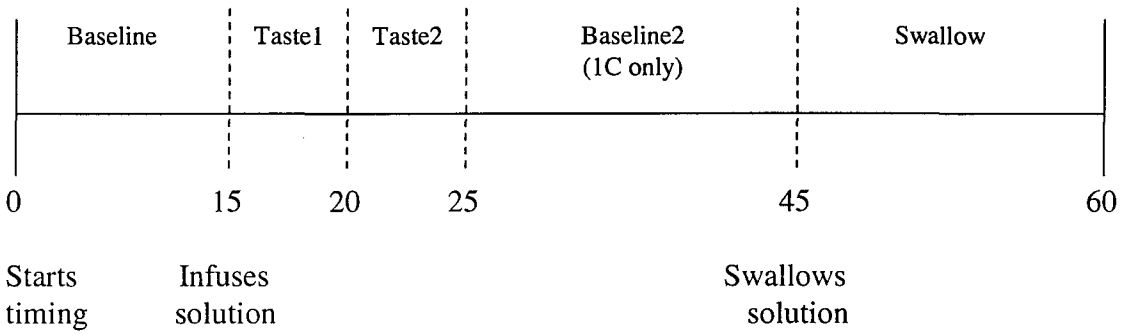


Figure 3.2 Timeline depicting participant actions and breakdown of time periods for each EMG trial. Note. Numbers indicate time in seconds.

3.2.3 EMG Data Reduction

Raw EMG signals were measured (in micro-volts) in each muscle region for each trial. Each raw signal was processed to yield mean amplitude values for each of the time periods. In Experiments 1C and two the EMG data for each flavour in each block was then aggregated i.e. the mean of both apple trials in block one were aggregated and mean of both apple trials in block two. Thus each participant had one score for each flavour in each block for each time period. In every experiment a log transform was conducted on the data to improve skewness. The baseline data (baseline1) was collected in case there were any unexpected effects of drinker status more generally for the EMG. However, no significant differences were found in the baselines and as the baselines were not actually measuring a response of interest the baselines were excluded from further analyses. The remaining EMG data for each muscle area was initially analysed using ANOVAs that included a factor of 'time period'. Each level of this factor related to each of the remaining time periods (taste1, taste2 and swallow). In each experiment main effects of time were always found but there were no interactions between time and the other variables, so the mean for all the time periods combined was used in the analyses that was reported herein

CHAPTER FOUR: LIKING FOR ALCOHOL IN HEAVY AND LIGHT DRINKERS # 1

4.1 EXPERIMENT 1A: SELECTION OF CONTROL FLAVOURS

4.1.1 Introduction

In order to compare liking for ethanol in heavy and light drinkers it was necessary to select control flavours for a study incorporating EMG measures. Two short Experiments (1A and 1B) were conducted in order to select these flavours. Experiment 1C was the main experiment that used the EMG and compared liking in heavy and light drinkers.

Several studies (e.g. Cabanac 1979; Kampov-polevoy, Garbutt and Janowsky 1999; Stewart *et al* 1994) have demonstrated that animals selectively bred for their tendency to consume alcohol and human alcoholics show a preference for sweet solutions and food, compared to control animals and human non-alcoholics. For this reason control flavours were required in order to investigate whether any potential difference in liking between light and heavy drinkers was specific to ethanol or if there are more general differences in liking. The identification of control flavours that varied in pleasantness also allowed an examination of the relation between subjective ratings of liking and the EMG measures. Experiment 1C used facial EMG as a measure of liking. The central claim of the Hu *et al* (1999; 2000) studies was that EMG could be used to measure taste liking because EMG responses correlated with subjective ratings of liking. Thus, measurement of EMG in response to flavours that differed in pleasantness allowed a further test of these findings. The aim of Experiment 1A was, therefore, to identify three flavours (pleasant, neutral and unpleasant) that could be used in future studies using EMG. Additionally, ethanol was included in order to gain an initial impression of how pleasant it was perceived. It was predicted that apple juice, grape juice and the sucrose solution would be rated as pleasant, water as neutral and the Tween (an unpleasant tasting biological detergent) and ethanol as unpleasant.

4.1.2 Method

4.1.2.1 Design

The experiment used a single factor within subjects design. Six types of solution were presented to each participant - grape juice, apple juice, 0.2% Tween, 10% ethanol, water, and 10g/500ml sucrose. Five trials of each solution (30 in total) were presented in a random order and subjective ratings of liking were obtained for each trial.

4.1.2.2 Participants

Ten participants volunteered to take part in the study, two of which were male. They were aged between 22 and 49 years with a mean age of 27 (SD = 8.6) years.

4.1.2.3 Materials

The solutions used were Evian bottled water, Safeway long-life apple juice, Safeway long-life grape juice, 96% fermentation ethanol (manufactured by Joseph Mills Ltd) diluted with Evian water to 10%, Polysorbate 20 (Tween) diluted to 0.2% with Evian water, and Fischer pure sucrose mixed with Evian water (10g/500ml). The solutions were presented as 2-3ml samples in clear 5ml sterile BD Plastipack disposable syringes.

4.1.2.4 Procedure

Participants were seated opposite the experimenter, who prepared each of the solutions behind a screen, out of sight, so that the participant could not see what the solution was. The solutions were presented to the participant at a time. The participants infused the solution into their mouths, tasted, swallowed and then made a rating of how much they liked the solution. After each trial the participant rinsed out their mouth with water. The participants were given the option of having a break whenever they wanted one. However, in practice none of the participants took long breaks and all of them finished the experiment within 15 minutes.

4.1.2.5 Data Reduction and Analysis

Each participant provided five ratings of liking for the five samples of each flavour. Mean values for these five samples were obtained so that each participant provided one mean liking rating for each flavour.

4.1.3 Results and Discussion

Figure 4.1 shows the mean liking ratings of each flavour. The apple and grape juices were rated as pleasant, water as neutral, and Tween and ethanol were rated as unpleasant. However, the sucrose was rated as neutral.

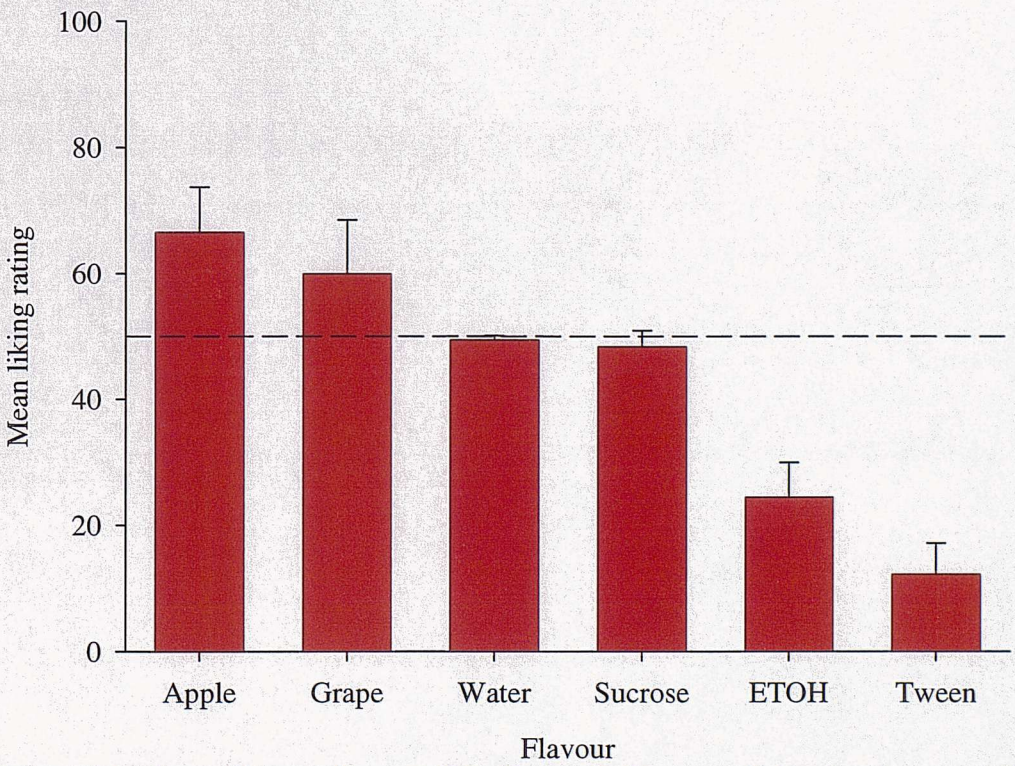


Figure 4.1 Mean liking ratings (+SE) for each flavour. Note. '----' = neutral rating (50); ETOH = 10% ethanol.

A one-way repeated measures ANOVA confirmed there was a significant main effect of flavour (see Table 4.1). The most liked, neutral and least liked flavours were required as controls so a series of paired t-tests (see Table 4.2) was conducted on the ratings for the apple, grape, water, and Tween solutions in order to confirm that these controls did differ from one another. The t-tests confirmed a significant

difference between the apple, water and Tween. However, the grape juice was not found to be significantly different from water so it was decided that apple would make a better control than the grape for the next study. Therefore, it was decided that for Experiment 1C apple would be used as the pleasant solution, water as a neutral flavour and the Tween as an unpleasant flavour.

Table 4.1
Analysis of variance for liking ratings

Source	df	F	p
	Within subjects		
Flavour (F)	1.7	14.83**	<.00
Error	15.32	(870.11)	

Note. Values enclosed in parentheses represent mean square errors.
*p<.05. **p<.01.

Table 4.2
Results of paired t-tests for apple, grape, water and Tween

Solution	t	df	sig.
Apple Vs Grape	1.28	9	n.s
Apple Vs Water	2.32	9	<.05
Apple Vs Tween	4.98	9	<.01
Grape Vs Water	1.23	9	n.s
Grape Vs Tween	4.25	9	<.01
Water Vs Tween	8.31	9	<.01

Note. n.s = not significant.

4.2 EXPERIMENT 1B: INVESTIGATION OF INTENSITY AS AN INFLUENCE ON FACIAL EMG

4.2.1 Introduction

The aim of Experiment 1B was to investigate whether the intensity of the solutions might play a role in influencing the facial EMG in Experiment 1C. It might be argued that any differences between the pleasant and unpleasant flavours in the EMG responses could be the result of a difference in the intensity of each solution. That is, the strength of stimulation a flavour produces. For example, it might be supposed that a person would show a more visible facial reaction in response to the presence of a chilli sauce in the mouth, compared to a mouthful of water, but this may not necessarily represent a difference in liking. This might also explain some of the results of the few EMG studies using taste as a stimulus (e.g. Hu, Luo and Hui 2000). No studies to date appear to have considered this possibility. One method of testing this is to simply ask participants to rate the flavours to be used in Experiment 1C. If these solutions were rated at the same intensity then there would be no justification for supposing that this was influencing the results. In addition, liking ratings were also collected in order to replicate Experiment 1A. It was predicted that the water would not be considered very intense but that the other flavours would be rated at the same level of intensity.

4.2.2 Method

4.2.2.1 Design

The experiment used a within subjects design. Four solutions were presented to each participant – 0.2% Tween, 10% ethanol, apple juice and water over the course of 16 trials. The solutions were presented in a random order and consisted of four trials of each solution. Subjective ratings of liking and intensity were obtained for each trial.

4.2.2.2 Participants

There were 11 participants, four of which were male. They were aged between 20 and 30 years with a mean age of 22.7 (SD = 3.8) years.

4.2.2.3 Materials

The intensity ratings used a scale from 0-100 where 0 = very low intensity and 100 = very high intensity. An example of an intense flavour was given as a hot curry or tabasco sauce (see Appendix 2 for example sheets). The solutions used were Evian bottled water, Safeway long-life apple juice, 96% ethanol (manufactured by Joseph Mills Ltd) diluted with Evian bottled water to 10%, Polysorbate 20 (Tween) diluted to 0.2% with Evian water. The solutions were presented as 2-3ml samples in clear 5ml sterile BD Plastipack disposable syringes.

4.2.2.4 Procedure

The participant was seated opposite the experimenter, who prepared each of the solutions behind a screen and presented them in a syringe to the participants in a random order. The participants infused the solution into their mouths, tasted and swallowed and then made a rating of how much they liked the solution and how intense they found the solution. After each trial the participants rinsed their mouths out with water and were given the option of having a break whenever they needed one. However, in practice none of the participants took a long break and all participants finished the experiment within 20 minutes.

4.2.2.5 Data Reduction and Analysis

Each participant provided four liking and four intensity ratings for the four samples of each flavour. Mean values for these four samples were calculated so that each participant provided one mean liking rating and one mean intensity rating for each flavour.

4.2.3 Results and Discussion

4.2.3.1 Liking ratings

The results replicated the findings of Experiment 1A. From figure 4.2 it can be seen that again apple was consistently rated as pleasant while water was rated as neutral and Tween and ethanol as unpleasant.

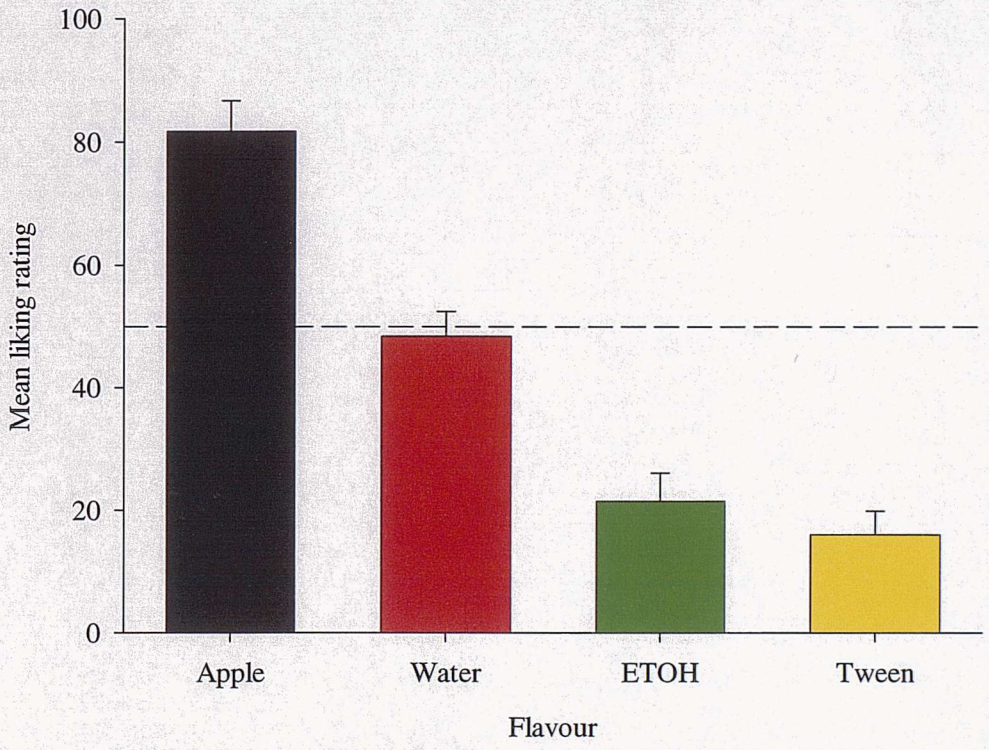


Figure 4.2 Mean liking ratings (+SE). Note. '----' = neutral rating (50).

Table 4.3 shows the results of a one-way repeated measures ANOVA. The results revealed a significant main effect of flavour.

Table 4.3
Analysis of variance for liking ratings

Source	df	F	p
	Within subjects		
Flavour (F)	1.87	57.63**	<.00
Error	18.71	(277.45)	

Note. Values enclosed in parentheses represent mean square errors. *p<.05; **p<.01.

Paired t-tests again (see Table 4.4) confirmed that the liking ratings for each flavour were significantly different from each other, except for the ethanol and Tween.

Table 4.4

Results of paired t-tests for liking ratings

Flavours	t	df	sig.
Apple Vs Water	5.83	10	<.01
Apple Vs Ethanol	7.6	10	<.01
Apple Vs Tween	11.24	10	<.01
Water Vs Ethanol	4.81	10	<.01
Water Vs Tween	12.38	10	<.01
Ethanol Vs Tween	1.2	10	n.s

Note. n.s = not significant

4.2.3.2 Intensity ratings

Figure 4.3 shows the mean intensity ratings for each of the flavours. It can be seen that the apple, ethanol and Tween appear to have been rated at a similar intensity although the apple was rated as slightly lower. The ratings for the water however, were very low in comparison.

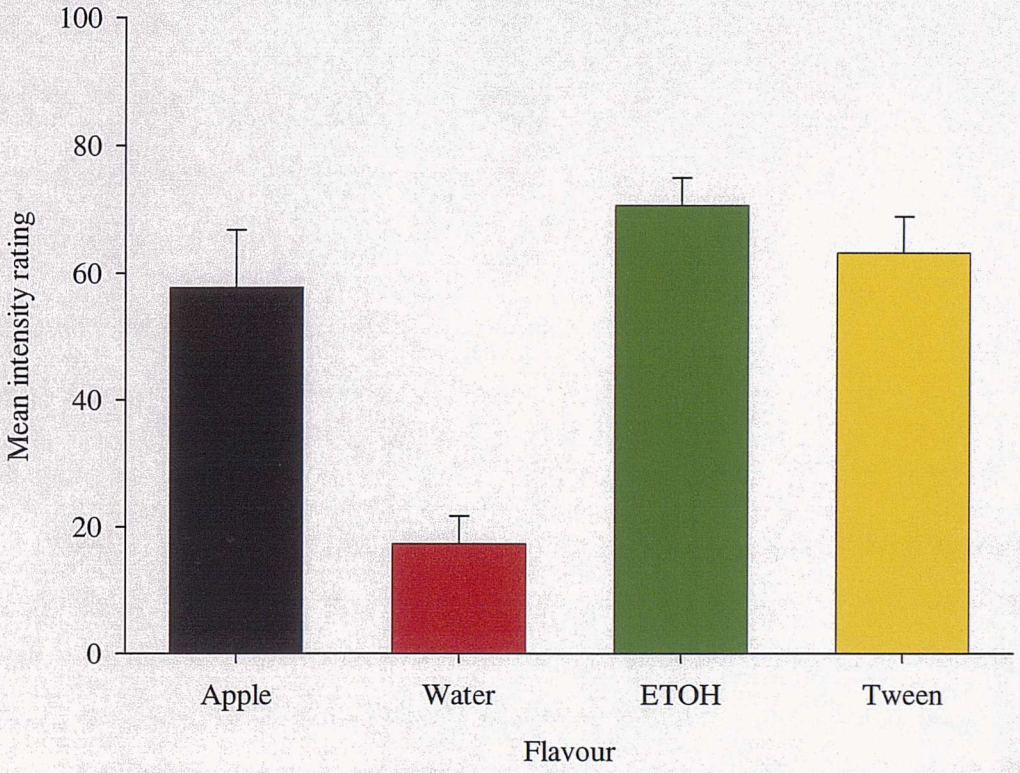


Figure 4.3 Mean (+SE) intensity ratings.

The results of a one-way repeated measures ANOVA for the intensity ratings are shown in Table 4.5. A main effect of flavour was found for the intensity ratings.

Table 4.5
Analysis of variance for intensity ratings

Source	df	F	p
Flavour (F)	3	16.41**	.00
Error	30	(381.31)	

Note. Values enclosed in parentheses represent mean square errors.
*p<.05; **p<.01.

Follow-up paired t-tests (see Table 4.6) confirmed that the ethanol, apple and Tween were not significantly different from each other. However, there was a significant difference between the water and all the other flavours.

Table 4.6
Results of paired t-tests for intensity ratings

Flavours	df	t	sig.
Apple Vs Ethanol	10	1.94	n.s
Apple Vs Tween	10	0.54	n.s
Ethanol Vs Tween	10	1.26	n.s
Apple Vs Water	10	3.85	<.01
Ethanol Vs Water	10	6.78	<.01
Tween Vs Water	10	5.82	<.01

Note. n.s = not significant.

The results for the liking ratings largely replicated the results from Experiment 1A. Again there was a significant difference in the liking ratings for each the all the flavours, except between the ethanol and Tween. The apple was rated as pleasant, water as neutral and the ethanol and Tween as unpleasant.

There was no significant difference in the intensity ratings between the apple, ethanol and Tween. This suggested that differences in the intensity of each flavour would not have an affect on the EMG data of Experiment 1C. As predicted the water was not rated as very intense and was rated significantly different from the other flavours. Therefore, if the EMG were likely to be affected by flavour intensity a difference would be expected between the water and the other flavours.

4.3 EXPERIMENT 1C: LIKING FOR ALCOHOL IN HEAVY AND LIGHT DRINKERS #1

4.3.1 Introduction

The purpose of Experiment 1C was to carry out an initial investigation of the dissociation between wanting and liking put forward by the IST. Experiment 1C was the first of two experiments that investigated whether people that differed in wanting for alcohol (heavy and light drinkers) also differed in their liking for alcohol (subjective ratings, facial EMG). Three muscle areas were selected for the EMG. The levator labii and zygomaticus major were selected as they had been shown in the literature to respond with higher EMG levels to unpleasant and pleasant stimuli, respectively. The third area was the orbicularis oris. There is no literature detailing this muscle area as responding to affective stimuli but as it is closely associated with oral stimuli this area was included to investigate if it would reflect liking. The solutions were also presented in blocks, in order to investigate any habituation effects on the EMG that may have arisen from the methodology. On the basis of the IST, it was predicted that heavy and light drinkers would not differ in their liking (either EMG or subjective ratings) for any of the flavours, including the ethanol.

4.3.2 Method

4.3.2.1 Design

The experiment used a two factor mixed design. The first factor was between participants with two levels; participants were assigned either heavy or light drinker status. The second factor was within subjects with four levels; all participants sampled four flavours – apple juice, 0.2% Tween solution, 10% ethanol solution, and water over the course of a 16 trial liking test. Flavour samples were presented as detailed in 3.2. The 16 trials were preceded by two practice trials of water. Each trial consisted of a 5ml sample and the trials were presented in two blocks, with two trials of each flavour in each block. The order of presentation of the trials in each block was randomised. Liking was measured by facial EMG recordings at the levator labii,

zygomatics major and orbicularis oris muscle regions and by obtaining subjective ratings of liking for each trial.

4.3.2.2 Materials

The solutions were Evian bottled water, Safeway long-life apple juice, 96% ethanol diluted with water to 10% and Polysorbate 20 (Tween). All the solutions, except practice solutions, were dyed blue using Supercook food colouring so that the solutions could not be distinguished visually.

4.3.2.3 Participants

There were 22 participants but three were excluded from data analysis because their EMG signals were not recorded properly due to experimenter error. Thus, the data presented below is based on the 19 participants that had complete data sets. There were four males and 15 females. The participants were aged between 18 and 60 years with a mean age of 24.3 (SD = 11.1) years. The mean number of units of alcohol consumed for the past week was 6.4 units (SD = 4.9) for the light drinker group and 22.4 units (SD = 7.1) for the heavy drinker group. The heavy drinker group contained 10 participants (two males and eight females) and the light drinker group nine participants (two males and seven females).

4.3.2.4 Data Reduction and Analysis

After data collection a technical fault was found. Several wires used for collecting data from the zygomaticus major area were found to be broken. The zygomatic data therefore had to be discarded. The remaining two channels (levator and orbicularis) were processed. After data reduction (see 3.2) each participant had one EMG score for each flavour for each channel in each block. Each participant also ended the experiment with four liking ratings for each flavour. The mean of these ratings was calculated so that each participant provided one mean rating for each flavour.

4.3.3 Results

4.3.3.1 Liking Ratings

Figure 4.4 shows the mean liking ratings for each flavour for the heavy and light drinkers. The results for the liking ratings replicated the data from Experiment 1A.

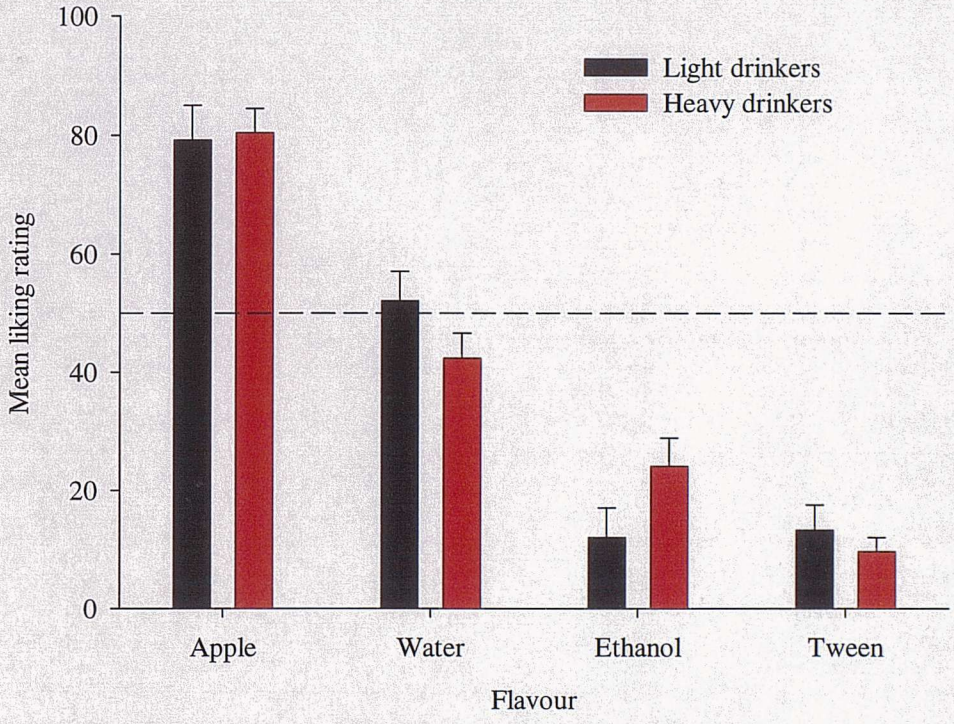


Figure 4.4 Mean liking ratings for heavy and light drinkers (+SE).
Note. '----' = rating of 50 (neutral).

Table 4.7 shows the results of a two-way mixed ANOVA (drinker status x flavour) carried out on the liking ratings. The results replicated those found in Experiment 1A. A significant main effect of flavour was found and follow-up paired t-tests (see Table 4.8) showed that all the flavours were rated as significantly different from each other. No effect of drinker status and no flavour x drinker status interaction was found. So there were no differences in the ratings of the four flavours, including ethanol, between the heavy and light drinkers. However, the flavour x drinker status interaction was close to significance and indicated that the heavy drinkers may have rated the ethanol as more pleasant compared to the light drinkers.

Table 4.7
Analysis of variance for liking ratings

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.00	.99
DS error	17	(275.18)	
	Within subjects		
Flavour (F)	3	116.45**	<.00
F x DS	3	2.53	.07
F error	17	(239.7)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

Table 4.8
Results of paired t-tests for liking ratings

Solution	t	df	sig.
Apple Vs Water	7.59	18	<.01
Apple Vs Ethanol	12.2	18	<.01
Apple Vs Tween	14.7	18	<.01
Water Vs Ethanol	6.2	18	<.01
Water Vs Tween	10.6	18	<.01
Ethanol Vs Tween	2.2	18	<.05

Note. n.s = not significant

4.3.3.2 EMG Data: levator labii

Figures 4.5 and 4.6 display the mean (log) EMG amplitudes for the heavy and light drinkers in response to the different flavours at the levator for block one and two, respectively. In both blocks the heavy drinkers responded with higher EMG levels to all the flavours, including the ethanol, compared to the light drinkers. In both blocks the heavy drinkers responded in a similar fashion to all the flavours. Some effect of block was evident in that the EMG responses became more uniform for both the heavy and light drinkers.

A three-way mixed ANOVA (drinker status x block x flavour) was conducted on the levator data. The results are shown in Table 4.9. The results revealed a main effect of drinker status, confirming that the heavy drinkers responded with significantly higher EMG levels, compared to the light drinkers. There was also a significant main effect of flavour and a significant block x flavour interaction. There was also a near significant block x drinker x flavour interaction. The block x flavour interaction was explored further by conducting separate one-way ANOVAs (flavour) for block one and block two. The results are shown in Table 4.10. The results showed that there was a significant effect of flavour in block one but not in block two.

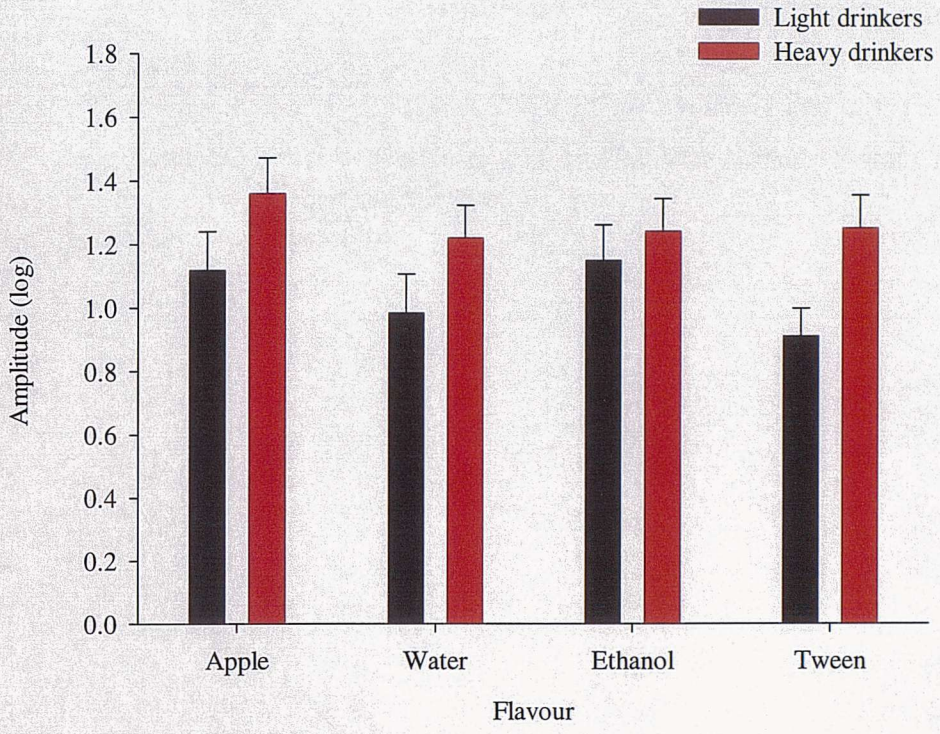


Figure 4.5 Mean (+SE) EMG amplitude (log) for heavy and light drinker in response to each flavour in block 1 at the levator labii.

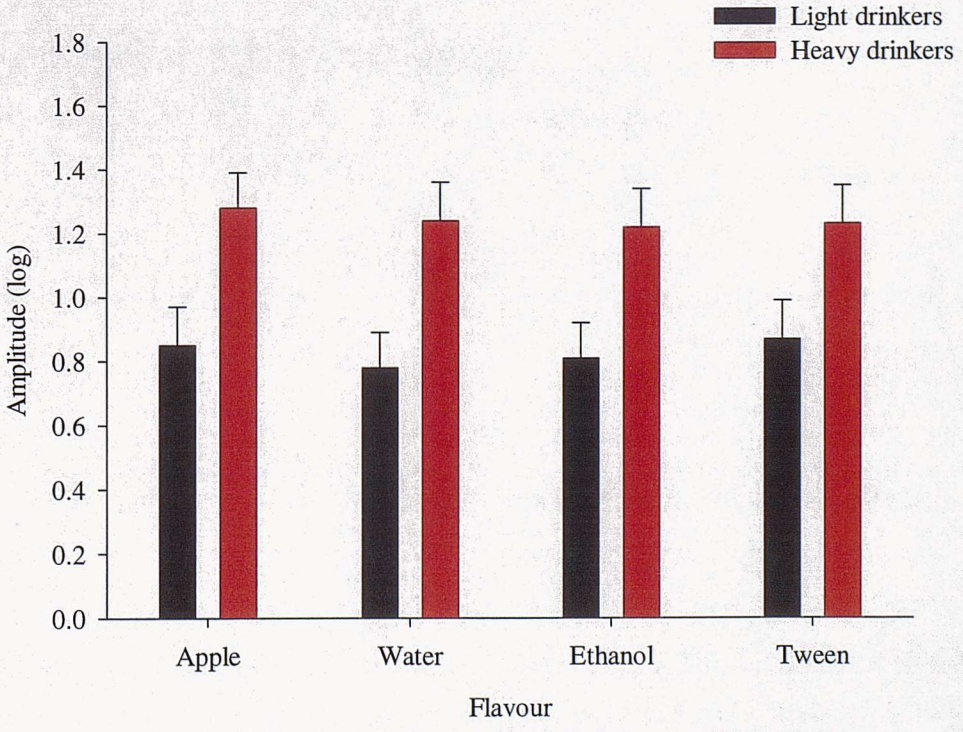


Figure 4.6 Mean (+SE) EMG amplitude (log) for heavy and light drinkers in response to each flavour in block 2 at levator labii.

Table 4.9
Analysis of variance for levator labii

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	5.46*	.03
DS error	17	(0.73)	
	Within subjects		
Block (B)	1	4.24	.06
B x DS	1	2.56	.13
B error	17	(0.13)	
Flavour (F)	3	3.76*	.02
F x DS	3	1.38	.26
F error	51	(<0.00)	
B x F	3	3.62*	.02
B x F x DS	3	2.63	.06
B x F error	51	(<0.00)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

Table 4.10
Analysis of variance for blocks one and two

Source	df	F	p
	Block one		
Flavour (F)	3	3.88*	.01
F error	54	(<0.00)	
	Block two		
Flavour (F)	3	1.69	.18
F error	54	(<0.00)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

A series of paired t-tests was conducted to test for specific differences between the flavours in block one. The results are shown in Table 4.11. They showed that EMG responding for the apple was significantly different from water and Tween but not ethanol. In both cases, the apple elicited higher levels of EMG than the water and Tween. None of the other flavours were significantly different from each other.

Table 4.11
Results of paired t-tests for block 1

Flavours	df	t	p
Apple Vs Water	18	3.0	<.01
Apple Vs Ethanol	18	1.08	n.s
Apple Vs Tween	18	2.78	<.05
Water Vs Ethanol	18	1.61	n.s
Water Vs Tween	18	0.35	n.s
Ethanol Vs Tween	18	1.78	n.s

Note. n.s = not significant.

4.2.3.3 EMG Data: orbicularis oris

A three-way mixed ANOVA (drinker x block x flavour) was conducted on the EMG data at the Orbicularis oris region (see Table 4.12). No significant main effect of block and no significant interactions were found so the Orbicularis data was collapsed across both blocks and this data is displayed in Figure 4.7, as the mean (log) amplitudes of the heavy and light drinkers in response to the four flavours. Figure 4.7 does not appear to show that the orbicularis responded differently to each of the flavours but there was a clear difference in EMG amplitude between the light and heavy drinkers. This was confirmed by the three-way ANOVA, which revealed a significant main effect of drinker status but no main effect of flavour and no significant interactions.

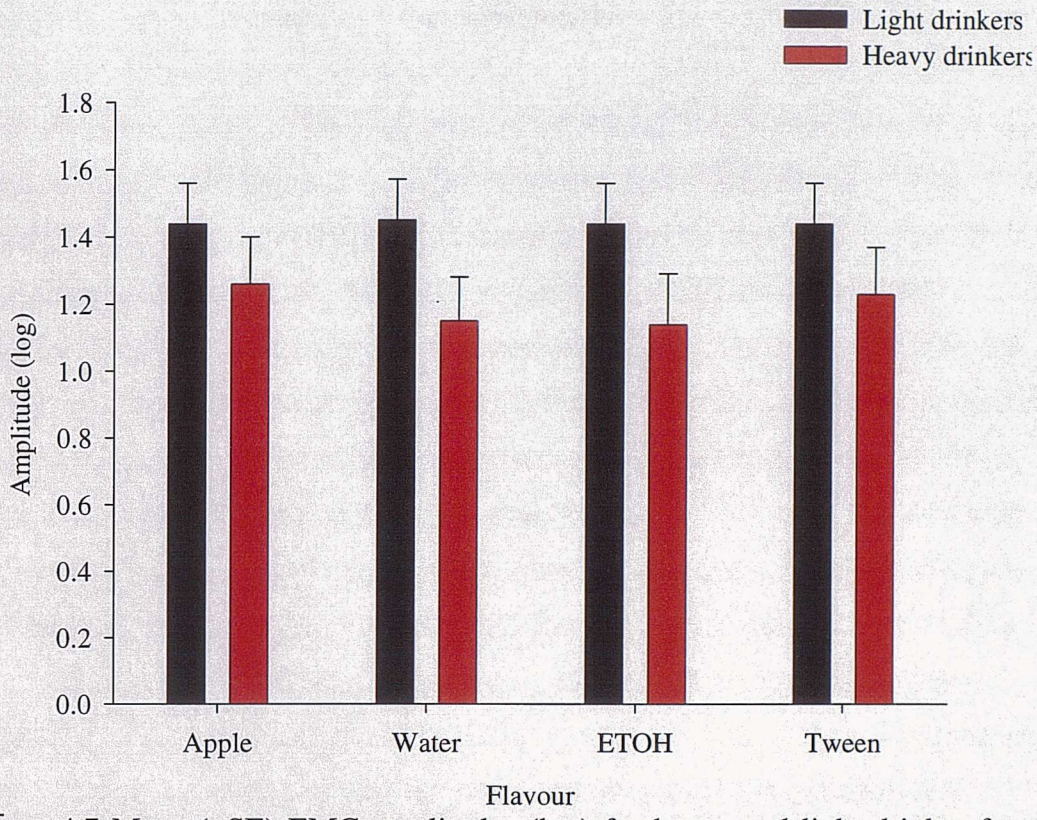


Figure 4.7 Mean (+SE) EMG amplitudes (log) for heavy and light drinker for each flavour at orbicularis oris, collapsed over both blocks.

Table 4.12
Analysis of variance for orbicularis oris

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	4.55*	.05
DS error	17	(4.3)	
	Within subjects		
Block (B)	1	3.84	.07
B x DS	1	2.05	.17
B error	17	(0.65)	
Flavour (F)	2.09	1.70	.20
F x DS	2.09	0.47	.63
F error	35.49	(0.10)	
B x F	3	0.07	.95
B x F x DS	3	0.96	.42
B x F error	51	(0.11)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

4.3.4 Discussion

Evidence for a link between wanting and liking would come in the form of a significant interaction between flavour and drinker status. Specifically, this interaction would reveal a difference in liking for ethanol between the heavy and light drinkers. The results revealed no such interaction on the liking ratings or on the EMG measures. This supported the predictions made from the IST, two groups of people that differed in wanting for alcohol did not differ in liking for alcohol. However, there was a near significant interaction between flavour and drinker status on the liking ratings. Furthermore, Figure 4.3 suggested that the heavy drinkers might have rated the ethanol as more pleasant than the light drinkers. Thus, although supporting the predictions the findings from the subjective ratings should be treated with caution.

Although the EMG data supported the predictions of the IST, the results revealed several interesting effects. Previous work (e.g. Hu *et al* 1999) indicated that EMG responses and subjective liking ratings are correlated and that EMG can differentiate between liking for flavours of a difference valence. Thus, it was argued that facial EMG could measure liking. Main effects of flavour for the EMG measures would indicate this. The analyses did not find an effect of flavour for the orbicularis suggesting that liking was not being measured. However, there was a significant interaction between block and flavour on the levator. Follow-up analyses indicated that there was an effect of flavour in block one but not block two. Specifically, in block one, the apple elicited higher EMG levels than the water and the Tween. This was the opposite of the predicted direction. Previous research (e.g. Schienle, Stark and Vaitl 2001) predicted that it would be the unpleasant tastes that would elicit a higher EMG response from the levator. A study by Lang *et al* (1993) reported that the zygomatic area has a 'U-shaped function'. That is, both very unpleasant and very pleasant stimuli elicited high zygomatic responses. The same may apply to the levator and it could be suggested that this was why high levator levels were observed in response to a very pleasant taste in this experiment. In any case, the fact that only one flavour elicited significantly different responses from the three other flavours, suggested that at best the levator was not a sensitive indicator of liking. This was despite the flavours clearly differing in valence, as measured by the subjective ratings.

There was also an effect of drinker status on the levator. Figures 4.5 and 4.6 indicated that the heavy drinkers had higher EMG responses for all the flavours

compared to the light drinkers. The presence of a near significant three-way interaction on the levator suggested that this difference was enhanced from block one to block two for the light drinkers as the EMG responses of the light drinkers decreased over the blocks, although those of the heavy drinkers did not. It also indicated that there may not have been a difference between the heavy and light drinkers for the ethanol in block one (see Figure 4.5). There was also a main effect of drinker status on the orbicularis, also indicating differences in EMG responding between the heavy and light drinkers across all the flavours for this muscle region. Initially, this might seem to provide support against the IST, in that, some difference in liking for ethanol was found between the heavy and light drinkers. However, this explanation is unlikely to be the case as there is reason to doubt that the EMG was measuring liking (see above). Thus, any differences between the heavy and light drinkers cannot be construed as a difference in liking.

This raised two questions. One was, what did the difference between the heavy and light drinkers indicate, if it was not a difference in liking? It is possible that this difference simply reflected a difference in general physiological responding between heavy and light drinkers. This might be seen as an example of what Greeley and Oei (1999) have termed the 'stress-dampening effect'. Finn and Pihl (1987; 1988) have demonstrated this effect in two studies. They measured cardiovascular responses to electric shock in men differing in their genetic risk for alcoholism (based on family history). They found that high-risk men responded with larger heart rate responses compared to the low-risk men. Furthermore, consuming a 1.0 – 1.32 ml/kg alcohol dose led to a drastic reduction in this reactivity in the high-risk men but increased it in the low-risk men. Finn and Pihl (1990) found the same result was found in a follow-up study using skin conductance and heart rate. However, a difference in physiological responding does not explain why the effect would differ between EMG sites. That is, why the heavy drinkers had higher EMG responses at the levator but lower at the orbicularis, compared to the light drinkers.

The second question is, why did the results not replicate the findings by Hu *et al* (Hu *et al* 1999; Hu and McChesney 1999; Hu, Luo and Hui 2000)? They analysed their data using spectral analysis and also by calculating changes in responses from baseline. However, analysing the data this way (unreported) did not change the results and measuring changes from baseline has been criticised by Tassinary and Cacioppo (2001) and Fridlund and Izard (1983). They claimed that this procedure is based on

the incorrect assumption that 'muscles evoke a certain resting level of "tonus" which should be subtracted by stimulus-evoked activity'. However, they cited evidence that facial muscles can show complete electrical silence at rest. Therefore any EMG activity recorded during rest periods (apart from 'weight bearing muscles') is evoked by stimuli at some level and may be taken to 'reflect ongoing affective processes' and not resting muscle tension. Two other methodological limitations may have also contributed to the discrepancy in EMG results in this experiment and the Hu *et al* research.

Firstly was the issue of the randomisation of the trials. In many cases this raised the issue of the 'pollution' of one flavour over the others. Many participants commented that one flavour (Tween in particular) altered the taste of subsequent flavours. They would report that by the end of the experiment 'everything tasted like Tween' and report a strong aftertaste of Tween in the mouth. This might have masked any effects of flavour. Furthermore, there was a near significant effect of block and a significant interaction between block and flavour for the levator, indicating some habituation may have occurred, which may have further masked any effects of flavour. Secondly, the action of the participants infusing the solutions into their mouths may have affected the results. This action elicited an EMG response in itself. This response may have 'hidden' the main response of interest. The initial splitting up of the EMG responses into different time periods was aimed at reducing this risk but there was also considerable variation in the manner in which participants infused the solutions into their mouths. Some participants opened their mouths very wide while other participants opened their mouths very little. It is doubtful that this issue can be overcome very easily as the solutions have to enter via the mouth. The best solution would be to attempt to standardise how the participants infuse the solution into their mouths.

Overall, the results replicated those of Experiment 1A and supported the predictions made from the IST. Some evidence for a dissociation between wanting and liking was found. Drinkers that differed in wanting for alcohol did not report a difference in liking for alcohol, as measured by the subjective ratings.

The results of the EMG did not support the prediction that the EMG can be used as a measure of liking but this may have been due to methodological considerations. These methodological considerations and the presence of near significant results indicated

that the results should be treated with caution and that this experiment should be replicated with an improved methodology.

CHAPTER FIVE: EXPERIMENT 2: LIKING FOR ALCOHOL IN HEAVY AND LIGHT DRINKERS # 2

5.1 Introduction

Experiment two was the second experiment that compared liking (facial EMG, ratings) in drinkers that differed in wanting (heavy/light) for alcohol. The aim of Experiment two was to repeat Experiment 1C with a refined methodology. Experiment 1C suggested some evidence of a dissociation between wanting and liking for alcohol using the subjective ratings, although a near significant difference in liking for ethanol between heavy and light drinkers was noted. The data for the EMG was not so clear and this may partly have been due to methodological limitations. Experiment two therefore aimed to address the limitations outlined in Experiment 1C and gather EMG data using an improved methodology.

Experiment two addressed the limitations of Experiment 1C by making a number of key changes to the methodology. Firstly, the flavours were presented in blocks of the same flavour so that 'pollution' from one flavour to another could not occur. Drawing on a study by Baeyens *et al* (1995) participants also ate a small piece of bread to help reduce any aftertaste from the previous flavour and were given breaks between each block. Secondly, the experimenter demonstrated to each participant how to infuse the solution into the mouth in an attempt to gain a more standardised method of infusing the solution into the participants' mouths. Participants were also to be corrected after they infused it into their mouths incorrectly. The aim of this was to reduce high levels of EMG responding that arose when participants opened their mouths very wide. This should reduce the possibility that affective responses would be masked by movement artifact.

The predictions were the same as for Experiment 1C. It was predicted, on the basis of IST, that the heavy and light drinkers would not differ in their liking (subjective ratings, EMG) for any of the flavours, including the ethanol.

5.2 Method

5.2.1 Design

The experiment used a two factor mixed design. The first factor was between participants with two levels; participants were assigned either heavy or light drinker status, based on self-reported alcohol consumption in the past week. The second factor was within subjects with four levels; all participants sampled four flavours – apple juice, 0.2% Tween solution, 10% ethanol solution, and water over the course of a 16 trial liking test. Flavour samples were presented as described in 3.2. The 16 trials were preceded by two practice trials of cranberry juice. Each trial consisted of a 4ml sample and the trials were presented in four blocks, one block for each flavour, with the order of blocks selected at random for each subject from a latin square. Liking was measured by facial EMG recordings at the levator labii, zygomatics major and orbicularis oris muscle regions and by obtaining subjective ratings of liking for each trial.

5.2.2 Participants

There were 52 participants, 24 males and 28 females. They were aged between 19 and 60 years with a mean age of 23.3 (SD = 6.0) years. There were 27 light drinkers (15 females, 12 males) and 25 heavy drinkers (13 females, 12 males). The light drinker group had consumed between 0 and 10 units, with a mean of 3.4 (SD = 3.7) units. The heavy drinker group had consumed between 10 and 61 units, with a mean of 21.3 (SD = 12.2) units.

5.2.3 Materials

The solutions were Evian bottled water, Safeway long-life apple juice, 96% ethanol diluted with water to 10% and Polysorbate 20 (Tween). Ocean Spray cranberry juice was used in the practice trials. Safeway's white bread was given to participants in between the blocks to take away the taste of the previous flavour. All the solutions,

except practice solutions, were dyed blue using Supercook food colouring so that the solutions could not be distinguished visually.

5.2.4 Data Reduction and Analysis

After data reduction (see 3.2) each participant had one EMG score for each flavour for each channel. Each participant also ended the experiment with four liking ratings for each flavour. The mean of these ratings was calculated so that each participant provided one mean rating for each flavour.

5.3 Results

5.3.1 Liking Ratings

Figure 5.1 shows the mean ratings for each of the flavours for the heavy and light drinkers. The data replicated the results of Experiment one.

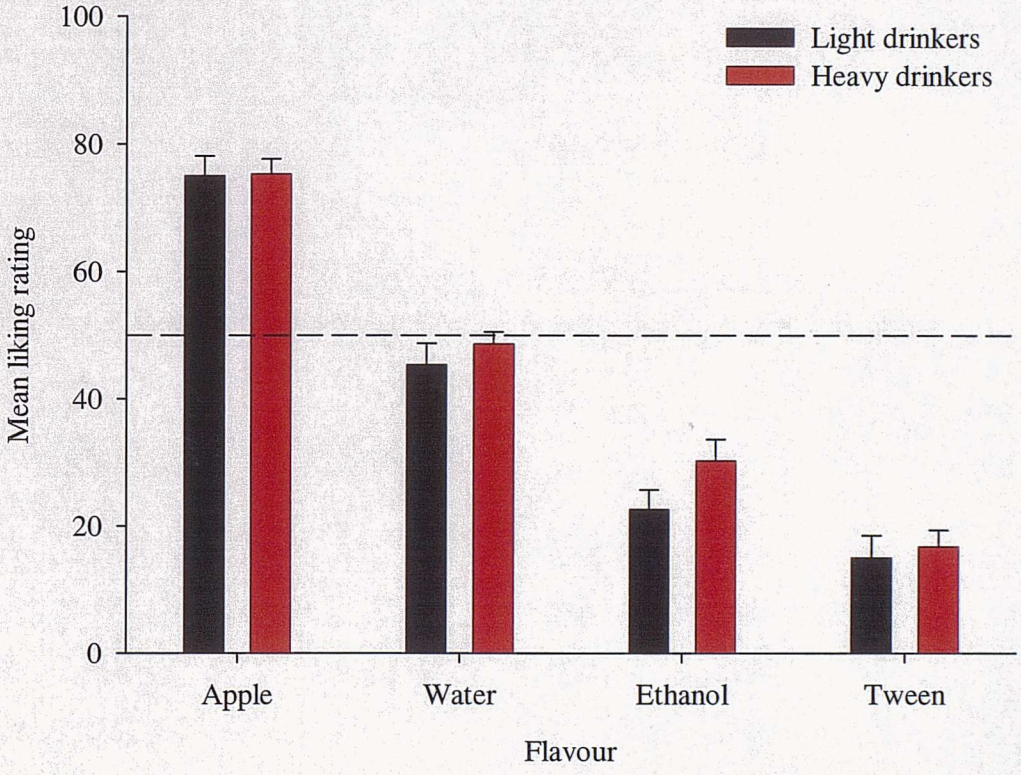


Figure 5.1 Mean liking ratings for heavy and light drinkers (+SE).
Note. '-----' = Neutral (50).

A two-way mixed ANOVA (drinker status x flavour) was conducted on the liking ratings. The results are displayed in Table 5.1. The results confirmed that there was a significant effect of flavour but no effect of drinker status and no flavour x drinker status interaction. So the heavy and light drinkers did not differ in their subjective ratings of liking for any of the flavours, including ethanol. Follow-up paired t-tests revealed a

significant difference in liking ratings between all the flavours. The results are shown in Table 5.2.

Table 5.1
Results of analysis of variance for liking ratings

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	2.05	.16
Error	50	(263.37)	
	Within subjects		
Flavour (F)	3	165.71 **	<.00
F x DS	3	0.62	.61
Error	150	(213.88)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

Table 5.2
Results of paired t-tests for liking ratings

Flavour	df	t	p
Apple – Water	51	10.75	<.01
Apple – Ethanol	51	16.65	<.01
Apple – Tween	51	20.12	<.01
Water – Ethanol	51	7.5	<.01
Water – Tween	51	10.49	<.01
Ethanol – Tween	51	3.61	<.01

Note. n.s = not significant.

5.3.2 EMG Data: levator labii

Figure 5.2 shows the mean (log) amplitudes for the EMG from the levator labii for the heavy and light drinkers. The heavy and light drinkers responded with similar EMG responses to the four flavours.

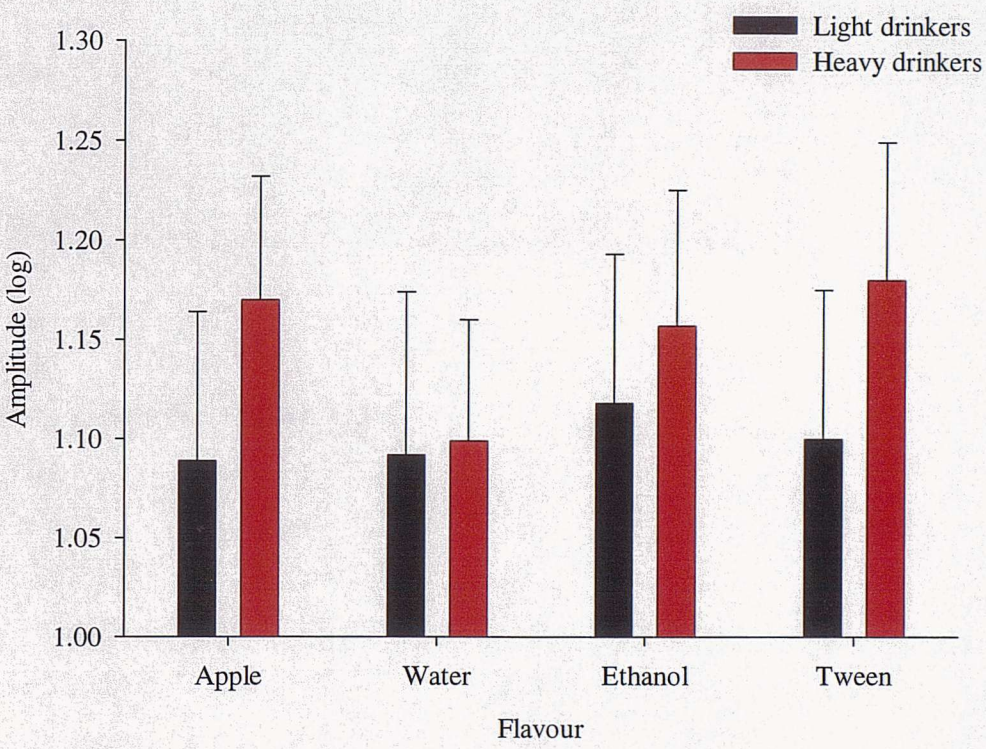


Figure 5.2 Mean (+SE) EMG amplitudes (log) at levator labii region for heavy and light drinkers.

A two-way mixed ANOVA (flavour x drinker status) was conducted on the levator labii data. The results are shown in Table 5.3. The results revealed a significant main effect of flavour but no significant effect of drinker status and no significant interaction. Follow-up paired t-tests conducted to explore the effect of flavour revealed that the apple, ethanol and Tween elicited significantly higher EMG responses than the water but not from each other (see Table 5.4).

Table 5.3
Results of analysis of variance for levator labii

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.43	.52
Error	50	(0.51)	
	Within subjects		
Flavour (F)	2.53	3.24*	.03
F x DS	2.53	0.13	.92
Error	126.27	(<0.00)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

Table 5.4
Results of paired t-tests for the levator

Flavour	df	t	sig.
Apple – Water	51	2.2	<.05
Apple – Ethanol	51	0.48	n.s
Apple – Tween	51	0.84	n.s
Water – Ethanol	51	2.34	<.05
Water – Tween	51	2.46	<.05
Ethanol – Tween	51	0.33	n.s

Note. n.s = not significant.

5.3.3 EMG Data: zygomaticus major

Figure 5.3 shows the mean EMG amplitudes (log) for the zygomaticus major for the heavy and light drinkers. The zygomaticus responded in a similar manner to all the flavours.

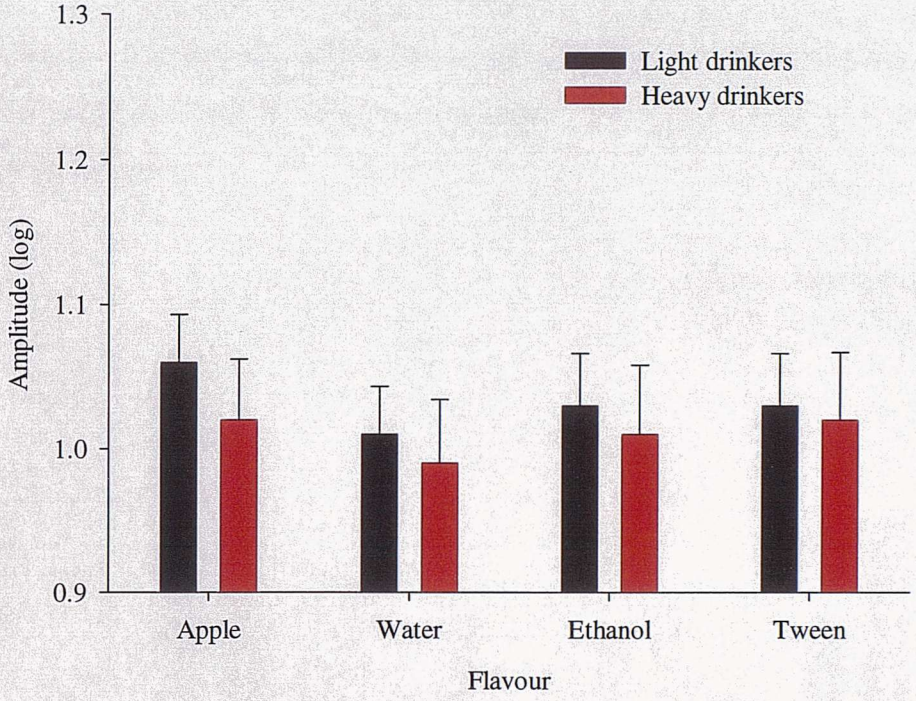


Figure 5.3 Mean (+SE) EMG amplitude (log) for heavy and light drinkers at zygomaticus major region.

A two-way mixed ANOVA (flavour x drinker status) was conducted on the EMG data at the zygomaticus major region (see Table 5.5). The results showed no significant main effect of flavour or drinker status and no significant interaction.

Table 5.5
Results of analysis of variance for the zygomaticus major

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.16	.69
error	50	(0.15)	
	Within subjects		
Flavour (F)	3	2.26	.08
F x DS	3	0.2	.90
F error	150	(<0.00)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

5.3.4 EMG Data: orbicularis oris

Figure 5.4 shows the mean EMG amplitudes (log) for the orbicularis oris for the heavy and light drinkers. As with the zygomatic there appeared to be little difference between the flavours.

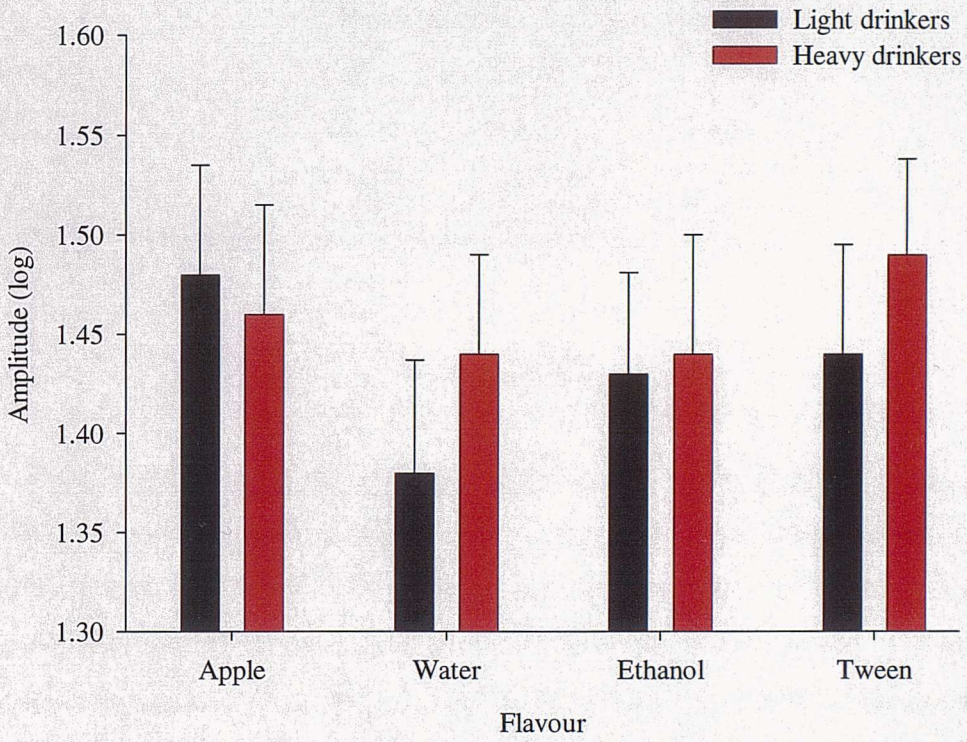


Figure 5.4 Mean (+SE) EMG amplitude (log) for each flavour at the orbicularis oris region.

A two-way mixed ANOVA (flavour x drinker status) was conducted for the orbicularis (See Table 5.6). No significant effects of flavour, drinker status and no significant interaction were found.

Table 5.6
Results of analysis of variance for orbicularis oris

Source	df	F	sig.
	Between subjects		
Drinker status (DS)	1	0.12	.73
error	50	(0.22)	
	Within subjects		
Flavour (F)	2.6	1.44	.24
F x DS	2.6	0.51	.65
F error	130.13	(<0.00)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

5.4 Discussion

As in Experiment 1C, evidence for a link between wanting and liking would have come in the form of a significant interaction between flavour and drinker status. The results revealed no such interaction for either the liking ratings or the EMG measures. The heavy and light drinkers, two groups that differ in wanting for alcohol, did not differ in liking for alcohol as measured by subjective ratings and facial EMG. The results of Experiment 1C revealed effects that indicated that the heavy and light drinkers might have differed in liking for ethanol. Specifically, Experiment 1C found a near significant interaction between flavour and drinker status for the subjective ratings that was indicative of a difference in liking for ethanol between heavy and light drinkers. Crucially, this effect was not replicated in this experiment, providing no reliable evidence for a difference in liking for ethanol between the heavy and light drinkers. Experiment 1C also found an unexpected overall difference between the heavy and light drinkers in EMG responding. This effect also proved unreliable and was not replicated in this experiment.

As in Experiment 1C, there was reason to doubt that the EMG was measuring liking. Despite the methodological changes made in this experiment the results were still in contrast to the findings of Hu *et al* (Hu *et al* 1999; Hu and McChesney 1999; Hu, Luo

and Hui 2000) that facial EMG could be used as a sensitive measure of liking. The zygomaticus and the orbicularis did not differ in their responding to any of the four flavours, even though they were clearly of a different valence (as indicated by the ratings). For the reasons outlined in Experiment 1C this suggested the EMG at these regions was not measuring liking. Again, the levator displayed some differentiation between the flavours. Specifically, the water elicited lower responses than the other three flavours. This could be explained by differences in flavour intensity, rather than differences in liking, as this follows the pattern of the intensity ratings from Experiment 1B. However, this explanation is plausible in this experiment but cannot be considered reliable as it was not present in Experiment 1C. As with Experiment 1C this suggested at best an insensitive measure of liking. An objection might be levelled at the choice of muscle areas for the EMG. One reason for the failure of the EMG to differentiate between the flavours could be because the act of oral consumption masks the affective responses of the muscle areas used in this experiment. One way to overcome this would be to use a muscle area not involved in oral consumption, such as the corrugator supercilli. Several studies (Hu *et al* 1999; Vrana 1993; 1994; Dimberg 1986a; 1987a) have shown that this muscle area can be used to measure affective responses to stimuli.

Although the results provided support for the claim of a dissociation between wanting and liking it might be argued that Experiment 1C and two only provided limited support because the dissociation was based on comparing single time point laboratory-based measures of liking (ratings, EMG) to self-reported wanting (alcohol consumption) for the past week. Incentive motivation theories (Toates 1986; Bindra 1974; Berridge 1999) all hold the view that liking and wanting are not static and vary over time. Thus, although several studies (Grant *et al* 1997; Wish, Hoffman and Nemes 1997; Elman *et al* 2000) have shown that self-reported drug use can be an accurate indicator of actual drug-use it might be argued that this measure of wanting only reflects an average level of wanting and does not capture adequately the momentary fluctuations in wanting that might well relate to liking. That is, the self-report provides a measure of average wanting over a week and the ratings liking at one precise point in time. Thus, differences in the temporal scale of the measures of wanting and liking may have been responsible for a

failure to find differences between the heavy and light drinkers. It could be that a concurrent laboratory-based measure of wanting would reveal a correlation between wanting and liking. Furthermore, alcohol consumption for the past week may not have reflected the typical drinking practices of the participants involved. Many studies (e.g. Midanik 1988; O'Callaghan and Callan 1992) using self-reported alcohol consumption assessed consumption over the past two weeks to a month. One week is a comparatively short time period. Most of the participants were also students and the study was run over an exam period, so some participants may have decided not to drink as much as they would have usually.

Another problem is that previous studies of wanting and liking have used an experimental manipulation to change wanting and compared this to liking. For example, animal studies (e.g. Berridge 1996; Treit and Berridge 1990) demonstrated changes in wanting but not liking by neural manipulations. Experiment 1C and two merely observed no difference in liking in two groups that were held to be different in wanting. A superior test of the dissociation would be to attempt to alter wanting but not liking using an experimental manipulation. This would be superior in that it would show an observed shift in wanting compared to liking, in a similar manner to the animal studies.

Overall, the results replicated the findings from Experiment one and provided some evidence for the dissociation between wanting and liking. However, the evidence was limited in that it rested on the failure to find a difference in liking for alcohol between two groups of drinkers held to differ in wanting for alcohol. Thus, It was decided to follow-up the finding of a dissociation with a more sophisticated test comparing laboratory measures of wanting and liking and attempting an experimental manipulation intended to alter wanting but not liking.

CHAPTER SIX: EXPERIMENT 3: DISSOCIATION OF WANTING AND LIKING USING A PRIMING DOSE OF ALCOHOL #1

6.1 Introduction

Most of the evidence for a dissociation between wanting and liking comes from animal studies (e.g. Treit and Berridge 1990; Berridge 1996; Pecina, Berridge and Parker 1997; Wyvell and Berridge 2000) that observed independent alteration of measures of wanting (consumption, goal-directed behaviour) and liking (affective reactions). These provided a direct test of the IST by independent manipulation of wanting and liking using neural interventions. In comparison, Experiments one and two failed to find a difference in liking between drinkers held to differ in wanting. Although suggestive of a dissociation, this failure to find an association between wanting and liking does not logically mean there was a dissociation. These findings might have been the result of methodological considerations and two weaknesses were identified with the research at this point. One was that differences in the temporal scale between the self-report measure of wanting and the liking ratings might have been responsible for the failure to find a difference in liking between the heavy and light drinkers (see 5.4 for detail). Second was that any difference observed between measures of wanting and liking could simply be the result of differences in the sensitivity of the measures employed. It could be argued that if the wanting measures were more sensitive, compared to the liking measures, it might be easier to observe a shift in wanting than in liking, and this could have masked any shift in liking. Experiment three was the first of three experiments that attempted to address the first weakness by comparing liking with a concurrent measure of wanting.

Toates' (1986; 1994) model of conditioned incentive motivation posited that incentive stimuli (food, drug) interact with internal 'drives' to produce motivational states. Thus, incentive stimuli can trigger an organism to interact with an incentive stimulus. In the example of food, the presentation/ingestion of a food stimulus can act as a trigger for consumption of the food. This is known as a 'priming effect'. For example, Cornell, Rodin and Weingarten (1989) demonstrated that priming with a brief exposure to

pizza or ice cream selectively increased subsequent intake of the food compared to unprimed participants. Eiserer (1978) found a similar effect by priming nondeprived rats with food pellets. Toates (1994) argued that the external incentive stimuli (food) 'stimulated' an internal physiological 'drive' (hunger) leading to an increased motivation to eat that particular food. Toates argued that priming with the incentive stimulus alters the hedonic evaluation of the stimulus, leading to increased motivation to eat. Thus, it was argued that priming increased liking for that particular food and this resulted in increased consumption (and therefore wanting) the food. The participants both liked and wanted the pizza/ice cream/pellets more (as indexed by increased consumption) than the unprimed participants. Wanting and liking for that stimulus had increased, resulting in an increased tendency to pursue that stimulus. Toates' made no distinction between an increase in liking and an increase in wanting, it was assumed that they were part of the same unitary process.

Priming effects have also been found using stimuli other than food. For example, Reid *et al* (1973) demonstrated a priming effect using self-stimulation of the brain in rats. Of more relevance to the present research, priming effects have also been observed using drugs (see de Wit 1996 for a review). Shiffman (1986) reported that exposure to smoking in social situations was one of the main causes of relapse, as reported by smokers using a relapse prevention hotline. Chornock *et al* (1992) reported that smokers that had been abstinent for three days all relapsed within two days after an experimental session, in which they smoked five cigarettes. This was in comparison to an unexposed group, in which 16% of participants remained abstinent eight days later. However, it should be noted that Elman *et al* (2002) reported that cocaine users did not show increased cocaine use after being administered the drug as part of a series of experiments. Jaffe (1989) gave nine cocaine users a 40mg intravenous dose of cocaine or a placebo and measured subjective measures of wanting and craving. They reported that the users reported significant increases on the measures of wanting and craving 15 minutes after receiving cocaine, compared to when they received placebo.

Priming effects have also been demonstrated in studies using alcohol (see Meyer 2000 for review). Some early studies reported the lack of a priming effect for alcohol. For

example, Marlatt, Demming and Reid (1973) primed social drinkers and alcoholics with either alcohol (one shot of vodka in tonic water) or a placebo (tonic water) and measured their subsequent alcohol consumption in a 'taste test'. They also told participants that the priming drink contained either alcohol or tonic water alone. They found that a priming effect was dependent on whether the participants were told that the priming dose contained alcohol or not, regardless of the priming drink consumed. Thus, those primed with alcohol but told that it was tonic water did not consume more than those simply given tonic water and told that it was tonic water. Conversely, those primed with placebo but told it contained alcohol, also consumed more alcohol in the 'taste test' than those given alcohol and told it was tonic water. This study suggested that alcohol does not prime an incentive motivation system and that cognitive factors are more important in any priming effect. However, other studies have shown that larger amounts of alcohol can produce priming effects on subsequent alcohol consumption.

Ludwig, Wikler and Stark (1974) primed 24 alcoholics with either a low (0.47g/kg) or high (0.95g/kg) alcohol dose or a placebo and placed them either in an inappropriate or appropriate (with alcohol-related cues) drinking environment. They then measured subjective craving and a behavioural measure of craving (button pressing) for alcohol. Priming with low and high doses of alcohol increased subsequent subjective craving and button pressing for alcohol. This was magnified in the groups that were also in placed in the appropriate drinking environment. The greatest effect resulted in participants placed in the appropriate environment and primed with a low dose of alcohol. The authors concluded that priming with alcohol acts as an appetiser, stimulating further alcohol consumption. Hodgson *et al* (1979) primed 20 moderately or severely dependent alcoholics with 15ml of vodka, 150ml of vodka and placebo (on different days). Three hours later the alcoholics were asked to drink at least one of five alcoholic test drinks. They found that a priming effect was only evident if dependence was taken into account. The severely dependent alcoholics consumed the test drink quicker after the high priming dose (150ml vodka) than after the low or placebo priming doses. However, the opposite was found with the moderately dependent alcoholics. They actually consumed the afternoon drink slower after the high dose compared to the low and placebo doses. A

follow-up study was conducted by Stockwell *et al* (1982). This study again used 20 moderately or severely dependent alcoholics. They all took part in four conditions that each took place on a different day. In two conditions, they were given a 60ml-priming dose of vodka and told they had received alcohol and then on another day they received the same dose but were told they had received placebo. In the other two conditions they received placebo and were told they had received placebo and then in the other condition told they had received alcohol. At intervals up to 60 minutes, they took a number of behavioural and subjective measures. They found that the severely dependent drinkers were more inclined to drink alcohol after the alcohol dose than after placebo and that it was irrelevant as to whether they were told they had been given alcohol or placebo. The moderately dependent drinkers were more inclined to drink alcohol after receiving alcohol if they had been told that it did contain alcohol. De Wit and Chutuape (1993) reported that normal social drinkers given a preload of alcohol (0.8g/kg) were more likely to choose alcoholic beverages on subsequent choice tests one hour later, compared to social drinkers given a placebo. More recently, Rose and Duka (2003) reported that a 0.6g/kg dose of alcohol increased subsequent desire (craving questionnaire, imagined consumption of drinks provided the opportunity) to consume alcohol 30 minutes later.

The evidence outlined above provides compelling evidence that priming with alcohol can increase subsequent alcohol consumption and subjective desire, even in nondependent drinkers. The Toates model would describe the increase in consumption as indicative of an increase of both wanting and liking for the alcohol. However, the IST claims that the studies above only measured wanting. As measures of liking were not taken in the studies above, it is not possible from those studies to determine whether there was also a parallel increase in liking. The IST would predict that an increase in liking would not have been necessary to lead to an increase in alcohol consumption. However, these studies suggest that the context of a priming study might provide a good test of the dissociation between wanting and liking. A priming study may be able to create the conditions under which a dissociation between liking an alcoholic beverage and concurrent wanting to consume it might be measured.

The IST also predicts that those with a history of drug use will have undergone greater sensitisation (of wanting) than those with less or no experience with drugs. Thus, heavy drinkers would be expected to show higher levels of wanting after priming with alcohol, compared to lighter drinkers. The studies by Hodgeson *et al* (1979; 1982) showed that the priming effect interacted with dependence level, which is analogous to heavy/light drinker status.

Thus, Experiment three aimed to test the dissociation of wanting from liking in the context of a priming study. If priming with alcohol shifts wanting and not concurrent liking this would provide compelling evidence for a dissociation. In order to address the issues raised in 5.4, further changes were made to the facial EMG measures. Facial EMG was again used as a measure of liking, using the site (levator labii) from which the best results were gained in the previous experiments. Measures from the zygomaticus and orbicularis were discontinued. However, measures from an additional site (the corrugator supercilli), that was considered to be more appropriate to measure an affective response free from interference from mouth movements involved in oral consumption, were included.

It was predicted, on the basis of IST, that priming with alcohol (relative to placebo) would have little or no effect on liking for alcohol but would lead to an increase in wanting for an alcoholic beverage. It was also predicted that this priming effect would have a greater impact on the heavy drinkers compared to the light drinkers.

6.2 Method

6.2.1 Design

There were two main parts to the experimental design. The first, a liking test, used subjective ratings and facial EMG as dependent measures. The second, a wanting test, used number of alcohol choices and amount of alcohol consumed in a choice test as dependent measures. The liking test used a three factor mixed design. There were two between participants factors; participants were assigned either heavy or light drinker

status on the basis of their self-reported alcohol consumption and were randomly assigned to either an alcohol-priming or a placebo-priming condition with the constraint that there were equal numbers of males and females in each condition. The within subjects factor was drink; all participants sampled two types of drink, beer and fruit juice. Facial EMG responses to each drink were recorded from the levator labii and corrugator supercilli and liking ratings were obtained. In the second part of the design wanting for alcohol was measured in five alcohol and soft drink choice tests. The type of drink chosen and the amount of each drink consumed were dependent variables indexing wanting. This part of the experiment used a two factor between subjects design with heavy or light drinker status and alcohol or soft drink priming condition as factors.

6.2.2 Participants

Sixty participants took part in the experiment. There were 12 females and 48 males, aged between 18 and 38 years with a mean age of 22.5 years (SD = 3.6). There were 30 participants in each drinker group (six females and 24 males in each group). The light drinkers had consumed between 10 and 21 units with a mean of 14.6 (SD = 3.1) units. The heavy drinkers had consumed between 22 and 87 units with a mean of 33.8 (SD =14.4) units. To take part in the experiment all participants were required to meet several criteria. They had to weigh over 50kg (males) or 60kg (females). Have no reason or professional advice for not consuming alcohol. Have had at least one drinking session in the past month in which they consumed at least two pints of beer, or equivalent, and have consumed at least 10 units of alcohol in the past week. They also had to register a negative breath alcohol reading at the start of both experimental sessions. This criterion was employed to satisfy the requirements of the Southampton Department of Psychology Ethical Committee, which was to confirm that the participants were regular drinkers and were familiar with the amounts of alcohol being administered in this study. To assess these criteria all participants completed a screening questionnaire (see Appendix 2.7 and Appendix 3 for predicted blood alcohol concentrations), were weighed in the laboratory, and filled in a self-report table detailing their alcohol consumption for the past week. At

the end of both sessions participants took a breath alcohol test. They were asked to rinse their mouths with water and the test was administered several minutes after they had last consumed alcohol. If the reading was 70mg% or above then the participants were asked to sign a disclaimer. One participant was unable to complete the liking test because of a head wound sustained between day one and day two.

6.2.3 Materials and Beverages

The five beers used were Foster's (4%), Carlsberg (4%), Carling (4.1%), John Smith's (4%) and Safeway's Strong Bitter (4.5%). The five fruit juices used were Safeway's long-life apple juice, orange juice, grapefruit juice and pineapple juice and Ocean spray cranberry classic juice. The practice trial in the liking test consisted of 5ml of tap water. The fruit juices were always presented first and then the beers but within those limits, the order was randomised. All solutions were served in 5ml clear BD plastipak disposable syringes and a china mug. All beverages were served chilled. The alcohol priming dose was ethanol diluted with Safeway's long-life grape juice to yield a 5% ethanol solution, the amount given was 0.2g/kg. For participants in the placebo priming condition grape juice was given in the same volume as would have been used, had the participant been allocated to the alcohol priming condition. While consuming the priming solution each participant held a Locketts extra strong throat lozenge in their mouths to mask the taste of any alcohol. During the choice tests the amount of alcoholic beverage available was calculated so that the maximum amount that could be consumed, if all choices were alcohol, would be 500ml of beer, in addition to any alcohol that had already been given if the participant was in the alcohol priming condition. The priming solutions were presented two identical china mugs. For the choice tests the solutions were served in white plastic cups with lids and a straw. Participants were unable to see what solution was contained in each cup.

6.2.4 Procedure

In order to minimize the chances that experimental demand characteristics might influence the results of liking and wanting tests, the experiment was presented as a test of recall and identification of different drinks and was carried out over two days. On day one participants sampled five different beers and five different fruit juices. These drinks were presented as described in 3.2. After sampling the drinks an appointment was then made for the main part of the experiment which took place on day two when, on arrival at the laboratory, participants were breathalysed to ensure a zero breath alcohol level. They were then given a verbal description of the experimental procedures before receiving a 0.2g/kg dose of alcohol or a placebo of equivalent fluid volume. Consumption of the priming dose was spread over 10 minutes after which there followed a break of 15 minutes and then the liking test. The liking test consisted of presentation of three solutions in the same manner as described in 3.2. Liking ratings and EMG responses to each sample were recorded. One of the solutions was a practice trial of water, which was always presented first. The next two trials involved beer and fruit juice presented in a counterbalanced order. The data from these trials are presented below. The participant was then disconnected from the EMG apparatus but remained seated for the wanting test. The wanting test consisted of five choice tests and, in each, participants were presented with two plastic cups, one contained beer, the other contained fruit juice. Different beers and fruit juices were presented in each trial. Participants chose one and were then asked to taste the beverage they had chosen and to provide a liking rating and a confidence rating to indicate how sure they were that they had tasted that drink on day one (see Appendix 2.4 for rating sheet). The experimenter left the room for five minutes while participants made their rating. Order of presentation of the beers and fruit juices in the choice tests was random and participants were not told hold many tests there would be. After completing the wanting test participants were debriefed and breathalysed again. Any participants with a breath alcohol level of more than 70mg% were to be asked to remain in the laboratory until their levels fell below 70mg% or sign a disclaimer. In the event six participants ended the experiment with a breath alcohol level above 70mg%.

For the choice tests the total number times alcohol was chosen and the total amount of beer consumed across all choice tests was calculated.

6.2.5 Data Analysis and Reduction

Mean beer and fruit juice liking ratings were calculated for the liking test. For the choice tests the total number times alcohol was chosen and the total amount of beer consumed across all choice tests was calculated.

The results were organised into two sections. The first section details the analyses of the liking test. These results are concerned only with the EMG measures and the subjective ratings of liking. They detail the influence of drinker status and priming on these measures. The second section details the results of the choice tests. These investigated the influence of drinker status and priming on the number of times beer chosen in the choice tests and total beer consumption.

6.3 Results

6.3.1 Liking Test

6.3.1.1 Liking ratings

Figure 6.1 shows the mean beer and fruit juice liking ratings for the heavy and light drinkers according to priming condition.

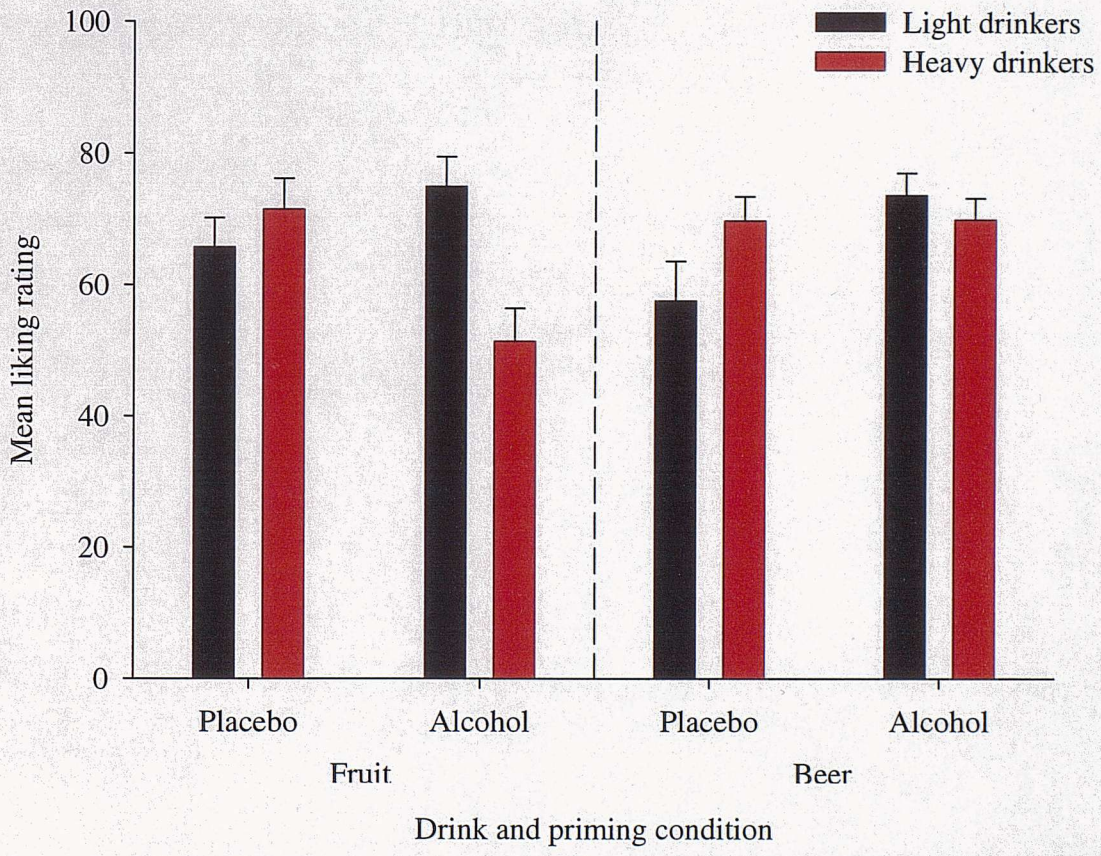


Figure 6.1 Mean fruit juice and beer liking ratings (+SE) for heavy and light drinkers according to priming condition. Note. '-----' = divide between fruit and beer ratings.

A three-way mixed ANOVA was conducted (drink x drinker status x priming) on the liking ratings. The results are displayed in Table 6.1. The results showed significant interactions between drink and drinker status, drink and priming condition, and drinker status and priming condition.

A series of paired and independent t-tests explored the specific differences of each of these interactions. Four t-tests were conducted for each of the interactions. Table 6.2 shows the results of the t-tests exploring the drink x drinker interaction. Paired t-tests were conducted for the heavy and light drinkers between the ratings for fruit juice and beer. Independent t-tests were conducted for the beer and fruit juice between the ratings given by the heavy and light drinkers. Despite the significant interaction, the t-tests revealed no specific differences between each of the groups.

Table 6.1
Results of analysis of variance for liking ratings

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.54	.47
Priming (P)	1	0.18	.68
DS x P	1	12.29**	<.00
Error	55	(303.59)	
	Within subjects		
Drink (D)	1	0.40	.53
D x DS	1	4.84*	.03
D x P	1	5.16*	.03
D x DS x P	1	1.27	.27
Error	55	(259.86)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

Table 6.3 shows the results of the t-tests for the drink x priming interaction. Two paired t-tests and two independent t-tests were conducted. The results revealed no significant differences between each of the groups. Table 6.4 shows the results of the independent t-tests exploring the drinker status x priming interaction. They revealed that the light drinkers in the alcohol condition gave higher ratings than the light drinkers in the placebo condition. The opposite was revealed for the heavy drinkers. The heavy drinkers in the alcohol condition gave lower ratings compared to the heavy drinkers in the placebo

condition. They also revealed that the heavy and light drinkers in the placebo condition did not differ in their ratings but the light drinkers gave significantly higher liking ratings than the heavy drinkers in the alcohol condition.

Overall the results showed that there were no differences in subjective liking for fruit juice and beer between the heavy and light drinkers. However, priming with alcohol or placebo had some effect on subjective liking. Specifically, priming with alcohol increased liking generally for the light drinkers but reduced it for the heavy drinkers.

Table 6.2
Results of t-tests for drink x drinker status interaction

Groups	df	t	sig.
	Paired t-tests		
Heavy drinkers:			
Fruit juice vs Beer	29	1.64	n.s
Light drinkers:			
Fruit juice vs Beer	28	1.10	n.s
	Independent t-tests		
Fruit: Heavy vs Light	57	1.73	n.s
Beer: Heavy vs Light	57	0.79	n.s

Note. n.s = not significant.*p<.05; **p<.01.

Table 6.3
Results of t-tests for drink x priming interaction

Groups	df	t	sig.
	Paired t-tests		
Placebo: fruit vs Beer	28	1.08	n.s
Alcohol: Fruit vs Beer	29	1.79	n.s
	Independent t-tests		
Fruit: Placebo vs Primer	57	0.96	n.s
Beer: Placebo vs Primer	57	1.84	n.s

Note. n.s = not significant.*p<.05; **p<.01.

Table 6.4
Results of t-tests for drinker status x priming interaction

Groups	df	t	sig.
Light: Placebo vs Alcohol	27	2.49	<.05
Heavy: Placebo vs Alcohol	28	2.49	<.05
Placebo: Heavy vs Light	27	1.75	n.s
Alcohol: Heavy vs Light	28	3.42	<.01

Note. n.s = not significant.

6.3.1.2 Facial EMG: levator labii

Figure 6.2 shows the levator responses to the fruit juice and beer of the heavy and light drinkers according to priming condition.

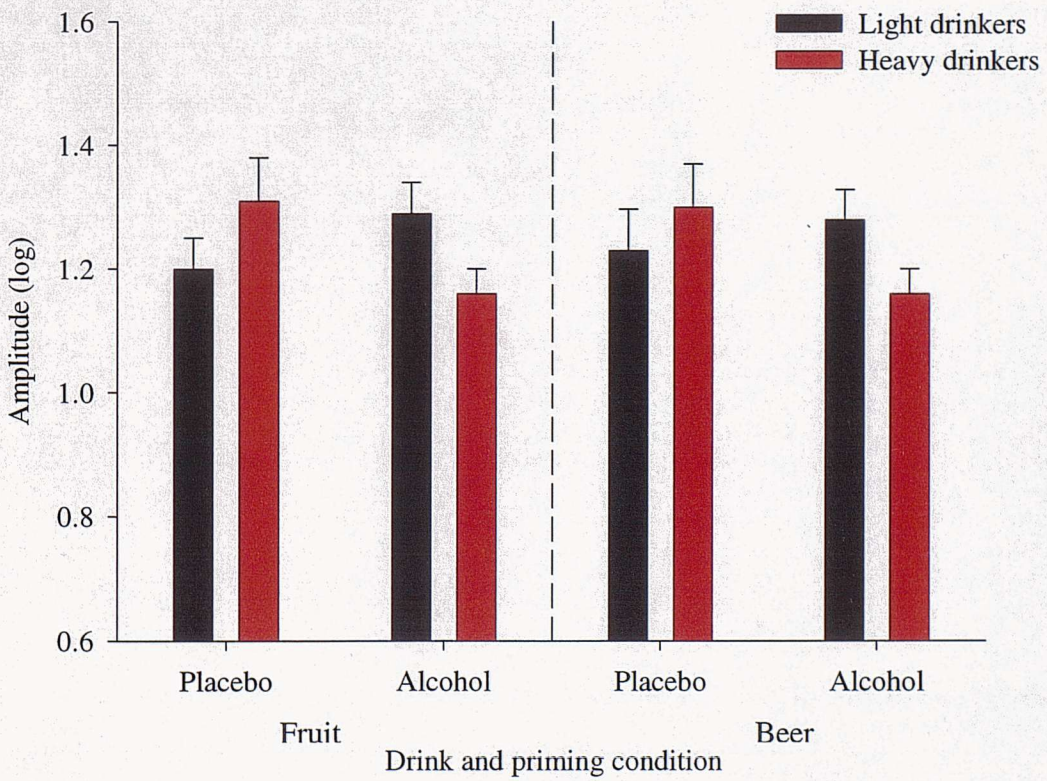


Figure 6.2 Mean (+SE) levator EMG amplitudes of heavy and light drinkers according to priming condition for fruit juice and beer. Note. '-----' = divide between fruit and beer responses.

A three-way ANOVA (drink x drinker status x priming) was conducted. The results are displayed in Table 6.5. The results revealed no significant effects of drinker status, priming condition, drink and no significant interactions. However, the drinker status x priming interaction was close to significance and suggested that priming with alcohol increased levator responding for the light drinkers and lowered it for the heavy drinkers, compared to placebo.

Table 6.5
Results of analysis of variance for levator labii

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.09	.76
Priming (P)	1	0.44	.51
DS x P	1	3.51	.07
Error	55	(387.27)	
	Within subjects		
Drink (D)	1	0.00	.99
D x DS	1	0.32	.58
D x P	1	0.33	.57
D x DS x P	1	0.85	.36
Error	55	(<0.00)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

6.3.1.3 Facial EMG: corrugator supercilli

Figure 6.3 shows the corrugator responses to the fruit juice and beer of the heavy and light drinkers according to priming condition.

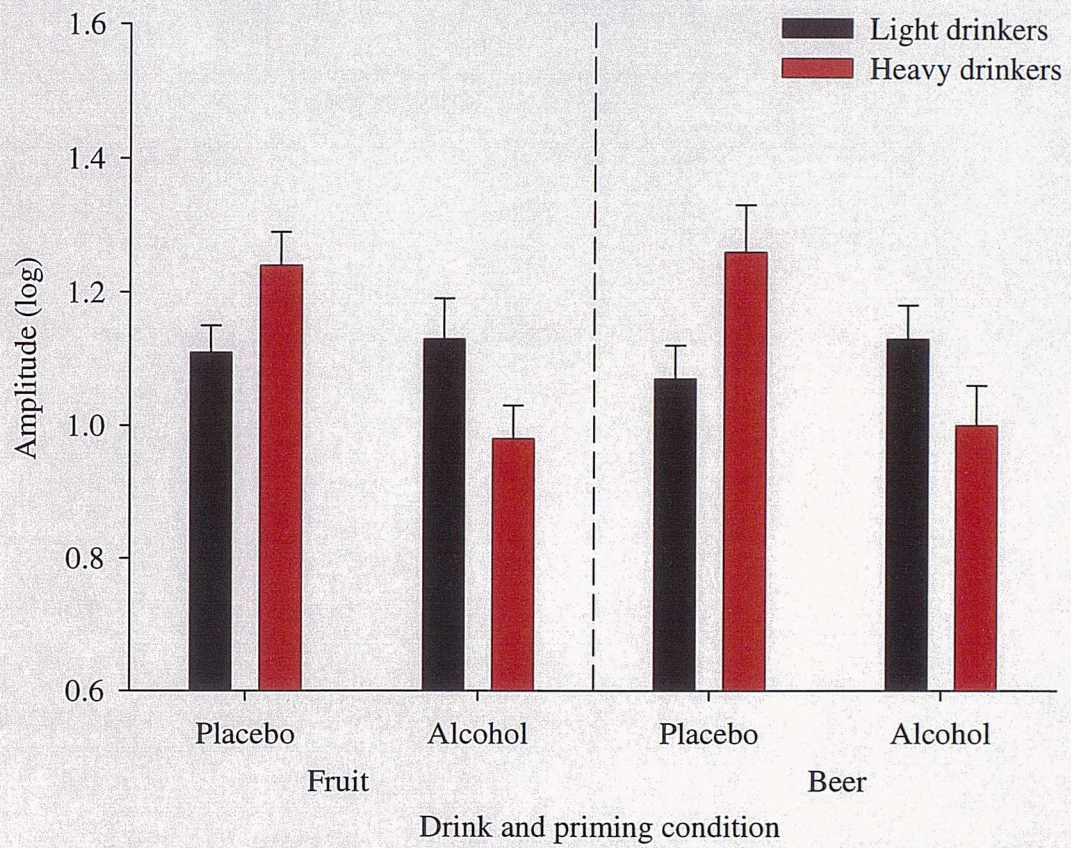


Figure 6.3 Mean (+SE) corrugator EMG amplitudes of heavy and light drinkers according to priming condition for fruit juice and beer. Note. '-----' = divide between fruit and beer responses.

A three-way ANOVA (drink x drinker status x priming) was conducted on the data. The results are displayed in Table 6.6. The results revealed no significant main effects of drinker status and solution type. However, there was a significant effect of priming and a significant drinker status x priming interaction.

Table 6.6
Results of analysis of variance for corrugator supercilli

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.03	.86
Priming (P)	1	4.45*	.04
DS x P	1	8.7**	.01
Error	55	(<0.00)	
	Within subjects		
Drink (D)	1	0.00	.99
D x DS	1	1.36	.25
D x P	1	0.21	.65
D x DS x P	1	0.29	.59
Error	55	(<0.00)	

Note. Values in parentheses represent mean square errors.
*p<.01; **p<.01.

A series of independent t-tests were conducted to explore the drinker status x priming interaction. The results are displayed in table 6.7. The heavy drinkers had significantly lower EMG responses in the alcohol condition compared to placebo condition and had significantly higher EMG responses in the placebo condition, compared to the light drinkers.

Table 6.7
Results of independent t-tests exploring drinker status x priming interaction

	df	t	sig.
Alcohol: Heavy vs Light	28	1.91	n.s
Placebo: Heavy vs light	25	2.31	<.05
Light: Alcohol vs placebo	27	0.66	n.s
Heavy: alcohol vs placebo	26	3.34	<.01

Note. n.s = not significant.

6.3.2 Wanting Test

Figure 6.10 shows the mean number of times that beer was chosen for each of the priming groups for the heavy and light drinkers. Beer choice was higher in the alcohol compared to the placebo condition for both the heavy and light drinkers.

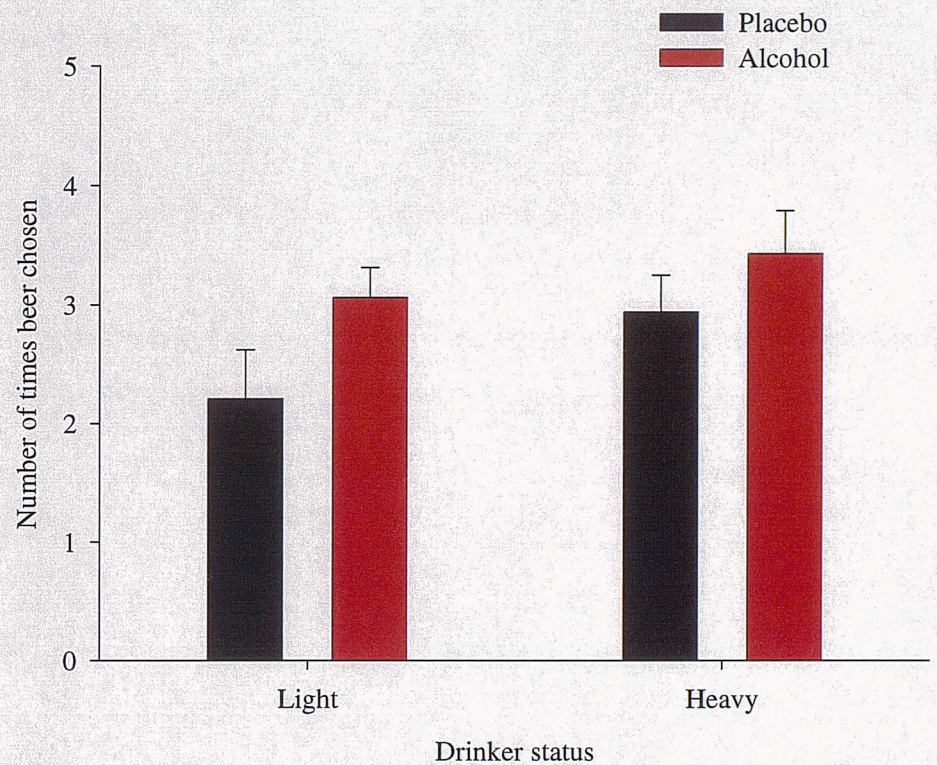


Figure 6.4 Mean (+SE) number of times beer chosen in choice tests for heavy and light drinkers according to priming condition.

The data for the number of times beer chosen was then analysed using a two-way ANOVA (drinker x priming). The results are shown in Table 6.8. The results revealed a main effect of priming, confirming that beer was chosen significantly more often in the alcohol-primed condition compared to the placebo-primed condition.

Table 6.8
Results of analysis of variance for number of times beer chosen in choice tests

Source	df	F	p
	Between groups		
Priming (P)	1	4.44*	.04
Drinker status (DS)	1	2.38	.13
P x DS	1	0.40	.53
Error	56	(1.65)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

Figure 6.5 shows the mean total fruit juice and beer consumption in the choice tests for the heavy and light drinkers according to priming group.

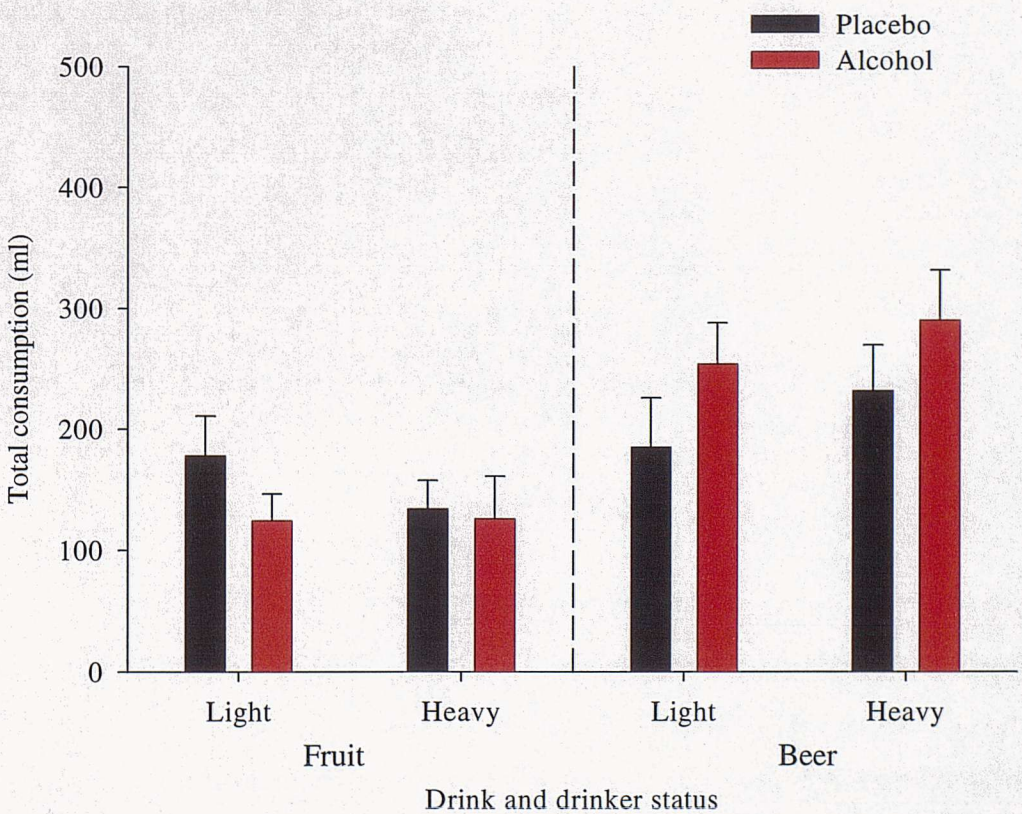


Figure 6.5 Mean (+SE) beer and fruit juice consumption in choice tests for heavy and light drinkers, according to priming group. Note. '-----' = divide between fruit juice and beer consumption

The data for the beer and fruit juice consumption was then analysed using a three-way ANOVA (drink x drinker x priming). The results are shown in Table 6.9. There were no significant main effects of priming or drinker status and no significant interactions. There was a significant main effect of drink indicating that more beer was consumed overall compared to the fruit juice.

Table 6.9
Results of analysis of variance for total fruit juice and beer consumption in choice tests

Source	df	F	p
	Between subjects		
Priming (P)	1	1.14	.29
Drinker status (DS)	1	0.44	.51
P x DS	1	0.34	.56
Error	56	(6912.83)	
	Within subjects		
Drink (D)	1	10.95**	<.00
D x P	1	2.46	.12
D x DS	1	1.07	.30
D x P x DS	1	0.21	.65
Error	56	(27109.97)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

6.4 Discussion

The results partially fulfilled the predictions made. Priming with alcohol was shown to increase wanting compared to priming with placebo, while having a weaker effect on liking. However, this priming effect did not have a larger impact on wanting for the heavy compared to the light drinkers. There was also some differential impact of priming with alcohol between the heavy and light drinkers on liking.

The results of the wanting test revealed that priming with alcohol had an effect on the beer choice measure. Those participants in the alcohol-primed condition chose beer

more often than those in the placebo condition. Although a similar effect seemed evident for the beer consumption measure, this effect was not found to be significant. No effect of priming with alcohol was found on fruit juice consumption and no differences between the heavy and light drinkers were found on any of the wanting measures.

The results of the liking test were more complex. The results for the liking ratings revealed no overall difference between the priming conditions or drinker groups but there were several significant interactions. Specifically, there were significant drinker status x priming, drink x priming interactions and drink x drinker status interactions. Further analysis of the drink x priming and drink x drinker status interactions revealed no specific differences. However, they suggested that the light drinkers liked the fruit juice more than the heavy drinkers and that priming with alcohol increased liking for beer but decreased liking for fruit juice. Figure 6.1 suggested the priming effect may have been specific to the beer ratings and that perhaps the light drinkers rated the fruit juice as more pleasant than the heavy drinkers. However, it cannot be concluded that there was a definite difference in the liking ratings between the priming conditions and drinker groups. In contrast, analysis of the drinker status x priming interaction revealed several interesting results. The heavy and light drinkers rated the drinks at the same level in the placebo condition. However, in the alcohol condition the light drinkers gave higher ratings and the heavy drinkers lower ratings than their counterparts in the placebo condition. So it can be said that alcohol had the general effect of reducing the liking ratings for the heavy drinkers but increasing it for the light drinkers.

The EMG results for the levator revealed that there were no differences between the heavy and light drinkers, the alcohol and placebo primed conditions and no differences in responding between the fruit juice and beer. The results for the corrugator were more complex. The results revealed that the heavy drinkers had reduced EMG responses in the alcohol compared to the placebo condition. This was not found for the light drinkers but the heavy drinkers were found to respond with higher EMG responses in the placebo condition, compared to the light drinkers.

Overall, the results of the wanting and liking tests revealed a clear priming effect on one measure of wanting and some effect of priming on two out of the three liking

measures. Closer consideration of the pattern of results for the liking ratings and the wanting test suggested evidence for a dissociation between wanting and liking. If wanting and liking are part of a unitary system, as suggested by Bindra (1974) and Toates (1986) then it would be expected that the priming manipulation would have had very similar effects on both the measures of wanting and of liking. Priming with alcohol increased wanting for alcohol on the choice measure. Figure 6.1 and the presence of the significant interaction between drinker status and drink on the liking ratings suggested that this increase in wanting was accompanied by a comparative increase in liking. However, as the follow-up analysis revealed no specific differences, the priming effect can be considered much weaker on the ratings compared to the choice measure. The finding that priming with alcohol had a differential impact on general liking ratings for the heavy and light drinkers does not suggest a close relationship between wanting and liking for alcohol. The heavy drinkers showed a decrease in their liking ratings overall, yet Figure 6.4 shows them choosing alcohol more than the light drinkers (although it is not significant) for whom alcohol increased liking. If wanting and liking were part of the same unitary process it would have been expected that any significant difference on liking between the heavy and light drinkers would have been reflected on the choice measure also. This can be construed as evidence of a dissociation as priming with alcohol had a stronger impact on wanting compared to liking. Furthermore, the drinker status x priming interaction suggested that priming had a differential impact on the heavy and light drinkers. Specifically, priming with alcohol lowered liking ratings for the heavy drinkers but increased it for the light drinkers. A differential effect of priming on the drinker groups was also seen at the corrugator. However, priming increased beer choice equally in the heavy and light drinkers. If all the measures were indexing the same process then a drinker status x priming interaction would have been seen on the choice data. Thus, this pattern of results supports the idea of a dissociation between wanting and liking.

The results for the levator also supported this conclusion, as no effects of priming or drinker status were found, although a close interaction between drinker status and priming condition was noted. Figure 6.2 suggested that the heavy drinkers might have had

lower EMG levels in the alcohol, compared to the placebo condition. However, this should not necessarily be construed as any indication of a difference in liking. More likely it is another example of the 'stress-dampening effect' (see 4.3.4), especially when considered alongside the corrugator data.

The results of the corrugator were less clear but when the results of Experiment one and two are considered it is likely that the EMG was not actually measuring liking. If the EMG at the corrugator was measuring an affective response these results would suggest that the heavy drinkers had higher levels of liking for the drinks compared to the light drinkers. In addition the priming dose of alcohol lowered this liking for the heavy but not the light drinkers. It is not clear how the incentive motivation theories could explain this. It is more plausible that, as in Experiment 1C, the EMG was not measuring liking and that the data is better explained by the 'stress-dampening effect' (see Greeley and Oei 1999 for review). On close inspection the results for the corrugator mirrored the results found in the Finn and Pihl (1987; 1988; 1990) studies. They found that men at high-risk for alcoholism were more responsive on physiological responding to electric shock than those at low-risk for alcoholism. Similarly, the heavy drinkers in this experiment responded with higher EMG responses compared to the light drinkers, in the placebo condition. Finn and Pihl also found that after a dose of alcohol (1.0 – 1.32 ml/kg) the high-risk men had drastically reduced physiological responding to the electric shock but the low risk men had increased responding. In this experiment the heavy drinkers responded with lower levels of EMG when primed with alcohol compared to placebo, although the light drinkers showed no difference. This is exactly as would be predicted by the Finn and Pihl studies with the exception that the light drinkers did not differ across priming conditions. This might be explained in terms of differences in the dose of alcohol used (a higher one was used by Finn and Pihl) and the fact that the stimuli in this study were not stress inducing (as opposed to electric shock). This would have meant that the light drinkers would have had no reason to respond with increased EMG response, which is indicative of muscle tension (and so stress).

The failure to find an effect of priming on the consumption measure or of priming to affect wanting differentially in the drinker groups may have been due to

methodological flaws. One was the effect of the cover story. The participants were told that the experiment was testing their ability to identify different beers and fruit juices from one session to the next. Many participants commented at the end of the experiment that they attempted to sample between beer and fruit juice equally in the choice tests. Thus, for many participants this would not have reflected their true wanting for alcohol. Furthermore, this may have also affected the choice measure of wanting. Secondly, were the screening requirements of the experiment. Participants were not admitted if they had consumed less than 10 units of alcohol in the previous week or had any form of alcohol dependence. This was an ethical requirement to avoid giving alcohol to very light or problem drinkers. It is a possibility that, as Robinson and Berridge (1993; 2001; 2003) have claimed, the sensitisation held to underlie the dissociation of wanting and liking for drugs is a progressive phenomena. It maybe that the participants in the present experiment did not differ enough in the amount of sensitisation they had undergone for an effect of drinker status to be apparent in the choice tests. The IST would predict that clearer results could be produced by studying populations that would be expected to show a more marked difference in the amount of sensitisation that they would have undergone. A clinical sample could be used to address this or an investigation of smokers could be carried out where it might be easier to recruit participants with more variation in levels of dependence.

In conclusion, the results provided some support for the IST. Priming with alcohol had a stronger impact on one measure of wanting compared to the measures of liking. However, the priming manipulation did not affect the consumption measure of wanting or have a greater impact on wanting in the heavy drinkers. Furthermore, the differential impact of priming on the heavy and light drinkers in the liking test, compared to the wanting test supported the claim of a dissociation between wanting and liking. There were some methodological considerations that might have explained these results. It was decided that the experiment should be replicated with a modified methodology.

CHAPTER SEVEN: EXPERIMENT 4: DISSOCIATION OF WANTING FROM LIKING USING A PRIMING DOSE OF ALCOHOL #2

7.1 Introduction

The previous experiment found that priming with alcohol had an impact on one measure of wanting (choice) compared to a weaker effect on the measures of liking (ratings, EMG). However, priming did not have an effect on the consumption measure of wanting and the priming manipulation did not have a greater impact in the heavy, compared to light, drinkers. This may have been due to methodological considerations. Experiment four aimed to replicate Experiment three and address the methodological issues raised.

Several changes were made to the methodology in Experiment four. Firstly, the priming dose of alcohol was increased from 0.2g/kg to 0.3g/kg. The original priming dose had been calculated based on the lowest possible dose used in the literature to elicit a priming effect. However, priming effects in the literature (e.g. Ludwig, Wikler and Stark 1974) have generally used higher doses than 0.2g/kg. Thus, it was felt that a higher priming dose might produce a more robust priming effect. The number of choice tests was also increased from five to 12 as it was felt that this may improve the accuracy of the choice measurement. Also, only one beer and one fruit juice were used in Experiment four for the ease of conducting the experiment.

The previous experiments relied on measures of taste liking (ratings, EMG) and behavioural measures of wanting (choice, consumption). Experiments one and two raised some doubts of the ability of the EMG to measure liking. At best it was considered a very insensitive measure and often could not be shown to be measuring liking at all. For this reason the EMG was not included as a measure of liking in Experiment four, with the focus shifting to the subjective ratings. Although, some concerns from the literature were raised in chapter two regarding the sole use of subjective ratings, they had clearly proved more reliable than the EMG in the context of Experiments one to three.

The predictions were the same as for Experiment three. It was predicted that priming with alcohol (relative to placebo) would have little or no effect on liking for alcohol but would lead to an increase in wanting for an alcoholic beverage. It was also

predicted that this priming effect would have a greater impact on the heavy drinkers compared to the light drinkers.

7.2 Method

7.2.1 Design

There were two main parts to the experimental design. The first, a liking test, used subjective ratings as the dependent measures. The second, a wanting test, used number of alcohol choices and amount of alcohol consumed in a choice test as dependent measures. The liking test used a three factor mixed design. There were two between participants factors; participants were assigned either heavy or light drinker status on the basis of their self-reported alcohol consumption and were randomly assigned to either an alcohol-priming or a placebo-priming condition with the constraint that there were equal numbers of males and females in each condition. The within subjects factor was drink; all participants sampled two types of drink, beer and fruit juice. Liking ratings were obtained for each trial. In the second part of the design wanting for alcohol was measured in 12 alcohol and soft drink choice tests. The type of drink chosen and the amount of each drink consumed were dependent variables indexing wanting. The second part of the experiment used a two factor between subjects design with heavy or light drinker status and alcohol or soft drink priming condition as factors.

7.2.2 Participants

Forty participants took part in the experiment. There were 23 females and 17 males, aged between 18 and 60 years with a mean age of 23.45 (SD = 9.1) years. There were 19 light drinkers (11 females, eight males) and 21 heavy drinkers (12 females, nine males). The light drinkers consumed between 9.5 and 17 units of alcohol in the last week, with a mean of 12.24 (SD = 2.4) units. The heavy drinkers consumed between 18 and 56 units of alcohol in the past week, with a mean of 25.1 (SD = 8.8) units. All participants had to fulfil the same screening requirements as in Experiment three.

7.2.3 Materials

The alcohol-priming solution consisted of Safeway's vodka (37.5%) diluted with Safeway's grape juice to yield a 5% alcohol solution. The beer used was Heineken (3.4%) and the fruit juice used was Safeway's pure unsweetened pineapple juice. In the liking test, the solutions were presented as 10ml samples in 30ml plastic measuring cups. In the choice tests all the beverages were presented as 50ml samples (one per choice test) in small, clear 50ml glasses.

7.2.4 Procedure

Each participant first consumed a 0.3g/kg dose of an alcohol solution or a placebo solution of the same volume. They were instructed to sip the solution over the course of 10 minutes. The solution was presented in two glasses and they were instructed to take five minutes to drink each. The participants then took a break of 15 minutes. Participants then completed a liking test, which consisted of four trials (two beer, two fruit juice). Immediately after drinking each solution, the participants provided a liking rating for the taste of the solution. At this point they also completed the Drug Effects Questionnaire (DEQ) and the alcohol craving questionnaire (ACQ-Now). However, the DEQ data was not reported as with hindsight the questions were not found to be applicable to the placebo condition. The ACQ data was not reported as no significant results were found and the questionnaire was not administered in subsequent experiments. Thus, it was felt the focus should be given to the primary measurements (liking ratings, choice tests). In the final part of the experiment, participants completed 12 choice tests. In each choice test participants were allowed to choose to drink either beer or fruit juice. They were then given at least one minute to taste the solution and provide a liking rating. They were told they could consume as much of the solution as they wished.

7.2.5 Data Reduction and Analysis

The liking ratings taken during the liking test were aggregated for each participant to yield one mean fruit juice and a mean beer rating for each participant. The number of times beer was chosen in the choice tests and the total amount of beer

consumed over the choice tests were calculated for each participant. The results were organised into two sections. These were the liking test and the wanting test.

7.3 Results

7.3.1 Liking test

Figure 7.1 shows the mean beer and fruit juice liking ratings for the heavy and light drinkers according to priming condition. No differences between the priming conditions or the heavy and light drinkers were evident. However, overall the fruit juice was rated as more pleasant than the beer.

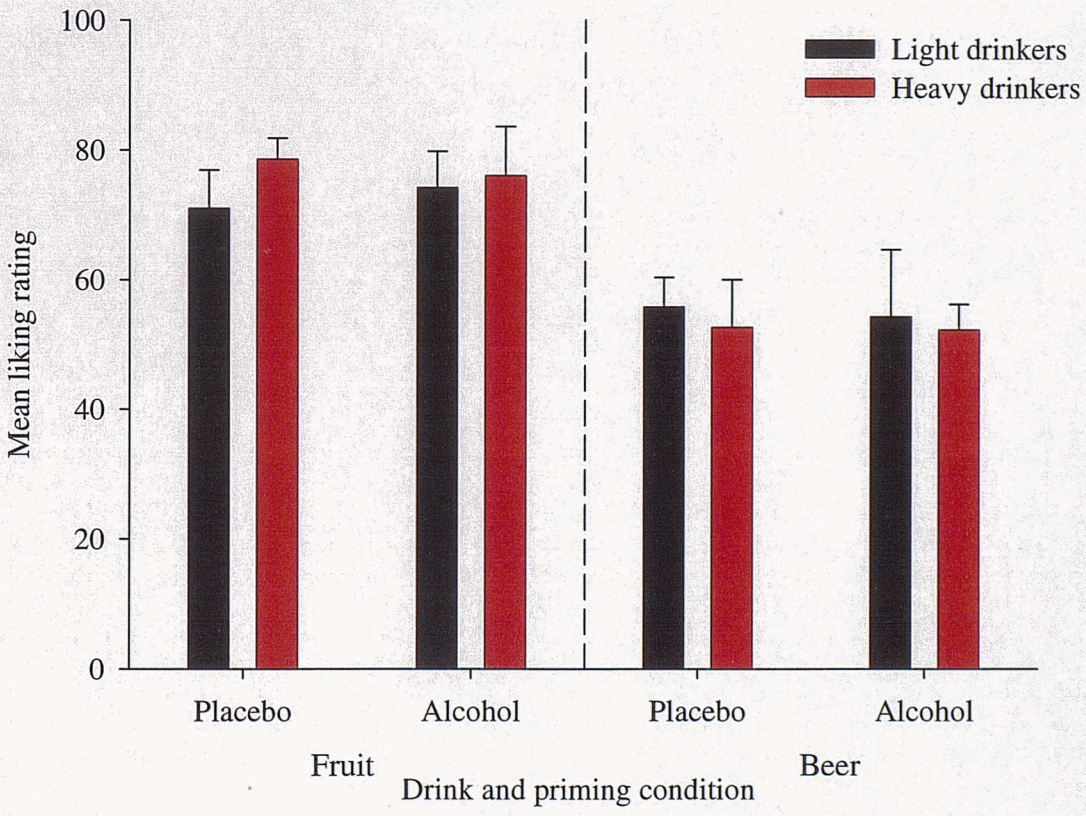


Figure 7.1 Mean beer and fruit juice liking ratings (+SE) for heavy and light drinkers according to priming condition. Note. '----' = divide between fruit juice and beer ratings.

A three-way mixed ANOVA (drink x drinker status x priming) was conducted on the mean liking ratings from the liking test. The results of the ANOVA are displayed in Table 7.1. The results showed a significant main effect of drink,

confirming that the fruit juice was rated as significantly more pleasant than the beer. There were no significant main effects of drinker status or priming and no significant interactions.

Table 7.1
Results of analysis of variance for liking test

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.05	.82
Priming (P)	1	0.01	.95
D x P	1	0.07	.80
Error	36	(387.21)	
	Within subjects		
Drink (D)	1	23.21**	<.00
D x DS	1	0.68	.42
D x P	1	0.02	.88
D x DS x P	1	0.16	.69
Error	36	(369.18)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

7.3.2 Wanting Test

Figure 7.2 shows the mean number of times beer was chosen in the choice tests, according to drinker status and priming condition.

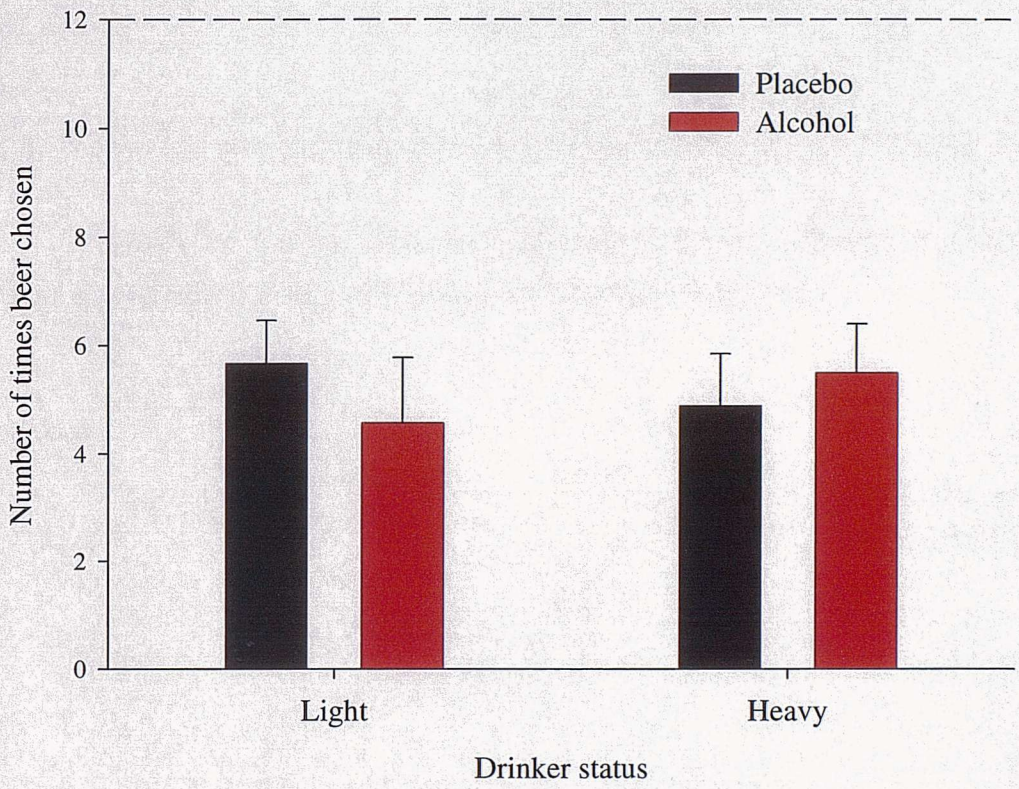


Figure 7.2 Mean (+SE) number of times beer chosen in choice tests according to drinker group and priming condition. Note. '----' = maximum number of possible beer choices (12).

A two-way ANOVA (drinker x priming) was conducted on the data for the number of times alcohol chosen in the choice tests. The results are shown in table 7.2. The results showed no significant effects of priming group or drinker status on beer choice and no significant interaction.

Table 7.2
Results of analysis of variance for number of times beer chosen in choice tests

Source	df	F	p
	Between subjects		
Priming (P)	1	0.06	.80
Drinker (D)	1	0.006	.94
P x D	1	0.78	.38
error	36	(8.9)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

Figure 7.3 shows the mean total fruit juice and beer consumption in the choice tests for the heavy and light drinkers according to priming group.

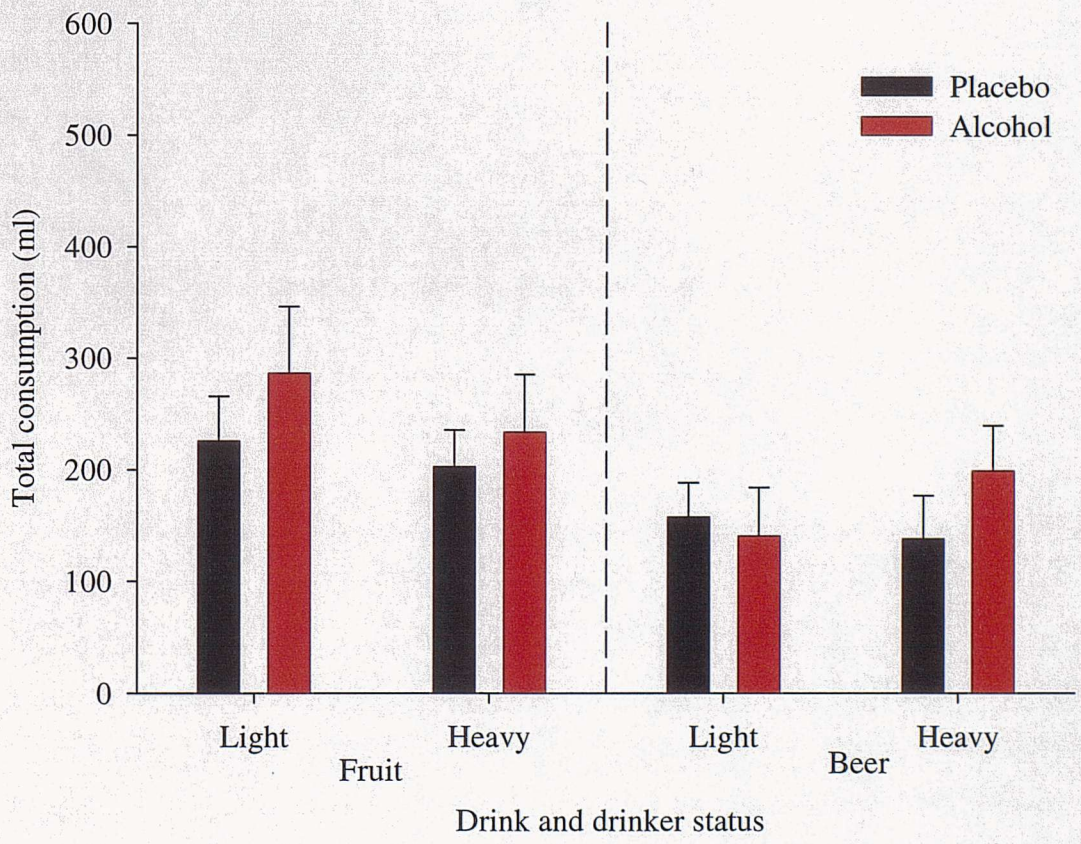


Figure 7.3 Total consumption of beer in choice tests (+SE) for heavy and light drinkers in alcohol and placebo priming conditions. Note. '---' = divide between fruit juice and beer data.

A three-way ANOVA (drink x drinker status x priming) was conducted for the total beer and fruit juice consumption data. The results are displayed in Table 7.3. The

results revealed no significant effect of drinker status, priming condition and no significant interactions. There was a main effect of drink indicating that overall more fruit juice than beer was consumed.

Table 7.3
Results of analysis of variance for total beer and fruit juice consumed in choice tests

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.10	.76
Primed (P)	1	1.28	.27
DS x P	1	0.16	.69
Error	36	(16965.91)	
	Within subjects		
Drink (D)	1	5.96*	.02
D x DS	1	0.79	.38
D x P	1	0.14	.71
D x DS x P	1	0.70	.41
Error	36	(19618.49)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

7.4 Discussion

The results did not fulfil the predictions. Priming with alcohol had no effect on the liking ratings or on the measures of wanting. This is in contrast to the robust priming effect found on the choice measure of wanting and the significant interactions found on the liking ratings in Experiment three. There was also no difference on the measures of wanting and liking between the heavy and light drinkers. Given that there was no effect of priming on the measures it is also not surprising that the priming manipulation did not have a greater impact on the heavy, compared to the light drinkers. The lack of a priming effect would also explain the failure to replicate the significant drinker status x priming and drink x priming interactions found on the liking ratings in Experiment three as there was no priming effect for these factors to interact with.

It is possible that this lack of significant findings was due to two methodological differences in Experiment four, compared to Experiment three. Most importantly, the fruit juice used in this experiment was rated as significantly more pleasant than the beer. In Experiment three the beers and fruit juices used were rated at the same level of pleasantness. This difference in pleasantness might have masked any priming effect on the measures of wanting and liking by inducing the participants to choose fruit juice more times than they did previously because it was liked far more strongly than the beer. Robinson and Berridge (1993; 2000; 2001; 2003) have maintained that wanting and liking for rewards usually cohere and that it is drug-induced sensitisation that results in a dissociation between wanting and liking. Even after sensitisation has occurred they still maintained that wanting and liking continue to interact in some complex manner. Specifically, liking is still seen as able to trigger wanting. The sensitisation that is held to underlie the dissociation of wanting and liking was also claimed to be a progressive phenomenon. Thus, the IST would predict that any difference in wanting and liking is likely to be much less pronounced in social compared to dependent drinkers. Therefore, the detection of a dissociation of wanting and liking in social drinkers might be more likely to be hidden by large differences in liking, as seen between the fruit juice and beer in this experiment. Similarly, the difference in liking between the beer and fruit juice may resulted in the failure to replicate the drink x drinker status interaction found in Experiment three.

There were also other differences that were introduced from Experiment three to four. The priming dose was higher, 0.3g/kg compared to 0.2g/kg in Experiment three and the participants completed the DEQ and ACQ questionnaires. It is not clear how these might have influenced the experiment. Possibly the questionnaires could have made the participants more aware of the aims of the experiment.

In conclusion, the results failed to provide support for the IST but this could be explained by methodological considerations. The methodological limitations identified led to the decision to attempt another replication of Experiment three in a subsequent Experiment.

CHAPTER EIGHT: EXPERIMENT 5: DISSOCIATION OF WANTING FROM LIKING USING A PRIMING DOSE OF ALCOHOL #3

8.1 Introduction

Experiment five was the third and last experiment that attempted to manipulate wanting independently of liking using a priming dose of alcohol. Experiment four failed to replicate the priming effect found in Experiment three. It was argued that the most plausible reason for this was the change in drinks from Experiment three to four. The purpose of experiment five was to replicate the original priming effect by addressing this in a new priming experiment that used the same drinks and a similar methodology (same number of choice tests and drinks) as in Experiment three.

Changes were made in the priming doses used in Experiments three and four. A 0.25g/kg priming dose was used, instead of the original 0.2g/kg dose and the 0.3g/kg dose in Experiment four. It also was possible that the questionnaires (DEQ and ACQ) completed in Experiment 4 (unreported) gave some indication as to the purpose of Experiment four and so it was felt prudent not to include it these measures in Experiment five.

The predictions were the same as for Experiment three. It was predicted, on the basis of IST, that priming with alcohol (relative to placebo) would have little or no effect on liking for alcohol but would lead to an increase in wanting for an alcoholic beverage. It was also predicted that this priming effect would have a greater impact on the heavy drinkers compared to the light drinkers.

8.2 Method

8.2.1 Design

There were two main parts to the experimental design. The first, a liking test, used subjective ratings as the dependent measure. The second, a wanting test, used number of alcohol choices and amount of alcohol consumed in a choice test as dependent measures. The liking test used a three factor mixed design. There were two between participants factors; participants were assigned either heavy or light drinker

status on the basis of their self-reported alcohol consumption and were randomly assigned to either an alcohol-priming or a placebo-priming condition with the constraint that there were equal numbers of males and females in each condition. The within subjects factor was drink; all participants sampled two types of drink, beer and fruit juice. Liking ratings were obtained for each trial of the liking test. In the second part of the design wanting for alcohol was measured in five alcohol and soft drink choice tests. The type of drink chosen and the amount of each drink consumed were dependent variables indexing wanting. This part of the experiment used a two factor between subjects design with heavy or light drinker status and alcohol or soft drink priming condition as factors.

8.2.2 Participants

Forty participants took part in the experiment. There were 24 females and 16 males, aged between 18 and 36 years with a mean age of 21.6 years (SD = 3.59). There were 20 participants in the light drinker group (12 females, eight males) and 20 participants in the heavy drinker group (12 females, eight males). The light drinkers had consumed between 9 and 18.5 units of alcohol in the past week with a mean of 13.7 (SD = 3.2) units. The heavy drinkers had consumed between 18.5 and 69.5 units of alcohol with a mean of 27.8 (SD = 11.2) units. To take part in the experiment all participants were required to meet the screening criteria outlined in Experiment three, although when the data was rechecked one participant had only consumed nine units of alcohol in the past week.

8.2.3 Beverages

The five beers used were Foster's (4%), Carlsberg (4%), Carling (4.1%), John Smith's (4%) and Boddington's bitter (3.8%). The five fruit juices used were Safeway's long-life apple juice, orange juice, grapefruit juice and pineapple juice and Ocean spray cranberry classic juice. All beverages were served chilled. The alcohol-priming dose was Safeway's vodka (37.5%) diluted with Safeway's long-life grape juice to yield a 5% ethanol solution. In the placebo condition the solution was simply grape juice. Both solutions were always served chilled. While consuming the priming solution each participant was asked to place a Locketts extra strong throat lozenge in

their mouths to mask the taste of the alcohol. The order that beer and fruit juice was presented in the liking test was counterbalanced. Each of the five beers and five fruit juices were presented an equal number of times although allocation of each one to the participants was randomised. Presentation of the beers and fruit juices in the choice tests was random. All the solutions were presented in clear glass pint glasses, except in the liking test. In the liking test the solutions were presented in 30ml plastic measuring cups.

8.2.4 Procedure

Participants first consumed a 0.25g/kg priming dose of alcohol or a placebo of the same volume. Participants spread out their consumption of the solution over the course of 10 minutes. Participants were told that the solution was grape juice and may or may not contain alcohol. They were also told that if it did contain alcohol it was quite a low concentration and they would probably not be able to tell by taste alone if it contained alcohol. After consuming the priming dose, participants were asked if they thought it contained alcohol. There was then a break of 15 minutes. Participants then completed a liking test. In this they four solutions (beer and fruit juice) and provided a liking rating. Immediately after this they completed five choice tests. In each choice test the participants were told to choose either beer or fruit juice. They were told that how many times they chose beer or fruit juice was entirely up to them. They were also told that they did not have to consume all of the solutions, just as much as they wished. They were then allowed to taste it and give a (bogus) liking rating. They were given two minutes to do this before moving onto the next trial. The experimenter measured the number of times beer was chosen how much of each solution was consumed.

8.2.5 Data Reduction and Analysis

Mean liking ratings for the beers and the fruit juices for each participant in the liking test were calculated. In the wanting test, each participant provided values for how often they had chosen beer and how much of each solution they had consumed in each choice test. The total beer and fruit juice consumed over all five choice tests was calculated.

8.3 Results

8.3.1 Liking Test

Figure 8.1 shows the mean fruit juice and beer liking ratings for the heavy and light drinkers according to priming condition. Both heavy and light drinkers rated the fruit juice and beer at a similar level in both priming conditions.

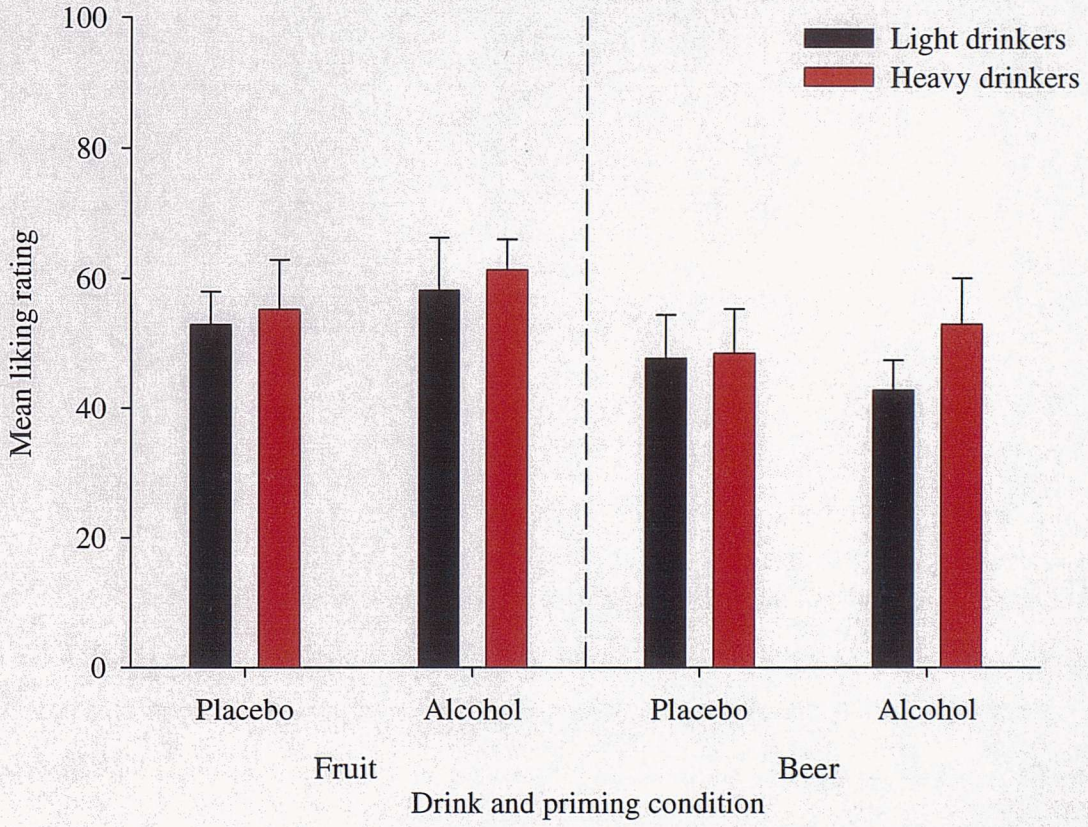


Figure 8.1 Mean fruit juice and beer liking ratings (+SE) for heavy and light drinkers according to priming condition. Note. '---' = divide between fruit juice and beer data.

A three-way mixed ANOVA (drink x priming x drinker status) was conducted on the data for the liking ratings. The results are shown in Table 8.1. There were no significant main effects of drink, drinker status or priming condition. However, the main effect of drink was close to significance and this indicated that the beer might have been rated as less pleasant than the fruit juice.

Table 8.1
Results of analysis of variance for liking test

Source	df	F	p
	Between subjects		
Priming (P)	1	0.35	.56
Drinker status (DS)	1	0.78	.38
P x DS	1	0.31	.58
Error	36	(406.3)	
	Within subjects		
Drink (D)	1	3.75	.06
D x P	1	0.40	.53
D x DS	1	0.09	.77
D x P x DS	1	0.22	.65
D error	36	(405.27)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01

8.3.2 Wanting Test

Figure 8.2 shows the mean number of times beer was chosen for the heavy and light drinkers in the placebo and alcohol conditions. Both the heavy and light drinkers chose beer more often when they were primed with alcohol compared with the placebo.

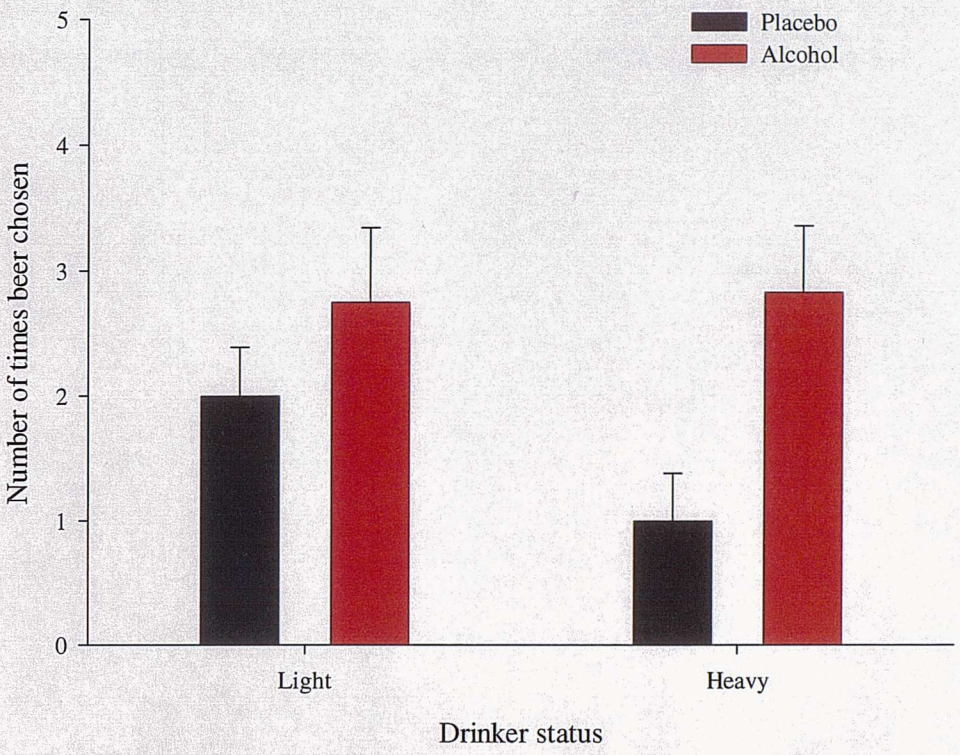


Figure 8.2 Mean (+SE) number of times beer chosen for the heavy and light drinkers in placebo- and alcohol-primed conditions.

The data for the number of times beer was chosen was then analysed using a two-way ANOVA (priming x drinker status). The results are displayed in Table 8.2. A main effect of priming was found, confirming that those participants in the alcohol-primed condition chose beer more often than those in the placebo condition. No main effect of drinker status and no significant interaction was found.

Table 8.2
Results of analysis of variance for number of times beer chosen

Source	df	F	p
	Between subjects		
Priming (P)	1	6.77*	.01
Drinker status (DS)	1	0.85	.36
P x DS	1	1.19	.28
Error	36	(2.37)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

Figure 8.3 shows the total amount of beer and fruit juice consumed by the heavy and light drinkers according to priming condition. Both drinker groups consumed more beer in the alcohol condition than in the placebo condition.

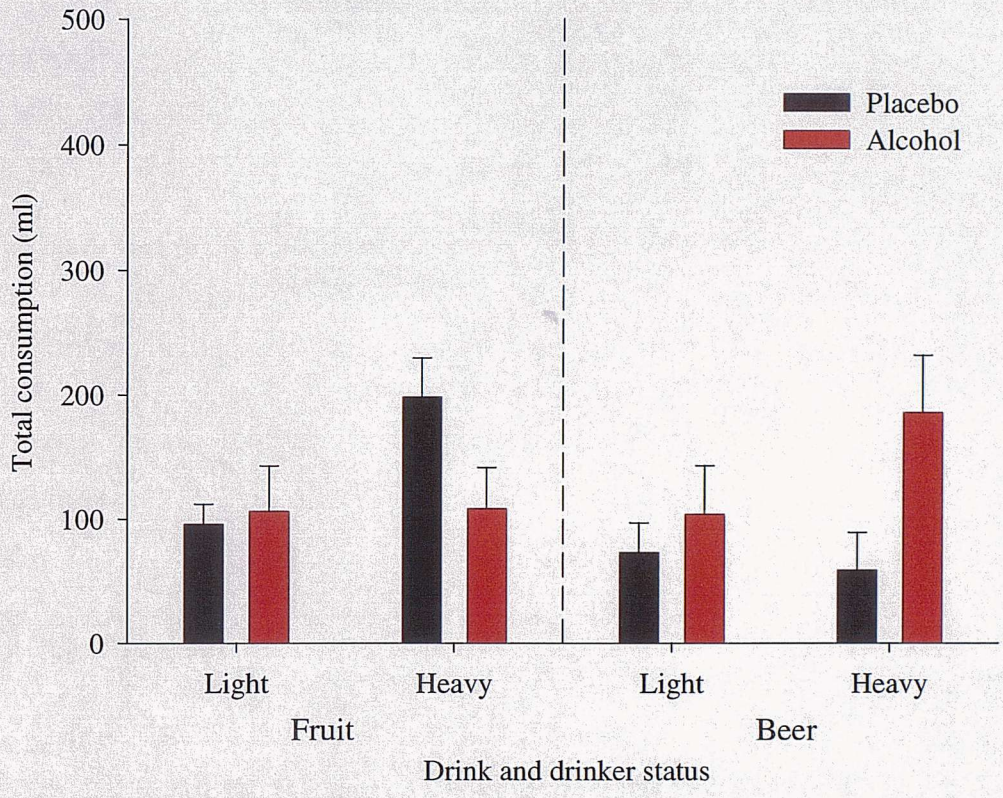


Figure 8.3 Mean (+SE) beer and fruit juice consumption in choice tests for heavy and light drinkers, according to priming group. Note. '-----' = divide between fruit juice and beer consumption.

The data for the total amount of beer and fruit consumed was then analysed using a three-way ANOVA (drink x priming x drinker status). The results are displayed in Table 8.3. There was no significant main effect of priming or drink. There was a main effect of drinker status indicating that the heavy drinkers had higher overall consumption for both beer and fruit juice, compared to the light drinkers. There was also a significant drink x priming interaction. This interaction was explored by conducting separate one-way ANOVAs for fruit juice and beer consumption. The results are displayed in Table 8.4. The results indicated that more beer was consumed in the alcohol compared to the placebo condition but there was no difference in fruit juice consumption across priming conditions. There was also a near significant three-way interaction. This indicated that the priming effect on the beer might have been larger for the heavy, compared to the light drinkers.

Table 8.3
Results of analysis of variance for total amount of beer and fruit juice consumed

Source	df	F	p
	Between subjects		
Priming (P)	1	0.85	.36
Drinker status (DS)	1	4.15*	.05
P x DS	1	<0.00	.96
Error	36	(8540.51)	
	Within subjects		
Drink (D)	1	0.68	.42
D x P	1	5.04*	.03
D x DS	1	0.12	.73
D x P x DS	1	3.43	.07
Error	36	(8483.53)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

Table 8.4
Results of analyses of variance exploring drink x priming interaction

	df	F	p
	Fruit		
Priming	1	0.93	.34
Error	38	(9354.02)	
	Beer		
Priming	1	5.37*	.03
Error	38	(13637.58)	

Note. Values in parentheses represent mean square errors.
*p<.05; **p<.01.

8.4 Discussion

The results fulfilled the prediction that priming with alcohol would affect wanting but not liking. The results from the liking test found no difference in the liking ratings, for either the beer or the fruit juice, between the alcohol and placebo priming conditions. This was in contrast to the results of the wanting test. Alcohol-primed participants chose and consumed more beer than placebo-primed participants. Furthermore, this effect was specific to the beer, with no comparative increase in fruit juice consumption across the priming conditions. However, the results did not fulfil the prediction that priming with alcohol would have a greater impact on the heavy compared to the light drinkers. The priming effect did not have a differential impact on the heavy and light drinkers in either the liking or the wanting test. However, the presence of a near significant three-way interaction suggested that the priming effect on the beer might have been larger for the heavy, compared to the light drinkers.

The results replicated and improved upon those of Experiment three and four. A far clearer priming effect was demonstrated, with significant effects on both measures of wanting and no significant effects on the liking measure. Presumably, this was due to the return to a similar methodology to Experiment three. No significant difference in the overall pleasantness of the fruit juice and beer was found (although it was close to significance), which presumably prevented any masking of the priming effect seen in Experiment four. The results provided support for the IST claim of a dissociation between wanting and liking. A clear and robust increase in wanting was observed as a result of priming with alcohol, while liking was unaffected. Thus, the increase in wanting cannot be attributed to an increase in liking. The IST would suggest that this independent increase in wanting was a result of sensitisation of wanting as a result of past alcohol consumption.

The lack of a differential affect of priming on the drinker groups maybe for the same reasons outlined in Experiment three. That is, the screening requirements of the experiment may have resulted in the heavy and light drinkers being too similar in their drinking habits for an effect of drinker status to be apparent in the choice tests. Again, this could be addressed by studying populations that would be expected to show a marked difference in the amount of sensitisation that they would have undergone.

These results suggest that the lack of a difference in liking between the heavy and light drinkers, observed in Experiments one and two, were not due to differences

in the temporal scale of the measures of wanting and liking. This is because the results showed a clear shift in wanting, while a concurrent measure of liking remained unaffected. However, it might still be objected that the results do not reflect a dissociation of wanting and liking but instead reflect a difference in the sensitivity of the measures used. It could be argued that the wanting measures are more sensitive to the priming effect, compared to the liking ratings. Thus, it might have been easier to observe a shift in choice and consumption than in the liking ratings and this could have hidden a comparative shift in liking. This argument is further strengthened when it is considered that there were some interactions on the liking ratings with priming condition in Experiments three. One way to overcome this would be to design an experiment that attempted the converse of this experiment. That is, attempt to alter the liking ratings, while leaving wanting unchanged. If the liking measure was less sensitive than the wanting measures, a change in this measure would be certainly be accompanied by a change in the wanting measures. However, if the wanting measures remained unchanged this would demonstrate that the evidence of a dissociation in the current research cannot be attributed in differences in the sensitivity of the wanting and liking measures.

In conclusion, the results supported the IST and demonstrated a dissociation between wanting and liking. Priming was found to selectively increase wanting (consumption, choice) but not liking (ratings). The subsequent experiment would attempt to address the argument that this was due to differences in the sensitivity of the measures by attempting to alter liking but not wanting.

CHAPTER NINE: DECREASING LIKING USING AN UNPLEASANT ADULTERANT

9.1 EXPERIMENT 6A: DETERMINING THE TWEEN SOLUTION FOR EXPERIMENT 6B

9.1.1 Introduction

Experiments three and five demonstrated a dissociation between wanting and liking by showing that a priming dose of alcohol could selectively increase measures of wanting but not liking. In 6.1 and 8.4 it was suggested that this dissociation could simply reflect a difference in the sensitivity of the measures used. For example if the measures of liking were less sensitive than the measures of wanting then priming might appear to affect wanting but not liking. To test this argument Experiment six attempted a manipulation that aimed to alter liking but not wanting. This would demonstrate a dissociation in itself and show that the evidence of Experiments three and five was not a result of differences in the sensitivity of the measures.

This involved an attempt to alter the liking ratings, independently of one of the measures of wanting (consumption). It was proposed that liking could be altered by adding Tween to beverages to make them less pleasant. Wanting and liking for straight and Tween adulterated beverages could then be compared. However, if liking were drastically reduced to the point where it was aversive this could influence wanting at some point. Therefore, a minimal concentration of Tween was needed that would result in a reliable reduction in liking. The aim of Experiment 6A was to arrive at such a concentration by examining the impact of several different concentrations of Tween on liking for beer and fruit juice.

9.1.2 Method

9.1.2.1 Design

The experiment used a within subjects design. Participants tasted a series of beer and fruit juice solutions over the course of 16 trials. Eight trials were fruit juice and eight were beer. The beer and fruit juice was adulterated with several concentrations of Tween (0%, 0.05%, 0.1%, or 0.15%), with two trials of each

concentration presented for each flavour. All trials were randomly presented. Subjective ratings of liking were obtained for each trial.

9.1.2.2 Participants

There were 24 participants. There were 15 females and nine males. They were aged between 18 and 60 years with a mean age of 24 (SD = 11.1) years. All participants in this experiment had taken part in Experiment four and completed this procedure at the end of that experiment.

9.1.2.3 Beverages

The fruit juice used was Safeway's pure unsweetened pineapple juice and the beer used was Heineken (3.4%). Tween (polysorbate 20) was used to adulterate the taste of each. All solutions were presented as 5ml samples in clear 30ml plastic measuring cups.

9.1.2.4 Procedure and Data Reduction

All the solutions were presented to each participant in a line on a tray. Participants were then instructed to drink each solution at their own pace and provide a subjective liking rating for each one. The mean liking rating for each solution was then calculated and paired t-tests were conducted to test for differences in liking between the straight solution and each adulterated solution.

9.1.3 Results and Discussion

Figure 9.1 shows the mean liking ratings for the four beer solutions. There was a steady reduction in reported liking for the solutions as the concentration of Tween increased.

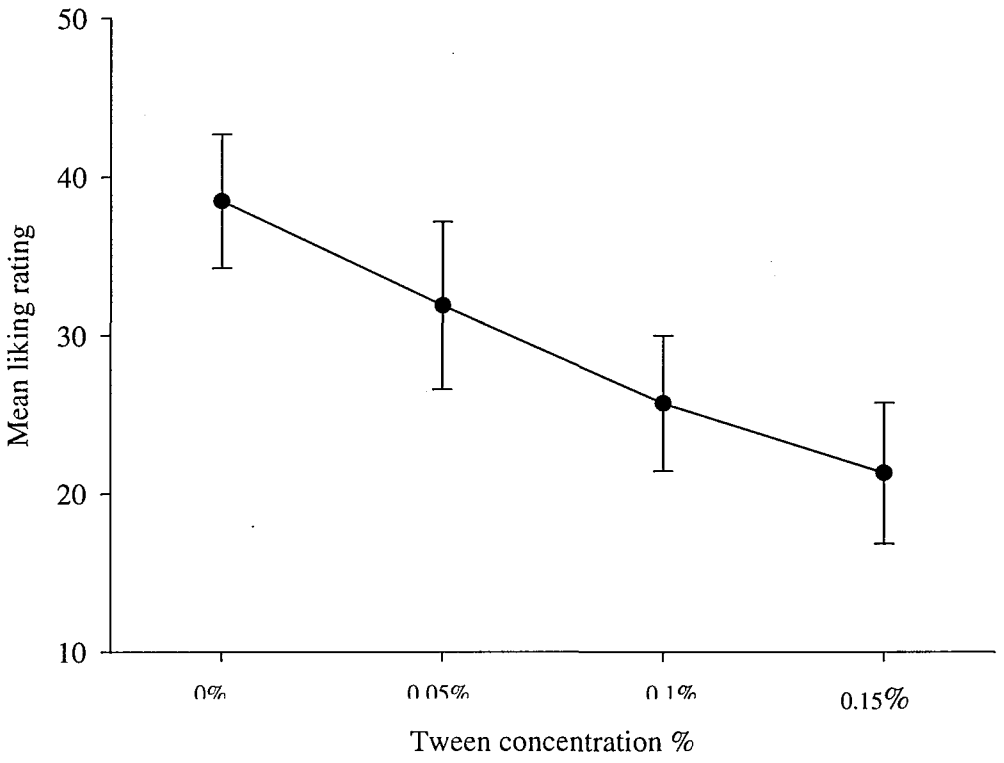


Figure 9.1 Mean liking ratings (+SE) for beer solutions.

Table 9.1 shows the results of a series of paired t-tests conducted on the liking ratings for the beer solutions. They showed that the beers with 0.1% and 0.15% concentrations of Tween were rated as significantly less pleasant than the straight beer. However, there was no significant difference in liking between the straight beer and the beer with 0.05% Tween. From this it was concluded that the smallest concentration of Tween likely to produce a significant difference in liking was 0.075% and it was decided to use this value for the adulterated beer in Experiment 6B.

Table 9.1
Results of paired t-tests for beer solutions

Solutions	t	df	sig.
0% vs 0.05%	1.66	23	n.s
0% vs 0.1%	3.97	23	<.01
0% vs 0.15%	4.98	23	<.01

Note. n.s = not significant.

Figure 9.2 shows the mean liking ratings for each of the fruit solutions. The addition of Tween to the fruit juice resulted in a reduction in subjective liking.

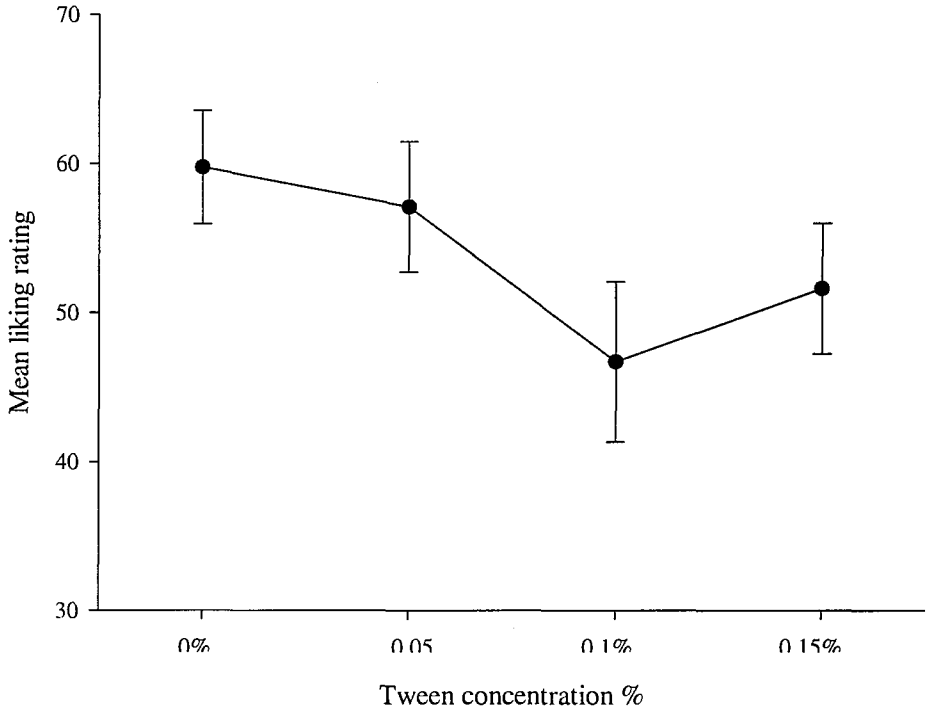


Figure 9.2 Mean liking ratings (+SE) for fruit juice solutions.

Table 9.2 shows the results of a series of paired t-tests conducted on the liking ratings for the fruit juice solutions. The results show that, as with the beer, the 0.1% and 0.15% Tween solutions were rated significantly different from the straight fruit juice. Again, the 0.05% solution was not rated as significantly different. Thus, the same conclusion was reached as with the beer and it was decided that a 0.075% Tween fruit juice solution would be used in Experiment 6B.

Table 9.2

Results of paired t-tests for fruit juice solutions

Solutions	t	df	sig.
0% vs 0.05%	0.85	23	n.s
0% vs 0.1%	3.10	23	<.01
0% vs 0.15%	2.11	23	<.05

Note. n.s = not significant.

9.2 EXPERIMENT 6B: DECREASING LIKING USING AN UNPLEASANT ADULTERANT #1

9.2.1 Introduction

Experiment 6B was the first of two experiments that investigated if changes in liking would be associated with changes in wanting. If changes in liking were not accompanied by changes in wanting then the argument that the dissociation, observed in the experiments three and five, was due to the liking measure being less sensitive would become less plausible. This was to be achieved by adulterating beer and fruit juice, using the Tween concentration derived from Experiment 6A. Participants in 6B were still assigned heavy and light drinker status in order to observe if they differed on the measures of wanting and liking. As the heavy and light drinkers differ by definition in their level of wanting, the IST would predict that they would differ on the measures of wanting.

It was predicted, on the basis of IST, that subjective liking (ratings) for both beer and fruit juice would be lower for the Tween adulterated beverages, compared to the straight beverages. The IST claims that the dissociation of wanting and liking for drugs occurs as the result of drug-induced sensitisation. Therefore they claim that there is usually no dissociation for non-drug rewards. Thus, it was predicted that the reduction in liking (ratings) would be accompanied by a reduction in wanting (consumption) for the fruit juice but not the beer.

9.2.2 Method

9.2.2.1 Design

The experiment used a three factor mixed design. There was a within participants factor of drink; all participants consumed two drinks, one beer and one fruit juice. The order of the drinks was counterbalanced. There were two between participants factors; 20 participants received drinks containing Tween (Tw+) and 19 participants received drinks that did not contain Tween (Tw-); participants were categorised as either heavy or light drinkers, based on alcohol consumption in the last

week. Subjective ratings of liking were obtained in response to each drink and total consumption of each drink was recorded.

9.2.2.2 Participants

There were 39 participants, 14 were male and 25 were females, aged between 18 and 39 years with a mean age of 21.28 (SD = 3.71) years. There were 20 participants in the light drinker group (13 females, seven males) and 19 in the heavy drinker group (12 females, seven males). The light drinkers had consumed between 9 and 26.5 units of alcohol in the past week with a mean of 12.8 (SD = 4.1) units. The heavy drinkers had consumed between 18 and 69.5 units in the past week with a mean of 27.82 (SD = 11.7) units. To take part in the experiment all participants were required to meet several criteria. They had to weigh over 50kg (males) or 60kg (females). Have no reason or professional advice for not consuming alcohol and have had at least one drinking session in the past month in which they consumed at least two pints of beer, or equivalent. They also had to register a negative breath alcohol reading at the start of the experiment. This criterion was employed to satisfy the requirements of the University of Southampton Psychology Ethical Committee, which was to confirm that the participants were regular drinkers and were familiar with the amounts of alcohol being administered in this study. To assess these criteria all participants completed a screening questionnaire (see Appendix 2.7) and were weighed in the laboratory. At the end of both sessions participants took a breath alcohol test. They were asked to rinse their mouths with water and the test was administered several minutes after they had last consumed alcohol. If the reading was 70mg% or above then the participants were asked to sign a disclaimer when they left the laboratory.

9.2.2.3 Materials

The beer used was Heineken (3.4%). The fruit juice used was Safeway's pure unsweetened pineapple juice. Both drinks were presented in clear pint glasses as 250ml volume solutions. The drinks were adulterated using Tween (polysorbate20) to yield solutions that were 0.075% Tween.

9.2.2.4 Procedure and Data Analysis

Participants were presented with one drink and asked to provide ratings on several dimensions. These included a dimension of liking (for taste) but also 'bogus' dimensions of 'sweetness', 'bitterness', sight of drink, 'smell of drink' and 'aftertaste'. Participants were given five minutes to rate each drink. They were instructed that they did not have to consume all of the drink, only enough so that they could provide accurate ratings. The participants were then provided with water to rinse their mouth and when they were ready the procedure was repeated with the second drink. The experimenter then measured how much of each drink had been consumed. From each participant, the experimenter obtained a liking rating and the volume consumed for each of the two drinks. Thus, each participant provided two liking ratings and two volume measurements.

9.2.3 Results

9.2.3.1 Liking Ratings

Figure 9.3 shows the mean liking ratings for the fruit juice and beer provided by the heavy and light drinkers according to Tween condition. Both the heavy and light drinkers rated the fruit juice and beer as slightly less pleasant in the Tw+ condition, compared to the Tw- condition. No effect of drinker status was apparent.

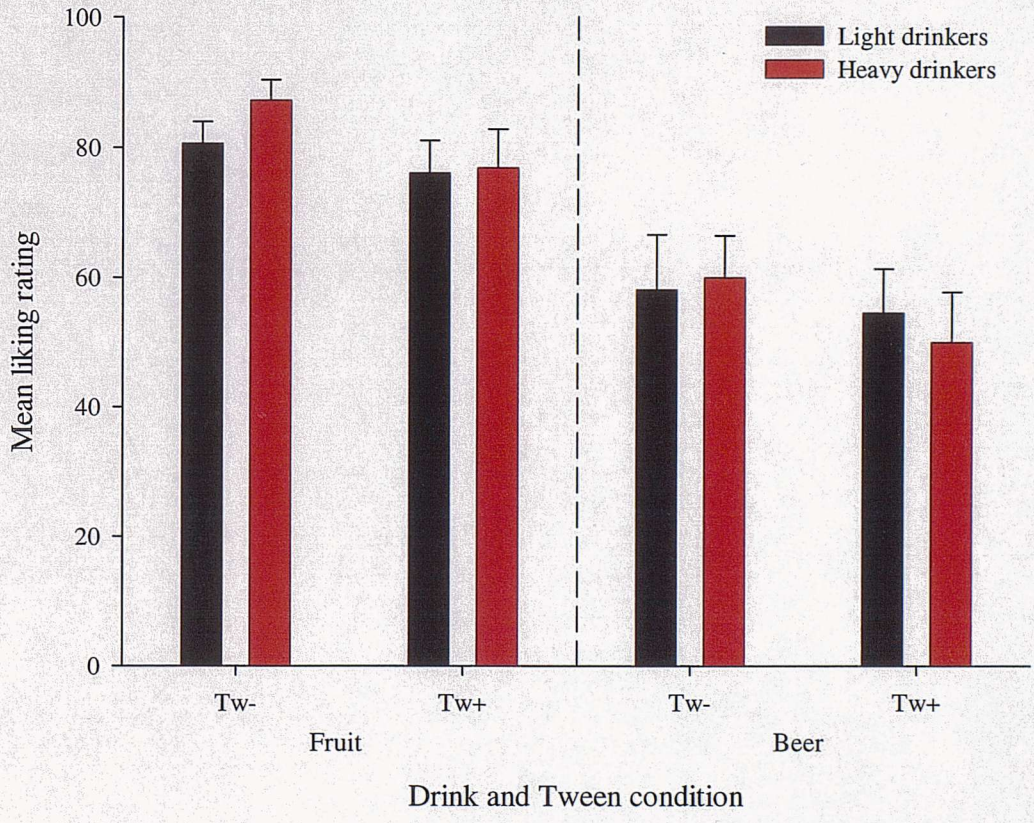


Figure 9.3 Mean fruit juice and beer liking ratings (+SE) for heavy and light drinkers in each Tween condition. Note. '----' = divide between fruit juice and beer data; Tw- = no Tween condition; Tw+ = Tween condition.

A three-way ANOVA (drink x Tween condition x drinker status) was conducted on the fruit juice and beer ratings. The results are displayed in Table 9.3. A significant main effect of drink was found indicating that the fruit juice was rated as more pleasant than the beer. No significant effects of Tween condition or drinker status were found and no significant interactions.

Table 9.3
Results of analysis of variance for liking ratings

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.08	.79
Tween (T)	1	2.74	.11
DS x T	1	0.51	.48
Error	35	(349.16)	
	Within subjects		
Drink (D)	1	31.51**	<.00
D x DS	1	0.34	.57
D x T	1	0.01	.94
D x DS x T	1	<0.00	.97
Error	35	(360.32)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

9.2.3.2 Wanting

Figure 9.4 shows the mean fruit juice and beer consumed by the heavy and light drinkers in each Tween condition. Both the heavy and light drinkers consumed similar amounts of fruit juice in each condition.

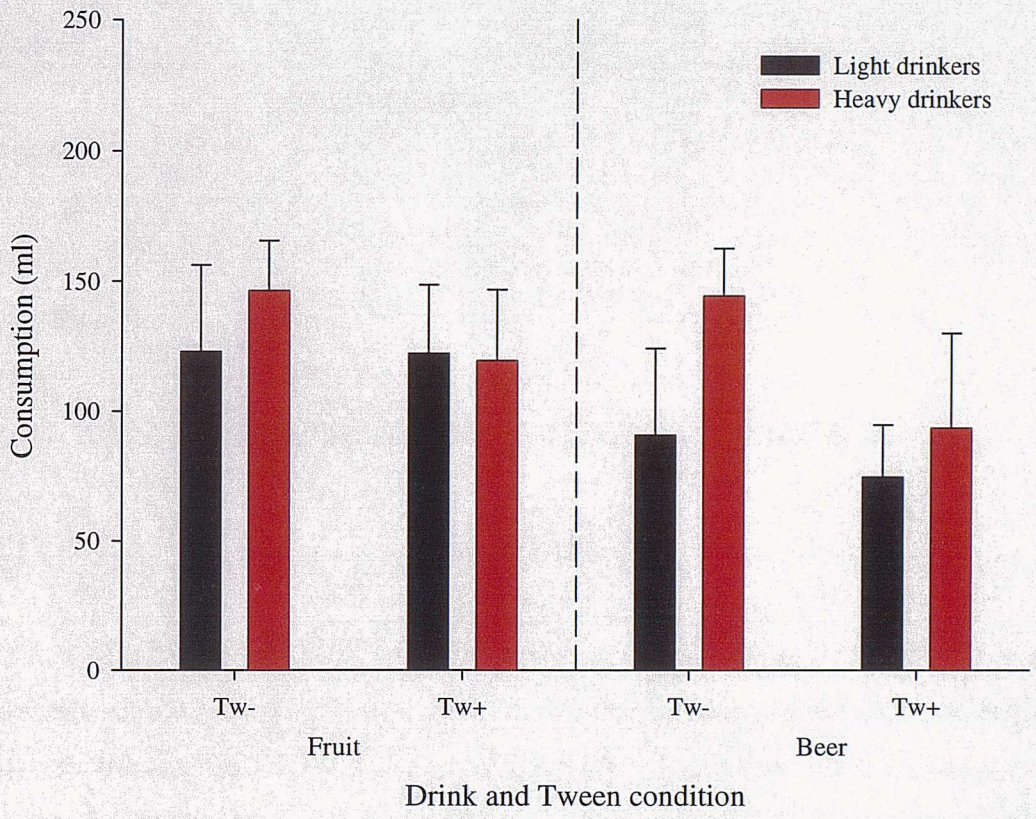


Figure 9.4 Mean (+SE) volume of fruit juice and beer consumed for heavy and light drinkers in each Tween condition. Note. '----' = divide between fruit juice and beer data; Tw- = no Tween condition; Tw+ = Tween condition.

A three-way ANOVA (drink x Tween condition x drinker status) were conducted on the beer and fruit juice consumption data. The results are displayed in Table 9.4. The results revealed a significant main effect of drink, indicating that more fruit juice than beer was consumed. No significant main effects of Tween condition or drinker status and no significant interactions were found.

Table 9.4
Results of analysis of variance for amount of fruit juice and beer consumed

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.92	.34
Tween (T)	1	0.96	.33
DS x T	1	0.40	.53
Error	35	(10972.63)	
	Within subjects		
Drink (D)	1	6.44*	.02
D x DS	1	1.50	.23
D x T	1	0.86	.36
D x DS x T	1	0.04	.85
Error	35	(2121.81)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

9.2.4 Discussion

The results did not fulfil the predictions made from the IST. Adding Tween to the beer and fruit juice did not result in a reduction in liking or wanting. Participants did not rate the beer or fruit juice as significantly less pleasant when Tween was added and there was no reduction in consumption of beer or fruit juice when Tween was added. No significant differences in the measures of wanting or liking were found between the heavy and light drinkers.

As the experiment failed to observe an effect of Tween on liking the results were rendered ambiguous and unable to provide a test of the dissociation. The experiment failed in the manipulation that was expected to result in a decrease in liking and so it is not possible to ascertain the effect of changes in liking on wanting. The failure to show a decrease in liking, as observed in Experiment 6A, may have been for two reasons.

One reason is differences between Experiments 6A and 6B. Experiment 6A showed that Tween produced a change in liking somewhere between the 0.05% and 0.1% concentrations. The effect of a 0.075% Tween concentration was not tested. It maybe that the 0.075% concentration of Tween was not strong enough to produce a

marked reduction in liking. A higher concentration of Tween may have been more suitable, so that more robust change in liking could be observed. A second reason could have been that the use of a between participants design masked any changes in liking and wanting because of individual variation in the participants. Experiment 6A also used a within participants design involving several trials of each solution used, which would have controlled with any individual variation in liking for the beer and fruit juice. Thus, a within participants design may have produced a more accurate result. To overcome this problem of individual variation, it was decided to run a new experiment using a within participants design that can better control for individual variation.

In conclusion, Experiment 6B did not provide support for the IST and the decision was taken to attempt to replicate the experiment using a modified methodology.

CHAPTER TEN: EXPERIMENT 7: DECREASING LIKING USING AN UNPLEASANT ADULTERANT #2

10.1 Introduction

Experiment seven was the second experiment that aimed to investigate if changes in liking are associated with changes in wanting. Experiment 6B cannot be considered a good test of the dissociation between wanting and liking because it failed to produce the necessary Tween induced change in liking. Experiment seven aimed to address the limitations in the methodology of Experiment 6B and again attempt to investigate if a change in liking would be associated with a change in wanting. It was decided that Experiment seven should be repeated using a within participants design and an increased Tween concentration. A 0.1% Tween concentration was chosen as this had been shown to produce a significant reduction in liking in Experiment 6A.

The predictions were the same as for Experiment 6B. It was predicted, on the basis of IST, that subjective liking for both beer and fruit juice would be lower for the Tween adulterated beverages, compared to the straight beverages. It was predicted that this reduction in liking (ratings) would be accompanied by a reduction in wanting (consumption) for the fruit juice but not for the beer.

10.2 Method

10.2.1 Design

The experiment used a three factor mixed design. There was a between participants factor of drinker status. Participants were assigned heavy or light drinker status, based on alcohol consumption in the past week. There were two within participants variables; drink and Tween condition. All participants sampled four drinks, two were beer and two were fruit juice. One beer and one fruit juice was adulterated with Tween (0.1%) and the other two drinks were straight beer and fruit juice. The order of the drinks was counterbalanced. Subjective ratings of liking were obtained in response to each drink and total consumption of each drink was recorded.

10.2.2 Participants

There were 30 participants, 17 females and 13 males, aged between 19 and 61 years with a mean age of 26.2 (SD = 10.0) years. There were 16 light drinkers (nine females, seven males) and 14 heavy drinkers (eight females, six males). The light drinker group had consumed between three and 14 units of alcohol in the past week with a mean of 9.6 (SD = 3.2) units. The heavy drinker group had consumed between eight and 66 units in the past week with a mean of 36 (SD = 16.1) units. All participants had to fulfil the same screening requirements as in Experiment 6B.

10.2.3 Materials

The beer used was Heineken (3.4%). The fruit juice used was Safeway's pure unsweetened pineapple juice. All drinks were presented in clear pint glasses as 200ml volume solutions. The drinks were adulterated using Tween (polysorbate20) to yield solutions that were 0.1% Tween. Participants recorded their ratings on an answer sheet.

10.2.4 Procedure and Data Analysis

Participants were presented with one drink at a time and asked to provide ratings on several dimensions. These included a liking (for taste) rating but also bogus ratings of 'sweetness', 'bitterness', sight of drink, 'smell of drink' and 'aftertaste'. Participants were given three minutes to rate each drink. They were instructed that they did not have to consume all of the drink, only enough so that they could provide accurate ratings. The experimenter then measured how much of each drink had been consumed. The participants were provided with water to rinse their mouth in between receiving each drink. The experimenter obtained a liking rating and the volume consumed for each of the two drinks from each participant. Thus, each participant provided two liking ratings and two volume measurements.

10.3 Results

10.3.1 Liking Ratings

Figure 10.1 shows the mean liking ratings for the fruit juice and beer provided by the heavy and light drinkers according to Tween condition. Both drinker groups rated the fruit juice in the same manner. The fruit juice with Tween (Tw+) was rated as more unpleasant than the straight fruit juice (Tw-). Both drinker groups rated the beer with Tween as more unpleasant compared to the straight beer.

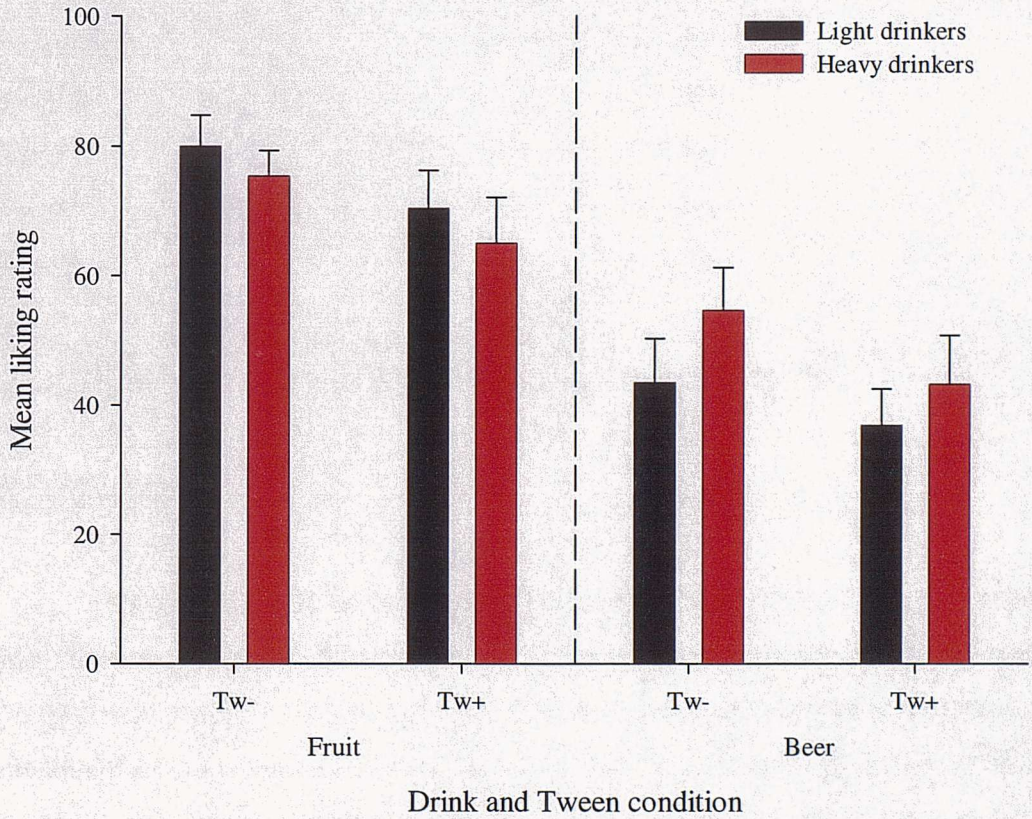


Figure 10.1 Mean fruit juice and beer liking ratings (+SE) for heavy and light drinkers in each Tween condition. Note. '---' = divide between fruit juice and beer data; Tw- = no Tween condition; Tw+ = Tween condition.

A three-way ANOVA (drink x Tween condition x drinker status) was conducted on the fruit juice and beer ratings. The results are displayed in Table 10.1. A significant main effect of Tween condition was revealed, confirming that the beverages containing Tween were rated as significantly more unpleasant than the straight beverages. A significant main effect of drink was found indicating that the

fruit juice was rated as more pleasant than the beer. No significant main effect of drinker status was found and no significant interactions.

Table 10.1
Results of analysis of variance for fruit juice and beer liking ratings

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.20	.66
Error	28	(539.50)	
	Within subjects		
Drink (D)	1	18.85**	<.00
Tween (T)	1	15.12**	<.00
D x DS	1	1.13	.30
D x T	1	0.03	.86
T x DS	1	0.32	.58
D x DS x T	1	0.13	.73
Error	28	(263.42)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

10.3.2 Wanting

Figure 10.2 shows the mean fruit juice and beer consumption by the heavy and light drinkers in each Tween condition. The light drinkers consumed less fruit juice in the Tween condition compared to the no Tween condition. The heavy drinkers consumed the same amount of fruit juice irrespective of Tween condition. Both drinker groups consumed similar amounts of beer irrespective of Tween condition.

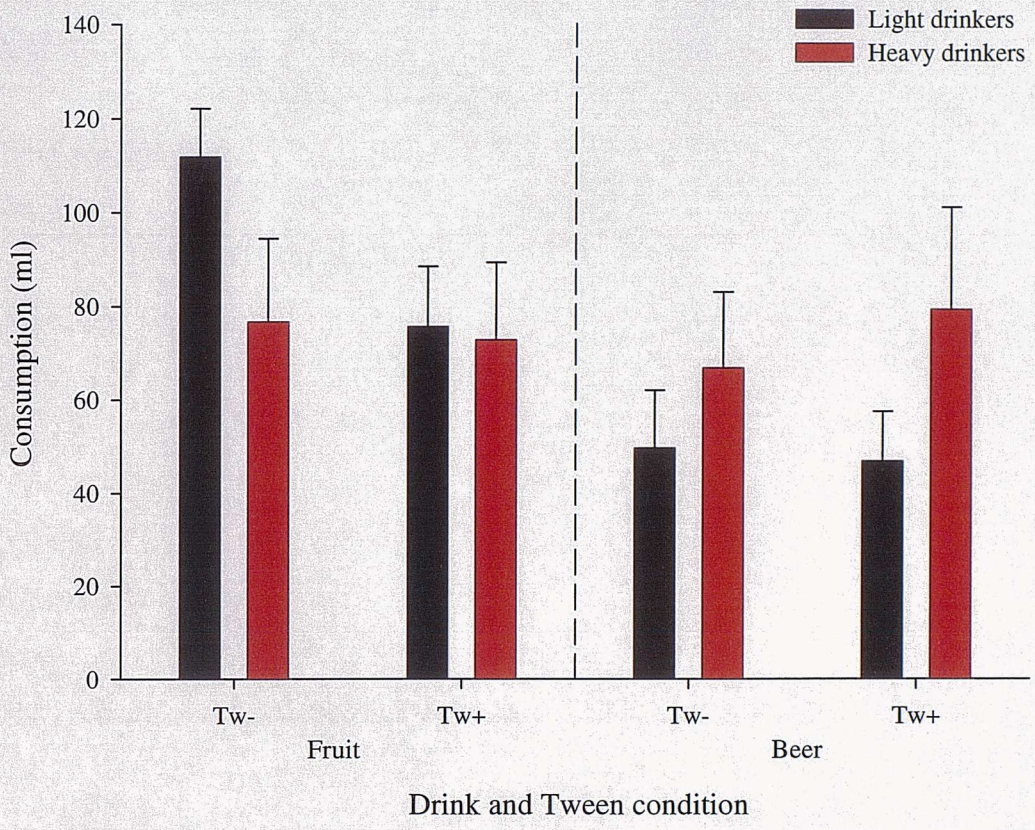


Figure 10.2 Mean (+SE) volume of fruit juice and beer consumed for heavy and light drinkers in each Tween condition. Note. '---' = divide between fruit juice and beer data; Tw- = no Tween condition; Tw+ = Tween condition.

A three-way ANOVA (drink x Tween condition x drinker status) was conducted on the beer and fruit juice consumption data. The results are displayed in Table 10.2. There were no significant main effects of Tween condition, drinker status or drink. However, there were significant interactions between drink and Tween condition (although this effect was marginal) and between Tween condition and drinker status. The drink by Tween condition interaction is displayed in Figure 10.3 and was explored using paired t-tests. The results of these t-tests are displayed in Table 10.3. Only t-tests testing the difference between Tween conditions for the beer and fruit juice were conducted as only the effect of Tween on each drink was of interest. The results revealed that less fruit juice was consumed in the Tw+, compared to the Tw- condition. Crucially, the same amount of beer was consumed in both Tween conditions.

Table 10.2
Results of analysis of variance for amount of fruit juice and beer consumed

Source	df	F	p
	Between subjects		
Drinker status (DS)	1	0.04	.84
Error	28	(6016.91)	
	Within subjects		
Drink (D)	1	3.25	.08
Tween (T)	1	2.03	.17
D x DS	1	2.8	.11
D x T	1	4.05*	.05
DS x T	1	4.92*	.04
D x DS x T	1	0.47	.50
Error	28	(1140.94)	

Note. Values in parentheses represent mean square errors. *p<.05; **p<.01.

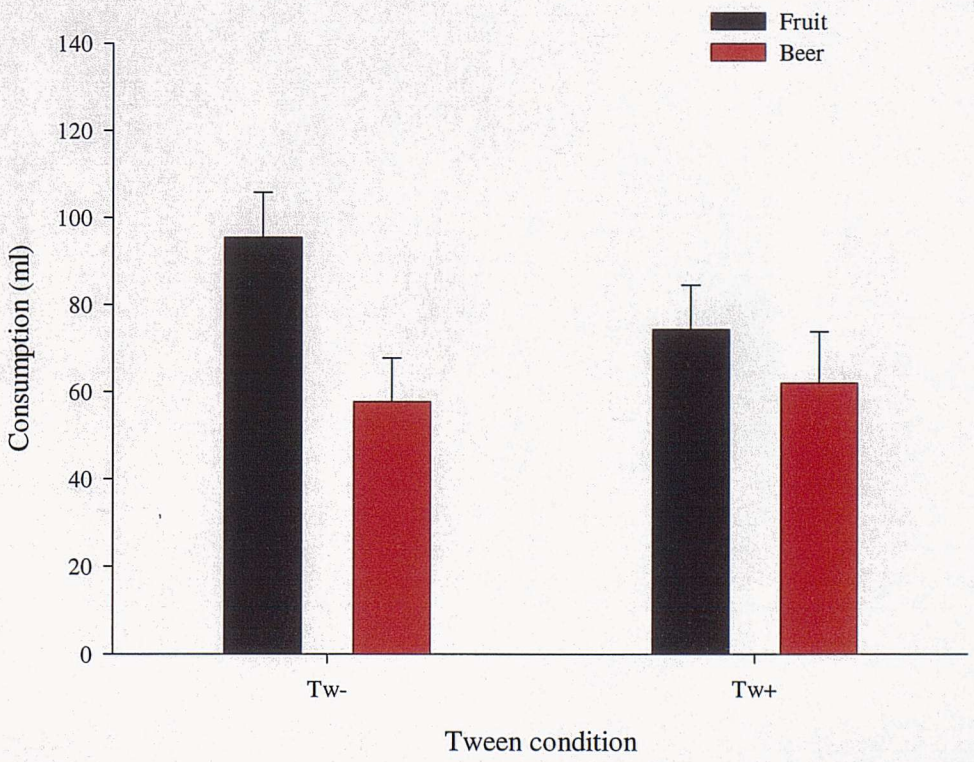


Figure 10.3 Mean (+SE) volume of fruit juice and beer consumed in each Tween condition, illustrating drink x Tween condition interaction. Note. Tw- = no Tween condition; Tw+ = Tween condition.

Table 10.3
Results of paired t-tests exploring drink x Tween condition interaction

	df	t	p
Fruit: Tw- vs Tw+	29	2.33	<.05
Beer: Tw- vs Tw+	29	0.56	n.s

Note. n.s = not significant.

The interaction between Tween condition and drinker status is displayed in Figure 10.4. A series of t-tests were conducted to follow-up this interaction. The results of the t-tests are displayed in Table 10.4. The results revealed that the light drinkers consumed less beer and fruit juice when Tween was added but there was no difference in consumption by the heavy drinkers between the Tween conditions.

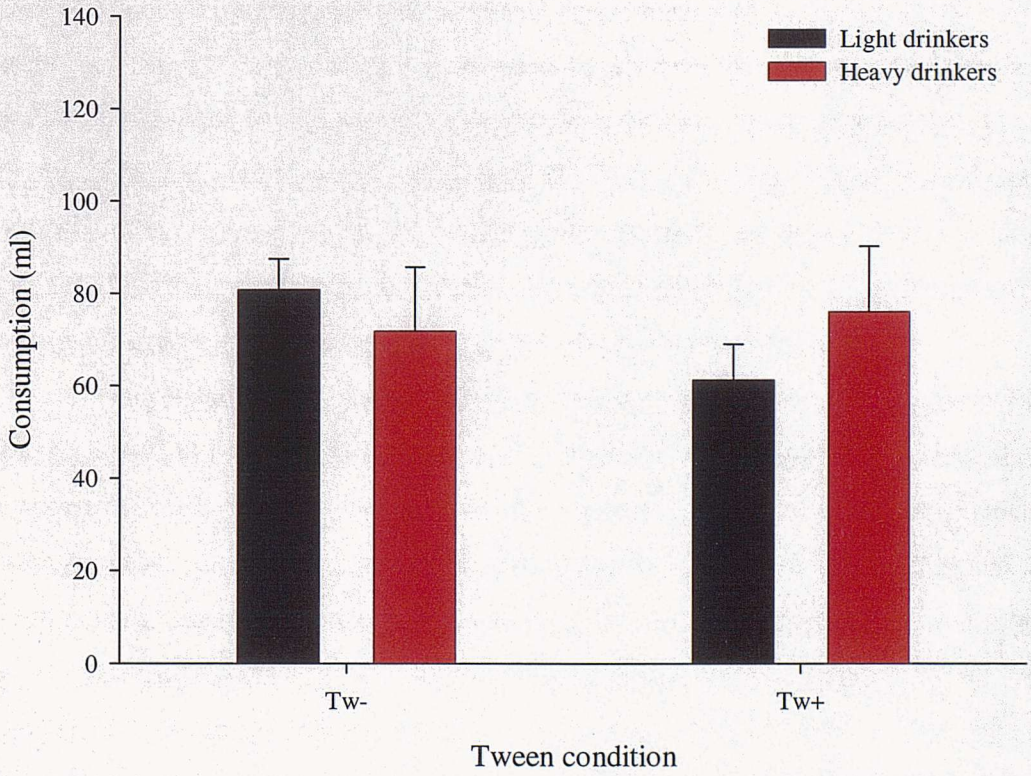


Figure 10.4 Mean (+SE) volume of both fruit juice and beer consumed by heavy and light drinkers in each Tween condition, illustrating drinker status x Tween condition interaction. Note. Tw- = no Tween condition; Tw+ = Tween condition.

Table 10.4
Results of t-tests exploring drinker status x Tween condition interaction

	df	t	p
	Independent t-tests		
Tw-: heavy vs light	18.7	0.59	n.s
Tw+: heavy vs light	28	0.95	n.s
	Paired t-tests		
Light: Tw- vs Tw+	15	2.81	<.05
Heavy: Tw- vs Tw+	13	0.51	n.s

Note. n.s = not significant.

10.4 Discussion

The addition of Tween resulted in a reduction in liking (ratings) for both the fruit juice and beer. This was accompanied by a concurrent reduction in wanting (consumption) for the fruit juice. However, wanting for the beer was not affected by adding the Tween. The effect of Tween on the measures of wanting and liking supported the predictions made from the IST. Liking and wanting decreased together for the soft drink but the two dissociated for an alcoholic beverage. The IST would attribute the beer specific dissociation as the result of attribution of sensitisation-induced incentive salience (wanting) as a result of past alcohol use.

The results were complicated by an interaction between drinker status and Tween condition. The results revealed that adding Tween resulted in a reduction in wanting for the light drinkers but not for the heavy drinkers. This suggests that wanting and liking dissociated for the heavy but not the light drinkers. The IST might explain these results as differences in the degree of neural-sensitisation undergone. The heavy drinkers would be predicted to have undergone a greater degree of sensitisation and thus wanting would dissociate from liking, whereas, sufficient sensitisation may not have been induced in the light drinkers for this to occur. However, this effect was not specific to the beer (there was no significant three-way interaction). It is not clear how the IST would explain this but in any case a dissociation between wanting and liking was demonstrated, based on subjective ratings and fluid consumption.

Experiment seven complemented the previous experiments that demonstrated that priming with alcohol increased wanting but not liking. This experiment showed the converse that liking could be reduced while leaving wanting unchanged. This also demonstrated that the dissociations in the priming experiments were not a result of a lack of sensitivity in the liking ratings. If the liking ratings had been less sensitive then the wanting measures would certainly have shifted for the beer but this was not the case.

In conclusion, Experiment 7 demonstrated that liking could be reduced, without a concurrent reduction in wanting. Furthermore, this dissociation was found to be specific to the heavy drinkers and the alcoholic beverage.

CHAPTER ELEVEN: GENERAL DISCUSSION

11.1 Summary

Chapter one provided a review of Robinson and Berridge's (1993; 2000; 2003) Incentive-Sensitisation Theory (IST). The IST claims that drug reward is composed of neurobiologically distinct systems of wanting and liking. Repeated drug use induces neural sensitisation of the wanting system but not the liking system. Drug use is thus characterised by a progressive increase in wanting but not necessarily liking. The IST therefore makes the key claim that under some conditions, including drug use, wanting and liking can dissociate from one another. Most of the literature providing support for the claims of the IST was conducted on animals, with very little research on humans. The current research attempted to test the claim of a dissociation between wanting and liking in humans, focusing on alcohol.

Chapter two outlined the methods that might be used to measure wanting and liking in humans. The same measures of wanting (choice, consumption) that were used for animals can be applied to humans. Additionally, subjective measures of wanting and liking can be utilized in humans. However, it was considered prudent to attempt to use a measure of liking in addition to subjective ratings. The animal studies had made use of the observation of animal affective responses (the taste reactivity test) to measure liking. The literature suggested that facial EMG could be used to formulate a human version of the taste reactivity test. This was then used in some of the subsequent experiments as a measure of liking.

The current research investigated the claim of a dissociation between wanting and liking over the course of seven experiments. These experiments used three methods; comparison of liking in heavy and light drinkers; increasing wanting independently of liking using a priming dose of alcohol; decreasing liking independently of wanting using an unpleasant adulterant.

11.1.1 Liking in Heavy and Light Drinkers

Experiments one and two aimed to compare liking (facial EMG, subjective ratings) for the taste of alcohol in heavy and light drinkers, who differed by definition in wanting for alcohol. Table 11.1 illustrates the key results for these experiments. Table 11.1 reports whether the factors in each experiment were significant, not significant or near significance. Effects were only reported in the table if they were significant or if they were especially relevant to the predictions of that experiment (such as the flavour x drinker status interactions in Experiments 1C and two). Follow-up analyses and the results of the minor experiments (1A and 1B) are not shown.

Table 11.1
Key results of Experiments one and two

Experiment	Factor	Liking measures			
		Ratings	EMG		
			L	O	Z
1C	F	sig	sig	n.s	-
	DS	n.s	sig	sig	-
	F x DS	near	n.s	n.s	-
2	F	sig	sig	n.s	near
	DS	n.s	n.s	n.s	n.s
	F x DS	n.s	n.s	n.s	n.s

Note. L = levator; O = orbicularis; Z = zygomaticus; F = flavour; DS = drinker status; sig = significant effect; n.s = not significant; near = near significant effect; - = not applicable.

It was found that the heavy and light drinkers did not differ in their subjective ratings of liking for the taste of an ethanol solution, as demonstrated by the lack of a main effect of drinker status and no significant flavour by drinker status interaction. A near significant difference was observed on the ratings for the ethanol in Experiment 1C, with the heavy drinkers rating the ethanol as more pleasant compared to the light drinkers. This indicated that the heavy drinkers might have liked the ethanol more than the light drinkers, suggesting an association between wanting and liking. However, crucially this was not replicated in Experiment two.

The results of the facial EMG were more complex. The facial EMG revealed no alcohol specific differences in responding between the heavy and light drinkers. In Experiment 1C some differences were found in the EMG responses (in the levator and orbicularis) between the heavy and light drinkers, in the form of main effects of drinker status on the levator and orbicularis. Initially, this might appear to suggest some overall differences in liking between the drinker groups, including the alcohol. However, these differences reflected general differences in responding to all the flavours, not just ethanol, and doubt was drawn over the ability of the EMG as a measurement of liking.

11.1.2 Increasing Wanting Using a Priming Dose of Alcohol

Experiments three to five compared the impact of a priming dose of alcohol on concurrent measures of wanting (consumption, choice) and liking (EMG, subjective ratings). The key results from these experiments are displayed in Table 11.2, in a similar manner to the results in Table 11.1. Again, follow-up analyses are not shown.

Experiment three found that a priming dose of alcohol had a larger impact on one measure of wanting (choice) compared to a weaker effect on the liking ratings. This was shown by a main effect of priming on the choice measure compared to a number of interactions between priming and the other factors on the liking ratings, that either found no significant results (D x DS; D x P) or revealed a different pattern of priming effects (DS x P), in the follow-up analyses. Priming did not affect the consumption measure of wanting and no differences in the priming effect on wanting were found between the heavy and light drinkers. The results of Experiment four found no priming effect on any of the measures of wanting and liking. Again, no differences were found between the heavy and light drinkers. In Experiment five, a clear priming effect was found on both measures of wanting (choice, consumption) but not on the liking (ratings) measure. This was illustrated by a main effect of priming on the choice measure and a significant drink by priming interaction on the consumption measure, indicating a priming effect on the alcoholic drink. In comparison, no significant effects of priming were found on the liking ratings. No significant interaction was found between priming group and drinker status on the wanting measures, indicating the priming effect did not have a differential impact

on the heavy and light drinkers. However, there was a near significant three-way interaction on the consumption measure, which indicated the priming effect on the alcoholic drink might have been larger for the heavy compared to light drinkers.

Table 11.2
Key results of Experiments three to five

Experiment	Factor	Measures				
		Liking			Wanting	
		Ratings	EMG		Choice	Cons
			L	C		
3	P	n.s	n.s	sig	sig	n.s
	D	n.s	n.s	n.s	-	sig
	DS	n.s	n.s	n.s	n.s	n.s
	DS x P	sig	near	sig	n.s	n.s
	D x DS	sig	n.s	n.s	-	n.s
	D x P	sig	n.s	n.s	-	n.s
4	P	n.s	-	-	n.s	n.s
	D	sig	-	-	-	n.s
	DS	n.s	-	-	n.s	n.s
5	P	n.s	-	-	sig	n.s
	D	near	-	-	-	n.s
	DS	n.s	-	-	n.s	sig
	DS x P	n.s	-	-	n.s	n.s
	D x P	n.s	-	-	-	sig
	D x P x DS	n.s	-	-	-	near

Note. Cons = consumption; L = levator; C = corrugator; DS = drinker status; D=drink; P = priming condition; sig = significant effect; n.s = not significant; near = near significant effect; - = not applicable.

11.1.3 Decreasing Liking Using an Unpleasant Adulterant

Experiments six and seven compared the effect of an unpleasant adulterant (Tween) on measures of wanting (consumption) and liking (ratings). The key results of these experiments are displayed in Table 11.3. The results of follow-up analyses and Experiment 6A are not shown. Experiment 6B found that a 0.075% concentration of

Tween did not reduce either liking or wanting for beer and fruit juice, as illustrated by the lack of a main effect of Tween on either measure. However, Experiment seven found that a 0.1% concentration of Tween reduced liking ratings (there was a main effect of Tween) for both beer and fruit juice but only reduced consumption for the fruit juice. Consumption for the beer was unaffected. This was demonstrated by the significant interaction between Tween and drink. Furthermore, adding Tween to the drinks lowered wanting (consumption) for the light drinkers but not for the heavy drinkers, as indicated by the interaction between drink and drinker status.

Table 11.3
Key results of Experiments six and seven

Experiment	Factor	Measures	
		Liking	Wanting
		Ratings	Consumption
6B	DS	n.s	n.s
	Tw	n.s	n.s
7	D	n.s	n.s
	DS	n.s	n.s
	Tw	sig	n.s
	Tw x D	n.s	sig
	Tw x DS	n.s	sig

Note. DS = drinker status; D=drink; Tw = Tween condition; sig = significant effect; n.s = not significant; near = near significant effect; - = not applicable.

11.2 Discussion of Results

11.2.1 Comparison of Heavy and Light Drinkers

It was concluded that the results from the first method of investigation were suggestive of a dissociation between wanting and liking. The results of Experiment one indicated this conclusion but there were several considerations that necessitated that the experiment should be replicated with an improved methodology, in the form of Experiment two. Experiment one found no significant differences between the heavy and

light drinkers on the liking ratings but the near significant interaction between flavour and drinker status indicated that there might have been a difference in liking for alcohol between the drinker groups. Thus, these results were treated with caution. The methodological issues centred on the measurement of the facial EMG. As no robust effect of flavour was observed, the differences between the heavy and light drinkers found on the EMG measures were concluded not to be indicative of differences in liking (see 4.3.4 for detail). It was argued that a more plausible explanation for the difference between the drinker groups, was that this pattern of responses was more indicative of Finn and Pihl's (1987; 1988; 1990) and Greeley and Olei's (1999) 'stress-dampening effect', or a similar process. It was suggested that the lack of clear effects of flavour might have been due to inter-participant variability in the self-administration of the solutions and the aftertaste effects of each trial on subsequent trials. Data from the zygomaticus muscle region had also been discarded due to a technical fault and it was therefore desirable to collect data from this region in a subsequent experiment.

Experiment two was conducted to address these issues. Changes were made in the method of collecting the EMG data (see 5.1 for details) and data from the zygomatic region was measured. In Experiment two, no difference between the heavy and light drinkers was found on the liking ratings and crucially the near flavour by drinker status interaction was not replicated. The heavy and light drinkers also did not differ on any of the EMG measures. However, doubt was again drawn over the ability of the EMG to measure liking, as again there was a lack of robust effects of flavour.

It was concluded from Experiments one and two that the heavy and light drinkers did not differ in liking for alcohol and provided support for the claim of a dissociation between wanting and liking. However, the method of comparing liking in heavy and light drinkers was argued to be limited in that it only observed a lack of a difference in liking, which does not logically mean there was a dissociation. Two key weaknesses were identified with the research at this point.

Firstly, the method of comparing liking ratings and facial EMG to self-reported alcohol consumption for the past week is limited in several ways. It might be argued that it is not valid to compare single time point laboratory-based measures of liking (ratings, EMG) to self-reported wanting (alcohol consumption) for the past week. It might be that

this measure of wanting only reflects an average level of wanting and does not capture adequately the momentary fluctuations in wanting that might well relate to liking. That is, the self-report provides a measure of average wanting over a week and the ratings liking at one precise point in time. Thus, differences in the temporal scale of the measures of wanting and liking may have been responsible for a failure to find differences between the heavy and light drinkers. Second was that any difference observed between measures of wanting and liking could simply be the result of differences in the sensitivity of the measures employed. It could be argued that if the wanting measure was more sensitive, compared to the liking measure, it might be easier to observe a shift in wanting than in the liking, and this could have hidden a comparative shift in liking. The second method of investigation aimed to address the first weakness by comparing concurrent measures of wanting and liking and the third and final method addressed the second weakness.

11.2.2 Increasing Wanting Using a Priming Dose of Alcohol

The second method of investigation compared the effect of a priming dose of alcohol on concurrent measures of wanting and liking. Experiment three found that priming with alcohol increased choice for subsequent alcohol. This was compared to a seemingly weaker effect of priming on the liking ratings. Although, there was no main effect of priming on the liking ratings the significant interactions indicated that there might have been some effect of priming with alcohol on liking. Even so, that there was a clearer effect of priming on wanting provided some support for the claim of a dissociation between wanting and liking. However, several of the predictions made from the IST were not fulfilled. There was no differential impact of priming for the choice measure between the heavy and light drinkers and there was no effect of priming on alcohol consumption. No significant effects were found on the levator data. Some effects were found on the corrugator data but it was most probable that these did not reflect differences in liking (see 6.4 for detail). Overall, there were continued doubts over the ability of the EMG as a measure of liking and it was decided not to continue to use it as a measure in subsequent experiments. It was proposed that the predictions might not have been fulfilled because of several methodological issues.

Thus, Experiment four attempted to replicate Experiment three with an improved methodology (see 6.4 and 7.1 for more detail). Several methodological changes were made from Experiment three to four. Firstly, it was suggested that the priming dose used in Experiment three (0.2g/kg) might have been too small to produce a robust priming effect. The priming dose was therefore increased (to 0.3g/kg) in Experiment four. The cover story used may have affected the strategies used by participants in the wanting test and so this was removed in Experiment four. The number of choice tests was also increased from five to 12 with the expectation that this might improve the accuracy of the choice measurement. Finally, the number of beers and fruit juices used was reduced from 10 to two (one beer and one fruit juice) in Experiment four.

Experiment four failed to provide support for the claim of a dissociation between wanting and liking. There were no significant effects of priming or drinker status on either the measures of wanting or liking. The failure to replicate the results of Experiment three was attributed to the changes made in the methodology. Most significantly, the change in the drinks used. Specifically, the main effect of drink on the liking ratings indicated that fruit juice was rated as significantly more pleasant than the beer. In comparison, in Experiment three the beers and fruit juices had been rated at the same overall level of pleasantness. This difference in pleasantness between the fruit juice and beer used in was proposed to have masked any effect of priming.

Experiment five also attempted to replicate Experiment three, addressing the limitations of Experiment four by returning to a similar methodology used in Experiment three. The methodology of Experiment five was identical to Experiment three, except that the cover story was not used and the EMG measures were not taken. Experiment five demonstrated that priming with alcohol increased both measures of wanting (consumption and choice) for alcohol but had no effect on liking (ratings), compared to priming with placebo. This demonstrated a dissociation as wanting was increased, while liking was unaffected by priming. This priming effect was not found to have a differential impact in the heavy and light drinkers, as predicted by the IST. However, the near significant three-way interaction on the consumption measure indicated that the priming effect might have been larger for the heavy drinkers, compared to the light drinkers.

It was concluded that Experiments three and five provided support for the claim of a dissociation between wanting and liking. Experiments three and five demonstrated that priming with alcohol led to increases in wanting (choice, consumption) for alcohol but had little (Experiment three) or no effect (Experiment five) on the measures of liking (EMG, ratings) for alcohol, compared to priming with placebo. This demonstrated a dissociation as the output of the wanting system was increased, while concurrent liking was unaffected or showed only very marginal effects of priming. Thus, Experiments three and five provide evidence of a dissociation between wanting and liking for alcohol but not the claim that this would be more marked for the heavy compared to light drinkers.

Experiments three and five successfully addressed the weakness noted with method one that differences in the temporal scale of the measures of wanting and liking might have been responsible for the failure to find differences in liking between the heavy and light drinkers, in Experiments one and two. If the failure to find an association between wanting and liking in the heavy and light drinkers was a result of differences in the temporal scale of the measures then a relationship between measures of wanting might still have been expected when wanting and liking were measured together, but this did not occur.

Although, the second method of investigation provided evidence for the claim of a dissociation between wanting and liking it might still be objected that results do not reflect a dissociation of wanting and liking but instead reflect a difference in the sensitivity of the measures used. It could be argued that wanting measures are more sensitive to the priming effect, compared to the liking ratings. Thus, it might have been easier to observe a shift in choice and consumption than in the liking ratings and this could have hidden a comparative shift in liking. This argument was further strengthened when it was considered that there were some interactions on the liking ratings with priming condition in Experiments three.

11.2.3 Decreasing Liking Using an Unpleasant Adulterant

The third method of investigation addressed this weakness by attempting to alter the liking ratings, while leaving wanting unchanged. If the liking measure was less

sensitive than the wanting measures, a change in liking measure would certainly be accompanied by a change in the wanting measures. However, if the wanting measures remained unchanged this would demonstrate that the evidence of a dissociation in the current research cannot be attributed in differences in the sensitivity of the wanting and liking measures. Additionally, this method could demonstrate a dissociation in its own right.

Thus, the third method of investigation investigated if a reduction in liking would be accompanied by a change on a concurrent measure of wanting. Experiment 6B was inconclusive as the Tween manipulation failed to alter liking. The failure to observe a shift in liking was suggested to be a combination of using a Tween concentration (0.075%) that was too low for differences in liking to be observed and the use of a between participants design, which did not control for variability in taste liking between participants. Thus, Experiment seven replicated Experiment 6B using a higher concentration of Tween (0.1%) and a within participants design. In Experiment seven, adding Tween was shown to lower liking for both beer and fruit juice. However, Tween lowered wanting for the fruit juice but not the beer. This demonstrated a dissociation between wanting and liking that was specific to the beer. Furthermore, it was concluded that the differences observed between wanting and liking in Experiments three to five were unlikely to be the result of differences in the sensitivity of the wanting and liking measures.

11.2.4 Summary of Main Conclusions

To summarise, the results provided evidence for a dissociation based on the three methods of investigation. Method one found that heavy and light drinkers, who differed by definition in wanting, did not differ on subjective ratings of liking for the taste of alcohol. This result might have been explained by temporal differences in the measures of liking and wanting but method two found that a priming dose of alcohol could increase measures of wanting without a concurrent increase in taste liking. The results of these methods could still have been explained as the result of differences in the sensitivity of the wanting and liking measures. However, method three demonstrated that a

manipulation that was strong enough to decrease liking for alcohol was not accompanied by a concurrent reduction in wanting for alcohol.

11.3 Implications for the IST and Incentive Motivation Theories

The following section is concerned with the implications of the current results for incentive motivation theories. Section 11.4 then discusses the results in relation to reinforcement theories of drug use. However, it should be noted that motivation for drug use has also been explained by theories that emphasise automatic cognitive processes (e.g. Tiffany and Carter 1998; Tiffany and Conklin 2000). These theories suggest that many of the seemingly complex actions required in acquiring and consuming drugs become 'automatised' with repeated practice, in a similar manner to acquiring complex skills such as driving a car. These theories provide an important alternative viewpoint in explaining drug use but are not discussed here for two reasons. One was simply in the interest of brevity. The second was that as the current research was concerned with the relationship between drug liking and wanting it was felt that the discussion should remain within the limits of theories that have focussed on the role of drug pleasure in motivating drug use.

Both the Bindra/Toates theories and the IST claimed that internal physiological states and incentive stimuli interact to activate a motivational system that increases the salience and ability of incentive stimuli to direct approach behaviour and interaction with incentive stimuli. The Bindra/Toates theories claimed that the underlying reason for motivation was the ability of incentive stimuli to produce pleasure. Thus, no distinction was made between wanting and liking by these theories. However, the IST claimed that under conditions of drug use wanting and liking could dissociate from one another. If the pursuit of pleasure were held to underlie motivation for alcohol a close association between wanting and liking would have been predicted. The current research would suggest that this is not always the case when the incentive stimuli is alcohol as results from all three methods of investigation suggested some divergence between wanting and liking. The current research suggested wanting and liking cohered for soft drinks but dissociated for alcoholic beverages.

11.3.1 Comparison of Liking in Heavy and Light drinkers

Heavy and light drinkers differ by definition in wanting for alcohol. That is, in a given period of time (a week in this case) they consume different amounts of alcohol. The Bindra/Toates model of incentive motivation posited that incentives are pursued (wanted) because of their ability to induce positive motivational states (pleasure). Thus, they would predict that the heavy drinkers would have wanted alcohol more because they liked it more. Alternatively, the IST would predict that the heavy and light drinkers would not differ in liking for alcohol, as alcohol-induced sensitisation can lead to increases in wanting independently of liking. Mention should also be made that in all the other experiments (three to seven) no difference in liking for alcohol was found between the heavy and light drinkers. Two significant interactions (drinker status x priming; drinker status x drink) were found with drinker status for the liking ratings in Experiment three. However, in each case no specific differences could be found in t-tests, so any effects were at best weak.

Overall, the comparison of the heavy and light drinkers revealed that they did not differ in taste liking for ethanol, as measured by subjective ratings and EMG. These results suggested that wanting and liking for alcohol are not closely associated, as would be predicted by Bindra (1974) and Toates (1986) and provided support for the IST claim of a dissociation between wanting and liking. The animal literature had provided evidence for a dissociation by independent manipulation of wanting and liking (e.g. Berridge 1996; Treit and Berridge 1990). Experimental manipulations along these lines were attempted in Experiments three to seven.

11.3.2 Increasing Wanting Using a Priming Dose of Alcohol

According to the Bindra/Toates models, the priming dose of alcohol would have generated a positive CMS. This would have modulated the hedonic valence of the alcohol (and alcohol-associated stimuli), resulting in an increased tendency to approach and consume further alcohol. These theories, predicted that priming with alcohol would increase both wanting and liking for alcohol. In comparison, the IST predicted that

priming with alcohol, compared to placebo, would increase wanting for alcohol but have no effect on liking for alcohol. The IST claims that this is because neural-sensitisation of the wanting system would result in increases in wanting but not necessarily liking in response to an alcoholic stimulus. The finding that priming with alcohol led to increases in wanting for alcohol but had little (Experiment three) or no effect (Experiment five) on the measures of liking for alcohol demonstrated a dissociation as wanting was increased, while liking was unaffected or showed only very marginal effects of priming. Thus, this suggested the increase in wanting was not the result of an increase in liking, as would be predicted by the older motivation theories, and provided support for the IST.

The IST predicted that the priming effect would be larger in heavier, compared to lighter drinkers. Studies have shown that repeated drug (including alcohol) administration leads to a progressive sensitisation (e.g. Masur and Boerngen 1980; Strakowski and Sax 1998). If repeated alcohol use results in more sensitisation then it would be thought that heavier drinkers should have undergone a higher level of sensitisation. It therefore follows that these heavier users should display higher levels of wanting for alcohol than lighter drinkers. Despite the presence of near significant results, the heavy drinkers failed to display a higher level of beer choice and consumption after priming with alcohol, compared to the light drinkers. Although the IST clearly predicted that the priming effect with alcohol would have been higher in the heavy drinkers, compared to the light drinker, this should not be regarded as critical for these experiments to provide support for the IST. Rather, these results might be explained by considering the screening requirements of the experiments in the current research. Participants were not admitted if they had consumed less than 10 units of alcohol in the previous week or had any form of alcohol dependence. This was an ethical requirement to avoid giving alcohol to very light or problem drinkers. It is a possibility that, as Robinson and Berridge (1993; 2001; 2003) have claimed, the sensitisation held to underlie the dissociation of wanting and liking for drugs is a progressive phenomena. It maybe that the participants in the present experiment did not differ enough in the amount of sensitisation they had undergone for an effect of drinker status to be apparent in the wanting test. The IST would predict that clearer results could be produced by studying populations that would be expected to show a more marked difference in the amount of sensitisation that they would have undergone.

11.3.3 Decreasing liking using an unpleasant adulterant

In a similar manner to the priming studies, the Bindra/Toates models of incentive motivation would predict that any changes in liking would be accompanied by changes in wanting. Thus, decreases in liking would be predicted to be accompanied by a decrease in wanting. However, the IST predicts that changes in liking for alcohol might not necessarily be accompanied by a reduction in wanting. Although, the IST holds that wanting and liking for an incentive usually cohere, they can dissociate for drugs as a result of the sensitisation of the wanting system.

The finding that Tween reduced liking for alcoholic and soft drinks but reduced wanting for the soft but not the alcoholic drink provided support for the claims of the IST. The IST would explain this as the result of an increase in wanting for alcohol as a result of sensitisation caused by prior alcohol use. Hence, a small reduction in liking would have no impact on wanting. The IST might explain the difference between the heavy and light drinkers in the effect of the Tween as differences in the degree of neural-sensitisation undergone. The heavy drinkers would be predicted to have undergone a greater degree of sensitisation and thus wanting would dissociate from liking, whereas, sufficient sensitisation may not have been induced in the light drinkers for this to occur. However, this effect was not specific to the beer (there was no significant three-way interaction). It is not clear how the IST would explain this but in any case a dissociation between wanting and liking was demonstrated, based on subjective ratings and fluid consumption.

11.3.4 Other implications

The results of the current research concur with the animal studies (e.g. Wyvell and Berridge 2000) that demonstrated that wanting and liking could be changed independently of each other. The current research has provided a direct test of the claim of a dissociation between wanting and liking in humans. This is significant in that most of the previous research on the IST has focused on animal studies, with the human data being much less extensive, and the theory has been criticised for this (e.g. Lowman *et al*

2000). The studies that have used humans have either tested the claim that sensitisation occurs (e.g. Strakowski *et al* 1996) or have not had the study of the dissociation as their research aim (e.g. Brauer *et al* 2001). The other research in humans dealing with a dissociation of wanting and liking were the unconvincing examples by Kahneman *et al* (Kahneman and Snell 1992; Kahneman *et al* 1993; Redelmeier and Kahneman 1996; Kahneman, Wakker and Sarin 1997). Furthermore, the current research focused on alcohol, as opposed to stimulant drugs, which have been the focus of most of the research on the IST. Several animal studies demonstrated that alcohol could induce sensitisation (e.g. Masur and Boergnen 1980) but none of the studies testing the claim of a dissociation of wanting and liking used alcohol.

Furthermore, the evidence of a dissociation between wanting and liking was found to be specific to the alcoholic beverages. Priming (Experiment five) was found to lead to increases in wanting for beer and not the fruit juice. Similarly, Experiment seven found that the Tween manipulation reduced wanting for the fruit juice but not the beer. This suggests that the dissociation is drug-specific. This supported the IST view that it is drug-induced sensitisation of wanting that results in the dissociation. The IST claims that wanting and liking for incentives usually cohere and that dissociations arise as the result of sensitisation by drugs. Thus, wanting and liking were predicted to dissociate only for the alcohol and not the soft drinks, which would not have induced prior sensitisation.

The current research has put the emphasis on the role of wanting in motivating drug use. However, a role for liking should certainly not be excluded from a full explanation of drug use. It is hard to deny that liking can have an important influence on initial drug consumption. For example, the aversive taste of alcohol may limit initial intake and the sweetening of alcohol (to make it more palatable) is usually needed to facilitate the acquisition of alcohol self-administration in rats (e.g. Samson, Pfeffer and Tolliver 1988). Rather, it is the IST's claim that it is after continued use, and particularly in dependence, that wanting progressively comes to dominate the motivation behind drug use and can become sufficiently strong to overcome any aversive effects associated with that drug. However, the IST does not precisely predict exactly when a dissociation between wanting and liking might become apparent in a drug-taking career. For this reason, that the current research suggests that dissociations occur in non-problem drinkers

is significant. In a sense, the dissociations shown by altering wanting and liking independently were quite fragile, in that changes in the methodology and differences in pleasantness of the solutions used appeared to result in non-significant results (see Experiment four). However, the fact that a dissociation can be shown in these social drinkers suggested that even in non-problem drinkers a motivational system based on wanting could play a role in maintaining alcohol-use. If these comparatively low levels of alcohol use can result in a dissociation, it is suggestive of how much more powerful the effect might be with much heavier alcohol use by dependent users.

If wanting and liking are indeed independent systems this may have implications for the motivation behind other addictions and disorders. Robinson and Berridge (2003) speculated that sensitisation of the wanting system may play a part in food bingeing, gambling 'addictions' and sexual compulsions but they failed to specify details of how this might operate. However, Bryant (unpublished) has suggested how the IST may aid explanation of the motivation behind deliberate self-harm (DSH). DSH is defined as 'intentionally injuring oneself without suicidal intent' (Klonsky, Oltmanns and Turkheimer 2003) and includes such behaviours as cutting and burning oneself. It has been observed (Schwartz *et al* 1989; Faye 1995) that DSH shares several of the common features of drug addiction. Strong urges to self-injure, similar to drug cravings have been reported by self-harming individuals. Once established, DSH is also a behaviour that is maintained (wanted) despite considerable negative consequences (e.g. pain, accidental death, interference in personal relationships). On the surface DSH appears to be a behaviour that is maintained (wanted), despite the several unpleasant (disliked) consequences. Thus, there is a similar possibility that this may operate along the lines of a dissociation between wanting and liking, as suggested by the IST.

When pain is inflicted on the body, endorphins are released in the brain. These bind to pain receptors, blocking pain sensation. Berridge (personal communication as cited in Bryant unpublished) has stated that neural-sensitisation could be caused by these endorphins. This could result in an increase in wanting independently of liking. If this were the case there might be expected to be an increase in wanting behaviour in response to DSH related stimuli. Bryant (unpublished) has suggested that this might be investigated by measuring attentional biases (wanting) to DSH related stimuli and

comparing this to the perceived valence (liking) of DSH related cues. The idea of a dissociation between wanting and liking in DSH is complicated by reports (e.g. Smith *et al* 1998) that DSH is used as a form of emotional tension reduction. The function it serves may produce some positive (liked) outcomes for the individual in terms of relief from other negative states (e.g. depression, loneliness). Thus, Bryant suggested that DSH could also be explained as an opponent process (see 11.3.1 for details on opponent process theory), whereby the pain is the a-process, which initiates a tension reducing b-process, which is reinforcing for the individual. In self-harm, the a-process would be the pain, followed by the endorphin related analgesic effect. In any case, the DSH example suggests the possibility that dissociations between wanting and liking may play a role in motivation for behaviours other than drug use.

In summary, the results provided support for the claim of a dissociation between wanting and liking and indicate that motivational theories should account for the ability of wanting and liking be altered independently of each other.

11.4 Implications for Reinforcement Theories

Chapter one also discussed Stewart, de Wit and Eikelboom's (1984) positive reinforcement theory of drug use. In a very similar manner to Bindra/Toates, Stewart, de Wit and Eikelboom claimed that drug use is maintained by the ability of drugs and their associated cues to induce positive affective states (i.e. pleasure). This positive affective state was assumed to alter the affective value of drugs and their associated stimuli and initiate drug taking. Much of the evidence they provided was based on the ability of small doses of a drug or conditioned drug stimuli to 'prime' animals to initiate drug seeking (e.g. de Wit and Stewart 1983). As with the Bindra/Toates models, these drug-taking (operant responding, consumption) behaviours were assumed to infer that the organisms both liked and wanted the drugs. However, the IST views these measures as indices of wanting, rather than liking which is not being directly measured. Thus, it was not possible to determine from the priming studies in the literature whether the increase in drug taking was accompanied by a change in liking.

Experiments three to five allowed a direct test of the effect of priming on wanting and liking, by comparing measures of wanting and liking after a priming dose of alcohol. As was predicted by the positive reinforcement model, the priming dose of alcohol did result in more alcohol being chosen (Experiments three and five) and consumed (Experiment five). However, there was no concurrent increase in liking, which remained stable across priming conditions. This suggested that pleasure may not be the sole underlying reason that drugs can be positively reinforcing. This was supported by the failure to find a concurrent reduction in alcohol consumption, when liking was reduced in Experiment seven and the failure find an association between wanting and liking in the heavy and light drinkers (Experiment 1C and two).

11.4.1 Opponent-process theory: tolerance to drug pleasure

However, there are other theories of drug use that emphasise tolerance and negative reinforcement in the maintenance of drug use. Negative reinforcement theories have traditionally explained drug use as motivated by the desire to relieve unpleasant withdrawal symptoms or escape aversive events in life (e.g. depression, stress). Drug use as motivated this way cannot solely explain drug use and Stewart, de Wit and Eikelboom's (1984) have argued that drug use can be motivated by positive reinforcement in the absence of negative states. However, some theories have explained drug use as an interplay between both positive and negative reinforcement. One such theory is Solomon's (Solomon and Corbit 1977; Solomon 1980) opponent-process theory. Solomon claimed that drugs initiate an a-process that is experienced as drug pleasure. Activation of the a-process then results in initiation of a b-process, which opposes the a-process and serves to counteract the effect of the drug and returns the body to homeostasis. The summed result of these two opposing processes is the subjective hedonic state experienced by an organism. These hedonic states are termed either positively reinforcing A-states (pleasurable) or negatively reinforcing B-states (aversive), according to the strength of the a- and b-processes respectively. Solomon also posited that repeated drug use strengthens the b-process that results in 'affective habituation' or tolerance to the pleasurable effects of drugs. Thus, with repeated use, higher drug doses

are needed to gain the same pleasurable drug experience as was initially experienced. The b-process is claimed to lag behind the a-process and continue after the homeostasis has been restored. With repeated drug use the b-process becomes so strong that it results in withdrawal symptoms when drugs use is not continued. Thus, drug use is maintained both to achieve a pleasurable A-state and avoid an unpleasant B-state. Opponent-process theory explains the increase in wanting with repeated drug use, not as a dissociation between wanting and liking, but as a result of tolerance to drug-pleasure (liking) and the desire to escape withdrawal.

The current research cannot provide a convincing test of the opponent-process theory. However, the results provided support for the IST and not the opponent-process theory because the latter does not account for the existence of a dissociation between wanting and liking. The opponent-process theory equates changes in drug consumption (wanting) with shifts in hedonic states and so in principle cannot explain the evidence of a dissociation in the current research.

Even though the current research might not be considered a convincing test of the opponent-process theory, Robinson and Berridge (1993; 2000; 2003) have provided several criticisms of the idea of increased wanting in drug use as a result of tolerance to drug pleasure. They agreed that sometimes drugs are taken for pleasure or to escape from withdrawal. However, they claimed that tolerance to drug pleasure can only explain short-term increases in drug taking and that there is little evidence linking the escalation of long-term drug use to tolerance to the pleasurable effects of drugs. They provided the example of amphetamine and cocaine. These drugs are often readministered by users as soon as the effects of the previous dose has worn-off. This can result in tolerance to the subjective effects because of the 'depression of brain reward systems'. However, this short-term tolerance is held to disappear after 24 hours and it was claimed that it cannot explain long-term drug use. They also noted that drug euphoria can be experienced years after continued drug use, instead of becoming tolerant. Furthermore, the pleasurable effects of morphine can sometimes increase because experienced users become tolerant to the aversive effects (e.g. nausea, vomiting) that are sometimes experienced by first time users.

Secondly, Robinson and Berridge (2000) observed that the alteration of subjective states has little impact on actual drug taking. For example, Haney, Foltin and Fischman (1998) investigated the effect of the dopamine agonist peroglide on cocaine self-administration and the subjective effects of cocaine, in 12 cocaine users. They found that peroglide decreased several of the subjective effects of cocaine, including subjective ratings of cocaine 'high' and 'potency', compared to a placebo. However, peroglide had no affect on actual drug self-administration. In follow-up study, Haney *et al* (1999) measured the effect of the dopamine agonist ABT-431 on cocaine self-administration and the subjective effects of cocaine, in nine cocaine users. Similar findings were reported to the previous study. ABT-431 decreased subjective ratings of dose 'high', 'liking', 'quality' and 'potency'. However, cocaine self-administration was unaffected. Under these conditions the opponent-process theory might predict that the participants would have increased their cocaine intake, in order to compensate for the reduction in the subjective pleasurable effects, but this was not the case.

Mention might also be made here of the studies by Lamb *et al* (1991) and Fischman and Foltin (1992) in which drug users self-administered cocaine and morphine with no awareness of the subjective effects (see 1.2.4 for details). If drugs were self-administered in order to experience the subjective pleasurable effects only, there would be no reason to self-administer them in the absence of subjective pleasure.

11.5 Limitations and Future Directions

A number of methodological improvements could be utilised in future experiments of the type conducted in the current research. The failure to observe a differential impact of priming with alcohol on the drinker groups, as predicted by the IST, raised two possibilities for improving the testing of this prediction in future studies. Firstly, clearer results might be obtained if the accuracy of the self-reported alcohol consumption measure was improved. As discussed in Experiment two, research (Midanik 1988; O'Callaghan and Callan 1992; Grant *et al* 1997; Wish, Hoffman and Nemes 1997; Elman *et al* 2000) has shown that self-report measures of drug use can be valid indicators of actual consumption but it may not have been accurate enough for the current research.

Dawson (1998) noted that week long self-report measures (as used in the current research) run the risk of obtaining an 'atypical picture of drinking patterns' and that most self-report measures typically analyse frequency and variability of alcohol intake. Using overall consumption alone may have reduced the accuracy of the measure. Thus, if the heavy and light drinkers were actually quite close in their drinking practices and the self-report measure was not as accurate as possible this might have hidden any effect of drinker status. In the future it may be more appropriate to use recognised questionnaires, such as Mehrabian and Russell's (1978) Alcohol Use Questionnaire.

Secondly, it was already noted (see 11.3.2) that the failure to observe differential priming effects of the heavy and light drinkers might have been due to the screening requirements of the experiments. The IST would predict that studying populations that would be expected to show a more marked difference in the amount of sensitisation that they would have undergone could produce clearer results. It may be that the participants did not differ enough in their drinking practices to show a radical difference in wanting for alcohol, such as the excess of wanting that the IST would predict in dependent users. In future experiments it might be necessary to compare groups that differ to a greater degree in drug use for a significant result to appear. A clinical sample could be used to address this or an investigation of smokers could be carried out where it might be easier to recruit participants with more variation in levels of dependence. Another alternative would also be to label participants based on a laboratory-based measure of wanting, rather than self-reported alcohol consumption. For example, participants could be classed according to how often they choose alcohol (or another drug) in a series of choice tests. Once participants have been assigned as high or low alcohol choosers they could then be compared on measures of liking for alcohol.

The method of categorising participants as heavy and light drinkers was an attempt to investigate if the progressive sensitisation of wanting could be demonstrated by observing differences in the effect of the priming manipulation on the measures of wanting. However, an objection might be raised over the assumption that categorising drinkers based on consumption is analogous to the level of sensitisation undergone. It is merely assumed with this method that the heavy drinkers would have undergone a larger degree of sensitisation. It might also be objected that the same measure (consumption) of

indexing differences in level of sensitisation (heavy and light drinkers) was also the same as one of the measures of wanting obtained during the experiments (consumption again). It would therefore be preferable to have an independent measure of sensitisation that does not rely on consumption. Wanting and liking could then be compared in individuals with differing levels of sensitisation rather than in individuals that differ in levels of wanting. At present an index of the level of neural-sensitisation has not been developed for humans. Ideally this might take the form of a neurobiological measure but it is not clear how this might be accomplished with current knowledge and technology. However, the literature can suggest some alternative possibilities. For example, it might be possible to classify individuals as 'sensitised' or 'non-sensitised' based on level of psychomotor sensitisation. For example, the Strakowski *et al* (1996; 1998; 2001) studies (see 1.5.1.1) measured psychomotor sensitisation using eye-blink rates. However, this method may be restricted to stimulant drugs and some might argue with the assumption that psychomotor sensitisation reflects sensitisation of wanting. Developing a questionnaire or interview could also assess sensitisation. For example, Bartlett *et al* (1997) also classified their participants as either 'sensitised' or 'non-sensitised' to cocaine (see 1.5.1.1) using interviews.

The use of facial EMG failed to provide a robust taste reactivity measure for humans. It would still be useful to be able to utilise measures of liking that do not rely on subjective report, especially as recent evidence (Berridge 2003, Berridge and Winkielman 2003) has suggested the possibility of unconscious liking. One possibility is the use of the traditional observational methods of studying facial responses, despite the limitations associated with these (see 2.1 for details). An alternative is the use of neurobiological markers to identify changes in liking. Davidson and Sutton (1995) and Davidson (2003) have cited literature using methods such as Positron Emission Tomography (PET), to identify the neural correlates of emotional affect. For example, Tranel and Damasio (2000) and Damasio *et al* (2003) observed that PET could show those brain areas activated during sadness, happiness, anger, fear and the processing of facial expression. If reliable neurological markers of positive and negative effect can be identified this could provide an additional measure of liking.

In terms of a direct continuation of the experiments in the current research, the next logical step would be to combine the Tween manipulation with a priming experiment. Perhaps the easiest way of doing this would be to repeat Experiment seven but administer a priming dose at the start of the Experiment. That is, prime participants with either alcohol or placebo and compare their effects on wanting (consumption) and liking (ratings) for straight and Tween adulterated alcoholic and soft drinks. It would be predicted, from the IST, that priming with alcohol would have no effect on the liking ratings and so they would be the same as those found in Experiment seven. That is, Tween adulterated alcoholic and soft drinks would have lower liking ratings, compared to the straight drinks. However, priming would be predicted to have an effect on wanting. Priming with placebo should lead to the same results as found in Experiment seven. Consumption for Tween adulterated soft drinks would be lower compared to the straight soft drinks and consumption of the alcoholic drink would be the same regardless of the presence of Tween. However, priming with alcohol should lead to increases in alcohol consumption regardless of the presence of Tween, compared to priming with placebo. No effect of priming with alcohol would be predicted on the soft drinks, although some effects might occur, as see in Experiment three. If such an experiment produced the results predicted by the IST this would provide compelling evidence for the theory. If priming with alcohol increased alcohol consumption, despite a reduction in liking by the Tween, this would demonstrate that not only can wanting and taste liking be altered independently of each other but they can be shifted in opposite directions at the same time.

A future experiment of this type should also consider using an alternative vehicle for the priming dose of alcohol. The current experiments used an alcohol/fruit juice mix and participants held a strong lozenge in the mouth while it was consumed. The aim was to attempt to hide the taste of the alcohol so that the taste cues of the priming solution would not act as a conditioned stimulus for the further consumption. The intention was that it would be the presence of alcohol in the body that exerted the effect on wanting (or liking) rather than the taste cues. However, using fruit juice in the priming solution may have produced undesired effects for some participants. In the past few years 'alcopops', usually fruit flavoured, have become popular with many drinkers. There is therefore the

possibility that the fruit juice may have acted as a conditioned stimulus for individuals that consumed 'alcopops'. Indeed, many of the participants in the current research reported consuming considerable amounts of alcopops in the past week. This may have adversely affected the results. One affect might have been to make it more likely for some participants to choose the alcoholic beverages in the choice tests or even to choose the fruit juice (if they thought it might contain alcohol or even be an 'alcopop'), even if their priming dose had contained no alcohol. In defence of the methodology the lozenge held in the mouth would have considerably altered the taste of the fruit juice used in the priming solution and this limitation should not be considered serious. Nevertheless, it should be considered in future experiments.

The current research focused on liking for the taste of alcohol. However, it maybe that liking for the intoxicating/subjective pleasurable effects of a drug that is more important, rather than a taste cue. Theories on the role of cues in drug use (e.g. Stewart, De Wit and Eikelboom 1984) and the Toates/Bindra models of incentive motivation claimed that, through a conditioning process, cues associated with incentives take on the affective properties of that incentive. Thus, if the effect of a drug is liked then the cue will also be liked. As they claimed wanting and liking were the same, liking for a cue should also cohere with measures of wanting. There is evidence that taste liking can be altered by pairing it with drug effects (e.g. Kiefer, Bice and Badia-Elder 1994; Kiefer 1995) but liking for cues can sometimes be associated with wanting, in a manner that would not be predicted by the IST. For example, there is evidence that some cues for 'wanted' drugs can also be 'liked' more, compared to neutral cues. Mogg *et al* (2003) measured attentional biases (eye movements, duration of gaze), which can be considered a measure of wanting, to smoking related (and neutral) cues in smokers and non-smokers. Ratings of the pleasantness of the visual cues were also measured. Smokers displayed an attentional bias to the smoking cues and rated them as more pleasant, compared to the non-smokers. Thus, nicotine users that also displayed wanting on a laboratory measure (attention to the cues) also rated the cues as liked more. Taste liking is considered an alcohol cue but it was not found to cohere with the measures of wanting in the current research. Robinson and Berridge (1993) argued that liking for cues is not the same as liking for the pleasurable effects of drugs. They pointed out that there was 'no doubt' that

an 'action or stimulus should come to predict.....or elicit pleasure, on its own' but they distinguish between this cue-liking and the pleasurable effects of a drug itself. They view the dissociation between the pleasurable effects of drugs and incentive salience as the phenomenon that they were interested in. Aside from this they say little about when and why liking for certain cues can be expected to dissociate or cohere with wanting and liking. This suggests two avenues for future research. As Robinson and Berridge view liking for the pleasurable effects of drugs as more important than liking for cues it would make more sense to investigate if the dissociation extends that far. This does not detract from the dissociations in the current research but it is the next logical step. Future research could therefore seek to expand upon the attempt to measure this in Experiment four, using the questionnaire measures of subjective wanting and the subjective effects of alcohol. The second avenue is to investigate when and why some cues might cohere with wanting and others with liking. This would be beneficial because these cues are assumed to predict or elicit wanting and liking. As the IST views wanting as the primary motivational process responsible for compulsive drug use, it would be useful to identify those cues that predict/elicit wanting and those that do not.

11.6 Final Conclusion

In conclusion, the current research provided evidence for the IST claim of a dissociation between wanting and liking for alcohol in humans using three lines of investigation. Two groups of drinkers that were held to differ in wanting for alcohol did not differ in liking for the taste of alcohol. This method was limited in some ways but more convincing evidence was provided by manipulations that altered wanting and liking independently of each other. Specifically, Priming with alcohol led to increases in wanting but not liking and small reductions in liking did not result in concurrent reductions in wanting for alcohol. These results suggested that wanting for alcohol can be dissociated from liking for the taste of alcohol.

APPENDICES

Appendix one: Consent and Debriefing Forms

A1.1 Consent Form for Experiment 1B

Alcohol Taste Study

Consent Form for Research Participants

I am Malcolm Hobbs a postgraduate research student. I am requesting your participation in a study regarding physiological responses to taste stimuli. This will involve the tasting of a series of solutions while physiological measures are taken. The experiment should last approximately 1 hour. The solutions contain Tween, apple, water and ethanol. If you have any reason to avoid cosmetics or colourings let the experimenter know now.

First you will be asked to do an alcohol breath test. If alcohol is registered then you will not be able to take part in the study today. You will then be asked to fill out an alcohol consumption questionnaire. You will be asked to administer the solutions yourself into your mouth and hold it there for 30 seconds before swallowing. As this is being done electrodes on your face will take physiological measures. After each solution you will be asked to provide a rating of how much you liked the solution. I will be in the room adjacent and will instruct you (via a microphone) when to taste each solution. Personal information will not be released to or viewed by anyone other than researchers involved with this project. Results of this study will not include your name or any other identifying characteristics. Please note that although alcohol is being used in this study the quantity is very small. In total you will receive about 5ml of alcohol (1/4 can of beer).

You participation is voluntary and you may withdraw your participation at any time. If you have any questions please ask them now.

Statement of Consent

I_____have read the above informed consent.
[participants name]

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 confidentially. In signing this consent letter, I am not waving 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 participate in the above study. Yes No

Signature Date
Name

I understand that if I have questions about my right 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, SO17 1BJ.

A1.2 Consent Form for Experiment two

Alcohol Taste Study

Consent Form for Research Participants

I am Malcolm Hobbs a postgraduate research student. I am requesting your participation in a study regarding physiological responses to taste stimuli. This will involve the tasting of a series of solutions while physiological measures are taken. The experiment should last approximately 45 minutes. The solutions contain Tween, apple, water and ethanol. If you have any reason to avoid cosmetics or colourings let the experimenter know now.

First you will be asked to do an alcohol breath test. If alcohol is registered then you will not be able to take part in the study today. You will then be asked to fill out an alcohol consumption questionnaire. You will be asked to administer the solutions yourself into your mouth and hold it there for 10 seconds before swallowing. As this is being done electrodes on your face will take physiological measures. After each solution you will be asked to provide a rating of how much you liked the solution and how intense you found the solution. I will be in the room adjacent and will instruct you (via microphone) when to taste each solution. Personal information will not be released to or viewed by anyone other than researchers involved with this project. Results of this study will not include your name or any other identifying characteristics. Please note that although alcohol is being used in this study the quantity is very small. In total you will receive about 5ml of alcohol (1/4 can of beer).

You participation is voluntary and you may withdraw your participation at any time. If you have any questions please ask them now.

Statement of Consent

I_____have read the above informed consent.
[participants name]

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 confidentially. In signing this consent letter, I am not waving 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 participate in the above study. Yes No

Signature Date
Name

I understand that if I have questions about my right 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, SO17 1BJ. Phone: (023) 80593995.

A1.3 Debriefing Form for Experiment 1B and Experiment two

Alcohol Taste Study
Debriefing Statement

The aim of this study was to investigate facial EMG responses to taste stimuli. The aim is to investigate differential responding to tastes in 3 muscle regions of the face. Certain muscle regions are associated with responses to negative and positive stimuli. The aim was to measure positive and negative facial responses to a negative, positive and neutral taste (and ethanol) and see how they correlate with the subjective measures and to explain any individual differences in responding to the ethanol.

Once again results of this study will not include your name or any other identifying characteristics. The experiment/researcher did not use deception. You may have a copy of this summary if you wish.

If you have any further questions please contact me Malcolm Hobbs at Mbh3@soton.ac.uk.

Thank you for your participation in this research.

References on the subject:

Berridge, K. (1999) Measuring hedonic impact in animals and infants: microstructure of affective taste reactivity patterns. *Neuroscience and biobehavioural reviews*, 24, 173-198.

Hu et al (1999) Facial EMG as an indicator of palatability in humans. *Physiology and behaviour.* 68(1-2), 31-35 (available on the biomedical electronic journals at the library homepage).

If you have 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) 8059 3995.

A1.4 Consent Form for Experiment three

Beer and fruit juice identification study

Information sheet

I am Malcolm Hobbs a Postgraduate researcher. I am requesting your participation in a study of the identification of different alcoholic and non-alcoholic beverages. The study is run over 2 days. The first day will take approximately 30 – 45 minutes and the second day 90 – 120 minutes. The study will test your ratings for different beverages under certain conditions

On day 1 you will first fill in a screening questionnaire to determine whether you can take part. Our procedures require that we only test people meeting certain criteria. If you are accepted into the study you will then sample 10 different solutions. 5 will be beer and 5 will be fruit juice. You will simply be asked to drink each one and make a liking rating for each. At the same time electrodes attached to your forehead and upper lip/nose will take physiological readings.

On day 2 there will be 3 different parts to the session. In the first part you will consume either an alcoholic solution or a control solution that tastes exactly the same as the alcoholic one. There will then be a break of 15 minutes. The second part will be similar to day 1. You will be asked to consume and rate a fruit juice and a beer solution while electrodes obtain physiological measures. The third part will involve identifying and rating a variety of beers and fruit juices. At the end you will be required to fill in a short questionnaire. 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.

NOTE ON ALCOHOL CONSUMPTION: The solutions consumed will be beer, fruit juice and in some cases an ethanol/fruit juice mix. The maximum amount of alcohol you will be asked to consume will be dependent on your weight. On day 1 it will be approximately 1 – 2 pints. On day 2 it will be approximately 2 – 3 pints. This means that you may experience a level of intoxication that exceeds the legal UK drink drive limit. You are therefore advised not to take part in any activities that may be dangerous under the influence of alcohol the rest of the day. In addition you will be breathalysed at the end of each session. If your breath alcohol level exceeds 70mg% (driving limit = 80mg%) you will be advised to remain in the laboratory until the level declines. If you choose to reject this advice you will be asked to sign a disclaimer saying that you take responsibility for your action.

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.

Statement of Consent

I _____ have read the above informed consent form.
[participants name]

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 confidentially. 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.

I confirm that I have not had any negative reactions to alcohol in the past or have not be advised not to drink by a doctor. I do not believe I am pregnant and I am not on any medication which gives advice not to drink. I am aware that I have been advised not to drive or take part in any activities for the rest of the day that might be dangerous under the influence of alcohol. I agree to stay in the building until my blood alcohol levels have fallen to or below 70mg%.

(Circle Yes or No)

I give consent to participate in the above study. Yes no

Signature Date

A1.5 Debriefing Form for Experiment three

Wanting Vs Liking: Behavioural and Subjective Measures during Alcohol Consumption

The aim of this research was to investigate wanting and liking for alcohol. Wanting and liking for drugs, food, etc has traditionally been seen as being governed by the same process. So if you like something you will also want it and vice versa. However, a recent theory has claimed that wanting and liking for drugs have separate underlying neural processes. Although they often cohere together, under certain conditions wanting and liking can be dissociated from one another. Repeated consumption of certain drugs (including alcohol) 'sensitises' a certain area of the brain that mediates 'wanting' but not liking. Thus in the presence of the drugs or cues associated with drug consumption the neurones become hyper-sensitive (they start firing more than usual). This gives rise to drug-seeking behaviour and 'wanting'. In addicts this can take the form of pathological craving. This can be independent of liking for a drug. So it is possible to have an uncontrollable craving for a drug yet derive little pleasure from it.

The current study seeks to take different measures of wanting and liking and compare them after a dose of either alcohol or placebo. In heavy drinkers the alcohol should 'stimulate' the wanting system (which should have been sensitised) giving rise to wanting for more alcohol but not more liking. So wanting and liking will be compared to each other to investigate if a dissociation occurs. Liking was measured by the liking ratings and the electrodes on the face which were measuring muscle movement (different muscles are associated with different emotions). Wanting was measured by how often you chose to rate alcohol and how much you drank of each solution. Wanting for alcohol can be either unconscious or conscious. Therefore it was necessary to deceive you into believing that the purpose of the study was to test your skill at identifying beer.

You are reminded that you should not drive or do any other activity for the rest of the day that may be dangerous under the influence of alcohol. You may have a copy of this summary if you wish. If you have any further questions please contact me Malcolm Hobbs at mbh3@soton.ac.uk or ask me now.

Thank you for your participation in this research.

Signature Date

Name

If you have 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) 8059 3995.

A1.6 Consent Form for Experiments four and 6A

Alcohol Study Consent and Information Form

Information sheet

I am Malcolm Hobbs a Postgraduate researcher. I am requesting your participation in a study investigation alcohol use. The study will take approximately one hour.

You will first fill in a screening questionnaire. You will **not** be allowed to take part in the study if you satisfy any of the following criteria:

- Your weight is below 60kg (females) or 50kg (males).
- You have certain health concerns.
- You are not familiar with the effects of alcohol intoxication that will be experienced in this study.

The experiment consists of 4 different parts. In the first part you will consume either an alcoholic solution (alcohol/fruit juice mix) or a control solution (fruit juice) that tastes like the alcoholic one. There will then be a break of 15 minutes. In the second part you will be asked to rate a fruit juice solution and a beer solution. The third part will involve choosing and rating several beers and/or fruit juices. The final part will involve tasting and rating another set of solutions. At various times in the experiment you will also be ask to fill in questionnaires.

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.

NOTE ON ALCOHOL CONSUMPTION: The solutions consumed will be beer, fruit juice and in some cases an ethanol/fruit juice mix. The maximum amount of alcohol you will be asked to consume will be dependent on your weight but it will be approximately 2 –3 pints. This means that you may be at or over the legal UK drink drive limit. You are therefore advised not to take part in any activities that may be dangerous under the influence of alcohol the rest of the day. Your breath alcohol level will be measured at the end of the study. If your level registers as 70mg% (driving limit = 80mg%) or over you will be asked to sign a disclaimer should you wish to leave the lab.

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.

Statement of Consent

I _____ have read the above informed consent form.
[participants name]

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 confidentially. 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.

I confirm that I have not had any negative reactions to alcohol in the past or have not be advised not to drink by a doctor. I do not believe I am pregnant and I am not on any medication which gives advice not to drink. I am aware that I have been advised not to drive or take part in any activities for the rest of the day that might be dangerous under the influence of alcohol. I agree to stay in the building until my blood alcohol levels have fallen to or below 70mg%.

(Circle Yes or No)

I give consent to participate in the above study. Yes No

Signature Date

A1.7 Debriefing Form for Experiments four and 6A

Wanting Vs Liking for Alcohol: Comparing Measures of Wanting and Liking for Alcohol

The aim of this research was to investigate 'wanting' and 'liking' for alcohol. Wanting and liking for drugs, food, etc has traditionally been seen as being governed by the same process. So if you like something you will also want it and vice versa. However, a recent theory has claimed that wanting and liking for drugs have separate underlying neural processes. Although they often cohere together, under certain conditions wanting and liking can be dissociated from one another. Repeated consumption of certain drugs (including alcohol) 'sensitises' a certain area of the brain that mediates 'wanting' but not liking. Thus, in the presence of the drugs or cues associated with drug consumption the neurones become hyper-sensitive (they start firing more than usual). This gives rise to drug-seeking behaviour and 'wanting'. In addicts this can take the form of pathological craving. This can be independent of liking for a drug. Therefore it is possible to have an uncontrollable craving for a drug yet derive little pleasure from it.

The current study is actually 2 experiments. The first part was one experiment. This seeks to take different measures of wanting and liking and compare them after a dose of either alcohol or placebo. A previous study by this researcher found that a 'priming' dose of alcohol led to a larger increase in wanting than liking. This experiment is a follow-up to this study. In heavy drinkers the alcohol should 'stimulate' the wanting system (which should have been sensitised) giving rise to wanting for more alcohol but not more liking. So wanting and liking will be compared to each other to investigate if a dissociation occurs. Liking was measured by the liking ratings. The second experiment was the last part of the session. Half the participants received the drinks with Tween (with makes it more unpleasant) and half received the drinks on their own. The amount of fluid you consumed (a measure of wanting) was measured and we were only interested in your liking rating (not the others). The aim was to compare changes in wanting and liking as a result of adding the Tween.

You are reminded that you should not drive or do any other activity for the rest of the day that may be dangerous under the influence of alcohol. You may have a copy of this summary if you wish. If you have any further questions please contact me Malcolm Hobbs at mbh3@soton.ac.uk or ask me now.

Thank you for your participation in this research.

Signature Date

Name

If you have 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) 8059 3995.

References on the topic (available on internet or in library):

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: an incentive-sensitisation theory of addiction. Brain Research Reviews, 18, 247-291.

Robinson, T. E., & Berridge, K. C. (2000). The Psychology and Neurobiology of Addiction: an incentive-sensitisation view. Addiction, 95 (supplement 2), S91-S117.

Robinson, T. E., & Berridge, K. C. (2001). Incentive-sensitisation and addiction. Addiction, 96, 103-114.

A1.8 Consent Form for Experiment five

Alcohol Study Consent and Information Form

Information sheet

I am Malcolm Hobbs a Postgraduate researcher. I am requesting your participation in a study investigation alcohol use. Day 1 will take approximately 1 hour.

You will first fill in some screening questionnaires. You will **not** be allowed to take part in the study if you satisfy any of the following criteria:

- Your weight is below 60kg.
- You have certain health concerns.
- You are not familiar with the effects of alcohol intoxication that will be experienced in this study.

The experiment consists of 3 different parts. In the first part you will consume either an alcoholic solution (alcohol/fruit juice mix) or a control solution (fruit juice) that tastes like the alcoholic one. There will then be a break of 15 minutes. In the second part you will be asked to rate a fruit juice solution and a beer solution. The third part will involve choosing and rating several beers and/or fruit juices.

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.

NOTE ON ALCOHOL CONSUMPTION: The solutions consumed will be beer, fruit juice and in some cases an ethanol/fruit juice mix. The maximum amount of alcohol you will be asked to consume will be dependent on your weight but it will be approximately 2 –3 pints. This means that you may be at or over the legal UK drink drive limit. You are therefore advised not to take part in any activities that may be dangerous under the influence of alcohol the rest of the day. Your breath alcohol level will be measured at the end of the study. If your level registers as 70mg% (driving limit = 80mg%) or over you will be asked to sign a disclaimer should you wish to leave the lab.

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.

Statement of Consent

I _____ have read the above informed consent form.
[participants name]

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 confidentially. 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.

I confirm that I have not had any negative reactions to alcohol in the past or have not be advised not to drink by a doctor. I do not believe I am pregnant and I am not on any medication which gives advice not to drink. I am aware that I have been advised not to drive or take part in any activities for the rest of the day that might be dangerous under the influence of alcohol. I agree to stay in the building until my blood alcohol levels have fallen to or below 70mg%.

(Circle Yes or No)

I give consent to participate in the above study. Yes No

Signature Date

A1.9 Debriefing Form for Experiment five

Wanting Vs Liking for Alcohol: Comparing Measures of Wanting and Liking for Alcohol

The aim of this research was to investigate 'wanting' and 'liking' for alcohol. Wanting and liking for drugs, food, etc has traditionally been seen as being governed by the same process. So if you like something you will also want it and vice versa. However, a recent theory has claimed that wanting and liking for drugs have separate underlying neural processes. Although they often cohere together, under certain conditions wanting and liking can be dissociated from one another. Repeated consumption of certain drugs (including alcohol) 'sensitises' a certain area of the brain that mediates 'wanting' but not liking. Thus, in the presence of the drugs or cues associated with drug consumption the neurones become hyper-sensitive (they start firing more than usual). This gives rise to drug-seeking behaviour and 'wanting'. In addicts this can take the form of pathological craving. This can be independent of liking for a drug. Therefore it is possible to have an uncontrollable craving for a drug yet derive little pleasure from it.

The current study seeks to take different measures of wanting and liking and compare them after a dose of either alcohol or placebo. A previous study by this researcher found that a 'priming' dose of alcohol led to a larger increase in wanting than liking. This experiment is a follow-up to this study. In heavy drinkers the alcohol should 'stimulate' the wanting system (which should have been sensitised) giving rise to wanting for more alcohol but not more liking. So wanting and liking will be compared to each other to investigate if a dissociation occurs. Liking was measured by the liking ratings. Wanting was measured by often you chose to rate alcohol and how much you drank of each solution.

You are reminded that you should not drive or do any other activity for the rest of the day that may be dangerous under the influence of alcohol.

You may have a copy of this summary if you wish. If you have any further questions please contact me Malcolm Hobbs at mbh3@soton.ac.uk or ask me now.

Thank you for your participation in this research.

Signature Date

Name

If you have 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) 8059 3995.

A1.10 Consent Form for Experiment 6B

Alcohol Study Consent and Information Form

Information sheet

I am Malcolm Hobbs a Postgraduate researcher. I am requesting your participation in a study investigation alcohol use. The study will take approximately 15 – 20 minutes.

You will first fill in a screening questionnaire. You will **not** be allowed to take part in the study if you satisfy any of the following criteria:

- Your weight is below 60kg.
- You have certain health concerns.
- You are not familiar with the effects of alcohol intoxication that will be experienced in this study.

You will first fill in a couple of questionnaires. You will then taste two drinks and provide some ratings about them. 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.

NOTE ON ALCOHOL CONSUMPTION: The solutions consumed will be beer and fruit juice. The maximum amount of alcohol you will be able to drink will be 1/2 pint of beer. You are advised not to take part in any activities that may be dangerous under the influence of alcohol the rest of the day. Your breath alcohol level will be measured at the end of the study. If your level registers as 70mg% (driving limit = 80mg%) or over you will be asked to sign a disclaimer should you wish to leave the lab.

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.

Statement of Consent

I _____ have read the above informed consent form.
[participants name]

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 confidentially. 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.

I confirm that I have not had any negative reactions to alcohol in the past or have not be advised not to drink by a doctor. I do not believe I am pregnant and I am not on any medication which gives advice not to drink. I am aware that I have been

advised not to drive or take part in any activities for the rest of the day that might be dangerous under the influence of alcohol. I agree to stay in the building until my blood alcohol levels have fallen to or below 70mg%.

(Circle Yes or No)

I give consent to participate in the above study. Yes No

Signature Date

A1.11 Debriefing Form for Experiment six

Wanting Vs Liking for Alcohol: Comparing Measures of Wanting and Liking for Alcohol

The aim of this research was to investigate a dissociation between 'wanting' and 'liking' for alcohol. Wanting and liking for drugs, food, etc has traditionally been seen as being governed by the same process. So if you like something you will also want it and vice versa. However, a recent theory has claimed that wanting and liking for drugs have separate underlying neural processes. Although they often cohere together, under certain conditions wanting and liking can be dissociated from one another. Repeated consumption of certain drugs (including alcohol) 'sensitises' a certain area of the brain that mediates 'wanting' but not liking. Thus, in the presence of the drugs or cues associated with drug consumption the neurones become hyper-sensitive (they start firing more than usual). This gives rise to drug-seeking behaviour and 'wanting'. In addicts this can take the form of pathological craving. This can be independent of liking for a drug. Therefore it is possible to have an uncontrollable craving for a drug yet derive little pleasure from it.

Half the participants received the drinks with Tween (with makes it more unpleasant) and half received the drinks on their own. The amount of fluid you consumed (a measure of wanting) was measured and we were only interested in your liking rating (not the others). The aim was to compare changes in wanting and liking as a result of adding the Tween. It was predicted that wanting and liking for the beer would not show a close relation with each other.

You are reminded that you should not drive or do any other activity for the rest of the day that may be dangerous under the influence of alcohol. You may have a copy of this summary if you wish. If you have any further questions please contact me Malcolm Hobbs at mbh3@soton.ac.uk or ask me now.

Thank you for your participation in this research.

Signature Date

Name

If you have 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) 8059 3995.

A1.12 Consent Form for Experiment seven

Alcohol Study Consent and Information Form

Information sheet

I am Malcolm Hobbs a Postgraduate researcher. I am requesting your participation in a study investigation alcohol use. The study will take approximately 15 – 20 minutes.

You will first fill in a screening questionnaire. You will **not** be allowed to take part in the study if you satisfy any of the following criteria:

- Your weight is below 60kg.
- You have certain health concerns.
- You are not familiar with the effects of alcohol intoxication that will be experienced in this study.

You will first fill in a couple of questionnaires. You will then taste four drinks and provide some ratings about them. 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.

NOTE ON ALCOHOL CONSUMPTION: The solutions consumed will be beer and fruit juice. The maximum amount of alcohol you will be able to drink will be 3/4 pint of beer. You are advised not to take part in any activities that may be dangerous under the influence of alcohol the rest of the day. Your breath alcohol level will be measured at the end of the study. If your level registers as 70mg% (driving limit = 80mg%) or over you will be asked to sign a disclaimer should you wish to leave the lab.

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.

Statement of Consent

I _____ have read the above informed consent form.
[participants name]

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 confidentially. 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.

I confirm that I have not had any negative reactions to alcohol in the past or have not be advised not to drink by a doctor. I do not believe I am pregnant and I am not on any medication which gives advice not to drink. I am aware that I have been

advised not to drive or take part in any activities for the rest of the day that might be dangerous under the influence of alcohol. I agree to stay in the building until my blood alcohol levels have fallen to or below 70mg%.

(Circle Yes or No)

I give consent to participate in the above study. Yes No

Signature

A1.13 Debriefing Form for Experiment seven

Wanting Vs Liking for Alcohol: Comparing Measures of Wanting and Liking for Alcohol

The aim of this research was to investigate a dissociation between 'wanting' and 'liking' for alcohol. Wanting and liking for drugs, food, etc has traditionally been seen as being governed by the same process. So if you like something you will also want it and vice versa. However, a recent theory has claimed that wanting and liking for drugs have separate underlying neural processes. Although they often cohere together, under certain conditions wanting and liking can be dissociated from one another. Repeated consumption of certain drugs (including alcohol) 'sensitises' a certain area of the brain that mediates 'wanting' but not liking. Thus, in the presence of the drugs or cues associated with drug consumption the neurones become hyper-sensitive (they start firing more than usual). This gives rise to drug-seeking behaviour and 'wanting'. In addicts this can take the form of pathological craving. This can be independent of liking for a drug. Therefore it is possible to have an uncontrollable craving for a drug yet derive little pleasure from it.

One of the beers and one of the fruit juices contained Tween (which makes it more unpleasant) and the other two were the straight versions of the drinks. The amount of fluid you consumed (a measure of wanting) was measured and we were only interested in your liking rating (not the others). The aim was to compare changes in wanting and liking as a result of adding the Tween. It is predicted that wanting and liking for the beer will not show a close relation with each other.

You are reminded that you should not drive or do any other activity for the rest of the day that may be dangerous under the influence of alcohol. You may have a copy of this summary if you wish. If you have any further questions please contact me Malcolm Hobbs at mbh3@soton.ac.uk or ask me now.

Thank you for your participation in this research.

Signature Date

Name

If you have 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) 8059 3995.

Appendix two: Questionnaires and Score Sheets

A2.1 Subjective Rating Score Sheet

Please provide a rating between 0 and 100 for how much you like each solution in the table below. Where 0 = extremely unpleasant, 50 = neutral and 100 = extremely pleasant.

Solution	Liking rating		Liking rating
1		16	
2		17	
3		18	
4		19	
5		20	
6		21	
7		22	
8		23	
9		24	
10		25	
11		26	
12		27	
13		28	
14		29	
15		30	

Note. Table above is not the same as appeared in all Experiments. Variations on this template were employed for each Experiment.

A2.2 Alcohol Consumption Questionnaire and Unit Calculation

Subject No.: **Age:** **Gender:**

In the space provided please write down what alcoholic drinks (beer, spirit, etc) you consumed and how much on each day for the past week. Use day 1 as yesterday and then work your way back from there.

	Drinks Consumed	**Units** (Do not fill in)
Day 1: Yesterday		
Day 2		
Day 3		
Day 4		
Day 5		
Day 6		
Day 7		
	Total units	

Note. The following guidelines were used to calculate the number of units:

1 pint of beer = 2 units.

330ml cans/bottles of beer = 1.5 units.

1 bottle of alcopop = 1.5 units.

1 glass of wine = 1 unit (one bottle = 6 units).

1 shot of spirit = 1 units

1 pint of juicy lucy = 5 units

1 pint of Snakebite = 2 units

Cocktails were treated as one unit unless the participant could identify exactly what the cocktail contained.

A2.3 Experiment three, four and five Choice Test Score Sheets

Participant Score Sheet:

Part One:

Please provide a rating in the box below as to how much you liked the taste of each solution. Give a number between 0 and 100, where 0 = extremely unpleasant, 50 = neutral and 100 = extremely pleasant.

	Rating
Fruit Juice 1	
Fruit juice 2	
Beer 1	
Beer 2	

Part Two:

	Rating
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Note. Score sheet above relates to Experiment 5. Experiments 3 and 4 used a variation of this template.

A2.4 Screening Questions

Screening form

Participants weight: **Age:** **Gender:** **No:**

1. Have you consumed the equivalent of 3 pints of beer or more (6 units), in the past month on a single drinking occasion? YES/NO

2. What is the largest amount of alcohol you have consumed on any one occasion in the past month (approximately)? ..... Units

3. How many drinking sessions on average do you think you have in a typical week? .....

4. How much do you drink in a typical drinking session? .....

5. Do you have any medical condition or have received any medical advice that specifies that you should not consume alcohol? YES/NO

6. Have you been given any professional advice to stop or reduce the amount of alcohol you drink? YES/NO

7. Is there any other reason why you shouldn't consume alcohol? .....

Appendix three: Blood Alcohol Level Calculations for Ethical requirements

A3.1 Equation Used to Calculate Blood Alcohol Concentration (BAC)

BAC = weight of alcohol (g) X 100/ Weight (kg) X Widmark factor

BACs were calculated using Widmark values for males = 0.68; females = 0.55; 1ml of alcohol = 0.79g; 1 pint of beer = 568ml. The answer is given a mg of alcohol per 100ml of blood (mg%) and it was assumed that alcohol is eliminated from the body at a rate of 10 – 25mg% per hour.

A3.2 Predicted BACs from Experiment 3 (Taken from Ethical Form)

Estimated blood alcohol concentrations (BACs) are shown below. BAC is primarily dependent on weight and elimination rate of alcohol, which differs between males and females. A previous study conducted in the department showed that female participants had a mean weight of 61kg and males a mean weight of 76.5kg. The lightest female was 49kg and the lightest male 59kg. To reduce the chances of BACs exceeding the UK drink driving limit by a large margin, females under 60kg and males under 50kg will not be admitted to the study. The estimated maximum BACs for the lightest and typical males and females are presented below. The UK BAC drink driving limit is 80mg alcohol per 100ml of blood (mg%). Some measurements are shown as g/kg. This means grams of alcohol per kg of body weight, so the amount of alcohol will be dependent on a participant's weight. At no point will any participant be allowed to consume more than 45g of alcohol on each day even if they weigh sufficiently enough to warrant it. This is roughly 0.5g/kg for a 95kg male and is equivalent to approximately 5.6 units.

Day 1

On day 1, in the sampling session, participants will consume 0.4g/kg. The session will last approximately 30 - 45 minutes.

Predicted peak BACs and beer consumed by end of day 1:

Typical Male (76.5kg) - Will drink 1.5 pints of 4.5% strength beer equivalent and have an estimated BAC of 58.82mg% by the end of the study.

Lightest Male (59kg) – Will drink 1.18 pints of 4.5% strength beer equivalent and have an estimated BAC of 58.82mg% by the end of the study

Typical Female (61kg) – Will drink 1.22 pints of 4.5% strength beer equivalent and have an estimated BAC of 72.72mg% by the end of the study.

Lightest Female (60kg) – will drink 1.22 pints of 4.5% strength beer equivalent and have an estimated BAC of 72.72mg% by the end of the study.

Day 2

Half the participants will be assigned to the alcohol priming condition. The priming dose will be 0.25g/kg for each person. This is equivalent to approximately a pint of 4% beer for a 70kg male. In the EMG taste test all participants will be required to consume an additional 25ml of beer (at approx. 4% -5%). In the choice tests participants will choose to rate fruit juice and beer (approx. 4% - 5%). The maximum amount of beer available for them to consume will be 500ml (approx.1 pint).

Estimated BACs at the end of the study that could be reached if the participants were in both the alcohol priming condition and consumed all the available alcohol are shown below. The beers will not exceed 5% and most will be around 4%. BACs have been calculated by assuming the beer is 4.5% strength:

Typical male (76.5kg): Will drink a maximum of 1.8 pints and have a BAC between 39 - 59mg% by the end of the study.

Lightest male (59kg): Will drink a maximum of 1.63 pints and have a BAC between 49 - 72mg% by the end of the study.

Typical female (61kg): Will drink a maximum of 1.65 pints have a BAC between 67.5 - 85mg% by the end of the study.

Lightest female (60kg): Will drink a maximum of 1.64 pints and have a BAC between 65 - 85mg% at the end of the study.

Exact BACs are hard to predict as there are large individual differences in the elimination rate of alcohol. However, the above values reflect conservative BAC estimations. The amounts of alcohol in each choice test need to be high to avoid ceiling effects (i.e if very small amounts were used all participants might consume all the

available alcohol) so that a valid measure of 'wanting' can be achieved. Likewise, the 0.25g/kg priming dose was chosen to maximise the likelihood of obtaining a priming effect with as small a dose as possible (according to literature).

At the end of day 2 most participants should be under the drink drive limit but some maybe at or slightly over the limit. Participants will, nevertheless, be explicitly advised, on both days, not to drive or to take part in any activities that might be dangerous under the influence of alcohol for the rest of the day. On discharge participant's BAC will be monitored with a breathalyser and participants will be advised to stay in the lab with the researcher until their BAC levels are below 70mg%. If a participant declines this advice they will be asked to sign a disclaimer, saying, have been advised to stay, that they they have chosen not to follow the advice, and that they take full responsible for their own actions. All participants will agree to follow this procedure at the point of entry into the study at a point where no alcohol has been consumed.

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