2005-04

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10.1037/0033-295X.112.2.446
PSYCHOL REV
AMER PSYCHOLOGICAL ASSOC

2005, 112, 2, 446-467

Imaginary Relish and Exquisite Torture: The Elaborated Intrusion Theory of Desire

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The authors argue that human desire involves conscious cognition that has strong affective connotation and is potentially involved in the determination of appetitive behavior rather than being epiphenomenal to it. Intrusive thoughts about appetitive targets are triggered automatically by external or physiological cues and by cognitive associates. When intrusions elicit significant pleasure or relief, cognitive elaboration usually ensues. Elaboration competes with concurrent cognitive tasks through retrieval of target-related information and its retention in working memory. Sensory images are especially important products of intrusion and elaboration because they simulate the sensory and emotional qualities of target acquisition. Desire images are momentarily rewarding but amplify awareness of somatic and emotional deficits. Effects of desires on behavior are moderated by competing incentives, target availability, and skills. The theory provides a coherent account of existing data and suggests new directions for research and treatment.

The imaginary relish is so sweet

That it enchants my sense.

—Shakespeare, *Troilus & Cressida*, Act 3, Scene 2

Here you are, innocently reading a psychology journal, and an article suddenly mentions someone drinking a cup of excellent coffee at a sidewalk café on a sunny Sunday morning. Chances are that you immediately imagine how good it would be to have a cup yourself. Maybe you imagine the smell of the freshly ground coffee beans, the smell and taste of the coffee, and perhaps even the sound of the grinder and the bubble and steam of the espresso machine. If you do not especially enjoy coffee or have just finished a cup, this image may have little appeal. But if you would really enjoy a cup of coffee right now, the image has a pleasurable piquancy—a tantalizing enchantment

that like a tickle to your foot, moves easily to a sense of torture if the desire cannot be fulfilled. From its inception, the thought captures your attention. It has strong emotive power, and there is a sense that it triggers action. You may even feel unable to continue to read this article until you get a cup.

What are the essential elements of this subjective experience? Our impression is that they include the intrusive and often unexpected nature of the initial thought, the imagery of the coffee and of drinking it, and the pleasure and torture that image brings. Once begun, it is difficult to stop thinking about it—in fact, it is difficult to think about anything else. If the affective impact of the desire is particularly strong, its fulfillment may seem imperative, although of course it is not inevitable.

In this article, we describe an elaborated intrusion (EI) theory of desires, which embodies these key aspects of the subjective phenomena as well as encompasses the wide range of related empirical evidence. As its name suggests, the theory distinguishes between associative processes that trigger *intrusive thoughts* about an appetitive target and the controlled processes of cognitive *elaboration* that tend to follow those thoughts that have stronger affective links. The processing priority provided to the elaboration is responsible for the interference with other cognitive tasks. The theory holds that emotive imagery and associated sensations are especially important in craving because somatosensory links contribute a particular piquancy and motivational power to the experience. Although the theory acknowledges the function of target salience in motivation (Robinson & Berridge, 1993), it highlights the affective nature of desires and draws attention to the duality of those affective reactions (i.e., the relish and torture in our article's title). In contrast to some who have concluded that craving is epiphenomenal (e.g., Tiffany, 1990), we argue that desires represent a strong motivating force, albeit one that is moderated by other factors such as competing desires, skills, or availability (e.g., we want to avoid being kept awake or are out of coffee). Our theory is unashamedly cognitive, with a focus on human motivation, but consistent with current neuroscientific findings from brain imaging and animal research.

In what follows, we define desire and distinguish it from its antecedents and consequences. We then provide an overview of the theory and work through its key propositions, examining the evidence for each, including evidence from our own laboratory. We complete the article with research predictions, including some implications for the treatment of dysfunctional desires.

What Do We Mean by Desire?

A coherent theory of desire requires clarity of definition and a distinction of desires from their antecedents, correlates, and consequences. It is especially important that we clarify these concepts because definitions have been subject to some contention, especially in the context of craving for drugs (Kozlowski & Wilkinson, 1987). We use *desire* in the sense of an affectively charged cognitive event in which an object or activity that is associated with pleasure or relief of discomfort is in focal attention. In humans it can be referred to as a conscious wish or urge to gain pleasure, relieve discomfort, or satisfy a want or to engage in consummatory behavior associated with these outcomes.[1] Desire is not simply an emotion (contrast Franken, 2003), although it clearly has affective quality: The psychological experience includes images or verbal thoughts about the attractive features of appetitive objects or activities (Salkovskis & Reynolds, 1994). It is better described as a preference for something (an object or activity; Zajonc, 1980). Desire is also conscious; whereas unconscious or implicit processes may underpin some behavioral responses (Robinson & Berridge, 2003; Tiffany, 1990), they are not themselves desire, although they can trigger desire. As Robinson and Berridge (2003) argued, "when cognitive elaboration translates

incentive salience attributions into the level of conscious awareness of the corresponding representations . . . the initial activation of an implicit 'wanting' system contributes to the explicit subjective experience of a conscious desire" (p.36).

Desires are events in time and can therefore be described on dimensions of duration and frequency as well as by their affective intensity. Like pain or fear, desires are direct experiences rather than metacognitions (cf. Toneatto, 1999), although reports or ratings are clearly metacognitive (and therefore subject to error). The distinction is important—brain activation patterns, for example, may be quite different when the person is attempting to evaluate or measure their desire rather than simply experiencing it. Reports of expectancies are even further divorced from the phenomena of desire because they represent reported beliefs about the likely consequences of target acquisition and do not necessarily correspond to the immediately relevant aspects of the target that are the focus of attention during a specific episode of desire.

Desires are sometimes inferred from correlated self-reported phenomena such as a difficulty in controlling such thoughts (Bohn, Krahn, & Staehler, 1995; Tiffany, Singleton, Haertzen, & Henningfield, 1993; Volpicelli, Alterman, Hayahida, & O'Brien, 1992), confidence in maintaining behavioral restraint, or intentions to acquire the target (Tiffany & Drobes, 1991; Tiffany et al., 1993). Although these reports may have practical utility in assessment instruments, in this article we separate the desires from these correlated or consequential phenomena to develop a coherent causal theory. A similar inferential issue is raised in animal research, in which we cannot ask for reports of cognition or emotion. Behavioral indices from humans and animals (consumption rate, approach latency, maximum reinforcement ratio, reinstatement of conditioned responses, etc.) at best represent indirect indices of the cognitive–emotional events (Koob, 2000; McGregor & Gallate, 2004). Desires should also be distinguished from their antecedents such as associated cognition, physiological deficits, or environmental cues. The occurrence of these events may increase the probability of desire, but they do not represent the phenomenon itself.

We began work on this theory as an explanation of craving for psychoactive substances. However, we see the theory as being applicable to all desires and argue that such a broad applicability is in fact essential to an adequate theory of desires and craving. Although psychoactive drugs appear to sensitize neural pathways involved in motivation (Berridge & Robinson, 2003; Robinson & Berridge, 1993, 2003), we argue that the key component processes in substance-related craving are the same as for other desires. Although we recognize that some people prefer to limit the use of the word *craving* to very strong or intense experiences (Kozlowski & Wilkinson, 1987), we argue for a continuity model of intensity and do not make qualitative distinctions between craving and desire. Support for a continuity across desired targets comes from various sources. Subjective reports indicate that the experience of desire is qualitatively similar across a range of targets, including food, soft drinks, alcohol, and tobacco (May, Andrade, Panabokke, & Kavanagh, 2004). Research into the causes, components and consequences of desire, discussed below, reveals no important differences between desires for different targets. Although some brain mechanisms for particular targets differ (e.g., thirst: Sewards & Sewards, 2000; hunger: Del Parigi et al., 2002)—as reflected in the differing subjective experience for specific physiological deficits—there also appears to be substantial commonalities in final cortical pathways. For example, dopamine antagonists attenuate the motivational properties of food, water, and drugs in deprived animals (Nader, Bechara, & van der Kooy, 1997). The mesocorticolimbic dopamine pathway appears to be particularly important in the action of incentives in general (Robinson & Berridge, 1993, 2003). Our article therefore develops a theory that aims to cover desires in general, whether these be mild or intense, for drugs or other motivational targets.

The EI Theory of Desire

The EI theory of desire derives its title from the separation of more basic, associative processes from higher level elaborative processes. The associative processes underlie apparently spontaneous, intrusive thoughts about a target that can arise while attention is primarily directed to another task. They may take the form of verbal or image fragments or an implicational awareness (cf. Barnard & Teasdale, 1991). Elaboration involves controlled processes of search for target-related information and the retention of this information in working memory, resulting in highly elaborated cognition about the target.

The distinction between the associative and elaborative processes is illustrated in Figure 1, with elements constituting the conscious experience of desire being displayed within the central box and triggers or sources of information being shown around it.

The processes underpinning intrusive thoughts involve learned associations to internal or external antecedent events (see Figure 1). Five types of these events are distinguished: physiological deficit states, negative affect, external cues, other cognitive activity, and anticipatory responses to the target (such as salivation). The associations themselves may be classically conditioned or they can be semantic or episodic in nature (e.g., recall of past experiences). The nature of these initiating processes, indicated by the thin arrows in Figure 1, means that demands for controlled processing or working memory are low, and this gives rise to the sense of spontaneity and intrusion in concurrent cognitive activity. Although associative connections tend to reactivate instigative factors, the intrusive thoughts themselves are transitory events. Unless they are attended or retained in working memory, thoughts about the target will be vulnerable to distraction by salient stimuli or cognitive associates that are unrelated to the target (e.g., "a cup of coffee might be nice—my last cup of coffee was with Jan—I'd really like to see Jan again").

However, when the target elicits powerful affective reactions or a keen sense of deficit,[2] we predict that intrusive thoughts will be followed by elaboration. We use *elaboration* in the conventional sense to mean mentally embellishing or going beyond the initial stimulus (thus *elaborative rehearsal* of a word may involve imaging its referent or thinking about how it is related to other stimuli or existing knowledge). The elaboration component of desire involves effortful cognitive processes (controlled processes) that are triggered by the intrusive thought and its associated affective response and are indicated by the thick arrows in Figure 1. Relevant information is sought and is then retained and manipulated in working memory. The search is both internal (increasing the salience of physiological states, episodic memories, and target-related cognition such as expectancies) and external (increasing the salience of relevant situational cues). Thus if someone spontaneously thinks "I need a cigarette" (the intrusive thought), he or she may then imagine smoking a cigarette, recall the last time he or she smoked, and wonder whether he or she has enough money to buy a pack of cigarettes. This type of cognition is what we refer to as elaboration.

If you strongly identified with the coffee scenario described at the start of this article and it triggered a desire to get a cup of coffee, you were engaging in elaborative rumination. The example illustrates that elaborative desires do not have to wait for associations to emerge—they can also be elicited on instruction. Regardless of the way in which elaboration is triggered, processing resources tend to be captured. You may well have found it difficult to concentrate on the subsequent material in this article because the elaborative processing competes for priority in the limited-capacity systems of working memory.

We argue that the coffee example was prototypical in its form. Sensory images are not just precipitants of desire but lie at its heart. Although we do not exclude the role of semantic processing

in desire, we predict that extended episodes of appetitive rumination will typically include the construction of sensory images that often are vivid and richly textured, lending the experience a sensory immediacy that contributes to its emotional impact and helps to explain the exquisite and tantalizing nature of the phenomenon.

The generation, maintenance, and manipulation of vivid images recruits several high-level cognitive processes (Baddeley & Andrade, 2000). Elements of an image, including sensory information (e.g., the smell of beer), generic characteristics (the typical color of beer), and specific episodes (how good the beer tasted on holiday), are retrieved from long-term memory. This retrieval process is controlled by executive processes of working memory (Rosen & Engle, 1997). Relevant information may also be obtained from the immediate environment and stored in appropriate subsystems of working memory. The visuospatial and auditory subsystems of working memory (Baddeley, 1986) serve as workspaces for storing the information thus retrieved. Manipulation of this information, by modality-specific rehearsal processes and amodal central executive processes, contributes to the experience of vivid, quasi-lifelike images.

We argue that progressive elaboration of the target-related thoughts, particularly in the form of imagery, is the key process underlying the persistence of desires during craving episodes. The operation of elaborative processes does not replace associative ones. Those original links remain activated, and their likelihood of emerging into consciousness is augmented by the increased attentional priority to target-relevant material. Each type of process helps to feed the other. So, the retrieval processes that were activated in the service of constructing an image of coffee may well have generated further intrusive thoughts. Response memories may also have been activated, and you may have started to elaborate plans for obtaining some coffee. Imagined strategies for obtaining coffee may include further images of it.

This is not to say that the episode is indefinitely self-sustaining, even when pleasure and a sense of deficit are elicited. In the scenario at the start of this article, you may have had a cup of coffee and now feel sufficiently satiated that further thoughts about it no longer elicit significant affect. Other competing cognitive tasks may also have terminated the episode. The continued operation of associative processes may have diverted attention to alternative desires, or you may have been so enthralled by this article that you preferentially allocated processing resources to it. Both associative and elaborative processes contain the reasons for the termination of episodes as well as the basis for their development. As a result of their operation, desires tend to fluctuate in salience and affective intensity over time, even in the context of significant deprivation.

We propose that imagery is particularly effective at maintaining and augmenting craving because of its effectiveness in activating emotional and motivational pathways. Consummatory fantasies provide a keen emotive edge and motivational power because of their similarity with the consummatory experience itself. Conversely, the physiological correlates of the affective experience, together with preconsummatory responses such as salivation, may lend further color to the sensory imagery. We predict that when other factors are controlled, a stronger sense of desire will be derived when the imagined experience is more closely associated with affect or is more subjectively vivid (Lang, 1994). More vivid imagery is likely when there are more environmental cues to assist its development, with the best set of cues provided by consuming a priming dose of the substance. For this reason, the theory is consistent with observations that a priming exposure, short of satiation, tends to increase rather than decrease desire (Ludwig, Wikler, & Stark, 1974).

These aspects of desire imagery would have significant evolutionary advantages. More vivid consummatory images would be elicited (and more intense reinforcement obtained) as the organism imagined or entered a setting where the target would most likely be found. Image vividness would

therefore assist in selection of behavioral alternatives and in prediction of outcomes. Approaches to the target would both increase image vividness and increase the potency of associated affective responses. This would reinforce approach and preparatory behaviors to acquisition of the consummatory target. Vivid imagery allows the organism to continue seeking out the consummatory target in the temporary absence of specific cues. Imagery thereby provides a motivational bridge across extended time periods before a consummatory target can be obtained.

We argue that desires make target acquisition more likely but not inevitable. Nor does the absence of desire preclude consumption. This is not the only route to behavior, but it is a compelling one that can overcome situational or intentional impedances. The impact of desire is moderated by the availability of the appetitive target, the balance of other salient incentives, and skills and self-efficacy in either procuring the target or inhibiting its acquisition (Bandura, 1999). The EI theory predicts that when other conditions strongly favor or inhibit consumption, the level of desire will be less predictive of consumption than when other conditions are less extreme. So, if you are reading this article with an open box of chocolates at your side, intense desire is not required before you take one. If you are reading it in a library where eating chocolate is forbidden, even an intense desire may not result in an attempt to obtain it. Degree of desire is also less relevant when competing incentives are high (e.g., a million-dollar modeling contract is riding on loss of weight) and you have the self-efficacy and skills to resist consumption. Alternatively, if you feel unable to resist temptation or there is no reason to do so, the degree of desire for chocolate is very likely to predict whether you leave the house to buy some.

Although both intrusive and elaborated thoughts appear to trigger target acquisition, they typically do so in different ways. Intrusive thoughts may bias choices of activities or trigger very simple absentminded behavior, like reaching for a cigarette, particularly when attention is focused on another task. Full awareness may sometimes follow that behavior rather than precede it. An associative linkage between focal attention to the target and a simple response is highly consistent with the associative processes underlying intrusive thoughts themselves. Alternatively, elaborated thoughts serve to maintain the desired target as a behavioral goal across temporal delays and provide response plans that facilitate target acquisition through the organization of behavioral sequences.

Affect is involved in all aspects of the EI theory. Both intrusive and elaborated thoughts are linked to reward processes that confer both hedonic tone and a tendency for the appetitive thoughts to capture and retain attention. But the predominant emotional reaction in many episodes of desire is negative because negative emotion is both a potential precursor of desire and a consequence of it. As a precursor, negative emotion primes awareness of specific physiological deprivation, and (via episodic and semantic connections) it primes activities that could return the person to a positive hedonic state. Once a desire-related thought emerges, awareness of any associated deprivation is further primed. The effect is heightened in the context of expected delay or frustration of target acquisition and under conditions such as repeated use of psychoactive substances, where the pleasure or relief afforded by thoughts about the substance is increasingly rapidly subsumed by a strong sense of deprivation.[3] When the perceived deficit is substantial, we can become caught in cycles of elaboration, fleeting reward, and intensified deficit as we think about the desired target. During a control attempt, guilt or anxiety about the intrusive thought or elaboration also contributes to the negative state. So the imaginary relish may be sweet, but the deprivation, guilt, and anxiety leave us tortured. We are like the legendary Tantalus, able to see food and drink but simultaneously tortured by our imagination (Drummond, 2001).

Components of the EI Theory and Related Evidence

The EI theory argues that cognitive processes and desire-related cognitions intervene between the factors that elicit desire and attempts to consume or abstain from consumption. In the following section we outline the main components of the theory and relate them to existing evidence. We begin, conventionally, with the factors that elicit desire and then discuss our more novel distinction between the automatic, associative processes underpinning the experience of intrusive thoughts and the controlled, elaborative processes underpinning the full-blown experience of desire. We describe the key role that mental imagery plays during an episode of desire and show why this leads to both pleasure and discomfort. Finally, we address the relationship between desire and consumption.

Factors That Elicit Desire

As shown in Figure 1, we argue that several factors may elicit desire. These include external cues that have conditioned associations to thoughts about the appetitive target and associations to other ongoing cognitive activity. Appetitive thoughts can also follow a physiological conditioned reaction to an external cue (e.g., "my heart missed a beat . . . she's here!"). A deficit state such as physiological deprivation or withdrawal from a substance may also elicit desire, as may aversive emotional states that are not necessarily related to somatic deprivation. For example, if a person has eaten chocolate to improve his or her mood in the past, an awareness of negative mood may be sufficient to trigger an association with eating chocolate, even if he or she has just eaten a hearty meal.

Eliciting factors trigger desire by one of two pathways. The first is via the availability of target-related associations in memory. These associations may be semantic, episodic, conditioned, or primed by previous cognitive activity. In each case, the association emerges through the unconscious, uncontrolled activation of memory. The involvement of learned associations introduces uncertainty into the prediction of whether a particular cue or train of thought will result in a specific desire, although the content of the thought or the salience of the cue will of course have an influence. So, our route home may remind us of ways we can buy alcohol, or we may remember the need to post a letter. Repeated elicitation of a particular desire in the context of specific internal or external cues would be expected to strengthen the association and increase the probability of the specific desire being elicited in that context, but even in that case the associative linkages still reflect a probabilistic relationship.

A second pathway to desire may introduce further uncertainty to the elicitation process. In this case, the initial intrusive thought is of an ambiguous sensation or deficit, and there is no dominant association to a specific target. Under these circumstances, elaborative processes that focus on attribution of the deficit are likely to be initiated. This notion is consistent with an elaboration likelihood model of affect (Petty & Cacioppo, 1984), which proposes that a negative mood increases motivation to alter the current mood state, with a consequent cognitive style directed toward evaluating the context and searching for features that could be causing the negative mood. The elaboration likelihood model is strongly supported by research evidence on the impact of affect on cognition (Petty & Cacioppo, 1984).

The involvement of attributional and associational processes implies that desires may arise from attributional errors or salient but misleading associations. An irregular heartbeat may be due to excessive caffeine rather than to a lover's arrival. Within the EI theory, the desire that is elicited will depend on the relative salience of the appetitive target and the cognitive availability of related material. We predict that cross-activation of desires will be common in conditions in which information about the physiological deficit is ambiguous.

Unless a ceiling in subjective desire is reached, the EI theory predicts that multiple prompts would have greater effects than those occurring singly because they increase the probability of one or more intrusive thoughts and contribute a richer body of semantic and sensory material to elaboration. In fact, more than one factor may often be required for a desire to emerge at all. So, recalling a blazing log fire is only likely to trigger a desire to find one if we are aware that we are cold: Conversely, an awareness of cold will only activate a desire for fire if that associate is activated or a related external cue is encountered.

Our list of eliciting factors is consistent with the existing research evidence, as is the view that the presence of multiple eliciting factors tends to increase the probability and strength of subsequent desire. The claim that eliciting factors operate via cognition in humans is consistent with evidence that attributional errors can occur and with demonstrations of the particular effectiveness of semantic and imaginal craving induction strategies.

Physiological deficit and negative moods. There is substantial evidence that deprivation or withdrawal can induce desire. For example in smoking, abstinence from cigarettes for 6–24 hr is associated with craving, and desire to smoke is reduced by nicotine substitution (Jorenby et al., 1996). The activation of appetitive associations during withdrawal is demonstrated by the priming of substance-related words (Jarvik, Gross, Rosenblatt, & Stein, 1995). Furthermore, the dopaminergic systems that appear to underlie incentive salience aspects of reward are differentially activated in situations in which animals are in deprived states (Nader et al., 1997).

However, a single-factor model of elicitation that is based on pharmacological effects is inconsistent with the current data on the elicitation of craving. For example, a transdermal nicotine patch alleviates cigarette craving that is associated with nicotine withdrawal but does not affect reactivity to smoking cues (Tiffany, Sanderson-Cox, & Elash, 2000). Nor does a pharmacological model account for the time course of desire during withdrawal. Such a model would for example predict that craving for cigarettes would parallel the curve of physiological withdrawal symptoms. However, a steady reduction in craving over 25 days can be seen from the day people quit smoking—a pattern that omits an initial increase as physiological symptoms rise in severity and extends well beyond the primary withdrawal period (Shiffman et al., 1997). In the EI theory, the activation of desires during a withdrawal period is subject to the total context of target-related associations and to the outcomes of any attributional search that may be initiated.

A sense of deprivation can be primed by a negative mood. So, a negative mood during withdrawal from cocaine is associated with more intense feelings of withdrawal than is a mood that is less negative (Robbins, Ehrman, Childress, Cornish, & O'Brien, 2000). In a study on smokers by Maude-Griffin and Tiffany (1996), a negative mood without accompanying cues resulted in significantly greater smoking urges than did either a neutral or a positive mood. The level of craving resulting from the negative mood alone was as high as that resulting from imagery about urges to smoke within a neutral mood context. Similar effects are seen when people with alcohol or cocaine dependence participate in a stressful task, whether they are seeking treatment or not (Sinha, Catapano, & O'Malley, 1999; Sinha, Krishnan-Sarin, & O'Malley, 1997; Sinha, Robinson, & O'Malley, 1998). The effect is replicable across a variety of stress-induction paradigms, including imagining a personalized stress situation, attempting a digit span task, or giving a videotaped speech (Sinha et al., 1997, 1999; cf. Droungas, Ehrman, Childress, & O'Brien, 1995).

Research on the availability of mood-consistent information (Bower, 1992) is highly consistent with a negative mood making a specific deprivation more highly available. Once a negative emotional state either primes or is attributed to a specific deprivation, the associated targets (e.g., cigarettes)

are also primed. In this way, a mood-consistent retrieval effect ironically results in the ultimate retrieval of information with positive or appetitive associations.

When physiological information is ambiguous, the EI theory predicts that cross-activation of desires (or attributional errors) may occur. Tentative support for this prediction comes from a recent study by Alsene, Li, Chaverneff, and de Wit (2003), who found that food abstinence increased craving for cigarettes (although smoking abstinence did not increase craving for food). The role of cognitive factors in determining the target of desire is consistent with animal research showing that motivational systems are not stimulus specific. Thus morphine can serve as a substitute for food reward in food-deprived animals (see Nader et al., 1997). The involvement of attributional processes in relation to physiological deficits is also consistent with smoking-related expectancies affecting both subjective craving and the perceived severity of withdrawal symptoms that are experienced during a period of nicotine withdrawal (Wetter et al., 1994).

In contrast to the evidence on negative mood, there is little evidence that a positive mood can prompt craving (Greeley & Ryan, 1995). In the laboratory, effects of a positive mood induction are comparable to those from a neutral mood (Maude-Griffin & Tiffany, 1996). Evidence that a small proportion of relapses in substance control occur in positive mood states (Cummings, Gordon, & Marlatt, 1980) is more plausibly explained in terms of social norms relating to substance use in celebrations rather than as direct effects of positive moods on craving. Within the EI theory, a positive mood is not by itself an elicitor of desire, except when physiological arousal from another source is misinterpreted as being related to the appetitive target. Additive effects of positive moods on other eliciting factors (see below) are seen as occurring because of the accentuation of the pleasure or relief that accompanies desire-related thoughts (i.e., the impact of the positive mood is after the instigation of the cognition).

Conditioned cues. Cues that are associated with past consumption or that signal the presence of a consummatory object can elicit desire, even in the absence of withdrawal or negative mood. Exposure to alcohol cues increases craving in both alcoholic and nonalcoholic drinkers (Cooney, Gillespie, Baker, & Kaplan, 1987; Kaplan et al., 1985; cf. Stormark, Laberg, Bjerland, Nordby, & Hugdahl, 1995), and watching someone pick up and hold a cigarette can induce smokers to crave cigarettes (Niaura, Abrams, Pedraza, Monti, & Rohsenow, 1992). Although much of the cue reactivity research has involved exposure to the sight, smell, or taste of the consummatory target, associations may also involve stimuli such as the time consumption usually occurs (Palij, Rosenblum, Magura, Handelsman, & Stimmel, 1996). They may include concurrent behaviors such as smoking while drinking alcohol (Burton & Tiffany, 1997). A richer set of cues or a set that is more strongly associated with consumption is more likely to elicit craving than are sets with weaker associations (Payne et al., 1992).

Cue reactivity is usually interpreted in terms of classical conditioning, either to withdrawal sensations (Ludwig & Wikler, 1974) or to previous consumption (Stewart, de Wit, & Eikelboom, 1984). A history of classical conditioning has sometimes been assumed rather than demonstrated (Greeley & Ryan, 1995), but there is evidence that conditioning can prompt craving. In Dols, Willems, van den Hout, and Bittoun (2000), smokers were shown sets of cards that depicted smoking cues. A random selection of cards was associated with subsequent nicotine administration: These cards later elicited stronger craving for nicotine than did the control cards, even though both sets showed smoking cues. Withdrawal responses for narcotics can also be conditioned in the laboratory (O'Brien, O'Brien, Mintz, & Brady, 1975), although drug agonistic effects are more consistently conditioned than are withdrawal symptoms (Niaura et al., 1988).

Recent studies have shown attentional biases toward target-related cues in substance users. Thus users are more likely to orient toward those cues in the environment that trigger or exacerbate craving. For example, smokers responded faster to probes that replaced smoking-related pictures than to probes that replaced control pictures (Mogg, Bradley, Field, & De Houwer, 2003), and a positive relationship between the strength of this bias and self-reported craving is obtained (Waters, Shiffman, Bradley, & Mogg, 2003). Franken (2003) argued that these attentional biases are the behavioral expression of dopamine-mediated sensitization of neural systems that attach incentive salience to drug-related cues (Robinson & Berridge, 1993, 2003). She suggested that "attentional focusing on drug cues may trigger more explicit cognitive processes such as positive drug-related expectancies and intrusive thoughts" (Franken, 2003, p. 572). In the EI theory, the intrusive thoughts in turn trigger cognitive elaboration that further increases attentional allocation to the antecedents of desire (see Figure 1).

There is some recent evidence to suggest that a cardiovascular response by alcohol-dependent people to pictorial alcohol cues could be observed even when the picture was so rapidly followed by a masking stimulus that the picture was not consciously accessible (Ingjaldsson, Thayer, & Laberg, 2003b). The effect was particularly seen in alcohol-dependent people who report experiencing higher levels of craving for alcohol (Ingjaldsson, Thayer, & Laberg, 2003a). When the high-craving group was exposed to masked alcohol cues they also showed a small increase in difficulty resisting alcohol (Ingjaldsson et al., 2003a). Together, these results suggest that preattentive psychophysiological responses to cues may occur and that the associational influences reflected in Figure 1 are not necessarily open to introspective awareness (which is why intrusive thoughts and associated desire phenomena feel spontaneous).

Anticipatory responses. Among the responses elicited by environmental cues are physiological anticipatory responses (e.g., salivation to food or drink or increased heart rate). These responses generally show a low correlation with subjective desire (Maude-Griffin & Tiffany, 1996). One reason may be that the person is not aware of the anticipatory responses, and without such awareness, the desire is not elicited, even if behavioral change follows. A study by Monti et al. (1993) on alcoholics who were participating in detoxification found that urges to drink were not related to the degree of salivary response to alcohol cues. Although, among those who did have a salivary response, awareness of the response was associated with stronger urges. In the EI theory, salivation may be a consequence of desire-related cognition, but it may also be induced directly by conditioned associations with an external or internal cue (including thoughts that are associated with the appetitive target but are not directly about it). In either case, the salivation may elicit or enhance the desire, but in the EI theory this would occur only if the response is attended to and is linked to the appetitive target. For example, the person may mistakenly believe that the salivation is due to hunger rather than to a desire for alcohol. Our argument is consistent with a tendency for desire for a particular target to be elicited when that target is highly salient (Rickard-Figueroa & Zeichner, 1985).

An informational model of anticipatory responses potentially allows error in the interpretation of internal stimuli (Schachter & Singer, 1962; cf. Lang, 1994; Marshall & Zimbardo, 1979). Such errors might be due to an insensitivity to physiological changes or to inattention to the sensory feedback, but they may also arise from misattribution of ambiguous internal states. This can result in responses to one appetitive object being confused with responses to another. So, responses to cigarette cues not only involve a rise in tobacco craving but can also involve increased desire for the person's drug of choice (Taylor, Harris, Singleton, Moolchan, & Heishman, 2000). Similarly, the desire of cocaine-dependent people for cocaine rises to a similar extent after erotic stimuli as it does after exposure to cocaine-related cues (Bauer & Kranzler, 1994). In this case, responses to the erotic

stimuli were apparently mistaken for responses to cocaine cues. Arousal that does not arise from desire (e.g., sympathetic nervous system arousal associated with anxiety) can also be misattributed to desire. When undergraduate men were interviewed by an attractive female researcher in a study conducted by Dutton and Aron (1974), they were more likely to telephone the researcher after the experiment if they were interviewed on a high suspension bridge than if they were interviewed on a low bridge. Fear arousal appears to have been misattributed to sexual arousal in the presence of a salient erotic cue. Such effects suggest that physiological responses act in concert with cognitive associations rather than providing unambiguous and specific information.

Desire-related thoughts. It is not only a matter of cognitive processes moderating the impact of external cues: The cues themselves can be cognitively generated. Just the knowledge of imminent consumption is enough to stimulate desire (Juliano & Brandon, 1998). The effect of cognitive associations is demonstrated by priming experiments, in which the priming of positive-expectancy words results in greater alcohol consumption than does the priming of neutral words (Roehrich & Goldman, 1995; Stein, Goldman, & Del Boca, 2000), and the priming of negative expectancies results in less consumption (Carter, McNair, Corbin, & Black, 1998). We argue that this change in behavior is likely to reflect a change in the salience of desire-related versus inhibitory or aversive thoughts about alcohol and, hence, in the net appetitive value of the alcohol.

Desire-related thoughts can also be deliberately induced by semantic instructions. An instruction to create an image of the appetitive target is very effective at inducing craving (Cepeda-Benito & Tiffany, 1996; Drobes & Tiffany, 1997; Kilts et al., 2001; Maude-Griffin & Tiffany, 1996; Tiffany & Hakenewerth, 1991; Zwaan & Truitt, 1998). In the EI theory, the directed construction of an appetitive image is prototypical of elaborative desire, rather than being just another type of eliciting process. So, subjective vividness of imagery correlates strongly with the level of urge in the laboratory (Drobes & Tiffany, 1997; Maude-Griffin & Tiffany, 1996; Tiffany & Drobes, 1990; Tiffany & Hakenewerth, 1991).

Berridge and Robinson (2003) suggested that "vivid cognitive images of reward, which potently elicit motivation, might also activate mesolimbic 'wanting' circuits [via] 'top-down' brain circuits involving corticolimbic projections" (p. 511). We suggest that the interactions between these high-level brain circuits and the mesolimbic wanting circuits are likely to be two way, such that increased wanting leads to further imagery, which serves not only to elicit motivation and desire but also to maintain it.

Simultaneous activation of eliciting factors. Unless a ceiling in subjective desire is reached, multiple prompts would be expected to have greater effects than would those occurring singly because they increase the probability of one or more intrusive thoughts and contribute a richer body of semantic and sensory material to elaboration. This does often appear to be the case.

Substance-related cues usually elicit stronger craving in the context of negative emotion than when they appear alone, and the effect of negative emotion and cues on craving is usually additive rather than multiplicative (Cooney, Litt, Morse, Bauer, & Gaupp, 1997; Payne, Schare, Levis, & Colletti, 1991; Robbins et al., 2000). This effect is consistent with negative moods and cue exposure operating as independent influences (as in the EI theory), rather than one moderating the other. This is also true of some other determinants of desire. Six hours of smoking deprivation plus imaginal cues had an additive rather than a multiplicative impact on craving for cigarettes in Drobes and Tiffany (1997), as did the combination of alcohol ingestion and exposure to smoking cues in Burton and Tiffany (1997).

Some combinations can result in factors that initially had little effect on desires acquiring an ability to contribute to the combination. A positive emotion, although itself an ineffective elicitor of craving (Greeley & Ryan, 1995), can augment the impact of substance-related imagery on craving, and the combined effect can be as strong as that of negative emotion (Maude-Griffin & Tiffany, 1996; Tiffany & Drobes, 1990; cf. Taylor et al., 2000). Berridge and Winkielman (2003) reported that participants exposed to subliminal affective faces did not report any change in mood, those exposed to happy faces drank more of a freely available soft drink, and those exposed to angry faces drank less, but only if participants were already thirsty. Within the EI theory, a positive mood would accentuate the ability of the appetitive thought to elicit reward because the positive emotion would share hedonic tone with the liking aspect of reward (Robinson & Berridge, 1993, 2003). There is also evidence that the presence of craving then modifies the emotional context by drawing attention to deprivation ("sense of associated deficit" in Figure 1). Ongoing smokers who imagined a positive emotional scene in a study by Maude-Griffin and Tiffany (1996) had a less positive emotional response when the scene included smoking images than when it omitted them. Conversely, inclusion of an urge component in a negative emotional context also blunted the negative mood.

Distinction of Associative and Elaborative Processes

The distinction between the processes underlying intrusive and elaborated thoughts is similar to the distinction of automatic and controlled processing, which has a long history in cognitive psychology (Shiffrin & Schneider, 1977). It is also similar to Stacy's (1995, 1997) distinction between memory associations and explicit introspections about expectancies, although it incorporates broader perspectives on the nature and origins of both phenomena. By using the term *intrusive thought*, we deliberately infer a parallel with similar phenomena that occur in a negative affective context, such as in anxiety or posttrauma reactions (Tunis, Delucchi, & Hall, 1994).

In contrasting intrusive and elaborated thoughts, we emphasize that it is the underlying processes rather than the contents of the cognition that we are contrasting. Whereas the process of elaboration provides an opportunity for the assembly of complex and highly articulated informational composites, an associative process may lead to a cascade of data that is similar to the content that is retrieved by directed search. For example, recall of an episodic memory may be triggered involuntarily by a sequence of associations or deliberately by directed search. Nonetheless, there is some evidence from self-report studies, discussed below, that people can distinguish subjectively between spontaneous thoughts that apparently trigger desire and images that are a key element of the desire itself.

The distinction between intrusive and elaborated thoughts is critical to developing an understanding of the initiation and impact of desire. Elaborated thoughts can be derived in response to instruction (as in the image at the start of this article), by initiating target-related search and retention processes. However, we contend that intrusive thoughts represent a more typical gateway to ruminative episodes and that they continue to be elicited throughout those episodes. It is intrusive thoughts that mediate the experience of sudden, unexpected yearning for a cigarette years after people stop smoking. Evidence that intrusive thoughts do often form a gateway to episodes of craving was obtained by our research group in a study based on a questionnaire given to prospective university students about the triggers and experience of a current craving for food, tobacco, soft drink, or alcohol (May et al., 2004). Of a list of potential triggers, "I suddenly thought about it" was rated jointly at the top with "I felt hungry/thirsty/tired/physical discomfort."

If intrusive thoughts almost inevitably lead to elaboration and if the process of elaboration then elicits additional associations, can a practical distinction be made between the two? We argue that

such a distinction can be made and that it is an important one. We predict that under some circumstances intrusive thoughts only have a fleeting impact on attention or attract only partial awareness. This is likely to occur when competing cognitive demands are substantial, especially if successful performance of the concurrent task has a high incentive value—for example, a momentary sensation of hunger during a public speech may soon be forgotten. Such fleeting attention will be more likely when there is a low level of deprivation or need or weak associations between the thought and affective and motivational systems (e.g., "Some carrots right now would be quite pleasant"). We would expect that these events would not be highly salient in memory but that people would be able to report on their occurrence as long as the report was proximal to the event. Self-report evidence in support of the phenomenon of fleeting intrusions is being provided by a current study we are conducting on people with alcohol misuse who are trying to reduce their drinking. Preliminary data from 49 participants showed that 92% reported experiencing at least some thoughts about drinking in the previous 24 hr that "just pop in and vanish" without an attempt to eliminate them. This suggests that fleeting intrusions may be a common phenomenon, even in the context of substance misuse.

The distinction between intrusive and elaborated thoughts also has importance for attempts at control. We propose that obsessive craving or desire (Anton, 2000)—in the sense of unwanted, intrusive appetitive thoughts—is a general feature of desire and its attempted suppression, rather than a phenomenon that is restricted to particular individuals. Suppression of a thought that has appeared in awareness should at best be ineffective because the intrusiveness of such thoughts is actually accentuated by the attempt (Lavy & van den Hout, 1990). Following Wegner (1994), we argue that the phenomenon occurs because of two parallel processes. On the one hand, distraction requires a high level of cognitive effort, and this effort is difficult to maintain in the face of competition for cognitive resources. On the other hand, the monitoring of violations, which requires fewer cognitive resources, activates desire thoughts (e.g., "Have I thought of alcohol yet? Oh no, I have now"). Furthermore, the detection of cognitive violations often leads to negative self-appraisals (e.g., "I'm so weak and disgusting to be thinking that") and reduced self-efficacy about control of thoughts and behavior. The resultant distress then intensifies a bias toward deficits and triggers further intrusive thoughts. The monitoring of violations in desire control is therefore another initiator of desire and ironically undermines the very control that is attempted. This is not to say that control of desire cognition is impossible. People can preempt intense episodes of desire by controlling potential triggers, for example, by avoiding situations that are rich in conditioned cues and maintaining positive mood. They may also engage in alternative pleasurable activities that command attention. Such strategies mean that people do not have to be totally at the mercy of their own associative processes (Bandura, 1999).

Associative effects on cognitive tasks. Our dual-process view of craving suggests that two different types of cognitive phenomena should be demonstrable. Effects of priming or activation of target-related networks should arise from the implicit or automatic associative route to desire. Interference with other demanding cognitive tasks should arise because the directed search and retention in elaboration requires limited cognitive resources. Some priming may of course occur because of increased exposure to target-related stimuli by users of a substance versus nonusers (e.g., Stacy, 1995). Increased priming during periods of subjective craving or deprivation provides stronger evidence of automatic cognitive processes. Such priming or activation is indicated by evidence that the lexical processing of smoking-related words is enhanced after overnight abstinence from smoking (Jarvik et al., 1995). Similarly, Aarts, Dijksterhuis, and De Vries (2001) showed that thirsty participants responded faster to drinking-related items in a lexical-decision task than did participants who were not thirsty. An increased availability of substance-related associations in the context of either overnight cigarette deprivation or an attempt to quit smoking was also

demonstrated by Phillips, Kavanagh, May, and Andrade (in preparation). In response to a request to generate words about relaxation, more smoking-related words were obtained from deprived or quit smokers than from either nonsmokers or nondeprived smokers. There is some evidence that the number of memory associations generated in response to drug-related stimuli predicts subsequent drug use and does so independently of a measure requiring elaborative processing (explicit expectancies; Stacy, 1997).

A commonly used paradigm involves a modification of the Stroop color-naming task. Overnight smoking deprivation results in impeded color naming of smoking-related words (Gross, Jarvik, & Rosenblatt, 1993), and food deprivation has similar effects on food words (Channon & Hayward, 1990; cf. Lavy & van den Hout, 1993). This may reflect priming or possibly attentional changes that direct processing toward desire-related stimuli.

Evidence from cognitive tasks on elaboration. Studies on concurrent cognitive tasks are consistent with our contention that the elaboration of desire-related thoughts engages considerable cognitive resources and therefore impairs performance on other tasks that compete for these resources. Because focal attention is one of the tasks that draws on limited working memory resources, an attentional task that is unrelated to the desire should be impaired by concurrent desire-related elaboration. So, probe reaction time is slowed during cue exposure with smokers (Cepeda-Benito & Tiffany, 1996; Sayette & Hufford, 1994), alcoholic patients (Sayette et al., 1994), and opiate addicts (Hillebrand, 2000). Probe reaction times in participants who are both substance deprived and exposed to related cues are significantly associated with the level of craving after the task (Green, Rogers, & Elliman, 2000; Sayette & Hufford, 1994; Sayette et al., 1994). Longer probe reaction times are also associated with the perceived frequency of obsessive thoughts about the substance in the previous week (Franken, Kroon, & Hendriks, 2000), indicating that people are often aware of a cognitive impact from substance-related intrusive thoughts and their elaboration and (because obsessive thoughts tend to be resisted during a control attempt) that such cognitive interference is probably made worse by the effects of attempted thought suppression.

Cognitive impairments are not restricted to speed of reactions to probes but occur on a wide range of tasks requiring sustained attention or working memory. For example, an imaginal urge induction in ongoing smokers impaired the accuracy of reading comprehension, particularly on more complex sentences and in participants with a low reading span (Zwaan & Truitt, 1998). Although mathematics performance was not impaired when heavy drinkers were exposed to alcohol-related cues in Bradizza, Lisman, and Payne (1995), that study tested only college students (who presumably had moderate to high mathematics ability) and confounded a positive emotion induction with cue exposure.

In summary, the evidence on cognitive tasks suggests that desires alter the ability of external cues to activate associated cognitions and conscious allocation of attention to target information. Furthermore, extended episodes of desire appear to take up resources in limited-capacity systems of working memory and thereby interfere with the performance of other tasks that compete for this capacity. The EI theory captures this phenomenon, placing elaborative imagery processes at the heart of desire.

Evidence for intrusive thoughts from attempts to inhibit them. When people are trying to inhibit the acquisition of appetitive targets, desire-related thoughts often resemble obsessional thinking (Modell, Glaser, Mountz, Schmaltz, & Cyr, 1992). The parallels include the intrusive quality of the thoughts, the difficulty in banishing them from awareness, and their tendency to produce distress (Modell et al., 1992). There are also parallels on a neuroanatomical level, with similar brain structures being activated in people with a preoccupation with craving as in obsessive–compulsive

disorder (OCD; Ciccocioppo, 1999; Grant et al., 1996; Volkow & Fowler, 2000). Although the intrusive quality of desires and urges partly derives from their association with pleasure and discomfort, particularly in the context of deprivation or withdrawal, another potential source of intrusion comes from attempts to suppress the thoughts. Although there is evidence that recall can be inhibited by prior practice of recall suppression (Anderson & Green, 2001), very different effects are obtained from suppression of highly available material that has already been retrieved. Even the suppression of nonemotive thoughts is a very difficult enterprise that can usually only be accomplished for short periods when other cognitive demands are low (Wegner, 1994). Attempts at suppression typically produce higher frequencies of the thought either during (Lavy & van den Hout, 1990; Merckelbach, Muris, van den Hout, & de Jong, 1991; Salkovskis & Campbell, 1994) or after the attempted suppression (Clark, Ball, & Pape, 1991; Clark, Winton, & Thynn, 1993; A. G. Harvey & Bryant, 1998). Distraction from emotive thoughts can however reduce the emotional response—at least in depression (Nolen-Hoeksema & Morrow, 1993).

There are very few studies on suppression of appetitive thoughts. In a study of heavy drinkers by Palfai, Monti, Colby, and Rohsenow (1997), participants who were instructed to suppress urge-related thoughts were significantly faster at judging the personal relevance of alcohol expectancies, suggesting that these were more cognitively accessible. Salkovskis and Reynolds (1994) examined the effects of thought suppression in smokers asked to monitor smoking thoughts, to suppress smoking thoughts, or to combine suppression and breathing exercises (relaxation). The relaxation instructions resulted in a lower frequency of smoking thoughts both during and after the task than did the other two conditions. Those in the monitoring group, who did not suppress smoking thoughts, had a lower frequency of the thoughts than those in the suppression group.

Although attempted suppression of desire-related thoughts is counterproductive, attention diversion without suppression may have some success. When external constraints mean that consumption is expected to be delayed, people sometimes initiate strategies to reduce the discomfort associated with unsatisfied desires (e.g., by diverting their attention from the cues). These strategies still require cognitive resources. When smokers believed they would have to wait 3 hr for a cigarette in a study by Juliano and Brandon (1998), exposure to smoking cues did not significantly increase their immediate subsequent level of craving but did increase their reaction time to auditory probes. In contrast, a group who believed they could smoke within 20 min showed an effect of smoking cues on immediate subsequent desire but no increase in probe reaction time. Even in continuing users, attempted control of desire is likely to be temporary or be affected by other tasks. So, a second rating of desire after the cognitive task showed effects of smoking cues that were of similar magnitude in both groups. Not only was the competing cognitive task affected by the attempt to control desire, but also apparently, it impeded that attempt.

In summary, the evidence on thought suppression in desire is that as in other kinds of intrusive thoughts, the attempted suppression of desire exacerbates its intrusiveness. In the EI theory, monitoring suppression increases the availability or salience of intrusive thoughts. An alternate strategy is needed to reduce this salience and the resources available for subsequent elaboration.

Neuroimaging studies. Patterns of brain activation during episodes of craving provide further evidence that is consistent with a distinction between associative and elaborative processes. A neuroimaging study of craving by Grant et al. (1996) used paraphernalia related to cocaine use to elicit craving in cocaine abusers and compared the resulting changes in glucose metabolism with a control condition (arts and crafts paraphernalia) and with control participants who did not use cocaine. Grant et al. noted that all the regions that responded to the drug paraphernalia in cocaine users are associated with memory. Regions associated with differences between conditions or with

increased levels of craving were those associated with working memory (dorsolateral prefrontal cortex), explicit episodic memory (dorsolateral prefrontal cortex, medial orbitofrontal cortex, retrosplenial regions of the limbic cortex, parahippocampal gyrus, and the cerebellum), and emotional expression or facilitation of memory encoding following emotional arousal (amydgala). The involvement of working memory and long-term memory areas is consistent with our contention that cognitive elaboration is a key component of craving.

Grant et al. (1996) suggested that the observed increase in orbitofrontal activity reflected intrusive thoughts. This interpretation is consistent with the activation of this same region in patients with OCD (Saxena, Brody, Schwartz, & Baxter, 1998; Zald & Kim, 1996). Grant et al.'s study therefore observed an activation of brain regions that was consistent with the occurrence of intrusive thoughts and elaborations. Subsequent neuroimaging studies have broadly replicated the finding that craving cues activate prefrontal and orbitofrontal regions associated with working memory, long-term memory, and intrusive thoughts (Bonson et al., 2002; Daglish et al., 2001; George et al., 2001; Maas et al., 1998; Posse et al., 2001). These findings are consistent with our hypothesis that desire involves cognitive elaboration, involving consciously directed retrieval of information from long-term memory and manipulation of that information in working memory as well as associative processes leading to intrusive thoughts. However the interpretation of data from neuroimaging studies clearly involves inferences about correlated activations rather than direct tests of the distinction between intrusive and elaborative processes, and the time resolution of current neuroimaging procedures is insufficiently short to capture relatively transient phenomena unless they are repeatedly activated.

Imagery Is a Key Type of Desire Cognition

We propose that a key and neglected feature of elaboration in desire is the development of images or fantasies about the consummatory target or experience or about the expected effects of consumption. In making this claim, we emphasize that such images are not restricted to visual content—in fact, some of the most powerful images may involve smell, taste, touch, or hearing. Although we acknowledge that verbal desire-related thoughts also occur, we argue that imagery is central to the naturalistic experience of most if not all of the more intense craving episodes. When people have the thought "what I would do for a log fire right now," we argue that it is not the propositional meaning of that sentence that makes their skin tingle and captures their attention. It is features that the thought elicits that seem more closely linked to our appetitive emotional reaction—the warmth of the fire, the smell and crackle of the logs, or perhaps the vision of our lover in the dancing firelight. Even in cases in which we encounter powerful environmental cues such as the wafting smell of freshly baked bread, we elaborate those cues internally, imagining the sight, texture, or taste of the bread. Subsequent responses are more to the elaborated image than to the simple cue.

We know that imagery is a very effective means of eliciting craving (e.g., Green et al., 2000; Tiffany & Drobes, 1990) and that the vividness of an imagined urge-induction scene is positively correlated with the strength of the craving thus induced (K. Harvey, Kemps, & Tiggemann, in press). There is some self-report data showing imagery during craving in naturalistic settings, but there has been no systematic study of desire imagery per se. Neuroimaging studies could potentially help to test the hypothesis that imagery typically occurs in craving, by showing activation during craving of brain areas associated with mental imagery tasks. We would expect that sensory images during craving would be associated with activation in similar areas to those activated in comparable types of imagery in the same sensory domain (e.g., Belardinelli et al., 2004; Handy et al., 2004; Knauff, Kassubek, Mulack, & Greenlee, 2000; Mazard, Tzourio-Mazoyer, Crivello, Mazoyer, &

Mellet, 2004; Parsons, 2003). Visual craving imagery would also be expected to recruit areas that overlap with those required for other visuospatial working memory tasks (Henson, 2001). However, existing neuroimaging studies on craving have typically used visual stimuli or imaginal cues in both the craving and neutral conditions, giving little scope for detecting differential activation of imagery regions during craving. Our imagery hypothesis could be tested by future studies of craving effects on brain activation during performance of tasks with minimal visual or imagery content.

Self-report data. Smokers in a study by Salkovskis and Reynolds (1994) reported that imagery formed an important component of craving. Images of "yourself under stress, having a cigarette to help calm down or cope" or "yourself in a relaxed place, enjoying a cigarette" were among the most frequent and intense smoking-related thoughts. In Westerberg's (2000) study, responses to questionnaire items referring to taste imagery were significantly associated with alcohol craving. Our ongoing study on people in an outpatient treatment program for alcohol misuse (referred to above) is finding that visual as well as taste imagery is emerging as a common feature of desire for alcohol but that sounds and smells are experienced by only a minority of participants. Imagery is not restricted to alcohol. Our research group has found that reports of imagery (e.g., "I am visualizing it") are commonly reported during craving for a range of substances, including foods (May et al., 2004).

Interference with imagery. Other recent studies support our hypothesis that mental imagery is a key component of craving by showing that unrelated imagery tasks reduce craving. A study by Panabokke, May, Eade, Andrade, and Kavanagh (in preparation) induced craving by asking smokers to abstain from smoking prior to coming into the laboratory and then to read a multisensory urge-induction script. A control group smoked ad lib until arriving at the laboratory and then read a multisensory neutral script. Participants rated their craving for cigarettes, then formed visual or auditory images in response to verbal cues (e.g., "a game of tennis," and "a telephone ringing," respectively), and again rated their craving after each of three blocks of six imagery trials. Craving in the abstaining smokers was reduced to the control group's level by visual imagery and by auditory imagery paired with a dynamic visual noise display known to disrupt imagery but not by auditory imagery alone.

K. Harvey et al. (in press) replicated this study with a sample of dieters and nondieting control participants. Participants imagined a food-related or control (holiday) scene and then performed three blocks of six imagery trials, as in Panabokke et al.'s study. For dieters and nondieters, the visual imagery task reduced craving more than the auditory imagery task, but this was the case only following the food-related induction scenario. The urge-induction scenarios used in both studies were intended to be multisensory so that any interference effects should not be attributable to the use of visual imagery to induce craving. Nonetheless, there is a need to replicate these findings without the use of an imagery task to induce craving.

Kemps, Tiggemann, Woods, and Soekov (2004) asked dieting and nondieting women to form images of food-related and nonfood items, to rate the vividness of their images, and to rate their level of craving for food. Food-related images were associated with higher craving ratings than were the nonfood images. Concurrent visuospatial tasks known to disrupt visuospatial imagery and working memory reduced the vividness of all images and, for the food-related images, reduced the associated level of craving. These studies thus show that interfering with visual imagery reduces craving, a finding consistent with our hypothesis that imagery is a key cognitive engine in craving.

Imagery and emotion. There is evidence that mental imagery taps many of the cognitive (Kosslyn, 1994) and brain processes used in perception (Klein, Paradis, Poline, Kosslyn, & Le Bihan, 2000; Kreiman, Koch, & Fried, 2000; O'Craven & Kanwisher, 2000; Wheeler, Petersen, & Buckner,

2000; Yoo, Freeman, McCarthy, & Jolesz, 2003). We suggest that activation of these processes triggers qualitatively similar emotional responses, regardless of whether the stimulus is perceived or imagined. There is evidence that imagery and emotion are closely linked. Imagining emotive memories or situations induces physiological changes indicative of heightened affect (Bywaters, Andrade, & Turpin, 2004b; Witvliet & Vrana, 1995). Intrusive imagery in posttraumatic stress disorder is characterized by high levels of arousal during the imagery period (Witvliet, 1997), and patients' images are particularly associated with memories of peak emotional distress during trauma ("hotspots"; Holmes, Grey, & Young, in press). Very recent research suggests that imagining (rather than verbally processing) negative situations leads to greater increases in state anxiety (Holmes & Mathews, 2004). There are indications that similar links between imagery and emotional arousal are also seen in desires: For example, imagining and describing experiences of craving induces increased systolic blood pressure and an increased heart rate during abstinence from opiate use (Weinstein, Wilson, Bailey, Myles, & Nutt, 1997).

Mental images that are rated as more vivid tend also to be rated as more emotive and arousing (Bywaters, Andrade, & Turpin, 2004a). Interfering with images of emotive scenes or memories by means of concurrent cognitive tasks leads to reductions in the rated emotional response to the images as well as reduced image vividness (Andrade, Kavanagh, & Baddeley, 1997; Kavanagh, Freese, Andrade, & May, 2001; van den Hout, Muris, Salemink, & Kindt, 2001).

In summary, there is empirical support for our claim that imagery is central to craving. Imagery is a common feature of the subjective experience of craving, and manipulations of imagery affect craving. Imagery of emotional scenes is associated with emotional responses, consistent with our argument that imagery, and elaborative processing more generally, triggers the emotional changes that characterize episodes of craving. The emotional aspects of desire are discussed next.

Desires Involve Both Pleasure and Discomfort

We argue that reward-related processes are critical both to the initiation and maintenance of appetitive rumination. Initial thoughts about the consummatory target generate some of the same neurochemical processes and physiological sensations that are related to ingestion of the target substance or engagement in the target activity (albeit in a weakened or partial form). The response may be heightened by generalized pleasurable arousal or by anticipatory physiological responses (such as salivation). In cases in which a strong sense of deprivation is present, the EI theory predicts that a transient and partial relief from the perceived discomfort is initially experienced. In situations in which deprivation is less severe or the stimulus is particularly attractive, the experience is predicted to be initially pleasurable. Neurochemical processes and brain pathways that underlie positive and negative reinforcement may well have significant differences (Verheul, van den Brink, & Geerlings, 1999), but within the EI theory they have a common function—immediately increasing the salience of the thought and reinforcing attention to it. Each successive elaboration initiates a further burst of this positive activation, and more articulated imagery improves the match of the experience to the actual activity, intensifying the momentary sense of pleasure or relief. Continued rumination is thereby reinforced.

However, awareness of pleasure or relief also draws attention to other aspects of somatic states. The partial and fleeting nature of the reaction and the fact that any preexisting physiological deficit has not been relieved are then in focal awareness. The positive sensation soon dissipates, but the sensations from the physiological deprivation remain available. Thus, the initial positive reaction reinforces elaboration, but a renewed and strengthened sense of deprivation then follows. The immediate and intensified relief afforded by elaborated imagery continues to motivate further search, despite a keen sense that the previous image was no substitute for the real thing.

Within the EI theory, the overall affective response to the desire or urge experience is expected to be positive or pleasurable only in situations in which there is no significant deficit state, because the aversive content of that state would otherwise dominate the experience. For this reason, a delay (or even the expectation of delay) turns an initially pleasurable desire into a highly aversive craving. The extent of delay that would produce such an aversive effect would be predicted to be shorter in cases in which deprivation was more severe or substance dependence was more marked.

Neuroimaging studies. Data from imaging studies are consistent with the notion that desires involve affective reactions. Desires are associated with activation of limbic regions that are associated with emotional processing and reward, such as the amygdala and anterior cingulate gyrus (Childress et al., 1999; Daglish et al., 2001; Del Parigi et al., 2002; Kilts et al., 2001; Maas et al., 1998; Posse et al., 2001). Selective anterior cingulate activation in response to drug cues precedes subjective reports of craving (Wexler et al., 2001) and is reduced by treatment for drug dependency (Schneider et al., 2001). These systems are common to other emotional situations. Thus Kilts et al. (2001) replicated the finding of increased amygdala activation following a personalized craving script rather than following a neutral script but found that amygdala activation did not differ significantly between the craving condition and a personalized anger script, suggesting that it reflects general emotion changes that are not specific to craving. Garavan et al. (2000) used functional magnetic resonance imaging to study 13 putative craving sites. Only 3 of these sites—anterior cingulate, right inferior parietal lobe, and caudate–lateral dorsal nucleus—showed greater activation in cocaine users watching a cocaine film than in cocaine users watching a sex film. Garavan et al. argued that the neural substrates of cocaine craving are the same as those of normal responses to evocative stimuli. Their findings, and those of Kilts et al. (2001), are consistent with the view that craving and desire in general are part of a continuum of phenomena generated by normal cognitive–emotional–motivational systems.

Pleasure and relief. Desires are pleasurable when consumption is imminent. Just thinking about prospective consumption clearly is pleasurable when there is no significant delay before consumption and there are no immediate concerns about negative effects from it (Zinser, Baker, Sherman, & Cannon, 1992). Although craving can be accompanied by physiological signs of withdrawal (Wikler, 1973), more consistent parallels between physiological cue reactivity and agonistic substance effects are seen (Drobes & Tiffany, 1997; Niaura et al., 1988; Stewart et al., 1984). The existence of internal reinforcement for craving is supported by associated activation of mesocorticolimbic dopamine reward pathways in the brain that are also activated by ingestion of most psychoactive substances (Koon, 1992; Stewart et al., 1984; Wise, 1996; cf. Robinson & Berridge, 1993, 2003). One suggested mechanism for an effect of naltrexone on alcohol craving is that it may blunt the pleasurable effects from imagined consumption (Verheul et al., 1999) as well as the effects of actual consumption. In the case of alcohol, there is also evidence for rises in the excitatory transmitter glutamate in the context of a conditioned cue—an effect that is likely to feed not only into memory systems but also into the emotion and reward systems (De Witte, 2004).

The existence of a reward mechanism for desire-related thoughts helps to explain the puzzle about why people would otherwise dwell on these thoughts, even though they ultimately feel dissatisfied and even tortured by the experience. This same mechanism may be the one responsible for expectancy effects from consumption. If a person with alcohol dependence has a drink they believe is alcohol, craving for alcohol is triggered, whether or not alcohol was actually present in the drink (Laberg, 1990; Ludwig et al., 1974). In fact, Ludwig et al. (1974) found only a differential increase in craving after alcohol when people were told they had received alcohol (cf. Stockwell, Hodgson, Rankin, & Taylor, 1982). This suggests that when the pharmacological effects of the substance are sufficiently weak or are easily confused with concurrent emotional reactions, the reward that is

triggered by imagined sensations can have a more powerful influence on craving than can the pharmacological effects of consumption. Similar effects can occur with relief of deficit states. The oral administration of methadone during the first 3 days of withdrawal from narcotics relieves withdrawal symptoms (Dawe & Gray, 1995), but the onset of symptom relief is too fast for a direct pharmacological effect of oral methadone, demonstrating that expectancies affect the perception of withdrawal. Such results are inconsistent with a neurochemical model of craving that sees cognitions as purely epiphenomenal but are consistent with reward or relief from perceived or imagined ingestion.

As already discussed, Robinson and Berridge (1993, 2003) see the mesocorticolimbic activation during craving after repeated use of a psychoactive drug as a reflection of nonhedonic incentive salience. In terms of the EI model, increased incentive salience would tend to increase the probability of intrusive thoughts (by increasing the attentional priority of the instigating factors in Figure 1). When incentive salience is strongly developed, it is conceivable that the number and attentional priority of associations would be sufficient to trigger elaboration even in the face of competing task demands, even if the affective component of the thought was reduced or eliminated. However we argue that the continued involvement of limbic structures implies a continued affective component to the desire and that the presence of this component continues to exert an influence on elaboration even when incentive salience is highly developed.

Rather than all affective responses to thoughts about psychoactive drugs being eliminated over the course of repeated drug use, there is a progressive move from positive to negative reinforcement over time (Robinson & Berridge, 1993, 2003), together with an increased tendency for the desire to accentuate a sense of deprivation. During this process, we argue that the affective accompaniment to desire becomes increasingly ambivalent and the quality of the positive component becomes increasingly characterized by relief rather than pleasure. This change to relief may implicate some different neural pathways than are seen in pleasure (Stewart, 2000), but we argue that the role of pleasure and relief in our theory is the same—hence the presence of both within a single box in Figure 1.

Aversion. Desires are particularly aversive in extended deprivation or attempted control. When consumption has to be substantially delayed or there is potent current motivation not to consume the substance, the predominant emotional response to craving is negative (Cooney et al., 1987; Zinser et al., 1992). The effect has been demonstrated with a wide range of consummatory targets including alcohol (Cooney et al., 1987), cigarettes (Zinser et al., 1992), cocaine (Powell, Bradley, & Gray, 1992), and food (McDiarmid & Hethrington, 1995). In a context of externally attributed deprivation, the predominant emotion is often frustration or anger (Sherman, Morse, & Baker, 1986). Within the EI theory, this effect is linked to a heightened sense of deprivation.

The association between craving and negative emotion during behavioral restraint is usually characterized by anxiety (Monti et al., 1993) or guilt (Cooney et al., 1987; McDiarmid & Hethrington, 1995), although more complex mixtures of negative emotions may also be seen (Powell et al., 1992). Anxiety over craving during an attempt at restraint shows some similarity to a "goal violation effect" (Marlatt & Gordon, 1985) within lapses in behavior control: It is as if the person sees imagined consumption as tantamount to a behavioral violation. The anxiety appears related to an expected difficulty in maintaining future restraint (Bandura, 1986; Marlatt & Gordon, 1985). The negative emotion is not simply an increased awareness of deprivation but involves an attribution of the desire to poor control (e.g., "I must still be hooked on it if I still feel this way: I'm in danger of losing control"). There is sound empirical evidence to support the idea that such

interpretations—far from being epiphenomenal to behavioral control—are powerful influences on addictive behavior (Bandura, 1982; Sitharthan & Kavanagh, 1990).

Physiological arousal. Subjective ratings of desires are loosely linked with physiological arousal (Cepeda-Benito & Tiffany, 1996; Cooney et al., 1997; Kaplan et al., 1985), with weak or nonsignificant associations often being observed (Drobes & Tiffany, 1997; Maude-Griffin & Tiffany, 1996; Tiffany & Hakenewerth, 1991). We argue that these results do not pose significant problems for the EI theory. Psychophysiological data such as increased heart rate are often ambiguous, potentially confusing activation from desires with preparation for action (Sayette et al., 2000), activation from concurrent tasks (Maude-Griffin & Tiffany, 1996), or anxiety (e.g., about potential loss of control; McCusker & Brown, 1991). Desires that involved more vivid sensory images might be expected within EI theory to have a closer relationship with physiological responses than would desires with less imaginal involvement. However, such an increased association would be expected only with physiological responses in closely related domains (e.g., perhaps between gustatory imagery and salivation). A close correspondence between psychophysiological arousal responses and subjective desire is not predicted by the theory, except where there is an awareness of both the psychophysiological response and its association with the appetitive target. Furthermore as already argued, the EI theory predicts that an initial positive response to the elaboration or intrusion is followed by an awareness of deficit and negative affect, so that a complex emotional response should occur. It also predicts that the speed and degree of the different reactions would vary, depending on the strength of associations to each affective response (based on the individual's learning history and the presence of neural sensitization or adaptation) and depending on the affective context (including the degree to which positive and negative aspects of target acquisition were primed). Averaging over episodes or individuals would obscure any such irregular patterns.

Just as we find difficulty interpreting the meaning of physiological arousal that accompanies desire, so it is likely that people experiencing desire have this problem as well. Arousal in response to desire may be thought to be anxiety or vice versa. We discussed evidence supporting misattribution of arousal above in the context of physiological responses being a trigger for desire. The issue also applies to the assessment of desire, which may be affected by whatever affective cues are salient at the time. Such measurement bias would have the effect of reducing any true association between desire and arousal (or, indeed, between desire and later behavior).

Lack of concordance is not of course restricted to desire. Rather, as Drummond (2000) pointed out, it is a hallmark of emotional reactions (Lang, 1979; Rankin, Hodgson, & Stockwell, 1979). Desynchrony among psychophysiological responses, subjective reports, and behavior was identified more than 20 years ago by Lang (1979), who developed a bioinformational model of emotion to explain the phenomenon. Part of the reason for desynchrony is that there are substantial individual differences in the patterning of arousal and in the information that is used to identify emotion. The desynchrony between response domains in craving and emotion highlights the affective nature of desire (Sayette et al., 2000) and the multiple components of the reward and relief reactions that accompany it. As in other emotional reactions, psychophysiological responses inform the subjective emotional experience of desire, but they do not constitute it.

Effects of expected delay. A recent study by Sayette et al. (2003) confirmed that even very short delays can be associated with different affective correlates of desires. In Experiment 2, smokers who were told that they could smoke within 15 s were more likely to show positive facial expressions than did smokers who were told that there would be a 60 s delay. An apparent trend to

more negative expressions in the longer delay conditions did not reach statistical significance in this sample.

In summary, the evidence on affect is consistent with our proposal that desire involves both positive and negative emotions. Animal research in motivation over the last 15 years potentially challenges this view. Essentially, this research suggests that drug use is driven by appetitive processes distinct from those that underpin feelings of pleasure. A range of psychoactive substances tend to result in reduced hedonic pleasure with repeated use (an aspect of tolerance), combined with increased sensitization of dopaminergic systems related to reward. This incentive sensitization is supported by examination of neural sensitization directly and by the effects of repeated drug use on learning and performance. For example, sensitization increases the speed with which rats learn how and where to acquire a drug (see Robinson & Berridge, 2003). Observations such as dissociations between liking for particular tastes and appetite for them (e.g., Berridge, Venier, & Robinson, 1989) led Robinson and Berridge (1993) to argue that liking or hedonic pleasure associated with reward should be distinguished from reward processes related to wanting or incentive salience. A distinction of the neural substrates underpinning hedonic processes from those related to incentive salience suggests that with repeated administrations of psychoactive drugs, the hedonic aspects of reward may become less important in driving continued elaboration of the desire than other pathways involved in reward.

We posit that a separation of hedonic and incentive salience aspects of reward does not challenge our position on the affective responses typically related to desires and does not exclude influences between hedonic responses and incentive salience. Although, as Robinson and Berridge (2003) have shown, unconscious wanting is a key mechanism underpinning motivated drug use, we argue that conscious positive affect is also important in the subjective experience of desire. In particular, the inclusion of pleasure or relief in the EI model as a proximal effect of desire-related cognition helps to explain why desire persists even though it is ultimately an aversive experience when deprivation is high and target acquisition is expected to be delayed or thwarted. We predict that cognitions about substance use, and particularly sensory images, will continue to elicit some immediate sense of pleasure or relief even in the context of repeated use or entrenched substance dependence and that this affective reaction rewards attention to and elaboration of the desire cognition. The repeated use of psychoactive substances results in a movement from a focus on pleasure to an increasing role for relief, and the subsequent sense of deprivation is amplified, leading to an increased ambivalence in the affective response. However, affective connotations to the cognition remain.

Desire Is One of Many Factors That Influence Target Acquisition and Consumption

Target acquisition behaviors and desire have mutual influences in the EI theory. Controlled processing of responses increases explicit desire and is itself maintained by desire. When target acquisition is being planned and directed, the process provides further information to elaborate the desire, and conversely the elaboration of desires often retrieves information that is relevant to response planning and direction. So, an exhausted traveler may elaborate a desire image that involves stopping at a nearby hotel and retiring to a soft bed. The reinforcing nature of the thought provides salient incentive information. However the construction of an elaborated, episodic image may also incorporate procedural information such as the route that can be taken to the hotel or how a reservation may be obtained. Of course, not all desire-related thoughts include response information, and some information that is generated in response direction may be incompatible with the desire (e.g., the cost of the room).

Popular conceptions of desire give it a central place in the development of excessive consumption (Jellinek, 1960). EI theory sees desire as only one of many factors in the determination of target

acquisition (cf. Tiffany, 1990), and it identifies several limitations to behavioral predictions from subjective desire reports. One limit to the predictive ability of desire is the way in which it is assessed. Although desire in the EI theory is a conscious cognitive event and therefore available to introspective judgment, assessment of desire requires accurate recollection of events that are variable in affective intensity and are sometimes fleeting. If the person is asked to make a single intensity rating about desires that occurred over periods as long as a week, the ratings are likely to be influenced by a range of biases including the salience of each desire episode and beliefs about the desire. Even if the global measure of desires or urges relates to a testing session, limits to the relationship with behaviors such as reaction times will be seen at specific test points (Cepeda-Benito & Tiffany, 1996), unless the level of desire is relatively constant. Attempts to predict consumption levels in the natural environment from desires that are assessed in a clinic or laboratory will also be weak (Rohsenow et al., 1994), unless the desires are particularly insensitive to both time and context (cf.Mischel, 1968). Reports are also potentially subject to self-presentation, especially if they are collected in a clinic setting (e.g., Stormark et al., 1995). Individual differences in these effects would impair the ability of desires to predict subsequent behavior.

An underestimation of predictive relationships may also result from a reliance on measures of desire intensity (Tiffany, Carter, & Singleton, 2000; Tiffany & Drobes, 1991; cf. Monti, Rohsenow, & Hutchison, 2000). We argue that desires vary not only in affective intensity and salience but also in frequency and duration. The time course of desire may sometimes be more important than its intensity at one point in time. Shiffman et al. (1997) found that duration of temptations to smoke on the "quit day" were strongly related to subsequent lapses and that lapses were preceded by linear increases in waking urges to smoke over the previous 3 days. Maintaining control in the face of sustained periods of high desire may present particularly demanding challenges.

A pathway to behavior through elaboration provides several ways in which the desire may not lead to an associated response, even when it is very strong. This aspect of the EI theory incorporates several social–cognitive elements (Bandura, 1986; Monti et al., 2000). First, we predict that the linkage to responses may be moderated by attention diversion. Because the response direction is dependent on limited working memory resources, if another cognitive task captures these resources, the response preparation will be interrupted (unless of course there are strong associative response links that can take over). Second, the operation of the desire occurs in the presence of other potential incentives. So, the tired traveler may continue home, with the prospect of a loved one waiting at home being sufficient to overcome the wish to stop at the hotel. Some of these considerations may involve disincentives—for example, the traveler's boss may be annoyed by the excuse of staying at the hotel. Third, the target may be thought to be difficult to achieve with the resources and skills that can be brought to bear. The tired traveler may not be sure of finding the hotel. In consequence of these other factors, the focus of response-related cognition may become the inhibition of the immediate response to the desire (taking the hotel exit) or engagement in incompatible activity (e.g., selecting a faster way to travel home).

Factors influencing explicit control of responses are not simply nuisance variables, muddying the power of desires to predict and determine behavior. The potential for competing incentives and for control of responses is a source of liberation, providing people with the power to select and control behavior, even in the face of strong desires (Bandura, 1999). High-risk situations can be predicted and avoided (Marlatt & Gordon, 1985), and coping strategies for them can be acquired and applied. Social assistance can be obtained to make behavioral inhibition easier. A search for successful past control can be initiated, so that self-efficacy is maximized. Disincentives for consumption and incentives for control can be elicited, including self-incentives. The desires themselves can be

preempted, and their nature and duration can be modified. These variables provide opportunities for self-regulation and for effective treatment.

The relationship between desire and behavior is modulated in complex ways by mood. Negative mood contributes directly to desire by accentuating the sense of target deficit and amplifies incentives for behavior that is expected to relieve the deficit. It also influences behavior through effects on self-efficacy. Negative mood impairs self-efficacy for target acquisition if there is any room for doubt (potentiating perceptions of high task difficulty and poor past achievement; Kavanagh, 1992; Kavanagh & Bower, 1985), but the impact on self-efficacy is even greater in behavior control because of the variability that typically exists in control achievements. The person will often see themselves as unable to inhibit target acquisition when they are feeling low (Kavanagh, 1992; Marlatt & Gordon, 1985).

Target acquisition may also occur without a high level of explicit desire. When the target is highly available and there are no significant disincentives for acquisition, it may take very little desire to initiate action (e.g., accepting a free drink on an aircraft). In the EI theory, target acquisition may also occur when associative processes trigger behavior with little cognitive elaboration. Associative processes may create decisional biases that indirectly result in acquisition becoming more likely. The notion that processes underlying response selection may operate outside awareness, through decisional biases, is not a new one (Kahneman & Tversky, 1982; Nisbett & Wilson, 1977; Zajonc, 1980). The EI theory does not assume introspective access to any of the cognitive processes it describes—only to the products of those processes. So, if an associative link has previously been established between a desired activity such as drinking and a particular route that passes a bar, it may sometimes be the preference for the route that is consciously experienced rather than an explicit desire for alcohol (cf. the notion of "apparently irrelevant decisions"; Marlatt & Gordon, 1985). Once in the context where the target is highly available or other incentive processes (e.g., social reinforcers) become operative, target acquisition may then occur even if the current explicit desire for alcohol is not particularly high.

EI theory predicts that an effect of decisional biases on behavior without any conscious desire for the target will be the exception rather than the rule. The EI theory posits that associative processes that trigger decisional biases also trigger intrusive thoughts. Therefore we predict that when a biased retrieval of response-related information does occur, it will typically be preceded by a transitory intrusive thought about the target. The person may not be fully aware that their decision is related to the fleeting thought, but they were aware of the thought at the time.

An associative link from stimulus cues to overlearned, automatized action schemata may also result in some acquisition behaviors (Tiffany, 1990). This idea has some plausibility when consumption in substance dependence is closely observed (Nil, Buzzi, & Bättig, 1984). A familiar example is a person lighting a cigarette when they already have one in an ashtray or even in their mouth. However, although complex response chaining can become automatic with repetition (driving a car is a familiar example), we predict that the effect of automatized action schemata will typically be restricted to simple behaviors (such as reaching for a cookie or lighting a cigarette) and to situations in which the appetitive target is readily available and attention is gripped by a concurrent task (such as reading this article). As Tiffany (1990) pointed out, absentminded lapses of this kind during a control attempt can be seen as a type of action slip that has been extensively studied in other domains (Norman, 1981). One reason for a restricted role for automatized responses is the same as in decisional biases: Elements of a complex response chain each have the potential to elicit associated intrusive thoughts about the target, at which point the process becomes explicit, and target acquisition is either inhibited or consciously pursued. A further reason is that minor changes

in the behavioral requirements almost always require controlled processing at some time during a response chain because minor variations of performance will be required on different occasions (e.g., the cigarette lighter is in a different place). Although we may well have another set of highly practiced skills we can bring into play to deal with the new situation, their selection requires controlled processing.

We therefore argue that the prototypical situation is that behavior is consciously directed. Conscious direction of target acquisition is initiated by and contributes to desire. When associative links trigger intrusive thoughts, the momentary awareness of desire results in conscious response direction, even when the component behaviors remain simple and well practiced. Target acquisition in the absence of desire represents an accidental lapse of control rather than the norm.

Predictive association. The presence of a relationship between desires and related behavior is supported by links between heightened craving and subsequent relapses in addictive disorders (Swan, Ward, & Jack, 1996). For example, Killen and Fortmann (1997) found highly significant relationships between high levels of craving by 2,600 former smokers and their relapse over the following 12 months. The relative increase in risk of relapse from high craving was substantial (2.18 for men and 1.60 for women). Laboratory studies also show an association between craving and work to obtain the substance, especially in situations in which reported craving is highly salient (Ludwig & Wikler, 1974).

The importance of thoughts about the target is illustrated by data on delay of gratification. One research paradigm involved giving children a choice between a small but immediate reward and a delayed and more substantial one (Mischel, Ebbeson, & Raskoff-Zeiss, 1972). If children attended to the desirable qualities of the delayed reward, they waited for shorter periods of time than when they were distracted from these thoughts (Mischel & Ebbeson, 1970; Mischel et al., 1972; Rodriguez, Mischel, & Shoda, 1989). Such findings support the generality of causal relationships between a preoccupation with consummatory thoughts and subsequent consumption.

Also consistent with the EI theory is that the correlations between subjective craving and subsequent consumption are often relatively weak (Tiffany, 1990, 1999; Weiss, Griffin, & Hufford, 1995). Although such results are often subject to the assessment problems discussed above, the evidence shows that desire does not have a univariate, causal relationship with related behavior. Not all consumption is related to high levels of desire, and high levels of desire do not necessarily lead to consumption (Kranzler, Mulgrew, Modesto-Lowe, & Burleson, 1999; Tiffany, 1990).

Associative pathway to target acquisition. Substance-related memory associations, an index of cognitive availability, have been shown to predict later consumption of both alcohol and marijuana (Stacy, 1997). Their predictive contribution is more powerful than substance expectancies and remains after previous consumption level is controlled. However, it is not clear which processes drive this predictive link—for example, the data are consistent with effects of intrusive thoughts on automatized responses, effects on retrieval of response information, or effects operating through conscious elaborative processes.

Neuroanatomical data. The idea that there may be separable influences from automatic and controlled aspects of desire on substance use gains some added credence from an elegant series of neuroanatomical studies by Bechara, Damasio, and Damasio (2000) on decision making. These studies have separated effects of frontal areas underpinning the situational reexperiencing of emotions (including the ventromedial orbitofrontal cortex [VM]) from ones implicated in working memory (including dorsolateral prefrontal areas). The studies rely on the effects of VM injury on the ability to learn appetitive event probabilities and make associated decisions. They suggest that

working memory relating to emotional consequences can be intact despite VM injury but that reexperiencing of the emotional reaction from memories of events is impaired by this injury. Optimally functional decision making requires both intact working memory and intact emotional associations.

This research is consistent with desire being an interplay between cognition and emotional–motivational systems and suggests that this interplay is a general feature of target acquisition and consumption. The work is also consistent with our suggestion that there is both an automatic and a controlled influence of desires on substance use, and the existence of two neuroanatomical pathways that appear to influence motivational decisions makes it conceivable that partial dissociation of the processes may sometimes occur (e.g., as previously argued, under situations of high competitive working memory load). It is not yet clear how the processes identified by Bechara et al. (2000) relate to our distinction between associative and elaborative processes.

Multiple determinants of consumption. Consistent with our contention, a limiting factor on the predictive effect of a specific desire on subsequent behavior is the moderation of its influence by competing incentives (Covington & Omelich, 1992). Desires focus on immediate reinforcement from the behavior (Powell et al., 1992). The desire would not occur if proximal negative consequences predominated (e.g., "I'll be sick if I eat another chocolate"). However, negative expectancies for the behavior (or positive expectancies for control) can also influence consumption (Breiner, Stritzke, & Lang, 1999). There are individual differences in the extent that negative expectancies are elicited in temptation situations (Avants, Margolin, Kosten, & Cooney, 1995), and increasing the salience and perceived relevance of inhibitory factors is an important therapeutic procedure in the reduction of substance misuse (Miller & Rollnick, 1991). Even the drinking of people with severe alcohol dependence can be moderated in the short term by introducing sufficient external rewards for control (Cohen, Liebson, Faillace, & Allen, 1971; Griffiths, Bigelow, & Liebson, 1977).

There is also substantial evidence in favor of behavioral influence from other social–cognitive variables (Bandura, 1986, 1999). The mastery of relevant skills in target acquisition or behavioral control (Bliss, Garvey, & Ward, 1999; Litman, Stapleton, Oppenheim, Peleg, & Jackson, 1984; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996) and the degree of related self-efficacy (Kavanagh, Pierce, Lo, & Shelley, 1993; Niaura, 2000; Sitharthan & Kavanagh, 1990) are particularly important factors. Situational difficulty also is important: This includes the availability of the appetitive target and possibility of consumption (Palij et al., 1996; Shiffman et al., 1996). When considering behavioral inhibition, it involves the situational difficulty in resisting consumption (Shiffman et al., 1996) and presence of response aids.

If there is nothing to inhibit consumption and the relevant object is readily available, consumption may occur at very low levels of desire. Conversely, consumption can be controlled even when craving is high, provided other variables favor restraint (Sitharthan, Sitharthan, Hough, & Kavanagh, 1997). This is consistent with the contention in the EI theory that desire is a factor affecting subsequent behavior, but that it is only one among many.

Summary of the Current Empirical Status of EI Theory

We began work on the EI theory partly in an attempt to integrate the evidence on craving and place it in the wider context of cognitive–emotional mechanisms of motivation and desire. The theory is highly consistent with both the evidence prior to 1999, when we began this work, and data that have emerged since that time. The empirical support includes data from proximal self-reports, but the potential for error in subjective judgments is explicated.

There is particularly well-documented evidence for the input and output components of the theory, that is, for factors that elicit desire and for the consequences of desire for behavior. A large body of data supports the view that conditioned cues, anticipatory responses, and negative affect trigger craving and that consumption is modulated by factors such as self-efficacy as well as by craving strength. Ongoing contention focuses on the extent that controlled response direction rather than decisional biases influences target acquisition and on the idea that biased decision making is typically preceded by conscious desire. The affective nature of desire is also well documented, although there is some contention over the extent to which affective responses drive attentional allocation to the target.

The distinction between intrusive thoughts and cognitive elaboration in craving is supported by data on the availability of target-related information and on the failure of attempted thought suppression as well as by self-reports of transient intrusive thoughts. Elaborated thoughts, resulting from directed search and retention of target-related information, are indicated by interference between desire-related ruminations and concurrent cognitive tasks and by data on instructed instigation of appetitive ruminations. The focus of the EI theory on the role of imagery is highly consistent with a range of data including evidence on the efficacy of imagery in eliciting desire, recent findings that visual imagery is particularly effective at reducing craving (K. Harvey et al., in press; Panabokke et al., under review), and self-reports of appetitive imagery during craving.

The balance of current evidence suggests that conscious desires are not merely epiphenomenal. They play an active role in the determination of target acquisition, albeit one that is modulated by many other factors. They directly affect cognition. Even when desires do not lead to related behavior, their occurrence can have functional impact. During desire episodes, the person will appear absentminded or lose concentration. This in itself could have important consequences on both work performance and leisure activities. In cases in which the desire is associated with an intense awareness of deficit, it would also reduce the pleasure obtained from other activities. These effects of desires may often be much more important than their influence on target acquisition, especially when that behavior is functional.

Predictions of the EI Theory

Although the EI theory provides a good fit with existing evidence, a true test of the theory requires that it be able to make predictions about new directions for research. Some recent findings from our own laboratories that have been inspired by the theory have been presented throughout the article, as have some specific predictions that can be investigated. Further tests of the theory could focus, inter alia, on the issues detailed below.

1. Automatic and elaborative processes in craving can be distinguished. Because this postulate is central to our theory, each of the following predictions are critical to it:

Unelaborated intrusive desire thoughts will occur on some occasions without being further elaborated. Although this is expected to be more common when deprivation is low or the target is not highly valued, there will also be at least some intrusions at times of higher deprivation, when concurrent cognitive activity impairs elaboration of the desire-related cognition.

Differential brain activation will be associated with unelaborated intrusive thoughts and elaboration.

Attempted suppression will increase the availability of desire-related information during the suppression task or immediately subsequent to it. Replication of the effects observed in the small number of studies on the matter to date is required. These observations would demonstrate a linkage

between desires and other research on intrusive cognition. Effects will still be present even when elaboration is inhibited by the presence of a competing task.

Attempted suppression of intrusive thoughts will lead to similar brain activation as in OCD because of close apparent parallels between the phenomena of thought suppression in craving and OCD. A similarity between orbitofrontal activation in desires and in OCD has previously been observed. Our view is that this effect will be particularly marked when an attempt is made to suppress the intrusive thought.

2. Our contention that desires typically involve sensory images is the most novel aspect of our theory, although the central model (as illustrated in Figure 1) does not stand or fall on this point because desire-related propositional representations could still elicit pleasure or relief and attentional allocation. Our assertion about the importance of imagery would imply the following:

Desires will show similar brain activation to that seen in imagery. Although existing brain activation data are consistent with this prediction, these studies have typically used imagery to evoke the desire. Research is needed in naturally occurring desire episodes in which imagery is not evoked instructionally.

Mutual competition will be seen between desire imagery and modality-specific concurrent tasks. Although we have already gathered some evidence on the effects of other imagery in suppressing desire, further research is needed to confirm our prediction of greater interference from competing tasks that require similar working memory resources then from those that do not.

Episodes of desire with more vivid sensory images will be rated as stronger in intensity.

3. While EI theory acknowledges that target acquisition can represent a learned behavior that need not be preceded by desire on every occasion, the theory asserts that changes in desires are involved in the causation of changes in target acquisition rather than being epiphenomenal. An appropriate test of this prediction requires that the measure of desire is proximal and sensitive and that other potential causal factors (i.e., competing incentives, target availability, and relevant skills) are controlled. Most current tests of behavioral predictions from desires do not meet these criteria.

Treatment Implications

The EI theory also has potential implications for treatment of addictive problems (see Kavanagh, Andrade, & May, 2004). We do not propose these treatment implications as providing a powerful test of the theory because it is difficult to control all relevant factors in even the best-designed clinical trial. To the extent that existing treatment already improves control skills sufficiently, there is also a potential for ceiling effects in behavioral outcomes and for a habituation of craving to environmental cues in the natural environment.

Existing psychological interventions already incorporate some elements that would be expected from EI theory to assist with craving. For example, the prediction and avoidance of high-risk situations for behavioral lapses (Chaney, O'Leary, & Marlatt, 1978) are likely to reduce the risk not only of relapse but also of intense desire. A cognitive approach may well examine the accuracy of overly positive expectancies from the addictive behavior or address secondary dysphoria about craving, among other cognitive targets (cf. Beck, Wright, Newman, & Liese, 1993). However, the application of other aspects of EI theory should further increase the effectiveness of existing psychological treatment for control of craving and its effects. These include the following:

For instigation of the desire: The identification of dysphoria and periods of nontarget deprivation as risks for desire elicitation; reattribution of desire during those states to other deprivation; and application of problem solving and response plans to prevent or address irrelevant deprivation.

For dysfunctional coping strategies: In vivo demonstration of the ineffectiveness of thought suppression and promotion of accepting and letting go of the desire-related thoughts (e.g., in mindfulness meditation; cf. Breslin, Zack, & McKain, 2002; Teasdale et al., 2000).

For functional coping: Once an understanding of accept and let go is achieved, the application of competing imagery or other tasks with high working memory load to deal with elaboration.

Conclusion

We propose a comprehensive theory of desire that does not view it as an epiphenomenon but also avoids an assertion that it is the sole determinant of target acquisition. The theory attempts to describe and explain the processes underpinning a variety of desires, including those for psychoactive substances. It incorporates both automatic or associative processes underpinning the subjective phenomenon of intrusive desire-related thoughts as well as more controlled processes of elaboration. It encompasses a phenomenon that offers an imaginary relish that enchants our senses but also can represent an exquisite torture like that experienced by the legendary Tantalus. The relish seduces us into successive elaborations of the desire, but the piquancy of this relish also amplifies a sense of deprivation and torture when the target cannot immediately be obtained. Our theory emphasizes the role of sensory images and anticipatory responses in desire cognition and particularly the potential of these sensory experiences to elicit strong affective reactions. It predicts not only that episodes of desire may interfere with other tasks but also that appropriately designed tasks may avert or halt the episode. The theory offers a rich source for programs of research in desire that may further elucidate the phenomenon.

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Received July 9, 2004

Revision received October 8, 2004

Accepted October 12, 2004

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We thank Albert Bandura, Paschal Sheeran, Sharon Dawe, Natalie Shockley, Ross Young, W. Jake Jacobs, and Craig Santerre for their comments on earlier versions of this article.

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Footnotes

[1]We do not speculate on the precise nature of desire-related cognition in animals, except to say that we expect the differences to relate primarily to the extent of elaboration and associated metacognitions rather than to the essential nature of the related attentional salience or affective response.

[2]The level of affective reaction that is needed before elaboration is triggered cannot be precisely specified a priori. Average levels of experimental manipulations such as deprivation durations may be derived empirically, but their impact will remain probabilistic.

[3]Compare Robinson and Berridge's (2003) distinction between liking and wanting, but note that we are talking about the conscious affective and cognitive experiences that constitute desire, whereas, at least in later expositions of their theory, Robinson and Berridge used liking and wanting to denote implicit underpinnings of desire.

Figure 1. The elaborated intrusion theory of desire. The central box contains the subjective components of desire. Rounded external boxes represent antecedents or external factors, and rectangular internal boxes are the products of automatic and elaborative processing, indicated by arrows. Automatic components of desire (thin arrows) lead to apparently spontaneous thoughts that are perceived as intrusive. An elaborative cycle (thick arrows) encompasses the cognitive processes involved in retrieval of semantic, episodic, and sensory information from long-term memory and the use of that information to construct quasi-lifelike images of the desired target. Elaborative

processing also increases the immediate likelihood of further activation of antecedents, through attentional changes and working memory prioritization (not indicated in the figure). Substance dependence increases the longer term likelihood of the activation of antecedents, through phenomena such as incentive sensitization (Robinson & Berridge, 1993). Although the immediate affective consequences of desire related imagery are positive, an increasing sense of associated deficit feeds back to negative affect.