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International Gambling Studies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rigs20

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To cite this article: Aurélien Cornil, Stéphane Rothen, Philippe De Timary & Joël Billieux (2021) Interference-based methods to mitigate gambling craving: a proof-of-principle pilot study, International Gambling Studies, 21:3, 426-449, DOI: 10.1080/14459795.2021.1903063

To link to this article: https://doi.org/10.1080/14459795.2021.1903063

Published online: 30 Mar 2021.

INTERNATIONAL GAMBLING STUDIES
2021, VOL. 21, NO. 3, 426–449
https://doi.org/10.1080/14459795.2021.1903063

Interference-based methods to mitigate gambling craving: a proof-of-principle pilot study

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ABSTRACT

Craving is central in the prognosis of gambling disorder. The elaborated intrusion theory (EIT) provides a sound framework to account for craving in addictive disorders, and interference methods inspired from the EIT have substantiated their effectiveness in mitigating substance and food-related cravings. The principle of these methods is to recruit the cognitive resources underlying craving (e.g., visuospatial skills, mental imagery) for another competitive and cognitively demanding task, thus reducing the vividness and overwhelming nature of craving. Here we conducted two experiments employing a between-subjects design to test the efficacy of interference methods for reducing laboratory-induced craving. In these experiments, gamblers (*n* = 38 for both experiments) first followed a craving induction procedure. They then performed either a visuospatial interference task (making a mental and vivid image of a bunch of keys [experiment 1] or playing the video game Tetris [experiment 2]; experimental conditions) or another task supposed not to recruit visuospatial skills and mental imagery (exploding bubble pack [experiment 1] or counting backwards [experiment 2]; control conditions). Results show that all methods successively mitigated induced craving. Although previous research evidenced the superiority of visuospatial tasks to reduce substance-related craving, our findings question their superiority in the context of gambling craving.

Abbreviations EIT: Elaborated intrusion theory of desire; GD: Gambling disorder; CEQ: Craving Experience Questionnaire; g-CEQ: gambling Craving Experience Questionnaire; g-CEQ-F: Gambling Craving Experience Questionnaire – Frequency form; g-CEQ-S: Gambling Craving Experience Questionnaire – Strength form; Psi-Q: Plymouth Sensory Imagery Questionnaire; PGSI: Problem Gambling Severity Index; S-UPPS-P: Short UPPS-P Impulsive Behavior Scale; DASS-21: Depression, Anxiety and Stress Scales; ANCOVA: Analysis of covariance.

ARTICLE HISTORY
Received 20 November 2020
Accepted 7 March 2021

KEYWORDS
Craving; urge; interference; gambling; problem gambling; elaborated intrusion theory of desire

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Introduction

The gambling landscape has significantly evolved in recent years and gambling opportunities have unprecedentedly exploded with the advent of Internet and mobile gambling (Brevers et al., 2019; Sharman et al., 2019). Moreover, involvement in gambling has tended to become normalized by advertisements, sponsorship, and popular movies (e.g., James Bond's Casino Royale; Campbell, 2006). The convergence of gambling and gaming activities also contributes to the trivialization of gambling and its popularization among younger individuals (Delfabbro et al., 2020; King & Delfabbro, 2020). Available 24/7 through the Internet, potentially anonymous, and accessible from almost anywhere via the smartphone, gambling attractiveness has never been so strong, appealing, and accessible.

In the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013), gambling disorder (GD) was reclassified as an addictive disorder on the basis of accumulating evidence that this condition shares many similarities with substance use disorders (e.g., Clark, 2010; Goudriaan et al., 2006; Potenza, 2006). Previous research demonstrated the role of craving in the development and prognosis of GD (Ashrafioun et al., 2013; Blaszczynski & Nower, 2002; Oei & Gordon, 2007; Sharpe, 2002; Smith et al., 2010; Van Holst et al., 2010), calling for the design and testing of specific psychological interventions that aimed to help people cope with or reduce craving experiences.

Recent cognitive models of craving provide a sound theoretical framework for developing new types of psychological interventions that are easily implementable in the clinical context (Andrade & May, 2003; Goldstein, 2019). In the current research, we aimed at testing methods derived from these recent cognitive models of craving.

The elaborated intrusion theory of desire

The elaborated intrusion theory of desire (EIT; Kavanagh et al., 2005; May et al., 2004) is a cognitive model of desire that was validated to explain substance and food-related cravings (May et al., 2015). According to this model, cravings, conceptualized as intense desires, are defined as 'affectively laden cognitive events, where an object or activity and associated pleasure or relief are in focal attention' (May et al., 2015). The model identifies five types of craving triggers: external cues (e.g., an advertisement), anticipatory responses (e.g., being tense), associated thoughts (e.g., thinking about someone with whom you often gamble), negative affect (e.g., depressive mood), and physiological deficit (e.g., withdrawal symptoms).

The EIT posits that intrusive desire thoughts constitute the key feature of craving experiences and result from confrontation with the above-mentioned triggers (external cues and/or anticipatory responses and/or associated thoughts). Desire thoughts consist of verbal thoughts (e.g., 'How nice it would be to gamble right now.') and mental images involving various sensorial modalities related to the object of the desire (e.g., picturing oneself gambling or imagining sounds related to the game). According to the theory, these desire thoughts allow one to partially fulfil a craving through the experience of pleasure and relief via imagery-related processes (Weber et al., 2017). The term 'urge', which is frequently and erroneously used as a synonym for craving, in fact refers to this motivational component of the craving experience (for a discussion, see Canale et al., 2019). This reinforcing urge generates the creation of a vicious spiral of desire thoughts. Yet, critically, another vicious spiral is involved, as the desire is satisfied only via mental imagery, which further promotes a sense of associated deficit reinforced by internal cues (negative affect and/or physiological deficit). The combined action of these two vicious spirals fosters the need to cope with that sense of associated deficit through the elaboration of more desire thoughts. The various processes that lead to a subjective state of craving involve automatic and associative mechanisms, but also recruit higher order cognitive functions such as attentional and working memory capacity (e.g., the visuospatial sketchpad is involved in creating vivid mental images).

In recent years, the EIT has increasingly been considered as a valid theoretical framework to account for gambling-related cravings. Capitalizing on a mixed-methods design, Cornil et al. (2018) demonstrated through a thematic analysis that the features and processes accounted for by the EIT also apply to gambling craving. Complementary quantitative analyses suggest that specific triggers (e.g., spontaneous thoughts) and experiential features (e.g., visual imagery) are relevant in the context of gambling craving. In another study, Cornil et al. (2019) validated an instrument generally used to assess substance and food-related craving based on the EIT, the Craving Experience Questionnaire (CEQ; May et al., 2014), in the context of gambling (g-CEQ). Based on the qualitative and phenomenological evidence collected (Cornil et al., 2018), some adaptations were made to increase the construct validity of the new scale. More precisely, items referring to smell, taste, and mouth imagery were removed, as they appear to be mostly irrelevant in the context of gambling craving, whereas auditory and tactile imagery items were added because these sensorial modalities better correspond to the experience of gambling craving (Cornil et al., 2018). Findings from these previous studies suggest that the use of psychological interventions derived from the EIT may be relevant in the context of gambling craving.

Interference-based psychological interventions

According to the EIT, attentional and working memory allocation plays a pivotal role in the elaboration of desire thoughts and the persistence and vividness of the craving experience (Kavanagh et al., 2005; May et al., 2004). Several studies have shown that inducing craving decreases cognitive performance, thus confirming that the craving process is underpinned by cognitive resources (Green et al., 2000; Kemps, Tiggemann, Grigg et al., 2008; Tiggemann et al., 2010). Shifting these limited resources to another cognitively demanding task is thus likely to reduce the vividness and overwhelming nature of desire thoughts and thus to interfere with or reduce craving (May et al., 2008; Van Dillen et al., 2013; Van Dillen & Van Steenbergen, 2018). Deprived from the required cognitive resources, the desire thoughts become less vivid and irresistible, thus decreasing the associated pleasure and/or relief. As a consequence, the craving experience becomes more tolerable and prone to disappear (May et al., 2008). Psychological interventions derived from the EIT that aim to interfere with the psychological processes postulated to underlie craving are generally described as 'interference-based' methods (Kemps et al., 2005; Steel et al., 2006). Such methods can also be considered within an emotional regulation framework, where they might be considered as 'attentional deployment' strategies in which the attentional focus is shifted in order to modify and cope with an emotional response (Gross, 2015). Interference-based techniques are sometimes confused with distraction techniques that aim to move the attentional focus away from the craving experience without directly targeting the hypothesized underlying processes, such as working memory or mental imagery. Although distraction-based techniques have been shown to reduce craving, recent research (Dodds et al., 2019) showed that interference-based methods that involve active processing of visuospatial working memory are significantly more effective.

In recent years, an increasing number of experiments have been conducted to test the potential of different types of interference-based methods in reducing craving. A non-exhaustive yet representative selection of such studies is detailed in Table 1. These studies were selected to exemplify the variety and specificities of interference-based methods that have been used across different populations, settings (induced, naturally occurring, real world), and types of craving (e.g., food, tobacco, alcohol, caffeine). Existing studies suggest, on the one hand, that interference-based methods can reduce or interrupt cravings, and, on the other, that methods involving visual imagery are the most effective. A limitation of some of the techniques used (e.g., modeling geometric forms with clay) is that they are not easily transferable to everyday life, thus limiting their potential clinical utility. A notable exception is the video game Tetris, which can easily be installed on a variety of portable technological devices used in daily life (e.g., tablets and smartphones). Tetris is characterized by a heavy load on visuospatial working memory and can thus be considered a relevant interference-based method (Skorka-Brown et al., 2014, 2015). Indeed, this video game decreased attentional biases toward food and reduced experimentally induced craving. It also helped participants who were sensitive to hedonic food cues not to respond to high-calorie food after a craving induction (Van Dillen & Andrade, 2016). Tetris also showed efficacy in diminishing naturally occurring craving strength and the vividness of related mental images (Skorka-Brown et al., 2014). Finally, playing Tetris for 3 minutes in a real-life setting helped to reduce the intensity of craving for psychoactive substances and food, as well as for a variety of appetitive behaviors such as sex, video gaming, and physical exercise (Skorka-Brown et al., 2015).

Although the efficacy of visuospatial interference has been found to be consistent across studies, uncertainty still abounds regarding the exact cognitive processes (e.g., the central role of visuospatial working memory) involved in desire thoughts. For example, Dodds et al. (2019) tested the effect of three different interference methods (Tetris, Corsi Block and Digit Span) on naturally occurring cravings. Their study showed that the various tasks similarly reduced craving, suggesting that tasks mobilizing either visuospatial or verbal working memory have an equivalent effect on craving, thus further questioning the cognitive processes underlying desire thoughts.

Current study

Given the central role of craving in the maintenance and relapse of GD, the development of specific interventions that target the implicated processes is an important step toward the improvement of psychological treatment for this condition. In this vein, the EIT provides a sound theoretical framework to account for the gambling craving and interference-based methods inspired from this model that have substantiated their

Table 1. Selection of studies that use interference-based methods.

Study	Target	Participants	Interference-based tasks and control conditions (CC)	Results
Kemps et al. (2005)	Induced **chocolate** craving	Chocolate cravers or not cravers, female university students	• Dynamic visual noise • Irrelevant speech	**Reduction** of craving and vividness Dynamic visual noise more effective than irrelevant speech
Steel et al. (2006)	Induced **food** craving	Food deprived or not-deprived female University students	• Dynamic visual noise	**Reduction** of vividness and intensity of craving
May et al. (2010) *4 experiments*	Induced **cigarette craving**	Smokers (>10 cigarettes/day) recruited in a University (staff and students)	• Auditory mental imagery • Visual mental imagery	**Reduction** of craving in visual condition but not in auditory condition
			• Auditory mental imagery and dynamic visual noise • Visual mental imagery	**Reduction** of craving in both conditions among deprived individuals
			• Auditory mental imagery • Visual mental imagery	**Interruption** of the increase of craving in visual imagery condition but not in auditory imagery condition
			• Clay modeling • Backwards counting (CC)	**Interruption** of the increase of craving in clay modeling condition but not in backwards counting condition
Knäuper et al. (2011)	Naturally occurring **food** or **drink** craving	University staff and students	• Pleasant imagery • Backwards alphabet (CC)	**Reduction** of craving Pleasant imagery more effective than reciting the backwards alphabet condition
Andrade, May et al. (2012) *2 experiments*	Induced **chocolate** craving	Chocolate lovers recruited from university staff and students	• Clay modeling • Backwards counting (CC)	**Reduction** of craving in clay modeling Clay modeling as effective as backwards counting
			• Clay modeling • Backwards counting (CC)	**Reduction** of the strength and the vividness of craving in Clay modeling condition Clay modeling more effective than backwards counting
Kemps and Tiggemann (2013)	Naturally occurring **food** craving	Female university students with food cravings (7/week)	• Dynamic visual noise	**Reduction** of the intensity of food craving Dynamic visual noise more effective than no intervention
Skorka-Brown et al. (2014)	Naturally occurring **food, drink, caffeine**, or **nicotine** craving	University students	• Puzzle video game Tetris • Load screen (CC)	**Reduction** of the strength and vividness of craving in Tetris condition Tetris more effective than load screen

(*Continued*)

Table 1. (Continued).

Study	Target	Participants	Interference-based tasks and control conditions (CC)	Results
Skorka-Brown et al. (2015)	In real world, **drugs, drink, food**, or **activities** craving	University students	• Puzzle video game Tetris • No task (CC)	**Reduction** of the strength and vividness of craving in Tetris condition Tetris more effective than simple monitoring
Schumacher et al. (2018)	Naturally occurring **food** craving	Female university students with food cravings (1/day)	• Mental imagery • Cognitive defusion (CC)	**Reduction** of the frequency and intensity of craving Mental imagery as effective as cognitive defusion
Dodds et al. (2019) *2 experiments*	Naturally occurring **food, drink, caffeine, nicotine, alcohol**, or **unspecified** craving	University students and the nearby city dwellers	• Puzzle video game Tetris • Corsi block task • Digit span task (CC)	**Reduction** of intensity, vividness, and intrusiveness but no difference across tasks
			• Corsi block task • Video watching (CC)	**Reduction** of intensity, vividness and intrusiveness more important in the task involving visuospatial working memory (Corsi block)

The lines separate experiments from one study.

Table 2. Demographics and gambling preferences.

	Experiment 1 *n* = 38	Experiment 2 *n* = 38
Education		
Primary	1	1
Secondary	17	21
Bachelor	5	6
Master	15	10
Occupation		
Employee	8	10
Self-employed	2	3
Unemployed	1	1
Student	24	22
Retired	1	1
Other[a]	2	1
Gambling preferences		
Scratch cards	68.42%	55.26%
Lottery	60.53%	57.89%
Betting	39.47%	47.37%
Slot machines	18.42%	18.42%
Poker	10.53%	13.16%
Online poker	7.89%	7.89%
Other[b]	2.63%	5.26%

[a]Volunteer, mutual fund, integration allowance
[b]Blackjack, roulette

effectiveness in mitigating substance and food-related cravings (see Table 1). In such a context, the present investigation aimed to test, for the first time (O'Neill, 2017), the efficacy of visuospatial interference methods in the context of experimentally induced gambling craving via two distinct experiments. Gamblers from the general population were recruited for this proof-of-principle study. In Experiment 1, we tested an intervention in which participants were asked to form a vivid mental image of a bunch of keys while manipulating them without seeing them. The target mental image of this interference-based method was chosen because keys are a common item that everyone carries, and because the task involves visuospatial and tactile senses that are relevant in the context of gambling craving (Cornil et al., 2018). In Experiment 2, we tested another type of interference-based method, which consists in playing the video game Tetris. This choice was based on recent studies suggesting that this video game, which has a heavy load on visuospatial working memory interferes with visual imagery involved in the elaboration of craving, can be successfully used to mitigate substance cravings (see Table 1 for more detail; Skorka-Brown et al., 2014, Skorka-Brown et al., 2015).

Experiment 1

Methods

Participants and recruitment

The sample comprised 38 community individuals (16 males and 22 females; mean age 29 years, age range 18–59 years) who gamble at least once a month. To be included in the experiment, participants had to be 18 years or older, fluent in French, and not in the

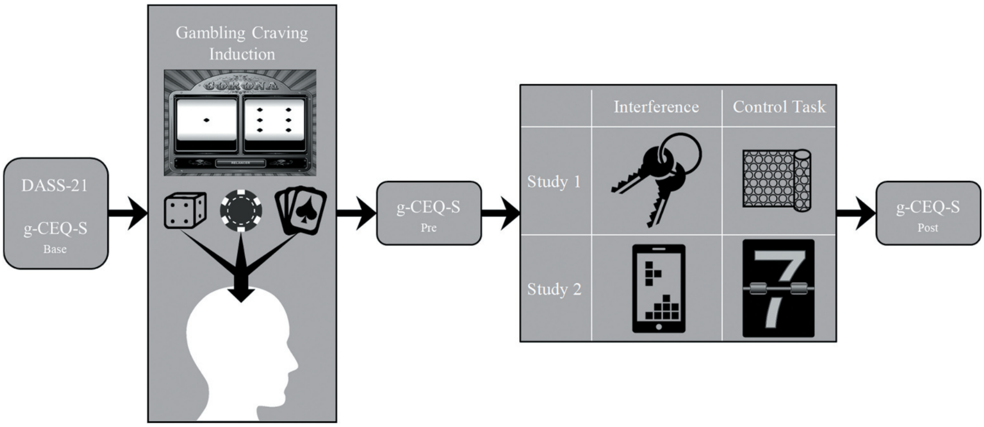

Figure 1. Experimental design for both experiments. DASS-21 = Depression, Anxiety and Stress Scales; g-CEQ-S = gambling Craving Experience Questionnaire – Strength form, at baseline (Base), pre-intervention (Pre), and post-intervention (Post). Pictograms are license-free or Noun Project creations (Joseph Elsbernd, Nikita Kozin, corpus delicti, and Magicon).

process of quitting or reducing gambling. Education, occupation, and gambling preferences are reported in Table 2. Participants were recruited through flyers at gambling venues, advertisements at the university campus, and social media. Participants who completed the whole experiment received 5 euros in compensation which could also be handed out in the form of scratch cards (see Experimental Design).

Questionnaires

Craving (i.e., the dependent variable) was measured with the g-CEQ, which has two forms: The frequency version (g-CEQ-F) is used to evaluate the rate of craving in a certain period (e.g., last week) and the strength version (g-CEQ-S) is used to assess a specific craving episode (here, the craving measured at baseline, post-induction but pre-intervention, and post-intervention; see below and Figure 1). Each form contains three subscales (intensity, imagery, and intrusiveness).

Other questionnaires were used as control variables:

- The short Plymouth Sensory Imagery Questionnaire (short Psi-Q; translated with back-translation; Andrade et al., 2014) was administered to assess the ability to create vivid mental images, a central feature of the craving experience (Andrade, May et al., 2012; Kavanagh et al., 2005).
- The Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) was used to assess and take into account the presence and severity of GD symptoms.
- The Short UPPS-P Impulsive Behavior Scale (S-UPPS-P; Billieux et al., 2012) measures impulsivity that is known to modulate craving experiences (e.g., Billieux et al., 2007; De-Sola et al., 2017; Rømer Thomsen et al., 2018).
- The Depression, Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995) were used to control for psychopathological symptoms.

Table 3. Characteristics and reliability of scales used.

Questionnaire	Author (year)	Number and Type of Items	Response Format	Composite reliability (CR) of scale or subscales in *experiment 1* and **experiment 2**
Gambling Craving Experience Questionnaire – Frequency (g-CEQ-F)	Cornil et al. (2019)	9 items distributed on 3 subscales (intensity, imagery and intrusiveness)	10-point Likert scale from 1 (*not at all*) to 10 (*constantly*)[a]	Range from *.88* to *.95* and from **.79** to **.91**
Gambling Craving Experience Questionnaire – Strength (g-CEQ-S)	Cornil et al. (2019)	9 items distributed on 3 subscales (intensity, imagery and intrusiveness)	10-point Likert scale from 1 (*not at all*) to 10 (*extremely*)[a]	Range[b] from *.86* to *.95* and from **.84** to **.94**
Problem Gambling Severity Index	Ferris and Wynne (2001)	9 items	4-point Likert scale: 0 (*never*), 1 (*sometimes*), 2 (*most of the time*), 3 (*almost always*)	*.78* and **.86**
Short Plymouth Sensory Imagery Questionnaire	Andrade et al. (2014)	21 items distributed on 7 subscales (vision, sound, smell, taste, touch, body, emotion)	11-point Likert scale ranging from 0 (*no image at all*) to 10 (*as vivid as real life*)	Range from *.64* to *.94* and from **.66** to **.92**
Short UPPS-P Impulsive Behavior Scale	Billieux et al. (2012)	20 items distributed on 5 subscales (negative urgency, positive urgency, lack of premeditation, lack of perseverance, and sensation seeking)	4-point Likert scale: 1 (*I agree strongly*), 2 (*I agree somewhat*), 3 (*I disagree somewhat*), 4 (*I disagree strongly*)	Range from *.78* to *.91* and from **.68** to **.92**
Depression, Anxiety and Stress Scales	Lovibond and Lovibond (1995)	21 items distributed on 3 subscales (depression, anxiety and stress)	4-point Likert scale: 0 (*did not apply to me at all*), 1 (*applied to some degree, or some of the time*), 2 (*applied to me to a considerable degree or a good part of time*), 3 (*applied to me very much or most of the time*)	Range from *.87* to *.91* and from **.66** to **.84**

[a]The g-CEQ-F and -S were validated after these studies in a version with an 11-point Likert scale ranging from 0 (*not at all*) to 10 (*constantly* or *extremely*).
[b]The CR range takes each administration of the g-CEQ-S into account

The questionnaires used in this study and their properties are presented in Table 3.[1]

Experimental design

Participants were informed about the topic of the study and general procedure, financial compensation, confidentiality, and the possibility of withdrawing from the study at any time. After reading the presentation, they answered an initial online questionnaire that was administered with the online platform Qualtrics, so that we could identify eligible participants. The inclusion criteria were gambling at least once a month, being over the age of majority (18 years in Belgium), speaking French, and not being involved in a gambling-related treatment. After having signed the informed consent document, participants completed demographics information and had to provide a valid e-mail address for the second part of the experiment. They also completed the following randomized questionnaires used as control variables: the short Psi-Q, g-CEQ-F, PGSI, and short UPPS-P. The participants who met the inclusion criteria were then contacted by e-mail to set up an appointment for the experimental phase. Participants completed the experiment individually in a laboratory with a trained and supervised master student (one per experiment) who installed them in front of a computer to start filling in questionnaires that were also hosted by Qualtrics. After a reminder about the experiment, the participants started by filling in the DASS-21. They then had to evaluate their current gambling craving with their baseline on the g-CEQ-S (g-CEQ-S_{Base}). A craving was then experimentally induced through the combination of an audio-guided imagery scenario and a gambling task (both available at https://osf.io/cmzgr/). The scenario was based on the work of Ashrafioun et al. (2012), and recent research showing its efficiency (Canale et al., 2019). The gambling task, designed with E-Prime 2.0, consisted in playing a slot machine with two dice (see Figure 1). Participants were told that they had three chances to obtain a total of 7 by summing the two dice to win five scratch cards of Win for Life (maximum win is 500€/month for life; worth 1€ each). The first trial was a miss (between 2 and 5 or between 9 and 12) as was the second (6 or 8). The third trial was a win, announced with a jingle and 'jackpot' mentions in the corners of the screen. The five tickets were placed on the desk, but participants were told not to scratch the cards yet. Before the intervention, they again completed the g-CEQ-S_{Pre} and were randomly assigned to the experimental or control conditions. Following the conditions described below (see Conditions section), craving was assessed a final time post intervention with the g-CEQ-S_{Post}. The participants were then debriefed, and a short mindfulness session (audio file available at https://osf.io/cmzgr/) was offered to avoid carryover effects. They could also choose to keep the five scratch cards or exchange them for €5.

All data, codes and materials are available from the Open Science Framework repository (https://osf.io/cmzgr/).

The ethical committee of the Psychological Sciences Research Institute (IPSY) at the UCLouvain (Louvain-la-Neuve, Belgium) approved the study protocol and participants signed an informed consent document. The recruitment and testing of participant took place between 2015 and 2017.

Conditions

In the experimental condition, the interference method consisted in manipulating with one's dominant hand a bunch of keys (one car key, one flat key, and one deadlock key tied

Table 4. Paired samples t-tests between g-CEQ-S subscales at T1 (baseline) and at T2 (post-induction) and between g-CEQ-S subscales at T2 and at T3 (post-intervention).

			T1		T2				
			M	*SD*	*M*	*SD*	*t*(37)	*p*	*d*
Experiment 1 (n = 38)	g-CEQ-S	Intensity	12.45	7.91	17.84	8.09	6.87	<.001	1.11
		Imagery	11.76	7.84	18.68	8.53	7.63	<.001	1.24
		Intrusiveness	8.58	6.50	12.47	7.62	3.92	<.001	.64
Experiment 2 (n = 38)	g-CEQ-S	Intensity	13.55	5.44	18.95	6.39	5.56	<.001	.90
		Imagery	14.03	7.07	19.55	7.45	6.21	<.001	1.01
		Intrusiveness	11.26	6.87	16.18	7.21	5.82	<.001	.94
			T2		**T3**				
			M	*SD*	*M*	*SD*	*t*(37)	*p*	*d*
Experiment 1 (n = 38)	g-CEQ-S	Intensity	17.84	8.09	11.45	6.88	−7.32	<.001	−1.19
		Imagery	18.68	8.53	11.76	7.39	−6.49	<.001	−1.05
		Intrusiveness	12.47	7.62	8.13	6.10	−3.96	<.001	−.64
Experiment 2 (n = 38)	g-CEQ-S	Intensity	18.95	6.39	15.21	5.86	−5.69	<.001	−.92
		Imagery	19.55	7.45	14.92	8.49	−5.95	<.001	−.97
		Intrusiveness	16.18	7.21	12.34	7.14	−4.82	<.001	−.78

g-CEQ-S = gambling Craving Experience Questionnaire – Strength.

on a keyring with a plastic fidelity card from a supermarket) in an opaque bag. During a 322-second recorded session (audio file available at https://osf.io/cmzgr/), participants were instructed to mentally picture the keyring (shape, texture, color, size) and each key one by one, and then to create a mental image of the entire bunch of keys as vividly as possible. This task was chosen because imagining a bunch of keys requires cognitive resources (working memory, visual sketchpad, and attention). Moreover, from a clinical utility viewpoint, this method is easily implementable in daily life. In the control condition, participants had to pop bubble wrap and count each bubble with the rhythm of a metronome (25 BPM; audio file available at https://osf.io/cmzgr/). Exploding bubble wrap is often used as a source of amusement and can be used as art therapy (Durrani, 2014) but we postulated that this task did not involve the visual cognitive resources that are essential in the elaboration of a craving (May et al., 2010).

Results

The analyses were conducted by using SPSS (IBM Corp, 2017) and RStudio (RStudio Team, 2016).

Induction of gambling craving and intervention efficacy

Gambling craving was induced with audio-guided imagery and a short gambling task. To ensure that the induction worked properly, we performed paired samples *t*-tests to compare the subscales of the g-CEQ-S_{Base} and g-CEQ-S_{Pre} (intensity, imagery, and intrusiveness). Results presented in Table 4 show a significant increase ($p < .001$) between baseline (T1) and pre-intervention (T2) for the three subscales of the g-CEQ-S with large effect sizes ($d > .80$), except for intrusiveness where a medium effect size ($d > .50$) occurred (Cohen, 1988). To evaluate the impact of the interventions on induced gambling craving, we used paired samples *t*-tests to compare the subscales of the g-CEQ-S_{Pre} and g-CEQ-S_{Post}. Results presented in Table 4 show significant decreases ($p < .001$) between T2 and post-intervention (T3) for the three subscales of

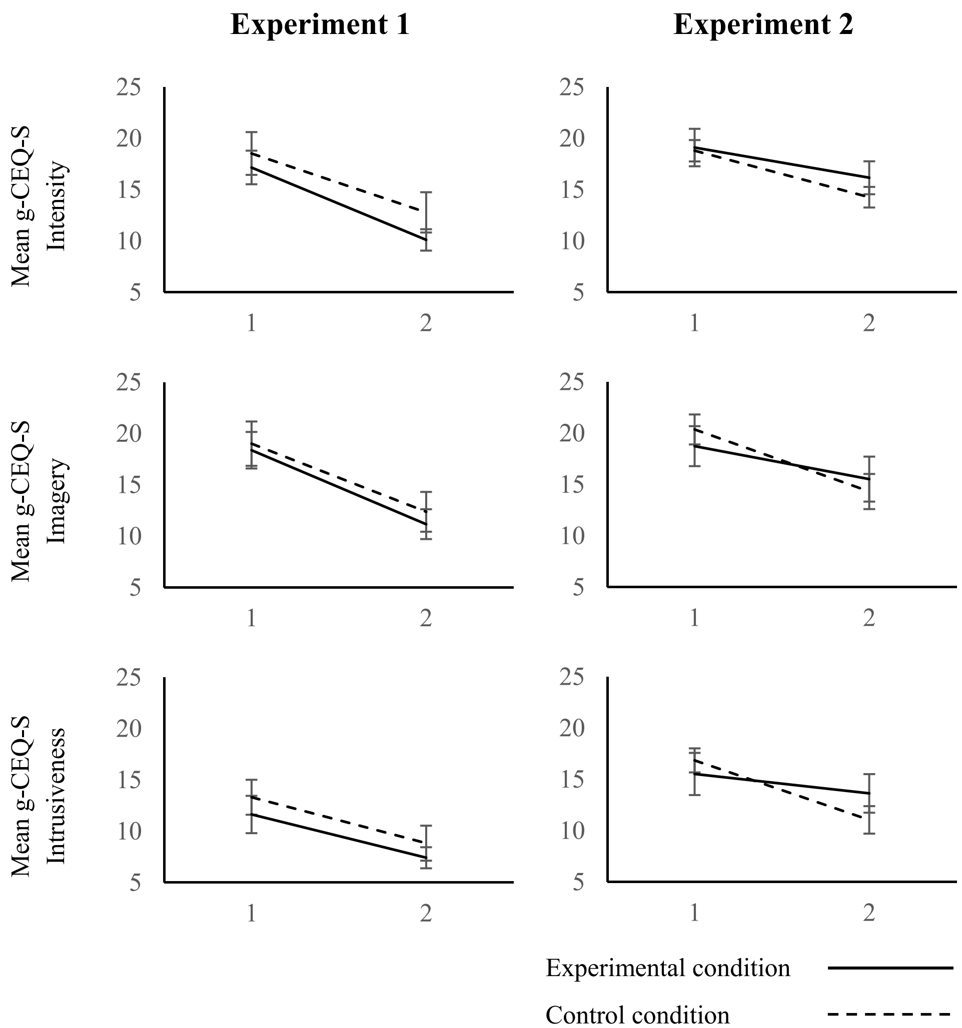

Figure 2. Mean ratings of each g-CEQ-S subscale at T2 (post-induction) and T3 (post-intervention) for Experiment 1 and Experiment 2. Error bars represent standard error of the mean. g-CEQ-S = gambling Craving Experience Questionnaire – Strength form. Error bars represent standard error of the mean. g-CEQ-S = gambling Craving Experience Questionnaire – Strength form.

the g-CEQ-S with large effect sizes (d > .80), except for a medium effect size (d > .50) for intrusiveness.

Condition differences

Independent sample t-tests were performed to evaluate the difference between experimental and control conditions for sex, age, and the following scales and their subscales: PGSI, short Psi-Q, S-UPPS-P, DASS-21, g-CEQ-F and g-CEQ-S_{Base}. We used a False Discovery Rate procedure (Benjamini & Hochberg, 1995) via an online calculator (Carbocation Corporation, 2016) to determine adjusted p-values with a false discovery rate at 5% for the 24 t-tests computed. No significant difference between conditions was found (see Appendix A, Table A1).

Effect of interference methods

Three repeated measures analyses of covariance (ANCOVA; one for each g-CEQ-S subscale) were performed with time (T2 and T3) as a within-subject factor, task as a between-subject factor (experimental and control), and PGSI as a covariate (in order to take into account individual differences in disordered gambling symptoms). In both the experimental and control conditions, the various craving subscales (intensity, imagery, and intrusiveness) decreased significantly over time (see Figure 2).

g-CEQ-S Intensity. There was a significant effect of time, $F(1,35) = 33.20$, $p < .001$, partial $\eta^2 = .487$, but no significant effect of condition, $F(1,35) = 0.87$, $p = .357$, partial $\eta^2 = .024$. The analyses revealed no significant interaction between time and condition, $F(1,35) = 0.53$, $p = .470$, partial $\eta^2 = .015$, or between time and PGSI, $F(1,35) = 1.08$, $p = .307$, partial $\eta^2 = .030$. No significant difference was found between experimental and control conditions for the g-CEQ-S intensity subscale at T2, $t(36) = 0.52$, $p = .609$, and at T3, $t(36) = 1.21$, $p = .237$.

g-CEQ-S Imagery. There was a significant effect of time, $F(1,35) = 30.92$, $p < .001$, partial $\eta^2 = .469$, but no significant effect of condition, $F(1,35) = 0.13$, $p = .717$, partial $\eta^2 = .004$. The analyses revealed no significant interaction between time and condition, $F(1,35) = 0.06$, $p = .807$, partial $\eta^2 = .002$, or between time and PGSI, $F(1,35) = 2.22$, $p = .145$, partial $\eta^2 = .060$. No significant difference was found between experimental and control conditions for the g-CEQ-S imagery subscale at T2, $t(36) = 0.23$, $p = .620$, and at T3, $t(36) = 0.71$, $p = .481$.

g-CEQ-S Intrusiveness. There was a significant effect of time, $F(1,35) = 16.84$, $p < .001$, partial $\eta^2 = .325$, but no significant effect of condition, $F(1,35) = 0.62$, $p = .438$, partial $\eta^2 = .017$. The analyses revealed no significant interaction between time and condition, $F(1,35) = 0.02$, $p = .878$, partial $\eta^2 = .001$, or between time and PGSI, $F(1,35) = 3.37$, $p = .075$, partial $\eta^2 = .088$. No significant difference was found between experimental and control conditions for the g-CEQ-S intrusiveness subscale at T2, $t(36) = 0.68$, $p = .503$, and at T3, $t(36) = 0.71$, $p = .481$.

Discussion of experiment 1

In this first experiment, we found that both tasks reduced gambling craving intensity, the vividness of mental images, and the intrusiveness of desire thoughts. Yet, contrary to our expectations, both task types similarly mitigated craving, indicating that our 'control' tactile task had the same effect on craving as did the method involving visual mental imagery. Our findings are not consistent with previous evidence showing that craving mainly depends on visuospatial processes (e.g., Andrade, May et al., 2012; Knäuper et al., 2011; May et al., 2010). However, these results might be explained by the involvement of working memory in the control condition (participants had to remember to explode the bubbles with the rhythm of a metronome and simultaneously to count the bubbles exploded), which is also a cognitive function postulated to underlie the craving process according to the EIT (Kavanagh et al., 2005; May et al., 2015). Such a view is consistent with the findings obtained by Dodds et al. (2019), who showed that a task that required verbal working memory (Digit Span) was as effective as other tasks focused on visuospatial cognitive resources (Tetris and Corsi Block) in order to reduce naturally occurring substance-related cravings. Moreover, we cannot exclude the possibility that some participants in the control condition used different strategies during the bubbles task (e.g., some participants used patterns to explode bubbles that may have involved visuospatial capacities). For this reason, our control condition might have been not optimal nor pure enough in terms of the cognitive mechanisms involved. We thus decided to use another control task in Experiment 2, namely backwards counting. Indeed, this task has been successfully used as a control condition in other interference-based studies and mobilizes verbal working memory but not visuospatial abilities (e.g., Andrade, Pears et al., 2012; May et al., 2010; Versland & Rosenberg, 2007).

Experiment 2

Methods

Participants and recruitment

The sample was composed of 38 community gamblers (gambling at least once a month) who did not take part in Experiment 1 (22 males and 16 females; mean age 28 years, age range 20–65 years). Demographics and gambling preferences are reported for both samples in Table 2. Inclusion criteria, recruitment, and compensation were the same as in Experiment 1.

Questionnaires and experimental design

The design replicates Experiment 1 with the same questionnaires and other tasks described in the Conditions section below (see Figure 1). All data, codes, and materials from this experiment is also available at https://osf.io/cmzgr/.

Conditions

The interference method consisted in playing the video game Tetris, as in previous studies (Skorka-Brown et al., 2014, 2015; Van Dillen & Andrade, 2016). Tetris (Electronics Arts, 2010) was displayed on a Samsung Galaxy S4 i9505. After a short explanation and a demonstration of the game, participants were asked to play Tetris for 3 minutes. The control condition consisted in a verbal task inspired by Versland and Rosenberg (2007), in which participants had to count backwards by 7 starting from 500 during the same length of time as in the interference condition (i.e., 3 minutes).

Results

As in Experiment 1, the analyses were conducted by using SPSS (IBM Corp, 2017) and RStudio (RStudio Team, 2016).

Induction of gambling craving and intervention efficacy

Gambling craving was induced as in Experiment 1. The efficacy of the gambling craving induction was checked by computing paired samples *t*-tests between the g-CEQ-S_{Base} and the g-CEQ-S_{Pre} (intensity, imagery, and intrusiveness). Results presented in Table 4 show significant increases ($p < .001$) between T1 and T2 for the three subscales of the g-CEQ-S with large effect sizes ($d > .80$) according to Cohen's guidelines (Cohen, 1988). The effect of both tasks of was evaluated by paired samples t-tests between the g-CEQ-S_{Pre} and the g-CEQ-S_{Post}. Results presented in Table 4 show significant decreases ($p < .001$) between T2 and T3 for the three subscales of the g-CEQ-S with large effect sizes ($d > .80$), except for a medium effect size ($d > .50$) for intrusiveness.

Condition differences

Independent samples t-tests were performed to evaluate the difference between both conditions on all variables tested in Experiment 1 and following the same Benjamini-Hochberg procedure to determine adjusted p-values. No significant difference between conditions was found (see Appendix A).

Effect of interference methods

As in Experiment 1, three repeated measures ANCOVAs (one for each g-CEQ-S subscale) were performed with time (pre and post) as the within-subjects factor, task as the between-subject factor (experimental and control), and PGSI as a covariate. In both experimental and control conditions, craving subscales (intensity, imagery, and intrusiveness) decreased significantly over time (see Figure 2).

g-CEQ-S Intensity. There was a significant effect of time, $F(1,35) = 4.79$, $p = .035$, partial $\eta^2 = .120$, but no significant effect of condition, $F(1,35) = 0.01$, $p = .918$, partial $\eta^2 < .001$. The analyses revealed no significant interaction between time and condition, $F(1,35) = 2.41$, $p = .130$, partial $\eta^2 = .064$, but they showed a significant interaction between time and PGSI, $F(1,35) = 4.18$, $p = .048$, partial $\eta^2 = .107$. Given the sample size, a graphical approach was favored to further investigate this interaction (Appendix B). Participants who presented more GD symptoms reported a higher intensity of craving at T2, which decreased more sharply than it did among those who presented fewer GD symptoms. No significant difference was found between experimental and control conditions for the g-CEQ-S intensity subscale at T2, $t(36) = -0.15$, $p = .882$, and at T3, $t(36) = -1.00$, $p = .326$.

g-CEQ-S Imagery. There was a significant effect of time, $F(1,35) = 14.23$, $p = .001$, partial $\eta^2 = .289$, but no significant effect of condition, $F(1,35) = 0.11$, $p = .748$, partial $\eta^2 = .003$. The analyses revealed no significant interaction between time and condition, $F(1,35) = 3.50$, $p = .070$, partial $\eta^2 = .091$, or between time and PGSI, $F(1,35) = 0.04$, $p = .81$, partial $\eta^2 = .001$. No significant difference was found between experimental and control conditions for the g-CEQ-S imagery subscale at T2, $t(36) = 0.67$, $p = .507$ and at T3, $t(36) = -0.43$, $p = .667$.

G-CEQ-S Intrusiveness. There was a significant effect of time, $F(1,35) = 5.45$, $p = .025$, partial $\eta^2 = .135$, but no significant effect of condition, $F(1,35) = 0.02$, $p = .894$, partial $\eta^2 = .001$. The analyses revealed a significant interaction between time and condition, $F(1,35) = 8.26$, $p = .007$, partial $\eta^2 = .191$, but no significant interaction between time and PGSI, $F(1,35) = 2.34$, $p = .136$, partial $\eta^2 = .063$. Post hoc analyses using paired-samples t-tests showed a significant reduction of the intrusiveness scores between T2 and T3 for the control condition, $t(18) = 5.31$, $p < .001$, but not for the experimental condition $t(18) = 1.89$, $p = .08$. No significant difference was found between experimental and control conditions for the g-CEQ-S intrusiveness subscale at T2, $t(36) = 0.58$, $p = .582$, and at T3, $t(36) = -1.12$, $p = .271$.

Discussion of experiment 2

As in Experiment 1, both tasks were found to reduce the gambling craving intensity, the vividness of mental images, and intrusiveness of desire thoughts. As no difference was found between the two conditions, Experiment 2 failed to demonstrate the higher efficiency of a visuospatial task in contrast to a verbal one in mitigating gambling craving. Although our findings further confirm the role of working memory and attentional resources in craving, they also challenge the central role of visual imagery in gambling craving. Of note, similar results have been found by Dodds et al. (Experiment 1 in Dodds et al., 2019) in the context of substance-related craving.

Experiment 2 also revealed an interaction effect between GD symptoms (measured with the PGSI) and the intensity of the craving episode, indicating that the reduction of craving intensity might be more pronounced among problematic gamblers. Although our sample is composed of community gamblers, these results suggest that the interventions tested might be particularly useful for at-risk or problematic gamblers and thus have clinical relevance.

Despite no main effect of the condition, the interaction between time and condition for the intrusiveness of desire thought indicates that the task influenced the decrease of craving intrusiveness. Indeed, counting backwards, the control task, was effective, whereas the effect of Tetris indicated only a downward trend. It is worth noting that the possibility cannot be excluded that, for some gamblers, Tetris might share some similarities with their favored gambling activity because of similar structural features such as the colors (e.g., slot machines) or a similar medium (e.g., sport betting often occurs via smartphone apps). These similarities might explain the unchanged level of craving intrusiveness found for this intervention.

General discussion

The two experiments presented in this paper tested, for the first time, the mitigating effect of two interference methods on laboratory-induced gambling craving that are easily implementable in daily life. The first method involved creating a multi-sensorial mental image (picturing a bunch of keys while manipulating them) and the second method involved playing a video game that mobilized visuospatial working memory. In both experiments, gambling craving intensity, imagery, and intrusiveness decreased as the result of the tasks used. These outcomes are broadly consistent with previous research that shows the usefulness of methods that tax working memory resources in reducing craving (e.g., Kemps et al., 2005; May et al., 2010; Skorka-Brown et al., 2015).

A central finding is that the methods focusing on visuospatial working memory – a postulated pivotal component underlying craving according to the EIT – have shown to be equivalent to control tasks that mobilize other cognitive resources in order to reduce gambling craving. This result is both surprising and important as previous studies (e.g., Andrade, Pears et al., 2012; Kemps, Tiggemann, Christianson et al., 2008; May et al., 2010) found that tasks involving the visuospatial sketchpad were the most effective for decreasing substance and food cravings. In contrast, all the methods used in the experimental and control conditions of the present experiments successfully reduced experimentally induced gambling craving (with the exception of intrusiveness in the context of playing the video game Tetris; see Discussion in Experiment 2 for more detail). However, to ascertain our results, further research comparing, for instance, auditory versus visual imagery in the context of gambling craving is required.

Our results are consistent with those obtained by Dodds et al. (2019), who observed an equivalent effectiveness of verbal and visuospatial tasks. These findings could be explained by interindividual differences in the subjective craving experience, which might be more or less related to verbal or specific mental imagery-related components (various sensorial modalities). Interference-based methods should thus be adapted in terms of each participant's subjective craving experiences (e.g., counting backwards for a verbal experience and playing Tetris for an imaging experience) or they should be combined (e.g., picturing a bunch of keys while manipulating them). It is thus possible that any task that taxes working memory resources has the potential to reduce craving. The interference methods should then be tailored according to individual differences preferences.

Both experiments focused on reducing one gambling craving episode, which does not allow us to evaluate the potential evolution of the frequency and the strength of future gambling craving. The long-term effect of interference methods is indeed questioned (Dodds et al., 2019; Van Dillen & Andrade, 2016), and the possibility cannot be excluded that their effect is only temporary (Kemps & Tiggemann, 2015).

The present study has some limitations to consider. Firstly, the control tasks of each study were not strictly equivalent, preventing the comparison of experimental tasks. However, as the control task from the first experiment might have involved visuospatial resources, we decided to use another 'purer' verbal task in Experiment 2. Secondly, our samples are composed of community gamblers and our results should be replicated in a clinical population. Thirdly, our sample size is relatively small. Nevertheless, we determined sample size in our experiments based on previous studies with similar aims (i.e., testing the effect of interference methods) and procedures (e.g., Kemps & Tiggemann, 2013; May et al., 2010; Skorka-Brown et al., 2015). Fourthly, as a decrease in craving was observed with all tasks used (experimental and control tasks), we cannot exclude that the diminution of craving was explained by a distraction or cognitive load effect, rather than by the effect of sensory imagery per se. Finally, one could argue that the results observed could be due to a natural decrease of craving rather than an effect of the interference methods per se. Yet, previous research that used comparable craving induction procedures and interference methods successfully showed differences in post-task self-reported craving across experimental conditions (e.g., Andrade, Pears et al., 2012; Kemps & Tiggemann, 2007; May et al., 2010). This was the case, for example, for studies showing the superiority of interference methods in comparison to 'mind wandering' or 'no-task' conditions (e.g., Kemps, Tiggemann, Christianson et al., 2008; May et al., 2012; Schumacher et al., 2018). This observation suggests that the effects obtained in the current study, which followed a similar experimental design to those of the previous studies, can reasonably be attributed to the interference methods and not to the spontaneous reduction of induced craving.

Despite these study limitations, the present results suggest that interference-based methods might constitute a sound approach to interfere with and mitigate gambling cravings. Given the low cost and highly flexible nature of interference-based techniques, the present proof-of-principle study opens new avenues for clinically oriented research. In particular, the efficacy of interference-based techniques in clinical populations, along with their potential long-lasting effects, should be tested in further research.

Note

1. Several questionnaires used in the design were not considered in this manuscript. First, the State-Trait Anxiety Inventory (state version; Gauthier & Bouchard, 1993) was omitted because an error occurred regarding the Likert scale used. Second, to reduce the number of variables used for the analyses and for clarity, we also excluded the following questionnaires: the Positive and Negative Affect Schedule (Gaudreau et al., 2006), the Self-Assessment Manikin (Morris, 1995), the gambling version of the Transaddiction Craving Triggers Questionnaire (Cornil, Rothen et al., 2019; Von Hammerstein et al., 2019), and a visual analogue scale for gambling craving.

Acknowledgements

We warmly thank Thibaud Miret y Alsina and Céline Lentz for the data collection and the members of Louvain Experimental Psychopathology (UCLouvain) for their useful feedback on earlier drafts of the manuscript.

Data availability statement

The data described in this article are openly available in the Open Science Framework at http://doi.org/10.17605/OSF.IO/CMZGR.

Open scholarship

This article has earned the Center for Open Science badges for Open Data and Open Materials through Open Practices Disclosure. The data and materials are openly accessible at http://doi.org/10.17605/OSF.IO/CMZGR.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This study was supported by a one-year grant from the Belgian National Lottery obtained by Joël Billieux in 2014.

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Appendices

Appendix A

Table A1. Independent samples *t*-tests between experimental and control conditions.

	Experiment 1			Experiment 2		
	Statistic	Mean difference	Benjamini-Hochberg Adjusted *p*	Statistic	Mean difference	Benjamini-Hochberg Adjusted *p*
Sex	1.73		.99	1.73		.57
Age	1.24	4.89	.88	−1.79	−6.58	.48
short Psi-Q Vision	.44	.63	.88	1.23	2.79	.61
short Psi-Q Sound	−.37	−1.11	.86	1.43	2.47	.55
short Psi-Q Smell	.75	1.42	.79	1.02	2.58	.55
short Psi-Q Taste	.56	1.32	.82	1.21	3.16	.61
short Psi-Q Touch	−.40	−.79	.87	.55	1.16	.75
short Psi-Q Body	−.94	−1.58	.84	1.49	2.21	.56
short Psi-Q Emotion	.09	.16	.97	.67	.95	.71
g-CEQ-F Intensity	.11	.26	1.00	−.50	−1.11	.74
g-CEQ-F Imagery	.06	.11	.96	−.94	−1.95	.70
g-CEQ-F Intrusiveness	.91	1.68	.74	−2.19	−3.68	.48
PGSI	.11	.11	1.00	−.90	−1.37	.68
Negative Urgency	1.58	1.53	.72	.61	.53	.73
Positive Urgency	2.35	1.74	.24	−.30	−.21	.77
Lack of Premeditation	−.56	−.42	.87	−.34	−.26	.81
Lack of Perseverance	−.91	−.68	.81	.39	.32	.80
Sensation Seeking	−.69	−.74	.80	1.50	.74	.67
DASS-21 Depression	1.41	1.95	.82	−2.37	−2.05	.56
DASS-21 Anxiety	1.73	2.37	.72	−.72	−3.21	.48
DASS-21 Stress	2.72	4.11	.24	−.72	−.79	.72
g-CEQ-S_{Base} Intensity	.84	2.16	.75	−1.75	−3.00	.43
g-CEQ-S_{Base} Imagery	1.01	2.58	1.00	−.90	.79	.77
g-CEQ-S_{Base} Intrusiveness	1.00	2.11	.88	−.90	−2.00	.65

Psi-Q = Plymouth Sensory Imagery Questionnaire; g-CEQ-F = gambling Craving Experience Questionnaire – Frequency form; PGSI = Problem Gambling Severity Index; DASS-21 = short version of the Depression Anxiety and Stress Scales; g-CEQ-S_{Base} = gambling Craving Experience Questionnaire – Strength form at T1 (baseline). Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995) was used to obtain adjusted *p*-values with a false discovery rate at 5% for the 24 *t*-tests of each experiment.

Appendix B

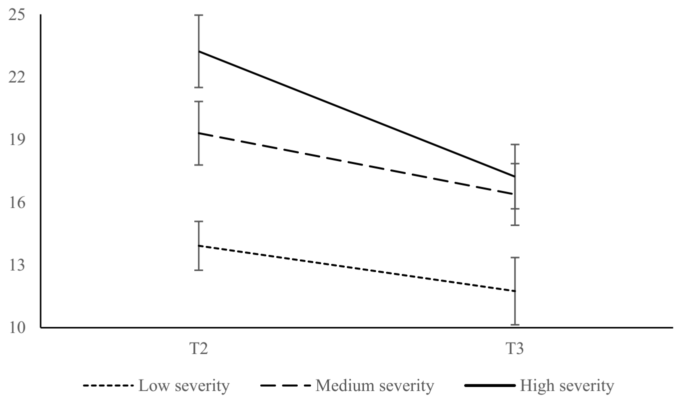

Figure B1. Mean ratings of the intensity subscale of the g-CEQ-S at T2 (pre-intervention) and T3 (post-intervention) for Experiment 2 across three categories of gambling severity. Error bars represent standard error of the mean. The sample was divided into three categories according to the Problem Gambling Severity Index scores: low severity (0–2; *n* = 12), medium severity (3–7; *n* = 13) and high severity (8–21; *n* = 13). g-CEQ-S = gambling Craving Experience Questionnaire – Strength form.