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# Sensory imagery in craving: From cognitive psychology to new treatments for addiction

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## Abstract

Sensory imagery is a powerful tool for inducing craving because it is a key component of the cognitive system that underpins human motivation. The role of sensory imagery in motivation is explained by Elaborated Intrusion (EI) theory. Imagery plays an important role in motivation because it conveys the emotional qualities of the desired event, mimicking anticipated pleasure or relief, and continual elaboration of the imagery ensures that the target stays in mind. We argue that craving is a conscious state, intervening between unconscious triggers and consumption, and summarise evidence that interfering with sensory imagery can weaken cravings. We argue that treatments for addiction can be enhanced by the application of EI theory to maintain motivation, and assist in the management of craving in high-risk situations.

# Sensory imagery in craving:

# From cognitive psychology to new treatments for addiction

Sensory imagery refers to our ability to mentally simulate the sight, sound, smell, taste, and feel of an experience. This imagery is emotive in a way that merely thinking about experiences is not: imagining distressing scenes increases anxiety relative to verbally thinking about them (Holmes & Mathews, 2005) while imagining positive scenes increases happiness (Holmes, Lang & Shah, 2008). The advertising industry is well aware of the power of sensory imagery to motivate consumer behaviour. Evocative descriptions of holiday resorts describe 'sun-kissed beaches' and 'turquoise waters'; food packaging lists the contents as 'mouth watering' and 'juicy'. We respond to these positive sensory labels by forming mental images of the target, often in its idealized form, and we are then biased in our decision-making by the assumed properties of the ideal (rather than the actual) product, and by a cascade of affective reactions to our imagery. The power of sensory imagery is also illustrated by its use in laboratory research to stimulate or exacerbate craving for drugs. For example, Tiffany and Hakenewerth (1991) asked cigarette smokers to 'imagine vividly' audio tapes containing either explicit urge-related descriptions of smoking situations or neutral social situations, and found that their physiological responses (heart rate, skin conductance levels) and self-reported desire to smoke increased for the urge scripts compared to the neutral scripts. In a similar study, Tiffany and Drobes (1990) found that more vivid imagery of smoking scenarios was associated with stronger urges to smoke. Likewise, alcohol craving can be induced by asking clients to imagine entering their favorite bar, ordering, holding and tasting a cold, refreshing glass of their favourite beer; guided imagery such as this can be more successful at inducing cravings in the laboratory than actually showing people a real drink (Litt & Cooney, 1999).

We define craving as a type of desire, "an affectively charged cognitive event in which an object or activity that is associated with pleasure or relief of discomfort is in focal attention" (Kavanagh, Andrade & May, 2005, p.447). Craving is often, but not necessarily, a particularly strong and intense desire. There is concurrence across the literature that craving is a conscious, cognitive and emotional state (e.g., Field, Munafò & Franken, 2009; Robinson & Berridge, 2003; Salkovskis & Reynolds, 1994), although (in common with other cognitive and emotional phenomena) people are not necessarily aware of its precursors or underlying processes. As the studies cited above illustrate, sensory imagery is a powerful tool for inducing craving. We argue that this is because imagery is a key component of the cognitive system that underpins human motivation in general. Imagery conveys the emotional qualities of the desired event, mimicking anticipated pleasure or relief, and continual elaboration of the imagery ensures that the target stays in mind. We contend that craving is a conscious state, intervening between unconscious triggers and consumption, and summarise evidence that interfering with sensory imagery can weaken cravings. We suggest that treatments for addiction may be enhanced by the application of imagery-based approaches to the maintenance of motivation and management of craving.

## Elaborated Intrusion theory

The role of sensory imagery in motivation is explained by Elaborated Intrusion (EI) theory (Kavanagh, Andrade & May, 2005; May, Panabokke, Andrade & Kavanagh, 2004). According to this theory (see Figure 1), there are two components in an episode of craving, an initial apparently spontaneous intrusive thought (which may be a schematic thought, a verbal thought, or image) followed by a cycle of elaborative cognition.

A wide range of stimuli of which we are most likely not focally aware, such as physiological cues (salivation, thirst, tiredness), negative mood, environmental cues, and

related thoughts, increase the likelihood that we will experience a conscious thought about the target of desire. The thought feels spontaneous, because we have been unaware of the precursor activity, which takes the form of automatic or overlearned associations that do not require conscious control. The thought is intrusive in the sense that, once conscious, it interrupts one's train of thought, but in many cases it may be fleeting, for example when a momentary thought about lunch interrupts an interesting conversation. Even in a sample of people starting to address alcohol-related problems, when we might expect alcohol-related thoughts to capture attention, 87% reported that these thoughts sometimes popped into mind but then vanished without effort (Kavanagh, May & Andrade, 2009).

Intrusive thoughts only become desires when they are elaborated, as might happen when a thought about drinking coffee interrupts one's attention to a dull lecture. Elaboration includes planning ways of achieving the desire ('I could buy a coffee), generating expectancies about satisfying the desire ('I'd be able to concentrate better once I've had a coffee'), and thinking about one's self-efficacy or ability to obtain the desired object or activity ('I've got change for the coffee machine in the lobby'). Importantly, though, elaboration involves sensory imagery. We imagine engaging in the desired activity and the image conveys some of the pleasure or relief of the real thing. We imagine the sort of coffee we will buy, the warmth, smell and taste of it, and the satisfaction of relieving our craving. More vivid and realistic images convey greater pleasure, and help us decide whether we really want an espresso or cappuccino, but they also make us more acutely aware of the separation between our current state and desired state. Accordingly, vividness of imagery is associated with strength of craving across a range of substances and activities (Kavanagh, May & Andrade, 2009; May, Andrade, Kavanagh & Penfound, 2008). If the desire thought has arisen in situations where consummation is not immediately possible and deprivation is acute, this realization can be unpleasant or uncomfortable. Furthermore, if the desire conflicts with

higher-order goals about abstinence, one may feel guilty and weak for wanting it. Thus desire imagery is briefly pleasurable but may ultimately become aversive. This negative emotion motivates us to achieve our desire and change our current situation.

[fig 1 about here]

## Craving as a conscious state

### *Unconscious triggers lead to conscious intrusive thoughts*

EI theory views sensory imagery as a key component of consciously mediated substance use, as in other motivated behavior. We hypothesise that sensory imagery serves as a mental bridge between initial transitory thoughts about drug use and actual consumption, assisting with the direction of behavior by constructing potential future events, as well as motivating it. While craving can occur without imagery, it is imagery than provides a rich sensory experience that accentuates relief or pleasure and aggravates feelings of deficit.

Craving for drugs can be triggered by drug-related stimuli in the environment (e.g., drug paraphernalia), related thoughts (e.g., thinking about a friend with whom one uses drugs), physiological withdrawal symptoms, anticipatory responses such as salivation, and negative mood. Negative mood is strongly associated with craving (Sayette & Huford, 1995; Maude-Grifin & Tiffany, 1996; Robbins, Ehrman, Childress, Cornish, & O'Brien, 2000) and may become increasingly important as addiction develops and any negative mood is increasingly misattributed to lack of the drug. Development of attentional biases in addiction (Field & Cox, 2008) increases the likelihood that drug-related stimuli will be processed, and so trigger the intrusive thoughts that lead to substance craving, but there is no direct link. The relationship between attentional biases and craving is weaker than would be expected if a direct, automatic relationship existed (Field, Munafò & Franken, 2009).

Unconscious triggers do not lead directly to consumption but instead increase activation of drug-related information in memory, which in turn increases the likelihood of experiencing a thought about drug use. These intrusive thoughts may be verbal thoughts or image fragments, and may be fleeting (Kavanagh et al, 2009; May et al, 2004). Trying to suppress thoughts about consumption tends to exacerbate rather than reduce their occurrence, and also leads to increased consumption, a behavioural rebound (Erskine, 2008). Once a thought has been experienced consciously, consumption may follow directly with little further thought, if the situation permits; but it is more likely that the substance is not immediately to hand and that actions need to be undertaken to obtain it. This provides the window for elaboration to occur, or for the thought to pass from the person's mind as new thoughts take precedence.

*Motivation is sustained by imagery-based elaboration of thoughts*

While passing thoughts can be experienced keenly, intense craving more typically involves elaboration. In this sense, intrusive thoughts are typically the gateway to prolonged or intense craving. As described above, elaboration includes many cognitive activities, including planning acquisition, evaluating self-efficacy in resisting craving, comparing conflicting goals, and generating expectancies of the effects of consumption. However, the key component that gives elaboration its greatest emotional bite, is sensory imagery.

Imagining the sight, smell, taste and bodily effects of consuming the substance mimics the sensory and emotional experience of actually consuming it. Imagery sustains motivation because it is emotionally charged (Bywaters, Andrade & Turpin, 2004; Holmes & Mathews, 2005). So, when a smoker imagines smoking a cigarette, they are not merely imagining what the cigarette would look like and taste like, they are also feeling how pleasurable the taste and effects of inhalation would be. An alcoholic anticipating the first drink of the day not only visualizes the drink but, by doing so, experiences similar pleasure or relief to actually

drinking it. The pleasure or relief felt when imagining substance use may be weaker than the real thing – a mere simulacrum. However, at times it may be even stronger than reality, because imagery allows us to mentally conjure up our ideal experience, where substance use is perfectly rewarding and lacks the inconveniences of everyday life, such as having to stand outside in the rain to smoke a cigarette. One smoker has pointed out to us that their imaginary cigarette is always the best cigarette they have ever had, and is better by far than the subsequent experience.

The pleasure or relief embodied by the initial image encourages further imagery, but imagery also has aversive effects. Imagery enhances awareness of deficit, as when a smoker imagines the satisfaction of taking a drag on a cigarette and, by comparison of their imagined and actual state, feels more keenly their current discomfort and lack of satisfaction. This is an instance of a general phenomenon that imagery-based 'mental contrasting' increases motivation (Achtziger, Fehr, Oettingen, Gollwitzer & Rockstroh, 2009). When deprivation is high and cannot be assuaged, the ensuing worsening of mood stimulates further, increasingly vivid and realistic imagery in a downward spiral with spikes of briefly pleasurable imagery leading to enhanced awareness of deficit and worsening mood.

In support of this model, sensory imagery is a consistent feature of people's subjective reports of their craving experiences, for a range of addictive (Salkovskis & Reynolds, 1994; Kavanagh, May & Andrade, 2009; May et al., 2004; Statham, Connor, Kavanagh, et al., 2011) and non-addictive substances (Harvey, Kemps & Tiggemann, 2005; May et al, 2004) and activities (May, Andrade, Kavanagh & Penfound, 2008). Elaborating sensory imagery not only extends episodes of craving, it makes the craving more intense, as the images become better articulated and more vivid. Particularly in the case of visual imagery, the strength or vividness of imagery, and the frequency of imagery, correlates with craving strength. For

example, Kavanagh et al. (2009) found that most people with alcohol problems have sensory imagery during their strongest craving episodes when they are trying to control their alcohol use, with their imagery combining more than two senses on average. The most common elements of alcohol imagery are imagining tasting a drink, picturing the drink, and imagining swallowing alcohol. As predicted by Elaborated Intrusion theory, frequent sensory imagery is associated with stronger and longer-lasting episodes of craving for alcohol (Kavanagh et al., 2009).

*Imagery favours temptation over abstinence*

Substance use often persists despite good intentions to quit. The central role of sensory imagery in craving helps to explain the relative weakness of our good intentions. We argue that generalized goals to change our lives, for instance to become healthier, can usually be imagined less vividly than can familiar, problematic behaviours, because we have less information in memory to draw on, and in particular little sensory information on which to base an image of an ideal future self that we have not yet experienced. Not only is less sensory information available, there is also a general tendency to use more abstract representations when thinking about the future than about more immediate events. In a wide-ranging review of goal constructs, Austin and Vancouver (1996, p. 345) noted that 'Goals at lower levels of abstraction… are invariably short term, whereas goals at higher levels must be longer term'. According to construal level theory, these 'High-level construals consist of general, decontextualized features that convey the essence of information about future events, whereas low-level construals include more concrete, contextual, and incidental details.' (Trope & Liberman, 2003, p.403). It is the richness of concrete, incidental details that in part determines vividness of imagery (Baddeley & Andrade, 2000). Thus lack of sensory information combined with high-level construal means that goals to become healthier are

difficult to imagine vividly. Images of habitual substance use are more concrete and proximal, making them more vivid and more salient or urgent when faced with a choice to give into an urge to use substances, or to resist temptation for better – but hard to imagine - future health.

More specific behavioural plans (e.g. I'll get up at 6 tomorrow morning and go for a run") help to address this specificity issue—and the potential utility of these 'implementation intentions' (Gollwitzer & Sheeran, 1996) is discussed further below. However, if the concrete plan relates to absence of a behavior (e.g. not smoking) rather than its presence (e.g. going for a run instead), we suggest it may be difficult to imagine concretely. Furthermore, to the extent that imagery about the more functional behavior focuses on distal consequences (e.g. living longer) rather than immediate ones (e.g. feeling good during the run), it will have less emotive power than the dysfunctional behavior (e.g. staying in a warm bed and having a cigarette). Indeed—as the example illustrates—there may be some immediately aversive aspects to the positive behavior. Unfortunately, it is the essence of dysfunctional behaviours that the expected positive consequences tend to be more proximal, concrete and certain than the feared negative ones.

## Automatic and controlled cognitive processes in addiction

In contrast to EI Theory's conscious role for craving, there is a strong tradition within psychology of seeing addictive behaviors as automatic or conditioned, learned initially through the positively reinforcing aspects of drugs' positive or euphoric effects and subsequently through negative reinforcement of withdrawal reversal. More recently, the incentive-sensitization model argues that addiction to drugs develops through sensitization of the brain's reward system to drug-related stimuli (Robinson & Berridge, 1993). Drug-related stimuli become increasingly rewarding, leading to unconscious 'wanting' that is distinct from pleasure-based 'liking'. In EI theory, the sense of deficit shown in Figure 1 and its association

with the target object or activity form the conscious equivalent of unconscious 'wanting' described by Robinson and Berridge. Berridge and Robinson (2003) suggested that vivid cognitive images of reward might activate 'wanting' in the same way as drug-related stimuli. We predict that the converse is also true, that 'wanting' will trigger vivid imagery, and that this imagery will activate the unconscious 'liking' pathways. Thus liking and wanting, in their conscious and unconscious forms, are normally closely coupled, becoming decoupled only as neural adaptations in response to repeated substance use blunt hedonic responses while accentuating the impact of deprivation (i.e. 'wanting' is strengthened independently of 'liking'). We predict that in this case sensory imagery becomes primarily focused on anticipated relief rather than pleasure.

Sometimes, exposure to conditioned stimuli is sufficient to trigger drug use with minimal conscious oversight and little or no craving, as when a smoker absent-mindedly lights another cigarette before finishing the current one. In this situation substance use is automated, with behavior driven by automatically activated action schemas without intervention from top-down control processes. In fact, Tiffany's (1990) theory sees craving as an epiphenomenon resulting from the conscious effort required to other inhibit these automated action schemas (in the case of abstinence attempts) or to seek solutions when their completion is prevented by the environmental or situational context. In Tiffany's model, craving does not directly cause consumption, but results from consumption's impossibility; its negative connotations still serve as a motivating factor to complete the schema and satisfy the desire.

We would also argue pragmatically that situations where consumption can be carried out automatically, without conscious action, are rare, because substance use usually requires more complex sequences of behaviors over extended time periods. Conscious mediation is

needed to orchestrate these sequences of behavior and to carry them out in the face of competing goals. While smokers may have a packet to hand and be able to light up a cigarette without conscious awareness of having done so, they are an unusual exception. A more typical instance of substance use has multiple steps, at least some of which require planning or conscious direction to be successful (e.g. calling a dealer, directing a taxi to a bar). During these steps the individual may also have thoughts assessing self-efficacy ('Can I get it?' 'Can I resist it?'), or activating expectancies ('It'd feel great right now'), and have to inhibit competing goals (e.g. to be healthier or save money).

We argue that sensory images provide a highly efficient medium by which we retain attention on the goal of obtaining an appetitive target during an extended sequence of thoughts and actions, and comparatively evaluate and prioritise competing goals (using affective associates of related imagery). If elaboration stops, then the conscious episode of craving ends: unconscious activation of drug-related memories and concepts remains, ready to trigger another episode, but until then the individual can pursue other goals.

## Clues to tackling craving imagery

The cognitive psychology of mental imagery explains how imagery can be prevented or weakened, while research into craving shows how preventing or weakening mental imagery can lead to reductions in craving.

Mental imagery involves activation of the same brain regions that are activated by actual perception: thus, neuroimaging studies show increased activity in visual areas of the brain when participants are seeing an object and when they are imagining an object (Ganis, Thompson & Kosslyn, 2004; Kosslyn, Thompson, Kim and Alpert, 1995). This 'mental seeing' also requires retrieval of information from long-term memory (generic knowledge of

the shape of a cigarette or colour of whisky, for example, and specific memories of smoking or drinking), generation of an image from the information so retrieved, and maintenance of that image in consciousness. Retrieval, image generation, and maintenance are carried out by the set of cognitive processes that are collectively known as 'working memory' (Baddeley, 1986; Baddeley 2000). Working memory is the means by which we are able to keep information consciously in mind while transforming it or using it to achieve some goal. In craving, working memory is involved when we work out if we have enough money to buy a drink, plan a route to the nearest bar, or imagine ordering and drinking. Accordingly, neuroimaging studies show increased activation in brain regions that support working memory during substance craving (e.g., Grant et al, 1996).

Sub-systems of working memory are specialized for processing auditory or visuospatial information. Imagining the appearance of a bartender pouring a drink uses visuospatial working memory, while imagining the clatter of coins as you win the slot machine jackpot uses auditory working memory. These subsystems have limited capacity, so visual imagery can be blocked by using visuospatial working memory to remember and tap a pattern on a keyboard, whereas auditory imagery is diminished by repeating a phrase aloud (Baddeley & Andrade, 2000). Even highly emotive autobiographical memories feel less vivid and less distressing (or less pleasurable) if they are recalled while performing a task that loads working memory (Kavanagh, Freese, Andrade & May, 2001; Lilley, Andrade, Turpin, Sabin-Farrell & Holmes, 2009; van den Hout, Muris, Salemink, & Kindt, 2010; van den Hout, Englehard, Smeets, et al 2010).

People perform less well on working memory tasks when they are craving than when they are satiated (Kemps, Tiggemann, & Grigg, 2008). As predicted by EI theory, visuospatial working memory tasks are particularly sensitive to effects of craving (Kemps,

Tiggemann & Parnell, 2010). The relationship is two-way, so people crave food and drugs less strongly when they carry out tasks that require working memory than when they have nothing else to do. For example, working memory loads reduce craving in response to tempting foods (Van Dillen, Papies & Hofmann, in submission)—consistent with their impact on emotional responses more generally (Van Dillen, Heslenfeld & Koole, 2009; Van Dillen & Koole, 2007). For clinical purposes, maintaining a perpetual, general working memory load that is sufficient to block craving is impractical, because it would block most normal cognitive activity as well as craving. This area of craving research has therefore focused on simpler tasks that selectively compete with particular aspects of working memory, specifically those needed for craving imagery. The aim is to blunt the craving or provide a brief respite rather than eliminating it altogether.

Visual, gustatory and olfactory imagery tends to be more prevalent in substance use than auditory imagery (Kavanagh et al, 2009; May et al, 2004, 2008). Because working memory research has focused on visuospatial and auditory modalities rather than those of other senses, experimental studies have generally compared the effects on craving of performing visual working memory tasks versus auditory or verbal tasks that control for generic working memory factors and allow us to test the specific effects of blocking visual imagery. Tasks that involve manipulating, remembering or imagining visual information make it difficult to visualize drug use simultaneously, and have been shown to lead to lower craving than verbal tasks that permit concurrent sensory imagery. Thus imagining neutral scenes (e.g., a rose garden) as opposed to neutral sounds (e.g., a telephone ringing) reduces cigarette craving in abstinent smokers to the levels reported by smokers who are allowed to smoke ad lib before the experiment (May et al, 2010). Imagining unrelated odors is also effective (Versland & Rosenberg, 2007), as are non-imagery tasks that require visuospatial working memory processes. For example, the development of cigarette craving is inhibited by

asking participants to view a changing but irrelevant visual display or to create specific forms out of modeling clay or plasticine (spheres, or cubes, or animal shapes) while their hands are out of sight (May et al., 2010). This clay modeling task has been shown to interfere with the encoding (Stuart, Holmes & Brewin, 2006) and recollection (Andrade, Bosworth & Baugh, in submission) of emotional visual material.

Consistent with the EI theory position that imagery is a general feature of motivation, similar findings have been obtained with food craving. These studies have either tested hungry participants craving food in general or participants craving chocolate, which is associated with rather specific cravings that cannot be satisfied by nutritionally similar foods (Michener & Rozin, 1994). This research has shown that craving can be reduced by imagining neutral scenes (Kemps & Tiggemann, 2007), by watching a rapidly changing visual display (Steel, Kemps & Tiggemann, 2006), and by performing tasks that require spatiomotor control as well as visual working memory processes, for example modelling plasticine or clay, making side to side eye movements, or tapping a pattern on a keyboard (Andrade, Pears, May & Kavanagh, under review; Kemps, Tiggemann, Woods & Soekov, 2004).

In excess, imagery can lead to satiation rather than desire, thus Morewedge, Huh and Vosgerau (2010) showed that imagining eating a chocolate sweet thirty times can reduce desire for chocolate, compared to imagining repeatedly putting a coin in a slot machine. As with imaginal exposure treatments for conditions such as spider phobia, this effect may be due to habituation, with the repeated image losing its emotive power over the course of the task, in much the same way that actually eating thirty chocolate sweets would exhaust their appeal, or saying a word over and over dissociates it from its meaning. Alternatively, the effect may occur through imaginary fulfillment of the goal to eat chocolates, as uncompleted goals remain hyper-accessible (Förster, Liberman & Higgins, 2005) and therefore liable to

trigger intrusive thoughts and craving (Berry, Andrade, May & Kavanagh, 2009). While repeated imagery appears effective in controlled settings, however, it is difficult to see how this could easily be applied in the natural environment, as the person may run an increased risk of consumption during early trials (Mischel, Ebbeson & Raskoff-Zeiss, 1972).

## Functional Decision Making: An imagery-based intervention

Craving is an important target for substance use treatments because it helps to sustain addictive behaviours (more cigarettes are smoked 'to relieve craving' than for any other reason; Piasecki, Robinson & Smith, 2008) and makes quitting difficult. Intense craving can occur long after physiological withdrawal symptoms have faded (e.g. because of exposure to previously conditioned cues), inducing discomfort and distress. It is an important trigger of relapse in people who have quit smoking (Killen & Fortmann, 1997; Shiffman, Engberg, Paty, et al., 1997; Zhou, Nonnemaker, Sherrill et al., 2009).

Several psychological treatments for addictive disorders are efficacious (e.g., Miller & Wilbourne, 2002; Tripodi, Bender, Litschge & Vaughn, 2010, in relation to alcohol dependence; Nordstrom & Levin, 2007, in relation to cannabis use disorders; Mottillo et al., 2009 in relation to cigarette smoking), both on their own and combined with pharmacological treatments (e.g., Donovan et al, 2008). However, there is room for improvement in psychological treatments for craving and relapse prevention.

One recent approach to improved psychological interventions in addiction has focused on precursors of craving and drug use, for example, modifying attentional biases to drug-related cues (e.g., Fadardi & Cox, 2009; Field & Eastwood, 2005; Schoenmakers et al, 2010). Despite arguments that attentional biases result from permanent changes in reward sensitivity in addiction (Franken, 2003) and evidence that attentional biases explain relatively little of the variance in craving between individuals (Field et al, 2009), trials on the modification of

attentional bias have been encouraging (e.g. Fadardi & Cox, 2009). Clinical effectiveness has yet to be established in large-scale trials, and it is not yet clear whether observed positive effects of attentional retraining are really due to changes in attention or to incidental aspects of the training such as encouraging clients to set conscious goals for avoiding being distracted by drug-related cues (e.g., Fadardi & Cox, 2009). From EI theory, we would predict that attentional bias modification would alter the probability of experiencing an intrusive thought about drug use, but would not necessarily alter the strength of craving should a thought occur and be elaborated.

These interventions aim to reduce the likelihood that drug-related cues will lead to craving. Another potential focus is the link between the cue or craving, and the subsequent problematic behaviour. Consciously directed behaviour has of course been the focus of psychological interventions for some decades, but more recent approaches attempt to focus on overlearned or automated response tendencies. So, tendencies to approach alcohol can be reduced, by training people to reduce the size of alcohol pictures on a computer screen by pushing a joystick (Wiers, Eberl, Rinck, Becker & Lindenmeyer, 2011). The effect can occur outside awareness, if the task focuses on responses to an irrelevant aspect of the stimulus (e.g. whether it is presented in landscape or portrait format). We await further published data on the extent this effect is maintained outside the laboratory.

An alternative way to address links with behaviour involves increasing the cognitive availability of health-promoting behaviours—for example, by encouraging people to articulate and rehearse detailed 'implementation intentions'. Implementation intentions are specific plans for responding to a particular cue: for example, 'when my friend offers me a cigarette, I shall say 'no' and chew some gum instead'. Implementation intentions are effective across a range of behaviours (Gollwitzer & Sheeran, 1996), including binge drinking

(Murgraff, White & Phillips, 1996) and cigarette smoking in adolescents with relatively weak smoking habits. However, positive effects have not been demonstrated for people with stronger cigarette habits (Webb, Sheeran & Luszczynska, 2009), and their power to provide a stand-alone intervention for other well-established addictive behaviours has yet to be demonstrated.

A potential problem with using implementation intentions to alter addictive behaviours is that cues to the desired behaviour (saying 'no' in the example above) are also cues to the undesired behaviour (accepting the cigarette). This is an instance of the more general problem that people have competing goals – to be healthy and to join in with friends who are smoking, to drive home safely and to relax with another drink. As discussed above, healthier goals are often more abstract, less familiar and more distant in time, whereas the less healthy goals are more immediate and more concrete. According to EI theory, we give into temptations even when consciously considering our actions because we can imagine the pleasures of indulging in familiar habits much more vividly than we can imagine performing a new behaviour or achieving a long-term goal. Recent work by Knäuper, in the context of improving dietary fruit intake, shows that implementation intentions can be made more effective by encouraging people to visualise vividly each component of their 'if…then' plan (Knäuper et al, 2011), in other words boosting the vividness of the new behaviour.

Taking these and other ideas from EI theory, we have been developing a new approach to treating addiction, called "Functional Decision Making" (FDM), which encourages clients to set concrete, proximal and visualizable goals that can better compete, mentally, with the temptations of drug use. Its development is informed by previous research on motivational interviewing.

Over the last three decades, motivational interviewing (MI, Miller, 1983; Miller & Rollnick, 2002) has progressively gained strong empirical support across a wide variety of behavioural domains (Dunn, Deroo & Rivara, 2001; Rubak, Sandbaek, Lauritzen, & Christenses, 2005), not only as a prelude to other treatment, but as a stand-alone treatment in its own right (Miller & Wilbourne, 2002). Using client-centred methods, it encourages people to explore their ambivalence towards change, and consider their potential for success in an attempt. Existing cognitive dissonance (Festinger, 1957) is amplified, so that concerns about current behavior and inconsistencies with self-concepts or life goals are drawn out. If they lack confidence in making a change, they are encouraged to review relevant past successes and consider their relevance to the contemplated attempt. The essence is to provide a context where people are encouraged to discuss change, but where they direct how far the discussion proceeds and whether a decision is made.

In the Project MATCH study, the largest randomised controlled trial on alcohol disorders to date, a four-session version of motivational interviewing (Motivation Enhancement Therapy, MET) gave similar outcomes to ten sessions of cognitive-behaviour therapy or twelve-step therapy (Project MATCH Research Group, 1997). However, effects on tobacco use have been somewhat modest (Hettema & Hendricks, 2010), and there are opportunities to further increase its impact.

Strengths of MI include its provision of a safe and empathic environment in which change can be contemplated and where existing concerns are amplified, while avoiding the induction of defensive responses (Miller & Rose, 2009). These core features are retained in FDM. However, based on EI theory, we suggest several ways in which a motivational approach may be made even more powerful. One aspect of FDM is to increase the role of implementation intentions in motivational interviewing. We argue that a close association

between the Stages of Change model (Prochaska & DiClimente, 1983) and MI (Miller & Rollnick, 2002; cf. Miller & Rollnick, 2009) has resulted in detailed discussion of change planning often being avoided unless the person expresses a wish to change. As a result, there is a risk that consideration of a functional goal may sometimes be insufficiently articulated for it to influence subsequent behaviour. In FDM, reviewing the potential benefits and costs of behaviour change is routinely preceded by encouragement of a more detailed, hypothetical discussion of ways in which change could be implemented than may be typical in standard MI with a person who does not form a commitment to change.

While MI seeks to engage people in behaviour change, it is in essence clinic-based. So, participants are not routinely encouraged to replicate the process of reviewing motivation within their natural environment. FDM represents a systematic generalization of the MI process into participants' everyday life, when they are tempted to engage in dysfunctional behaviour.

Within the clinic, MI brings competing motivations about dysfunctional behaviour and its alternatives into simultaneous awareness. Importantly, some participants report that this is the first time they have looked at all these factors at once. We argue that in the natural environment, competing motivations often vary in their salience through time, to the point where 'ambivalence' is better characterized as an alternation of motivations. So, at an end-of-week celebration on a Friday evening, it is considerably harder to think about the downsides of alcohol than on Saturday morning. We contend that this 'empathy gap' is not only due to the influence of 'visceral factors' such as physiological drug withdrawal symptoms (Loewenstein, 1996): it is also due to the role of imagery in motivation. Positive aspects of behaviour control are harder to visualise on Friday evening because they conflict with vivid images of alcohol that are easier to bring to mind in that context. These alcohol images have a

mental advantage because they are at least initially rewarding, whereas images of hangovers are not. The rewards they promise are also more immediate and may appear more likely than the effects of hangover. The generation of imagery about alcohol and its consumption consumes working memory capacity, and makes it more difficult to form a rational decision. How then can the salience of the benefits of alternative behaviours be enhanced in the natural environment? Part of the answer may be to provide more rehearsal opportunities during motivational interviewing sessions, by increasing the number of times that participants summarise the benefits of behaviour change within sessions, and recall in the temptation context may also be enhanced by referring to cue cards that list those benefits. Furthermore, MI is in essence hypothetical—it encourages participants to guess the potential advantages of behaviour change. Tracking actual positive outcomes and rehearsing those memories and future instances of similar events conveys detail and immediacy to those motivations within the temptation context. MI already uses cognitive therapy techniques to help people question whether the perceived disadvantages of behaviour control always occur, and whether they are necessarily as powerful as the person currently expects (e.g. does alcohol always make you more sociable?). A further focus of monitoring is therefore to continue to test positive assumptions about the dysfunctional behaviour on any occasions when it recurs.

However, none of these changes may constitute a substantial alteration of optimal existing MI. A more fundamental contribution from FDM is its explicit application of EI theory.

Because both craving and the decision to use substances are essentially conscious, cognitive phenomena, they are susceptible to interference from ongoing cognitive activities. The laboratory studies discussed in this paper suggest a range of simple tasks that might be useful for reducing the intensity of craving: in particular, tasks that selectively engage processes of visuospatial working memory. Extrapolating to everyday life, craving should be

reduced by spending a few minutes vividly recollecting a happy memory or scene, making models from plasticine or clay, playing Tetris (see Holmes, James, Coode-Bate & Deeprose, 2009) or even watching a screensaver with high contrast, continually changing visual properties. We predict that these interventions will be useful, at least where motivation to beat craving is high. A recent field study by Knäuper and colleagues supported this prediction. They tested participants who wanted to reduce their consumption of a food or drink for which they regularly experienced strong cravings. Participants were instructed to imagine performing their favourite activity whenever they experienced a strong craving for food or drink. Craving strength and actual consumption were reduced in this condition compared with a control condition where participants recited the alphabet backwards whenever they experienced a strong craving (Knäuper, Pillaya, Lacaillea, McCollama & Kelsoa, in press).

FDM takes these ideas a step further, by applying them within an MI framework. MI does not routinely incorporate imagery. In contrast, FDM encourages participants to use imagery to increase the incentive value of competing, healthy goals by making them more frequently and vividly imagined. Rather than using any positive image to interfere with craving imagery, FDM uses images that are derived from the MI process. As already noted, the disadvantages of substance use are aversive to rehearse and are likely to be avoided. Accordingly, FDM focuses on imagery about the advantages of behaviour control, and of pleasurable goals that are inconsistent with substance use. Participants are encouraged to generate a series of images about the benefits they expect to receive from changing their behaviour, and to rehearse these images within sessions and in the natural environment. Where possible, we focus on proximal, probable and highly valued benefits of behaviour change (e.g. responses of their partner to coming home sober), which offer the best chance of competing with the affective power of craving. When positive outcomes of control are experienced, they are rehearsed in imagination: Projecting memories of actual events into the

future is likely to maximise the credibility, vividness and affective power of that imagery. Since novel, episodic imagery is more effortful and more demanding of working memory, the emphasis of all the imagery is on variations of unfolding past and future events, rather than on static, unchanging pictures or mere rehearsal of past events.

Similarly, when considering the likely benefits of change within the session, participants are encouraged to create detailed imagery about that change. If they later decide to implement change, we encourage them to rehearse the steps of their change plan in imagination, together with behavioural solutions to potential problems. We argue that this detailed imagery about their implementation intentions will boost self-efficacy and help to cue behaviours both via its episodic nature and by associations with environmental stimuli embedded in it. If rehearsal of implementation intentions, change plans and the benefits of change were to focus on imagery, EI theory predicts that this imagery will offer much more powerful support for adherence to functional goals than a verbal consideration of benefits or plans. We are currently conducting trials of FDM, to demonstrate its ability to enhance other motivational methods.

## Thought acceptance and mindfulness

FDM deals with disrupting the link between intense desire and substance use. A further focus of EI-based treatment is on an earlier stage in the craving cycle, disrupting the tendency of intrusive thoughts to trigger elaboration in the first place.

Simple thought suppression is counterproductive, due to ironic effects of thought monitoring (Wegner, Schneider, Carter & White, 1987). A more effective strategy may be to use acceptance-based or meditation mindfulness (Kabat-Zinn, 2003), which encourages individuals to view thoughts as transient events and to accept that unwanted thoughts will sometimes pop into mind. Letting thoughts come and go again breaks the cycle of attempted

thought suppression, increased thoughts, feelings of failure or rumination on the thoughts, and renewed but counterproductive suppression. In addiction, the aim is to help participants see that there is no need to elaborate a thought about substance use, because it will go again of its own accord. A thought about a substance is not a sign that they need and must have the substance – it is just a thought.

Mindfulness-based therapies teach individuals to become aware of their whole, changing, sensory experience. Training in mindfulness aims to increase awareness of all thoughts and sensations, and thereby decrease the salience, and elaboration of, unwanted thoughts. Mindfulness-based interventions also reduce distress about the craving, by helping the person to observe their thoughts without engaging with them or being concerned about what they may mean. Bowen, Witkiewitz, Dillworth et al (2006) found that prison inmates who took part in a mindfulness course while incarcerated reported significantly less use of alcohol, cocaine and marijuana in the three months following their release. Witkiewitz and Bowen (2010) reported that craving mediated the relationship between negative affect (depressive symptoms) and alcohol or drug use in a control group of substance abusers undergoing treatment as usual, but that this relationship was abolished in an experimental group undergoing mindfulness based intervention. Zgierska, Rabago, Chawla et al., (2009) conducted a systematic review of the efficacy of mindfulness meditation based interventions for substance use disorders, and found that the majority showed positive outcomes compared to baseline or other therapy, although the variety of interventions made a definitive conclusion premature. Of particular relevance for our argument, this review noted that the mindfulness approaches differed to conventional cognitive behavioural therapies through the focus upon providing the client with the skills to control their responses to thoughts, rather than targeting antecedent cues in an attempt to reduce substance related thoughts.

Future directions for craving interventions

Mindfulness training includes strategies such as body scanning that help increase awareness of experiences and thoughts other than the unwanted ones. Body scanning involves shifting attention from one part of one's body to another, a process that is likely to involve – or be enhanced by - visual imagery of the attended parts of the body. Recent studies have shown that body scanning reduces intrusive thoughts about food as effectively as a distraction technique involving guided sensory imagery of a woodland walk (May, Andrade, Berry, Batey, Kavanagh 2010), that it reduces desire to smoke compared with listening to a natural history tape, and that it can be used effectively and unsupervised by people at home (Ussher, Cropley, Playle, Mohidin & West 2009). These studies used pre-recorded audio-tapes, but with practice people can conduct body scanning without such aids, and future research could evaluate the effectiveness of self-guided body scanning in reducing cravings.

Interventions like body scanning, which combine positive or neutral sensory imagery with acceptance of intrusive thoughts, should be particularly effective at reducing craving, because the acceptance component should reduce the likelihood of intrusions being elaborated while the competing imagery and attentional control elements simultaneously disrupt any elaboration that does occur by competing for visuospatial and executive working memory resources. The intervention as a whole therefore promises to break the vicious circle whereby intrusive thoughts trigger sensory imagery that in turn triggers further thoughts. As Ussher et al (2009) showed, these techniques have potential as self-help tasks that can be used at home with minimal training.

# Conclusions

Sensory imagery is central to craving, providing its emotional bite and prolonging episodes of craving in the face of competing desires to abstain. Stronger, more vivid imagery predicts stronger craving, while blocking imagery with specific competing tasks has been shown to reduce craving. The development of substance craving can be inhibited by clinical interventions such as mindfulness training that disrupt the elaboration of intrusive thoughts, reducing substance-related sensory imagery. We anticipate that Functional Decision Making, a new clinical approach based on multi-sensory imagery of personally relevant positive aspects of behaviour control, will enhance the individual's ability to avoid dysfunctional behaviour at the critical moments when they are most tempted.

References

Achtziger, Fehr, Oettingen, Gollwitzer & Rockstroh, (2009). Strategies of intention formation are reflected in continuous MEG activity, *Social Neuroscience, 4*(1), 11-27.

Andrade, J., Bosworth, S. & Baugh, S-J. (under review). Effect of clay modelling on vividness and emotionality of autobiographical memories

Andrade, J., Pears, S., May, J. & Kavanagh, D.J. (under review). Use of a clay modeling task to reduce chocolate craving.

Austin, J. T., & Vancouver, J. B. (1996). Goal constructs in psychology: Structure, process, and content. *Psychological Bulletin, 120*(3), 338–375

Baddeley, A. D. (1986). *Working Memory*. Oxford: Oxford University Press.

Baddeley, A. D. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Science, 4(11)* 417-423.

Baddeley, A. D. & Andrade, J. (2000). Working memory and the vividness of imagery. *Journal of Experimental Psychology: General 129(1):* 126-145.

Berridge, K. C., & Robinson, T. E. (2003). Parsing reward. *Trends in Neuroscience, 26,* 507–513.

Berry, L-M., Andrade, J. & May, J. (2007). Hunger-related intrusive thoughts reflect increased accessibility of food items. *Cognition and Emotion, 21,* 865-878.

Bowen, S., Witkiewitz, K., Dillworth, T.M., Chawla, N., Simpson, T.L., Ostafin, B.D., Larimer, M.E., Blume, A.W., Parks, G.A. & Marlatt, G.A. (2006). Mindfulness meditation and substance use in an incarcerated population. *Psychology of Addictive Behaviors, 20(3),* 343-347.

Breslin, F. C., Zack, M., & McMain, S. (2002). An information-processing analysis of mindfulness: Implications for relapse prevention in the treatment of substance abuse. *Clinical Psychology: Science and Practice, 9,* 275–299.

Bywaters, M., Andrade, J. & Turpin, G. (2004). Determinants of the vividness of visual imagery: The effects of delayed recall, stimulus affect and individual differences, *Memory*, *12*(4), 479-488.

Donovan, D. M., Anton, R. F., Miller, W. R., Longabaugh, R., Hosking, J. D., Youngblood, M. (2008). Combined pharmacotherapies and behavioral interventions for alcohol dependence (The COMBINE Study): Examination of posttreatment drinking outcomes. *Journal of Studies on Alcohol & Drugs*. *69*, 5-13.

Dunn, C., Deroo, I., Rivara, F. P. (2001). The use of brief interventions adapted from motivational interviewing across behavioural domains: A systematic review. *Addiction, 96,* 1725-1742.

Erskine, J.A.K. (2008) Resistance can be futile: Investigating behavioural rebound. *Appetite 50,* 415-421.

Fadardi, J. S. & Cox, W.M. (2009). Reversing the sequence: reducing alcohol consumption by overcoming alcohol attentional bias, *Drug and Alcohol Dependence, 101*, 137–145.

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford (CA): Stanford University Press.

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence, 97*, 1-20

Field, M., & Eastwood, B. (2005). Experimental manipulation of attentional bias increases the motivation to drink alcohol. Psychopharmacology, 183, 350-357.

Field, M., Munafò, M. R., & Franken, I. H. A. (2009) A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin, 135*, 589-607.

Förster, J., Liberman, N. & Higgins, E. T. (2005). Accessibility from active and fulfilled goals. *Journal of Experimental Social Psychology, 41,* 220-239.

Franken, I. H. A. (2003). Drug craving and addiction: Integrating psychological and neuropsychopharmacological approaches. *Progress in Neuro-Psychopharmacology & Biological Psychiatry, 27*, 563–579.

Ganis, G., Thompson, W. L., & Kosslyn, S. M. (2004). Brain areas underlying visual mental imagery and visual perception: an fMRI study. *Cognitive Brain Research, 20*, 226-241.

Gollwitzer, P. M. & Sheeran, P. (1996). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology, 38,* 69-119.

Grant, S., London, E. D., Newlin, D. B., Villemagne, V. L., Liu, X., Contoreggi, C., et al. (1996). Activation of memory circuits during cue-elicited cocaine craving. *Proceedings of the National Academy of Sciences, USA, 93,* 12040–12045.

Harvey, K., Kemps, E., & Tiggemann, M. (2005) The nature of imagery processes underlying food cravings. *British Journal of Health Psychology, 10,* 49-56.

Hettema, J. E., Hendricks, P. S. (2010). Motivational interviewing for smoking cessation: A meta-analytic review. *Journal of Consulting and Clinical psychology, 78,* 868-884.

Holmes, E. A., James, E. L., Coode-Bate, T., & Deeprose, C. (2009). Can playing the computer game 'tetris' reduce the build-up of flashbacks for trauma? A Proposal from Cognitive Science. PLoS ONE, 4(1), e4153, doi:4110.1371/journal. pone.0004153.

Holmes, E. A., Lang, T. J. & Shah, D. M. (2008). Developing interpretation bias modification as a "cognitive vaccine" for depressed mood: Imagining positive events makes you feel better than thinking about them verbally. *Journal of Abnormal Psychology, 118*, 76-88.

Holmes, E. A. & Mathews, A. (2005). Mental imagery and emotion: A special relationship? *Emotion, 5,* 489-497.

Kabat-Zinn J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice, 10,* 144-156.

Kavanagh, D.J., Andrade, J., & May, J. (2005). Imaginary relish and exquisite torture: The elaborated intrusion theory of desire. *Psychological Review, 112*, 446-467.

Kavanagh, D. J., Freese, S., Andrade, J., & May, J. (2001). Effects of visuospatial tasks on desensitization to emotive memories, *British Journal of Clinical Psychology, 40*, 267-280.

Kavanagh, D. J., May, J., & Andrade, J. (2009). Tests of the elaborated intrusion theory of craving and desire: Features of alcohol craving during treatment for an alcohol disorder, *British Journal of Clinical Psychology, 48,* 241-254.

Kemps, E. & Tiggemann, M. (2007). Modality-specific imagery reduces cravings for food: An application of the Elaborated Intrusion theory of desire to food craving. *Journal of Experimental Psychology: Applied, 13(2),* 95-104.

Kemps, E., Tiggemann, M., & Grigg, M. (2008). Food cravings consume limited cognitive resources. *Journal of Experimental Psychology: Applied, 14*, 247-254.

Kemps, E., Tiggemann, M. & Parnell, J. (2010). The selective impact of chocolate craving on visuospatial working memory. *Appetite, 55,* 44-48.

Kemps, E., Tiggemann M., Woods, D., & Soekov, B. (2004). Reduction of food cravings through concurrent visuo-spatial processing. *International Journal of Eating Disorders, 36,* 31-40.

Killen, J. D., & Fortmann, S. P. (1997). Craving is associated with smoking relapse: Findings from three prospective studies. *Experimental and Clinical Psychopharmacology, 5,* 137-142.

Knäuper, B., McCollam, A., Rosen-Brown, A., Lacaille, J., Kelso, E., & Roseman, M. (2011). Fruitful plans: Adding targeted mental imagery to implementation intentions increases fruit consumption. *Psychology and Health, 26,* 601-617.

Knäuper, B., Pillaya, R., Lacaillea, J., McCollama, A. & Kelsoa, E. (in press). Replacing craving imagery with alternative pleasant imagery reduces craving intensity, *Appetite*.

Kosslyn, S. M., Thompson, W.L., Kim, I.J., & Alpert, N.M. (1995). Topographic representations of mental images in primary visual cortex. *Nature 378*: 496-8.

Lilley, S., Andrade, J., Turpin, G., Sabin-Farrell, R., & Holmes, E. A. (2009). Visuo-spatial working memory interference with recollections of trauma, *British J Clinical Psychology, 48*. 309-321.

Litt, M. D. & Cooney, N. L. (1999) Inducing craving for alcohol in the laboratory. *Alcohol Research and Health, 23(3)* 174-178.

Loewenstein, G. (1996). Out of control: Visceral Influences on Behavior, *Organizational Behavior and Human Decision Processes, 65*(3), 272–292

Maude-Griffin, P. M., & Tiffany, S. T. (1996). Production of smoking urges through imagery: The impact of affect and smoking abstinence. *Experimental and Clinical Psychopharmacology, 4,* 198–208

May, J., Andrade, J., Panabokke, N., & Kavanagh, D. (2010). Visual imagery tasks suppress craving for cigarettes. *Behaviour Research and Therapy, 48,* 476-485.

May, J., Andrade, J., Batey, H., Berry, L-M., & Kavanagh, D. J. (2010). Less food for thought: Impact of attentional instructions on intrusive thoughts about snack foods. *Appetite, 17,* 126–137.

May, J., Andrade, J., Kavanagh, D. & Penfound, L. (2008). Imagery and strength of craving for eating, drinking and playing sport. *Cognition and Emotion 22,* 633-650.

May, J., Panabokke, N., Andrade, J., & Kavanagh, D. (2004). Images of desire: cognitive models of craving. *Memory, 12,* 447–461.

Michener, W. & Rozin, P. (1994) Pharmacological versus sensory factors in the satiation of chocolate craving. *Physiology &. Behavior. 56*, 419-422Morwedge, C.K., Huh, Y.E., & Vosgerau, J. (2010) Thought for Food: Imagined Consumption Reduces Actual Consumption. *Science 330 (6010),* 1530-1533.

Miller, W. R. (1983). Motivational interviewing with problem drinkers. *Behavioural Psychotherapy, 11,* 147-172.

Miller, W. R., & Rollnick, S. (2002). *Motivational Interviewing: Preparing People for Change*. 2nd ed. New York: Guilford Press.

Miller, W. R., & Rollnick, S. (2002). Ten things that motivational interviewing is not. *Behavioural & Cognitive Psychotherapy, 37,* 129-140.

Miller, W. R., & Rose, G. S. (2009). Toward a theory of motivational interviewing. *American Psychologist, 64,* 527-537.

Miller, W. R., & Wilbourne, P. L. (2002). Mesa grande: A methodological analysis of 636 clinical trials of treatments for alcohol use disorders. *Addiction, 97*, 265−277.

Mischel, W., Ebbeson, E. B., & Raskoff-Zeiss, A. (1972). Cognitive and attentional mechanisms in delay of gratification. *Journal of Personality and Social Psychology, 21,* 204–218.

Morewedge, C. K., Huh, Y. E. & Vosgerau, J. (2010). Thought for food: Imagined consumption reduces actual consumption, *Science,* 330, 1530-1533.

Mottillo, S., Fillon, K. B., Bélisle, P., Joseph, L., Gervais, A., O'Loughlin, J., Paradis, G., Pihl, R., Pilote, L., Rinfret, S., Tremblay, M., & Eisenberg, M. J. (2009). Behavioural interventions for smoking cessation: a meta-analysis of randomized controlled trials, *European Heart Journal, 30,* 718-730.

Murgraff, V., White, D., & Phillips, K. Moderating binge drinking: it is possible to change behavior if you plan it in advance. *Alcohol and Alcoholism, 6,* 577–582.

Nordstrom, B. R. & Levin, F, R. (2007). Treatment of cannabis use disorders: A review of the literature. *American Journal on Addictions. 16*, 331-342.

Piasecki, T.M., Richardson, A.E. & Smith, S.M. (2007) Self-monitored motives for smoking among college students. *Psychology of Addictive Behaviours,* 21(3), 328-337.

Prochaska, J. Q., & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology, 51,* 390-395.

Project MATCH Research Group (1997). Matching alcoholism treatments to client heterogeneity: Project MATCH posttreatment drinking outcomes. *Journal of Studies on Alcohol, 58,* 7–29.

Robbins, S. J., Ehrman, R. N., Childress, A. R., Cornish, J. W., & O'Brien, C. P. (2000). Mood state and recent cocaine use are not associated with levels of cocaine cue reactivity. *Drug and Alcohol Dependence, 59*, 33– 42.

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

Robinson, T. E. & Berridge, K. C. (2003). Addiction. *Annual Review of Psychology, 54*, 25-53.

Rubak, S., Sandbaek, A., Lauritzen, T., & Christenses, B. (2005). Motivational interviewing: a systematic review and meta-analysis. *British Journal of General Practice, 55,* 305–312.

Salkovskis, P. M. & Reynolds, M. (1994). Thought suppression and smoking cessation. *Behaviour Research and Therapy 32*(*2):* 193-291.

Sayette, M. A., & Hufford, M. R. (1995). Urge and affect: A facial coding analysis of smokers. *Experimental and Clinical Psychopharmacology, 3,* 417– 423.

Sayette, M. A., Loewenstein, G., Griffin, K. M., & Black, J. J. (2008). Exploring the cold-to-hot empathy gap in smokers. *Psychological Science, 19,* 926-932,

Schoenmakers, T. M., de Bruin, M,, Lux, I. F., Goertz, A. G., Van Kerkhof, D. H., & Wiers, R. W. (2010). Clinical effectiveness of attentional bias modification training in abstinent alcoholic patients. *Drug & Alcohol Dependence, 109,* 30-36.

Shiffman, S., Engberg, J., Paty, J., Perz, W. G., Gnys, M., Kassel, J. & Hickcox, M. (1997). A day at a time: Predicting smoking lapse from daily urge. *Journal of Abnormal Psychology, 106*, 104-116.

Statham, D. J., Connor, J. P, Kavanagh, D. J., Feeney, G. F. X., Young, R. McD., May, J. & Andrade, J. (2011). Measuring alcohol craving: Development of the Alcohol Craving Questionnaire. *Addiction*. DOI: 10.1111/j.1360-0443.2011.03442.x .

Steel, D., Kemps, E., & Tiggemann, M. (2006). Effects of hunger and visuo-spatial interference on imagery-induced food cravings. *Appetite, 46,* 36-40.

Stuart, A.D.P., Holmes, E.A. & Brewin, C.R. (2006). The influence of a visuospatial grounding task on intrusive images of a traumatic film. *Behaviour Research and Therapy, 44,* 611-619.

Tiffany, S. T. (1990). A cognitive model of drug urges and drug-use behavior: Role of automatic and nonautomatic processes. *Psychological Review, 97,* 147–168.

Tiffany, S.T. & Drobes, D.J. (1991). The development and initial validation of a questionnaire on smoking urges. *British Journal of Addiction*. *86*, 1467-1476.

Tiffany, S.T. & Hakenewerth, D.M. (1991). The production of smoking urges through an imagery manipulation: Psychophysiological and verbal manifestations. *Addictive Behaviors*. *16*: 389-400.

Tripodi, S. J., Bender, K., Litschge, C. & Vaughn, M. G. (2010). Interventions for reducing adolescent alcohol abuse: a meta-analytic review. *Archives of Pediatrics & Adolescent Medicine*, *164,* 85-91.

Trope, Y. & Liberman, N. (2003). Temporal construal. *Psychological Review, 110*, 403-421.

van den Hout, M., Muris, P., Salemink, E., & Kindt, M. (2001). Autobiographical memories become less vivid and emotional after eye movements. *British Journal of Clinical Psychology, 40*, 121-130.

Ussher, M., Cropley, M., Playle, S., Mohidin, R., & West, R. (2009). Effect of isometric exercise and body scanning on cigarette cravings and withdrawal symptoms. *Addiction, 104,* 1251-1257.

Van den Hout, M., Englehard, I.M., Smeets, M.A.M., Homsveld, H., Hoogeveen, E., de Heer, E., Toffolo, M.B.J., & Rijkeboer, M. (2010). Counting during recall: Taxing of working memory and reduced vividness and emotionality of negative memories. *Applied Cognitive Psychology, 24(3)* 303-311.

Van Dillen, L. F., Heslenfeld, D.J., & Koole, S.L. (2009). Tuning down the emotional brain: An fMRI study of the effects of cognitive load on the processing of affective images. *NeuroImage, 45*, 1212–1219.

Van Dillen, L. F., & Koole, S. L. (2007). Clearing the mind: A working memory model of distraction from negative mood. *Emotion, 7*, 715-723.

Van Dillen, L. F., Papies, E. & Hofmann, W. (in submission). Turning a blind eye on temptation. How task load can facilitate self-regulation.

Versland, A., & Rosenberg, H. (2007). Effect of brief imagery interventions on craving in college student smokers. *Addiction Research and Theory, 15*(2), 177-187.

Webb, T. L., Sheeran, P. & Luszczynska, A. (2009). Planning to break unwanted habits: habit strength moderates implementation intention effects on behavior change. *British Journal of Social Psychology, 48*, 507–523.

Wegner, D. M., Schneider, D. J., Carter, S., & White, T. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology, 53,* 5-13.

Wiers, R. W., Eberl, C., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2011). Retraining automatic action tendencies changes alcoholic patients' approach bias for alcohol and improves treatment outcome. *Psychological Science, 22,* 490-497.

Witkiewitz, K. & Bowen, S. (2010). Depression, craving, and substance use following a randomized trial of mindfulness-based relapse prevention. Journal of Consulting and Clinical Psychology, 78(3), 362-374.

Zgiergska, A., Rabago, D., Chawla, N., Kushner, K., Koehler, R., & Marlatt, A. (2009) Mindfulness Meditation for Substance Use Disorders: A Systematic Review. *Substance Abuse, 30(4)* 266-294

Zhou, X., Nonnemaker, J., Sherrill, B., Gilsenan, A. W., Coste, F., & West, R. (2009). Attempts to quit smoking and relapse: Factors associated with success or failure from the ATTEMPT cohort study. *Addictive Behaviors, 3,* 365–373.

Figure caption

Figure 1. The Elaborated Intrusion theory of motivation, showing the contribution of triggers (rounded external boxes), intrusive thoughts ('desire thoughts'), and sensory imagery to craving (central square box). Thick arrows show the controlled processing cycle of conscious imagery and associated affect; thin arrows represent automatic influences on desire (reprinted from Kavanagh, Andrade & May, 2005, with permission).

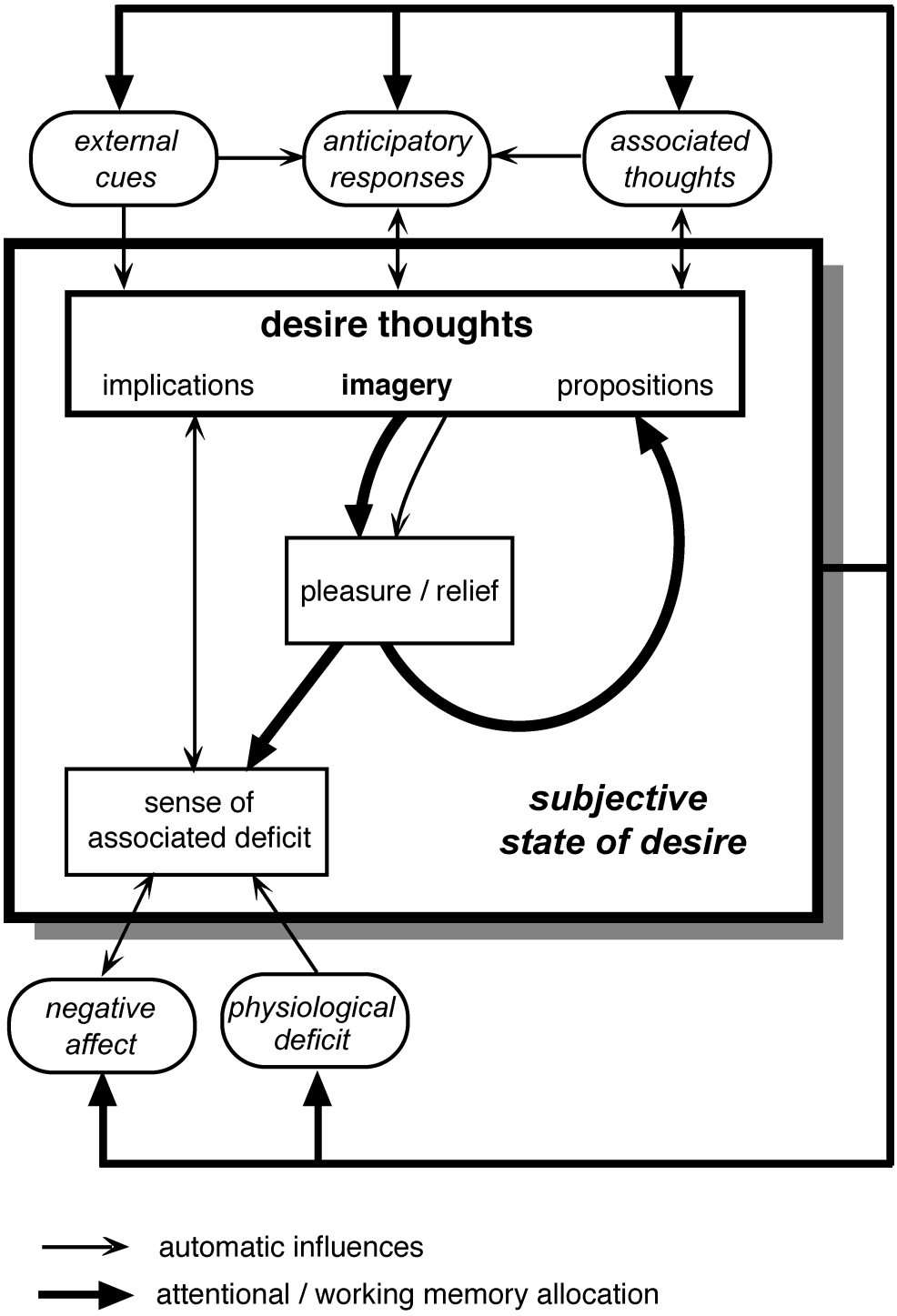
external cues
anticipatory responses
associated thoughts
desire thoughts
implications
imagery
propositions
pleasure / relief
sense of associated deficit
subjective state of desire
negative affect
physiological deficit
automatic influences
attentional / working memory allocation

Figure 1