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An investigation on the effects of a visuospatial imagery task on smoking related craving

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2009

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Abstract

Twenty eight undergraduate students participated in a study to examine the impact of a visuospatial imagery intervention and an articulatory cognitive intervention on self-reported smoking related craving, based on the framework introduced by the Elaborate Intrusion Theory of craving. A significant interaction between the duration of the experiment and self-reported craving was obtained, with a significant negative impact on craving after the articulatory cognitive task, indicating that the visuospatial imagery intervention demonstrated an inhibitory effect on substance related elaboration. A simple modality-specific imagery task, blocking intrusive substance related imagery by utilizing the same cognitive components of craving, worked to subdue the intensity of craving and may therefore provide the means of an independent strategy for abstaining tobacco smokers.

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Ethical Statement

The study conforms to the guidelines of the University of Plymouth for research involving human participants.

Each participant was fully informed about the interests and aims of the current study, with a detailed instruction of the experimental task before being asked for their informed consent.
No important information was withheld and the participants were made aware of the possibility to ask, at any time, if unsure about anything.
Each participant was told in the briefing and debriefing that the participation in the experiment was voluntary and that they could withdraw from the experiment at any time with no negative consequences.
No extraordinary harm was expected, and the Health and Safety regulations of the University of Plymouth were strictly followed. In case of any further questions about the experiment the contact information of the project supervisor was provided for each participant.
A complete and detailed debriefing was given to each participant.
Each participant was assured that only the supervisor and the team involved in the experiment will have access to the data and that there is no direct link between the name and data collected.

The data used in this study was collected in cooperation with Alexander Wheatley. However, for the analysis a reduced set of the combined data was used.

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Introduction

> *The thick and penetrating layers of cigarette smoke had been stopped months ago. Even the tenacious scent of nicotine, imbedded in many fabrics and materials, had been vanished or covered, and yet with the first sip at a nice and aromatic cup of coffee it is back, the urge to smoke a cigarette. What are those powerful processes that constitute the urge many people experience, which easily can lead to relapse, and is there a possibility to beat that urge?*

The reoccurring compulsion to 'devote' or to 'give one self over' (lat. '*addicere*'), to a specific activity, despite the harmful consequences to one's health or social life, is captured in the concept of addiction. The phenomenon has been described within the discipline of psychology many decades ago, with the attempt to specify a clinical impression of the symptoms forming the complex structure of addiction (Jellinek, 1960; Edwards & Gross, 1976). Due to the complexity of addiction around 98 different models and theories have been identified and mentioned by West (2006), each of them trying to provide answers for the aetiology and maintenance of the alcohol and other drugs (AOD) dependency syndrome. It is suggested that smoking is the greatest cause of death and disability than any other single disease, and that it could be responsible for more than 8 million deaths worldwide a year by 2030, as the worldwide use of tobacco continues to rise (WHO, 2008). Due to the short-lived effects of smoked tobacco, smokers experience withdrawal effects and a strong desire to smoke only a short period of time after their last consumption (Hendricks, 2006).

The occupying thoughts and the intense desire, which are well known and referred to as craving, has been identified as an important motivational factor in the maintenance of substance abuse and relapse after prolonged periods of abstinence (Schiffman et al., 1997; Tiffany, 1990; Jellinek, 1955). However, despite the numerous accounts on addiction and the early recognition of craving as a central component of addiction, there is no consensus within the scientific community about either a valid definition, or behavioural interventions to eliminate or counteract craving (Kavanagh, Andrade, & May, 2004). This study will investigate the phenomenon of smoking related craving on the basis of a cognitive concept of craving, the Elaborate Intrusion Theory (Kavanagh, Andrade & May, 2005) in order to gain further supporting evidence for the underlying theory.

Early theories of craving have been focused on the causes of craving, and the most prominent models of craving derived from a classical/operant conditioning background, i.e. the Cue-exposure Theory (Drummond, 2000), and a neurobiological background (Koob & LeMoal, 2001, Robinson & Berridge, 2000). Conditioning theories of craving suggested that certain stimuli, such as cigarette related cues, paired with withdrawal symptoms, become conditioned stimuli, which in return elicit conditioned withdrawal effects leading to craving (Wikler, 1948; Drummond, 1995). Although craving has been found as a conditioned response to withdrawal symptoms (O'Brian, O'Brian, Mintz & Brady, 1975), and with even more consistent results for drug agonistic effects (Niaura et al., 1988; Kavanagh et al., 2005), conditioning theories of craving fail to

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provide a clear description of the complete process of craving, including underlying cognitive structures, which are important in the development of therapies to overcome addiction.

With around 500 gaseous compounds and around 3500 particles in cigarette smoke (National Cancer Institute, 2001), neurochemical and physiological responses have been translated into neurochemical or neuroadaptive models of craving and addiction (Anton, 1999). Here, homeostasis, i.e. the aspired balance of critical body and brain functions, regarding the adaptation to a prolonged presence of psychotropic substances, e.g. alcohol or nicotine, is central to the neuroadaptive hypothesis (Koob and LeMoal, 1997; Koob and Roberts, 1999). In particular, reward memory has been suggested as a key feature in maintaining the maladaptive behaviour. It is suggested that the rewarding effects of drugs have their origin in the mesocorticolimbic system, where the neurotransmitters dopamine, glutamate, gamma-aminobutyric acid (GABA), and endogenous opioids normally operate on a homeostatic basis (Koob et al., 2001), and with an imbalance in the system leading to states of withdrawal and craving. Pharmacotherapies used in the treatment of addiction find their range of application here, as psychotropic drugs, such as 'Naltrexone', 'Acamprosate', 'Tiapride', and 'Disulfiram' have been identified as beneficial in the treatment of addiction, reducing not only the consumption but also the craving for the desired substance (Anton et al., 2006; Swift, 1999; Ray et al., 2007), however the effect on craving is not consistent throughout scientific research (Epstein & King, 2004). Despite the described underlying neurobiological processes during acute withdrawal in neurobiological models, there is no clear account for the time course of desire (Kavanagh et al., 2005), nor is there a clear explanation of the underlying processes for a relapse after a prolonged period of abstinence when long-term recollective memory is assumed to initiate reward memory circuits (Anton, 1999). Therefore, models merely based on conditioning or neurological changes are limited due to their emphasis on the causes of craving, failing to offer a complete picture of craving, especially with concepts, such as memory, attention, executive functions and higher order brain regions identified important in craving (Grant et al., 1996; Lyvers, 2000).

However different the accounts on craving appear, there is a general consensus about the ability of environmental cues to elicit episodes of withdrawal and craving, and with recent research demonstrating an attentional bias towards desired target stimuli in substance users (Robbins & Ehrman, 2004), it can be suggested that substance users are more likely to orientate towards cues in the environment that elicit or exacerbate craving. For example, smokers tested with the dot-probe task (MacLeod, Mathews, & Tata, 1986) showed a significant faster reaction for smoking-related pictures in comparison to unrelated control pictures (Mogg, Bradley, Field, & DeHouwer, 2003), with a positive relationship between the strength of the bias and self-reported craving (Waters, Shiffman, Bradley, & Mogg, 2003; Mogg & Bradley, 2002; Kavanagh et al., 2005). This strong cue reactivity has been incorporated into several models of craving (e.g. Drummond, 2000; Tiffany, 1990). The selective attention in substance users, i.e. the cognitive process of selectively focusing on a single aspect of the environment while ignoring other things, as demonstrated in several studies is closely linked with the notion of limited attentional capacity (Broadbent, 1958; Cowan, 1997), and recent studies using the commonly known Stroop colour-naming task paradigm (Stroop, 1935) showed an impeded colour naming of smoking-related words in overnight smoking deprived

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participants (Gross, Jarvik, & Rosenblatt, 1993), and similar effects on food words in food deprived participants (Channon & Hayward, 1990). Furthermore, research comparing measurements of working memory with effects of smoking cessation found a strong negative relationship, indicating a working memory deficit during acute abstinence from smoking (Mendrek et al., 2006).

With the notion of working memory and attentional deficits during craving episodes, it can be suggested that target cues trigger strong associations, which lead to cognitive rumination about the desired substance, presenting a difficulty for the craving person to focus on something else. The intuitive attempt to just suppress craving-related thoughts, or simply try to relax appeared to be an ineffective strategy, as mere thought suppression and relaxation has been demonstrated as an unreliable method (Salkovskis and Reynolds, 1994; Reynolds, Valmana, Kouimtsidis, Donaldson, & Ghodse, 2005). Therefore, a cognitive model as represented by the Elaborate Intrusion Theory (Kavanagh et al., 2005), which integrates all the identified factors and offers an explanation of their interaction is of advantage when examining the phenomenon of human craving, or the development of innovative psychological interventions for craving.

The Elaborate Intrusion Theory describes craving as the desire to engage in a certain behaviour, and as a result of thoughts and images about that particular behaviour, including the awareness of affective and physiological states. The major proposition imbedded in the Elaborate Intrusion Theory (EI Theory) is that substance craving involves conscious cognition of intrusive thoughts caused by learned associations with the potential to determine appetitive behaviour, which is in contrast to former assumptions craving being just epiphenomenal to appetitive behaviour (Tiffany, 1990). The conscious cognition, i.e. elaboration, involves controlled processes of search for target-related information and the retention of the information in working memory, as a result from basic associative processes. The associative processes find their expression in intrusive thoughts about the desired target, and can be triggered by internal or external antecedent events, such as physiological states, negative affect, external cues, cognitive activity, or anticipatory responses to the target. The intrusive thoughts can easily become focus of attention as they possess the ability to elicit positive affective responses, reinforcing thoughts about the desired substance which in return might cause further associations in a self-perpetuating system. However, unless those intrusions are intended they are transitory effects, vulnerable to distraction by other more salient stimuli or cognitive activity, as the entailed elaborate processes compete with limited resources of working memory. Here, a clear distinction between elaborate and intrusive thoughts, similar to the distinction of automatic and controlled processing (Shiffrin & Schneider, 1977), is important in the context of initiation and impact of craving episodes and their behavioural outcome.

Moreover, it is suggested that desire related rumination include the construction of vivid sensory images, which contribute to the richness and the emotional impact of craving episodes. The images represent information stored in long-term memory, such as sensory information (e.g. the smell of a cigarette), generic characteristics (e.g. the softness and typical colour of tobacco), and specific episodes (e.g. the kick of the first cigarette in the morning). Although the sensory images are immediately rewarding, due to the activation of emotional and motivational pathways, over a prolonged period of time the increased awareness of the discrepancy between actual and desired state may actually result in negative affect, leading to elaborate plans for target acquisition. From

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an evolutionary, and even an everyday perspective, this might be of advantage in times of scarcity or unavailability of a consummatory target, as vivid imagery and elaborate thoughts during the absence of a specific target or even target cues allow for a continuous search until the consummatory target can be obtained again. In line with the EI theory, intrusive thoughts and elaborate processes regarding, for example dairy products initiated by malnutrition, are perfectly well adapted mechanism in everyday day human motivated behaviour, and only when associated with substances or behaviour detrimental to human health or functioning, this mechanism becomes maladaptive. Although this is not the only route to human behaviour, vivid imagery represents a problem for people who try to abstain from harmful substances such as nicotine or alcohol.

With regard to the EI Theory it is suggested that craving episodes are particularly vulnerable in their transition from intrusive thoughts to elaborate thoughts, where intrusions, often in form of sensory imagery, compete for limited attentional resources provided by executive processes of working memory. With an assumption of a reciprocal relationship between the demands for cognitive resources in sensory imagery and other cognitive tasks, a task demanding working memory resources might also possess the power to decrease the intensity of craving or at least interrupt elaboration. Regarding the working memory model by Baddeley (Baddeley, 1986; Baddeley & Hitch, 1994), which incorporates an attentional component, i.e. the central executive, and two temporary storage systems, the phonological loop and the visuospatial sketchpad (VSSP), a modality-specific intervention provides a substantial opportunity for imagery alteration. These two storage sub-systems store auditory and visual information respectively, which is retrieved from long-term recollective memory. Due to the limited capacity of these sub-systems two simultaneous visual, or auditory tasks would have to share the limited resources between them, which in return would lead to a decrease in imagery vividness. Research examining the intensity of imagery about distressing events found that a concurrent visuospatial task reduced the experienced intensity of the imagery and also moderated the distress that was elicited (Kavanagh, Freese, Andrade, & May, 2001). Furthermore, interference with the phonological loop with an articulatory suppression task analogously demonstrated a reduced vividness and associated distress of predominantly auditory images (Kemps & Tiggemann, 2007).

Recent data collected, regarding sensory imagery in smoking deprived samples, suggested a dominance of visual imagery over auditory imagery in smoking-related desire (May, Andrade, Panabokke, & Kavanagh, 2004). A study by Panabokke et al. (under review) tested the effect of either a visual or auditory imagery task (as used by Baddeley and Andrade, 2000) on the intensity of craving in either a deprived, or non-deprived sample. The study showed a significant reduction of craving strength after the visual imagery task, whereas an auditory imagery task had no effect. However, the study used a multi-sensory urge-induction script (Tiffany & Hakenewerth, 1991) to elicit craving in the deprived sample, which exposed the participants to visual imagery prior to the experimental task, as it was used amongst others in the induction script, leading to a possible priming effect of visual imagery, which could be responsible for the effects found in the study. Furthermore, in a study by Versland and Rosenberg (2007), participants reported multiple forms of instructed and even non-instructed imagery, and it could also be argued that instructed auditory imagery might possibly entail visual imagery. Therefore, this study refrained from using a urge-induction script, instead

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applied an in vivo target substance manipulation task to elicit substance craving. The study by Panabokke et al. employed a non-deprived condition as a control condition, which demonstrated an impact of abstinence and urge induction on craving in cigarette smokers, as also found by Drobes and Tiffany (1997). With clear evidence for an increased craving after abstinence and urge induction the present study also refrained from introducing a non-deprived condition.

Regarding the positive results gained by latter research, one of the main aims of the present study was to take the matter of interest a step further using a more applied approach. Due to the suggested ineffectiveness of Nicotine Replacement Therapies (NRTs) in cue-provoked craving and with cue-induced craving as a main factor of relapse (Waters et al., 2004), not only NRT users, but also everyone trying to abstain from smoking would benefit from a treatment attenuating craving. However, visual imagery scripts as applied in former studies, might possess certain limitations as applied craving interventions, as long scripts containing instructions for visual imagery not only appear inconvenient, but also, over long periods of usage, a similarity in the elicited images might lead to a diminishing effectiveness. Therefore, the present study applied a visual imagery task more readily applicable in an everyday craving situation.
The task that was suggested to utilise visuospatial resources, involved participants having to mould different shapes out of 'plasticine' by touch, and was taken from a study by Steward, Holmes, & Brewin (2006). Due to the manipulation task executed out of the participant's sight, a constant visual imagery, monitoring the progress of the intended shape, was assumed. Thus, the constant visual imagery was seen as loading on the Visual Spatial Sketchpad inhibiting intrusive thoughts about smoking, leading to an interference with craving. Plasticine is a synthetic material which is similar to coloured modelling clay, but remains a soft and malleable consistency. It is readily available in any crafts or toy shops, and it is also clean to use, which would make it an ideal object for an applied intervention in acute craving episodes.

In the present study the participants were instructed to either take part in a visuospatial imagery task, consisting of a plasticine manipulation task (Stewart, Holmes, & Brewin, 2006), or a articulatory cognitive distracting task, i.e. a counting-backwards exercise, in order to gather further evidence for the attenuating effects of a concurrent visuospatial imagery task on smoking-related craving. It was predicted that the visuospatial imagery task would reduce the subjectively experienced craving intensity and inhibit further substance-related rumination, and that the articulatory cognitive task would conversely not interfere with craving. It was also predicted that there would be a significant interaction between the experimental interventions over the course of the experiment.

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Method

Design

A mixed-factor between and within subjects design was used, in which the participants were semi-randomly, on the basis of their mean baseline craving scores, assigned to either a 'visuospatial imagery' condition or an 'articulatory cognitive' condition (between subjects factor), in order to counterbalance a confounding inequality of baseline craving.

Participants

Twenty eight undergraduate students at the University of Plymouth participated in the study as part of a course requirement after they had given their informed consent. Participation criteria were a minimum of 10 cigarettes per day, and an abstinence period from the time the participants went to bed until participation ended. The participant pool consisted of four male and twenty four female students, with a mean age of 22 years, being on average a smoker for 2-5 years, and an average consumption of 10-15 cigarettes per day. The students were naïve about the purpose of the experiment.

To ensure the participation requirements the volunteers were screened by completing an altered version of the Fagerstrom Nicotine Dependency Test (FNDT), (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) to test for a minimum of 10 cigarettes per day.

Furthermore, the participants were asked to complete a carbon monoxide breath test to ensure the required period of abstinence, with a cut off level of 15 ppmCO (parts per million).

Procedure

Preceding the experiment, participants were given a detailed briefing, explaining the course of the experiment, and each participant was informed about the confidentiality of the data obtained, and their right to withdraw from the experiment at any time with no further consequences. All participants were tested between 10:00 and 12:00 hours in order to minimise craving strength fluctuations (West & Schneider, 1987). After the informed consent of the participants a carbon monoxide test, using a carbon monoxide breath test precision instrument, 'Bedfont EC50 Micro Smokerlyzer', provided by the University of Plymouth, was performed to ensure the required abstinence period.

Prior to the experimental task the participants were asked to be seated at a desk and to place their own packet of cigarettes, or tobacco on the surface of the table in front or them. The participants were then required to take out the remaining cigarettes of the packet, count the cigarettes, or use some of the tobacco to roll a cigarette, and place them into a provided repository. This in vivo smoking cue exposure procedure was used to elicit a strong craving experience prior to the experimental interventions (Drobes and Tiffany, 1997). The cigarettes were placed out of sight, with the assurance of return once the experiment was finished.

Followed by the urge induction, an amended version, to the needs of the experiment, Fagerstrom Nicotine Dependency Test (FNDT) was administered to measure the level of dependency and to gain further information on the smoking

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background of each participant to verify valid participation (Heatherton et al., 1991). For the detailed questionnaire used in this study please refer to Appendix A. The participants were then asked to complete scales to give the baseline ratings of craving strength and mood. The pre-test level of craving strength was assessed with the Factor 1 scale items from the 'Questionnaire on Smoking Urges' (QSU; Tiffany and Drobes, 1991). The Factor 1 scale items reflected primarily the intension and desire to smoke, and the anticipation of pleasure form smoking. Each item was rated on a 9-point scale reaching from '1=strongly disagree' to '9=strongly agree'. Mood was measured using a shortened 3- item mood scale, with two negative items and one positive item, derived from a factor analysis carried out by J. May (personal communication) on 60 volunteers over four previous questionnaire studies (May et al., 2004). The three items demonstrated a strong correlation r=+.921 with the original total scale as used by Diener and Emmons (1984). Each item assessing the degree to which participants currently experienced different states of mood, i.e. 'gloomy', 'glad', and 'angry', was rated on a 9-point scale reaching from '1=Not at all' to '9=Very much'.

On completion of the baseline measures each participant was semi-randomly, on the basis of their mean level of craving strength, assigned to either the 'visuospatial imagery' task, or the 'articulatory cognitive' task, and were given detailed instructions for the allocated task. Duration of both experimental tasks was two minutes.

In the 'visuospatial imagery task' condition students were required to perform a plasticine manipulation task (Stuart, Holmes & Brewin, 2006). For the task 500 grams of 'Lewis newplast' plasticine, also known as 'modelling clay', and three round (Ø=10 cm) plastic containers were used. One repository contained pre-prepared plasticine balls (Ø=2 cm). The participants were instructed to use both of their hands to form small cubic or pyramidal shapes alternately out of the provided ball-shaped pieces of plasticine underneath the table surface, and once the required shape was finished to place it in the equivalent container. As the plasticine manipulation task was concealed from view, participants were forced to monitor the current state of the shape using visual imagery. To enhance compliance the participants were given a minimum target of each three shapes.

Participants allocated to the 'articulatory cognitive task' were instructed to count down by one from the number 100 until they reached the number 10 in a continuous loop, and to remain counting even if accidentally a mistake was made.

Immediately after each experimental condition the participants were again requested to complete the Factor 1 from the QSU and the 3-item mood scale.

Finally, participants were given a detailed debrief, including necessary information for further questions, or withdrawal from the data pool, and were thanked for their participation. The data was manually collected and scored by an experimenter for further processing.

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Results

The participants' data (N=28) was manually collected. For each participant a level of nicotine dependency was obtained, which was used to compute the mean levels of dependency for each experimental condition. With a mean of 2.81 (*SD*=0.46) in the 'visuospatial imagery' condition and a mean of 3.12 (*SD*=0.52) in the 'articulatory cognitive' condition, a follow-up t-test revealed no significant difference between the levels of dependency and condition $t(26)=-1.71$, $p=.09$.

Two ratings of craving strength and mood were obtained from each participant, i.e. one prior to experiment as a baseline measure and a second after the experimental intervention.

A subsequent mixed-model factorial ANOVA (significance level p=.05) revealed a significant difference of the craving scores prior and after the experimental intervention (within-subject variables) $F(1,26)=5.43$, $p=.03$, $\eta^2=.17$, but with no significant difference between the treatment conditions (between-subjects variables) $F(1,26)=0.17$, $p=.68$, $\eta^2=.007$. However, there is a significant interaction between 'visuospatial imagery' condition, 'articulatory cognitive' condition and time, with a larger influence of time on craving intensity in the 'articulatory cognitive' condition $F(1,26)=9.73$, $p=.004$, $\eta^2=.27$, as depicted in figure 1.

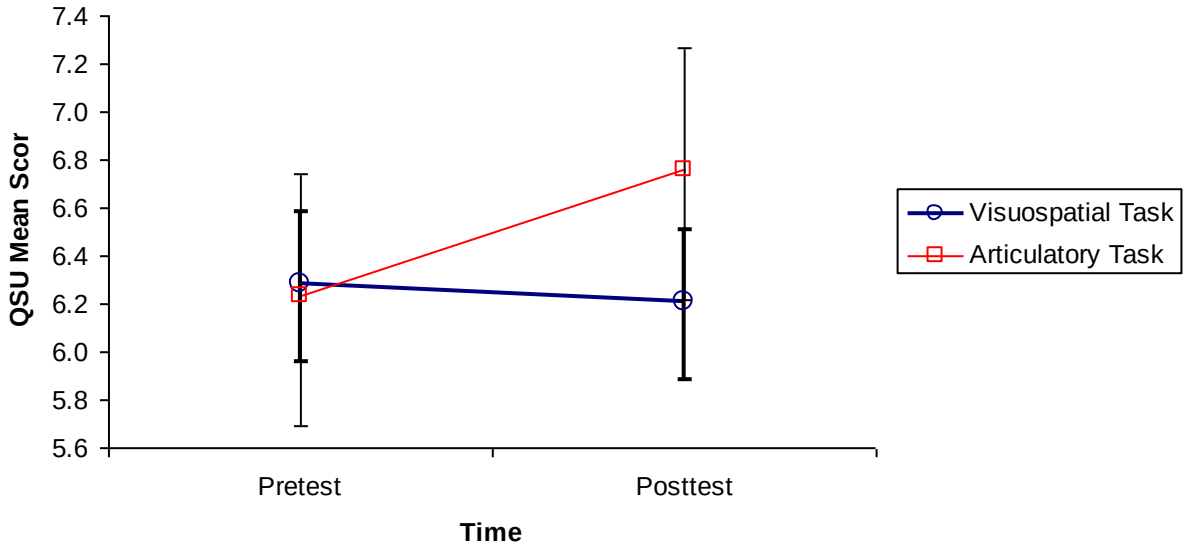

Figure 1.

Average level of craving before and after the experiment including the standard error

The pre- and post-test measures of craving strength of the complete participation pool (N=28) was used to compute the descriptive statistics for both experimental conditions. From the descriptive statistics it became evident that the decline in the subjectively felt intensity of craving from before (M=6.28, SD=1.14) and after the intervention (M=6.21, SD=1.20) within the 'visuospatial imagery' condition, was not very large and a subsequent t-test revealed no significant difference $t(13)=0.96$, $p=.35$.

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However the craving, respectively the mean craving score in the 'articulatory cognitive' condition increased over the course of the experiment, as the mean QSU score before the intervention was M=6.23 (SD=1.90) and after the intervention it was M=6.76 (SD=2.03), and a subsequent t-test revealed a significant difference $t(13)=-2.99$, $p=.01$.

For the evaluation of possible influences of mood on the dependent variable only half of the participants (N=14) contributed with their collected *Mood* scores, due to limitations in the experimental design. Despite a small but insignificant improvement of *Mood* after the experiment $F(1,12)=0.31$, $p=.59$, $\eta^2=.03$, there was no significant difference between the treatment conditions $F(1,12)=0.01$, $p=.95$, $\eta^2=.000$, and there was no significant interaction between the treatment conditions over the course of the experiment $F(1,12)=0.06$, $p=.81$, $\eta^2=.005$, as shown in Figure 2.

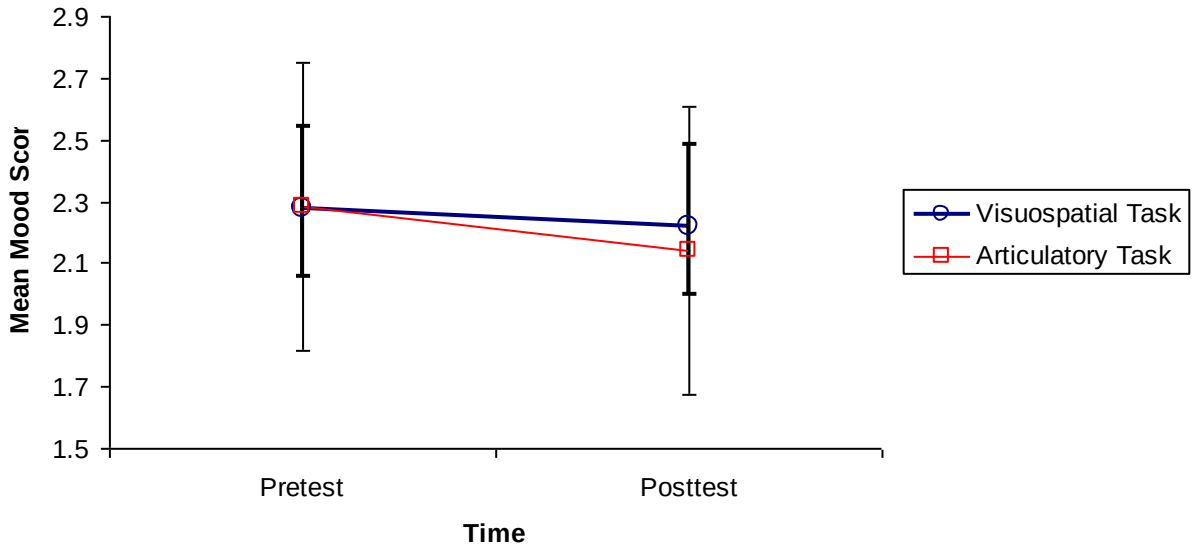

Figure 2.

Average level of mood before and after the experiment including the standard error

The calculated mood mean scores for the 'visuospatial imagery' condition before (M=2.28, SD=0.65) and after the experiment (M=2.22, SD=0.54), and the 'articulatory cognitive' condition before (M=2.29, SD=1.24) and after the intervention (M=2.14, SD=1.25), clearly showed an equal and constant range throughout the experimental conditions. As already suggested by the results gained from the analysis of variance and the descriptive statistics, a further correlation of the *Mood* scores with the *Craving* scores demonstrated no significant relationship between the scores prior r=+.054, n=13, $p=.86$, two-tailed, and after r=+.097, n=13, $p=.752$, two-tailed.

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Discussion

This study was purposely conducted to examine the effect of a concurrent visuospatial imagery task on smoking-related craving, with a further investigation of a possible influence of mood and level of dependency on the effects of the experiment. The results gained from the experiment showed a significant difference in craving strength over the course of the experiment with a significant interaction between the two experimental interventions, as predicted by the hypothesis, indicating that the concurrent visuospatial imagery task resulted in lower levels of craving post intervention. The participants engaged in the visuospatial imagery task were able to control their in vivo cue-induced craving and also reduce the experienced craving intensity slightly, whereas participants engaged in the articulatory cognitive task were not able to control their craving, which resulted in significantly higher craving after the intervention. The discrepancy between the results for both conditions can neither be attributed to the level of dependency nor to mood, concluding the results represent further supportive evidence for the underlying cognitive processes described in the Elaborate Intrusion Theory by Kavanagh et al. (2005).

The present study, however, did not exactly replicate the results found by former research carried out by Panabokke et al. (under review). In the study by Panabokke and colleagues a significant decrease in craving after a concurrent visual imagery task, and with a constant level of craving throughout the experiment in an auditory imagery task condition, was demonstrated. As aforementioned, a possible confounding problem in the study by Panabokke constituted the multi-sensory urge-induction script, which included visual imagery prior to the experimental intervention, possibly influencing the results gained in the study, by priming visual imagery in each participant. It was a major concern of the present study to eliminate this confounding factor by introducing an in vivo cue-exposure procedure to elicit craving, which therefore might have rendered the effect found after the visuospatial imagery intervention. In addition, with the usage of written instructions for the auditory imagery task (as used by Baddeley and Andrade, 2000) in the study by Panabokke and colleagues, the occurrence of visual imagery alongside auditory imagery can not be excluded, which might have helped keeping the level of craving constant in the auditory imagery condition.

Research carried out by Versland and Rosenberg (2006) found similar results with respect to the effect of a concurrent visual imagery task on smoking-related craving in a deprived sample. In their study the experienced craving intensity after the intervention was only slightly lower than at baseline, which is in line with the present study, although a 'during-intervention' measure in the study by Versland and Rosenberg showed a significant decrease in craving in the visual imagery condition, demonstrating the effectiveness of a visual imagery task on smoking-related craving, with a possible fast recovery of the transitory effects of an intervention. The present study did not assess craving intensity during the two minute intervention, in order to avoid any interference in form of conscious elaboration of craving with the subjectively reported craving intensity after the intervention. The measurement during the intervention by Versland and colleagues might have caused the increase in craving measured after the intervention, despite contrary findings by Shadel, Niaura, & Abrams (2001), that the act of completing the QSU-Brief was not associated with increased levels of self-reported craving.

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An unexpected aspect of the current study was the large increase in craving after the articulatory cognitive intervention. No current theory of craving would predict that such an unrelated cognitive task, i.e. the counting-backwards exercise, would evoke smoking-related craving. Any conclusion if this increase in craving was a natural phenomenon and should have been expected, can only be suppositional at this stage, as no control condition, i.e. with no intervention, was employed in this study. With regard to former research and the applied cognitive or imagery tasks, such as 'serial seven task' (Versland & Rosenberg, 2006) and 'auditory imagery task' (Panabokke et al., under review), which use cognitive resources, the mere 'counting backwards exercise' employed in the present study might have been replaced or assisted by automatic processes, leaving cognitive capacities for target-related rumination. Any strong negative affect caused by an experienced unpleasantness of the articulatory cognitive task causing the large increase in craving appeared unlikely as a slight improvement of mood was measured after the intervention with no relationship between mood and craving strength. Therefore, further investigations regarding the captured phenomenon might provide more conclusive answers.

The findings from the present study represent further supportive evidence for the Elaborate Intrusion Theory, as postulated by the EI Theory and demonstrated by the present study, a concurrent task loading on the visuospatial sketchpad entailed interference with craving-related imagery, thus inhibited further elaboration, which lead to a diminishing intensity of experienced craving over time. Conversely, a concurrent task using different working memory resources was unable to reduce craving or inhibit further substance-related rumination, which accentuated the importance of working memory component-specific interventions in acute smoking-related craving, as other cognitive distracting techniques appeared to be ineffective, or even exacerbate smoking-related craving. Moreover, caution must be advised, as high demands on working memory is associated with a negative impact on executive control, which leave substance users particularly vulnerable when trying to abstain (Bunge et al., 2001; Hester & Garavan, 2004). Thus, a cognitive model defining concrete operations during craving episodes, such as the EI Theory, and derived applications from the theory are of essence in the development of interventions assisting the deficiency in executive functions, inhibiting maintenance or even relapse responses.

The present study and the results of previous experiments (Panabokke et al., under review; May et al., 2004; Versland & Rosenberg, 2006), have practical implications in the development of treatments for nicotine dependence based on visual imagery interventions, in particular as it has been shown that Nicotine Replacement Therapies (NRTs), despite their ability to reduce overall craving, do not attenuate cue-induced craving (Waters et al., 2004), and pharmacotherapies are more effective when combined with cognitive behavioural therapy (Monti et al., 2001; May et al., 2004). Much research in the addictions has empirically established a relationship between craving responses to substance cues and relapse after substance cessation (e.g. Drummond et al., 1995; Niaura et al., 1988; Shiffman, 1979). Furthermore, it has been demonstrated that when information, which is currently stored in working memory, is reencountered, it is more difficult to exert executive control over it, either by switching away from it, or inhibiting a response to it. Thus, substance-related cues in the environment, which are capable of triggering intrusions and the consequential process of ruminations in working memory, may reinforce a cue-induced and perpetuating craving, or rumination cycle, as

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it is more difficult to control attention directed towards them when reencountered (Hester & Garavan, 2005). Intuitive attempts of thought suppression in order to inhibit cue processing has been demonstrated as an ineffective strategy (Salkovskis & Reynolds, 1994), but which could also paradoxically contribute to the maintenance of intrusive thoughts in working memory due to the increased affordance provided by the increased level of attention allocated. Therefore, the development of interventions that reduce craving or provide a technique to prevent spontaneous cue-induced craving from exacerbating to an unbearable level, by occupying the same working memory components which contribute to perpetuating craving cycle, would help people who are trying to abstain from smoking to remain so. The plasticine manipulation task employed in the present study, and first applied by Stuart and colleagues (2006) has demonstrated it's superiority over an articulatory cognitive intervention in keeping smoking-related craving at bay. This intervention was chosen due to it's simplicity and the ease with which it was applicable and transferable into real-life situations with minimal instructions. Not only would the plasticine manipulation intervention, or conceivably any shape moulding device, be helpful in acute smoking withdrawal episodes short after smoking cessation when experienced craving is strongest (Tiffany & Drobes, 1991), but also long after pharmacotherapies attenuated the acute symptoms and cue-induced craving constitute the most prevailing reason for relapse. This would provide an inexpensive form of relapse prevention, whereby the former substance user could be the provider of their own means to prevent relapse and stay smoke free.

As this study was the first using a plasticine manipulation task, contrary to the instructed visual imagery task applied by former research, the gained results need replication before more powerful conclusions can be drawn. A limitation of the present study constituted the small participant pool available for analysis. A larger participant pool and also a longer duration of the interventions applied in the experiment could have provided more consistent results with former research, as the trend towards a larger reduction of craving with the visuospatial intervention was emerging. Possible variations of the present experiment could consist of an introduction of a control condition, i.e. no intervention condition, as the articulatory cognitive intervention showed an unexpected significant increase in craving, with neither mood nor level of dependency related to the effect captured. Moreover, an implementation of an overt plasticine manipulation condition, in order to compare tactile versus visual monitoring on the overall effectiveness of the interventions could be useful for future applied addiction therapy interventions.

With modality-specific imagery demonstrated effective in smoking-related and food-related craving (Panabokke et al., under review; Kemps & Tiggemann, 2007; Steel, Kemps, & Tiggemann, 2006), and the postulation of identical cognitive processes in all addictions made by the Elaborate Intrusion Theory, future research into other clinical conditions could provide vital information on the transferability of the concurrent task approach on the according disorder and gather further supportive evidence for the EI Theory. Substance related addictions, such as alcohol or opiate dependency, and non-substance related addictions, such as gambling or excessive use of other media, should be of particular interest, as imagery modalities could be investigated, leading to a greater understanding of the subject matter with clear implications for the future development of interventions. Conceivably, clinical conditions with similar perpetuating and detrimental elaborative cycles, such as anxiety, obsessive compulsive disorder

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(OCD), and post traumatic stress disorder (PTSD) should be vulnerable to interventions breaking the ruminative cycle by eliminating salient items from working memory using modality-specific imagery, which in return could lead to a significant decrease of the experienced symptoms.

To summarise, the framework of mechanisms involved in human desire has been laid out by Elaborate Intrusion Theory by Kavanagh and colleagues (2005), suggesting that imagery is central to human desire, reinforcing the vicious cycle of craving by occupying higher-level cognitive processes, e.g. the different structural elements of working memory (as proposed by Baddeley, 1986), in the rumination about the desired substance or behaviour, which impairs performance on concurrent cognitive tasks, and amplifies the emotional response. Latter research was able to verify the hypothesis that a concurrent modality-specific imagery task interferes with the vividness of intrusive images, leading to a diminished intensity of experienced craving. The present study, which used a plasticine manipulation task and a counting backwards exercise, forming the visuospatial imagery and respectively, the articulatory cognitive intervention, found a significant difference between the experienced craving strength prior and post experimental interventions with a significant interaction of the two experimental factors, indicating that the visuospatial imagery intervention managed to subdue craving with a trend towards a slow but progressive reduction. Due to the different methodological approach, in comparison to former research regarding the urge induction and the applied imagery intervention, the results gained in the study, in particular the slightly lower decline in craving after the visuospatial intervention as anticipated, leave room for further investigations.

As a final remark, it can be said that there is cumulative empirical evidence supporting the cognitive model of craving represented by the Elaborate Intrusion Theory. However, with craving being a subjective phenomenon, in vitro studies must heavily rely on either self-reported measures of craving or physiological responses, which at present, are not absolutely reliable. A transition into longitudinal real-life research appears to be of essence, especially with view to efficient future psychological treatments which will benefit the treatment of addiction, as applications tested in vivo in the first weeks of frequent intrusive thoughts after substance cessation, will offer a better test for effectiveness. The first step in that direction was made by the present study by testing for an effective tool to provide the means for an individual management of smoking-related craving, which hopefully will lead to further research providing much needed assistance in many governments efforts for a smoke free and healthier society.

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Appendices

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