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FULL-LENGTH REPORT

The associative learning roots of affect-driven impulsivity and its role in problem gambling: A replication attempt and extension of Quintero et al. (2020)

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ABSTRACT

Background and aims: Negative/positive urgency (NU/PU) refers to the proneness to act rashly under negative/positive emotions. These traits are proxies to generalized emotion dysregulation, and are well-established predictors of gambling-related problems. We aimed to replicate a previous work (Quintero et al., 2020) showing NU to be related to faulty extinction of conditioned stimuli in an emotional conditioning task, to extend these findings to PU, and to clarify the role of urgency in the development of gambling-related craving and problems. *Methods:* 81 gamblers performed an acquisition-extinction task in which neutral, disgusting, erotic and gambling-related images were used as unconditioned stimuli (US), and color patches as conditioned stimuli (CS). Trial-by-trial predictive responses were analyzed using generalized linear mixed-effects models (GLME). *Results:* PU was more strongly related than NU to craving and severity of gambling problems. PU did not influence acquisition in the associative task, whereas NU slightly slowed it. Extinction was hampered in individuals with high PU, and a follow-up analysis showed this effect to depend on relative preference for skill-based and casino games. *Discussion and conclusions:* Results suggest that resistance to extinction of emotionally conditioned cues is a sign of malfunctioning emotion regulation in problematic gambling. In our work, the key effect was driven by PU (instead of NU), and gambling craving and symptoms were also more closely predicted by it. Future research should compare the involvement of PU and NU in emotion regulation and gambling problems, for gamblers with preference for different gambling modalities (e.g., pure chance vs skill games).

KEYWORDS

emotion regulation, positive urgency, negative urgency, gambling, craving, predictive learning task

INTRODUCTION

Urgency facets and gambling

Impulsivity is defined as the tendency to act rashly or with lack of forethought, and comprises both cognitive, conscientiousness-related facets, and incentive or emotion-related facets (Verdejo-García, Lozano, Moya, Alcázar, & Pérez-García, 2010). According to the UPPS-P model of impulsive behavior, the affect-driven facet of impulsivity is neuropsychologically separable from cognitive impulsivity (lack or perseverance and lack of premeditation) and from sensation seeking, and can be further factorized into positive and negative urgency, namely, the tendency to lose control over behavior when experiencing strong positive and negative affect, respectively (Cyders et al., 2007; Smith et al., 2007).

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Nevertheless, the necessity of dissociating positive from negative urgency remains a topic of discussion. On the one hand, a recent large network analysis suggests that urgency could be better conceptualized as a single construct (Billieux et al., 2021). On the other, a number of studies have shown differential correlations of positive and negative urgency with other constructs or aspects behavior (e.g., Grimaldi, Napper, & LaBrie, 2014; Zapolski, Cyders, & Smith, 2009). Still, and beyond its composition, there is some agreement that (1) urgency reflects the synergistic effects of heightened emotional reactivity and compromised emotion regulation (Billieux et al., 2021), and (2) it accounts for a large part of the shared variability between several psychological disorders, especially (although not exclusively) those characterized by externalizing behavior (Settles et al., 2012). According to a recent and well-supported theoretical proposal (Carver & Johnson, 2018), altered regulation of emotion-driven behaviors and thoughts (i.e., urgency) is a common transdiagnostic psychopathology risk factor, whereas reward sensitivity would determine whether that vulnerability is expressed in the form of internalizing or externalizing behavior.

In consonance with this proposal, urgency has been identified as a key factor in the etiology of addictive processes, including gambling disorder (Cyders et al., 2016; MacLaren, Fugelsang, Harrigan, & Dixon, 2011). It has been suggested that positive urgency may lead to increases in gambling involvement in early stages of the disordered gambling cycle, when the addictive activity is still predominantly driven by appetitive motives (Cyders & Smith, 2008). Negative urgency, in turn, would be more prominent in clinical samples (e.g., Torres et al., 2013), and would be associated with a larger risk of comorbidity (e.g., Grall-Bronnec et al., 2012).

Unfortunately, this depiction is not congruent with the totality of available evidence. On the one hand, some studies have indeed found negative urgency to be a stronger predictor of gambling severity than positive urgency in the high end of the gambling severity continuum (e.g., Jara-Rizzo, Navas, Catena, & Perales, 2019; Savvidou et al., 2017; Torrado et al., 2020). On the other hand, some studies have reported the opposite pattern –positive urgency showing a greater capacity to account for gambling-related problems, relative to negative urgency–, even in clinical samples. For example, in a study by Velotti and Rogier (2021) positive urgency (but not negative urgency) was a significant predictor of severity in individuals with gambling disorder. Similar results have been reported by Willie, Gill, Teese, Stavropoulos, and Jago (2022), who found positive urgency, but not negative urgency, to predict problem gambling and online gambling disorder, using hierarchical regression. Canale, Scacchi, and Griffiths (2016) found that only positive urgency was associated with higher scores of problem gambling and gambling frequency in an adolescent sample. And in a study by Mestre-Bach et al. (2020) positive urgency predicted gambling severity in a sample of male patients with gambling disorder. Although this study suggested that negative urgency could be more strongly related to gambling symptom severity in women, a study by Farstad and von Ranson (2021), with a sample of women showing at-risk gambling, at-risk binge eating, or both, reported positive urgency (but not negative urgency) to be linked with problem gambling severity. Rogier, Colombi, and Velotti (2020) also found that positive urgency was the only significant predictor of severity scores, and attributed the seemingly inconsistent results to the different sample compositions across studies, in terms of gambling preferences and motivations. In accordance with this argument, Howe, Vargas-Sáenz, Hulbert, and Boldero (2019) found that positive urgency was more strongly associated with certain game types, such as Internet gambling, games of skill, and cards and board games.

Finally, some studies report both positive and negative urgency to be significant and independent predictors of problem or disordered gambling. For instance, Brunault, Mathieu, Faussat, Barrault, and Varescon (2020) explored the link between impulsivity facets and gambling severity in male gamblers with and without self-reported ADHD. In both groups, positive and negative urgency were associated with problem gambling. Mestre-Bach et al. (2019) also showed both positive and negative urgency to vary across groups with increasing gambling severity. Steward et al. (2017) conducted a path analysis to explore the associations between impulsivity measures and gambling severity. Their results revealed significant and independent relations of positive and negative urgency with severity in younger patients, but only the one of negative urgency remained significant in older patients. Using mediation analysis, Kim, Poole, Hodgins, McGrath, and Dobson (2019) reported both negative and positive urgency to be associated with problem gambling severity, with coping motives mediating these associations (although see Canale, Vieno, Griffiths, Rubaltelli, & Santinello, 2015). In Haw's (2017) study both positive and negative urgency were predictors of gambling severity in a sample composed by regular electronic gaming machines (EGM) players, with negative urgency being a much stronger predictor than positive urgency. Similar results are reported by Blain, Richard Gill, and Teese (2015), although, interestingly, negative urgency highly correlated with the preference for EGMs gambling modality, whereas positive urgency correlated with EGMs, card/dice games and off-line games. Other studies reporting similar associations between the two impulsivity facets and gambling problems are Albein-Urios, Martinez-González, Lozano, Clark, and Verdejo-García (2012), Clark et al. (2012), Marmurek, Switzer, and D'Alvise (2015), and Michalzuk et al. (2011).

In summary, evidence supports the role of urgency as a vulnerability and chronification factor for gambling-related problems, yet the potentially distinct roles of positive and negative urgency in different stages, problem severity levels or subpopulations remain unclear. The present study aims to contribute to better define the neurocognitive mechanisms of positive and negative urgency, and their roles in clinically relevant aspects of gambling, such as gambling problems severity and gambling craving.

The role of emotion regulation in the association between urgency and disordered gambling

As noted above, urgency is tightly linked to emotion regulation. In their dual model, Etkin, Büchel, and Gross (2015; see also King, Feil, & Halvorson, 2018) proposed a distinction between intentional (or strategic) and incidental modes of emotion regulation. The former is hypothesized to be goal-driven and to require engagement and model-based control, that is, to involve the conscious identification of the emotion to be regulated, followed by the identification and implementation of the best available strategy to modulate it (e.g., reappraisal). The latter would be model-free, and would depend on relatively simple associative processes, with extinction of conditioned emotional responses as the paradigmatic example. In line with associative learning research (Dunsmoor, Niv, Daw, & Phelps, 2015), extinction is driven by error-prediction signals, and involves a change of the affective meaning of a stimulus that has lost its predictive value. As a result, the conditioned response this stimulus previously triggered is progressively attenuated. Importantly, extinction is not simply unlearning, as it requires the formation of a context-dependent inhibitory association that competes for expression with the original excitatory one when the conditioned stimulus is presented again (Bouton, Westbrook, Corcoran, & Maren, 2006). According to Etkin et al.'s model, this arbitration process, although relatively simple and incidental, is in essence regulatory.

Based on this model, Navas, Billieux, Verdejo-García, and Perales (2019) proposed negative urgency as a psychometric proxy to the malfunctioning of incidental mechanisms of emotion regulation. This idea was directly tested and mostly confirmed by Quintero et al. (2020), who found an association between negative urgency and slowed extinction of emotion-laden conditioned associations in a simple acquisition-extinction associative learning task. This study thus supported incidental emotion regulation processes as a plausible explanatory mechanism for negative urgency. Complementarily, it also explored the relationship between negative urgency and two clinically relevant aspects of disordered gambling: craving and severity of problem gambling symptoms.

As noted earlier, negative urgency is defined as the proneness to rash action under the effect of negative affect, and it seems to underlie a range of related disorders and to partially account for their comorbidity. So, negative urgency could impact on gambling severity via this overarching, domain-general mechanism. Or, alternatively, it could hamper craving control, and dysregulated craving could, in turn, prompt compulsive gambling (craving is probably the single best momentary predictor of addictive behavior and relapse; Tiffany & Wray, 2012). Quintero et al.'s results supported only the second possibility: negative urgency predicted gambling severity, but only via heightened craving (negative urgency was strongly associated with craving, and this with severity, but the link between negative urgency and severity remained non-significant when craving was controlled for).

The present study

Quintero et al.'s study, however, presents two major limitations. First, the study focused exclusively on negative urgency, under the initial assumption that positive urgency plays a secondary role in disordered gambling symptomatology. However, that assumption seems now unwarranted, in view of the evidence briefly reviewed above that positive urgency could play a substantial and independent role in the risk of disordered gambling.

And second, a substantial part of the sample in Quintero et al.'s study were lottery players, and their average severity of problem gambling symptoms was low. This composition is potentially problematic in inferential and representativity terms. Lottery is a very widespread, pure chance, relatively nonhazardous gambling modality. Hence, the association of negative urgency with gambling craving and severity was probably driven by only a small fraction of participants who presented higher severity scores.

Here, we intend to replicate and extend these findings. In addition to severity of disordered gambling symptoms (SOGS), craving, and negative urgency (brief UPPS-P), positive urgency was measured and included in the analyses. The decision to keep the two urgency dimensions separated is based on the previously mentioned evidence showing differential correlation patterns for positive and negative urgency, but also on methodologically practical reasons. Even if a common emotion dysregulation factor underlies the two urgency dimensions, urgency also comprises an emotion reactivity component (Billieux et al., 2021). People differ in their reactivity to appetitive and aversive states, and these states can be differentially involved in motivating gambling (and especially in gambling craving) for different individuals (e.g., van Holst, van den Brink, Veltman, & Goudriaan, 2010), so urgency could manifest itself differently depending on which emotions are more relevant in motivating gambling. In other words, differential correlation patterns of positive and negative urgency can provide indirect evidence on the role of appetitive and aversive states on craving and gambling behavior.

Importantly, recruitment explicitly excluded non-gamblers and lottery-only gamblers. This recruiting procedure was aimed at obtaining a sample much more representative of the population of gamblers incurring some risk of gambling-related problems, while still allowing a large severity range.

Extinction was assessed with the same task described in Quintero et al. (2020). In brief, different color patches were used as conditioned stimuli (CS), and erotic, disgust, gambling-related, and neutral pictures were used as unconditioned stimuli (US). During acquisition, each CS was probabilistically paired to one US type. During extinction, the CS-US contingency was degraded to zero (with no explicit warning or separation), except for the neutral picture, for which the association with its corresponding CS remained the same as during acquisition. In each trial, right after the onset of the CS, the participant was asked to predict which type of picture would follow. This predictive response was dichotomized (correct/incorrect prediction) and used as the dependent variable in analyses of task performance. The main aspect of this response to be analyzed and interpreted was the rate with which CS-related predictions progressively reflected the degradation of CS-US contingencies during extinction.

Regarding negative urgency, we expect to replicate the two previously described findings. Negative urgency is hypothesized to be specifically associated with slowed extinction of predictive responses for CSs associated with emotion-laden pictures. And the relationship between negative urgency and severity is hypothesized to be mediated by craving.

Regarding positive urgency, our hypotheses remain open. If negative urgency is, as initially assumed, a stronger index of emotion dysregulation than positive urgency, its relationship with slowed extinction, craving and severity should be weaker or non-existent. On the contrary, if positive and negative urgency are manifestations of the same construct, their pattern of association should be similar to the ones of positive urgency. In case mixed patterns are found, these will be subject to supplementary analyses using gambling participation measures as covariates.

METHODS

Openness and transparency

All data and analysis code are available at the following Open Science Framework (OSF) link: https://osf.io/tyjmq/?view_only=1062e72b26814d1f90a5994a899c02c7.

Following the 21-word solution proposed by Simmons et al. (2012), we report here how sample size was determined, all data exclusions, all manipulations, and all study measures.

The present study attempts to closely replicate and to extend Quintero et al.'s (2020). In their data analysis plan and preregistration, Quintero et al. estimated in $n = 70$ their minimum sample size. This sample size was sufficient to yield differential sensitivity in their study, so the same criterion was taken as reference here, and no specific power analyses were carried out. In view of the potential loss of participants not reaching the learning criterion in the acquisition-extinction task, data collection continued until $n = 81$. The learning criterion and the final sample for analyses including the acquisition-extinction task ($n = 65$) are detailed in the Statistical Analysis section. For the reasons mentioned the previous section, the two studies also differed in sample composition, with the present study not recruiting any lottery-only gamblers.

Direct manipulations were only those regarding the experimental component of the study, that is, the design of the acquisition-extinction learning task, and are reported in the Measures (Acquisition-Extinction Predictive Learning Task) and Statistical Analysis sections.

The key input and output measures for analyses were the same in the two studies and were collected using virtually identical methods, although some supplementary measures, not relevant for the present purposes, were different in the two protocols (with the most relevant difference being the collection of psychophysiological measures here, but not in the original study; see Other Variables in the Measures section). Importantly, positive urgency was collected in the two studies but analyzed only in the current one, for the reasons detailed in The Present Study section.

In view of the adherence to Quintero et al.'s methods, we did not consider preregistration for the present study as strictly necessary. Nevertheless, when judging the relative strength and reliability of the evidence provided by the two studies, there are two important considerations for the reader to make. On the one hand, Quintero et al.'s study slightly departed from the preregistration (as explicitly acknowledged in their article). On the other, the present study closely followed the original study's methods and procedure, but a key aspect of the study (namely, the inclusion of positive urgency in the analysis) was not explicitly preregistered.

Participants and procedure

We initially recruited 81 participants (18 self-identified as female, 63 as male, 0 non-binary), 65 of whom reached the learning criterion in the acquisition-extinction task, so that $n = 65$ was the final sample for the analyses involving that task (whereas analyses with self-report instruments were carried out in the full sample). Table 1 displays descriptive statistics of males and females in the full sample, and Fig. 1 depicts the distribution of variables of theoretical interest, also for the whole sample. (Please note that the psychometrics file in the OSF link contains all psychometric input and output variables from the analyses reported here, and can be easily tabulated in any alternative way). Severity of problematic gambling symptoms will be considered as a continuous variable, so no categorical thresholds will be established or discussed. Still, the average SOGS score ($M = 3.68$), especially for the majority of males in the sample, and its distribution clearly indicate that a nontrivial proportion of participants presented a high-risk of disordered gambling.

A multi-method recruitment procedure was used. Notices were posted or handed in gambling venues, social networks, and University facilities. Researchers also visited University classes during breaks to inform students about the possibility

Table 1. Descriptive statistics for sociodemographic variables and scores in target measures of the sample

	Gender	Age	Neg. urg.	Pos. urg.	SOGS	Craving
Mean	Male	22.80	2.53	2.56	3.68	2.76
	Female	24.90	2.54	2.64	2.56	3.07
Median	Male	20.00	2.75	2.50	3.00	3.00
	Female	23.50	2.63	2.63	1.50	3.00
SD	Male	6.23	0.74	0.61	3.17	0.91
	Female	8.67	0.68	0.45	2.66	1.11
Minimum	Male	18.00	1.00	1.50	0.00	1.00
	Female	18.00	1.00	1.50	0.00	1.00
Maximum	Male	46.00	4.00	4.00	13.00	5.00
	Female	55.00	3.50	3.25	11.00	5.00

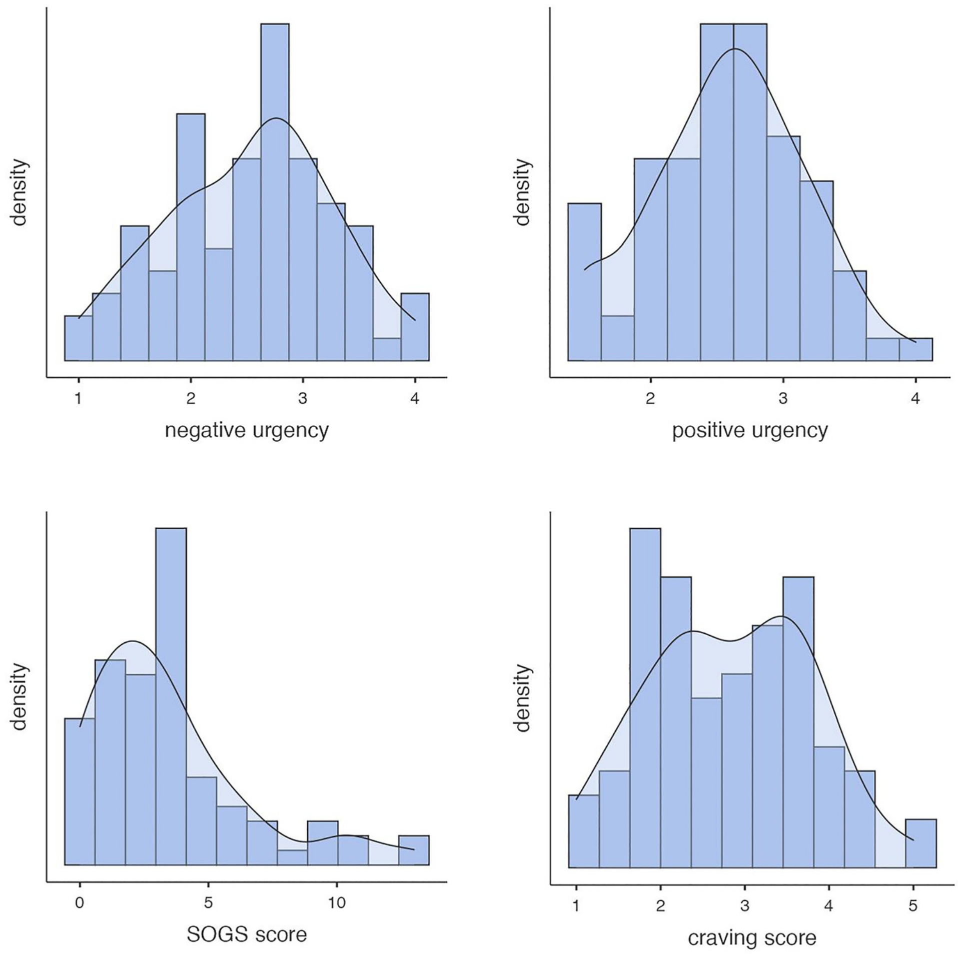

Fig. 1. Distributions of the variables of interest for the whole sample of participants in the study

of participating in the study. A snowball method was subsequently used to recruit the rest of participants. After first contact, potential participants were interviewed by phone to ensure inclusion criteria were met, namely, being 18 years old or older, fluent in Spanish, and having engaged in any gambling activity at least with an average frequency of once a month in the last year. Potential participants who reported having ever been diagnosed or treated for any psychopathology, or informed of any history of neurological disease or brain trauma causing unconsciousness for 10 min or longer, did not take part in the study.

Once recruited, participants were invited to visit the laboratory where the experiment took place. After providing informed consent, participants were randomly assigned an identifying code, which in no case could be linked to their personal information. The procedure consisted of three blocks of tasks: emotion-related questionnaires (block A), gambling-related questionnaires (block B), and the learning task (block C). These blocks were counterbalanced in order to control for order and carryover effects, and the order in which each participant carried out the protocol was recorded. The experimental session lasted approximately 150 min. Participants received €10 per hour as compensation.

Data was collected between October 2019 and May 2021. Individuals who participated in the experiment during the covid-19 pandemic signed a Statement of Responsibility developed by the research center, declaring that they had complied with safety and health regulations before attending the experiment. They also were informed that appropriate measures were taken to limit the risk of covid-19 transmission in the laboratory. Unlike the participants who participated in the study before March 2020, during the pandemic participants had to wear a facemask during the whole of their stay in the research center facilities.

Measures

South Oaks gambling screen. This instrument is one of the most widely used screening questionnaires to assess disordered gambling symptoms' severity. The Spanish version has shown good psychometric properties (Echeburúa, Báez, Fernández-Montalvo, & Páez, 1994), and a recent meta-analysis has concluded that SOGS is a reliable instrument for evaluating gambling addiction (Esparza-Reig, Guillén Riquelme, MartíVilar, & González Sala, 2021). For the sample in the current study Cronbach's $\alpha = 0.826$.

Positive and negative urgency. To measure positive and negative urgency, we used the two corresponding subscales from the Spanish version of the 20-item UPPS-P impulsive behavior scale (Cándido, Orduña, Perales, Verdejo-García, & Billieux, 2012). Each subscale includes four items with response options in the 1–4 range. For the present analysis, the score for each subscale was computed by averaging responses to the items in that subscale, coded in such a way that 1 corresponded to the lowest, and 4 to the highest degree of impulsivity. This scale is one of the most commonly used self-report measures of impulsivity, and has shown good psychometric properties (Pilatti, Lozano, & Cyders, 2015). In the present study, Cronbach's α values were 0.782 and 0.637 for negative and positive urgency, respectively.

Craving. We used the same craving scale as in Quintero's et al. (2020) work in order to be consistent across studies. The scale consists of three items which were developed with the intention of assessing three different manifestations of gambling craving: (a) intense urge, "*At times, I cannot help feeling an intense desire to gamble*", (b) stimulus-driven compulsivity, "*Some situations, events or stimuli incite me to gamble, even if I had not planned it*", and (c) attentional bias, "*Gambling-related situations, events or stimuli immediately grab my attention*". Each item is rated on a five-point Likert-type scale, from 1 (totally disagree) to 5 (totally agree), where higher scores indicate a higher craving experience. For this study, the craving scale showed a good level of internal consistency (Cronbach's α = 0.812).

Gambling habits. Participants were classified in accordance with their gambling preferences. According to Navas et al. (2017),[1] Type I gamblers are those showing a preference for skill-based, high-arousal games, such as cards and sports betting, as well as casino games, while Type II gamblers are those who prefer chance, lower arousal games such as slots, lotteries, and bingo. During the interview with the researcher, participants were asked to identify their favorite gambling activity, and were assigned to one type or the other based on their declared preference.

Gambling habits were also explored using an adapted version of the Canadian Problem Gambling Index (CPGI; Ferris & Wynne, 2001). This extensive instrument includes (a) an assessment of severity of gambling-related problems (the Problem Gambling Severity Scale, PGSI), and two more sections (b) to assess the presence of common gambling correlates, and (c) to assess gambling involvement. Although three sections were administered, only the involvement section (adapted for gambling games with detectable presence in Spain) was analyzed in the present study. In that part, participants were presented with a list of 18 gambling activities (scratch cards, pools and lotteries, card games in licensed venues, card games in family and social gatherings, card games in other unlicensed venues, online card games, land-based bingo, online bingo, land-based slots, online slots, land-based casino games [excluding cards and slots], online casino games [excluding cards and slots], land-based sport bets [excluding pools], online sport bets [excluding pools], betting on one's skills, stock market or currency trading [excluding funds], land-based other, online other). For each one, participants were asked if they had engaged in that type of game/activity in the last year. If the answer was no, they were asked to skip it and to consider the next activity. In case of a positive answer, they were asked to report how often they had played that type of game in the last 12 months, using an ordinal 7-point scale (1–5 times a year, 6–11 times a year, monthly, 2–3 times a month, weekly, 2–6 times a week, daily), and how much they spent on an average day in which they had participated in that activity.

There was a high degree of correspondence between preference as classified using the declared preferred game, and measures of involvement in different game types. For each participant, frequency of participation scores for Type-I and Type-II games were summed separately, which yielded total Type-I and Type-II games participation scores. For self-identified Type-I gamblers (N = 66), mean (SD) frequency score was 9.70 (4.84) for Type-I games, and 3.65 (3.74) for Type-II games. Accordingly, for self-identified Type-II gamblers (N = 14), mean (SD) frequency score was 3.21 (3.21) for Type-I games, and 10.29 (5.48) for Type-II games. Data on the preferred game was missing for one participant.

Acquisition-extinction predictive task. The experimental task was identical to the one in Quintero et al. (2020), programmed and administered using E-prime software (Psychology Software Tools, 2012). In this task, participants were asked to learn to predict, as accurately as they could, the occurrence of each picture type (Unconditioned Stimulus, US: neutral, disgusting, erotic, and gambling related pictures) on the basis of the previously presented color patch (Conditioned Stimulus, CS: red, blue, yellow, green).

Disgusting and neutral pictures were chosen based on their arousal and valence values from the IAPS database (Lang, Bradley, & Cuthbert, 2005). Erotic and gambling-related images were obtained from an Internet search, were matched in size with IAPS pictures (1,024 × 768), and were assessed individually by participants in the arousal, dominance, and valence dimensions at the end of the task. Before starting the learning task, participants were asked which set of erotic images (female nudes, male nudes), and which type of gambling-related pictures (sport betting, slot machines, casino bingo, online bingo, casino poker, online poker) they preferred to see throughout the task, based on their sexual orientation and their gambling habits. In each trial, a picture from the relevant category was randomly selected from a predefined set. Disgusting and neutral IAPS pictures in the two corresponding sets are the ones referenced in the

[1]The difference between this classification and the more common skill/chance one is that casino games such as roulette are included along skill games (e.g., poker, sports bets) in the Type I category, whereas the Type II category consists of all other pure chance games (e.g., slots, lotteries, bingo). At difference with the customary classification, mostly based on theoretical criteria, Navas et al.'s classification was based on empirical clustering of gamblers' behavior. In any case, as the only relevant difference between the two is the categorization of roulette, and the number of roulette gamblers in the present sample is rather small, it is extremely unlikely the adoption of one classification or the other could have had a relevant impact on results.

supplementary_materials.doc file available at the OSF link (Section 1). Gambling-related and erotic sets consisted of 20 items each. In Section 2 of the same supplementary materials file, we report the results of analyzing participants' SAM assessments of these two picture types. In brief, pictures were effective at generating the expected emotions, and valence and arousal assessments for gambling-related pictures were a function of individual differences in SOGS severity and gambling craving.

The task started with a practice phase (with stimuli different to the ones used for the main task), for participants to familiarize with the response mode (pressing a key for each type of image), and to get accustomed to the task pace. The main task was divided into two parts, an acquisition and an extinction phase, with no warning or perceptual discontinuity between them. Each phase consisted of two blocks of 96 trials each (which yields two acquisition and two extinction blocks, and 384 trials in total). Blocks were considered as such only for pseudorandomization purposes (trial types were randomly distributed within each block, in order to ensure that they were sufficiently dispersed throughout the whole task), again with no warning or perceptual discontinuity between them. The distribution of trials in each acquisition and extinction block was as described in Table 2.

Each trial started with a brief presentation (300 ms) of a fixation point in the center of the screen, followed by a patch of one color (out of four possible). This patch (CS) remained on screen for 1,500 ms, after which the participant was asked to predict the type of picture they thought it would be presented next (disgusting, gambling-related, erotic, neutral). To collect the predictive response, a response menu with four options ("disgusting", "neutral", "erotic", "gambling"), corresponding to four keys in the computer keyboard, was presented onscreen. After the participant made their prediction, the color patch was replaced with the picture (US) corresponding to the current trial (see Table 2).

Other Variables. Finally, some questionnaires were administered but not related to the objectives of this study, and brain activity (EEG) was also recorded during the performance of the predictive task using BrainVision Recorder (Brain Products GmbH, version 1.20.0801). In other to avoid analytical flexibility and potential HARKing, none of these variables was analyzed before completing and interpreting the analyses carried out for the present purposes. To the date of the present submission, they remain unanalyzed.

The questionnaires included in the protocol but not directly relevant for the aims of the present study were the following: the *Emotional Regulation Questionnaire* (ERQ; Spanish version, Cabello, Salguero, Fernández-Berrocal, & Gross, 2013), the *Beck's Depression Inventory* (BDI-II; Spanish version, Sanz, Perdigón, & Vázquez, 2003), the *Symptom Checklist-90 Revised* (SCL-90-R; Derogatis & Unger, 2010), the *Internet Gaming Disorder Severity Scale* (IGD9; Spanish version, Beranuy et al., 2020), the *Gambling Related Cognitions Scale* (GRCS; Spanish version, Del Prete et al., 2017), the *brief Gambling Motives Inventory* (bGMI; Barrada et al., 2019), the *MultiCAGE CAD-4* (Pedrero-Pérez et al., 2007), the *Positive Affect and Negative Affect Scale* (PANAS; Spanish version, Sandín et al., 1999), a screening consisting of nine items for DSM criteria for Gambling Disorder, and an adaptation of Quintero's craving scale for gaming behavior. As noted earlier, the *Canadian Problem Gambling Index* was also part of the protocol. The PGSI and correlates parts were however not considered for analysis.

Statistical analyses

The relationships between positive and negative urgency, SOGS, and craving scores are initially assessed using partial correlations, with gender and age as control variables. Subsequently, a mediation model, with positive and negative

Table 2. Frequency of conditioned-unconditioned stimuli (US-CS) combinations (trial type) in each acquisition and extinction block of the task

Acquisition					
		US			
		Erotic	Gambling	Disgust	Neutral
CS	A	18	0	0	6
	B	0	18	0	6
	C	0	0	18	6
	D	2	2	2	18
Extinction					
		US			
		Erotic	Gambling	Disgust	Neutral
CS	A	2	2	2	18
	B	2	2	2	18
	C	2	2	2	18
	D	2	2	2	18

Note: A, B, C and D stand the four different types of colors that could be used as CS during the task.

urgency as input variables, craving as mediator, SOGS score as output variable, and gender and age as background confounders, is tested using the mediation analysis function from the SEM module in JASP 0.16.2 (JASP Team, 2022).

The relationship between (1) negative urgency and acquisition, (2) positive urgency and acquisition, (3) negative urgency and extinction, and (4) positive urgency and extinction, are analyzed using generalized linear mixed-effects (GLME) models with a logit link. The response in each trial of the corresponding phase (acquisition or extinction) is coded as 1 (CS-congruent) if the participant predicted the US that was paired with the CS presented in that trial, and 0 (CS-incongruent) if they predicted any other US or did not make any prediction in the designated time. These analyses were performed including only the participants who performed the task well enough to consider they had understood the instructions. The criterion to select those participants ($n = 65$) was to make at least a 50% of CS-congruent responses (96 out of 192) during the acquisition phase.

Fixed-effects predictors in the model are CS type (corresponding to the four colors of the patches used as CSs), trial number (ranging from 1 to 48 for each CS type), and urgency, along with first and second-order interactions between them. The participant identity code is the only random-effects factor in the model. The predictor of theoretical interest (positive or negative urgency, depending on the specific analysis) is zero-centered and scaled to facilitate model convergence. Importantly, trial number is log-transformed before entering the model. This is done to reflect the characteristic negative acceleration of learning curves. For a detailed justification of this transformation see Quintero et al. (2020), and Robinson, Perales, Volpe, Chong, and Verdejo-Garcia (2021).

The effect of CS type is decomposed into three contrasts: C1 [−3, 1, 1, 1], corresponding to the comparison between the CS paired with the neutral US and the rest; C2 [0, −2, 1, 1], comparing the CS paired with disgust and the two CS paired with erotic and gambling related pictures; and C3 [0, 0, −1, 1], comparing the two CS paired with erotic and gambling-related pictures against each other. p-values are computed using z-approximation significance tests. p-values are considered significant at $p = 0.05$, except for contrasts involving C1, C2 and C3 (corrected threshold $p = 0.05/3 = 0.017$).

Additionally, all significant effects in the four models are double-checked using hierarchical tests. Each hierarchical test involves pitching the model containing the effect of interest (and all the effects at the same or a lower complexity level; e.g., for a second-order interaction, all the other possible second-order interactions along with first-order interactions and non-interactive effects), against the same model without the effect of interest. The Akaike Information Criterion (AIC) and a χ^2 test are used to select the best-fitting model in each comparison. The result of this comparison is interpreted as an assessment of whether or not the effect of interest substantially contributes to accounting for observed variance in the response.

The significance of effects identified as substantial using this triple criterion (z-approximation tests in the global model, plus hierarchical comparisons using AIC and χ^2 tests) are corroborated in a further model including age, gender, and their first and second-order interactions with trial number and CS type as fixed-effect control covariates.

Analyses regarding GLME models are run using the lme4 statistical package (Bates, Mächler, Bolker, & Walker, 2015) in R programming software (version 4.0.3; The R Core Team, 2020).

Ethics

The procedure of this study complies with the ethical standards of the Helsinki Declaration of 1975, as revised in 2008, and was approved by the Human Research Institutional Review Board of the University of Granada, as part of the GBrain2 Project (Reference: PSI2017-85488-P, IRB approval number 406/CEIH/2017). All participants were informed about the nature of the study, and all provided informed consent.

RESULTS

Positive and negative urgency, craving, and SOGS severity

Table 3 displays partial correlations between positive and negative urgency, craving, and SOGS scores for the 81 participants in the total sample, conditional on age and gender. As expected, positive and negative urgency were strongly correlated. Both positive and negative urgency also correlated with disordered gambling symptoms' severity (SOGS) and with gambling craving. Importantly, positive urgency correlated with craving more strongly than negative urgency. This is indicative that, in this sample, cravings were more strongly driven by appetitive cues than by aversive ones.

The details and results of the mediation analysis are fully disclosed (and graphed) at the OSF link (mediation_analysis.jasp file). Negative urgency had a significant direct effect on SOGS scores ($\beta = 0.252$, $z = 2.470$, $p = 0.014$). The direct effect of positive urgency was non-significant ($\beta = 0.077$, $z = 0.660$, $p = 0.509$), but its indirect effect via craving was significant ($\beta = 0.230$, $z = 3.168$,

Table 3. Partial correlations between positive and negative urgency, craving, and SOGS

		Neg. urg.	Pos. urg.	SOGS
Positive urgency	r	0.490		
	p	<0.001		
SOGS score	r	0.383	0.420	
	p	<0.001	<0.001	
Craving score	r	0.214	0.504	0.529
	p	0.058	<0.001	<0.001

Note: Partial correlations controlling for 'age' and 'gender'.

$p = 0.002$). Contrarily, the indirect effect of negative urgency via craving was non-significant ($\beta = -0.019$, $z = -0.393$, $p = 0.694$). This combination of direct and indirect effects yielded significant total effects for both positive and negative urgency, although the former was stronger ($\beta = 0.307$, $z = 2.709$, $p = 0.007$; and $\beta = 0.233$, $z = 2.069$, $p = 0.039$).

This mediation analysis was complemented with a regression analysis of craving over positive and negative urgency (with gender and age as covariates). In accordance with the mediation analysis, positive urgency was positively associated with craving ($\beta = 0.530$, $t = 4.626$, $p < 0.001$), whereas negative urgency was not ($\beta = -0.043$, $t = -0.382$, $p < 0.703$).

Effect of negative urgency and positive urgency on acquisition

The relationship between negative urgency and acquisition in the acquisition-extinction task was analyzed using a generalized linear mixed-effects (GLME) with a logit link, as described above. Fixed-effects predictors in the model were CS type (corresponding to the four colors of the patches used as CSs), log-transformed trial number (ranging from 1 to 48 for each CS type), and negative urgency, along with first and second-order interactions between them. The participant identity code was the only random-effects factor in the model.

The left panel of Table 4 displays the odd ratios (OR), confidence intervals (CI), and p-values for all effects in the model. The only theoretically relevant significant effect was the interaction between negative urgency and trial number. The OR for that effect indicates that acquisition was slightly slower for participants with high negative urgency scores. A hierarchical test (pitching the model containing all first order interactions against the equivalent without the negative urgency × trial number interaction), confirmed this result [AIC = 10,880, and AIC = 10,883, respectively, $\chi^2 = 4.758$, $p = 0.029$]. As shown in the right panel of Table 4, that effect survived the inclusion of age and gender (and their interactions with the other predictors) in the model.

The same type of analysis was carried out for the relationship between positive urgency and acquisition. The left panel of Table 5 displays the odd ratios (OR), confidence intervals (CI), and p-values for all effects in the model. Positive urgency interacted with the C3 component of CS-type in the no-covariates model. The hierarchical test confirmed the contribution of the positive urgency × CS-type interaction to model fit [AIC = 10,873, and AIC = 10,884, respectively, $\chi^2 = 17.066$, $p < 0.001$]. As shown in the right panel of Table 5, the C3 × positive

Table 4. Effect estimates in the generalized linear mixed-effects model for CS-congruent responses during acquisition (with negative urgency as impulsivity predictor)

	No covariates model			Gender/age controlled		
Fixed part	*OR*	*CI*	*p*	*OR*	*CI*	*p*
Intercept	0.39	0.31–0.49	**<0.001**	0.34	0.27–0.45	**<0.001**
Trial number (log)	2.39	2.27–2.52	**<0.001**	2.52	2.38–2.67	**<0.001**
CS type						
C1	1.14	1.05–1.24	**0.002**	1.19	1.08–1.31	**<0.001**
C2	1.17	1.05–1.32	**0.007**	1.21	1.06–1.38	**0.005**
C3	1.06	0.86–1.30	0.581	0.98	0.78–1.23	0.865
Negative urgency (NU)	1.11	0.86–1.42	0.425	1.14	0.88–1.47	0.312
CS type × trial number						
C1 × trial number	1.00	0.98–1.03	0.779	0.99	0.96–1.03	0.713
C2 × trial number	1.02	0.98–1.06	0.400	1.01	0.97–1.06	0.657
C3 × trial number	0.95	0.88–1.03	0.203	0.97	0.89–1.06	0.485
NU × trial number	0.93	0.88–0.99	**0.016**	0.93	0.88–0.98	**0.013**
CS type × negative urgency						
C1 × NU	1.07	0.98–1.16	0.138	1.07	0.98–1.17	0.142
C2 × NU	1.09	0.96–1.23	0.176	1.11	0.98–1.26	0.099
C3 × NU	0.97	0.78–1.20	0.758	0.96	0.77–1.20	0.724
Trial number × CS type × negative urgency						
C1 × trial number × NU	0.97	0.94–1.00	0.077	0.97	0.95–1.01	0.109
C2 × trial number × NU	0.96	0.92–1.00	0.064	0.96	0.91–1.00	0.044
C3 × trial number × NU	1.06	0.97–1.14	0.182	1.05	0.97–1.14	0.204
Random part						
σ^2	3.29			3.29		
τ_{00}	0.59 $_{\text{id}}$			0.58 $_{\text{id}}$		
ICC	0.15			0.15		
Marginal R^2/Conditional R^2	0.163/0.291			0.182/0.305		

Abbreviations: CS = Conditioned stimuli; CI = Confidence Interval; NU, Negative urgency; ICC = Intraclass correlation coefficient; OR = Odds ratio. *Note*: Significant results are marked in bold.

urgency effect remained significant after including the gender and age covariates in the model.

Figure 2 displays the observed proportion of CS-congruent responses throughout the acquisition phase and across the four CS types, for high and low negative urgency participants (top row), and for high and low positive urgency participants (bottom row). Please note that the median split was performed for visualization purposes only, but positive and negative urgency were treated as continuous variables in all models. Proportions are shown as directly observed and not adjusted for covariates. The effects of positive and negative urgency on acquisition are rather small and mostly restricted to acquisition of the CS-erotic US association. In addition, the effect of positive urgency was preasymptotic.

Effects of positive and negative urgency on extinction

The same logic was followed for extinction analysis. Table 6 displays the odd ratios (OR), confidence intervals (CI), and *p*-values for all effects in the model for the relationship between negative urgency and extinction. Negative urgency had no significant direct or interactive effects in any of the two models (with and without the inclusion of age and gender covariates). Extinction proceeded as expected, with the predictive response gradually decreasing for emotion-laden CSs, and remaining high for the neutral US-paired CS (contingency was not degraded for neutral stimuli during this phase of the task). The CS × trial type interaction thus obeys to this difference in the contingencies of the emotion-laden CS and the neutral one.

Results were very different for positive urgency. As shown in the left panel of Table 7, positive urgency interacted with CS type and trial number. Namely, the rate of extinction of emotion-laden CSs (relative to the constant baseline defined by the neutral CS) was a function of positive urgency (see C1 × positive urgency and C1 × trial number × positive urgency significant effects in both models). The second-order interaction was corroborated by a hierarchical test [AIC = 13,139, and AIC = 13,147, for the models with and without the effect, respectively, $\chi^2 = 14.001$, $p = 0.003$], and survived after covariate control.

Figure 3 displays the observed proportion of CS-congruent responses throughout the extinction phase and across the four CS types, for high and low negative urgency participants (top row), and for high and low positive urgency participants (bottom row). Again, the median split was performed for visualization purposes only, and proportions are shown as directly observed and not adjusted for covariates. The figure shows quite an evident slower extinction for participants with high positive urgency scores.

Table 5. Effect estimates in the generalized linear mixed-effects model for CS-congruent responses during acquisition (with positive urgency as impulsivity predictor)

	No covariates model			Gender/age controlled		
Fixed part	*OR*	*CI*	*p*	*OR*	*CI*	*p*
Intercept	0.39	0.31–0.50	**<0.001**	0.35	0.27–0.45	**<0.001**
Trial number (log)	2.39	2.27–2.52	**<0.001**	2.51	2.37–2.67	**<0.001**
CS type						
C1	1.14	1.05–1.23	**0.002**	1.19	1.08–1.30	**<0.001**
C2	1.16	1.03–1.31	**0.012**	1.20	1.05–1.36	**0.007**
C3	1.07	0.87–1.32	0.498	1.00	0.79–1.25	0.970
Positive urgency (PU)	1.14	0.89–1.46	0.303	1.20	0.92–1.55	0.173
CS type × trial number						
C1 × trial number	1.00	0.98–1.03	0.769	0.99	0.96–1.03	0.741
C2 × trial number	1.02	0.98–1.06	0.355	1.01	0.97–1.06	0.642
C3 × trial number	0.95	0.88–1.02	0.176	0.97	0.89–1.05	0.438
PU × trial number	0.96	0.91–1.01	0.131	0.96	0.91–1.02	0.187
CS type × positive urgency						
C1 × PU	1.02	0.94–1.12	0.583	1.02	0.93–1.12	0.658
C2 × PU	0.88	0.78–1.00	**0.044**	0.90	0.79–1.02	0.105
C3 × PU	1.30	1.05–1.62	**0.016**	1.33	1.06–1.66	**0.013**
Trial number × CS type × negative urgency						
C1 × trial number × NU	0.99	0.96–1.02	0.355	0.99	0.96–1.03	0.732
C2 × trial number × NU	1.02	0.98–1.07	0.336	1.02	0.98–1.07	0.361
C3 × trial number × NU	0.93	0.87–1.01	0.080	0.92	0.84–0.99	0.030
Random part						
σ^2	3.29			3.29		
τ_{00}	0.59 $_{id}$			0.58 $_{id}$		
ICC	0.15			0.15		
Marginal R^2/Conditional R^2	0.159/0.287			0.178/0.300		

Abbreviations: CS = Conditioned stimuli; CI = Confidence Interval; PU, positive urgency; ICC = Intraclass correlation coefficient; OR = Odds ratios. *Note*: Significant results are marked in bold.

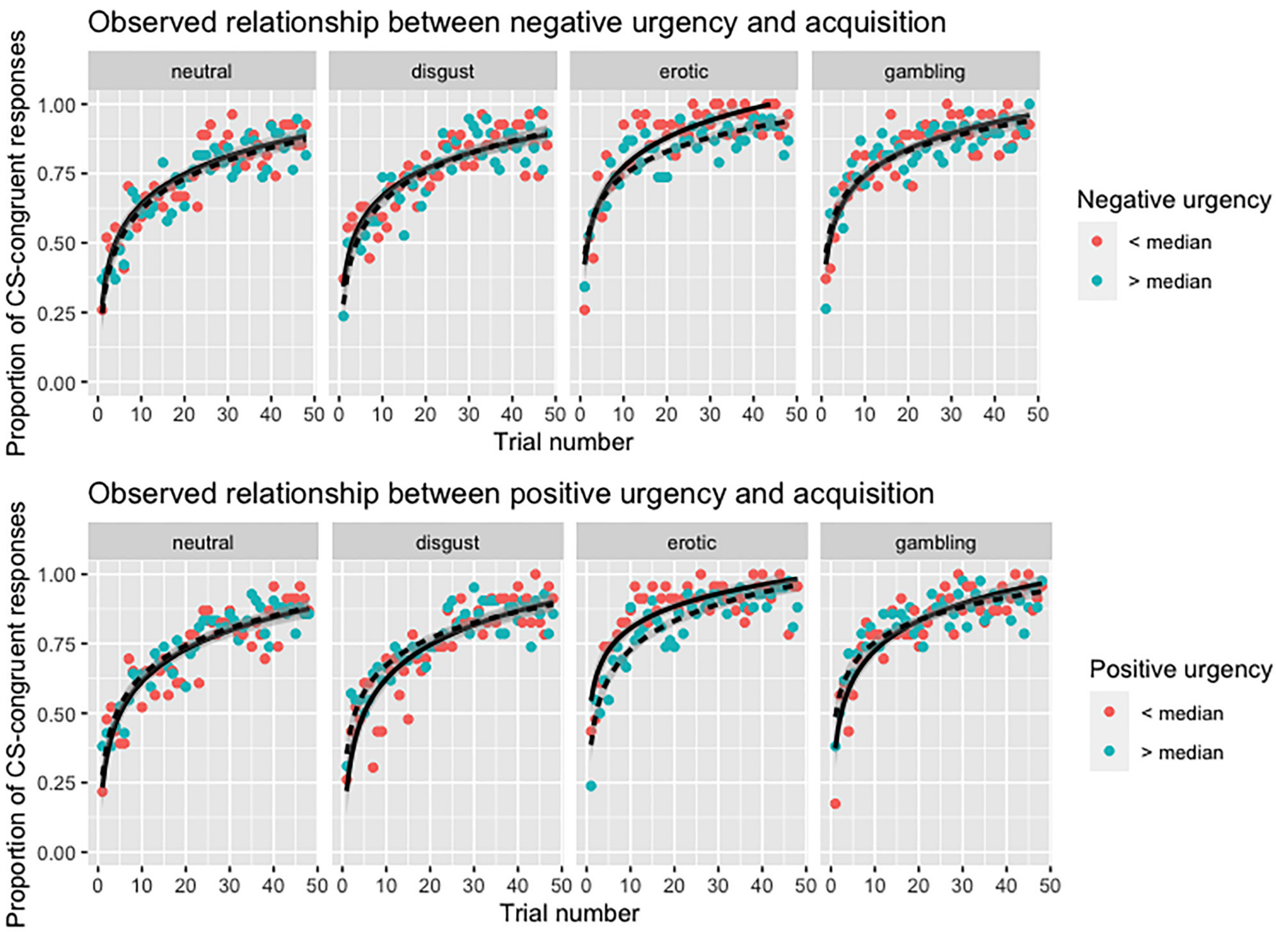

Fig. 2. Observed proportions (and logarithmic trendlines) of CS-congruent responses across CS-type and NU/PU during acquisition. NU and PU were median-split for visualization purposes only

These analyses show the effect of positive urgency was restricted to emotion-laden CSs (disgusting, erotic, and gambling-related). In view of that, a simplified model was built excluding the neutral CS-type. As expected, this model yielded a significant trial × positive urgency interaction ($z = 2.022$, $p = 0.043$). Given that no components of the CS-type × trial × positive urgency interaction were significant (i.e., the effect of positive urgency on extinction was similar for the three remaining emotion-laden CS-types; all $p > 0.35$), a further simplified model was built without the second-order interaction. The trial × positive urgency interaction also remained significant in this model ($z = 2.056$, $p = 0.040$).

Post-hoc exploratory analyses: the moderating role of gambling preferences on the positive urgency-extinction association

In order to test whether positive urgency effects on extinction were modulated by gambling preferences, a preference measure was computed from gambling frequency measures (as collected in the gambling habits questionnaire). Frequency scores for type-II games (lotteries, bingo, and slots, either online or land-based) and type-I games (card games, sport bets, and casino games) were first separately summed, and then zero-centered and scaled. The type-I/type-II classification of games was based on Navas et al. (2017). The preference score was computed as the difference between these two standardized frequency measures. This difference score will thus be more negative as the individual shows an exclusive preference for participating in type-II games, and more positive the more exclusively their participation is biased towards type-I games. Individuals with mixed patterns will be located somewhere in-between these extreme scores.

This preference measure, plus its interaction with trial, its interaction with positive urgency, and the preference × positive urgency × trial interaction were added as fixed-effects predictors to the last (simplified) model of the previous section. The trial × positive urgency interaction survived in this model ($z = 2.661$; $p = 0.008$). More interestingly, however, this effect was qualified by a significant preference × positive urgency × trial interaction ($z = 2.452$; $p = 0.015$); that is, the detrimental effect of positive urgency on extinction was strongly modulated by gambling preferences. As shown in Fig. 4, participants with a more biased preference for participating in type-I games showed a neat positive urgency effect on extinction, whereas this effect

Table 6. Effect estimates in the generalized linear mixed-effects model for CS-congruent responses during extinction (with negative urgency as impulsivity predictor)

	No covariates model			Gender/age controlled		
Fixed part	*OR*	*CI*	*p*	*OR*	*CI*	*p*
Intercept	5.32	3.66–7.73	**<0.001**	5.80	3.85–8.74	**<0.001**
Trial number (log)	0.61	0.58–0.64	**<0.001**	0.59	0.56–0.62	**<0.001**
CS type						
C1	1.14	1.04–1.24	**0.003**	1.23	1.11–1.35	**<0.001**
C2	0.96	0.85–1.08	0.518	0.99	0.87–1.13	0.887
C3	0.89	0.72–1.09	0.251	0.87	0.69–1.10	0.240
Negative urgency (NU)	0.88	0.60–1.31	0.540	0.87	0.59–1.29	0.497
CS type × trial number						
C1 × trial number	0.83	0.81–0.85	**<0.001**	0.81	0.78–0.83	**<0.001**
C2 × trial number	1.03	0.99–1.08	0.097	1.02	0.98–1.07	0.297
C3 × trial number	1.00	0.93–1.07	0.931	1.00	0.92–1.08	0.943
NU × trial number	1.00	0.95–1.05	0.932	1.00	0.94–1.05	0.872
CS type × negative urgency						
C1 × NU	0.95	0.87–1.04	0.254	0.97	0.89–1.06	0.477
C2 × NU	1.06	0.93–1.20	0.388	1.05	0.92–1.19	0.450
C3 × NU	1.08	0.87–1.34	0.467	1.06	0.85–1.33	0.581
Trial number × CS type × negative urgency						
C1 × trial number × NU	1.01	0.98–1.04	0.365	1.01	0.98–1.04	0.561
C2 × trial number × NU	0.98	0.94–1.02	0.396	0.99	0.95–1.03	0.582
C3 × trial number × NU	0.98	0.92–1.06	0.666	0.99	0.92–1.07	0.816
Random part						
σ^2	3.29			3.29		
τ_{00}	1.94 $_{\text{id}}$			1.91 $_{\text{id}}$		
ICC	0.37			0.37		
Marginal R^2/Conditional R^2	0.138/0.458			0.150/0.462		

Abbreviations: CS = Conditioned stimuli; CI = Confidence Interval; NU, Negative urgency; ICC = Intraclass correlation coefficient; OR = Odds ratio. *Note*: Significant results are marked in bold.

tended to vanish in participants who participate in type-II games in a more exclusive manner.

DISCUSSION

Our results reinforce previous findings that affect-driven impulsivity (urgency) is linked to gambling craving and symptoms of problematic gambling, and also support its association with difficulties to extinguish conditioned associations between initially neutral stimuli and unconditioned, emotion-laden pictures. This association between urgency and slowed extinction cannot be explained as resulting from previous deficits in acquisition. Although in the present study urgency significantly interfered with acquisition, this effect was small, partial, and, in the case of positive urgency, preasymptotic. In other words, performance differences between high and low-urgency individuals are not attributable to insufficient understanding of the task, or more general faulty reinforcement learning, as observed with associative learning tasks in other addictive disorders (Robinson et al., 2021).

However, the specific pattern of relationships shown by positive and negative urgency depicts a complex picture that requires detailed discussion. Although both positive and negative urgency correlated with severity of disordered gambling symptoms, negative urgency remained a significant predictor after controlling for craving (i.e., its relationship with severity was independent of craving, as shown by its significant direct effect in the mediation model), whereas the effect of positive urgency was explained away by craving. This result is suggestive of a mediational role of craving in the positive urgency – severity association. In accordance with the argument presented in the introduction, if craving is an intrinsically emotional state, the finding that urgency exerts its effect on gambling symptoms severity via craving suggests that urgency reflects a difficulty with regulating emotions, including regulation of craving.

This pattern of conditional and unconditional associations is compatible with the view that craving (at least in some subpopulations of gamblers) is triggered and fueled by appetitive cues, namely those that signal the availability of a reinforcer or share motivational features with it (Barrus, Cherkasova, & Winstanley, 2015; Cornil et al., 2018; Ostlund & Marshall, 2021). Individuals with higher positive urgency scores will experience more intense cravings (hyperreactivity to appetitive cues), and will find it more difficult to control gambling when experiencing such craving states (compromised regulation).

There are at least two other pieces of evidence that strengthen the view that cravings are more incentive-related than aversive, at least in the current sample. As detailed in

Table 7. Effect estimates in the generalized linear mixed-effects model for CS-congruent responses during extinction (with positive urgency as impulsivity predictor)

	No covariates model			Gender/age controlled		
Fixed part	*OR*	*CI*	*p*	*OR*	*CI*	*p*
Intercept	5.55	3.84–8.01	**<0.001**	6.10	4.06–9.18	**<0.001**
Trial number (log)	0.61	0.58–0.64	**<0.001**	0.58	0.55–0.62	**<0.001**
CS type						
C1	1.11	1.02–1.21	**0.019**	1.20	1.09–1.33	**<0.001**
C2	0.94	0.84–1.07	0.359	0.97	0.84–1.11	0.653
C3	0.89	0.72–1.10	0.281	0.88	0.69–1.11	0.270
Positive urgency (PU)	1.32	0.90–1.93	0.149	1.35	0.90–2.01	0.142
CS type × trial number						
C1 × trial number	0.84	0.81–0.86	**<0.001**	0.81	0.79–0.84	**<0.001**
C2 × trial number	1.04	1.00–1.08	0.059	1.03	0.98–1.08	0.193
C3 × trial number	0.99	0.93–1.07	0.875	0.99	0.92–1.07	0.889
PU × trial number	1.01	0.96–1.06	0.763	0.99	0.94–1.05	0.711
CS type × Positive urgency						
C1 × NU	0.87	0.80–0.95	**0.003**	0.92	0.84–1.01	0.082
C2 × NU	0.92	0.81–1.04	0.178	0.90	0.78–1.02	0.104
C3 × NU	1.10	0.89–1.35	0.385	1.05	0.84–1.32	0.678
Trial number × CS type × Positive urgency						
C1 × trial number × PU	1.05	1.02–1.08	**<0.001**	1.04	1.01–1.07	**0.014**
C2 × trial number × PU	1.02	0.98–1.06	0.383	1.03	0.99–1.08	0.131
C3 × trial number × PU	0.97	0.91–1.04	0.429	0.99	0.92–1.07	0.766
Random part						
σ^2	3.29			3.29		
τ_{00}	1.86 $_{id}$			1.86 $_{id}$		
ICC	0.36			0.36		
Marginal R^2/Conditional R^2	0.151/0.458			0.158/0.462		

Abbreviations: CS = Conditioned stimuli; CI = Confidence Interval; PU, Positive urgency; ICC = Intraclass correlation coefficient; OR = Odds ratios. *Note*: Significant results are marked in bold.

the analyses reported in the supplementary materials file, (a) individual differences in craving intensity predicted participants' assessments of affective valence and arousal for the gambling-related pictures used as USs (see Images _SAM_SOGS.jasp file in the OSF link mentioned earlier). That is, people reporting more intense cravings also valued gambling images more positively. And (b) negative urgency predicted severity independently of craving, but did not predict craving itself (after controlling for positive urgency). That means that the role of negative urgency here would be more general. As we have previously hypothesized, and partially evidenced (see Perales et al., 2020; Navas et al., 2019), the transdiagnostic nature of negative urgency would make people with disordered gambling more vulnerable to other conditions (especially in the high end of the externalizing continuum), increasing the risk of clinical complications not necessarily caused by gambling itself.

That said, the present study failed to replicate the key results reported by Quintero et al. (2020). First, in that study negative urgency did not predict severity in a direct manner, but a direct association between negative urgency and craving was found. Given the strong overlap between positive and negative urgency, the possibility exists that the negative urgency-craving link would have disappeared if positive urgency had been controlled for. Or, alternatively, as both clinical and laboratory studies suggest, not only appetitive, but also aversive cues and states (e.g., stress) could trigger and fuel cravings (Bresin, Mekawi, & Verona, 2018; Koob & Volkow, 2016). If this were the case, it would remain to be explained why aversive states dominated craving in Quintero et al.'s study, whereas appetitive ones did so in the present one.

And second, and most importantly, our results also contrast with Quintero et al.'s with regard to the relationship between urgency and extinction. As noted earlier, extinction of affect-laden associations can be interpreted as an index of incidental emotion regulation. Slowed extinction of these associations can reflect a hampered modulation of emotional responses by contextual cues, leading to inappropriate emotional reactions. However, in the present study, it was positive urgency, instead of negative urgency, the facet of impulsivity that was associated with slowed extinction. Moreover, slowed extinction in high positive urgency individuals was evident for all CS paired with emotion-laden US, regardless of the hedonic sign of such US (negative in the case of disgusting pictures, and positive in the case of gambling-related and erotic pictures). That is, the urgency-related alteration of the associative mechanisms of extinction seems to extend to a broad range of conditioned emotions.

Our supplementary analyses provide, however, a viable (but *ex post facto*) mechanism for our suspicion that

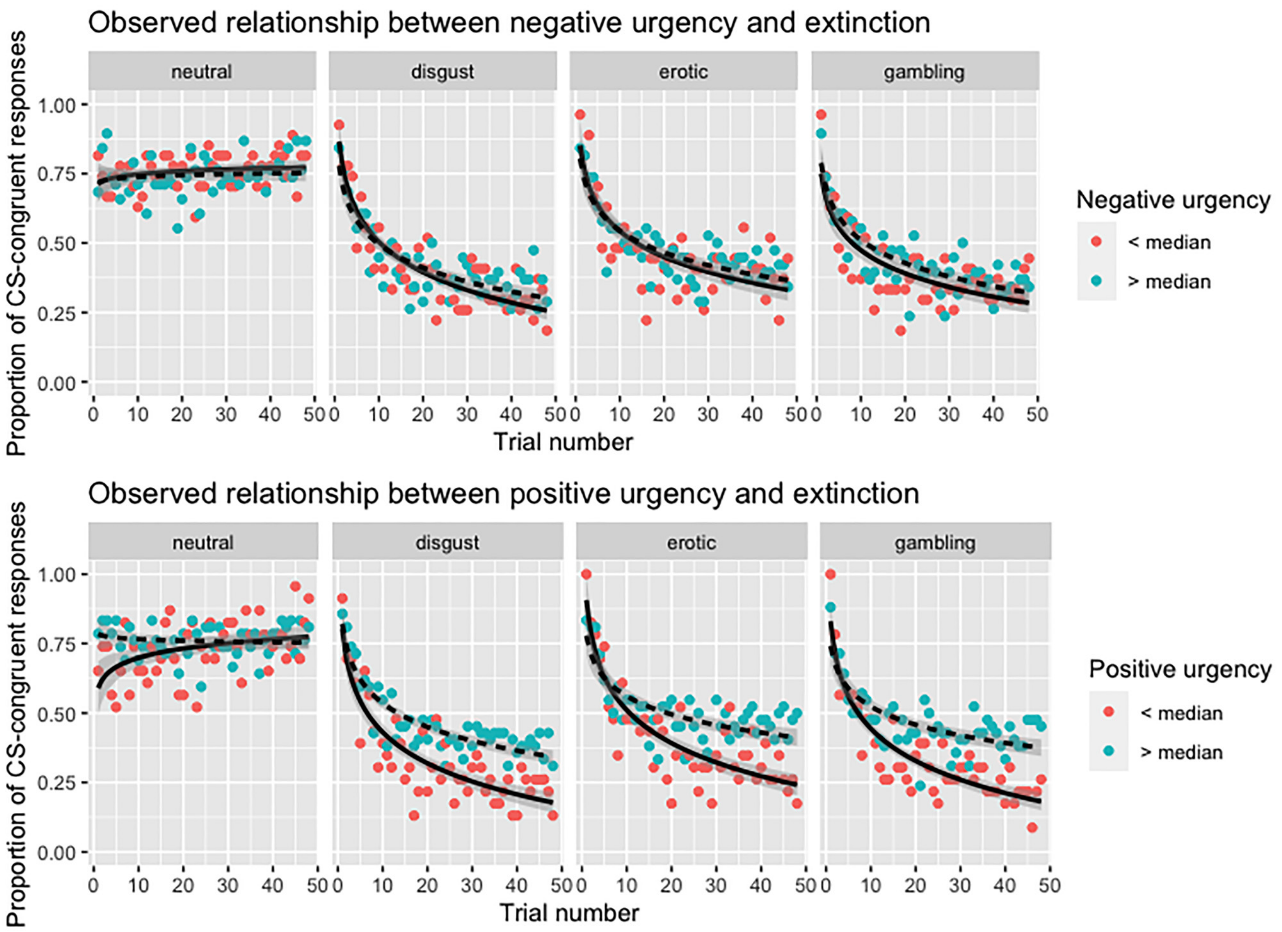

Fig. 3. Observed proportion (and logarithmic trendlines) of CS-congruent responses across CS-type and NU/PU during extinction. NU and PU were median-split for visualization purposes only

replication failure could be due to sample differences between studies. As noted above, the possibility exists that urgency is expressed differently depending on the differential sensitivity of the individual to aversive or appetitive states. If that were the case, an individual with slowed extinction of affect-laden stimuli would show elevated positive or negative urgency scores depending on a pre-existing proneness to overreact to appetitive or aversive drives. This proposal is highly tentative, but it is supported by (a) the almost symmetrical association of positive/negative urgency with slowed extinction and gambling cravings in the present and our previous study, and (b) the finding, in the current study, that slowed extinction is associated with positive urgency only in gamblers with preference for Type-I games. Actually, Navas et al. (2017) found that Type-I gamblers are more sensitive to reward and have more positive expectancies about gambling than individuals preferring Type-II games (see also Balodis, Thomas, & Moore, 2014).

If this idea results to be correct, it could indirectly help resolve the apparent puzzle regarding why in some studies urgency seems to be unifactorial, whereas in some other positive and negative urgency seem to have differentiable etiological roles in addictive behaviors. According to our proposal, positive and negative urgency have a common etiological root in the malfunctioning of processes of contextual control of conditioned emotional states, but can manifest itself differently depending on the interaction of such processes with more fundamental traits of sensitivity to appetitive and aversive drivers (e.g., activity of Gray's BIS/BAS systems; Bijttebier, Beck, Claes, & Vandereycken, 2009).

Limitations and final remarks

This study is not free of limitations. The most important ones arise from its cross-sectional nature, which limits the possibility of making causal statements. Note, however, that the chain of nodes in mediation analysis responds to the logic that traits (positive and negative urgency) have a causal influence on states (craving), and these on behaviors (problem gambling symptoms).

A second limitation arises from the ambiguous status of the present study as a direct or conceptual replication. There are variations in this study relative to the original one that are substantial enough for this attempt not to be considered a direct replication, with several of such variations being included simultaneously. We are aware that further research is required in which all hypotheses are preregistered, including the ones regarding the relative roles of positive

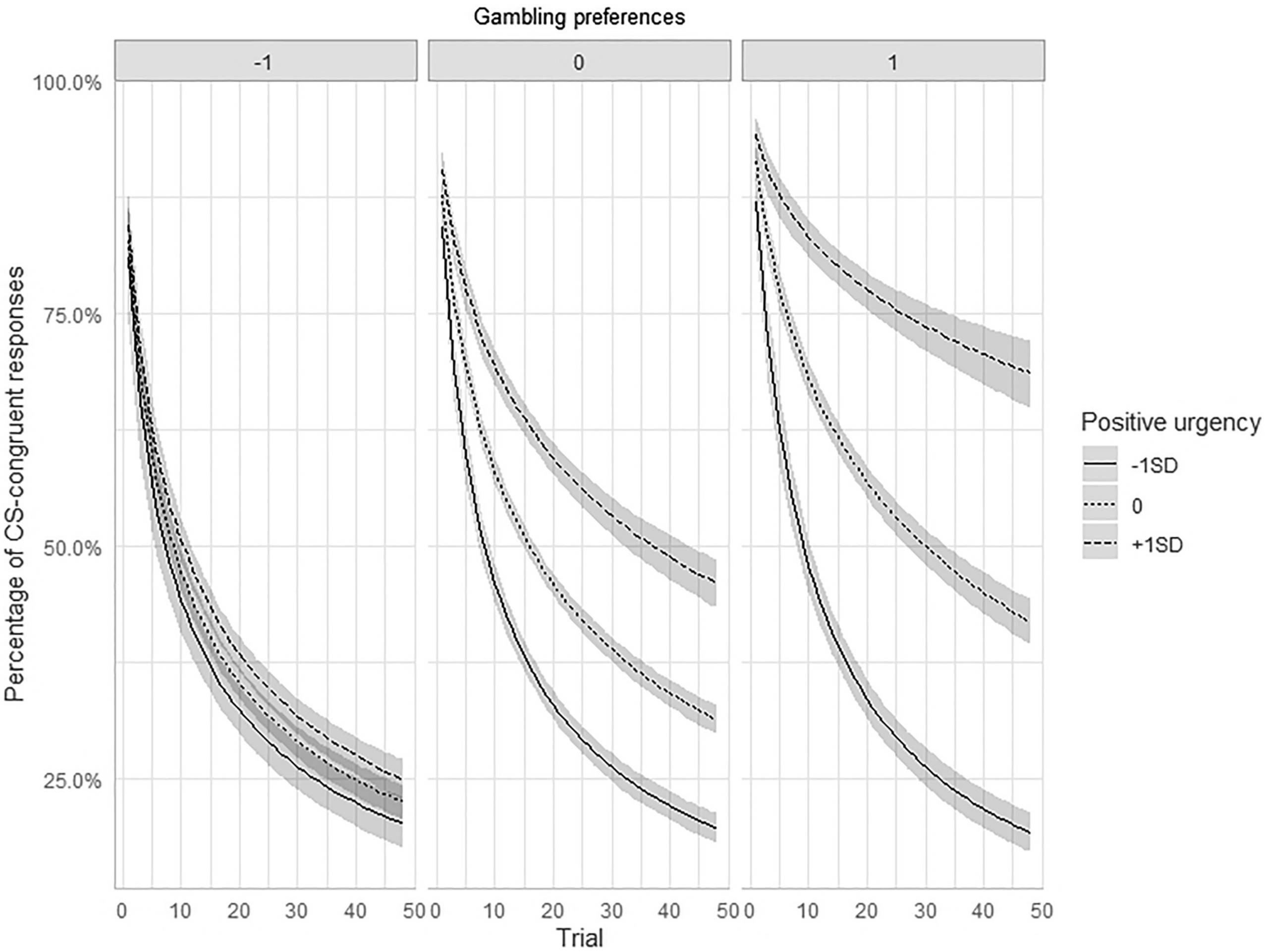

Fig. 4. Predicted values of conditioned responses (percentage of CS-congruent responses) for CSs associated with type-I and type-II gambling preferences as a function of positive urgency

and negative urgency, and the ones regarding the roles of gambling preferences (ideally, in a sample in which preferences for type I and type II gambling modalities are well balanced).

Additionally, the craving measure used in this study is not broadly validated, but theoretically rooted in the incentive sensitization hypothesis. The idea that a common sensitization process makes reward-related cues acquire the capacity to elicit strong desire, attentional capture, and automatic approach responses is however supported by the strong convergence of the three items, both in the current and Quintero et al.'s (2020) studies.

The strengths of the study stem from its carefully preplanned design and data analytic plan. In these conditions, the fact that the original results were not replicated does not take the research question to square one, but opens new pathways for investigation. The evidence that (a) emotion regulation, impulsivity, and craving control are intertwined, (b) they play a key role in the etiology of gambling problems, and (c) they can be at least partially traced back to basic learning processes is solid, and improves our understanding of the connection between basic processes of behavioral control and addiction. The picture is however more complex that initially considered, and implies that gambling research can no longer ignore the importance of individual heterogeneity. Further research on the link between gambling preferences and the affective content and valence of craving, and the role of regulation of positive and negative emotions in craving control for different subpopulations of individuals with gambling problems, is warranted.

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