J Gambl Stud (2017) 33:807–823
DOI 10.1007/s10899-016-9650-6

ORIGINAL PAPER

Cue-Reactive Rationality, Visual Imagery and Volitional Control Predict Cue-Reactive Urge to Gamble in Poker-Machine Gamblers

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Published online: 1 November 2016
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Abstract Poker-machine gamblers have been demonstrated to report increases in the urge to gamble following exposure to salient gambling cues. However, the processes which contribute to this urge to gamble remain to be understood. The present study aimed to investigate whether changes in the conscious experience of visual imagery, rationality and volitional control (over one's thoughts, images and attention) predicted changes in the urge to gamble following exposure to a gambling cue. Thirty-one regular poker-machine gamblers who reported at least low levels of problem gambling on the Problem Gambling Severity Index (PGSI), were recruited to complete an online cue-reactivity experiment. Participants completed the PGSI, the visual imagery, rationality and volitional control subscales of the Phenomenology of Consciousness Inventory (PCI), and a visual analogue scale (VAS) assessing urge to gamble. Participants completed the PCI subscales and VAS at baseline, following a neutral video cue and following a gambling video cue. Urge to gamble was found to significantly increase from neutral cue to gambling cue (while controlling for baseline urge) and this increase was predicted by PGSI score. After accounting for the effects of problem-gambling severity, cue-reactive visual imagery, rationality and volitional control significantly improved the prediction of cue-reactive urge to gamble. The small sample size and limited participant characteristic data restricts the generalizability of the findings. Nevertheless, this is the first study to demonstrate that changes in the subjective experience of visual imagery, volitional control and rationality predict changes in the urge to gamble from neutral to gambling cue. The results suggest that visual imagery, rationality and volitional control may play an important role in the experience of the urge to gamble in poker-machine gamblers.

Keywords Poker-machines · Slot machines · Gambling cue-reactivity · Urge · Imagery · Volitional control · Rationality

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Introduction

Problem gambling refers to a collection of behaviours, which may reflect individual difficulties in "limiting money and/or time spent on gambling" (Delfabbro 2012, p. 2), where such behaviour is maintained in spite of significant financial, psychological and interpersonal costs (e.g., Wanner et al. 2006). Problem gambling is therefore, by definition, maladaptive and a significant body of research has sought to understand the processes, which contribute towards individuals engaging in gambling. Gambling is believed to have a high social cost within Australia, with research suggesting that problem gambling behaviour costs Australian communities approximately five billion dollars per year as well as negatively impacting upon the well-being of multiple individuals in problem gamblers' lives (Australian Government 2014; Productivity Commission 2010).

Gambling behaviour involving poker-machines (i.e., electronic gaming machines also referred to as "pokies" and slot-machines) reflects the most prevalent preferred gambling modality within problem gambling populations in Australia (Dickerson 2004), contributing twelve of the nineteen billion dollars generated in gambling revenue nationally (Productivity Commission 2010). Thus, understanding why individuals engage in poker-machine gambling is of significant interest yet relatively little research has been conducted specifically within the poker-machine gambler population. One of the key variables of interest, which has been evaluated in regards to gambling behaviour is the *urge* to gamble.

Urge to Gamble

A number of phenomenological variables have been discussed in relation to the urge to gamble including physiological arousal, affect and a variety of cognitive processes (Ashrafioun et al. 2012), yet a precise definition of urge to gamble has yet to be agreed upon within the literature. The majority of descriptions conceptualise the urge to gamble as being characterised by a subjective motivation or impulse to engage in gambling, seek out a particular gambling stimulus and/or experience a particular sensation (e.g., Bradizza et al. 1994; Rohsenow and Niaura 1999). For problem gamblers, the urge to gamble has been suggested to be strongly provoked by gambling-related cues (Blaszczynski and Nower 2002). The provocation of an urge to gamble by gambling-related cues is typically understood in terms of classical and operant conditions theories. Following an initial learning experience in which a given behaviour is experienced as in some way rewarding, an urge to repeat such behaviour is experienced which may then become self-reinforcing as this behaviour is continued (e.g., Kushner et al. 2007). The repeated pairings of anticipation, gambling behaviour and intermittent reward with the various stimuli surrounding the gambling experience may result in these stimuli cueing the urge/impulse to engage in gambling. Salient cues that become paired with urge to gamble may include visual (e.g., flashing lights on poker-machines), auditory (e.g., sound of poker-machines paying out), or environmental stimuli (e.g., public bars where poker-machines are typically placed). These cues, in turn, motivate individuals to engage in further gambling and strengthen this association. The gambling cues which provoke an urge to gamble are therefore of interest as they are believed to be crucial to the perpetuation of maladaptive gambling behaviours (Freidenberg et al. 2002).

Based on this conceptualisation, cue-reactivity paradigms have been used to assess increases in the subjective urge to engage in gambling upon exposure to gambling cues. Within gambling and addiction research the urge to engage in a particular behaviour (e.g.,

gambling, consuming alcohol, eating) has typically been conceptualised and measured as a continuous unidimensional construct (e.g., Tricker et al. 2016). Cue-reactivity paradigms in addiction research typically involve obtaining a measure of urge at baseline, following the presentation of a neutral cue and then following the presentation of an addiction-relevant cue (e.g., Rock and Kambouropoulos 2008). This paradigm aims to derive a measure of "cue-reactive urge" from the increase in urge between a neutral and addiction-relevant cue whilst controlling for baseline (Rock and Kambouropoulos 2007).

A small number of studies have been conducted in regards to gambling cue response in heterogeneous groups of gamblers; however, the majority of these studies have not employed both a baseline and neutral cue (Tricker et al. 2016). Such research indicates that gamblers display an increase in the urge to gamble in response to gambling cues (e.g., videos, pictures, imagined scenarios) associated with their preferred gambling modality, relative to stimuli associated with a non-preferred gambling mode (Sodano and Wulfert 2010; Wulfert et al. 2009) and relative to a baseline (pre-gambling cue) condition (Ashrafioun et al. 2012). Furthermore, this research has demonstrated a significant positive association between problem-gambling severity and gambling urge (Ashrafioun et al. 2012).

Tricker et al. (2016) conducted the first study of its kind to examine cue-reactive urge specifically within a population with a preferred gambling modality of poker-machines. Tricker and colleagues conducted an online repeated measures study, which evaluated urge to gamble (as measured by a 0-to-10 visual analogue scale) in 37 poker-machine gamblers at baseline, following a neutral cue and following a gambling cue. The study demonstrated that, after controlling for baseline urge to gamble, problem-gambling severity, as measured by the *Problem Gambling Severity Index* (PGSI; Ferris and Wynne 2001), significantly predicted an increase in participants' urge from neutral cue (i.e., video of women making tea) to gambling cue (i.e., video of same women engaging in poker-machine gambling). McKeith et al. (2016) replicated this finding utilising the same cue-reactivity paradigm in a sample of regular poker-machine gamblers.

Collectively, the small body of research described indicates that the urge to gamble can be reliably cued by stimuli associated with a salient gambling modality (such as the images associated with poker-machines) and that cue-reactive urge is predicted by problem gambling severity (Ashrafioun et al. 2012; Sodano and Wulfert 2010; Tricker et al. 2016; Wulfert et al. 2009). However, the cognitive processes that contribute to the urge to gamble remain poorly understood. One approach to addressing this issue is to determine the degree to which other cognitive and affective processes are associated with the unidimensional construct of urge to gamble (Tricker et al. 2016). The first study to have adopted this approach in poker-machine gamblers was conducted by Tricker et al. (described above) who reported that cue-reactive altered state of awareness (measured using a subscale of the Phenomenology of Consciousness Inventory; PCI; Pekala 1991) mediated the relationship between problem gambling severity and cue-reactive urge to gamble. McKeith et al. (2016) also reported that cue-reactive altered state of awareness predicted urge to gamble, but did not find that this significantly mediated the relationship between problem gambling severity and urge. We note, however, that the unidimensional nature of this PCI subscale provides merely a general measure of an altered state of awareness as the extent to which one's current state of awareness is qualitatively different from one's typical experience. Thus, this PCI subscale does not speak to the issue of which, if any, phenomenological variables might characterize a particular altered state of awareness and, thus, contribute to the prediction of cue-reactive urge to engage in poker-machine gambling. In the sections

below we argue that three pertinent phenomenological variables are rationality, volitional control and visual mental imagery.

Urge to Gamble and Rationality

Due to the odds of winning and the negative life impact associated with the behaviour, poker-machine problem gambling can be conceptualised as an irrational behaviour and irrational thinking is believed to play a central role in gambling (Walker 1992). It has been hypothesised that problem gambling behaviour is subject to a number of cognitive biases and reasoning errors. Specifically, erroneous appraisals regarding the perceived randomness, controllability and independence of events are believed to influence the persistence of gambling behaviours (Ladouceur et al. 2001; Tavares et al. 2003). Indeed, a number of studies that have asked poker-machine gamblers to verbalise their thought processes whilst gambling have identified various irrational cognitions that occur across gamblers. These reported cognitions have been classified in terms of thoughts pertaining to the controllability of outcomes, superstitious rituals and hypotheses, inappropriate rationalization of near misses, personification of the poker-machine and thoughts relating gambling success to personal skill (Delfabbro and Winefeld 2000; Ladouceur et al. 1991). The presence of such irrational cognitions has been found to predict risk taking in gambling (Delfabbro and Winefeld 2000). Whilst the presence of irrational thinking during gambling has been established, individual perception of these cognitive processes and their impact upon the urge to gamble has yet to be understood.

Whilst the above research has demonstrated that gambling may be paired with an increase in the occurrence (i.e. reported frequency) of irrational cognitions (e.g. fallacious reasoning irrespective of awareness that one has engaged in such reasoning), one facet of rationality that remains to be examined in gambling behaviour is the subjective experience of one's thinking as clear and rational versus being conceptually muddled. This distinction can be seen to reflect the difference between the occurrence of thoughts which would be objectively classified as irrational, versus an individual experiencing their own thinking as being becoming less clear or irrational. As noted by Tricker et al. (2016), a variety of research has demonstrated that gamblers report a significant change within their conscious experience when gambling. Such descriptions include experiencing a drug-like high (Oakes et al. 2012) or a dissociative state associated with the gambling experience (Jacobs 1988). Such accounts may infer a shift in subjective experience of thought processes and perhaps a change in the degree to which one's thinking is experienced as rational.

The PCI contains a "rationality" subscale which assesses the extent to which an individual's thinking is clear, distinct and easy to comprehend versus the extent to which this experience their thinking as confused, muddled and non-rational (Rock and Kambouropoulos 2012). It might reasonably be hypothesised that, when faced with a gambling cue, problem gamblers experience a subjective decrease in the clarity and perceived rationality of their thinking and that this shift contributes to the urge to gamble. Such confused or muddled thinking in response to gambling cues might be hypothesised to partially account for the persistence of gambling behaviours in the face of significant losses. Additionally, the subjective experience of "non-rational" thinking when exposed to a gambling cue could be conceptualised as reflecting one phenomenological element or sub-system of a cue-reactive altered state of awareness, which has previously been demonstrated to mediate the relationship between problem gambling severity and cue-reactive urge to gamble (Tricker et al. 2016).

Urge to Gamble and Visual Mental Imagery

Visual mental imagery has the potential to be a pertinent variable in relation to the urge to engage in poker-machine gambling behaviour (Whiting and Dixon 2013), yet there has been little research regarding mental images and gambling. Furthermore, no research has evaluated the *cue-reactive*-imagery (i.e., imagery experienced *following* a gambling cue) and its relationship with cue-reactive urge to gamble. We note, however, that Ashrafioun et al. (2012) examined urge to gamble in a sample of 48 university student gamblers following exposure to either a script designed to elicit gambling-related mental imagery or to gambling-related photographs. Gambling urge significantly increased from baseline to gambling cue in each condition, suggesting that mental imagery relating to gambling may be sufficient to cue an increase in the urge to gamble.

A study by Whiting and Dixon (2013) examined the impact of a brief mental imagery task on gambling behaviour across 31 participants within a student population. Participants were either asked to imagine gambling on a slot machine 30 times and placing coins into a laundry machine three times, or to imagine gambling on a slot machine three times and placing quarters in a laundry machine 30 times. Subsequently, both groups were allowed to play a real slot machine and stop whenever they wished to finish. Interestingly, the results showed that those who imagined playing the slot machine 30 times prior to gambling played significantly fewer trials than those who imagined playing only three times. This finding could be interpreted as indicating that this gambling-related imagery resulted in lower subjective urge to gamble. However, it should be noted that this trial did not evaluate a problem gambling population.

The notion that mental imagery may increase the urge to engage in a salient behaviour is supported by the fact that generating smoking-related visual mental imagery increases the subjective urge to smoke in regular smokers (Tiffany and Drobes 1990). This relationship has also been demonstrated in relation to cocaine use (Kilts et al. 2004). Similarly, recalling a previous food craving experience or imagining eating particular foods has been found to be associated with increased urge to eat (Kemps and Tiggemann 2015). Across a wide range of research in the mental health field, mental imagery, both past and future focused, has been found to be associated with changes in affect and behaviour and mental images may come to be spontaneously elicited by salient cues (e.g., Holmes et al. 2015). Consequently, it may be hypothesized that gambling-related stimuli trigger mental images of gambling behaviours (e.g., past wins and/or future imagery of oneself winning), which would, in turn, be associated with increases in subjective urge to gamble. However, to date, no research has been conducted into the presence of mental imagery in problem gamblers in response to gambling cues, and its relationship with cue-reactive urge to gamble remains unknown. It should be noted that the term "mental imagery" may denote the mental representation of a variety of sensory information (including sound, touch or smell; Holmes et al. 2015).

Urge to Gamble and Volitional Control

Tricker et al. (2016) suggested that volitional control is a pertinent variable to consider when evaluating the urge to gamble. Volitional control (i.e., the extent to which one feels that they are able to control a particular aspect of experience) has been researched in problem gambling in terms of gambler perception of their control over their gambling behaviour or their ability to refuse to engage in gambling (Martin et al. 2010). Research

suggests that subjective sense of lack of control over gambling behaviour is associated with higher levels of gambling intention and problem gambling behaviours (Blaszczynski and Nower 2002; Martin et al. 2010; Wu and Tang 2012).

However, whilst previous research has evaluated volitional control of one's behaviour, the extent to which an individual feels in control of their own cognitive processes (e.g., content of thoughts, images, direction of attention) has not been investigated in relation to gambling behaviour and the urge to gamble. As noted above, problem gamblers often report a shift in their conscious experience in response to gambling cues and when engaged in gambling, with dissociative states being reported in a number of studies (e.g., Jacobs 1988). Additionally, there is evidence that problem gamblers report higher levels of preoccupation with intrusive thoughts compared to non-problem gamblers (Blaszczynski 1999). This finding might suggest that, in a similar fashion to the subjective experience of rationality, gambling-related cues may prompt a shift in conscious experience in poker-machine problem gamblers, whereby they experience a decreased sense that they are able to exert control over their cognitions. The PCI provides a suitable measure of this aspect of volitional control, with a dimension that evaluates the extent to which one has "complete control" over their thoughts and attention versus becoming passive and receptive to conscious experience (Pekala 1991). It may, therefore, be hypothesised that gambling cues would come to provoke a decrease in volitional control in poker-machine problem gamblers and that this would predict cue-reactive urge.

The Current Study

The present study aimed to investigate whether cue-reactive visual imagery, rationality and volitional control improved the prediction of cue-reactive urge to engage in poker-machine gambling after accounting for the effects of problem-gambling severity. The study sought to test this question using retrospective analysis of the data collected as part of McKeith et al.'s (2016) wider study of urge to gamble in poker-machine gamblers, in which the phenomenological variables of interest were not analyzed or reported. Specifically, the present study evaluated the data of poker-machine gamblers who reported experiencing problems associated with their gambling behaviour in order to test the following hypotheses:

H1 Urge to gamble will increase from neutral cue to gambling cue, while controlling for baseline urge to gamble.

H2 Cue-reactive visual imagery, rationality and volitional control will improve the prediction of cue-reactive urge to gamble after accounting for the effects of problem-gambling severity.

Method

Participants

Thirty-one poker-machine gamblers were recruited following the selection criteria established in previous studies of poker-machine problem gamblers (e.g. McCormick et al. 2012; MacLaren et al. 2012); participants self-identified as having engaged in playing poker-machines at least twice in the past year and stated that poker-machines were their

preferred mode of gambling. Due to the proposal that problem gamblers experience greater changes in the urge to gamble in response to gambling cues than non-problem gamblers (Baudinet and Blaszczynski 2013) a further selection criterion was stipulated; participants had to score at least one on the PGSI. A score of one indicates that they experienced at least "low levels" of problems associated with gambling (where zero reflects no problems associated with gambling; see Ferris and Wynne 2001). Participants were recruited by placing advertisements including the link to the online survey on social media sites, online gambling forums and message boards, and in newspaper advertisements within New South Wales, Australia. A total of 153 participants completed the initial demographic questions within the survey, and 115 dropped out prior to completion of the survey. Seven participants who completed the survey were excluded on the basis of not meeting the study entry criteria. Participant recruitment was undertaken as part of recruitment in a wider study of urge to gamble in poker-machine gamblers, the results of which have been previously reported (McKeith et al. 2016).

The final sample had a mean age of 33.31 years ($SD = 9.01$) with 26 males and five females participating. The average PGSI score for the sample was 7.55 ($SD = 7.23$) indicating "moderate" levels of problem gambling as defined by the authors of the scale (Ferris and Wynne 2001). The sample reported their frequency of poker-machine gambling as daily (19 %), every two-to-three days (19 %), weekly (23 %), every two weeks (23 %), and monthly (16 %), with no participants indicating longer breaks in their gambling. Eleven participants (35 %) reported low levels of problems associated with gambling, eleven (35 %) reported moderate problems associated with gambling and nine (29 %) reported "problem gambling" according to the cut-offs defined by the authors of the PGSI (Ferris and Wynne 2001).

An a priori power analysis was conducted in order to determine the number of participants required to detect a large effect size ($f^2 = .35$), with four predictors, at the .8 power level. The power analysis suggested 40 participants would be required. As only 31 suitable participants completed the study within the 4-month recruitment period an a posteriori power analysis was conducted. This involved calculating the statistical power achieved based on the sample size and effect size observed, using the software package, G*Power 3 (Faul et al. 2007). Based on a sample size of 31 participants, four predictors, the observed f^2 of 2.45 and an alpha level of $p < .05$ the power exceeded .99 for the present study. Consequently, the sample size and achieved power was sufficient for detecting a significant effect. This sample size is consistent with other cue-reactivity studies on problem gambling populations (e.g., Tricker et al. 2016).

Materials and Measures

Following the methodology outlined by Tricker et al. (2016), the following study materials were presented within an online survey hosted on the Qualtrics™ platform (Qualtrics, Provo, Utah, USA).

Demographic Questionnaire

A brief demographic questionnaire asked participants to report their age, gender, preferred gambling modality and frequency of gambling behaviour.

Problem Gambling Severity Index (PGSI; Ferris and Wynne 2001)

The PGSI was utilized to measure problem gambling severity. The PGSI is a nine-item measure, which yields a total score indicating severity of problem gambling. It consists of four questions which assess the frequency of problem gambling behaviors (e.g., "How often have you gone back another day to try and win back the money you lost") and five that assess the frequency of the occurrence of adverse consequences of gambling (e.g., "How often have you felt guilty about the way you gamble or what happens when you gamble?"). Respondents are asked to provide a frequency rating in response to each statement based on a four-point scale (0 = *never*, 1 = *sometimes*, 2 = *most of the time*, 3 = *almost always*). The authors of the PGSI suggested that a total score of zero indicates no problems with gambling; 1–2 reflects low level of problems; 3–7 reflects moderate level of problems; and 8–27 indicates problem gambling (Ferris and Wynne 2001). The PGSI has been demonstrated to have good internal consistency (Cronbach's alpha = .84) and test–retest reliability ($r = .78$), as well as good criterion validity ($r = .83$) with *Diagnostic and Statistical Manual of Mental Disorders-IV* (APA 1994) classifications of problem gambling (Ferris and Wynne 2001). The Cronbach's alpha for the current study was .94.

Neutral and Gambling Video Cues

The study utilized the video cues employed by Tricker et al. (2016). As noted above, the neutral cue displayed two women making tea in a kitchen environment and lasted a total of 3 min. The gambling cue displayed the same two women playing poker machines in a public bar environment and also lasted for 3 min. The gambling cue had been previously demonstrated to elicit a significant increase in the urge to gamble, relative to the neutral cue (see Tricker et al. 2016). Both videos were recorded on the same device, and were displayed in the same resolution and aspect ratio.

Phenomenology of Consciousness Inventory (PCI; Pekala 1991)

The present study utilized the PCI to measure the variables of visual imagery, rationality and volitional control. The PCI is a retrospective 53-item measure designed to assess different dimensions of phenomenology within a discrete time-period. The full measure assesses 12 major dimensions of phenomenology (e.g., volitional control, rationality, positive affect, altered state of awareness; Pekala 1991). The PCI presents a number of paired statements for each of the major dimensions, with each statement designed to indicate the presence/intensity of a given phenomenological variable. Participants are asked to respond to each pair of statements on a seven-point dipole scale where 0 indicates no or little intensity and 6 indicates much or complete intensity (Pekala and Wenger 1983), with a mean score for the items related to each dimension calculated.

Rationality The Rationality dimension consists of three pairs of statements which assess the extent to which individuals feel their thinking was clear and rational during the defined time period (e.g., "My thinking was clear and understandable" versus "My thinking was unclear and not easy to understand").

Visual Imagery The Visual Imagery dimension consists of four pairs of statements which assess the amount of visual mental imagery experienced (e.g., "I experienced a great deal of visual imagery" versus "I experienced no visual imagery at all") and the vividness of mental imagery (e.g., "My visual imagery was so vivid and three-dimensional it seemed

real" versus "My visual imagery was so vague and diffuse, it was hard to get an image of anything").

Volitional Control The Volitional Control dimension consists of three pairs of statements, which assess individuals' perception of their control of their thoughts and attentional processes during the defined time period (e.g., "The thoughts and images I had were under my control; I decided what I thought or imagined" versus "Images and thoughts popped into my mind without my control").

The rationality, visual imagery volitional control sub-scales of the PCI were administered at three time-points within the study. Participants were asked to respond to the items based on their last 5 min of experience (i.e., baseline), based on their experience whilst watching the neutral stimulus, and following the gambling cue. The PCI has good internal consistency and criterion validity with Cronbach's alphas ranging from .7 to .9 (Pekala et al. 1986). Furthermore, the PCI has demonstrated criterion validity by reliably discriminating between qualitatively different states of phenomenology (Pekala et al. 1986).

Visual Analogue Scale (VAS)

Urge to Gamble was assessed using a visual analogue scale which asked participants to indicate "In the present moment, how strong is your urge to play poker machines?". The scale ranged from zero ("*no urge*") on the left to 10 ("*extreme urge*") on the right. The VAS was presented as a scale running horizontally across the screen and participants were required to place a sliding bar along this scale to indicate their current urge to gamble. Visual analogue scales have been utilized to assess urge in a variety of cue-reactivity studies (e.g., Kambouropoulos and Rock 2010) and specifically with the assessment of urge to gamble in poker-machine gamblers, using the Qualtrics platform (Tricker et al. 2016).

Design

The study employed the within-subject cue-reactivity design utilised by Tricker et al. (2016) where all participants completed measures at baseline, neutral cue and after a gambling cue. Consistent with established cue-reactivity methodology (e.g., Monti et al. 1987), all participants were presented with the measures and cues in a fixed order, with the gambling cue the last to be presented. This design (as discussed by Tricker et al. (2016) and McKeith et al. (2016)) is considered to be the most conservative method for evaluating changes in urge and phenomenological variables that are due to the gambling cue and avoids unwanted carry-over effects of the salient cue that would be present in a counterbalanced paradigm (Rohsenow and Niaura 1999).

Procedure

Ethical approval for the study was obtained from the University of New England Human Research Ethics committee. Following approval, an invitation to participate, which contained a brief overview of the study and a direct link to the Qualtrics survey, was posted in the locations described above. Potential participants who clicked on the study link were presented with the study information sheet and asked to consent to participate. Participants completed the demographics questionnaire, PGSI and then baseline measures of the VAS and PCI sub-scales. Participants were then presented with the neutral cue and were unable to proceed with the survey until the video had been watched in its entirety. They were then presented with the VAS and PCI sub-scales again followed by the gambling cue. After

watching the gambling cue participants completed the VAS and PCI sub-scales for a final time and were presented with a study debriefing page which also provided links to a variety of problem gambling resources.

Statistical Methods

In order to establish whether the experimental manipulation was successful within the sample, a repeated measures analysis of covariance (ANCOVA) was employed. The ANCOVA assessed whether participant self-reported urge to gamble increased from neutral to gambling cue. Baseline urge to gamble was controlled for by entering this as a covariate.

A hierarchical regression was conducted to examine whether problem-gambling severity, visual imagery, rationality and volitional control were statistically significant predictors of cue-reactive urge to gamble (*H2*). A specific focus of this analysis was to determine whether visual mental imagery, rationality and volitional control statistically significantly improved prediction of cue-reactive urge to gamble after controlling for levels of problem-gambling severity. The entry method was block-wise and, thus, we relied on logic, rather than statistical findings, when selecting our predictors.

Results

Hypothesis 1

Descriptive statistics for this analysis are presented in Table 1 and change in urge to gamble across the three time-points is represented in Fig. 1.

The results of the ANCOVA revealed a significant main effect of cue, $F(1, 29) = 10.549$, $p = .003$, partial $\eta^2 = .265$. The ANCOVA, therefore, indicated that, after controlling for baseline urge to gamble, urge to gamble increased significantly from neutral cue ($M = 2.16$, $SD = 2.34$) to gambling cue ($M = 4.26$, $SD = 3.20$). *H1* was supported.

Hypothesis 2

Intercorrelations between the study variables are presented in Table 2. Testing revealed that the hierarchical multiple regression assumptions of univariate and multivariate outliers, multicollinearity, normality, linearity and homoscedasticity of residuals were satisfied. At step 1, problem-gambling severity was a statistically significant predictor of urge to gamble (gambling cue) $R^2 = .33$ (Adjusted $R^2 = .30$), $F(1, 29) = 14.11$, $p = .001$.

The inclusion of visual imagery, rationality and volitional control at step 2, statistically significantly improved prediction of urge to gamble $\Delta R^2 = .383$, $F(3, 26) = 11.443$, $p = .001$ (see Table 3). At both steps, R was significantly different from zero; Step 1 $R = .57$, $F(1, 29) = 14.11$, $p = .001$; Step 2, $R = .84$, $F(4, 26) = 15.92$, $p = .001$. *H2* was supported.

Post-hoc analysis

In the aforementioned multiple regression an interesting effect emerged wherein, once the variance explained by all other predictors had been removed, the association between

Table 1 Means and standard deviations for urge to gamble, visual imagery, rationality and volitional control at baseline, neutral and gambling cue

Measure	Condition					
	Baseline		Neutral		Gambling	
	M	*SD*	*M*	*SD*	*M*	*SD*
Urge to gamble	2.90	2.93	2.16	2.34	4.26	3.20
Visual imagery	2.85	1.17	2.89	1.16	3.37	1.24
Rationality	4.69	1.17	4.71	1.15	4.23	1.40
Volitional control	4.37	1.23	4.00	1.19	3.81	1.38

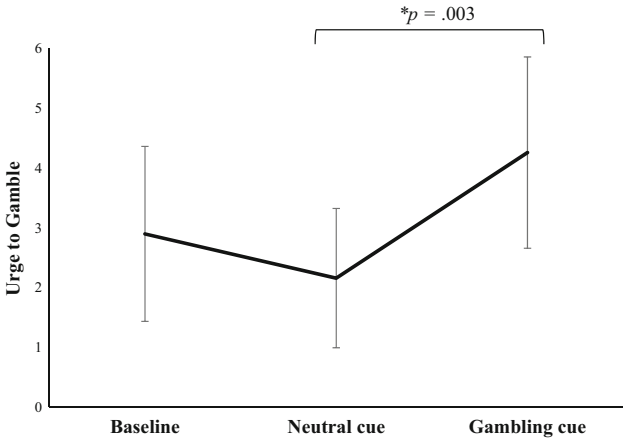

Fig. 1 Means and standard deviations for urge to gamble at baseline, neutral and gambling cue presentation. *p value reflects results of ANCOVA where, after accounting for baseline urge to gamble, there was a significant increase in urge to gamble from neutral to gambling cue

volitional control and urge to gamble became significantly positive ($sr = .219$, $p = .049$). Before the variance explained by all the other variables had been removed, the (zero-order) correlation of this association was negative ($r = -.469$). Regression coefficients that reverse in this way are not uncommon and have been discussed at length in the literature (e.g., Gelman et al. 2007; Knaeble and Dutter 2015; Oksanen 1987; Visco 1978, 1988), but they do warrant scrutiny.

We ran further post hoc analyses to better understand this reversing coefficient of volitional control. Volitional control was highly correlated with rationality ($r = .859$) and to a lesser extent visual imagery ($r = -.408$) and problem gambling ($r = -.271$). Furthermore, the coefficient for volitional control reversed the most when rationality was entered into the model, though visual imagery partly contributed to this effect also. A reversing coefficient can be a consequence of an interaction between (a) the reversing coefficient and (b) the predictor(s) most responsible for the reversal. Accordingly, we added to the preceding regression presented in Table 3 the interaction term between volitional control and rationality. This interaction term uniquely accounted for 4.88 % of

Table 2 Intercorrelations between cue-reactive urge to gamble, visual imagery, rationality, and volitional control

	Problem gambling severity	Urge to gamble	Visual imagery	Rationality	Volitional control
Problem gambling severity		.572**	.623	−.299	−.271
Urge to gamble			.589***	−.640***	−.469**
Visual imagery				−.391*	−.408*
Rationality					−.859***
Volitional control					

Urge to gamble = urge to gamble following gambling cue presentation minus urge to gamble following neutral cue presentation; mental imagery = imagery following gambling cue presentation minus imagery following neutral cue presentation; rationality = rationality following gambling cue presentation minus rationality following neutral cue presentation; volitional control = volitional control following gambling cue presentation minus volitional control following neutral cue presentation

*** $p < .001$; ** $p < .01$; * $p < .05$

Table 3 Hierarchical regression analysis with problem-gambling severity, visual imagery, rationality and volitional control as predictors of cue-reactive urge to gamble

Predictor	ΔR^2_{Adj}	*B*	Std. error	β	*t*	*p*	*sr*
Step 1	.304					.001	
Problem gambling		1.98	.053	.572	3.765	.001	
Step 2	.665					<.001	
Problem gambling		.126	.039	.365	3.250	.003	.343
Visual imagery		1.115	.351	.374	3.179	.004	.336
Rationality		−1.133	.313	−.756	−3.617	.001	−.382
Volitional control		.800	.388	.431	2.063	.049	.218

the variance ($p = .033$), alongside the main effects uniquely explaining 7.90 and 17.72 % for volitional control and rationality, respectively. The R^2_{Adj} of the overall model explained 71.1 % of the variance in urge to gamble, 4 % more variance than the model without this interaction term. The contributions of the other predictors were very similar in the models both with and without the interaction. The interaction is presented in Fig. 2 and shows that cue-reactive rationality is a stronger predictor of urge to gamble at lower levels of cue-reactive volitional control than at higher levels. In short, the interaction we observed here is able to account for the reversing coefficient.

Discussion

The aim of the current study was to investigate the role of cue-reactive visual imagery, volitional control and rationality in predicting cue-reactive urge to gamble in a sample of poker-machine problem gamblers. The sample demonstrated a significant increase in urge to gamble from neutral to gambling cue whilst controlling for baseline. This finding supports *H1* and confirms that the experimental manipulation was successful within this sample. This is consistent with the findings of McKeith et al. (2016), from which the

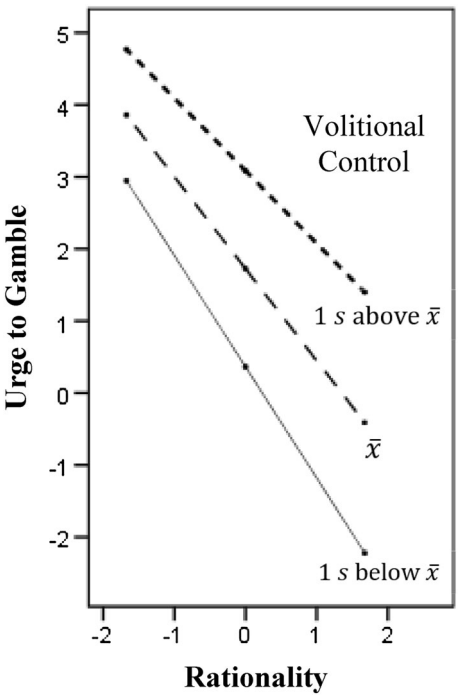

Fig. 2 The interaction between cue-reactive rationality and volitional control regarding cue-reactive urge to gamble

participant data for the present study was retrospectively drawn. McKeith et al. reported that in a wider sample of regular poker-machine gamblers (including those who reported no problems with their gambling behaviour) participants demonstrated an increase in urge to gamble from neutral to gambling cue. This cue-reactive increase in urge supports the premise that, through the process of classical conditioning, visual gambling cues (such as flashing lights, poker-machines and others playing poker-machines) have become sufficiently associated with the participants' gambling behaviour and reward experiences to reliably provoke an increase in the subjective urge to gamble (Blaszczynski and Nower 2002).

Problem-gambling severity was found to positively predict urge to gamble in response to the gambling cue. This finding is consistent with the results of Tricker et al. (2016) and lends support to the proposal that individuals with problematic gambling behaviours will demonstrate a greater increase in the urge to gamble, in response a gambling cue, than non-problem gamblers (Baudinet and Blaszczynski 2013; Blaszczynski and Nower 2002). The mechanism through which higher levels of problem gambling severity predict greater cue-reactive urge is yet to be fully understood (Baudinet and Blaszczynski 2013). A simple explanation could be that higher levels of problem gambling will be likely to be associated with greater frequency of gambling behaviour, meaning more concrete experiences where gambling stimuli, gambling behaviour and reward experiences are paired. The principles of classical conditioning mean that greater frequency of pairings between these stimuli should result in a stronger association and conditioned response (i.e., greater cue-reactive urge to gamble; Baudinet and Blaszczynski 2013; Blaszczynski and Nower 2002). However, the relationship may not be so straightforward. The investigation of anxiety disorders has demonstrated that some individuals may be more predisposed towards learning a

conditioned fear response than others (e.g., Indovina et al. 2011). It would, therefore, seem reasonable to hypothesise that certain individual differences variables may predispose those individuals who develop problem gambling behaviours to acquire this cue-reactive response in relation to changes in urge, but also in relation to the observed phenomenological variables. In regards to the changes in visual imagery observed in the present study, there is evidence that the propensity to experience visual mental imagery is a trait variable (Dadds et al. 2004). Given that mental imagery may contribute to an increased urge to engage in behaviours associated with the content of such images (e.g., cocaine use; Kilts et al. 2004) the tendency to experience visual mental imagery could potentially predispose certain individuals to experience cue-reactive gambling imagery and, consequently, a heightened desire to gamble.

Cue-reactive visual imagery, rationality and volitional control were found to significantly improve the prediction of cue-reactive urge to gamble after accounting for the effects of problem-gambling severity. *H2* was, therefore, supported. Furthermore, the combined regression model accounted for 71 % of the variance in the dependent variable, suggesting that the four predictors may play a key role in contributing to the subjective impulse towards gambling behaviour. As the first study to evaluate such variables in relation to poker-machine gambling (or any form of gambling), these results are notable and may have some significant implications for our understanding of the urge to gamble.

The results may imply that a variety of changes in conscious experience (increases in visual imagery and decreases in the sense of control over one's thinking and its clarity) may contribute to the subjective impulse to engage in gambling. Consequently, research which simply aims to measure changes in affect and urge in relation to gambling cues may risk failing to account for cognitive processes directly impacting on gamblers' experience and, potentially, their gambling behaviour. Furthermore, as such variables are not currently an active target of psychological interventions for problem gambling behaviour, the results suggest that such treatments may benefit from addressing cue-reactive imagery, rationality and/or volitional control. Future research should, therefore, seek to further understand how these phenomenological variables contribute towards the urge to gamble and whether the manipulation of such variables can lead to fluctuations in the urge to gamble.

Limitations

A number of limitations of the study methodology exist, in addition to those already highlighted regarding this cue-reactivity paradigm (see McKeith et al. 2016; Tricker et al. 2016). The sample size may be seen to limit the generalisability of the findings, though it is notable that the sample obtained within the present study is comparable to other studies of cue-reactive urge to gamble (e.g. Tricker et al. 2016). The nature of the sample may also be problematic. Participants had to opt-into respond to the study advertisement and then choose to progress through the survey to completion. Consequently, many potential participants may have read the study advert and made the decision not to participate and many participants who began the survey (75 %) dropped out prior to completion of the survey. The possibility of selection bias must therefore be considered; are those who chose not to participate and who dropped out reflective of a subgroup(s) of gamblers that may have been less likely to complete the study due to individual differences variables (such as high distractibility or impulsivity)? It is not possible to determine whether the relationship between the phenomenological variables found in the present study would be observed in a broader sample which was not subject to this selection bias.

Due to the high rates of drop-out observed in previous online studies of poker-machine gamblers (Tricker et al. 2016) the present study was designed with the aim of minimising the time required of participants to complete the study. This was done in order to maximise the likelihood of participant continuing to the end of the survey. Consequently, the study did not obtain any measures of substance use, anxiety or depression nor any measure that allowed us to determine whether participants met diagnostic criteria for pathological gambling. Such information would have provided a richer understanding of the nature of the study sample and may also have been pertinent in understanding individual problem gambling severity. This omission must, therefore, be considered a limitation of the study. Future extensions of this research should aim to incorporate measures accounting for such variables.

As noted above, the study measures utilised allowed us to quantify changes in conscious experience in response to the gambling cue, but not to determine the content of conscious experience beyond an increase in visual mental imagery. This limits the extent to which we are able to draw conclusions about the nature of the relationship between these phenomenological variables. A further limitation in measurement is that no information regarding changes in affect was obtained nor any measure of the affective valence of visual mental imagery. Given that changes in affect have been linked to the urge to gamble and to gambling behaviour (e.g., Gee et al. 2005) it would be helpful to ascertain whether the observed changes in imagery, rationality and volitional control were associated with increases in positive or negative affect (such as anxiety). Cue-reactive changes in affect would, therefore, be valuable to consider in future extensions of this research.

Finally, as noted by McKeith et al. (2016), the ecological validity of the gambling cue must be considered. Classical conditioning suggests that gambling behaviour could come to be associated with any number of cues across sensory experience (Blaszczynski and Nower 2002). The gambling cue utilised in the present study was merely an audio-visual representation of gambling watched on a computer screen or mobile device. As a result the gambling cue clearly would not be expected to be as visceral a cue of the urge to gamble as when individuals encounter multiple salient cues in a real-world environment. Nevertheless, in the present study a significant cue-reactive increase in the urge to gamble was observed in response to a less salient cue than individuals would be expected to encounter within real-world scenarios. This finding demonstrates the strength of association between visual gambling stimuli and the urge to gamble in poker-machine gamblers. Future research should, therefore, aim to measure changes in imagery, rationality and volitional control and the urge to gamble within an in vivo poker-machine cue-reactivity paradigm.

Conclusion

The present study adds to the growing body of research which demonstrates that problem gambling severity predicts cue-reactive urge to gamble in poker-machine problem gamblers. More importantly, this is the first study to demonstrate that changes in the subjective experience of visual mental imagery, volitional control and rationality predict changes in the urge to gamble from neutral to gambling cue. This study highlights the importance of investigating state-like variables that may be conceptualized as phenomenological 'triggers' of cue-reactive urge to gamble. A detailed understanding of such triggers may, ultimately, inform the psychological treatment of problem gambling.

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