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5 Playing 'Tetris' reduces the strength, frequency and vividness of naturally occurring
6 cravings

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1 Abstract

2 Elaborated Intrusion Theory (EI) postulates that imagery is central to craving, therefore a
3 visually based task should decrease craving and craving imagery. This study provides
4 the first laboratory test of this hypothesis in naturally occurring, rather than artificially
5 induced, cravings. Participants reported if they were experiencing a craving and rated the
6 strength, vividness and intrusiveness of their craving. They then either played 'Tetris' or
7 they waited for a computer program to load (they were told it would load, but it was
8 designed not to). Before task completion, craving scores between conditions did not
9 differ; after, however, participants who had played 'Tetris' had significantly lower craving
10 and less vivid craving imagery. The findings support EI theory, showing that a
11 visuospatial working memory load reduces naturally occurring cravings, and that Tetris
12 might be a useful task for tackling cravings outside the laboratory. Methodologically, the
13 findings show that craving can be studied in the laboratory without using craving
14 induction procedures.

15 157 words

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1 Introduction

2 Although cravings are an everyday occurrence amongst the general population
3 (Lafay et al., 2001) they are linked to a variety of negative effects, even when they are
4 resisted; for example, by causing distress and distraction (Green, Rogers & Elliman,
5 2000). Craving can also be a precursor to binge eating in the general population
6 (Gendall, Joyce, Sullivan & Bulik, 1998), early dropout from weight loss program's
7 (Sitton, 1991), and the development of obesity (Schlundt, Virts, Sbrocco, & Pope-Cordle,
8 1993).

9 Elaborated Intrusion Theory (Andrade, May & Kavanagh, 2012; Kavanagh,
10 Andrade & May, 2005; May, Andrade, Kavanagh & Hetherington, 2012) conjectures that
11 craving is principally a working memory process where affectively-charged sensory
12 images are maintained primarily in the visuo-spatial sketchpad. An internal or external
13 trigger leads to a spontaneous thought that, depending on its salience and on current
14 cognitive demands, will either be elaborated or ignored. When elaboration occurs,
15 images are developed, maintained and elaborated using internal and external
16 information (for example, recalling memories of previously eating chocolate). Previous
17 research has shown that visual images are central to craving imagery, although other
18 senses are also involved. In Kavanagh, May, and Andrade's (2009) study, respondents
19 on an alcohol dependence programme reported an average of 2.3 sensory modalities in
20 their alcohol craving imagery. May, Andrade, Pannaboke and Kavanagh (2004) found
21 over 60% of respondents reported visualising or tasting the substance they were craving.

22 Visual and auditory imagery load the limited-capacity, modality-specific slave
23 systems of working memory, the visuospatial sketchpad and phonological loop
24 respectively (Baddeley & Andrade, 2000). Involvement of these slave systems in a task
25 can be blocked by irrelevant task loads such a task involving spatial manipulation or

1 visual distraction in the case of the visuospatial sketchpad, or a verbal task in the case of
2 the phonological loop. In support of the EI theory hypothesis that visual imagery is a key
3 component of craving, there is accumulating evidence that visuospatial loads or
4 competing neutral visual images selectively reduce craving, for cigarettes (May,
5 Andrade, Panabokke, & Kavanagh, 2010; Versland & Rosenberg, 2007) and for food
6 (Andrade, Pears, May & Kavanagh, 2012; Harvey, Kemps & Tiggemann, 2005; Kemps
7 & Tiggemann, 2007; Kemps, Tiggemann & Hart, 2005; Kemps, Tiggemann, Woods &
8 Soekov, 2004; McClelland, Kemps and Tiggemann, 2006; Steel, Kemps & Tiggemann,
9 2006).

10 Van Dillen, Nordgren, and Andrade (2013) used the visuospatial task of playing
11 the computer game Tetris to block craving for food. Stuart, Holmes and Brewin (2006)
12 had used this task to block encoding of visual images while participants watched a
13 traumatic film; in the week that followed the film, participants experienced fewer intrusive
14 images from segments of the film during which they had played Tetris than from other
15 segments of the film. Holmes, James, Coode-Bate and Deeptose (2009) found similar
16 reductions in intrusive imagery when Tetris was played after viewing the traumatic
17 material. In Van Dillen et al.'s study, Tetris reduced attentional biases to food pictures,
18 reduced craving, and led to fewer participants choosing chocolate or marzipan as a
19 reward rather than a piece of fruit. Tetris is assumed to load heavily on visuospatial
20 working memory because it requires the player to rotate and move geometric shapes
21 rapidly in order to complete rows of shapes without leaving gaps. It is easy to access
22 over the internet, giving it the potential to be used as a take-home task to help people
23 manage craving or traumatic imagery.

24 We aimed to replicate van Dillen et al.'s (2013) finding, with an important
25 difference. Previous studies of craving in the laboratory, including those cited above,

1 have induced cravings when participants have come into the laboratory. For example,
2 Andrade, Pears et al. (2012) asked participants to inspect and evaluate chocolates; van
3 Dillen et al. (2013) asked participants to select items from a menu. The reasoning behind
4 craving inductions is that the novelty and cognitive demand of the laboratory setting may
5 itself reduce cravings, even when participants have abstained from the substance prior to
6 taking part in the study. There is a risk, though, that working memory loads are doing
7 nothing more than removing an artificially induced desire. We therefore recruited an
8 unselected sample and aimed to measure and manipulate any naturally occurring
9 cravings that they were experiencing.

10 Naturally occurring cravings might be more resistant to intervention because
11 they are triggered by physiological deficit or conditioned cues. We therefore wanted to
12 maximize the chance of finding an effect of visuospatial interference by comparing Tetris
13 against a condition with minimal working memory demands, but at the same time we
14 needed a control condition that would ensure that participants did not become distracted
15 by anything else in their environment and would not be aware that they were in the
16 control group. We therefore followed van Dillen et al. (2013) by using a 'wait' condition.
17 Van Dillen et al. told participants that the computer was old and the programme might
18 take a while to load. They looked at a blank screen while waiting. In our study,
19 participants saw a fake load screen that appeared to be showing Tetris loading, but
20 never actually loaded.

21 Van Dillen et al. (2013) used behavioural measures of craving, that is, response
22 biases to tempting foods and food choices at the end of the experiment, and a four-item
23 craving scale. We used the Craving Experience Questionnaire (CEQ; Andrade, Pears et
24 al., 2012; May et al., 2013) developed from the Alcohol Craving Experience
25 questionnaire (Kavanagh, May & Andrade, 2009; Statham et al., 2012), to assess

1 craving phenomenology in the control and intervention conditions. The CEQ provides a
2 measure of craving strength, imagery, and intrusiveness. We also asked participants if
3 they were under the influence of alcohol (including being hung-over) to check if this was
4 a confounding variable, because Burton and Tiffany (1997) found that when people had
5 consumed alcohol they had a general increase in craving compared to when they had
6 not.

7

8 Method

9

10 Participants

11 A total of 121 (27 males) participants from Plymouth University Undergraduate
12 Participation Pool were recruited, aged between 18 and 30 years ($m = 19.74$ years), in
13 partial fulfillment of a course requirement to participate in research.

14

15 Design

16 The design was a between subjects quasi experiment. Participants were
17 randomly assigned to one of two conditions (experimental or control) prior to taking part.
18 They were then allocated to either a craving or not craving group depending on the
19 craving level they reported on entering the lab.

20

21 Materials

22 A Samsung 10.1inch Netbook was used to display the load screen. This
23 'program' was written in Microsoft PowerPoint and used a timed slideshow to show a
24 'load bar' slowly progressing, and then a message saying 'Load Error'.

1 Tetris was played on a 15inch computer monitor with a standard keyboard. The
2 computer game 'Tetris' was downloaded from www.80smusiclyrics.com/games/html

3
4 Participants rated their craving on a single-item scale of 1 (not craving at all) to
5 100 (craving something very much). More detailed information about craving
6 phenomenology was collected using the Craving Experience Questionnaire (CEQ;
7 Andrade, Pears et al., 2012; May et al., 2013), adapted to encompass any sort of craving
8 rather than just craving for chocolate. The CEQ-S_{now} asked participants to rate the
9 strength, imagery vividness, and intrusiveness of their current craving on an eleven point
10 scale anchored 'Not at all' and 'Extremely'. A typical question for assessing craving
11 strength was 'Right now, how strongly do you want it?', for imagery 'Right now, how
12 vividly do you picture it?', and for intrusiveness 'Right now, how hard are you trying not to
13 think about it?'. This questionnaire provided a snapshot of craving experience
14 immediately before the experimental period began. The CEQ-S_{then} assessed craving
15 experience during the experimental period (load screen or Tetris). It asked the same
16 questions but retrospectively, in relation to the period since participants completed the
17 CEQ-S_{now} during which they were playing Tetris or watching the load screen For
18 example, the imagery item became 'During that time, how vividly were you picturing it?'.
19 The CEQ-F_{then} used similarly phrased questions to ask participants to rate the *frequency*
20 of their cravings, images, and intrusive thoughts during the period since doing the CEQ-
21 S_{now}, on an eleven point scale anchored 'Not at all' to 'Constantly', for example, 'During
22 that time, how often did you picture it?'. The 'then' versions of the CEQ were used to
23 assess changes in craving experience while participants were playing Tetris, rather than
24 taking a snapshot of craving once the game ended, to avoid contamination by a re-

1 kindling of craving once the interference ended. Andrade, Pears et al. (2012) and May et
2 al. (2013) reported Cronbach's alpha ratings over 0.90 for each scale.

3

4 Procedure:

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6 The study was approved by the Plymouth University Faculty of Science and
7 Technology Research Ethics Committee. Participants were tested between 9am and
8 4.45pm, to allow for variance in cravings across the day (Hill, Weaver & Blundell, 1991).
9 Participants were also tested in pairs to control for time of day effects, with one person in
10 each pair assigned randomly to each task.

11 After being briefed, participants completed a short questionnaire asking for their
12 demographic information. They were then asked what, if anything, they were craving and
13 completed the CEQ-S_{now} in relation to their craved substance or activity.

14 Participants then either played 'Tetris' or waited for a screen to load, according to
15 their random allocation. The 'load screen' program was designed so that 'Tetris' never
16 loaded and ended with a 'Load Error' message. Both tasks took 3 minutes. To ensure
17 that the participants did not realise that the 'load screen' was a control measure it was
18 loaded on a Netbook and then passed to the participant with the 'program' having
19 started. Participants in this control condition were told that the experimenter had written
20 the program to run 'Tetris' with features that the 'normal Tetris' did not have.

21 Next, participants completed the CEQ-S_{then} and CEQ-F_{then} to assess their craving
22 experience during the load screen or Tetris period. Finally, they were asked if they were
23 aware of the condition to which they had been assigned. Note that participants who
24 reported not craving anything, still completed all parts of the experiment, answering N/A
25 to craving questions.

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Results:

A total of 121 participants were tested. Two people reported being aware of their assigned condition and their results were removed from the analysis. Of the 119 participants remaining, 80 reported craving something (58 food or drink, 10 caffeine, 12 nicotine) and 39 were not craving anything. Data from participants who reported no craving are not analyzed further. Hill, Weaver and Blundell (1991) found that cravings were typically higher in the afternoon compared to other times of day, but a chi-square analysis found no relationship between time of day and number of participants reporting craving: $\chi^2(1, N=119) = 0.280, p = .299$, therefore time of day is not analyzed further.

Craving was measured by a single-item scale before and after participants had completed their assigned task (Table 1).

Insert Table 1 about here

The effect of task on craving was examined using a 2(time) x 2(task condition) repeated measures ANOVA. Craving reduced over time, $F(1,78) = 14.26, p < .001, \eta_p^2 = .16$. The main effect of condition was not significant, $F < 1$, but there was the predicted interaction between condition and time with greater reduction in craving for the Tetris condition than for the load screen condition, $F(1,78) = 5.67, p = .020, \eta_p^2 = .07$. The interaction remained significant after removing nine participants with weak craving defined as a score below 20 on the single-item craving scale ($N = 3$) and/or who reported being under the influence of alcohol ($N = 7$), $F(1,69) = 5.17, p = .026, \eta_p^2 = .07$, and

1 when only participants' craving food or drink were considered, $F(1,56) = 12.17, p = .001,$
2 $\eta_p^2 = .18.$

3 To obtain a more detailed picture of craving change, participants' responses on
4 the CEQ_{now} and CEQ_{then} were averaged across factors, to give scores for craving
5 strength, imagery, and intrusiveness (see Andrade, Pears et al., 2012; May et al., 2013).
6 These data were subjected to 2(time) x 2(task condition) repeated measures ANOVAs.

8 Insert Table 2 about here

9
10 A 2(time) x 2 (condition) repeated measures ANOVA was used to compare
11 before (now) and after (then) scores from the CEQ questionnaires. The main effect of
12 condition on craving strength was not significant, $F < 1$. Craving strength reduced over
13 time, $F(1,78) = 18.71, p < .001, \eta_p^2 = .19,$ and the interaction showed that this reduction
14 was larger for the Tetris condition, $F(1,78) = 9.60, p = .003, \eta_p^2 = .11.$ Craving imagery
15 showed a similar null effect of condition overall, $F < 1,$ and reduction over time ($F(1, 78) =$
16 $39.02, p < .001, \eta_p^2 = .33)$ and interaction between time and condition ($F(1, 78) = 11.29,$
17 $p = .001, \eta_p^2 = .13).$ Craving intrusiveness also showed no main effect of condition, $F(1,78)$
18 $= 1.46, p = .23, \eta_p^2 = .02,$ and a significant reduction over time, $F(1, 78) = 20.73, p < .001,$
19 $\eta_p^2 = .21,$ but the interaction did not reach statistical significance, $F(1, 78) = 1.17, p = .28,$
20 $\eta_p^2 = .02).$

21 A one way ANOVA of scores on the CEQ-F_{then} showed that participants
22 experienced less frequent cravings and less frequent craving imagery while playing
23 Tetris than while watching for the load screen, $F(1, 78) = 7.53, p = .008, \eta_p^2 = .09,$ and
24 $F(1, 78) = 15.91, p < .001, \eta_p^2 = .17$ respectively. The frequency of craving-related intrusive

1 thoughts differed in the same direction but the difference fell just short of statistical
2 significance ($F(1, 78) = 3.80, p = .055, \eta_p^2 = .05$).

3

4 Discussion

5 This study examined naturally occurring cravings and to our knowledge is the
6 first experimentally-controlled laboratory manipulation of natural rather than artificially-
7 induced cravings. Kemps and Tiggemann (2013) recently reported that a visual
8 interference task reduced naturally-occurring cravings for food in the field, but did not
9 include a control condition to test that the craving reductions exceeded those that would
10 happen naturally during the time taken to complete the task. The load-screen condition in
11 the present study performed this function.

12 The findings show that studying naturally-occurring cravings, rather than inducing
13 cravings artificially, is a viable option for laboratory research. Around two-thirds of
14 participants reported craving something at the time of completing the experiment and
15 their mean craving levels were reasonably high, around the mid-way point on the
16 baseline single-item craving and CEQ measures. It is possible that our predominately
17 young, female, undergraduate sample experienced stronger cravings than the general
18 population because cravings decrease in strength and frequency with age and women
19 typically experience more cravings than men (Lafay et al., 2001; Pelchat, 1997). In an
20 ecological momentary assessment study of a somewhat broader sample (73% university
21 students), participants reported a current desire on 50% of the sampling occasions and a
22 recent desire on a further 28% of occasions. As in the present study, desires to eat or
23 drink were the most frequently reported (36.7%; Hofmann, Baumeister, Förster, & Vohs,
24 2011). In contrast to previous research (Hill, Weaver and Blundell, 1991), there was no
25 change in craving frequency across the day.

1 Playing Tetris for 3 minutes reduced craving strength and craving image
2 vividness compared with watching a load screen. This finding supports Elaborated
3 Intrusion Theory (Kavanagh et al., 2005), which posits that imagery is central to craving
4 and that the development, maintenance and elaboration of craving images requires
5 working memory resources, and in particular visuospatial working memory. Van Dillen et
6 al. (2013) found that Tetris reduced behavioural indices of craving following a craving
7 induction, specifically attentional biases to food pictures and choice of high calorie rather
8 than fruit snacks, as well as self-reported craving. The present study extends their
9 findings by showing that Tetris weakens naturally occurring cravings, with the implication
10 that other previous studies of effects of working memory loads on craving (e.g., Andrade,
11 Pears et al., 2012; Kemps & Tiggemann, 2007; May et al., 2010) should also generalise
12 to ecologically valid cravings.

13 The findings support the prediction of EI theory that visuospatial tasks weaken
14 cravings via effects on craving imagery, by showing that playing Tetris reduced the
15 vividness and frequency of craving imagery. However, they do not rule out an
16 interpretation that any working memory load would have the same effect, regardless of
17 sensory modality. It remains to be tested whether the effects of Tetris on craving are due
18 specifically to visuo-spatial interference, or to general task demands. Previous research
19 has shown effects of visual tasks over non-visual working memory tasks assumed to
20 impose similar executive processing loads. For example, May et al. (2010) reported
21 reductions in cigarette craving when participants imagined neutral visual scenes
22 compared with when they imagined neutral sounds. In the field, Knäuper, Pillay, Lacaille,
23 McCollam, & Kelso (2011) showed that positive visual imagery reduced food cravings
24 over a four-day period compared with reciting the alphabet backwards, a reasonably
25 demanding verbal working memory task. These findings suggest that the visuospatial

1 component of playing Tetris might give benefits over and above those of an equally
2 difficult verbal task, but this prediction has not yet been tested.

3 There is a risk that temporary reductions in craving might lead to later increases.
4 Distraction tasks can increase the 'ironic' effects of thought suppression, leading to
5 behavioural rebound (Erskine, 2008). Although we did not test the long-term impact of
6 playing Tetris, we think it is unlikely to lead to increased craving or consumption in the
7 longer term, for three reasons. First, there is evidence that other visuospatial interference
8 tasks reduce craving and consumption over periods of weeks (Kemps & Tiggemann
9 2013; Knäuper et al., 2011). Second, participants did not receive the thought
10 suppression instructions that are typically associated with rebound effects. Third,
11 Casselli, Soliani and Spada (2013) incidentally included Tetris as a resting phase
12 following manipulations of thought focus in the laboratory. Overall, craving did not
13 increase over the next three days, during which participants continued using their
14 assigned thought focus strategy, suggesting that Tetris did not lead to a rebound. There
15 appeared to be an increase in craving in one 'distraction' condition, where participants
16 focused their thoughts on geographical locations. Casselli et al. did not report how often
17 participants used this distraction technique over the three days, or whether they thought
18 about locations associated with their desired activity. Nonetheless, this finding raises the
19 concern that any distraction might lead to increases in craving over time because, as
20 Casselli et al. suggest, participants can learn to use it as a thought avoidance strategy.
21 We suggest that the two tasks are rather different, with Casselli's directing people's
22 thoughts to a neutral topic and ours specifically loading the visuospatial working memory
23 processes that people need for elaborating craving images. Future research should test
24 the long-term impact of craving interventions and test whether that impact differs
25 according to the type of distraction employed. Elaborated Intrusion theory predicts that

1 tasks that specifically load working memory processes needed for craving imagery will
2 help break the vicious cycle of desire-related thoughts leading to desire imagery, which
3 leads to more desire thoughts. Predictions about the effects of more general distractions
4 are mixed: Instructions to think about other things may help cue neutral images, which
5 would interfere with desire imagery, or they may be interpreted as a tool for suppressing
6 desire thoughts, which could be counter-productive.

7 Although playing Tetris did not completely suppress craving, decreasing it by
8 around 24%, this reduction could be sufficient to help people manage their cravings, as
9 suggested by van Dillen's et al.'s (2013) finding that people were less likely to choose a
10 high-calorie snack after playing Tetris. Future research could test if manipulating the
11 duration and difficulty of Tetris can increase its effects on craving. Kemps and
12 Tiggemann (2013) found a similar 23% reduction in craving intensity when women
13 watched a visual interference display known to disrupt visual imagery (Andrade, Kemps,
14 Wernier, May & Szmalec, 2002). Women who were given the opportunity to watch the
15 display when they craved food reported fewer craving-related thoughts than those in the
16 control condition who just kept a food diary. We predict that playing Tetris will have
17 similar benefits for consumption in field settings, particularly because, anecdotally,
18 participants said they enjoyed playing Tetris, which is important if using it as a take-home
19 task to help people manage their cravings.

20 Although this study tested an unselected sample of undergraduates, we expect
21 the findings to generalise to people trying to control their consumption because there is
22 evidence that other visuospatial tasks are effective when people are motivated to control
23 rather than indulge their cravings (e.g., Kemps, Tiggemann & Christianson, 2008). In a
24 comparison of craving phenomenology across different substances, May et al. (2013)

1 found similar mean scores for craving strength across chocolate (mean CEQ-S = 4.40),
2 cigarettes (4.54), and food (4.68), with the mean for an outpatient sample meeting DSM-
3 IV-TR criteria for current alcohol dependence being somewhat higher (5.22) but within
4 the range reported by participants in the present study. Further research would be
5 needed to examine the effectiveness of Tetris to decrease cravings in a clinical
6 population.

7 The Craving Experience Questionnaires showed that craving strength and
8 imagery both decreased more when participants played Tetris than when they watched
9 the load screen. Craving intrusiveness changed over time but not differentially by
10 condition. This finding is consistent with EI theory's assumption that elaboration loads
11 working memory and will be inhibited by concurrent working memory loads, whereas
12 intrusive thoughts result from automatic, associative processes that are not dependent
13 on working memory. However, EI theory also predicts that the process of elaboration will
14 stimulate further intrusive thoughts, so we predict that over longer periods, the effects of
15 playing Tetris on craving would eventually lead to reductions in intrusions too.

16 In conclusion, we have shown that playing Tetris for a brief period is sufficient to
17 reduce naturally occurring cravings that participants were already experiencing when
18 they entered the laboratory. Tetris reduced the vividness and frequency of craving
19 imagery, as well as craving intensity. This is an important finding for generalising
20 previous tests of EI theory with induced cravings to naturally occurring cravings for food
21 and drink, and possibly for addictive substances too, and a step towards developing a
22 take-home task for helping people to reduce cravings to tolerable levels.

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1

Condition	N	Craving Before	Craving After	Difference	% change
Load	42	57.90 (21.37)	54.74 (25.04)	3.17 (20.57)	-5.5%
Tetris	38	58.82 (20.61)	44.84 (25.75)	13.97 (19.94)	-23.8%

2

3 Table 1: Means (and Standard Deviations) of scores on the single-item craving measure
4 before and after the load screen and Tetris conditions

5

Craving factor	Condition	CEQ-S _{now}	CEQ-S _{then}	CEQ-F _{then}
Strength	Load	4.13 (2.20)	3.74 (2.66)	3.27 (2.86)
	Tetris	4.96 (3.00)	2.63 (2.37)	1.76 (1.94)
Imagery	Load	4.14 (2.40)	3.25 (2.81)	3.27 (2.60)
	Tetris	4.88 (2.36)	1.92 (2.25)	1.28 (1.70)
Intrusiveness	Load	3.30 (2.64)	2.43 (2.29)	2.43 (2.53)
	Tetris	3.00 (2.52)	1.58 (2.14)	1.39 (2.17)

1

2 Table 2: Mean craving strength, imagery and intrusiveness reported in the CEQ-S_{now},
3 CEQ-S_{then}, and CEQ-F_{then}. (± S.D.)

4