



The Interrelation Between Emotional Impulsivity, Craving, and Symptoms Severity in Behavioral Addictions and Related Conditions: a Theory-Driven Systematic Review

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Abstract

Purpose of Review Here, we systematically review all available evidence on the triadic relationship between positive and negative urgency, craving, and severity of symptoms of candidate behavioral addictions.

Recent Findings Current theoretical models attribute a central importance to craving in the chronification and prognosis of behavioral addictions and other problematic non-substance-related behavioral patterns. Craving, in turn, has been convincingly shown to be an affect-laden state, and its control can be conceptualized as partially resulting from emotion regulation mechanisms. However, some gaps remain: first, there is no consensus on the predominantly appetitive or aversive nature of craving; and, second, although positive and negative urgency have been proposed as proxies to incidental emotion regulation mechanisms, their direct or indirect role in craving regulation and severity of problematic behaviors is still poorly known.

Summary According to our results, craving emerges as a central construct, partially resulting from emotion dysregulation as assessed by urgency. The preponderance of positive urgency shown by most studies in this review also reinforces the view of positive emotions as a ‘trojan horse’ in addictive processes. Negative urgency, in turn, seems to be a complication factor that could underlie gambling addiction and other related mental health conditions. Most studies, however, are about gambling behavior, with the few studies in other domains precluding firm conclusions about the differences or similarities between them.

Keywords Severity · Craving · Positive urgency · Negative urgency · Impulsivity · Behavioral addiction

Introduction

Despite not being explicitly listed as a diagnostic criterion in current nosologies [1, 2], craving has been attributed a key role in the etiology of gambling disorder (GD) [3] and other candidate behavioral addictions [4]. This has caused a proliferation of craving scales for these conditions [3, 5–7]. Unfortunately, with noteworthy exceptions (e.g., [8]), such a proliferation has not been accompanied by an analogous effort to study the etiological mechanisms of craving or its processual similarities across behavioral domains.

Among the aspects of craving in non-substance addictions remaining to be clarified, there is no consensus regarding its predominantly aversive or appetitive nature [9, 10]. If considered a negative affective state, craving would account for addictive behavior maintenance by virtue of negative reinforcement (i.e., avoidance or escape; [11, 12]). This aversive state can be triggered by stress or physiological symptoms, but also by cues that have previously been associated with the object of

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addiction [13, 14]. Alternatively, some well-supported models conceptualize craving as a predominantly appetitive state [15]. For instance, the Incentive-Sensitization Theory of addiction (IST) [16] suggests that reiterative stimulation of the mesocorticolimbic pathways by addictive agents would increase the incentive properties of cues related to such agents, turning them into “motivational magnets” and generating maladaptive “wanting” that progressively decouples from the pleasure of consummation, or “liking” [17]. Complementarily, according to the Elaborated Intrusion Theory of desire (EIT) [18], this state would be accompanied by reward-related intrusive thoughts and imagery that would interfere with its control.

Nonetheless, aversive and appetitive components could coexist in craving states [10, 19]. Moreover, the affective content of craving may differ from person to person, and may even change at different stages of addiction, or different contexts [9, 18]. Whatever the case, the emotional or affective nature of craving is uncontroversial, and hence craving control can be considered, at least in part, as emotion regulation [20].

Emotion dysregulation is an umbrella term for a range of difficulties to modulate the valence, intensity, and time course of emotional or affective states, so that emotions transpire in ways that hinder progress towards one’s goals, and increase the susceptibility to some mental health conditions, including addictive disorders [21–24]. According to recent literature, certain types of emotion dysregulation are expressed as a proneness to rash action under the influence of strong positive and negative affect [25–27]. This proneness—known as urgency or emotion-driven impulsivity—is a component in the UPPS-P impulsive behavior model (along with lack of premeditation, lack of perseverance and sensation seeking [28]), and has two facets (positive and negative urgency), depending on the valence of the underlying emotional state. Importantly, urgency has been specifically linked with malfunctioning of automatic or incidental aspects of emotion regulation [29].

In more direct connection with the aims of the present study, Chester et al. [30] pioneered the idea that urgency could be involved in the vulnerability of individuals to acquire conditioned craving responses in substance use disorder (SUD), or in the impact of such craving states on lack of control over addictive behaviors. That idea was further extended to gambling disorder by Navas et al. [31], and other candidate behavioral addictions by Perales et al. [32••]. According to them, urgency would be a risk factor for addiction by fueling craving. Hence, craving is expected to mediate the effect of urgency on addictive behaviors. Complementarily, urgency could also impact addictive behaviors independently of craving. Actually, some evidence exists that urgency could underlie problematic behaviors that are not in the core of behavioral addiction but could be comorbid with it, and could increase its severity and ensuing harms [31, 32••, 33, 34•].

Aims and Scope of the Present Review

Beyond the mere correlations between urgency, craving, and addictive behavior, there are important gaps in the literature that need to be addressed. First, it remains under-investigated whether positive or negative urgency plays a larger role in craving and the severity of addictive behaviors. And second, conditional associations between constructs could cast light on the etiology of craving and behavioral addictions. Effects of urgency on addictive behaviors that survive after statistically controlling for craving would reveal a direct impact of urgency on the severity of behavioral addiction that is not mediated by craving regulation mechanisms. Complementarily, mediation analyses involving urgency, craving, and severity of addictive behaviors would clarify the form of the joint contribution of craving and urgency to behavioral addictions.

Our review will thus include behavioral addictions currently acknowledged by current psychiatric classifications, namely GD and IGD, as well as other conditions not involving the use of substances with substantial support in the literature for its potential future inclusion in the category of behavioral addictions. Depending on the methodological approach and the type of results provided, studies will be classified in the following categories. *Level 1 studies* will include those assessing bivariate correlations between the variables of interest. *Level 2 studies* will include regression and conceptually similar analyses (e.g., hierarchical and multilevel modeling) that pitch craving against urgency measures as predictors of behavioral addiction severity measures, and urgencies against each other as predictors of craving. These studies may provide information on the relative weights of the associations of positive and negative urgency with craving, and thus help clarify the appetitive/aversive nature of craving in the realm of behavioral addictions. Complementarily, they could reveal whether urgency can contribute to severity by ways that are not related to craving control. Finally, *Level 3 studies* are causality-informed ones, including prospective or longitudinal research, and studies using structural-equation modeling or path analysis techniques. Assuming causal precedence of traits over transient states, reported links can clarify whether urgency predicts symptoms directly, or indirectly (via craving). Again, a direct path would imply that urgency can affect gambling/gaming problems independently of craving. The indirect path, in turn, could be interpreted as evidence that people with high urgency scores experience stronger cravings, that is, that urgency contributes to the emergence of craving awareness.

Method

This systematic review was conducted following the PRISMA guidelines [35]. The flowchart (Fig. 1) illustrates the process followed during the search, screening, and item selection

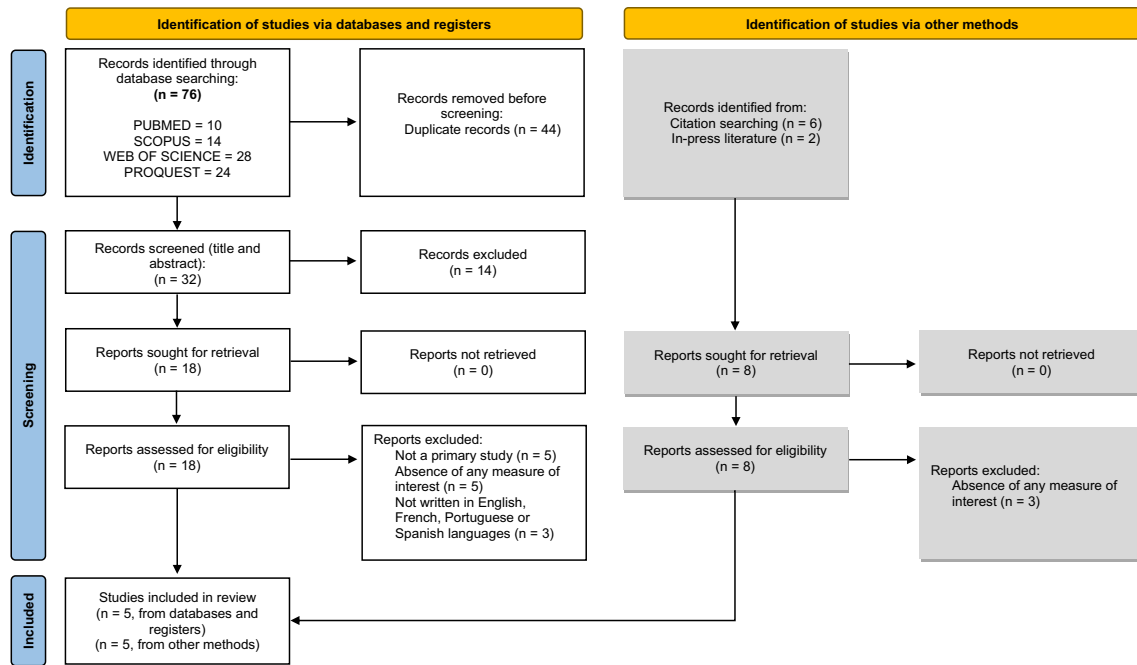


Fig. 1 PRISMA flowchart for article selection

phases. In addition, the entire workflow was pre-registered in Prospero on January 1st, 2023, and can be accessed through the following link: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=386907. The only substantial deviation from the protocol was the substitution of the Cochrane Collaboration risk-of-bias assessment tool (as this is aimed at clinical studies, and not really appropriate in our case).

Eligibility Criteria

To be included in the review, studies had to meet the following inclusion criteria: (IC1) to be a peer-reviewed primary study; (IC2) to explicitly measure urgency, behavioral addiction symptoms severity, and craving-related measures with validated instruments (i.e., self-reports instruments), or behavioral or neurophysiological measures of reactivity to realistic craving-triggering cues; and (IC3) to have been carried out with participants regularly engaged in gambling, video gaming, or other non-substance, potentially addictive activity, proposed as such in the literature, included or not in currently dominant psychiatric classifications.

Recovered items were excluded if they met the following exclusion criteria: (EC1) impossibility to retrieve the full-text manuscript; (EC2) not being a primary study (i.e., any kind of review or monograph), or not to be a peer-reviewed report (i.e., dissertations, posters, commentaries, books and book chapters, essays, and *corrigenda* or *errata*); and (EC3) not being written in English, Spanish, French or Portuguese.

Finally, we contacted the corresponding authors of those studies that met the inclusion criteria, but in which reported analyses could not provide information of interest for the

purpose of the systematic review. The inclusion or exclusion of these articles depended on whether or not the authors provided the requested information on analyses or data.

Search Strategy and Information Sources

Four electronic bibliographic databases (PubMed, ProQuest, Scopus and Web of Science) were examined for eligible studies. Search algorithms are disclosed in Sect. 1 of the Appendix.

The search was conducted on January 11th, 2023. Complementarily, a backward and forward citation analysis was conducted to uncover the most relevant previous and derivative works that were missed in the initial search and that could serve as eligible records for the goals of the study. The searches were rerun on March 3rd, 2023 to check if any new documents had surfaced since January 11th.

Selection Process

The first, fourth and last authors independently conducted the automatic term-based search. After removing duplicate records, the title and abstract of the remaining papers were screened in order to check for inclusion criteria. In case the title and abstract did not provide sufficient information to apply the inclusion criteria, the article was retrieved and assessed entirely. To ensure the three authors were totally independent carrying out their task of deciding whether or not to select an article, each of them made an independent

judgment for each retrieved record. Inter-rater disagreements regarding the inclusion of the studies were solved by discussion. In case a difference remained unresolved, the third author was brought into the discussion until consensus was reached. Subsequently, once a set of studies had been retained, a backward and forward citation analysis was conducted to uncover relevant studies that were missed in the initial search. Any study known by these means to be in early stages of the publication process (under review or in press) was considered and assessed using the same eligibility criteria.

Data Collection Process

Table 1 shows a summary of the main features and conclusions of the selected articles. As noted earlier, in case a selected paper recorded the variables of interest, but the authors had not provided the relationship between them in the original paper, corresponding authors were directly contacted by e-mail. In order to remain as undemanding as possible, we only asked for information on correlations between the variables of interest, or for access to the raw scores in these measures to perform the necessary analyses ourselves.

Statistical Analyses

Results directly reported in the original studies were complemented with regression and mediation analyses performed on complete datasets when these were openly accessible [37], when provided on demand by the original authors [41–43], or belonged to studies by our own team [33, 34•, 39]. For the sake of systematicity, we report comparable analyses across samples.

First, raw correlations between constructs of interest were collected and, when necessary, recalculated as r coefficients (i.e., when they were reported in the original articles using correlation indices other than r). Correlation coefficients as originally reported are however available in Sect. 2 in the Appendix. Secondly, we regressed craving upon positive and negative urgency (with age and gender as covariates when these were available). Third, we regressed behavioral addiction symptoms severity on craving, positive urgency and negative urgency, with the same potential confounders when available. Finally, we ran mediation analyses on the same datasets with positive and negative urgency as input variables, craving as mediator, and severity as output variables. Age and gender were included as background confounders when possible (as well as sample source in the analysis conducted on the video gamers dataset). In all cases, analyses were run with the default parameters in the JASP statistical analysis package 0.17.1 [44]. Unfortunately, these analyses cannot be publicly shared as we do not hold rights

over part of the data. Still, original databases are publicly accessible in the case of four studies [33, 34•, 37, 39].

Study Quality and Sensitivity

General quality of all studies, including risk of bias and internal validity, was independently assessed by two reviewers. The methodological details of the tool used, and the procedure followed are fully disclosed in Sect. 3 of the Appendix. The final quality categorization is shown in the rightmost column of Table 1. All studies present a fair or good level of quality. They were independently rated by the first and last authors, resulting in a good agreement between the two experts ($\kappa=0.730$) in the first round. Disagreement was resolved by discussion and consensus.

Additionally we assessed sensitivity for correlational and regression analyses. For correlation analyses we computed the minimum detectable correlation (calculated as r), so that, for the actual sample size in each study, it can be easily assessed whether the study was underpowered to declare as significant the observed correlation reported. For regression analyses, we report the minimum detectable non-corrected model R^2 , namely, the amount of variance explained by the whole set of predictors that was detectable with the current sample size for each regression analysis and dataset. The procedure followed, and the results of these sensitivity analyses are disclosed in Sect. 4 of the Appendix.

Results

Study Selection

The automatic term-based search conducted independently by the three authors resulted in the retrieval of 76 studies, 32 of which remained after removing duplicate records. 27 articles were excluded after applying eligibility criteria. Therefore, a final set of 5 studies were retained after the full-search procedure [36–40]. The backward and forward citation analysis added 3 items to the previous search [41–43]. Finally, as described in the "Selection Process" section, 2 records known to be in the process of publication, and meeting the inclusion criteria, were also included [33, 34•].¹ The authors of one of the selected papers did not respond to our request, so, in terms of evaluation and discussion, 9 records containing 10 samples were finally included in this systematic review.

¹ Although these studies were recovered from gray literature when the search was conducted, both of them are now published.

Table 1 Descriptive information of the selected articles

Study	N	Participants	Severity index	Urgency index	Craving index	Behavioral disorder	Type of study	Main findings	Quality assessment
Schulte et al. (2021) [36]	46	26 OO 20 FA	YFAS 2.0	UPPS-P	FCI	Food Addiction	Level 1	Higher emotional dysregulation, cravings and impulsivity are found in overweight individuals who are also affected by food addiction	Fair
Cornil et al. (2021) [37]	38 38	38 Gm 38 Gm	PGSI	S-UPPS-P	g-CEQ	Gambling	Level 1	Methods with and without mental imagery are successful in reducing craving induced in the laboratory	Good
Shirk et al. (2021) [38]	172	172 UPo	PPUS	UPPS-P	PCQ	Problematic Pornography Use	Level 2	Problematic pornography use is associated with psychiatric comorbidities, frequency of use and craving	Fair
Quintero et al. (2020) [39]	70	65 Ge 5 NG	SOGS	UPPS-P	GCS	Gambling	Level 2	Negative urgency is a complex construct. It was found to predict higher craving scores and craving, in turn, predicted more severity	Good
Albein-Urios et al. (2014) [40]	26	26 GD	SCID	UPPS-P	WCQ	Gambling	Level 1	The groups generated in a latent class analysis showed differences in impulsivity that did not appear in groups with conventional diagnoses	Fair
Cornil et al. (2019) [41]	274	274 Gf	PGSI	S-UPPS-P	g-CEQ	Gambling	Level 1	The new scale based on the Elaborated Intrusion Theory of desire (g-CEQ) can be used to measure gambling craving in clinical and research contexts	Fair
Kim et al. (2021) [42]	213	213 Gc	PGSI	S-UPPS-P	GACS	Gambling	Level 1	Offering tangible rewards in social casino games may increase participation in these games, but not necessarily the decision to gamble with real money	Fair
Canale et al. (2019) [43]	165 256	165 Gy 256 Gy	PGSI	S-UPPS-P	GACS	Gambling	Level 1	The French Gambling Craving Scale (GACS) has good psychometric properties, which justifies its use in research and clinical work	Fair

Table 1 (continued)

Study	N	Participants	Severity index	Urgency index	Craving index	Behavioral disorder	Type of study	Main findings	Quality assessment
Muela et al. (2023) [33]	81	81 Gm	SOGS PGSI	UPPS-P	GACS	Gambling	Level 3	Positive urgency, as a trait indicating emotional dysregulation, predicts craving and severity in a sample of problem gamblers	Good
Rivero et al. (2023) [34•]	232 222	232 SIVGp 222 EtVGp	IGD9	S-UPPS-P	CVG	Gaming	Level 3	Dysregulation of positive affect influences the onset and control of craving. Craving, in turn, emerges as a central feature in gaming severity	Fair

OO Overweight or Obesity; *FA* Food Addiction; *YFAS 2.0* Yale Food Addiction Scale 2.0; *UPPS-P* Impulsive Behavior Scale (59 items); *FCI* Food Craving Inventory; *Gm* Gamblers at least once a month; *PGSI* Problem Gambling Severity Index; *S-UPPS-P* Short UPPS-P Impulsive Behavior Scale (20 items); *g-CEQ* gambling Craving Experience Questionnaire; *UPo* Users of Pornography; *PPUS* Pornography Use Scale; *PCQ* Pornography Craving Questionnaire; *Ge* Gamblers who had ever gambled; *NG* Non-Gamblers; *SOGS* South Oaks Gambling Screen; *GCS* Gambling Craving Scale developed for the study; *GD* Gambling Disorders; *SCID* Structured Clinical Interview for DSM-IV Disorders-Clinician Version; *WCQ* Weiss Craving Questionnaire; *Gf* Gamblers at least a few times a year; *Gc* Gamblers who gambled and played social casino games; *GACS* Gambling Craving Scale; *Gy* Gamblers who had gambled at least once in the past year; *SIVGp* Spanish frequent Video Game players; *EtVGp* Ecuadorian frequent Video Game players; *IGD9* Internet Gaming Disorder Scale; *CVG* Craving for Video Games

Study Characteristics and Data Availability

Table 1 shows the characteristics of the 10 initial studies. Of these, 6 were initially classified into *Level 1* category [36, 37, 40–43], 2 as *Level 2* [38, 39], and 2 as *Level 3* [33, 34•, 37, 41, 42]; three others performed correlation analyses between the variables of interest for us and shared their results [36, 40, 43]; and the remaining 3 other studies belong to our own team [33, 34•, 39], so we had direct access to all data. As noted earlier, the necessary data or analyses never became available for one of the studies, so it is not included in further analyses.

We therefore ended up with 9 studies that fitted into the *Level 1* category, 2 into *Level 2*, and 2 into *Level 3*. After contacting the authors, we ended up with 6 studies for which we had the necessary information to conduct *Level 2* and *Level 3* analyses. Unfortunately, these studies were not representative of the diversity of potential behavioral addictions (1 study on food addiction; 1 study on video gaming; 7 studies on gambling).

Level 1 Analyses

Correlations between constructs of interest across studies are displayed in Table 2. Correlations that were not originally reported as *r* coefficients have been recalculated to allow comparability and pooling of effects across studies. Correlations as originally reported (specifying the correlation index used) are available in Sect. 2 the Appendix accompanying this manuscript.

To make interpretation easier, these correlations have been meta-analyzed across studies. Pooled effects and confidence intervals for all studies (9 datasets), as well as separately for gambling only (7 datasets) are reported in the two bottom lines of Table 2. The statistical features of these meta-analyses are detailed in Sect. 5 of the Appendix.

Findings from Correlation Analyses Between Urgency and Severity

The correlational analyses reported here correspond to 9 datasets from 8 studies (the authors of one of the studies were only able to share the results of the correlations between urgency and craving, as the gambling severity variable was categorical, and no quantitative severity measure was available). Symptoms severity and positive and negative urgency were positively correlated in almost all cases [33, 34•, 41–43]. The only exceptions were (a) Quintero et al.'s study [39], where gambling severity was not significantly correlated with negative urgency; (b) the two samples from [37], in which negative and positive urgency correlated positively with gambling severity, but without reaching significance; and (c) the study on food addiction [36], where a significant positive correlation was found between negative urgency and severity, but not between positive urgency and severity.

Table 2 Results of the correlations between the variables of interest and pooled effects (meta-analysis)

Study	Samples	Severity-NU	Severity-PU	Severity-Craving	NU-PU	Craving-NU	Craving-PU
Schulte et al. (2021) [36]	S1	.502***	0.165	.429*	.636***	.333*	.165
Cornil et al. (2021) [37]	S1 S2	.115 .178	.242 .266	.752*** .485**	.586*** .478**	.240 .269	.278 .186
Quintero et al. (2020) [39]	S1	.160	.269*	.609***	.425***	.254*	.448***
Albein-Urios et al. (2014) [40]	S1	-	-	-	.814***	.695**/.662**	.266/.286
Cornil et al. (2019) [41]	S1	.179**	.221***	.650***/.408***	.573***	.128*/.241***	.104/.136*
Kim et al. (2021) [42]	S1	.395***	.471***	.468***	.697***	.247***	.312***
Canale et al. (2019) [43]	S1	.259***	.228**	.556***	.595***	.307***	.270***
Muela et al. (2023) [33]	S1	.387***	.415***	.501***	.507***	.224*	.512***
Rivero et al. (2023) [34•]	S1	.198***	.265***	.579***	.543***	.111*	.252***
Pooled effects [CI] for all studies		.272 [.191, .352]	.297 [.219, .375]	.537 [.467, .608]	.580 [.525, .636]	.227 [.163, .291]	.289 [.204, .375]
Heterogeneity	<i>Q</i> statistic	17.501*	16.370*	21.163**	16.218*	8.240	18.483*
	<i>I</i> ²	54.47%	52.30%	64.85%	49.95%	27.39%	60.30%
	<i>Tau</i> ²	.0073 (.0072)	.0064 (.0067)	.0067 (.0056)	.0031 (.0033)	.0024 (.0043)	.0091 (.0082)
Publication bias	Egger's test	-.881	-.656	-.299	-1.246	1.248	-.051
Pooled effects [CI] for gambling studies		.264 [.175, .354]	.314 [.218, .409]	.538 [.449, .626]	.580 [.509, .651]	.256 [.194, .318]	.309 [.201, .417]
Heterogeneity	<i>Q</i> statistic	10.711	14.074*	18.349**	13.170*	.718	17.287**
	<i>I</i> ²	45.09%	54.61%	67.59%	54.55%	0%	64.70%
	<i>Tau</i> ²	.0060 (.0080)	.0083 (.0093)	.0091 (.0081)	.0044 (.0051)	0 (.0037)	.0127 (.0120)
Publication bias	Egger's test	-1.014	-.589	.372	-2.109*	-.047)	.032

For the fourth study [40], we provide information regarding craving as measured with the Weiss Craving Scale, and with a visual analogue scale (VAS), respectively. Similarly, for the fifth study [41], we provide information regarding craving as measured with the gambling Craving Experience Questionnaire for Frequency (g-CEQ-F), and with the Gambling Craving Scale (GACS), respectively. *NU* negative urgency; *PU* positive urgency. Results in bold indicate statistically significant results. * $p < .05$, ** $p < .01$, *** $p < .001$. Note: The original values reported in each of these studies (differing in the specific correlation index used) can be found in Sect. 2 of the Appendix

Pooled effects show a slightly stronger correlation between positive urgency and severity than between negative urgency and severity, a difference that seems slightly larger for gambling studies than for the whole set of studies. This discrepancy seems to be due to the fact that Schulte et al.'s food addiction study shows a difference in a direction opposite to the other studies, with negative urgency more strongly correlated with severity than positive urgency.

Findings from Correlation Analyses Between Urgency and Craving

The correlational analyses reported here correspond to 10 datasets from 9 studies. For the 7 gambling studies (8

datasets in total), results were not totally consistent. In 4 of the datasets, the relationship between positive urgency and craving was higher than the one between craving and negative urgency, with 3 of these relationships being statistically significant (this pattern of results was the same for the dataset of video gamers). In the remaining 4 datasets, we found 3 statistically significant relationships between negative urgency and craving. Finally, the study on food addiction showed a statistically significant and positive relationship for negative urgency and craving, but not for positive urgency.

As it happened with urgency-severity correlations, pooled effects show a slightly stronger correlation with craving for positive than for negative urgency. The magnitude of that difference was similar for gambling studies and the whole set of studies. However, Rivero et al.'s video gaming study

and Schulte et al.'s food addiction study showed differences in opposite directions, with the former showing a clearly stronger correlation for positive urgency and the latter showing a stronger correlation for negative urgency. Among gambling studies, results are mixed.

Findings from Correlation Analyses Between Craving and Severity, and Between Positive and Negative Urgency As expected, in all datasets where it was possible to assess the relationship between craving and severity (9 datasets from 8 studies), the results showed a strong positive relationship. The same can be said of the relationship between the two urgency facets (10 datasets from 9 studies). Pooled effects reflect this consistency, supporting the previously presented proposals that craving strongly contributes to severity of behavioral addictions, and that positive and negative urgency probably reflect different facets of a common construct.

Level 2 Analyses

In most cases, age and sex/gender were included in analyses as control covariates. This was not the case for the regression analyses conducted on two specific datasets. In one of them [34•], data source was also included as covariate, and in the other [42] these variables were not available. These regressions (as well as the mediation analyses shown later) were not meta-analyzed due to the small number of studies available, and to the heterogeneity arising from the added non-systematicity of covariate control and target behavioral domain, which would have probably rendered pooled effects misleading. In the following subsections we report the standardized regression coefficient (β), the t statistic, and the observed p value for each significant predictor. R^2 values correspond to each complete regression model such effects belong to, including the theoretically relevant predictors and the covariates (when included in the model). Detailed results from all regression models are disclosed in Sect. 6 of the Appendix.

Findings from Regression Analysis of Craving Over Positive and Negative Urgency

Regression results showed some degree of consistency between them and with the previously reported correlations. In 4 datasets [33, 34•, 39, 42], only positive urgency was positively and independently associated with craving ($\beta=0.530$, $t=4.626$, $p<0.001$, $R^2=0.275$; $\beta=0.145$, $t=2.993$, $p=0.003$, $R^2=0.297$; $\beta=0.379$, $t=3.214$, $p=0.002$, $R^2=0.282$; $\beta=0.271$, $t=3.250$, $p=0.001$, $R^2=0.099$). In 1 dataset [41] negative urgency was associated with craving, when measured by the Gambling Craving Scale (GACS, [45]; $\beta=0.236$, $t=3.228$, $p=0.001$, $R^2=0.060$), whereas positive urgency was

not. There were no significant associations between urgency and craving in the 2 datasets from [37], nor in the one [41] in which craving was measured by the frequency form of the gambling Craving Experience Questionnaire (g-CEQ-F). In other words, the previously shown privileged association between positive urgency and craving (over the one between negative urgency and craving) for the gambling and video gaming studies seems to emerge more clearly when positive and negative urgency are pitched against each other. The only dataset showing the opposite pattern [41] is the one for which the model had the smallest predictive power, as measured by R^2 .

Findings from Regression Analysis of Severity over Positive and Negative Urgency, and Craving

Here the results were mixed. In 2 datasets [41, 42], gambling severity was positively associated with positive urgency ($\beta=0.174$, $t=2.611$, $p=0.010$, $R^2=0.207$; $\beta=0.285$, $t=3.896$, $p<0.001$, $R^2=0.342$) and craving ($\beta=0.392$, $t=6.984$, $p<0.001$, $R^2=0.207$; $\beta=0.352$, $t=6.534$, $p<0.001$, $R^2=0.342$). This pattern of results was the same when craving was measured by the g-CEQ-F in the first [41] of these two datasets ($\beta=0.130$, $t=2.370$, $p=0.018$ for positive urgency; $\beta=0.652$, $t=14.127$, $p<0.001$ for craving; $R^2=0.463$). In 2 datasets [33, 34•] $\beta=0.252$, $t=2.377$, $p=0.020$, $R^2=0.381$; $\beta=0.109$, $t=2.409$, $p=0.016$, $R^2=0.365$) and craving ($\beta=0.435$, $t=4.074$, $p<0.001$, $R^2=0.381$; $\beta=0.499$, $t=11.093$, $p<0.001$, $R^2=0.365$). And, in the 3 remaining datasets [37, 39] only craving was positively associated with gambling severity ($\beta=0.712$, $t=5.708$, $p<0.001$, $R^2=0.592$; $\beta=0.455$, $t=2.925$, $p=0.006$, $R^2=0.285$; $\beta=0.637$, $t=5.465$, $p<0.001$, $R^2=0.376$) whereas urgency was not. In all cases, the strength of the association of gambling severity with craving was larger than with (positive or negative) urgency.

Level 3 Analyses

As noted earlier, in these analyses craving was modelled as a partial mediator of the effects of positive and negative urgency on symptoms severity, under the assumption that basic emotion regulation dysfunction (as measured by urgencies) makes vulnerable individuals experience stronger cravings and these translate into more severe behavioral problems. At this level, we did not consider the studies in which results showed no significant correlations between urgencies and severity to begin with (i.e., both datasets from [37]).

In one of the remaining datasets [41], there was a significant direct effect of positive urgency on the severity score ($\beta=0.081$, $z=2.640$, $p=0.008$). The direct effect of negative urgency on severity was not significant ($\beta=0.070$, $z=-0.123$, $p=0.902$), but its indirect effect via craving was

significant ($\beta=0.032$, $z=2.958$, $p=0.003$). The indirect effect of positive urgency was not significant ($\beta=0.034$, $z=-0.069$, $p=0.945$). The total effect was significant only for positive urgency ($\beta=0.088$, $z=2.401$, $p=0.016$), but not for negative urgency ($\beta=0.075$, $z=1.163$, $p=0.245$).

In a second dataset [42], a strong direct effect of positive urgency on severity ($\beta=0.464$, $z=3.927$, $p<0.001$) and an indirect effect of also positive urgency via craving ($\beta=0.209$, $z=2.928$, $p=0.003$) were found. The direct effect of negative urgency on severity ($\beta=0.448$, $z=1.531$, $p=0.126$) and the indirect effect via craving ($\beta=0.185$, $z=0.696$, $p=0.486$) were not significant. Again, total effects were only significant for positive urgency ($\beta=0.492$, $z=4.950$, $p<0.001$), but not for negative urgency ($\beta=0.484$, $z=1.683$, $p=0.092$).

In a third dataset [33], negative urgency ($\beta=0.434$, $z=2.470$, $p=0.014$) but not positive urgency ($\beta=0.626$, $z=0.660$, $p=0.509$) had a significant direct effect on severity. However, positive urgency had an indirect effect via craving ($\beta=0.392$, $z=3.168$, $p=0.002$) whereas negative urgency did not ($\beta=0.205$, $z=-0.393$, $p=0.694$). Both negative ($\beta=0.479$, $z=2.069$, $p=0.039$) and positive ($\beta=0.611$, $z=2.079$, $p=0.007$) urgency yielded significant total effects.

A fourth dataset [34•] yielded the same pattern of results. Negative urgency ($\beta=0.129$, $z=2.427$, $p=0.015$) but not positive urgency ($\beta=0.164$, $z=1.478$, $p=0.178$) showed a significant direct effect on video gaming severity. For indirect effects, it was positive urgency ($\beta=0.088$, $z=2.909$, $p=0.004$) but not negative urgency ($\beta=0.068$, $z=0.553$, $p=0.581$) the impulsivity dimension that had an effect on severity via craving. Total effects resulted statistically significant for both positive ($\beta=0.183$, $z=2.605$, $p=0.009$) and negative urgency ($\beta=0.146$, $z=2.407$, $p=0.016$).

In a fifth dataset [39], we only found an indirect effect of positive urgency on the severity score via craving ($\beta=0.390$, $z=2.880$, $p=0.004$), but not for negative urgency or the rest of effects.

Discussion

The aim of this review was to explore the available evidence on the triadic relationship between urgency, craving and severity of behavioral addiction symptoms, and to assess its compatibility with current theoretical approaches to the etiology of craving and its role in non-substance addictive processes.

Ten studies that met the inclusion criteria were identified through a systematic literature search. Relevant information was accessible for 9 of the studies, so these 9 considered for analysis and discussion. 7 of these studies were about disordered or problematic gambling, 1 about food addiction, and 1 about problematic use of video games. By itself, this

scarcity of studies reflects that the conjoint role of urgency and craving in non-substance problematic behaviors is an under-researched topic, especially in behavioral domains other than gambling.

The studies taken into consideration present a fair or good level of quality, so their general validity seems not to be compromised. All of them used self-report measures, and most of them did not perform power or sensitivity analyses to calculate the necessary sample size (see Sect. 3 of the Appendix for an item-by-item assessment of study quality). Our *a posteriori* quality and sensitivity analyses show, however, that limited power or differences in quality are probably not affecting the interpretability of results. In general, better powered, good quality studies did not yield results that look substantially different from those with smaller samples or a fair quality level (although the possibility to use these quality indices as moderators is precluded by the small number of studies available). This is probably due to the fact that the triadic urgency-craving-severity relationships were not the focus of these studies. That is, although these constructs were measured, their significance or relative strength were not central to test the focal hypothesis of most studies, so there was not a clear incentive to incur questionable research practices or publication bias.

Taken together, the correlational results show a clear three-way association between the constructs of interest. However, the association between craving and severity of symptoms stands out as the strongest and most systematically replicated one. This association was robust, positive, and significant in all analyses under scrutiny, and thus also after pooling, which reveals the crucial role of craving in the etiology of behavioral addictions. The central position of craving for the prediction of gambling-related symptoms and other patterns of problematic behavior suggests that craving should be considered a core symptom of behavioral addiction, and should be included in its diagnosis and definition, in line with recent theoretical proposals [3, 46, 47••].

Among the other correlations, the ones between severity and urgency dimensions were relatively consistent among them and with pooled correlations, with positive urgency correlating with severity more strongly than negative urgency in most cases. 4 of the 7 gambling datasets showed a significant positive correlation of both urgency dimensions with gambling severity, and the same result was found in video game players. In the 3 remaining gambling studies, 2 found no significant urgency-severity associations, and 1 found a positive relationship between positive urgency and severity. In contrast, in the food addiction sample, it was negative urgency (instead of positive urgency) the dimension significantly associated with severity. So, this study is the clearest exception to the general trend. Although this could be attributable to the different behavioral domain under scrutiny, it is soon

to derive any conclusions in this direction. Still, a promising line of future research would be to directly attempt a corroboration of this difference by directly comparing different domains of problematic behavior in a single study.

On the contrary, the correlations between craving and urgency dimensions were less consistent, making it difficult to draw strong conclusions from correlation analyses alone. Fortunately, regressions partly clarified the meaning of these correlations. The most salient result was that, once craving was controlled for, the associations between urgencies and severity were substantially attenuated. Seemingly, a substantial part of the effect of positive and negative urgency on severity is explained away by craving. This is compatible with the abovementioned idea that craving is a core component of behavioral addictions, but also with the one that the influence of urgency on severity is channeled by the emergence of craving states.

Whether positive or negative urgency plays a stronger role in craving emergence is, however, still uncertain, although evidence seems to be more consistent for positive than for negative urgency, which could indicate that regulation of positive affect is more relevant for craving control than regulation of negative affect. The origin of existing differences in regression results across studies remains, however, unclear. As noted earlier, these differences do not seem to be determined by sensitivity or study quality. Tentatively, it is possible that the relative role of positive and negative affect regulation in craving emergence depends on sample characteristics not taken into consideration in the present review, as gaming/gambling preferences or general sensitivity to reward and punishment.

Results from mediational analyses were mostly compatible with this view. 4 of the 5 datasets analyzed at this level yielded a significant indirect effect of positive urgency on symptoms severity, via craving. This indirect effect is congruent with the proposal that craving consists in part of appetitive or affectively positive components, and that positive urgency impacts on the emergence or regulation of such components. In other words, individuals with a tendency to lose control under positive affective states would experience more acute craving states in the presence of reward-related cues, which in turn, would interfere with attempts to control their potentially addictive behavior [15, 17, 20].

In two datasets negative urgency was a significant direct predictor of severity independently of craving. This finding supports the models proposing that negative urgency can be conceptualized as a common transdiagnostic factor in externalizing behavior problems characterized by emotional dysregulation [26, 27, 31]. High urgency in these individuals would manifest as a higher risk of comorbidities and behavioral complications beyond lack of control over the specific problematic activity. Importantly, however, the two

studies showing this effect are the one on video gaming [34], which also has the largest sample size in our review, and only one on gambling [33], which is among the few ones assessed as presenting the highest quality level. The latter is also atypical in the sense that its sample was relatively young, and consisted of mostly poker players and sport bettors, which makes it more similar to the characteristic video gamer sample. Although, again, it is soon to draw any conclusions, further research on the possibility that this pattern (with negative urgency having a direct effect on severity, and positive urgency having an indirect effect via craving) is more characteristic of populations with these features or playing preferences is warranted.

In summary, from the bulk of results it can be concluded that (a) craving is associated with all other constructs under assessment, which reinforces its centrality, and the idea that it is an affective state and, as such, is sensitive to malfunctioning of emotion regulation processes. (b) Positive and negative urgency tend to independently correlate with craving for the activity in question, with positive urgency generally showing a stronger and more consistent association with craving than negative urgency. This seems to imply that aversive and appetitive states can coexist in craving, but also that appetitive components probably play a more central role, at least in the populations and activities assessed in the present review. And finally, (c) the tight relations between positive urgency and craving, on the one hand, and craving and severity of symptoms, on the other, are combined in a positive urgency-craving-severity chain. In contrast, negative urgency does not participate in that link to the same degree, and frequently exerts a direct effect on severity that could reflect the kind of complications that contribute to the co-occurrence of some behavioral addictions (especially gambling disorder) with other mental health conditions and addictive behaviors (e.g., substance use disorders).

Limitations

These conclusions are however subject to a number of considerations. First, the samples in the present review are majoritarily convenience samples in which participants with clinically significant problems are underrepresented. That could account for the prevalence of positive over negative urgency in predicting craving, as it has been proposed that the relative weight of positively and negatively valenced components of craving could change as the addictive process progresses, and problems become more severe [48].

Second, apart from the severity range, there are other features that could also limit the generalizability of results. Most importantly, a number of studies have shown that gamblers preferring high arousal, skill-based games, such as sport betting or poker, are, on average, more

sensitive to reward than those preferring low arousal, pure chance games as slot machines or scratch cards [49]. Although, to the best of our knowledge, it has never been directly tested, the preponderance of positive motives in skill-based games could make dysregulation of positive affect more important for gamblers preferring these games, whereas dysregulation of negative affect would be more consequential for gamblers preferring pure chance games. Well-powered studies testing patterns of relations across samples differing in severity or game preferences, but using the same methods and measures, are long due.

Third, there are some exceptions to the general pattern of relations found. The most noteworthy of them was the finding of a direct effect of positive urgency on severity in one of the gambling datasets [42]. This finding converges with the pattern found in another gambling dataset, in which a direct effect of positive urgency on severity, and an indirect effect of negative urgency via craving were observed [41]. In other words, at least in some cases, positive urgency could also have an influence on the development of addictive behaviors independently of craving.

Fourth, and more generally, the scarcity of studies in domains other than gambling that have used the three measures of interest precludes drawing any conclusions about potential differences between behavioral addictions. The pattern of relations in the gaming study seems rather similar to the prevailing one in gambling studies, whereas the only study on food addiction diverges from that pattern. More research is needed to know whether these similarities and differences are more than mere coincidences.

Finally, it is important to note that different studies often use different severity and craving scales. Although severity scales are generally founded on a common diagnostic criteria approach, that is not the case for craving. Actually, the definition of craving and the underlying model can substantially differ across scales, with some scales attributing more importance to the feelings experienced during craving, and others to the cognitive elements of attentional capture and elaboration. Tentatively, that could explain why studies with the g-CEQ-F [41], developed from the EIT model, seem to yield results different from those using other scales.

Conclusion

This review is the first to globally assess the pattern of relationships between urgency, craving, and severity of symptoms in *bona fide* or putative behavioral addictions. The review has been successful in showing quite a congruent picture of the role of craving and emotional impulsivity in gambling addiction, in which craving emerges as a central construct, partially resulting from emotion dysregulation as

assessed by urgency. The preponderance of positive urgency shown by most gambling studies in this review also reinforces the view of positive emotions as a ‘trojan horse’ in addictive processes [15]. Negative urgency, in turn, seems to be a complication factor that could underlie gambling addiction and other related mental health conditions.

For other putative behavioral addictions (only problematic gaming and food addiction) the available evidence is clearly insufficient to draw firm conclusions, but this review shows that our logic can be extended beyond gambling. This review should inspire future attempts to establish the role of urgency and craving in these and other candidate addictions without repeating the same mistakes, making comparisons across samples and domains possible from the start, and prioritizing transparency and reproducibility of results.

APPENDIX

Section 1: Search Specifications per Database

All searches were conducted on January 11th and March 3th, 2023.

MEDLINE (via PUBMED: 1985-Present)

- Fields: Title + abstract
- Limits: none
- Algorithm as per data base: (*urgency*[Title/Abstract] OR *UPPS**[Title/Abstract]) AND (*craving*[Title/Abstract] OR *"attentional capture"*[Title/Abstract] OR *"cue reactivity"*[Title/Abstract] OR *urge*[Title/Abstract] OR *urges*[Title/Abstract]) AND (*"gambling problems"*[Title/Abstract] OR *"gambling disorder"*[Title/Abstract] OR *"pathological gambling"*[Title/Abstract] OR *"problematic gambling"*[Title/Abstract] OR *"disordered gambling"*[Title/Abstract] OR *"problem gambling"*[Title/Abstract] OR *"gambling addiction"*[Title/Abstract] OR *"gaming problems"*[Title/Abstract] OR *"gaming disorder"*[Title/Abstract] OR *"disordered gaming"*[Title/Abstract] OR *"disordered video gaming"*[Title/Abstract] OR *"IGD"*[Title/Abstract] OR *"gaming addiction"*[Title/Abstract] OR *"problematic gaming"*[Title/Abstract] OR *"problematic video gaming"*[Title/Abstract] OR *"compulsive overeating"*[Title/Abstract] OR *"compulsive eating"*[Title/Abstract] OR *"eating addiction"*[Title/Abstract] OR *hyperphagia*[Title/Abstract] OR *"binge eating"*[Title/Abstract] OR *"uncontrolled eating"*[Title/Abstract] OR *"food addiction"*[Title/Abstract] OR *"internet use disorder"*[Title/Abstract] OR *"IUD"*[Title/Abstract] OR *"internet addiction"*[Title/Abstract])

OR "love addiction"[Title/Abstract] OR "emotional dependence"[Title/Abstract] OR smartphone[Title/Abstract] OR "social media"[Title/Abstract] OR "problem spending"[Title/Abstract] OR "compulsive buying"[Title/Abstract] OR "compulsive shop*" [Title/Abstract] OR workahol* [Title/Abstract] OR "work addiction"[Title/Abstract] OR "compulsive sexual behavior*" [Title/Abstract] OR "compulsive sexual disorder"[Title/Abstract] OR "CSD"[Title/Abstract] OR "compulsive sexual behavio*" [Title/Abstract] OR "pornography use"[Title/Abstract] OR "exercise addiction"[Title/Abstract] OR "compulsive exercis*" [Title/Abstract]

- **N = 10**

Scopus (via Scopus; 1788-Present)

- Fields: Title + Abstract
- Limits: none
- Algorithm as per database nomenclature: ((TITLE ((urgency OR upps*) AND (craving OR "attentional capture" OR "cue reactivity" OR urge OR urges) AND ("gambling problems" OR "gambling disorder" OR "pathological gambling" OR "problematic gambling" OR "disordered gambling" OR "problem gambling" OR "gambling addiction" OR "gaming problems" OR "gaming disorder" OR "disordered gaming" OR "disordered video gaming" OR "IGD" OR "gaming addiction" OR "problematic gaming" OR "problematic video gaming" OR "compulsive overeating" OR "compulsive eating" OR "eating addiction" OR hyperphagia OR "binge eating" OR "uncontrolled eating" OR "food addiction" OR "internet use disorder" OR "IUD" OR "internet addiction" OR "love addiction" OR "emotional dependence" OR smartphone OR "social media" OR "problem spending" OR "compulsive buying" OR "compulsive shop*" OR workahol* OR "work addiction" OR "compulsive sexual behavior*" OR "compulsive sexual disorder" OR "CSD" OR "compulsive sexual behavio*" OR "pornography use" OR "exercise addiction" OR "compulsive exercis*"))) OR (ABS ((urgency OR upps*) AND (craving OR "attentional capture" OR "cue reactivity" OR urge OR urges) AND ("gambling problems" OR "gambling disorder" OR "pathological gambling" OR "problematic gambling" OR "disordered gambling" OR "problem gambling" OR "gambling addiction" OR "gaming problems" OR "gaming disorder" OR "disordered gaming" OR "disordered video gaming" OR "IGD" OR "gaming addiction" OR "problematic gaming" OR "problematic video gaming" OR "compulsive overeating" OR "compulsive eating" OR "eating addiction" OR hyperphagia OR "binge eating" OR "uncontrolled eating" OR "food addiction" OR "internet use disorder" OR "IUD" OR "internet addiction" OR "love addiction" OR "emotional

dependence" OR smartphone OR "social media" OR "problem spending" OR "compulsive buying" OR "compulsive shop*" OR workahol* OR "work addiction" OR "compulsive sexual behavior*" OR "compulsive sexual disorder" OR "CSD" OR "compulsive sexual behavio*" OR "pornography use" OR "exercise addiction" OR "compulsive exercis*"))

- **N = 14**

Web of Science Core Collection (via Web of Science; -Present)

- Fields: Title + Abstract
- Limits: Core Collection of Web of Science
- Algorithm per data base: (TI=((urgency OR UPPS*) AND (craving OR "attentional capture" OR "cue reactivity" OR urge OR urges) AND ("gambling problems" OR "gambling disorder" OR "pathological gambling" or "problematic gambling" OR "disordered gambling" or "problem gambling" OR "gambling addiction" OR "gaming problems" OR "gaming disorder" OR "disordered gaming" OR "disordered video gaming" OR "IGD" OR "gaming addiction" OR "problematic gaming" or "problematic video gaming" OR "compulsive overeating" OR "compulsive eating" OR "eating addiction" OR hyperphagia OR "binge eating" OR "uncontrolled eating" OR "food addiction" OR "internet use disorder" OR "IUD" OR "internet addiction" OR "love addiction" OR "emotional dependence" OR smartphone OR "social media" OR "problem spending" OR "compulsive buying" OR "compulsive shop*" OR workahol* OR "work addiction" OR "compulsive sexual behavior*" OR "compulsive sexual disorder" OR "CSD" OR "compulsive sexual behavio*" OR "pornography use" OR "exercise addiction" OR "compulsive exercis*")) OR AB=((urgency OR UPPS*) AND (craving OR "attentional capture" OR "cue reactivity" OR urge OR urges) AND ("gambling problems" OR "gambling disorder" OR "pathological gambling" or "problematic gambling" OR "disordered gambling" or "problem gambling" OR "gambling addiction" OR "gaming problems" OR "gaming disorder" OR "disordered gaming" OR "disordered video gaming" OR "IGD" OR "gaming addiction" OR "problematic gaming" or "problematic video gaming" OR "compulsive overeating" OR "compulsive eating" OR "eating addiction" OR hyperphagia OR "binge eating" OR "uncontrolled eating" OR "food addiction" OR "internet use disorder" OR "IUD" OR "internet addiction" OR "love addiction" OR "emotional dependence" OR smartphone OR "social media" OR "problem spending" OR "compulsive buying" OR "compulsive shop*" OR workahol* OR "work addiction" OR "compulsive sexual behavior*" OR "compulsive sexual disorder" OR "CSD" OR "compulsive sexual behavio*" OR "pornography use" OR "exercise addiction" OR "compulsive exercis*"))

- N = 28

ProQuest (via ProQuest; -Present)

- Fields: Title + Abstract
- Limits: none
- Algorithm as per data base: *title((urgency OR UPPS*) AND (craving OR "attentional capture" OR "cue reactivity" OR urge OR urges) AND ("gambling problems" OR "gambling disorder" OR "pathological gambling" OR "problematic gambling" OR "disordered gambling" OR "problem gambling" OR "gambling addiction" OR "gaming problems" OR "gaming disorder" OR "disordered gaming" OR "disordered video gaming" OR "IGD" OR "gaming addiction" OR "problematic gaming" OR "problematic video gaming" OR "compulsive overeating" OR "compulsive eating" OR hyperphagia OR "binge eating" OR "uncontrolled eating" OR "food addiction" OR "internet use disorder" OR "IUD" OR "internet addiction" OR "love addiction" OR "emotional dependence" OR smartphone OR "social media" OR "problem spending" OR "compulsive buying" OR "compulsive shop*" OR workahol* OR "work addiction" OR "compulsive sexual behavior*" OR "compulsive sexual disorder" OR "CSD" OR "compulsive sexual behavio*" OR "pornography use" OR "exercise addiction" OR "compulsive exercis*)) OR abstract((urgency OR UPPS*) AND (craving OR "attentional capture" OR "cue reactivity" OR urge OR urges) AND ("gambling problems" OR "gambling disorder" OR "pathological gambling" OR "problematic gambling" OR "disordered gambling" OR "problem gambling" OR "gambling addiction" OR "gaming problems" OR "gaming disorder" OR "disordered gaming" OR "disordered video gaming" OR "IGD" OR "gaming addiction" OR "problematic gaming" OR "problematic video gaming" OR "compulsive overeating" OR "compulsive eating" OR "eating addiction" OR hyperphagia OR "binge eating" OR "uncontrolled eating" OR "food addiction" OR "internet use disorder" OR "IUD" OR "internet addiction" OR "love addiction" OR "emotional dependence" OR smartphone OR "social media" OR "problem spending" OR "compulsive buying" OR "compulsive shop*" OR workahol* OR "work addiction" OR "compulsive sexual behavior*" OR "compulsive sexual disorder" OR "CSD" OR "compulsive sexual behavio*" OR "pornography use" OR "exercise addiction" OR "compulsive exercis*))*
- N = 24

Section 2: Correlation Coefficients as Reported in the Original Studies

In the main text, and in order to allow for comparability, all correlation coefficients between constructs of interest were

recalculated as Pearson's r . For the sake of transparency, the correlation coefficients reported in the original studies (i.e., before transforming them into Pearson's r coefficients) are reported in Table 3 of this Appendix.

Section 3: Quality Assessment

The *National Heart, Lung and Blood Institute (NHLBI)* study quality assessment tool [51] was used in order to assess the risk of bias and internal validity of the articles included in the systematic review. Taking into consideration the different nature of the selected studies, two different versions of this tool (i.e. two different templates) were used: (1) *Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies*, and (2) *Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control Group*. Each version of the NHLBI study quality assessment tool comprises between 12 and 14 questions, carefully crafted to aid reviewers in evaluating fundamental aspects of the studies and testing potential flaws concerning study methods and outcomes.

The authors in charge of reviewing the quality of the articles may select "yes," "no" or "other" (i.e. "cannot determine", "not applicable", "nor reported") options in response to each question of the corresponding template. Subsequently, the reviewers must assign a final rating of "good", "fair" or "poor" based on a critical overall assessment of the characteristics that they consider more relevant. The tool offers a guide to help in this process.

In this work, the first and last authors independently assessed the quality of each article included in the systematic review. Importantly, as none of the selected articles were cohort studies, some of the questions (Q9, Q11 and Q14) of the second template (*Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies*) were adapted to be used with cross-sectional studies. Following this, inter-judges agreement was calculated for each study separately (for responses across items), and for the final assessment (across studies) using Cohen's Kappa for categorical variables. Analyses were run using the rater agreement module provided by the JASP statistical analysis package 0.17.1 [44]. Total agreement was reached by discussion at the end of the process.

Table 4 in this Appendix shows the responses given by the reviewers across items and studies, *after* resolving disagreements by discussion and consensus. Kappa values in the rightmost column of the table refer to responses given by the two reviewers *before* discussion.

Of the ten studies, three were assessed as presenting good quality [33, 37, 39], and seven as presenting fair quality [34, 36, 38, 40–43]. For the cross-sectional studies [33, 34, 36, 38–40], the main weaknesses of those ranked as having fair quality were (a) not carrying out a priori sample size estimations or power analyses, and (b) the exclusive use of self-report input and output variables. For pre-post studies [37, 41, 43], in all the cases, the

two authors considered that the participants in the study were not representative of those who would be eligible for a possible intervention in the general or clinical population.

Section 4: Sensitivity/Power Analyses

These analyses were conducted using Gpower version 3.1.9.7 [52], and results are shown in Table 5 of this Appendix.

For correlations, we ran a two-tail sensitivity analysis with an 5% alpha level and 80% power, and the sample size of each study. This yielded the minimal detectable correlation coefficient for each study, which can be compared with observed correlations, as reported in Table 2 of the main manuscript.

Similarly, for regressions, we computed the minimal detectable model's R^2 . Apart from setting alpha and desired power levels at 5% and 80%, the number of predictors in each study (including control covariates) was also taken into consideration. These R^2 values can be compared with those reported in the Results section of the main manuscript and in Sect. 6 of this Appendix (Table 6).

Section 5: Meta-analyses

To provide an overview of the relative strengths of the associations between the variables of interest, we proceeded to run 6 meta-analyses with all datasets for which we had

correlational data (9 datasets), and other 6 restricted to gambling studies (7 datasets). First, the sample size and r correlation coefficients were extracted for each dataset and pair of variables, recomputing correlations that were originally reported as Spearman's Rho or Kendall's Tau (see Table 2 in the main manuscript and Table 3 in this Appendix).

For each meta-analysis, a random effects model was fitted to the data using the MAJOR statistical module for Jamovi (version 2.2.5; [53]). The following settings were used: raw correlation was selected as outcome measure; heterogeneity (Tau^2) was estimated using the restricted maximum likelihood estimator (RMLE); the Q statistic, which assesses the extent of variation caused by sampling error, and the I^2 test, which evaluates the proportion of observed variance reflecting an actual difference in effect sizes, were computed; and the potential publication bias was tested using the Egger's test. Pooled effects are reported in the bottom rows of Table 2 in the main manuscript.

Section 6: Full report of regression analyses

Finally, here we disclose the results of all regression analyses, regardless significance of the models or the individual predictors in such models. Results can be found in Table 6 and Table 7.

Table 3 Results of the correlations coefficients as originally reported between the variables of interest

Study	Samples	Correlation's coefficient used	Severity—NU	Severity—PU	Severity—Craving	NU-PU	Craving—NU	Craving—PU
Schulte et al. (2021) [36]	S1	Pearson's r	.502***	.165	.429*	.636***	.333*	.165
Cornil et al. (2021) [37]	S1	Kendall's τ	.051	.197	.561***	.514***	.104	.201
	S2	Kendall's τ	.103	.23	.288*	.344**	.151	.128
Quintero et al. (2020) [39]	S1	Spearman's ρ	.183	.244*	.640***	.387***	.280*	.420***
Albein-Urios et al. (2014) [40]	S1	Pearson's r / Spearman's ρ	-	-	-	.814***	.471/.534*	.278/.379
Cornil et al. (2019) [41]	S1	Spearman's ρ	.162**	.243***	.553***/.380***	.552***	.097/.288***	.051/.111
Kim et al. (2021) [42]	S1	Pearson's r	.395***	.471***	.468***	.697***	.247***	.312***
Canale et al. (2019) [43]	S1	Pearson's r	.259***	.228**	.556***	.595***	.307***	.270***
Muela et al. (2023) [33]	S1	Pearson's r	.387***	.415***	.501***	.507***	.224*	.512***
Rivero et al. (2023) [34•]	S1	Pearson's r	.198***	.265***	.579***	.543***	.111*	.252***

Note: For the fourth study [40], we provide information when craving was measured with the Weiss Craving Scale and with a visual analogue scale (VAS), respectively. Similarly, for the fifth study [41], we provide information when craving was measured with the gambling Craving Experience Questionnaire for Frequency (g-CEQ-F) and with the Gambling Craving Scale (GACS), again, respectively. NU: negative urgency; PU positive urgency. Results written in bold are statistically significant. * $p < .05$, ** $p < .01$, *** $p < .001$. Note: For one of the studies [40], the authors recommended the use of Pearson's correlation coefficient for the correlation between positive and negative urgency, and Spearman's correlation coefficient for the correlation with craving (since the latter was not normally distributed)

Table 4 Results of the study quality assessment through the NHLBI tool after full agreement

Studies	Type of design	NHLBI assessment questions														Total yes	Total no	Other	Rate	Cohen's Kappa
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14					
Schulte et al. (2021) [36]	Cross-sectional	Yes	Yes	NA	Yes	No	NA	NA	NA	Yes	NA	Yes	NA	NA	No	5	2	NA	Fair	0.960
Cornil et al. (2021) [37]	Pre-post	Yes	Yes	No	Yes	Yes	Yes	NR	NA	Yes	NA	Yes	NA	-	-	8	1	NA, NR	Good	1.000
Shirk et al. (2021) [38]	Cross-sectional	Yes	Yes	NA	No	NA	NA	NA	NA	Yes	NA	Yes	NA	NA	No	4	3	NA	Fair	1.000
Quintero et al. (2020) [39]	Cross-sectional	Yes	Yes	NA	No	Yes	NA	NA	NA	Yes	NA	Yes	NA	NA	Yes	6	1	NA	Good	0.963
Albein-Urios et al. (2014) [40]	Cross-sectional	Yes	No	NA	Yes	Yes	NA	NA	NA	Yes	NA	Yes	NA	NA	Yes	6	1	NA	Fair	0.960
Cornil et al. (2019) [41]	Pre-post	Yes	No	No	Yes	No	Yes	Yes	NR	NA	Yes	No	NA	-	-	5	4	NA, NR	Fair	0.813
Kim et al. (2021) [42]	Experimental	Yes	No	NA	No	Yes	NA	NA	NA	Yes	No	Yes	NR	Yes	Yes	6	3	NA, NR	Fair	1.000
Canale et al. (2019) [43]	Pre-post	Yes	No	No	Yes	No	Yes	NR	NA	Yes	Yes	No	NA	-	-	5	4	NA, NR	Fair	0.714
Muela et al. (2023) [33]	Cross-sectional	Yes	Yes	NA	Yes	Yes	NA	NA	NA	Yes	NA	Yes	NA	NA	Yes	7	0	NA	Good	1.000
Rivero et al. (2023) [34•]	Cross-sectional	Yes	Yes	NA	Yes	Yes	NA	NA	NA	No	NA	Yes	NA	NA	Yes	6	1	NA	Fair	1.000

NA: not applicable; NR: not reported. Note: The complete questions can be found on the NHLBI website via this link: <https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>. Boxes Q1 through Q14 show the item ratings after full agreement between the two authors rating each study. The last column on the right shows the Cohen's Weighted Kappa value resulting from the inter-judges agreement after two of the authors independently rated the items in each of the studies (this is, before full agreement). This table was adapted from Westlake et al. [50]

Table 5 Minimum detectable effect sizes for correlation and regression analyses

Study	<i>N</i>	Minimum detectable effect size for correlations (ρ)	Minimum detectable effect size for linear regressions (model's R^2)
Schulte et al. (2021) [36]	46	0.389	-
Cornil et al. (2021) [37]	38	0.423	0.18
Shirk et al. (2021) [38]	172	0.21	-
Quintero et al. (2020) [39]	70	0.322	0.104
Albein-Urios et al. (2014) [40]	26	0.497	-
Cornil et al. (2019) [41]	274	0.167	0.028
Kim et al. (2021) [42]	213	0.189	0.036
Canale et al. (2019) [43]	165	0.214	-
Muela et al. (2023) [33]	81	0.301	0.09
Rivero et al. (2023) [34•]	454	0.116	0.017

Table 6 Results of regression analyses of craving over positive and negative urgency

Studies	Cornil et al. 2021 (1)			Cornil et al. 2021 (2)			Quintero et al. 2020			Cornil et al. 2019			Kim et al. 2021			Muela et al. 2023			Rivero et al. 2023			
	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	
NU	0.172	0.841	0.406	0.221	1.097	0.281	0.106	0.906	0.368	0.143	1.956	0.052	0.058	0.696	0.487	0.026	-0.043	-0.382	0.703	0.026	0.55	0.583
PU	0.228	1.158	0.255	0.071	0.37	0.714	0.379	3.214	0.002	0.064	0.886	0.376	0.271	3.250	0.001	0.145	4.626	<.001	<.001	0.145	2.993	0.003
Age	-0.19	1.177	0.248	0.013	0.076	0.94	-0.191	-1.728	0.089	0.134	2.198	0.029	-	-	-	-0.058	-0.102	0.919	-0.058	-1.440	0.151	
Sex	-	1.475	0.15	-	-0.163	0.871	-	-2.350	0.022	-	-2.799	0.005	-	-	-	-	1.091	0.279	-	-6.365	<.001	
Source	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.354	<.001
Full model	$R^2=0.181$			$R^2=0.078$			$R^2=0.282^{***}$			$R^2=0.058^{***}$			$R^2=0.099^{***}$			$R^2=0.275^{***}$			$R^2=0.297^{***}$			

NU Negative Urgency; PU Positive Urgency; β standardized beta coefficient. Results in bold are statistically significant. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 7 Results of regression analysis of severity over positive and negative urgency, and craving

Studies	Cornil et al. 2021 (1)			Cornil et al. 2021 (2)			Quintero et al. 2020			Cornil et al. 2019			Kim et al. 2021			Muela et al. 2023			Rivero et al. 2023			
	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	
UN	-0.095	-0.643	0.525	-0.070	-0.385	0.703	-0.001	-0.013	0.99	-0.009	-0.164	0.87	0.109	1.519	0.13	0.252	2.377	0.02	0.109	2.409	0.016	
UP	0.127	0.885	0.383	0.195	1.136	0.264	-0.009	-0.075	0.94	0.13	2.370	0.018	0.285	3.896	<.001	0.077	0.635	0.527	0.062	1.338	0.182	
Craving	0.712	5.708	<.001	0.455	2.925	0.006	0.637	5.465	<.001	0.652	14.127	<.001	0.352	6.534	<.001	0.435	4074	<.001	0.499	11.093	<.001	
Age	0.06	-0.509	0.614	0.127	0.825	0.415	0.052	0.495	0.622	-0.133	-2.853	0.005	-	-	-	0.003	0.032	0.974	0.003	0.081	0.936	
Sex	-	0.908	0.371	-	-0.120	0.905	-	0.684	0.496	-	0.581	0.562	-	-	-	-	-2.365	0.021	-	-1.536	0.125	
Source	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.030	0.304
Full model	$R^2=0.592^{***}$			$R^2=0.285^*$			$R^2=0.376^{***}$			$R^2=0.463^{***}$			$R^2=0.342^{***}$			$R^2=0.381^{***}$			$R^2=0.365^{***}$			

NU Negative Urgency; PU Positive Urgency; β standardized beta coefficient. Results in bold are statistically significant. * $p < .05$, ** $p < .01$, *** $p < .001$

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Declarations

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects. Therefore, there was no informed consent.

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