

The Elaborated Intrusion Theory of Desire:
A 10-year retrospective and implications for addiction treatments

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Abstract

Ten years after the publication of Elaborated Intrusion (EI) Theory, there is now substantial research into its key predictions. The distinction between intrusive thoughts, which are driven by automatic processes, and their elaboration, involving controlled processing, is well established. Desires for both addictive substances and other desired targets are typically marked by imagery, especially when they are intense. Attention training strategies such as body scanning reduce intrusive thoughts, while concurrent tasks that introduce competing sensory information interfere with elaboration, especially if they compete for the same limited-capacity working memory resources. EI Theory has spawned new assessment instruments that are performing strongly and offer the ability to more clearly delineate craving from correlated processes. It has also inspired new approaches to treatment. In particular, training people to use vivid sensory imagery for functional goals holds promise as an intervention for substance misuse, since it is likely to both sustain motivation and moderate craving.

It is now 10 years since the initial papers describing Elaborated Intrusion (EI) Theory, which maps cognitive and emotional processes that trigger and support desire (Kavanagh, Andrade & May, 2005; May, Andrade, Panabokke & Kavanagh, 2004). While EI theory is a general theory of desire, an initial impetus for our work was to bring together diverse theory and research on addiction within a single motivational framework that explained the cognitive processes underpinning cravings and their impact on addictive behaviors, and research on addictions continues to be a major focus. This paper examines the extent to which EI theory has achieved its aim, and examines implications for the management of addictive behaviors. We do not provide a comprehensive review: Rather, we provide examples of research that illustrate the large body of evidence.

EI Theory defines cravings or desires as affectively laden cognitive events, where an object or activity and associated pleasure or relief are in focal attention (Kavanagh et al., 2005; Kavanagh et al., 2013). Importantly, this distinguishes desires from their often unconscious precursors and from potentially correlated but separate phenomena such as intentions or perceived behavioral control, which are frequently confused with desires in research (Kavanagh et al., 2013). Cravings are viewed as intense desires, rather than being qualitatively different, and we argue that addictive substances recruit the same cognitive and biological mechanisms as those serving other appetitive targets, including those underpinning survival, consistent with existing neurobiological work (Robinson & Berridge, 2003).

In common with many other theories of addictive craving, EI theory (see Figure 1) argues that physiological withdrawal, environmental and cognitive associations and negative mood are potential triggers of desire, and holds that people are typically unaware of these processes. Initial awareness sometimes even follows an anticipatory conditioned response such as salivation. These triggers increase activation of drug-related representations in memory, via automatic associative processes, and this priming increases the likelihood of an

apparently spontaneous thought about substance use intruding into consciousness. For example, Berry, Andrade and May (2007) showed that the extent of priming of food-related words was associated with the frequency of intrusive thoughts about eating. Even in addicted samples, intrusive thoughts about drug use sometimes come and go without triggering elaboration (Kavanagh, May & Andrade, 2009). However, if the target is associated with pleasure or relief, or the thought elicits a greater awareness of deprivation, cognitive elaboration is likely to ensue. Elaboration may be semantic or focus on physiological sensations, but the cognitive heart of desire is affectively charged sensory imagery that simulates the experience of target acquisition and consumption. This mental imagery of the target and its acquisition serve to ready the individual for target-directed behaviour. This focus on imagery is a distinguishing feature of EI theory.

[Figure 1 about here]

Sensory imagery is important in motivating target-directed behavior, because it conveys some of the pleasure or relief of the real thing. More vivid and realistic images convey greater pleasure, and help us choose between different possible versions of the target, but they make us more acutely aware of the separation between our current state and our desired state. Thus desire imagery is briefly pleasurable but, if the desire remains unfulfilled, ultimately aversive. This negative emotion motivates us to achieve our desire and change our current situation. As we progressively approach the target, the increasingly rich cues serve to heighten the vividness of consumption imagery, giving acquisition even greater urgency and attentional priority.

EI theory has been widely cited in recent theories of addiction (e.g. Skinner & Aubin, 2010; Caselli, et al., 2012) and food cravings (e.g., Kemps & Tiggeman, 2010; Ferriter & Ray, 2011) and is increasingly being referred to in the wider psychopathological (e.g., Roskow-

Ewoldsen, 2006; Holmes & Matthews, 2010; Treasure et al. 2011; Watkins, 2011) and motivational literatures (e.g., Hofmann, Schmeichel and Baddeley, 2012; Hofmann & van Dillen, 2012). Its breadth of appeal and explanatory power rests upon its general approach to desire as a cognitive motivational state, bringing together automatic, bottom-up associative processes and controlled, top down cognitive processes.

This breadth is reflected in the wide range of contexts where EI Theory is cited. Wray, Gass and Tiffany (2013) acknowledge its explanation of weak relationships between craving and relapse to smoking, in its contention that the relationships are moderated by attentional allocation, competing incentives, mood and self-efficacy. Lovibond and Colaguri (2013) turned to EI Theory for a cognitive explanation of people learning Pavlovian associations between cues and chocolate rewards, despite long delays. Schlauch et al. (2013) drew on EI theory to advocate a greater focus on positive affect in craving and addiction research, while Gollwitzer & Sheeran (2006) recruited it to explain why desirable distractions can divert people from their intentions to achieve goals, arguing that motivated behaviour involved shielding goal striving from unwanted influences.

Crucially, EI theory has provided the theoretical basis for a large body of research, which has substantiated its key predictions and inspired important advances in assessment and intervention.

Evidence on key propositions of EI Theory

Distinction of intrusive thoughts and elaboration

A central proposition of EI Theory is its distinction between intrusive thoughts about a target and their subsequent elaboration. Automatic associative processes that operate outside awareness can, when other cognitive demands allow, break through into consciousness, giving rise to the subjective perception of a thought as spontaneous (May et al, 2004). This

apparent spontaneity serves to orient attention towards the thought and any related stimuli, giving it further potency. Evidence for the distracting effects of intrusive thoughts is given by Sayette, Schooler and Reichle (2009), who found that smokers deprived of nicotine for six hours were more prone to mind-wandering while reading than non-deprived smokers, with smoking-related thoughts distracting them from the primary task.

EI Theory does not predict whether particular triggers have greater precedence, but individual differences in their weighting may be expected. Schmidt et al. (2013) found that the craving of alcohol dependent patients was associated with greater tension reduction expectancies, but only when they had poor interoceptive awareness (indexed by heart rate estimation). The authors argued that cognitive triggers (here, alcohol expectancies) become more important when somatic perception is less acute, and that mindfulness training may address this problem.

EI theory predicts that attentional biases will increase the likelihood of consciously noticing drug cues or experiencing an intrusive thought about the drug, but other factors (e.g. salience, concurrent cognitive load) will determine whether attention to the thought is maintained. These predictions have been supported. While there is an association between craving and substance-related attentional bias (Field & Cox, 2008), the relationship is weak and primarily occurs when craving is intense and direct measures of attention are used (Field, Munafò & Franken, 2009). Attentional biases to addictive cues appear mainly to operate following awareness: they do not appear at subliminal, pre-attentive durations, but at longer durations are associated with increased use or dependence (Ho, et al., 2103). Training participants to attend towards alcohol cues increases cravings, but only for those who become aware of the contingency (Field et al, 2007).

The ability of elaboration to intensify desires was already well supported by laboratory-based inductions when we first published EI Theory. That this occurs without instruction is supported by Nordgren and Chou (2013), who found that hungry dieters who had time to deliberate about a choice of snacks chose more unhealthy ones, compared to a group who had to make an immediate choice: Presumably, the additional time gave them the opportunity to elaborate positive thoughts about the unhealthy snack. Elaboration also appears to increase the salience of further target-related associations: Oh and Taylor (2013) found that people who had unwrapped a chocolate bar, seen images of chocolate, and then sat undistracted for 15 minutes showed a greater attentional bias to chocolate cues than a group who had completed a 15-minute exercise session instead.

Explicitly training participants to direct attention away from food cues also reduces related thoughts, craving (Kakoschke, Kemps, & Tiggemann, 2014; May, Andrade, Batey, Berry, & Kavanagh, 2010) and consumption (Kakoschke et al., 2014). Similarly, Achtziger, Gollwitzer & Sheeran (2008) found that a simple instruction ‘...if I think about my chosen food, then I will ignore that thought!’ helped people to double the reduction in consumption of a target food over one week. Ravis & Sheeran (2013) instructed binge drinkers to form the intention that ‘if I am at the limit for a binge, then I ignore the urge to drink and will look at the situation as if I were someone else’, citing EI Theory. This implementation intention reduced the frequency of binge drinking over the following month.

Attentional redirection can involve mindfulness-related activities. Brief training to view reactions as transient mental events enabled participants to eliminate their spontaneous tendency to ‘approach’ pictures of food in a study by Papies, Barsalou & Custers (2012). Similarly, scanning bodily sensations reduces thoughts about food (May, Andrade, Batey et al., 2010) and cigarettes (May, Andrade, Willoughby & Brown, 2012). Conversely, a specific focus on breathing and abdominal sensations may not be effective in food craving

(May, Andrade, Batey et al., 2010), presumably because it may focus attention on hunger-related sensations. Effects on craving are more reliably obtained during laboratory-based body scanning than afterwards (Hamilton, Fawson, May, Andrade & Kavanagh, 2013; May, Andrade, Batey et al., 2010; May, Andrade, Willoughby & Brown, 2012), although Ussher, Cropley, Playle, Mohidin and West (2009) found that 10 minutes of audio-directed body scanning reduced the intensity of cravings for cigarettes 30 minutes later, in comparison to a control group who read about natural history. Undertaking isometric exercises while seated, which also required attention to different body parts, had similar effects to body scanning in that study. Differential effects on craving from applying the intervention in the natural environment were more transient: while still evident up to 5 minutes afterwards, they were lost by 30 minutes, perhaps because the natural environment was less neutral than a laboratory environment and contained additional cues to reconstitute cravings. These studies compared the attentional control conditions with similar tasks, to demonstrate that the effects were unlikely to be due to general cognitive load, but were related to the creation, maintenance and manipulation of sensory imagery unrelated to the desired substance. Consistent with this body of research, trait mindfulness was associated with less preoccupation with alcohol in a study with undergraduates by Ostafin, Kassman & Wessel (2013).

EI Theory draws attention to the fact that craving often occurs in the context of competing desires, for example to reduce consumption. Attention of participants can also be redirected to negative consequences of consumption. Szasz, Szentagotai & Hofman (2012) instructed undergraduate smokers to think about negative consequences of smoking (bad breath, yellow teeth, impotence, cardiovascular disease, cancer). These participants had less intense craving for cigarettes and lower dysphoria over the remainder of the experimental session than did those who were instructed to suppress or nonjudgementally accept thoughts about smoking.

Giuliani, Calcott & Berkman (2013) trained participants to cognitively reappraise tempting foods negatively, by imagining themselves as very full, focusing on the negative consequences of eating, remind yourself that you can save that food for later, or imagining that something bad had happened to the food (e.g., being sneezed on). Cognitive reappraisal resulted in less reported desirability of a high-energy food than if the person focused on it, especially if it was one they craved. Thus the content of the elaboration, as well as the extent of elaboration, determines the strength of desire.

Elaborated imagery is central to intense desire

The prominence of imagery in subjective reports of craving has been repeatedly substantiated in studies on addictive substances (Kavanagh et al., 2009; May et al., 2004; Statham et al., 2011) and other appetitive targets (Harvey, Kemps & Tiggemann, 2005; May et al., 2004; May, Andrade, Kavanagh & Penfound, 2008), as have relationships between more intense imagery and greater craving (Kavanagh et al., 2009). Imagery emulates the multisensory nature of actual consumption, thus craving for alcohol and cigarettes is less marked by auditory than by visual, olfactory and gustatory images (Kavanagh et al., 2009; May et al., 2004).

An implication of the contention that elaboration typically involves the articulation of visuospatial imagery is that this process will compete for working memory capacity with other visuospatial tasks. Consistent with our prediction, participants who were craving chocolate showed impaired performance on visuospatial – but not verbal/auditory – tasks (Tiggeman, Kemps & Parnell, 2010), if they gave priority to elaboration of craving (Kemps, Tiggeman & Grigg, 2008).

On the other hand, investing attentional resources in a visuospatial task such as neutral visual imagery should interfere with craving. This prediction has been confirmed for both cigarette

(May, Andrade, Panabokke & Kavanagh, 2010b; Versland & Rosenberg, 2007) and food cravings (Hamilton, Fawson, May, Andrade, & Kavanagh, 2013; Kemps & Tiggeman, 2007, 2009; Kemps, Tiggeman & Bettany, 2012). Other visuospatial tasks such as clay modeling out of sight (Andrade, Pears, May, & Kavanagh, 2012; May, Andrade, Panabokke & Kavanagh, 2010), playing the mobile app Tetris® (Skorka-Brown, Andrade & May, 2014), tapping a spatial pattern or maintaining lateral eye movements (McClelland, Kemps & Tiggeman, 2006) also reduce craving for these targets. Even passive exposure to sensory stimuli can disrupt imagery and craving. Examples are odours (Kemps & Tiggeman, 2013b; Kemps et al., 2012) and dynamic visual noise (changing patterns of black/white squares on a screen; Kemps, Tiggeman & Christianson, 2008; May Andrade, Panabokke & Kavanagh, 2010; McClelland et al., 2006; Steel, Kemps & Tiggeman, 2006).

Mental imagery about consumption does not always enhance craving for appetitive targets: it can also elicit satiation. Repeated imagery focussing upon motor actions of eating food can have a habituating effect, reducing subsequent food consumption (Morewedge, Huh & Vosgerau, 2010). While a clinical application of this strategy may carry risk, in maintaining attention to the appetitive target, it may offer a way to modify craving imagery when aversive or irrelevant imagery or other competing tasks do not sufficiently blunt its vividness and affective power.

Applications of EI Theory

Measurement of craving

EI Theory has informed advances in the measurement of craving, by providing a framework against which components of existing substance specific scales can be evaluated and compared. Kavanagh et al. (2013) reviewed a wide range of measures intended to assess alcohol craving, arguing that most confounded craving with behaviours, expectancies,

intentions and perceived control. They also noted that retrospectivity of reporting produces a significant risk of error, and argued that a focus on a recent highly salient episode and on episode frequency or duration may be the best options when ecological momentary assessment is impractical. Among established measures, the Penn Alcohol Craving Scale and the Obsessive subscale of the OCDS were seen to have the greatest conceptual coherence and research support.

Statham et al. (2011) had already developed the Alcohol Craving Experience (ACE) questionnaire, based on EI Theory, which assessed the frequency of craving and the nature of the most intense episode over the previous week. Inclusion of imagery in the ACE was strongly supported by the ability of image frequency to predict 12-16% of the variance in alcohol consumption measures in Connor et al. (2014). May et al. (2014) showed that a generalized version of the ACE (the Craving Experience Questionnaire, CEQ) had a consistent internal structure that applied not only to alcohol, but also to cigarettes, food and chocolate. Jauregui-Lobera, Boleros-Rios, Valero & Prieto (2012) validated items from the CEQ with students who had been induced to crave food, and confirmed that vivid multisensory imagery was associated with urge strength, with the exception of auditory imagery. In a multiple regression, three imagery items and an expectancy item predicted urge strength, outweighing age, sex, imagery ability, depression and anxiety measures, and scales from the Food Craving Inventory.

Others have used EI Theory to guide their development of novel questionnaires, such as the Food Preoccupations Questionnaire (Tapper and Pothos, 2010). Building upon EI Theory's focus on elaborative cognition, Caselli and Spada (2011) developed the Desire Thinking Questionnaire (DTQ), measuring 'verbal perseveration' and 'imaginal prefiguration', both of which predicted alcohol use in alcohol dependent volunteers seeking treatment, and nicotine dependence in smokers (Caselli et al., 2012). Caselli and Spada (2010, 2013) also constructed

the Metacognitions about Desire Thinking Questionnaire (MDTQ) to assess the degree to which individuals held positive or negative beliefs about desire thinking and their ability to control desire related thoughts, providing a link to metacognitive approaches to depression and anxiety disorders.

While a lack of conceptual clarity has historically bedeviled research into craving and has held back major advances, distinguishing the experience of craving from its consequences now provides a solid basis for better understanding and assessment of craving and its modulation.

Therapeutic approaches

Several strategies that modulate craving in the laboratory have potential application to treatment, and some have been piloted in the field. For example, undergraduates experienced less intense food cravings over 4 weeks and consumed fewer calories after craving, when they used a hand-held device to display dynamic visual noise in response to food cravings (Kemps & Tiggemann, 2013a). Skorka-Brown et al. (in preparation) have undertaken a similar trial using Tetris®, and Knäuper, Pillay, Lacaille, McCollam and Kelso (2011) found that the intensity of cravings over 4 days was reduced when undergraduates who wanted to reduce cravings for a specific food or drink vividly imagined engaging in a favourite activity whenever they experienced the craving. There were no such changes for groups who formed implementation intentions to reduce their craving, without explicit imagery instructions, or who performed the verbal task of counting backwards. Hsu et al. (2013) trialled a smartphone app (iCrave), which gave a written instructions to create specified neutral images when users craved snacks, and asked users to record both snacking and successful behavioural control. Over a week, community volunteers using iCrave ate fewer unhealthy snacks (but similar amounts of healthy snacks) as others who simply tracked their snacking.

Rodriguez-Martin, Gomez-Quintana, Diaz-Martinez and Molerio-Perez (2013) designed a self-help manual based on EI theory, using imagery and non-imagery tasks that selectively target the components of cravings in working memory, to prevent an elaborative response to the initial target-related intrusion. Over 3 months, they found that dieters randomly allocated to using the manual improved on measures related to craving, compared with others who were just asked to control craving using willpower. BMI decreased by 6%, compared to no change in the control group.

To date, mindfulness-based treatments have received the most attention in randomised controlled trials with clinical populations. While mindfulness is not derived from EI Theory, its elicitation of sensory and cognitive awareness to changing experience and emotional distancing ('disidentification') is expected to impede elaboration of craving thoughts, while acceptance of the thoughts avoids the risks of increasing the salience and emotional impact of subsequent thoughts by attempting suppression or engaging in negative metacognitions.

Available trials on substance abuse typically use mindfulness as a component rather than as the sole treatment. A systematic review of these treatments in 2009 summarized seven randomized controlled trials (Zgierska et al., 2009): While five of the six with per-protocol data gave positive differential effects on substance use, only two of the four that used a more stringent intention-to-treat approach to the analysis did so. A later study (Bowen et al., 2009) examined a treatment combining mindfulness with cognitive-behavioral relapse prevention ('Mindfulness-Based Relapse Prevention'), testing it against usual aftercare in 168 patients who had completed initial treatment for substance use disorders. Eight weekly 2-hour group sessions of the treatment resulted in improved substance use outcomes at 2 and 4 months after entry, but not at 6 months. Consistent with EI Theory, increased acceptance, awareness, and nonjudgment mediated the differential effects of the treatment on craving (Witkeiwitz, Boweb, Douglas & Hsu, 2013).

EI Theory may also be applied in clinical settings, to increase motivation for functional behaviors. In a novel intervention for anorexia nervosa based upon EI Theory, Treasure et al (2010) trialled ‘vodcasts’ (short videoclips with imagery, music and commentary) on nutritional needs, mindful eating and motivational reflection in four patients. Cardi et al. (2012) compared one of these vodcasts with a control condition of classical music. Patients with restrictive eating disorders consumed more of a test meal and had less anxiety and fewer negative thoughts following the vodcast.

Future directions

We have recently argued that EI Theory has potential to enhance the impact of motivational interventions (Kavanagh Andrade, May & Connor, 2014), by eliciting imagery about the benefits of functional behavior change, together with examples of past successes and effective strategies. This new approach (Functional Imagery Training) not only employs imagery throughout sessions: It uses routine activities, calendar reminders and SMSs to cue participants to rehearse and elaborate the imagery in the natural environment, to maintain motivation in the face of temptations. The imagery is episodic and multisensory, recreating actual recalled experiences and imagining future events, and emphasizing pleasurable aspects. We expect that this imagery will not only boost motivation, but will also interfere with craving imagery. We anticipate that a focus on the benefits of functional outcomes (e.g. feeling alert and healthy after restricting alcohol the night before) will be more successful in sustaining behaviour change than a focus on potential negative outcomes of dysfunctional behavior (e.g. a hangover), because people will be more motivated to engage in pleasurable than aversive imagery in the natural environment (Andrade, Kavanagh & May, 2012; May, Andrade, Kavanagh & Hetherington, 2012). Trials of this approach are in progress.

Beyond craving and addiction

As a general theory of desire, EI theory was never intended to apply only to addictive substances. Toates (2009) draws upon EI Theory throughout his integrative framework for explaining sexual motivation, arousal and behaviour, and Friese and Hofmann (2012) refer to the theory to explain why individuals low in attentional control succumb to impulses and find it harder to exert self-control when viewing erotic material. From a marketing perspective, Ramanathan and Menon (2006) based their model of repeated indulgence over time upon EI theory, in particular the strengthening of positive affective associations from each episode. In social psychology, Ijzerman et al. (2012) used EI Theory to support their argument that cognitive appraisal was a necessary component of emotional and bodily responses to social exclusion and ostracism, rather than their being automatic consequences. EI theory has even been applied to explain why people gain pleasure from pictorial representations in literature (Albers, 2008).

In a parallel with EI Theory's emphasis on the role of mental imagery in elaboration, Holmes, Arntz & Smucker (2007) advocated imagery rescripting for a range of psychopathologies, including PTSD, eating disorders, depression, and phobias. Holmes, Geddes, Colom and Goodwin (2008) argue that imagery suggests a unifying explanation for key unexplained features of bipolar disorder including ubiquitous anxiety, mood instability and creativity, and suggest that imagery should form part of CBT for bipolar treatment. Holmes, Lang & Shah (2009) described a form of imagery-based interpretation bias modification as a 'cognitive vaccine' that could help individuals withstand depressed mood, and Pictet et al. (2011) provide evidence to advocate training dysphoric individuals in forming positive mental imagery, as part of cognitive behavioural therapy for depression.

Conclusions

EI theory now has a substantial evidence base confirming key predictions. Intrusive thoughts and sensory images are ubiquitous across desires for addictive and everyday substances. Retraining attentional biases to desire-cues, guided imagery, and mindfulness-based strategies help to reduce intrusive thoughts and lower craving. Blocking desire imagery with competing images or cognitive loads in the same modality reduces the strength and frequency of unwanted desires, while encouraging sensory imagery of desired outcomes helps increase behaviours to achieve them.

For addiction research, EI theory provides a comprehensive account of the cognitive processes underpinning drug cravings, explains their motivational power, and points the way to interventions that reduce elaboration or harness mental imagery to strengthen functional desires. It has also underpinned improvements in tools for assessing craving. The wider influence of EI theory has been to help establish the important role of mental imagery in psychopathology and its treatment more generally. Based on this review, we suggest that addiction research will benefit from a greater focus on the commonalities of mental processes across different substance addictions, and that EI theory provides a framework achieving this aim.

References

- Achtziger, A, Gollwitzer, PM, Sheeran, P. (2008). Implementation intentions and shielding goal striving from unwanted thoughts and feelings. *Personality and Social Psychology Bulletin*, 34(3), 381-393.
- Albers, P. (2008). Theorizing visual representation in children's literature. *Journal Of Literacy Research*, 40(2), 163-200.
- Andrade, J, May, J, Kavanagh, DJ. (2012). Sensory imagery in craving: From cognitive psychology to new treatments for addiction. *Journal of Experimental Psychopathology*, 3 (2), 127-145.
- Andrade, J, Pears, S, May, J, Kavanagh, DJ. (2012). Use of a clay modeling task to reduce chocolate craving. *Appetite*, 58, 955–963.
- Berry, L.-M, Andrade, J, May, J. (2007). Hunger-related intrusive thoughts reflect increased accessibility of food items. *Cognition and Emotion*, 21(4), 865-878.
- Berry, L.-M, May, J, Andrade, J, Kavanagh, DJ. (2010). Emotional and behavioural reaction to intrusive thoughts. *Assessment*, 17, 126-137.
- Bowen, S, Chawla, N, Collins, SE, Witkiewitz, K, Hsu, S, Grow, J...Marlatt, A. (2009). Mindfulness-based relapse prevention for substance use disorders: A pilot efficacy trial. *Substance Abuse*, 30, 295–305.
- Cardi, V, Kan, C, Roncero, M, Harrison, A, Lounes, N, Tchanturia, K, Meyer, C, Treasure, J. (2012). Mealtime support in anorexia nervosa: A within-subject comparison study of a novel vodcast intervention. *Psychotherapy and Psychosomatics*, 81(1), 54-55.
- Caselli, G, Nikcevic, A, Fiore, F, Mezzaluna, C, Spada, MM. (2012). Desire thinking across the continuum of nicotine dependence. *Addiction Research Theory*, 20(5), 382-388.

- Caselli, G, Soliani, M, Spada, MM. (2013). The effect of desire thinking on craving: An experimental investigation. *Psychology of Addictive Behaviors*, 27(1), 301-306.
- Caselli, G, Spada, MM. (2010). Metacognitions in desire thinking: A preliminary investigation. *Behavioural and Cognitive Psychotherapy*, 38(5), 629-637.
- Caselli, G, Spada, MM. (2011). The Desire Thinking Questionnaire: Development and psychometric properties. *Addictive Behaviors*, 36(11), 1061-1067.
- Caselli, G, Spada, MM. (2013). The Metacognitions about Desire Thinking Questionnaire- Development and psychometric properties. *Journal of Clinical Psychology*, 69(12), 1284-1298.
- Connor, JP, Kavanagh, DJ, Andrade, J, May, J, Feeney, GFX, Gullo, MJ, White, AM, Fry, M-L, Drennan, J, Previte, J, Tjondronegoro, D. (2014). Alcohol consumption in young adults: the role of multisensory imagery. *Addictive Behaviors*, 39, 721–724.
- Ferriter, C, Ray, LA. (2011). Binge eating and binge drinking: An integrative review. *Eating Behaviors*, 12(2), 99-107.
- Field, M, Cox, WM. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence*, 97(41671), 1-20.
- Field, M, Duka, T, Eastwood, B, Child, R, Santarcangelo, M, Gayton, M. (2007). Experimental manipulation of attentional biases in heavy drinkers: Do the effects generalise? *Psychopharmacology*, 192(4), 593-608.

- Field, M, Munafò, MR, Franken, IHA. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin*, 135(4), 589-607.
- Friese, M, Hofmann, W. (2012). Just a little bit longer: Viewing time of erotic material from a self-control perspective. *Applied Cognitive Psychology*, 26(3), 489-496.
- Giuliani, NR, Calcott, RD, Berkman, ET. (2013). Piece of cake. Cognitive reappraisal of food craving. *Appetite*, 64, 56-61.
- Gollwitzer, PM, Sheeran, P. (2006). Implementation intentions and goal achievement- A meta-analysis of effects and processes. *Advances in Experimental Social Psychology*, 38, 69-119.
- Hamilton, J, Fawson, S, May, J, Andrade, J, Kavanagh, DJ. (2013). Brief guided imagery and body scanning interventions reduce food cravings. *Appetite*, 71, 158-162.
- Harvey, K, Kemps, E, Tiggemann, M. (2005). The nature of imagery processes underlying food cravings. *British Journal of Health Psychology*, 10, 49-56.
- Ho, MC, Chang, CF, Li, RH, Tang, TC. (2013). Attentional biases for betel nut cues in heavy and light chewers. *Psychology of Addictive Behaviors*, 27(4), 1044-1049.
- Hofmann, W, Schmeichel, BJ, Baddeley, AD. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences*, 16(3), 174-180.
- Hofmann, W, Van Dillen, L. (2012). Desire: The new hot spot in self-control research. *Current Directions in Psychological Science*, 21(5), 317-322.

- Holmes, EA, Arntz, A, Smucker, MR. (2007). Imagery rescripting in cognitive behaviour therapy: Images, treatment techniques and outcomes. *Journal of Behavior Therapy And Experimental Psychiatry*, 38(4), 297-305.
- Holmes, EA, Geddes, JR, Colom, F, Goodwin, GM. (2008). Mental imagery as an emotional amplifier: Application to bipolar disorder. *Behaviour Research and Therapy*, 46(12), 1251-1258.
- Holmes, EA, Lang, TJ, Shah, DM. (2009). 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(1), 76-88.
- Holmes, EA, Mathews, A. (2010). Mental imagery in emotion and emotional disorders. *Clinical Psychology Review*, 30(3), 349-362.
- Hsu, A, Yang, J, Yilmaz, Y, Haque, MS, Can, C, Blandford, A. (2014). Persuasive technology for overcoming food cravings and improving snack choices. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. New York: ACM. Pp. 3403-3412.
- Ijzerman, H, Gallucci, M, Pouw, WTJL, Weissgerber, SC, Van Doesum, NJ, Williams, KD. (2012). Cold-blooded loneliness: Social exclusion leads to lower skin temperatures. *Acta Psychologica*, 140(3), 283-288.
- Jauregui-Lobera, I, Bolanos-Rios, P, Valero, E, Prieto, IR. (2012). Induction of food craving experience; the role of mental imagery, dietary restraint, mood and coping strategies. *Nutricion Hospitalaria*, 27(6), 1928-1935.

- Kakoschke, N, Kemps, E, Tiggemann, M. (2014). Attentional bias modification encourages healthy eating. *Eating Behaviors, 15(1)*, 120-4.
- Kavanagh, DJ, Andrade, J, May, J. (2005). Imaginary relish and exquisite torture: The Elaborated Intrusion theory of desire. *Psychological Review, 112 (2)*, 446-467.
- Kavanagh, DJ, Andrade, J, May, J, Connor, JP. (2014). Imagery-based skills training for wellbeing—An alternative to motivational interviewing for alcohol misuse. A response to McCambridge and Rollnick (2013). *Addiction, 109 (7)*, 1062-1063.
- Kavanagh, DJ, 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.
- Kavanagh, DJ, Statham, DJ, Feeney, GFX, Young, RMCD, May, J, Andrade, J, Connor, J. (2013). Measurement of alcohol craving. *Addictive Behaviors, 38 (2)*, 1572-1584.
- 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. (2009). Competing visual and olfactory imagery tasks suppress craving for coffee. *Experimental and Clinical Psychopharmacology, 17(1)*, 43-50.
- Kemps, E, Tiggemann, M. (2010). A cognitive experimental approach to understanding and reducing food cravings. *Current Directions in Psychological Science, 19(2)*, 86-90.
- Kemps, E, Tiggemann, M (2013a). Hand-held dynamic visual noise reduces naturally occurring food cravings and craving-related consumption. *Appetite, 68*, 152-157.

- Kemps, E, Tiggemann, M (2013b). Olfactory stimulation curbs food cravings. *Addictive Behaviors*, 38(2), 1550-1554.
- Kemps, E, Tiggemann, M, Bettany, S. (2012). Non-food odorants reduce chocolate cravings. *Appetite*, 58(3), 1087-1090.
- Kemps, E, Tiggemann, M, Christianson, R. (2008). Concurrent visuo-spatial processing reduces food cravings in prescribed weight-loss dieters. *Journal of Behavior Therapy and Experimental Psychiatry*, 39(2), 177-186.
- Kemps, E, Tiggemann, M, Grigg, M. (2008). Food cravings consume limited cognitive resources. *Journal of Experimental Psychology: Applied*, 14(3), 247-254.
- Kemps, E, Tiggemann, M, Martin, R, Elliott, M. (2013). Implicit approach-avoidance associations for craved food cues. *Journal of Experimental Psychology-Applied*, 19(1), 30-38.
- Kemps, E, Tiggemann, M, Orr, J, Gear, J. (2014). Attentional retraining can reduce chocolate consumption. *Journal of Experimental Psychology-Applied*, 20(1), 94-102.
- Knäuper, B, Pillay, R, Lacaille, J, McCollam, A, Kelso, E. (2011). Replacing craving imagery with alternative pleasant imagery reduces craving intensity. *Appetite*, 57(1), 173-178.
- Lovibond, P. F, Colagiuri, B. (2013). Facilitation of voluntary goal-directed action by reward cues. *Psychological Science*, 24(10), 2030-2037.
- May, J, Andrade, J, Batey, H, Berry, L.-M, Kavanagh, DJ. (2010). Less food for thought: Impact of attentional instructions on intrusive thoughts about snack foods. *Appetite*, 55, 279-287.

- May, J, Andrade, J, Kavanagh, DJ, Feeney, GFX, Gullo, M, Stathan, DJ, Deas, J, Connolly, JM, Cassimatis, M, Young, RMc D, Connor, JP. (2014). The Craving Experience Questionnaire: A brief, theory-based measure of consummatory desire and craving. *Addiction*. doi: 10.1111/add.12472
- May, J, Andrade, J, Kavanagh, DJ, Hetherington, M. (2012). Elaborated intrusion theory: A cognitive-emotional theory of food craving. *Current Obesity Reports*, 1(2), 114-121.
- May, J, Andrade, J, Kavanagh, DJ, Penfound, L. (2008). Imagery and strength of craving for eating, drinking and playing sport. *Cognition and Emotion*, 22, 633-50.
- May, J, Andrade, J, Panabokke, N, Kavanagh, DJ. (2004). Images of desire: cognitive models of craving. *Memory*, 12, 447-461.
- May, J, Andrade, J, Panabokke, N, Kavanagh, DJ. (2010). Visuospatial tasks suppress craving for cigarettes. *Behaviour Research and Therapy*, 48, 476–485.
- May, J, Andrade, J, Willoughby, K. Brown, C. (2012) An attentional control task reduces intrusive thoughts about smoking. *Nicotine Tobacco Research*, 14(4), 472-478.
- McClelland, A, Kemps, E, Tiggemann, M. (2006). Reduction of vividness and associated craving in personalized food imagery. *Journal of Clinical Psychology*, 62(3), 355-365.
- Morewedge, C. K, Huh, Y. E, Vosgerau, J. (2010). Thought for food: Imagined consumption reduces actual consumption. *Science*, 330(6010), 1530-1533.
- Nordgren, LF, Chou, EY. (2013). A devil on each shoulder: When (and why) greater cognitive capacity impairs self-control? *Social Psychological and Personality Science*, 4(2), 233-237.

- Oh, H, Taylor, AH. (2013). A brisk walk, compared with being sedentary, reduces attentional bias and chocolate cravings among regular chocolate eaters with different body mass. *Appetite*, 71, 144-149.
- Ostafin, BD, Kassman, KT, Wessel, I. (2013). Breaking the cycle of desire: Mindfulness and executive control weaken the relation between an implicit measure of alcohol valence and preoccupation with alcohol-related thoughts. *Psychology of Addictive Behaviors*, 27(4), 1153-1158.
- Papies, EK, Barsalou, LW, Custers, R. (2012). Mindful attention prevents mindless impulses. *Social Psychological and Personality Science*, 3(3), 291-299.
- Pictet, A, Coughtrey, AE, Mathews, A, Holmes, EA. (2011). Fishing for happiness: The effects of generating positive imagery on mood and behaviour. *Behaviour Research And Therapy*, 49(12), 885-891.
- Ramanathan, S, Menon, G. (2006). Time-varying effects of chronic hedonic goals on impulsive behavior. *Journal of Marketing Research*, 43(4), 628-641.
- Rivis, A, Sheeran, P. (2013). Automatic risk behavior: Direct effects of binge drinker stereotypes on drinking behavior. *Health Psychology*, 32(5), 571-580.
- Robinson, TE, Berridge, KC. (2003). Addiction. *Annual Review of Psychology*, 54, 25–53.
- Rodriguez-Martin, BC, Gomez-Quintana, A, Diaz-Martinez, G, Molerio-Perez, O. (2013). Bibliotherapy and food cravings control. *Appetite*, 65, 90-95.
- Roskow-Ewoldsen, B. (2006). Converging on a richer understanding of human behavior and experience through a blending of cognitive and clinical psychology. *Journal of Clinical Psychology*, 62(3), 367-371.

- Sayette, MA, Schooler, JW, Reichle, ED. (2010). Out for a smoke: The impact of cigarette craving on zoning out during reading. *Psychological Science, 21(1)*, 26-30.
- Schlauch, RC, Gwynn-Shapiro, D, Stasiewicz, PR, Molnar, DS, Lang, AR. (2013). Affect and craving: Positive and negative affect are differentially associated with approach and avoidance inclinations. *Addictive Behaviors, 38(4)*, 1970-1979.
- Schmidt, AF, Eulenbruch, T, Langer, C, Banger, M. (2013). Interoceptive awareness, tension reduction expectancies and self-reported drinking behavior. *Alcohol and Alcoholism, 48(4)*, 472-477.
- Skinner, MD, Aubin, HJ. (2010). Craving's place in addiction theory: Contributions of the major models. *Neuroscience and Biobehavioral Reviews, 34(4)*, 606-623.
- Skjorka-Brown, Andrade, J, May, J. (in preparation).
- Statham, DJ, Connor, JP, Kavanagh, DJ, Feeney, GFX, Young, RMcD, May, J, Andrade, J. (2011). Measuring alcohol craving: Development of the Alcohol Craving Questionnaire. *Addiction, 106*, 1230-1238.
- Steel, D, Kemps, E, Tiggemann, M. (2006). Effects of hunger and visuo-spatial interference on imagery-induced food cravings. *Appetite, 46(1)*, 36-40.
- Szasz, P. L, Szentagotai, A, Hofmann, SG. (2012). Effects of emotion regulation strategies on smoking craving, attentional bias, and task persistence. *Behaviour Research and Therapy, 50(5)*, 333-340.
- Tapper, K, Pothos, EM. (2010). Development and validation of a Food Preoccupation Questionnaire. *Eating Behaviors, 11(1)*, 45-53.

- Tiggemann, M, Kemps, E, Parnell, J. (2010). The selective impact of chocolate craving on visuospatial working memory. *Appetite, 55(1)*, 44-48.
- Toates, F. (2009). An Integrative Theoretical Framework for Understanding Sexual Motivation, Arousal, and Behavior. *Journal of Sex Research, 46(41700)*, 168-193.
- Treasure, J, Crane, A, McKnight, R, Buchanan, E, Wolfe, M. (2011). First do no harm: Iatrogenic maintaining factors in anorexia nervosa. *European Eating Disorders Review, 19(4)*, 296-302.
- Treasure, J, Macare, C, Mentxaka, IO, Harrison, A. (2010). The use of a vodcast to support eating and reduce anxiety in people with eating disorder: A Case Series. *European Eating Disorders Review, 18(6)*, 515-521.
- 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 Dillen, LF, Papiers, EK, Hofmann, W. (2013). Turning a blind eye to temptation: How cognitive load can facilitate self-regulation. *Journal of Personality and Social Psychology, 104(3)*, 427-443.
- Versland, A, Rosenberg, H. (2007). Effect of brief imagery interventions on craving in college student smokers. *Addiction Research Theory, 15(2)*, 177-187.
- Watkins, E. (2011). Dysregulation in level of goal and action identification across psychological disorders. *Clinical Psychology Review, 31(2)*, 260-278.
- Witkiewitz, K, Bowen, S, Douglas, H, Hsu, SH. (2012). Mindfulness-based relapse prevention for substance craving. *Addictive Behaviors, 38(2)*, 1563–1571.

Wray, JM, Gass, JC, Tiffany, ST. (2013). A systematic review of the relationships between craving and smoking cessation. *Nicotine Tobacco Research, 15(7)*, 1167-1182.

Zgierska, A, Rabago, D, Chawla, N, Kushner, K, Koehler, R, Marlatt, A. (2009).

Mindfulness meditation for substance use disorders: A systematic review. *Substance Abuse, 30*:266–294.

Figure 1. The Elaborated Intrusion theory of motivation, showing the contribution of triggers (rounded external boxes), intrusive thoughts ('desire thoughts'), and sensory imagery to desire (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).

Figure 1:



