A cognitive approach to Gambling Craving: Conceptualization, Assessment, and Intervention

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To Chloé and Timothée, my beloved children

"A man who gives way to pleasure will be swept away by craving
and his thoughts will make him suffer, like waves."

The Buddha, Dhammapada v. 339

"The imaginary relish is so sweet
That it enchants my sense."

Shakespeare, *Troilus & Cressida*, Act 3, Scene 2, 1609

"The only way to get rid of a temptation is to yield to it.
Resist it, and your soul grows sick with longing for the things it has forbidden to itself,
with desire for what its monstrous laws have made monstrous and unlawful.

Oscar Wilde, *The Picture of Dorian Gray*, 1890

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Abstract

Research has highlighted the pivotal role of craving in the onset and perpetuation of gambling disorder. This has led to a growing interest about craving in research and in clinical practice, even though it is not included as a diagnostic criterion in international nosography manuals. Craving was systematically studied by reusing existing models and assessment instruments related to substance-use disorders and by applying a confirmatory approach, which might have resulted in neglecting the unique features of gambling craving. In this PhD thesis, we instead adopted an exploratory approach to improve the conceptualization, assessment, and treatment of gambling craving. In a first study, a mixed-method approach was used to explore the phenomenology of gambling craving. The results were put into perspective with the elaborated intrusion theory (EIT) of desire, an increasingly popular cognitive theory of desire and craving that has been applied to substance and food craving in the recent years. This first study supports the relevance of the EIT to account for gambling craving. The next two studies investigated the properties of two instruments that aim to assess gambling craving. On the one hand, the gambling craving scale is a widely used tool that is used to evaluate gambling craving in research. Yet, we found that this scale rather measures urge, a motivational component of craving that corresponds to positive and negative expectations. On the other hand, and by capitalizing on the results from our first study, we adapted and validated in the context of gambling the Craving Experience Questionnaire, which is theorized in the EIT. Our gambling version of the questionnaire presented the same factorial structure as the original one. In a fourth study composed of two experiments, we tested the effect of interference-based methods, also grounded in the EIT, on laboratory induced gambling craving. We found that these interventions successfully diminished laboratory-induced gambling. These encouraging results should be reproduced in clinical samples. The final chapter consists in a study protocol presenting a multiple single-case design that aims to test the interference-based methods among clinical gamblers and in a real clinical setting. Overall, this PhD thesis offers perspectives of tailored assessment and psychological intervention among individuals presenting problematic gambling patterns, and it supports the relevance for further clinical investigation.

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Chapter 1

General introduction

General introduction

Gambling activities have a history whose first traces date back to 4000 BC. Gambling-related items, such as bones or rods, were found in the pyramids and are mentioned in the Bible (Reith, 1999). The gambling landscape has obviously dramatically changed since then, and nowadays the gambling industry provides a wide variety of gambling activities in order to attract all types of public: poker, casino games, lottery, slot-machine, bets, etc. Access has further expanded thanks to the internet and smartphones, which make these activities available seven days a week, 24 hours a day, anonymously, just as gaming. Structural characteristics of gambling (e.g., design, light, background) and games features (e.g., pay-to-win, eSport betting and gambling simulators) further contribute to the overlap between gambling activities and video games and to the expansion of the gambling industry (Fiedler et al., 2018; Hilbrecht et al., 2020). Advertising and sponsorship contribute to normalize gambling in our society. In the perception of the general population, while gambling is occasionally considered a weakness, it is also often associated with an opportunity to dream, to feel excitement or to share a fun moment with friends. Sometimes, however, the gambler loses control and this may lead to different types of harm: financial struggle, relationships and familial conflicts or breakdowns, emotional and psychological distress (e.g., guilt, depression), health deterioration, cultural isolation, damage to work or study performance, and criminal activity (Langham et al., 2015). This relevant public health issue is now recognized and gambling disorder is included in main nosography manuals (diagnostic and statistical manual of mental disorders [DSM], international classification of diseases [ICD]), but it was suggested that health practitioners, government agencies and researchers need to pay more attention to gambling disorder in order to better understand, prevent, regulate, and treat it (Romanczuk-Seiferth et al., 2019).

The purpose of the present PhD thesis is to contribute to addressing this need by investigating a specific process involved in the development, persistence and relapse of gambling disorder: craving (e.g., Ashrafioun, Kostek, et al., 2013; Blaszczynski & Nower, 2002; Young & Wohl, 2009).

Our introduction first aims to provide an up-to-date synthesis of the available evidence regarding gambling disorder and then, on how influential models account for craving (not specifically in relation to gambling disorder). After that, we present gambling craving research conducted before this doctoral thesis to clearly emphasize the gap in the literature that our work tried to address. Although neurobiological aspects take up an important part of the literature on craving, they are only briefly presented in order to focus on the cognitive approach that we embraced in the current thesis. Our approach is anchored in a cognitive and empirical psychopathology perspective that aims to translate experimental data into concrete practical applications and implementable interventions in everyday life (Andrade & May, 2003; Goldstein, 2019; Philippot & Hermans, 2006).

In the gambling context, we cruelly lack models explaining the mechanisms underlying craving, and the related experimental and laboratory work is scarce. Indeed, most of the theories used to explain gambling craving draw from the literature on substance-related craving, with a priori postulated validity. The research conducted in the frame of this PhD thesis distinguishes itself from previous work, which used a confirmatory approach. Our *first study* aims at investigating the relevance of the elaborated intrusion theory of desire (EIT; Kavanagh et al., 2005; May et al., 2004), a model that has received a growing interest in the literature and which posits that craving requires cognitive resources (attention and working memory). A mixed-methods approach was preferred to investigate gambling craving. Indeed, the qualitative methodology enabled an in-depth investigation of the phenomenon through subjective representation of the experience, whereas the quantitative part allowed us to identify its most significant aspects. The results were put into perspective with the elaborated intrusion theory of desire in order to verify its relevance in the context of gambling craving.

The *next two studies* focused on the assessment and evaluation of gambling craving, through the psychometric investigation of two specific gambling craving-related measures. The first one, the gambling craving scale (GACS; Young & Wohl, 2009), is a widely used multidimensional tool adapted from the Questionnaire of Smoking Urges (QSU; Tiffany & Drobes, 1991). Its psychometrical properties and factorial structure were investigated, and its scope was questioned. Our study conducted on the GACS also aimed to clarify how the terms "craving" and "urge" have been erroneously used interchangeably in the literature. The second assessment instrument is an adaptation of the craving experience questionnaire (CEQ; May et al., 2014) for gambling (g-CEQ). The CEQ is based on the EIT and has been designed for and tested across food and substance-related desire. According to data from the initial qualitative study for this thesis, several items were modified to fit the specificities of gambling craving. In order to evaluate the validity of the g-CEQ to measure gambling craving, its psychometric properties were also investigated.

The *fourth study* of this thesis tested the effect of interference-based methods on induced gambling craving in a laboratory setting among gamblers from the community. Interference is a type of intervention based on the EIT. It aims at monopolizing attentional resources and working memory to prevent the occurrence of other complex cognitive processes, such as craving. Given that previous research tended to show a preponderant role for the visuospatial sketchpad (e.g., Andrade, Pears, et al., 2012; Knäuper et al., 2011; May, Andrade, Panabokke, et al., 2010), two experiments were conducted to compare methods involving this type of resource with techniques requiring other components of working memory. We finally present the design of a *last study* that will test the usefulness of interference in a clinical population of treatment-seeking gamblers. This study will allow to verify whether this type of method can help people in need and who experience real difficulties in relation to gambling craving.

The general discussion offers some perspective on the topics of this thesis. A new conceptualisation of gambling craving is proposed, based on relevant elements from the literature and the outcomes of the first study. Suggestions are then provided to improve the assessment of gambling craving in the clinical context. We also put forward some

recommendations for the use of interference-based methods. Finally, in a broader perspective, we offer insights for a holistic approach (i.e., from the triggers to behaviours) of craving considered across substances and behaviours.

1. Gambling disorder

Gambling is generally defined as an activity which consists of putting at stake a valuable object or, more often, money, without possibility to withdraw, in order to win a prize, and whose outcome is determined by chance (Ferentzy & Turner, 2013; Robert Ladouceur, 2004a). According to this definition, the following activities can be categorized as gambling: casino games (e.g., poker, blackjack, roulette), slot-machines, lotteries, bets, scratch cards and stock exchange. Although these activities are grouped under the same heading, each type of gambling has its own characteristics. For instance, some require skill, training or experience, such as poker, blackjack or betting, while others rely purely on luck and chance, such as scratch cards, lotteries or slot machines. Skill-based gambling may induce a sense of control, an overestimation of the gambler's influence on the outcomes, thus leading to the continuation of the activity. Meyer and colleagues (2011) examined the characteristics of several types of gambling in Germany to rate their addictive power. They sorted the activities from the lowest to the highest risk based on an empirical validation: lotteries, scratch cards, live sport betting, online poker, gaming machines, and slot machines. Even if electronic gaming machines are associated with the highest degrees of gambling problems (Dowling et al., 2005), a recent study (Booth et al., 2020) highlights the potential harmfulness of all types of gambling activities: this research showed that one third of their participants, who gambled exclusively on lotteries and/or scratch cards, present with risky gambling behaviours.

The convergence of gambling and gaming, and recent technical development have further increased the attractiveness, the availability and the accessibility of gambling activities through the internet. No need to leave the house: everything is within the reach of a mouse or a smartphone. Internet gambling also offers a large range of online products: casino games, poker, sports or eSports betting, betting exchanges, bingo, lotteries, skill games (e.g., puzzles, chess, racing), and practice games (sites to learn how to gamble without real money; Gainsbury, 2012). Papineau and colleagues (2018) have found that online gamblers reported more negative consequences than offline gamblers on seven dimensions of their life (e.g., sleep, mental health, gambling problems) and mixed (online and offline) gamblers declared issues in fifteen spheres of life (e.g., excessive drinking, work disruptions, upheaval of significant relationships).

Gambling can thus have a deleterious impact on one's life, to the point of becoming functionally impairing. Many stories testify to the damage caused by gambling through the ages and today (e.g., Cuneo, 2016; Dostoyevsky, 1887; France, 1902), leading to bankruptcy, divorce, criminal activity and suicide. When the gambler has lost control and persists in their behaviour despite those heavy consequences, they can be diagnosed with gambling disorder.

1.1 Gambling as a mental condition: diagnostic evolution

According to Hunt and Blaszczynski (2019), gambling was for the first time considered as a clinically relevant issue when von Hattingberg (1914) reported his psychodynamic presentation of gambling. This approach continued to focus on "compulsive gambling", seeing it as the result of underlying psychoneurosis, oedipal disorders, masturbatory complexes and masochistic tendencies (Bergler, 1957). The operant and classical conditioning theories provided a framework for behavioural and learning-based theories that presented problematic gambling as a result of psychophysiological arousal, inter-individual differences, personality traits (such as sensation seeking), and reinforcement and punishment sensitivity (e.g., Anderson & Brown, 1984; Jacobs, 1986). The cognitive theories completed behavioural ones by adding explanatory psychological factors: motivations (search for pleasure or relief from negative affect; e.g., Blaszczynski & Nower, 2002), cognitive distortions (i.e., cognitions that prevent the random and uncontrollable character of chance from being taken into account; M. Grall-Bronnec et al., 2012; Toneatto et al., 1997) and the chasing phenomenon (Lesieur, 1977).

The recognition of what was then coined up as "pathological gambling" took a further step by being incorporated into the two major classifications of mental illnesses: the ninth version of the ICD (ICD-9; World Health Organization, 1975) and the third edition of the DSM (DSM-III; American Psychiatric Association, 1980). In the ICD-9, pathological gambling was integrated in the section of disturbance of conduct – considered compulsive – not elsewhere classified, while in the DSM-III, it was categorized as a disorder of impulse control not elsewhere classified. No classification change was implemented in the following edition of the two nosologies: both the ICD-10 (World Health Organization, 1990) and the DSM-IV (American Psychiatric Association, 1994) still consider pathological gambling as an impulse (-control) disorder, an inability to resist a desire to engage in deleterious behaviour, often preceded by significant arousal, providing pleasure or relief, and potentially followed by guilt. This category also includes intermittent explosive disorder, kleptomania, pyromania, and trichotillomania.

In the most recent versions of both nosographic manuals (i.e., DSM-5; American Psychiatric Association, 2013; ICD-11; World Health Organization, 2018), "pathological gambling", considered pejorative and obsolete, was renamed "gambling disorder", which was supported by the public and preferred to "problem gambling" (often used to designate a sub-threshold diagnostic) and to "compulsive gambling" (potentially confusing in relation to anxiety disorders; Petry et al., 2014). Moreover, recent research highlighting important similarities between substance use and gambling disorders has led to the grouping of substance use and gambling disorders under a single category called "disorders due to substance use or addictive behaviours" in ICD-11 and "substance-related and addictive disorders" in DSM-5. Indeed, there is a strong relationship between addictive behaviours, such as gambling, and substance use disorders (Fauth-Bühler et al., 2017; J. E. Grant et al., 2010; Petry et al., 2014; Reed et al., 2019):

- similar symptoms (e.g., craving), cognitive deficits (impaired decision-making abilities) and personality traits (e.g., impulsivity),
- high rates of comorbidity,
- initial pleasure that gradually diminishes over time, demanding an increase in use (i.e., tolerance),
- same genetic vulnerabilities and family background,
- comparable natural development and history (early onset, relapse),
- common neurobiology, more specifically regarding the reward and motivation circuits,
- similar effective treatments.

The ICD-11 characterized gambling disorder as "a pattern of persistent or recurrent gambling behaviour, which may be online (i.e., over the internet) or offline". The symptoms, presented in Table 1, must be present for at least 12 months. However, the time required may be reduced depending on the severity of the symptoms. The symptoms are not better explained by a bipolar disorder, or hazardous gambling, which is the sub-threshold diagnosis of gambling disorder.

Table 1. Comparison of gambling disorder diagnostic in ICD-11 and DSM-5

ICD-11	DSM-5
Impaired control (1)	Irritability when prevented from gambling (withdrawal; 2) Failure to quit or regulate (3) Preoccupation (4) Chasing (6)
Prioritization of gambling compared to other interests and activities (2)	
Continuation or escalation of gambling despite severe personal, family, educational, occupational or other significant life consequences (3)	Endangerment or loss of relationship, employment or studies (8)
	Tolerance (1) Use for mood regulation (5) Lies (7) Borrow (9)

Note. Criteria shortened for clarity.
The criteria are arranged to highlight the overlaps and differences between the 2 classification systems.
The numbers in brackets indicate the order of presentation in the original classification.

According to DSM-5, individuals can be diagnosed with gambling disorder, defined as "persistent and recurrent problematic gambling behaviour leading to clinically significant impairment of distress" (American Psychiatric Association, 2013; p. 585). The criteria (see Table 1) allow for a diagnosis when present for one year or more. The gambling behaviour cannot be better explained by a manic episode. Compared to DSM-IV, the number of symptoms required for a diagnosis to be established has been lowered, from five criteria out of ten to four out of nine. Indeed, the "illegal acts" criterion was removed due to its modest impact on prevalence rates (Petry et al., 2014).

The new classifications brought about another change to diagnosis, introducing the idea of a continuum. As mentioned above, the ICD-11 has created the category “hazardous gambling or betting”. The DSM-5 differentiates between episodic and persistent gambling disorder. This distinction is in line with the general philosophy of DSM-5 that integrates a dimensional perspective and with the 5-year longitudinal study by Reith and Dobbie (2013), who found that variation in gambling behaviour was rather the norm than the exception. The DSM-5 also offers three levels of severity based on the number of criteria covered (i.e., 4 to 5 = mild; 6 to 7 = moderate; 8 to 9 = severe).

Despite this research-based progress, the diagnostic approach has global limitations across disorders (Dudley et al., 2011; Randall-James & Coles, 2018; Sleczka et al., 2015). It has negative impact on service-users and emphasizes the biology. It does not consider frequent comorbidities, context and ethnical background, intra-diagnosis differences (e.g., different types of gambling activities), nor explanatory mechanisms. Moreover, it relies on expert judgment and attributes equivalent weighting to all criteria. Finally, it fails to categorize all clinical situations. The subsequent diagnosis-based treatments may lead to neglecting underlying psychological processes such as motivations, affect, cognitions, and relationships (Billieux et al., 2015). Indeed, a person that gambles for financial motives must not be treated in the same way as someone who gambles to have social contacts. The transdiagnostic approach proposes an alternative to the structural diagnostics, with holistic theories, case conceptualizations and functional analyses. These conceptual frameworks enable the identification of underlying processes (e.g., experiential avoidance, cognitive biases, self-confidence, inhibition, etc.) that will be the targets of a tailor-made intervention (Kinderman, 2019; Kinderman & Tai, 2007; Nef et al., 2012).

More specifically, Sleczka et al. (2015) found that the importance of certain criteria fluctuates as a function of the severity of the gambling disorder and depends on gambling preferences. Moreover, Temcheff and colleagues (2016) showed that “illegal acts”, a criteria no more included in DSM-5, was the second most discriminant criterion, after lies, to differentiate between social and problem gamblers, thus arguing against its exclusion. Several articles (e.g., Parhami et al., 2014; Petry et al., 2005) have also confirmed the high comorbidity frequency for gambling disorder: substance (alcohol, nicotine, drug) use, mood, anxiety and personality disorders. Finally, the use of the number of criteria to evaluate gambling disorder severity appears to have low clinical and research relevance: often, the differences observed between the levels across evaluations of psychopathology, and between the consequences of the symptoms (J. E. Grant et al., 2017), were found to be non-significant.

However, even if diagnosis-based treatments are questioned in clinical practice (Randall-James & Coles, 2018), the inclusion of gambling (and other addictive behaviours) in nosographical systems is fundamental as it raises awareness on potential impairment related to subclinical gambling activities and contributes to improving public health systems, by enabling policies to prevent and reduce harm (Stein et al., 2018).

1.2 Prevalence and epidemiology

Gambling is generally considered a recreational and harmless activity (Calado & Griffiths, 2016); about 90% of the general population has already experienced some gambling activity (Black & Shaw, 2019), and 65.3% gambled in the past year (Gowing et al., 2015). Although unproblematic gambling is by far the most common form of gambling, some individuals may develop problem (or risky) gambling, or even, in its pathological form, gambling disorder. Calado and Griffiths (2016) have reviewed 69 studies about gambling prevalence among adults worldwide. They found that the lifetime prevalence of problem gambling and gambling disorder ranges between 0.7% and 6.5% in the general population. The prevalence of problem gambling in the previous year ranges from 0.12% to 5.8% worldwide. The variability across studies might be related to the different instruments used to screen gambling problem, time frames, threshold, survey description to participants, populations and survey methods (Black & Shaw, 2019; Volberg & Williams, 2014).

Men are more susceptible to develop a gambling disorder than women (Black & Shaw, 2019). The literature reports a ratio of slightly more than two men to one woman (Blanco et al., 2006; Zimmerman et al., 2006). However, women and men differ in their favoured activities, which might partially explain this difference (Holtgraves, 2009). According to Black and colleagues (2015), the age of onset also varies across genders, being earlier among men (M = 28.6 years) than among women (M = 41.8 years). On average, the age of onset of the gambling disorder ranges from 34.2 to 36.9 years (Black et al., 2015; J. E. Grant et al., 2006). In the DSM-5 (American Psychiatric Association, 2013), gambling disorder can be regular or episodic, with oscillations between periods of abstinence, recreational gambling and heavy gambling. In their review of longitudinal studies, LaPlante and colleagues (2008) have found that individuals can recover from gambling disorder, even if the condition is severe. Their results suggest that gambling problem is not systematically progressive and persistent. In their longitudinal study, Reith and Dobbies (2013) followed 50 gamblers with different profiles during 5 years. They describe four different trajectories for gambling behaviours between problematic, recreational and abstinent categories: (a) consistent (34.1%; remain in the same initial category), (b) reduction (6.8%; move from the problematic category or gamble less), (c) progression (18.2%; increased level of gambling activity), and (d) non-linear (40.9%; alternating between periods of problematic and reduced use). These results further support the statement that variation is more frequent than stability.

1.3 Assessment

One of the main issues highlighted by epidemiological reviews of gambling disorder is the variety of self-reported questionnaires used (Black & Shaw, 2019; Volberg & Williams, 2014). Indeed, in their review of worldwide gambling prevalence among adults, Calado and Griffiths (2016) included studies that used eight different questionnaires, and Volberg and Williams (2014) mention three others. A recent review of assessments of gambling disorder (Otto et al., 2020) listed 31 different screening instruments. A substantial part of these questionnaires consists in the operationalization of the ICD and DSM taxonomies. Here are some examples: the Diagnostic Interview Schedule for pathological gambling (Robins et al.,

1996), the Composite International Diagnostic Instrument (Robins et al., 1988), the National Opinion Research Centre DSM-IV Screen for Gambling Problems (Gerstein et al., 1999), the Diagnostic Interview for Gambling Severity (Winters et al., 1997), and the Massachusetts Gambling Screen (MAGS; Shaffer et al., 1994). Other questionnaires have been developed to measure gambling severity. The main ones are: the Gamblers Anonymous Twenty Questions (Gamblers Anonymous, 1984), the Lie/Bet scale (Johnson et al., 1998) the Problem and Pathological Gambling Measure (Williams & Volberg, 2010), the Victorian Gambling Screen (Ben-Tovim et al., 2001) the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987) and the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001).

Table 2. Comparison of the DSM-5 diagnostic of gambling disorder, the SOGS and the PGSI on criteria or items, range and cut-offs

		DSM-5	**SOGS**	**PGSI**
Tolerance		✓		✓
Withdrawal		✓		
Loss of Control		✓	✓[a]	✓
Preoccupation		✓		
Use for mood regulation		✓		
Chasing		✓	✓	✓
Lies		✓	✓[b]	
Personal consequences		✓	✓	✓
Borrow		✓	✓[c]	✓
Problem recognition			✓	✓
Criticism			✓	✓
Guilt			✓	✓
Financial problems				✓
Range		0-9	0-20	0-27
Cut-offs	Non-problematic	0-3	0	0
	Mild or low	4-5		1-2[d]
	Moderate	6-7	1-4	3-7[d]
	Severe or problematic	8-9	5 or more	8 or more

[a] Also includes a *helplessness* item
[b] *Bad faith* item assimilated to *lies*
[c] Includes 11 items about *borrow* of which 9 are accounted for the total score
[d] Currie et al. (2010) proposed new cut-offs for moderate (1-4) and problematic (5-7) levels of gambling.

Even if the range of gambling screening tools is large, many questionnaires have been created for clinical purposes and few have had their psychometric properties thoroughly tested. Moreover, criteria from ICD and DSM, even if used for clinical, scientific and public health decision-making, are based on clinical practice and a consensus between experts. The lack of empirical evidence makes scales based on these classifications less reliable and valid. Otto and colleagues (2020) reviewed instruments evaluating gambling disorder and found that only three tools were compared to semi-structured interviews, which is considered a reference for psychiatric diagnostic (Brugha et al., 1999). They reported validity of the

MAGS (based on the DSM), the SOGS and the PGSI. Barbaranelli and colleagues (2013) also considered the SOGS and the PGSI valid and reliable, but they found the psychometric properties of the first questionnaire not sound enough. Table 2 compares the two scales and the DSM-5 criteria of gambling disorder.

1.3.1 South Oaks Gambling Screen (SOGS)

The SOGS (Lesieur & Blume, 1987) was developed to assess gambling behaviour with lifetime as the timeframe; however, the authors suggest that it can be adapted to cover other periods (Lesieur & Blume, 1993), such as a 12-month timeframe (Stinchfield, 2002). Although designed for clinical settings, it has widely been used for research purposes (Calado & Griffiths, 2016; Stinchfield, 2014). It is composed of 20 items (see Table 2) that are summed up for scoring (more items are provided to assess types of game, amount spent, heredity and credit). The questions are mainly dichotomous (yes or no, respectively scored 1 and 0) and the final score allows to distinguish between 3 categories of gamblers (for range and cut-offs, see Table 2). A 5-items version was also developed for a survey in the general population (Room et al., 1999).

This scale, despite its brevity and wide use in the literature, has some limitations. For instance, borrowing has a heavy weight (9 items) in the total score (Stinchfield, 2014). A study conducted by Ladouceur and colleagues (Robert Ladouceur et al., 2000) also showed that items could be misunderstood, leading to an overestimation of the gambling severity. Finally, because of the binary nature of most items, this scale fails to provide a continuum approach to the disorder.

1.3.2 Problem Gambling Severity Index (PGSI)

Ferris and Wynne (2001) have developed the Canadian Problem Gambling Index (CPGI) to answer a need for a meaningful assessment of problem gambling in the general population, including social and environmental indicators (Stinchfield, 2014). The CPGI includes 31 items, nine of which are considered in the calculation of the Problem Gambling Severity Index (PGSI). The items are rated on a 4-point Likert scale (0 = Never; 1 = Sometimes; 2 = Most of the time; 3 = Almost always) and relate to the past 12 months. Range and cut-offs are described in Table 2. The other items of the CPGI are used to create more complete respondents profiles (e.g., gambling practices, comorbidities, cognitions). There are similarities between PGSI, SOGS and DSM-IV items and criteria, which may explain the correlations among the three types of measure (Svetieva & Walker, 2008). The PGSI is therefore not really considered as a new scale, but rather as an alternative selection from a pool of pre-existing items (Stinchfield, 2014). Still, it is considered to have superior construct and classification validity than the SOGS (McMillen & Wenzel, 2006) and also a higher internal validity (Currie et al., 2010).

1.4 Risk Factors

The Conceptual Framework of Harmful Gambling (see Figure 1; Abbott et al., 2018; Gambling Research Exchange Ontario, 2019; Hilbrecht et al., 2020) offers a comprehensive

modelling of the environmental and individual risk factors which play a role in the prognosis of gambling disorder. Multidisciplinary experts from different countries contributed to its elaboration and updates. The following sections introduce the eight major factors from the framework and the related literature. The first part briefly presents the gambling-specific factors that can be considered as external, while the second one focuses on internal general factors.

Figure 1. The conceptual framework

Note. From "The Conceptual Framework of Harmful Gambling: A revised framework for understanding gambling harm", by Hilbrecht et al., 2020, *Journal of Behavioral Addictions, 9*(2), p. 192 (https://doi.org/10.1556/2006.2020.00024). Copyright 2020 by the authors.

1.4.1 Gambling specific factors

Four factors bring together the main themes and groups considered relevant for categorizing gambling risk factors: gambling environment, gambling exposure, gambling types and gambling resources.

Gambling environment

The economic, social and political environment can influence the harmfulness of gambling through several mechanisms.

The gambling industry affects *economics* in different ways. At a macro level, it is a source of employment and wages (Humphreys & Marchand, 2013), and income for the state through taxes (Walker & Jackson, 2011), while at a micro level it creates social costs (Walker & Barnett, 1999) such as crime, debt and bankruptcy.

The *socio-political environment*, also influenced by cultural and economic motives, determines the adoption of gambling in a jurisdiction.

Promoting health and well-being through *public policy*, and the *culture of social responsibility* (i.e., the moral balance between revenue generation and responsible practices for governments and the gambling industry) also contributes to the perception of gambling activities.

In the third edition, *responsible gambling* was added to gambling environment factors as it refers to harm-reduction practices that can be promoted by the different stakeholders. The Reno Model (Blaszczynski et al., 2004) explains those practices by highlighting the need for adequate information so that the gambler is able to knowingly choose if and how to gamble. Following some criticism, the model was modified by Nower and Caler (2018), who placed it in a broader context to encourage consideration of the factors influencing the gambler's individual responsibility.

The *social and economic impact* is also considered in its positive (e.g., government revenue, entertainment availability) and negative (e.g., gambling problems and harms such as loss of relationship or job) aspects.

In the same vein as responsible gambling, *low-risk limits* have been defined as guidelines on gambling frequency, expenditure and percentage of income spent on gambling (Currie et al., 2017). Below the prescribed thresholds, the gambling activity is considered "safe". This approach is controversial as there is no standard unit of consumption, as for alcohol, and the limits can vary across population or game type (Abbott, 2017). However, this idea should be further explored, taking these considerations into account.

Gambling exposure

Gambling exposure refers to the possibility for one person to be confronted to gambling related content and to be influenced towards gambling activities.

The *gambling setting* includes elements that are likely to favour harmful gambling in land-based or online venues, such as the availability of cash machines or alcohol, perceived safety of the venue, or the possibility to gamble on different sites and games.

The *accessibility* of gambling venues or the permanent possibility to gamble online are also considered a risk factor. With the internet, there is no need to leave the house: everything is within the reach of a mouse or smartphone. Internet gambling also offers a large range of products online: casino games, poker, sports betting, betting exchanges, bingo, lotteries, skill games (e.g., puzzles, chess, racing), and practice games (sites to learn how to gamble without real money; Gainsbury, 2012). According to Papineau et al. (2018), online gambling involves harmful consequences in more spheres of life than offline gambling.

If the accessibility of gambling increases harm when initially available, it may reach a plateau and then decrease after some time due, for instance, to normalization and protection policies. This *adaptation* to gambling exposure (Abbott et al., 2001; Shaffer et al., 1999) still needs more research, but it offers lines of thought for prevention and harm reduction.

The *marketing and messaging* category targets the influence of advertising and media representation of gambling behaviour and of the income of the gambling industry.

Finally, the *convergence of gaming and gambling* was added to the gambling exposure factor as it represents a risk, especially for younger people (Gainsbury et al., 2015). This confusion is fostered in several areas. For instance, it is possible to bet on specific video games known as eSports; moreover, the same media used to play games, such as computers or smartphones, also allow gambling. Several types of gambling are designed to look like games, using themes or characters from video games, and presenting skills as an asset to win. Moreover, it is sometimes possible to gamble in video games through casino mini-games, potentially creating a feeling of confidence in gambling without the consequences (Gainsbury et al., 2015), or through "in-game purchasing" (i.e., micro-transactions) such as loot-boxes or skins (King & Delfabbro, 2020). Evidence on the harm caused by this convergence is expanding but it will need more research, as it is constantly and rapidly evolving.

Gambling types

There are many types of gambling activities which can be played offline, in specialized locations, or online and 24/7, through the internet. They are usually classified on a continuum between games relying on chance, such as lotteries, scratch cards, number games (e.g., bingo or Keno), casino games (e.g., roulette or craps) and electronic gaming or slot machines, and games where skills and strategy can have an impact, such as betting (sports and esports) or card games (e.g., poker or blackjack). Several studies have shown the harmfulness of games where skill and knowledge may apply (e.g., sports betting; Cantinotti et al., 2004) or when control can be perceived (e.g., slot-machines; Parke & Griffiths, 2006; Pickering et al., 2020), and more specifically among younger gamblers (Bonnaire et al., 2017).

The *structural characteristics* describe the features (technology and configuration) specific to each type of game, such as jackpot size or latency before the result. Indeed, games with more frequent opportunities to bet and larger prizes are considered more exciting and are associated with greater harm or problematic gambling (Browne et al., 2015; Harris & Griffiths, 2018). The "bonus" offers (free spins or money to spend) also constitute an appealing component of many online games and slot machines. There are also games that allow losses disguised as wins (win is less than the stake) and "near-misses", which consist in an outcome very close to a win. Examples of near-misses are getting two sevens in the first rows and a cherry in the last row at a slot machine, with a seven just below, or betting on the zero at roulette and seeing that the ball falls on 32, which is right next to it. Those two characteristics increase a sense of improving one's own skills to actually win, thus reinforcing the illusion of control (Barton et al., 2017; Murch & Clark, 2016). The visual (e.g., light) and auditory (e.g., bell) stimuli contribute to the addictive power of gambling (Dixon et al., 2010; Meyer et al., 2011) and can reinforce the illusion of control as the same signals are emitted in case of a win or a loss disguised as win (Barton et al., 2017). Based on the ten structural characteristics of games that they found most relevant, Meyer and colleagues (2011) classified several types of gambling in Germany, from the lowest to the highest risk: lotteries, scratch cards, live sport betting, online poker, gaming machines, and slot machines.

Nevertheless, a recent study (Booth et al., 2020) showed that one third of their participants, who gambled exclusively on lotteries and/or scratch cards, were at some level of gambling risk.

People have different reasons to gamble and might find specific games more appealing than others, as they bear different *motivational characteristics*. The most obvious motive to gamble is the possibility to win money (McGrath et al., 2010), either to compensate the losses, to improve the standard of living, or because winning is associated to a successful and happy life. Problem gamblers tend to consider this reason more important than recreational gamblers who prioritize outing and socialization (Back et al., 2011). Even if the social context can be important, its involvement in promoting or protecting from harmful gambling patterns remains unclear (Quinlan et al., 2014). People may want to spend more time with others and, consequently, spend more time and money in gambling. However, gambling with others may require maintaining control in order to avoid criticisms. Gambling might also be motivated by the thrill that it can provide, or by the need to escape from one's problems. The enhancement and the coping motives have been relied to positive and negative reinforcements processes and systematically linked to problematic gambling in the literature (e.g., Blaszczynski & Nower, 2002; Bonnaire et al., 2006; Lambe et al., 2015; S. H. Stewart & Zack, 2008). Those four factors (financial, social, enhancement and coping) are assessed by the Gambling Motives Questionnaire financial (GMQ-f; Devos et al., 2017; Schellenberg et al., 2016), a widely used tool to measure reasons to gamble. Abbott et al. (2018) have included competition and demonstration of skill against others as another motivation to gamble. This motive might be related to the achievement motivation in video games, as it relates to competition and it requires knowledge of the game (Zanetta Dauriat et al., 2011). The emergence of new gambling offers and the convergence with gaming is also susceptible to give rise to new types of motivation.

Gambling resources

The gambling resources are means to prevent and reduce gambling harms.

The *service access and use* describe the influence of the social and cultural context which can influence the seek for help. The environment can indeed favour self-care and the search for help, if the adequate structure is available, but it can also do the opposite if it induces a sense of trivialization, denial, or shame.

There are also policies and programs (e.g., self-exclusion or pop-up messages during the game) for *harm reduction, prevention, and protection* that help to limit gambling exposure. The literature highlights a need to better study their impact (Tanner et al., 2017). These measures are in tension with marketing and advertisement (e.g., commercials during sport events or sponsorship) from the gambling industry.

Several tools have been created to carry out a *risk assessment* of the different gambling types, by measuring their harmfulness (e.g., M. D. Griffiths et al., 2008; Meyer et al., 2011). They allow to identify gambling with unacceptable risk and to modify factors in order to decrease the hazard.

Some of the gamblers who encounter problems with gambling could benefit from treatment. There are different evidence-based *interventions* to treat gambling disorder. The availability and cost of services have an impact on access and the level of severity required to use them, especially given that only a small proportion of problem gamblers (from 7 to 12%) seek treatment (Abbott et al., 2018). A large body of research supports the usefulness of psychotherapy in the treatment of gambling disorder (Pallesen et al., 2005), showing in particular the benefits of cognitive behavioural therapy and motivational interviewing (e.g., Cowlishaw et al., 2012; Gooding & Tarrier, 2009; Petry et al., 2017). Mindfulness-based treatments were also found to be effective to decrease gambling disorder symptomatology (Maynard et al., 2018). Shorter interventions have also shown their value (Quilty et al., 2019; Toneatto, 2016) and, although face-to-face treatment is more effective (Pallesen et al., 2005), phone consultations are also beneficial (Tse et al., 2013). Despite the evidence that supports interventions, more studies with sound methodology are needed to validate them (Smith, Dunn, et al., 2013). Pharmacotherapy may also benefit from more research, as the evidence that medications are relevant for gambling disorder is quite limited (Bartley & Bloch, 2013). In a more recent meta-analysis (Mouaffak et al., 2017), the opioid antagonists (e.g., naltrexone) were found to be beneficial for pathological gambling and other disorders assimilated to behavioural addictions according to the authors (i.e., kleptomania, trichotillomania, and impulsive compulsive disorders). Moreover, several medications addressing comorbidities (substance use disorder, bipolar spectrum disorder or Parkinson's disease) can also influence vulnerability to gambling disorder (Yip & Potenza, 2014). Mutual support groups, such as Gamblers Anonymous, offer a place to share with people that have been through similar experiences, providing advice, support, motivation and information (Binde, 2012). Oei and Gordon (2008) found that members of groups with a greater attendance, participation and social support were less susceptible to relapse. Moreover, combining Gamblers Anonymous with therapy may improve the involvement in treatment and decrease the risk of relapse (Petry et al., 2017). The last kind of intervention is self-help, which has expanded beyond manuals and workbooks to online venues and smartphones. Even if considered less efficient than in-person intervention, this type of intervention presents some advantages: easy access, anonymity, and being free or inexpensive. Moreover, its effectiveness is supported by the literature, although it requires further research on constantly evolving possibilities (Chebli et al., 2016; van der Maas et al., 2019).

1.4.2 General factors

The four general factors cover the main areas of scientific study of gambling harm: cultural factors, social factors, biological factors, and psychological factors. They are susceptible to interact with other factors and to be related to life events.

Cultural factors

The culture helps to determine values, preferences, and beliefs. This factor includes the aspects that vary across the globe and that influence the attitude towards gambling, also addressing the treatment aspects as well as the consequences of gambling problems.

The *ethnicity and traditions* explain the impact of foreign cultures (e.g., ethnic minorities, migrants, or refugees) on gambling harm. For instance, gambling can be considered shameful, preventing the seek for help (Abbott et al., 2018); but gambling-permissive culture, such as that of Asians (mainly Chinese), can similarly generate more gambling problems when exposed to the larger opportunities to gamble in Western countries such as the United States (W. Kim, 2012).

For *indigenous peoples*, the first occupants of a land or territory, gambling can be considered as a ritual, spiritual, social, and/or recreative activity (Williams et al., 2011) and studies found that they are more prone to develop gambling problems (Breen & Gainsbury, 2013).

The *socio-cultural attitudes* refer to the view of a given socioeconomic system towards gambling, and its variations between permissive and disapproving in function of political context, socio-economical class and demographics (Binde, 2009).

The consideration of gambling also fluctuates across *religions and other belief systems*, with polytheistic religions (e.g., Buddhism, Hinduism) being positive, and a large part of monotheistic religion (e.g., Islam, Mormons) disapproving gambling and dissuading its adherents from gambling (Abbott et al., 2018; Eitle, 2011). Faith can allow people to overcome their gambling issue through community support and rituals such as the Serenity Prayer that is used in Gamblers Anonymous program (Ferentzy et al., 2010). However, magical thinking, which may be included in beliefs, are susceptible to contribute to hazardous gambling (Passanisi et al., 2017).

When repeatedly frequenting the same gambling venues, getting to know other gamblers and staff, some *gambling cultures* may emerge in casinos or betting facilities (Hayano, 1982; Krauss, 2010; Rosecrance, 1986). It might be very appealing for people with frustrating social life in the outside world (Ocean & Smith, 1993). For such gamblers, abstinence is often associated with a loss of an important social network (Abbott, Volberg, & Rönnberg, 2004).

Gender was previously included in the biological factors but its cultural repercussions on gambling harm are considered more relevant. Being male is a well-established risk factor for gambling (Dowling et al., 2017) as it is generally perceived as a more adequate or respectable activity for men. They tend to gamble more frequently and larger amounts of money. They prefer strategic or skilled games and are motivated by enhancing their social image (skill and intelligence) but also by the conformity to masculinity (Hunt & Gonsalkorale, 2018). Women are more prone to gamble to reduce stress and for escapism motivations (Schull, 2002). They usually start gambling at an older age than men and seek treatment faster (Nelson et al., 2006). Despite the different gambling patterns across men and women, the gender might be a mediator for different risk factors such as risk-taking and social anxiety (Wong et al., 2013).

Social factors

The social aspect of life and interactions with family, friends, colleagues and neighbours affect the attitudes, behaviours and beliefs related to gambling, either by favouring or by preventing them. It also influences the implementation of gambling venues.

The following *social demographics* are related to more harmful gambling: younger (under 30 years old), male, single or divorced, with a lower socioeconomic status, and with lower levels of education (Abbott, Volberg, Bellringer, et al., 2004; Black & Shaw, 2019; Volberg & Williams, 2014). The effect of homelessness and house insecurity were also documented in the last edition of the current section (Sharman et al., 2016). Even if related to other risk factors, the effect of employment and wealth on gambling behaviour remains unclear (Abbott et al., 2018).

The *family and peer involvement* explains how gambling opinions and habits of relatives can favour or prevent gambling harms. The family dysfunction and detrimental experiences in childhood are linked to posterior gambling issues (Dowling et al., 2017; Poole et al., 2017) and an authoritative or monitoring parenting style may help prevent gambling problems (Dane et al., 2008). If gambling alone is considered a risk factor and is associated with high stakes, gambling with others can also promote risky behaviours (H. M. Park & Manchanda, 2015) and, if "gambling friends" are considered as support system due to shared difficult experiences, they can facilitate gambling (Rosecrance, 1986).

In order to build pertinent knowledge and idea of gambling and to raise awareness, the *education system* may play a role by informing young people (Dickson et al., 2004). Even if teachers and institutions do not always consider it as a priority (Derevensky et al., 2014), there is evidence that intervention have an impact and that the benefit is generally maintained (Lupu & Lupu, 2013).

Gambling opportunities are distributed differently in function of the *neighbourhood*, with more gamblers and problem gamblers in areas closer to venues (Pearce et al., 2008). Those neighbourhoods are characterized by low social capital (distrust among residents and low civic participation) and social disadvantages (Griswold & Nichols, 2006; Lussier et al., 2007).

Stigmatization of gamblers is a source of shame and embarrassment which may hinder any search for help (Gainsbury et al., 2014; Suurvali et al., 2009). Gamblers can be stereotypically seen as greedy, irrational, desperate, antisocial, selfish, irresponsible, violent, etc. (Brown & Russell, 2020; Horch & Hodgins, 2013). Even if there is a lack of research about what can be done to reduce the impact of stigma on gamblers (Hing et al., 2014), some leads from other stigmatized conditions may be considered: interventions based on contact, education, and advocacy/protest styles (Brown & Russell, 2020).

Gambling can sometimes be considered as a *deviance*, a behaviour against prescribed norms and social rules (Castellani, 2000). This had led research to investigate problem gambling in incarcerated population, showing high rates of gambling problems in prison (Williams et al., 2005) which might be explained by a relation between criminal lifestyle and gambling, with common underlying factors (e.g., impulsivity; Mestre-Bach et al., 2018), or by criminogenic problem gambling, the fact that gambling may induce criminal activities such as, robbery, theft, forgery, fraud, (Abbott et al., 2018) "borrowing" money at workplace (Binde, 2016), violence at home (Dowling et al., 2016) or in gambling venues (M. D. Griffiths et al., 2005).

Biological factors

The biology, and more specifically the functioning of the brain, is related to gambling vulnerabilities. However, it is unclear if the altered neurobiology is a cause, or a consequence of gambling problems.

Studies on families and twins have allowed exploring the interactions between *genetic inheritance* and the environment in order to clarify their respective contributions. However, the rates of genetic impact vary from 8% to 50% across studies (Black et al., 2006; Slutske et al., 2010; Walters, 2001) which might be explained by different definitions and measurement of problem gambling and the proximity of relatives taken into account. Specific studies on twins tend to indicate that the genetics account for about 50% of the development of a gambling issue (Lobo, 2016). Although these rates are in line with estimates for other dependencies (Agrawal & Lynskey, 2008), they must be taken with caution as heritability is also affected by non-shared environmental factors (Slutske et al., 2010). The influence of genes related to dopamine transmission has also been considered, but more research is still needed (Abbott et al., 2018).

Neurobiology has investigated the differences of brain functioning between problem gamblers and healthy controls, revealing differences of activities in areas related to reward processing, impulsivity and decision making (Goudriaan et al., 2008; Kovács et al., 2017; Limbrick-Oldfield et al., 2013). Reinforcement schedules in gambling (e.g., random ratio and frequency) are prone to elicit a dopamine (neurotransmitter involved in the reward circuit) release, keeping the reward circuit active similarly to what is observed in substance use disorders (Anselme et al., 2013; Zack et al., 2014). Besides pharmacotherapy, new types of interventions have emerged from these studies such as transcranial magnetic stimulation and transcranial direct current stimulation (Dickler et al., 2018; Goudriaan & Schluter, 2019; Soyata et al., 2019).

Psychological factors

The psychological characteristics result from the interaction of a person's biology and context. They influence the propensity to develop harmful gambling. The literature has investigated those factors mostly through cross-sectional studies and, even if some longitudinal studies exist, further research is required to understand them better.

Personality and temperament explain the differences in thoughts, behaviours, and emotions between individuals. Impulsivity is an umbrella construct which englobes four components according to recent literature (Cyders & Smith, 2007; Whiteside et al., 2005): positive and negative urgency (the propensity to act rashly under the effect of a positive or negative emotion), lack of perseverance (inability to continue and complete an unpleasant task), lack of premeditation (tendency to act without thinking about the consequences) and sensation seeking (preference for new and exciting activities). Urgency is related to gambling disorder diagnosis and heavier consequences of gambling on life, while sensation seeking seems to be linked only to gambling type and frequency. Associations with the other facets are less clear and not systematic (Billieux et al., 2014; Blain et al., 2015; Canale et al., 2015;

Cyders & Smith, 2008; Grubbs & Chapman, 2019; MacLaren et al., 2011; Yan et al., 2016). Impulsivity has also impacts on treatments, with more dropouts (Leblond et al., 2003) and less involvement (Maccallum et al., 2007). The link between personality and gambling has also been investigated through higher order traits from the "Big Five" model (Costa & McCrae, 1992). Higher neuroticism, lower conscientiousness and lower agreeableness are reported among problem or at-risk gamblers (MacLaren et al., 2011; Nikolas & Hopwood, 2014). However, Canale and colleagues (2017) argue that the UPPS model of impulsivity is more relevant to investigate personality with regard to gambling as it implies narrower and more precise constructs. Besides normal personality traits, several disordered traits have been found to be present among almost 50% of treatment-seeking problem gamblers. Here are the most prevalent co-occurring personality disorders ranked by frequency: narcissistic, antisocial, avoidant, obsessive-compulsive and borderline personality disorders (Dowling et al., 2015a).

Research show that avoidance (i.e., the tendency to escape from situations that may cause distress) is more used that other *coping styles* (e.g., problem-solving or emotional expression) by problem gamblers and that using avoidance is related to higher level of hazardous gambling (Borsoi & Toneatto, 2003; Calado et al., 2017; Jauregui et al., 2017). This is in line with research showing that escapism is a strong predictor of problem gambling symptoms (Lambe et al., 2015; S. H. Stewart & Zack, 2008; Wood & Griffiths, 2007).

Self-perceptions are also linked to gambling with studies showing that gamblers have low self-esteem (Delfabbro et al., 2006; Kaare et al., 2009). However, overconfidence is also positively associated with gambling disorder (Goodie, 2005). This striking difference may be due to the type of game, where those involving skills and played with others can be used to raise self-esteem and demonstrate superiority (Abbott et al., 2018).

Attitudes towards gambling can also be shaped by *social learning*. Having family members who gamble may help to trivialise gambling; but when family or friends are victims of harmful gambling experiences, this can act as a deterrent (Abbott et al., 2018).

Gambling has also been investigated with regards to *lifespan development*. A first gambling experience at younger age is also considered a risk factor (Johansson et al., 2009) and gambling disorder usually occurs between mid-20s and late 30s, with gender differences (see "Prevalence and epidemiology"; Black et al., 2015; Black & Shaw, 2019). However, gambling can be harmful at a later age (Subramaniam et al., 2015; Thompson & McNeilly, 2016).

According to Dowling et al. (2015b), about three quarters of people seeking treatment for a gambling disorder suffer or suffered from one or several *comorbid disorders*. Links with substance use disorders are well-documented: alcohol, nicotine and illicit drugs (Cunningham-Williams et al., 2005; Kessler et al., 2008; Petry et al., 2005, 2018; Welte et al., 2004). The co-occurrence of gambling disorder with other behavioural addictions has been also explored and links were found with the following: compulsive buying (Granero et al., 2016), gaming disorder (Jiménez-Murcia et al., 2014) and problematic internet use (Baggio et al., 2016). Several personality disorders are also associated with problem

gambling (see "Personality and temperament"; Dowling et al., 2015a). Strong and consistent associations with mood disorders (e.g., major depression and bipolar disorder) and anxiety disorders (e.g., obsessive compulsive disorder, posttraumatic stress disorder) are emphasized by research (Black et al., 2013; Black & Shaw, 2019; Cunningham-Williams et al., 2005; Kessler et al., 2008; Petry et al., 2005; Specker et al., 1996). Finally, the literature supports links with eating disorder (Jiménez-Murcia et al., 2013; H. S. Kim et al., 2018), attention deficit disorder (Black & Shaw, 2019; Karaca et al., 2017), impulse control disorders (J. E. Grant & Kim, 2003a; Specker et al., 1995), psychosis (Haydock et al., 2015) and Parkinson's disease (because of the medication; Santangelo et al., 2013). The co-existence of mentioned psychological afflictions with gambling disorder raises a question of temporality; longitudinal studies (Afifi et al., 2016; Hartmann & Blaszczynski, 2018) have shown that gambling disorder may appear before, during and/or after the outset of those disorders.

Poor *subjective well-being* is related to harmful gambling (Loo et al., 2016; Tang & Oei, 2011) as it often involves more stress (Biback & Zack, 2015), distress and negative emotions (Rogier & Velotti, 2018). Conversely, healthier gambling practices are linked to higher levels of well-being (Lee et al., 2014).

The *adverse childhood experiences* factor was added in the last version of the conceptual framework. It examines the favouring influence of traumatic experiences, neglect, incarceration, separation or divorce, substance use and mental disorders in the household on harmful gambling (Hodgins et al., 2010; Poole et al., 2017; Thege et al., 2017).

Problem gamblers often have poor *judgement and decision making* when it comes to gambling, meaning that their ability to evaluate risks in order to decide is impaired. An association of risky gambling was found with impairment of probability weighting (e.g., overestimation of the chance to win; Ligneul et al., 2013), or loss aversion (e.g., wins considered as more important than losses of the same amount of money; Genauck et al., 2017). The relation with heuristic (i.e., automatic and fast) and analytic (i.e., controlled and slow) processes have also been investigated, but results from d'Astous and Di Gaspero (2015) have showed that both modes of thinking can be used by gamblers. Cognitive distortion and biases, also called gambling fallacies, also contribute to harmful gambling (Goodie & Fortune, 2013; Jacobsen et al., 2007; Robert Ladouceur, 2004b). Six recurrent fallacies were identified by Leonard et al. (2015) with the four first being the most cited and the two last being related to statistical principles: hot hand fallacy (belief that someone who is winning has more chance to continue winning), Monte-Carlo fallacy (assumption that random events are related), belief that luck is dispositional (feeling that luck favour and disfavour aspects of the game; such as colours or numbers), illusion of control (confidence in one's ability to impact the outcome by using strategies), insensitivity to sample size (failure to understand that winning, a statistical exception, occurs more frequently in reduced opportunities to gamble than in repeated gambling) and base rate neglect (denial of the base frequency of an event, leading to an overestimation). These biases are facilitated by certain features of the games, such as the button to stop slot-machines or the possibility to choose numbers at the lottery.

2. Craving

Craving is a phenomenon that has received a growing interest in the literature since the 1950s (Drummond, 2001; Skinner & Aubin, 2010). It is considered an important process in clinical treatment of substance use and addictive disorders. Indeed, craving is linked with the initiation of problematic consumption and its maintenance, with the severity of disorders, and with the propensity to relapse (Hormes, 2017; Kozlowski & Wilkinson, 1987; Pickens & Johanson, 1992; Tanabe et al., 2019; Tiffany, 1995), especially when it is measured in a time frame close to consumption (Serre et al., 2015). Although craving does not systematically lead to consumption and relapse is not necessarily triggered by craving (Skinner & Aubin, 2010; Tiffany, 1990), it is established as a key process in substance use disorders (Flaudias et al., 2019; Skinner & Aubin, 2010). Patients with substance use disorder often report moderate to intense craving (Fatseas et al., 2015; Oslin et al., 2009), and such craving are generally considered as important target of the intervention (Pavlick et al., 2009).

The definition and the role of craving remain debated. Even if it can broadly be defined as an intense "desire", there is no consensus on an operational definition and a reference model (Anton, 1999; Rosenberg, 2009). It is also debated whether craving, considered as an extreme form of desire, is distributed along a continuum of desire, or should rather be conceptualized as a categorical phenomenon (Sayette, 2016; Sayette et al., 2000). Moreover, craving is often linked or mixed up with other terms, such as urge or desire (Shadel et al., 2004; Young et al., 2008) and, sometimes, its definition also includes the intention to consume a substance or perform a behavior (e.g., Anton, 2000), further contributing to the conceptual chaos around the construct. As a result, several assessment instruments, each with their own limitations (Sayette et al., 2000), have been developed, making it difficult to compare outcomes from different studies that use disparate tools (Ray et al., 2013). Those various definitions and measurements (self-reported, non-verbal) are an issue to the evaluation of techniques and treatments efficacy in research and in clinical practice. Consequently, it is important to put the models into perspective and to refer to the most relevant theoretical construct in order to pave the way to future clinical research on gambling disorder.

2.1 Conceptualization

Craving is defined as an "urgent desire, longing, yearning" (Oxford English Dictionary, n.d.) and is considered to be so urgent that it captures the focus of thoughts (Hormes & Rozin, 2010). In the literature, craving is described as a subjective experience (Pickens & Johanson, 1992; Tiffany & Wray, 2012) and the term is used interchangeably with other ones such as: urge, desire, drive, temptation, need, obsession, compulsion, etc. (Anton, 2000; Shadel et al., 2004; Young et al., 2008) and Kozlowksi and Wilkinson (1987) already pointed out its misuses more than three decades ago. There is even more disarray when checking translations in different languages, as an equivalent word is scarce (Hormes & Rozin, 2010). Several operational definitions have been proposed, related to various modelling, leading to the impossibility of reaching a consensual definition (Drummond, 2001).

In their review, Skinner and Aubin (2010) presented 18 models of craving divided into four main categories. Historically the first theories of craving, the *conditioning-based models,* consider that craving results from withdrawal-related processes (i.e., punishment if abstinence) or from reward-related perspective (i.e., reinforcement due to positive aspects of consumption). Among those, the incentive model (J. Stewart et al., 1984) also considers the association of alcohol with cues (e.g., bar, friends) which may then trigger similar psychological and physiological responses as drinking. The *psychobiological models* study more specifically the neurobiological mechanisms involved in craving, such as the role of neurotransmitters (dopamine, serotonin, glutamate, GABA, and endogenous opiates), permanent neurobiological changes, brain structures (e.g., amygdala, basal ganglia, dorsolateral prefrontal cortex, nucleus accumbens, and orbitofrontal cortex), and (anti) reward system (e.g., Anton, 1999; Berridge & Robinson, 2016; Koob & Le Moal, 2008; Paulus et al., 2009; Robinson & Berridge, 1993; Verheul et al., 1999). Both types of model – conditioning-based and psychobiological – fail to consider the subjective cognitive processes and emotions occurring while experiencing craving (e.g., memories, expectations, interpretation of reactions, anxiety, guilt, shame, etc.; de Timary & Billieux, 2014) and describe the underlying mechanisms of craving rather than craving itself. According to the *motivations models*, craving is part of a dysfunctional decision making pattern (e.g., W. M. Cox & Klinger, 1988). These broader models include craving as a part of their motivation conceptualization, providing insights on its role. However, they do not explain the underlying mechanisms involved in the craving experience. On the contrary, the *cognitive*[1] *models* address the subjective experience of craving; they allow direct empirical test and have clear clinical implications, allowing to target mental and subjective aspects of craving (May et al., 2004). These models consider that craving requires higher order cognitive functions (e.g., memory, expectancies, attention) and that it results from impaired information-processing system (i.e., structure that regulates how information is acquired, manipulated, and converted into behaviour; Tiffany, 1999). The following sections present a selection of models described in past reviews (Drummond, 2001; Skinner & Aubin, 2010; Tiffany, 1999) and then comprehensively approach a more recent cognitive theory of craving that has received a growing interest in the literature and is the central theoretical account supporting the present PhD thesis, the EIT (e.g., Kavanagh et al., 2005, 2009; May et al., 2015). As previously mentioned, other terms (e.g., urge) designate craving in research, and the following models are described with the terms used by the authors.

2.1.1 Cognitive labelling model

The cognition-arousal model (Schachter & Singer, 1962) posits that an emotion emerges from the cognitive interpretation of a biophysiological arousal. This analysis provides a label of the emotion whose intensity depends on the importance of the physiological sensation (Tiffany, 1999). According to the subsequent cognitive labelling model developed in link with alcohol (Melchior & Tabakoff, 1984), external cues, associated to drinking by

[1] Although these theories refer to mental states that include not only cognitions but also emotions, they are labelled "cognitive models" in the literature. The term "cognitive" will be used accordingly in this manuscript.

conditioning, elicits physiological (e.g., heart rate increase) and cognitive (e.g., memories of drinking episodes) responses that will be interpreted and labelled "craving", which is considered as an emotion (de Timary & Billieux, 2014). Concretely, an individual in a shop would notice the same bottles of whisky that they drank with their friends (cognitions). They would begin to feel sweaty hand and racing heart (physiology) and would interpret those sensations as a manifestation of craving.

Although this model offers treatment perspectives through cognitive reframing of craving (Drummond, 2001), it has received little empirical validation (de Timary & Billieux, 2014). The cognition-arousal theory is outdated since it was shown that physiological arousal is unnecessary to elicit emotions (Reisenzein, 2017), undermining the basic assumption of the cognitive labelling model. Moreover, there is no significant relation between the intensity of sensations and the strength of craving (Tiffany, 1990), which also refutes a core postulate underlying this theory.

2.1.2 Outcome expectancy model

Based on the cognitive social learning theory, Marlatt (1985a) defines craving as arising from the expectancy of positive outcomes (e.g., pleasure, relief, relaxation) of consumption. This anticipation relies on motivational (i.e., the desire to experience the pleasant consequences of consumption) and informational (i.e., the beliefs about the effect of consumption) processes and is triggered by the environment (Tiffany, 1999). For instance, when a person walks by the bar that they are used to go in, they may think that alcohol would help them to relax after a stressful day (belief) and desire to drink alcohol (motivation). The authors distinguish craving (i.e., the expectation of positive outcome) from the intention to yield to it, which they call *urge*, justifying how a person can experience a craving without necessarily relapsing. This specific definition of the urge is not very common though, as many authors use craving and urge in an interchangeable way (Skinner & Aubin, 2010).

The literature investigating the validity of this model is currently insufficient (Skinner & Aubin, 2010; Tiffany, 1999) and the link between urge and outcome expectancy remains to be further explored and established (Niaura, 2000). However, recent research has highlighted the role of beliefs through the concept of metacognitions (i.e., cognitions on the functioning of thinking) and its relation with craving (Flaudias et al., 2019; Spada, Caselli, et al., 2015)

2.1.3 Dual-affect model

According to Baker and colleagues (1986), the urge can be viewed as an emotion that raises the likelihood of using a substance. It is induced by two distinct affective networks that contains interoceptive, exteroceptive and contextual information about positive-affect and negative-affect urge (Skinner & Aubin, 2010). Both systems are mutually-exclusive and triggered by different cues (see Table 3; de Timary & Billieux, 2014; Skinner & Aubin, 2010; Tiffany & Drobes, 1991). The intensity of an urge depends on the coherence between those cues stored in each network; a greater match is related to a stronger urge (Skinner & Aubin, 2010).

A person with an alcohol use disorder could feel an urge to drink when feeling euphoric (positive mood) or when they walk by their favourite bar (availability), partially activating the positive-affect network. This urge will be more powerful if both cues co-occur (de Timary & Billieux, 2014).

The distinction between positive and negative emotions systems from this model is supported by brain imaging studies (Davidson, 1992) and it also explains how positive and negative affects can both be related to craving (Drummond, 2001). However, Skinner and Aubin (2010) point out some limitations of the model. For instance, the reason why users do not all become addict is not explained. Moreover, data used to elaborate this model comes from research on smoking, impeding external validity (Skinner & Aubin, 2010; Tiffany, 1999). Finally, the assumption that both systems are mutually inhibiting is challenged by the correlation of the positive and negative aspects of the urge (Tiffany & Drobes, 1991).

Table 3. Comparison of the triggers of the positive-affect and negative-affect networks

Positive-affect Network	Negative-affect Network
Positive affect or context	Negative affect or context
	Withdrawal symptoms and cues
Availability of the substance	Unavailability of the substance
Initial intake of a small dose	
Expectancy of pleasant outcomes of consumption	Expectancy of withdrawal symptoms or of relief from negative affect

2.1.4 Cognitive processing model

The Cognitive Processing Model (CPM; Tiffany, 1990, 1999; Tiffany & Conklin, 2000) posits that substance intake is an automated response to certain stimuli (internal or external cues), which is acquired by experience (like learning to drive a car) and which requires few cognitive resources. When the automatized sequence of psychoactive substance consumption fails and is interrupted (e.g., when the product is not or no longer available or when the addicted individual tries to prevent themself from consuming; see Figure 2), the craving occurs and triggers a voluntary response or proactive behaviour (May et al., 2004). According to the CPM, when substance consumption is blocked, cue reactivity increases and withdrawal symptoms becomes more salient, along with negative emotions, resulting in an urge to consume and in compulsive drug seeking. The CPM predicts that an addicted person in a state of substance deprivation will mobilize intense effort, and thus demanding cognitive resources, to either obtain or refrain from consuming the desired substance. It also explains how consumption and relapse may occur without craving and vice-versa, and why relapse is still possible, through the automatized process, after cessation of withdrawal symptoms (Skinner & Aubin, 2010; Tiffany, 1999).

The perceived importance of the obstacle is related to the strength of the urge, and the risk of yielding to craving is more intense when people are convinced that it will keep increasing until the consumption. It is also more difficult to resist a craving when other stressors – also demanding cognitive resources to be overcome – are present (Skinner & Aubin, 2010; Tiffany, 1990).

As the CPM considers craving as an epiphenomenon (Tiffany, 1990; Tiffany & Carter, 1998), the theory does not support the use of treatments targeting craving itself (Tiffany & Conklin, 2000).

An individual who has developed a problematic consumption pattern would usually enter an "automatic pilot" behaviour. They get dressed to go out and, twenty minutes later, they are drinking a beer in an armchair, sometimes without really knowing what has happened in between. The craving arises, for instance, when they arrive in front of their usual shop, closed for renovations. They then get a sense of frustration, starts to feel tense, and actively seeks for a solution to drink. They could also decide to stop drinking and make effort to change their habits and fight craving. Nevertheless, after a big argument that is preoccupying (i.e., less resources available for regulation), they might decide that it is just too much to bear and renounce their abstinence.

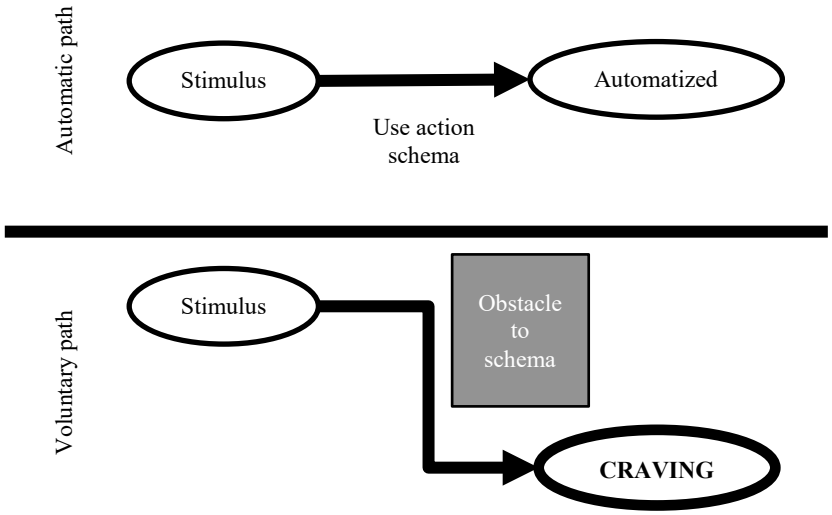

Figure 2. The cognitive processing model

Note. Adapted from "Cognitive concepts of craving," by S. T. Tiffany, 1999, Alcohol and Research World, 23(3), p. 220. Copyright 2005 by the author.

Even if this theory has been supported by research (e.g., Cepeda-Benito & Tiffany, 1996), it has essentially been tested in populations of smokers (Drummond, 2001). Moreover, although it provides a description of what triggers a craving, it does not clarify the mechanisms underlying the craving phenomenon (May et al., 2004). Wertz and Sayette (2001) have also found that, if a substance is available, the related craving increases. Finally,

it does not explain the role of imagery despite its use to elicit craving, why craving is considered an aversive experience, and how craving leads to use (Panabokke, 2004).

2.1.5 The elaborated intrusion theory (EIT) of desire

According to the EIT, craving is an emotionally charged mental state in which an object or behaviour linked to pleasure and/or relief is maintained in focal attention (Kavanagh et al., 2005). Contrary to the cognitive labelling model and the dual-affect model, the EIT does not consider craving as an emotional process per se, even though emotion-related processes are involved in the craving experience. The authors state that craving lies on a continuum of desire, and consider that both constructs do not qualitatively differ (May et al., 2004). Kavanagh et al. (2005) explain that craving results from the intrusion of a thought related to the object of desire, and its subsequent elaboration (Figure 3). Although this original thought may be induced voluntarily (Cepeda-Benito & Tiffany, 1996), it is more frequently perceived as spontaneous and linked with conditioned (automatic) internal and external triggers (see below) (Kavanagh et al., 2004). The intrusive thought may consequently occur during another activity and, as a transitory phenomenon, naturally disappear. However, when the intrusive thought triggers emotional answers (pleasure, relied and deficit), it is likely to be kept in working memory and elaborated with mental images and inner speech, using massive cognitive resources. This process induces a subjective state of desire or craving (see below).

2.1.5.1 Triggers of the intrusion

Five types of triggers can elicit craving: external cues, anticipatory responses, associated thoughts, negative affect and physiological deficit (Andrade, May, et al., 2012; Kavanagh et al., 2004; May et al., 2004). One trigger is enough to elicit the whole process, but the simultaneous activation of different factors increases the probability to create more intrusive thoughts and thus provide extra material to elaborate.

Those five triggers (rounded boxes on Figure 3) are divided into two distinct pathways. The first one goes through external or internal stimuli that have been connected to the object of desire and that subconsciously cause an intrusive thought. Because the following triggers may be associated to different types of desire, they do not necessarily lead to a craving for substance. The *external cues* that are associated to the object of desire can induce craving (Cooney et al., 1987; Kaplan et al., 1985; Niaura et al., 1992; Rose et al., 2013) and cue-induction is often used to elicit craving for substances (e.g., Ferguson & Shiffman, 2009; Lovett et al., 2015; Sinha & Li, 2007; Waters et al., 2004) and behaviours (e.g., Ashrafioun, Kostek, et al., 2013; Trotzke et al., 2019; Wegmann et al., 2018). Classical conditioning to withdrawal or to consumption explain this phenomenon of cue-reactivity (Ludwig & Wikler, 1974; J. Stewart et al., 1984). Moreover, attentional biases toward related stimuli foster the salience of cues among substance users, facilitating the occurrence of craving (Field et al., 2009; May, 2013). The intrusion can also be initiated by *associated thoughts*; these cognitively generated cues are related to the substance through memories. In the flow of thoughts, a memory related to consumption can arise and activate a cognitive network linked to the desired activity (May et al., 2004). This type of trigger can occur following semantic

instructions (Kavanagh et al., 2005) such as observed when tasks requiring to create a mental image of the product do elicit craving (Cepeda-Benito & Tiffany, 1996; Maude-Griffin & Tiffany, 1996; Tiffany & Drobes, 1991). The third trigger, *anticipatory responses*, can emerge from the two first ones (cues and cognitions) by classical conditioning. Those physiological manifestations must be perceived as caused by the appetitive target to induce craving. The influence of this factor is often described as less pronounced (Maude-Griffin & Tiffany, 1996) but this might be due to a lack of awareness (Kavanagh et al., 2005). If this first pathway is activated, an individual could see an advertisement for the chocolate that they like (external cue) and think about the marvellous chocolate cake that they ate – three slices – yesterday at a friends' birthday party. They would start salivating and thinking about how much they would enjoy chocolate. Alternatively, they might think that their daughter is out of chocolate cereal and that they must hurry before the shop closes.

The second pathway, initiated by the last two triggers, leads to the intrusive thought through a sense of perceived deficit. Its effect depends on the context given that this feeling must also be interpreted as associated to the object of desire in order to create an intrusive thought. The *physiological deficit* covers deprivation and withdrawal symptoms, which are known to elicit craving (Jorenby et al., 1996; Oliver et al., 2013). *Negative affect* can also prime the sense of deprivation as it enhances the desire to modify the present mood (Kavanagh et al., 2005). Research has shown the increasing effect of negative mood on craving (Fox et al., 2007; Maude-Griffin & Tiffany, 1996; Sinha et al., 1999; R. C. Taylor et al., 2000). Positive affect, even if part of the mechanism as pleasure and relief, is not considered a desire trigger. For instance, an individual may feel stomach-ache (i.e., physiological deficit), putting them in a bad mood. They start thinking that drinking alcohol would relieve their ache and make them feel better. Alternatively, they might interpret this signal as hunger and go to the closest restaurant.

2.1.5.2 The elaboration process: Subjective state of desire or craving

The intrusion of the desire thought does not require dedicated cognitive resources because the associative processes are automatic (thin arrows in Figure 3), and it does not involve craving as long as the thought remains unconscious. Indeed, the craving involves a second conscious mechanism, the elaboration of this initial thought, which may occur if no competing content is considered more important to proceed. Contrary to the intrusion, this phase is cognitively demanding and requires attentional and working memory allocation (thick arrows in Figure 3).

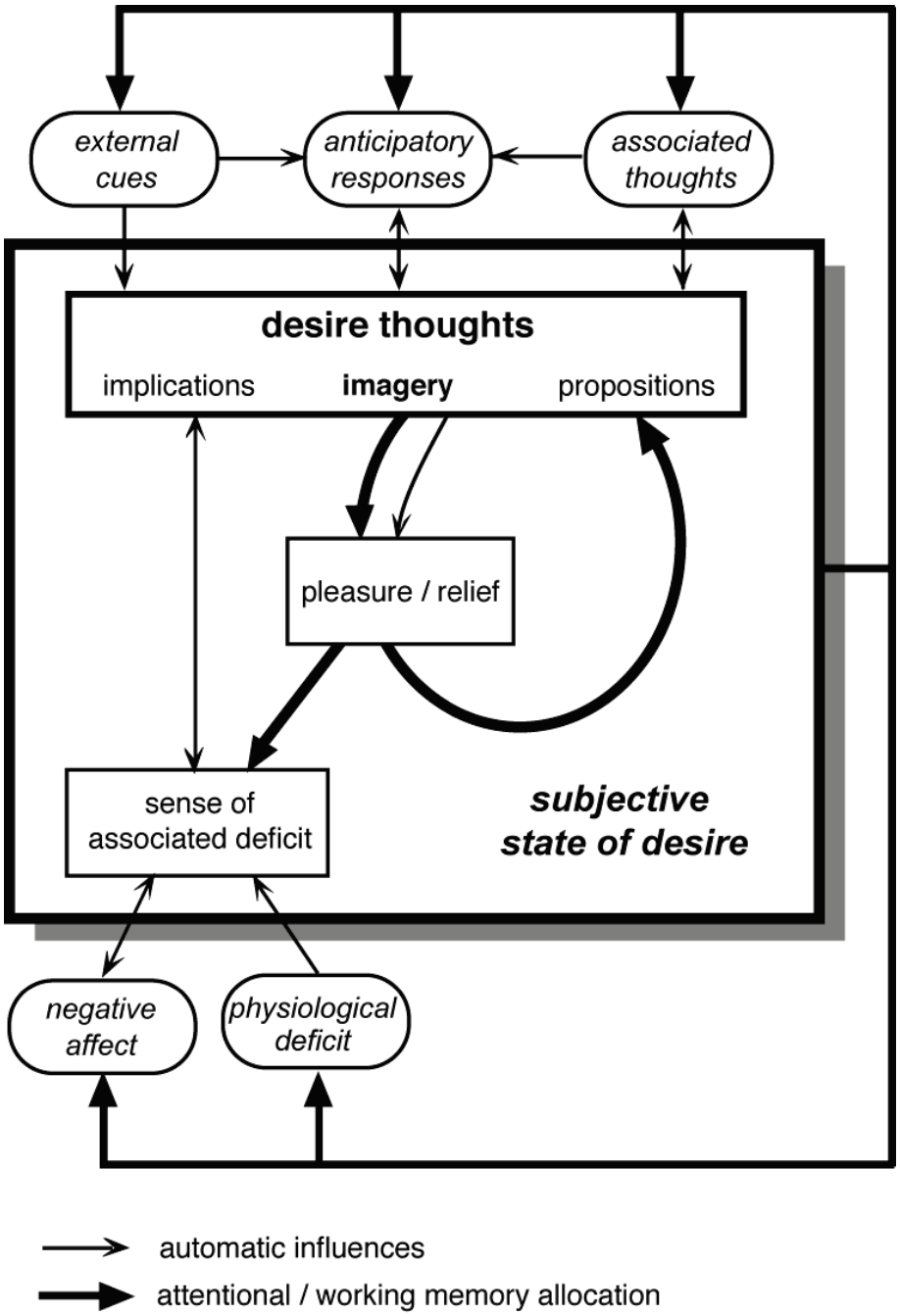

Figure 3. The elaborated intrusion theory of desire

Note. Adapted from "Imaginary Relish and Exquisite Torture: The Elaborated Intrusion Theory of Desire," by D. J. Kavanagh, J. Andrade and J. May, 2005, *Psychological Review, 112*(2), p. 448 (https://doi.apa.org/doi/10.1037/0033-295X.112.2.446). Copyright 2005 by the American Psychological Association. Reprinted with permission.

The *desire thoughts* include the initial intrusive thought and the subsequent elaborations. It is composed of semantic propositions ("cold" representation or "knowing") and implicational awareness ("hot" representations or "feeling") described by May et al. (2004). It also includes verbal perseveration (i.e., the self-talk about the target; Caselli & Spada, 2010, 2015), but, more importantly, imagery, which is the key component of desire according to the authors of the EIT (Andrade, May, et al., 2012; K. Harvey et al., 2005; Kavanagh et al., 2005; May et al., 2008, 2015; Statham et al., 2011). These images that emerge from long-term memory appear to strongly invigorate the behaviour (Connor et al., 2014) and relate to the consumption target (including the planning of its acquisition), the wanted effect and the experience. Even if the visual modality is considered the most relevant (e.g., May, Andrade, Panabokke, et al., 2010), the other sensorial modalities (taste, smell, hearing, touch, etc.) may play a role in the mental imagery. The mental images are perceived as experiences close to the reality as the brain activity is similar (Kosslyn, 2005). They also induce emotions whether the object is perceived or imagined, and an increased vividness is related to enhanced emotion (Bywaters et al., 2004a, 2004b; Kavanagh et al., 2009). Consequently, desire thoughts generate *pleasure and relief*, reinforcing the elaboration in a first vicious circle (desire thoughts, pleasure/relief, desire thoughts). However, if the deprivation is extended or voluntary, the awareness of the *sense of associated deficit* arises through a contrast between imagery and reality (confrontation of current and desired states), making the desire aversive. This creates a request of more elaboration to cope with the sense of deficit, provoking a second vicious circle (desire thoughts, pleasure/relief, sense of deficit, desire thoughts; Kavanagh et al., 2005). Finally, the elaboration process draws attention to the triggers for treatment in the working memory in order to further fuel new thoughts related to the object of desire.

2.1.5.3 Resolution of the desire: Beyond the EIT

The EIT distinguishes between craving and the addictive behaviour per se, contrary to the theories that consider craving as a mechanism composed of obsession and compulsion (e.g., Anton, 2000). In fact, Kavanagh et al. (2005) describe three factors susceptible to lead to the target acquisition or to block it. *Attention diversion* is susceptible to interrupt the elaborative process by moving the cognitive resources allocated to craving toward another competitive cognitive task. The orientation of working memory and attention may be influenced by the presence of *other incentives*. The decision to engage in consumption also relies on *resources and skills* to get the target or to avoid yielding to temptation. The two later factors, resources and skills, can be linked with components of the appraisal theory of emotion by Scherer (1999), respectively *goal significance*, which allows to select the incentives according to personal objectives or needs, and *coping potential*, which determines the ability to handle a situation instead of being overwhelmed. These resources are also connected to *self-efficacy* (sense of competence to cope) which is an important factor to predict whether relapse will follow cue exposure (Marlatt & Witkiewitz, 2005). Scherer (1999) also evokes that *novelty* and *valence* are relevant criteria in the appraisal process. However, we consider that both are encompassed in the subjective state of desire because novelty is evaluated through the activation of memories, and valence is covered by both positive (pleasure and relief) and

negative (sense of deficit) aspects of the experience. Finally, according to the appraisal theory, an individual evaluates the *compatibility with standards* (internal and external). The assessment of the affective phenomenon is followed by the preparation of the behaviour (action tendency to approach or avoidance) and, eventually, the behaviour itself.

2.2 Craving across disorders

Craving is a well-established diagnostic criterion that was included to define substance-use disorders in the ICD-10 (Winstock, 2012), and then in the DSM-5 (Romanczuk-Seiferth et al., 2014), increasing consistency between both nosologies. Hasin et al. (2013) have found that the addition of craving improved the diagnosis of substance use disorders in several studies with a good fit with the other criteria. They also report that behavioural, imaging, pharmacological and genetic evidence support its inclusion. A recent study (Kervran et al., 2020) found that, among the 11 DSM-5 criteria defining substance (alcohol, opiates, cocaine, tobacco, and cannabis) use disorders, craving had higher factor loadings on a global score of the targeted disorder and discriminated better than the other symptoms.

Gambling disorder were moved in the addictive disorders section in DSM-5, and thus aligned with substance use disorders. However, the definition of this "behavioural addiction" does not include craving as a diagnostic criterion. Indeed, preoccupation (i.e., remembering or planning related experiences) replaces craving for both types of disorders. The relevance of craving for behavioural addictions and related conditions is, however, well documented. (J. E. Grant et al., 2010; for a review, see Hormes, 2017): gambling (see section 3.), internet-use disorders (Brand et al., 2016), internet gaming disorder (Bargeron & Hormes, 2017; Ko et al., 2009, 2013) internet communication use (Hormes et al., 2014; Wegmann et al., 2018), problematic online sexual activities (Allen et al., 2017; Antons et al., 2019; Chen et al., 2018), addictive physical exercise (Berczik et al., 2012; Roderique-Davies et al., 2018), compulsive buying (Müller et al., 2015), and excessive indoor tanning (Petit et al., 2014).

Although it is not included in the nosologies, craving is also reported in relation to food, especially highly processed food, sugar and fat (Schulte et al., 2015). Food craving is both a potential sign of an eating disorder (e.g., Binge Eating Disorder), and a phenomenon that can be experienced in the life of people without psychopathological condition (Hormes, 2017) Individuals with and without eating disorder report food craving (Gendall et al., 1997; Kemps & Tiggemann, 2013b; Knäuper et al., 2011; Van den Eynde et al., 2012), especially before binge eating episodes (Gearhardt et al., 2011). Frequent and strong food craving is susceptible to reduce psychological and emotional wellbeing, to damage nutrition and health, and to decrease physical aspect standards. Accordingly, Taylor (2019) recommends that clinicians take food craving into account when treating patients with an eating issue.

2.3 Assessment

The measurement of craving is challenged by the lack of consensus on a unique operational definition. This results in a large variety of tools and methods that have been reviewed by several authors, either in a transdiagnostic approach (Ray et al., 2013;

Rosenberg, 2009; Sayette et al., 2000) or with a focus on specific substances or behaviours (for alcohol, see Drobes & Thomas, 1999; Kavanagh et al., 2013; for food, see M. Taylor, 2019; for cigarette, see Colby et al., 2000; for gambling, see section 3.1). In the following sections, we briefly introduce non-verbal measures and take a more in-depth look at self-reported assessments

2.3.1 Non-verbal and proxy measurements

Although self-reported questionnaires are more frequently used and are considered the gold standard to assess craving (Sayette et al., 2000), other procedures have been used to approximate craving:

- reinforcement value of the consumption, for instance by asking to choose between drug use and certain amounts of money (R. R. Griffiths et al., 1993),
- drug use to reflect craving as an intention to consume, for instance through the latency between the authorization to consume and the actual consumption (e.g., MacKillop & Lisman, 2005),
- psychophysiological measures such as heart rate, sweat, skin conductance (for a review, see Carter & Tiffany, 1999), salivation (e.g., Monti, Rohsenow, Rubonis, Niaura, Sirota, Colby, & Abrams, 1993), startle eye blink (e.g., Elash et al., 1995), facial expression (e.g., Sayette & Hufford, 1995), neuroimaging techniques (e.g., Sinha & Li, 2007),
- drug-related dreams (e.g., Christo & Franey, 1996),
- cognitive indices such as attentional bias (e.g., Field & Cox, 2008) and working memory impairment (e.g., Bechara & Martin, 2004),
- approach/avoidance motivation (e.g., Curtin et al., 2005),
- emotions (e.g., facial coding analysis; Sayette et al., 2003),
- impulsivity (e.g., delay discounting; MacKillop et al., 2010).

These methods have been used in previous research to approach craving as they allow avoiding reactivity and biases related to self-reporting. However, access to appropriate equipment may be limited (i.e., for physiological assessment). These techniques have also been criticized (for critical reviews, see Ray et al., 2013; Rosenberg, 2009; Sayette et al., 2000) for lack of sensitivity and of specificity (variations attributable to other factors). Consequently, the non-verbal and proxy evaluations should be consistent with the theory of craving used in each study with a proper rationale.

2.3.2 Self-reported questionnaires

In line with the differences in definition, the relevance and validity of the numerous questionnaires measuring craving is strongly debated. However, self-report is the most common way to evaluate the intensity of craving (Rosenberg, 2013). Authors of craving assessment reviews (e.g., Kavanagh et al., 2013; Rosenberg, 2013; Sayette et al., 2000) usually categorize existing scales in two categories, according to the number of items.

2.3.2.1 Single item scales

Craving is often measured with visual analogue scales, asking participants – often with limited theoretical and methodological justification – to rate the intensity of their desire or urge from "none" or "not at all" to "extreme" or "strongest" (Rosenberg, 2013). This type of assessment is easy to administrate and to score, has face validity (measures what it intends to measure), can be repeated, and captures rapid changes (Rosenberg, 2009; Tiffany et al., 2000). However, the approach has several limitations pointed out in several papers (Ray et al., 2013; Rosenberg, 2013; Sayette et al., 2000; M. Taylor, 2019). In particular, such approach fails to capture the complexity of multidimensional constructs and is susceptible to low reliability and to how the respondent understands the question (i.e., different conceptualization of craving).

2.3.2.2 Multi-item scales

In his reviews, Rosenberg (2009, 2013) distinguishes between four major conceptions of craving that allow to categorize multi-item self-report craving questionnaires: (a) obsession-compulsion, (b) approach-avoidance, (c) multidimensional experience (substance desire or urge, intention to use, anticipation of pleasure or relief, and impaired control), and (d) intensity, duration and frequency. A selection of scales that are widely used, representative of the conceptions, and/or original (i.e., not adapted from another work) are presented in Table 4. Ray et al. (2013) posits that the timeframe of questionnaires is an important feature which varies as a function of the conception of craving; it can be considered as a transient state (e.g., QSU; Tiffany & Drobes, 1991) or as a trait, more stable in time (e.g., Penn Alcohol Craving Scale; PACS; Flannery et al., 1999). Some scales (e.g., Food Craving Questionnaire; FCQ; Cepeda-Benito et al., 2000; Craving Experience Questionnaire; CEQ; May et al., 2014) have been developed to measure both state and trait craving in two complementary versions.

The Yale-Brown Obsessive-Compulsive Scale (YBOCS; Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989) was initially created to assess the symptomatology of obsessive compulsive disorder. As Modell et al. (1992) found similarities between craving for alcohol and obsession-compulsion mechanisms, the scale was adapted for heavy drinkers (YBOCS-hd; Fedoroff et al., 1999). Unfortunately, the psychometric properties of the 10 items of the YBOCS-hd were not properly evaluated and its administration was included in a broader interview that takes time to administer by a trained person (Anton et al., 1995).

Consequently, the Obsessive Compulsive Drinking Scale (OCDS; Anton et al., 1995) was developed to allow for a more convenient and time-saving self-assessment which also conceptualizes craving as a phenomenon related to obsessive compulsive disorders. This scale is composed of 14 items and is the most frequently used to assess alcohol craving; it has been translated in several other languages and authors have developed short and adolescent versions (Kavanagh et al., 2013). Its two-factor structure has been questioned by several studies (e.g., Connor et al., 2008; Kranzler et al., 1999) and, according to de Wildt et

al. (2005), the Obsessive-Compulsive Drinking Scale rather measures the consequences of craving than craving itself.

The Temptation and Restraint Inventory (Collins & Lapp, 1992) evaluates the effort to reduce or refrain from drinking and the preoccupation with and intention to consume. This 15-item tool, according to Kavanagh et al. (2013), does not properly assess craving.

The QSU (Tiffany & Drobes, 1991) is anchored in Tiffany's (1990) cognitive processing model (see section 2.1.4) and evaluates four aspects of nicotine urge (see Table 4). Among the 32 items covering these dimensions, 15 questions were linked to Factor 1 covering pleasant expectations, enjoyment, and satisfaction, and 11 questions were related to Factor 2 rather covering relief and intense desire. The 6 remaining items were not included in any factor. Shorter versions (e.g., L. S. Cox et al., 2001; Dethier et al., 2014) were developed in order to allow the capture of quick changes; but it also served as a basis for the creation of other scales accounting for alcohol, heroin, cocaine, marijuana, etc. and their shorter versions (Rosenberg, 2009). However, according to Kavanagh et al. (2013) measures based on the QSU mistake craving for intention and for control of consumption, and the number of factors is inconsistent across scales.

The authors of the Jellinek Craving Questionnaire (Ooteman et al., 2006) constituted a pool of 129 items of which 24 have been selected to cover four dimensions of craving (see Table 4) in a one-dimension scale applicable on two timeframes (present and past). The scale showed good convergent validity but present and past versions poorly correlated, indicating a potential problem in the imaging instructions for the past-version (Kavanagh et al., 2013).

The Food Craving Questionnaire (FCQ; Cepeda-Benito et al., 2000) is composed of two forms: state (FCQ-S) and trait (FCQ-T) and has been translated in six languages beside English (M. Taylor, 2019). The FCQ-S measures instant craving for food and includes five facets (see Table 4). Construct validity is supported by higher scores before eating compared to after eating (Cepeda-Benito et al., 2000). The FCQ-T evaluates nine stable dimensions of craving (see Table 4) among which several types of triggers. It has good test-retest reliability (Cepeda-Benito et al., 2000) except for some subscales among overweight participants. The factor structure of both versions of the scale has been replicated in other studies, even if fewer subscales were considered enough by some authors (M. Taylor, 2019). The scale has been adapted in a reduced version (Meule et al., 2014) and in a version in which the object of craving is "tasty food" (Nijs et al., 2007).

The CEQ (May et al., 2014) was developed to evaluate craving as conceptualized by the EIT. Initially validated for alcohol as the Alcohol Craving Experience questionnaire (ACE; Statham et al., 2011), the CEQ resulted from this adaptation of the ACE to fit other types of desire. It is composed of two 10-item forms: strength (CEQ-S) of a specific craving episode (e.g., now, last time) or an approximation of craving in a timeframe (e.g., last week), and frequency (CEQ-F) of craving during a specified timeframe (e.g., last 10 minutes). Each form is divided into three subscales: intensity of the desire, vividness of mental imagery, and intrusiveness of thoughts. The CEQ was tested for food, chocolate, cigarette, and alcohol, showing good psychometric properties (May et al., 2014). Although, its criterion validity is

not well-documented, this scale can be tailored for several types of craving, has strong theoretical validity, and was supported by several studies in the validation research (M. Taylor, 2019).

Table 4. Presentation of multi-item self-report craving questionnaires

Name of scale **Authors (year)**	**Substance; conception**	**Number of items; subscales**	**Timeframe; response format**
Yale-Brown Obsessive Compulsive scale for heavy drinking (YBOCS-hd) Modell et al. (1992)	Alcohol; obsession-compulsion	10; obsession and compulsion	Not specified; 5-point Likert scale from 0 to 4
Obsessive-Compulsive Drinking Scale (OCDS) Anton et al. (1995)	Alcohol; obsession-compulsion	14; obsession and compulsion	Not specified; 5 item-specific choices on a Likert scale from 0 to 4
Temptation and Restraint Inventory (TRI) Collins & Lapp (1992)	Alcohol; approach-avoidance	15; cognitive and emotional preoccupation (1), and cognitive and behavioural control (2)	Not specified; 9-point Likert scale from 1 *(never*) to 9 (*always*)
Jellinek Alcohol Craving Questionnaire (JACQ) Ooteman et al. (2006)	Alcohol; multi-dimensional	24; none (items about feelings of urge, uncontrolled thoughts, temptation, and physical sensations)	Present and past; 5-point Likert scale from 1 *(not at all*) to 5 (*very much*)
Questionnaire of Smoking Urges (QSU) Tiffany & Drobes (1991)	Cigarette; multi-dimensional	32; intension, desire, and positive outcomes (1); relief from withdrawal and negative emotions and strong desire (2)	Present; 7-point Likert scale from 1 *(strongly disagree*) to 7 (*strongly agree*)
Food Craving Questionnaire (FCQ) Cepeda-Benito et al. (2000)	Food; multi-dimensional, intensity, duration, and frequency	15 for state and 39 for ***trait***; desire, ***intentions/plans***, positive reinforcement, negative reinforcement, lack of control, ***thoughts***, hunger, ***emotion***, ***environmental triggers***, ***guilt***	Present and ***usual***; for state version: 5-point Likert scale from 1 *(strongly disagree*) to 5 (*strongly agree*); for ***trait*** version: 6-point Likert scale from 1 *(not applicable or never*) to 5 (*always*)
Penn Alcohol Craving Scale (PACS) Flannery et al. (1999)	Alcohol; intensity, duration, and frequency	5; none (items about thoughts intensity/ frequency/duration, ability to resist, and global craving	Past week; 7 item-specific choices on a Likert scale from 0 to 6
Craving Experience Questionnaire (CEQ) May et al. (2014)	Food, alcohol, cigarettes; multi-dimensional, intensity, duration, and frequency	10 for strength and 10 for frequency; intensity, imagery, intrusiveness	Present, past; for strength and frequency 11-point Likert scale from 0 *(not at all*) to 10 (*extremely or constantly*)
Weiss Craving Questionnaire (WCQ) Weiss et al. (1995)	Cocaine; intensity	5; Present: desire, use in related environment / Past 24: desire, urge frequency, cued urge	Present and past 24h; 9-point Likert scale with adapted anchors

Note. Adapted from Rosenberg (2013).

The Weiss Craving Questionnaire (Weiss et al., 1995) aims at assessing cocaine craving with only five questions. Although composed of patients, the sample size was small and included repeated measures in their analyses.

The 5 items of the PACS (Flannery et al., 1999) constitute a brief measurement of craving covering the frequency, intensity, and duration of drinking thoughts, mean craving in the last week, and difficulty to resist consuming which is related to self-efficacy. This measurement has high internal consistency, anticipates relapse, and correlates with the OCDS.

In conclusion to this overview of self-reported craving questionnaires examples, it must be mentioned that the mayhem in the definitions of craving lead to confusion in its measurement. The scales often include craving related concepts in the evaluation of craving. As a result, the influence of craving on behaviours cannot be truly apprehended (Kavanagh et al., 2013; May et al., 2015). The retrospective evaluation of craving also remains a challenge as subject to memory bias; proximal assessment should be favoured.

2.4 Intervention

Craving is considered an important treatment target when dealing with addictive behaviours (Cavicchioli et al., 2020; Chakroun-Baggioni et al., 2017; Coates et al., 2019; Enkema & Bowen, 2017; Hasin et al., 2013; Hormes, 2017; Tiffany & Wray, 2012), which has fostered research that aims to develop and validate specific interventions targeting craving.

Sayette (2016) presents several methods that have been tested across substances. *Pharmacotherapy* reduces craving, decreasing relapse risk (Baker et al., 2006). For instance, naltrexone, an opioid antagonist, is used for alcohol and is supposed to dissociate cues from the reinforcing feeling (Wiers & Heinz, 2015). Nicotine substitutes may also be effective to reduce cigarette craving (Brandon et al., 2011). Research has also focused on non-invasive *brain stimulation* processes (i.e., transcranial magnetic stimulation and transcranial direct current stimulation), but effects on craving seem to be mixed. *Cue exposure* therapy consists in provoking craving to observe its natural decrease or to develop coping strategies; preliminary results for alcohol were promising (Loeber et al., 2006; Monti, Rohsenow, Rubonis, Niaura, Sirota, Colby, Goddard, et al., 1993) but findings related to other substances were less definitive. A recent review of intervention targeting food craving (Wolz et al., 2020) indicates that *cognitive regulation strategies* including reappraisal, suppression, and distraction decrease subjective craving. Improved *emotion management* also reduces substance craving (Szasz et al., 2012; Zargar et al., 2019). As people with a substance use disorder are prone to develop attentional biases toward the desired drug cues which elicit craving, *attention retraining* can also be effective to prevent craving (Deleuze et al., 2013; May, 2013). *Motivation enhancement strategies*, such as implementation intentions (Gollwitzer, 1999) and functional imagery training (Andrade et al., 2016; Solbrig et al., 2019) encourages individuals to follow goals and help building self-efficacy (May, Andrade, Kavanagh, et al., 2012), which may serve to overcome craving.

These various techniques and treatment may help reducing craving occurrence, intensity or frequency, but they tend to focus on triggers or precursors rather than the experience itself. Based on the EIT, and particularly relevant in the context of the current thesis, May et al. (2015) recommends mindfulness-based treatments and interference methods.

2.4.1 Mindfulness

Jon Kabat-Zinn was the first to use mindfulness in the context of psychotherapy. He defined it as "the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment to moment" (Kabat-Zinn, 2003, p. 145). Mindfulness aims to develop the ability to maintain the attention on a specific focus (e.g., the breathing) and to bring back the attention to the focus when distracted, without further elaboration (Bishop et al., 2004). The experience is considered with curiosity, without judgement, intention to change it, nor avoidance (Heeren & Philippot, 2010). This acceptance is supposed to lead to conscious and adaptive response to stimuli by reducing avoidance and automatic reactions (Bishop et al., 2004; Bowen et al., 2010; von Hammerstein et al., 2016).

Although not directly related to the EIT, mindfulness promotes attitude of awareness and acceptance of intrusive desire thoughts and sense of deficit without elaboration that may prevent the craving process to expand (May et al., 2015). The Mindfulness-Based Relapse Prevention program (MBRP) intends to reduce craving by identifying and promoting conscious responses to craving triggers (Bowen et al., 2010). However, a recent review and meta-analysis (S. Grant et al., 2017) questioned the effect of MBRP on craving because clinical effect was similar to other interventions (e.g., relapse prevention, cognitive behavioural therapy, health education), also on the long term (no difference of frequency and of quantity). As MBRP is susceptible to impact both triggers and craving, its mechanisms remain to be further investigated. In their review, Zgierska et al. (2009) concluded that the combination of cognitive behavioural therapy and mindfulness meditation may enhance treatment outcome by increasing awareness of craving. Another review and meta-analysis (Li et al., 2017) confirms the small-to-large effects of mindfulness interventions on craving. Eventually, mindfulness proved relevance to reduce craving with more focused interventions or techniques (for a review, see Tapper, 2018) such as decentering strategy (Tapper & Turner, 2018), defusion and acceptance exercises (Hulbert-Williams et al., 2019; Schumacher et al., 2018; Szasz et al., 2012), body scanning (Hamilton et al., 2013; May, Andrade, Batey, et al., 2010; May, Andrade, Willoughby, et al., 2012) and "urge surfing" (Bowen & Marlatt, 2009). However, these interventions do not necessarily show superiority to other control tasks, and could be considered as interference-based methods that load the working memory (Tapper, 2018).

2.4.2 Interference

According to the EIT, the craving requires cognitive resources (attention and working memory) for the elaboration of desire thoughts (Andrade, May, et al., 2012; Kavanagh et al., 2005; May et al., 2015). This assumption has been supported by research that used imagery

scripts, substance deprivation, cue exposure, or a combination of those approaches in order to elicit craving during other tasks (Kemps & Tiggemann, 2013a). Alcohol, cigarettes, food, and drugs craving increased reaction time (Cepeda-Benito & Tiffany, 1996; Green et al., 2000; Hillebrand, 2000; Sayette et al., 1994; Sayette & Hufford, 1994) and disrupt performance on working memory tasks (Madden & Zwaan, 2001; visuospatial working memory, Kemps, Tiggemann, & Grigg, 2008; Tiggemann et al., 2010). Conversely, if an individual craving for a substance or food voluntarily focuses on another competing task, moving resources allocated to the elaboration process (thick arrows in Figure 3) toward this task, the vividness of desire thoughts is supposed to decrease, and the experience should fade and become more bearable (May et al., 2008; van Dillen et al., 2013; van Dillen & van Steenbergen, 2018).

A large range of methods based on this interference principle have been tested across various substances, populations, and settings (induced, naturally occurring, real world) and proved relevant to reduce craving. Tasks involving visuospatial sketchpad were of particular interest as they are expected to be more effective, given the frequent and vivid report of participant of visual images[2] (unpublished analyses; May et al., 2014). *Dynamic visual noise* (random black and white dots flickering; Quinn & McConnell, 1996) reduced the intensity and vividness of craving for food (Kemps et al., 2004; Kemps, Tiggemann, & Christianson, 2008; Kemps & Tiggemann, 2013c; McClelland et al., 2006; Steel et al., 2006) and chocolate (Kemps et al., 2005). Several studies have shown the relevance of *visual imagery* to mitigate craving for food or drink (Hsu et al., 2014; Kemps & Tiggemann, 2007; Knäuper et al., 2011; Schumacher et al., 2018; Hamilton et al., 2013 for multi-sensory imagery), coffee (Kemps & Tiggemann, 2009); chocolate (Schumacher et al., 2017), and cigarette (May, Andrade, Panabokke, et al., 2010; Versland & Rosenberg, 2007). *Clay modeling* task also demonstrated effectiveness to reduce cigarette (May, Andrade, Panabokke, et al., 2010) and chocolate (Andrade, Pears, et al., 2012). The *video game Tetris* reduced craving for food, drink, caffeine, nicotine, drugs, alcohol use, and other activities (Dodds et al., 2019; Skorka-Brown et al., 2014, 2015; van Dillen & Andrade, 2016).

Other studies have investigated the impact of methods involving other sensorial modalities. *Olfactory imagery* decreased craving for cigarette (Versland & Rosenberg, 2007), coffee (Kemps & Tiggemann, 2009) and food (Kemps & Tiggemann, 2007) and *olfactory cues* were useful to reduce cigarette (Sayette et al., 2019) and food (Kemps & Tiggemann, 2013b) craving. *Auditory imagery* was also tested but no evidence showed that such task reduced craving (e.g., Kemps & Tiggemann, 2007; May, Andrade, Panabokke, et al., 2010).

[2] To compare the relevance of the sensorial modalities involved in craving, we asked for the database used to validate the Craving Experience Questionnaire (May et al., 2014). Each subset of data (different substances, timeframes, and studies) was considered separately. Paired-sample *t*-tests were used to compare, for both strength and frequency forms, the visuospatial (picture) items to the other (taste, smell, mouth sensation, and body sensation) items from the imagery subscales. Results show that the taste items are frequently rated higher than the picture items but that the latter are almost always rated as equal or superior to smell, mouth, and body items.

Tasks targeting the phonological loop were also examined, even if frequently used as control tasks. *Irrelevant speech* (audio recording of a foreign talk) which loads the phonological loop was found effective on chocolate craving (Kemps et al., 2005). *Backward alphabet and counting* reduce food, drink and chocolate craving (Andrade, Pears, et al., 2012; Knäuper et al., 2011), but to a lesser extent than tasks involving visuospatial processes. The *digit span* task (writing an auditory sequence of numbers) also reduced food, drink, nicotine, alcohol and unspecified craving (Dodds et al., 2019; van Dillen et al., 2013).

3. Gambling Craving

Gambling craving (for related constructs, see section 2.1) has received growing interest in the past 20 years. It is considered an important factor involved in maintenance, relapse, and treatment drop-outs related to gambling disorder (Ashrafioun, Kostek, et al., 2013; Hodgins & el-Guebaly, 2004; Oakes et al., 2012; Oei & Gordon, 2008; Smith et al., 2010, 2015; Smith, Pols, et al., 2013; Young & Wohl, 2009). Important models have also included this process in the mechanisms explaining gambling disorder (Blaszczynski & Nower, 2002; Sharpe, 2002). According to existing research, gambling craving should be a target for treatment and can be used to evaluate the effectiveness of gambling treatments (Caler et al., 2016; Hormes, 2017; Pickering et al., 2018). Brain imaging studies also showed similar activation for craving related to substance and to gambling (Kober et al., 2016; van Holst et al., 2010b). Using adapted questionnaires from the substance use field, the literature has compared self-reported craving between gambling and cocaine or alcohol. The results surprisingly indicated stronger craving among people with a gambling disorder than those with a substance use disorder (Castellani & Rugle, 1995; de Castro et al., 2007; Tavares et al., 2005).

Despite the mentioned evidence and the inclusion of craving as a diagnostic criterion across addictive disorders in DSM-5 (American Psychiatric Association, 2013), craving was not included as such for gambling disorder as it is still uncertain whether craving is essential in the diagnosis of gambling disorder (Rash et al., 2016).

3.1 Conceptualization

In their review of methods to evaluate gambling craving, Ashrafioun and Rosenberg (2012) report several definitions of the phenomenon. For instance, gambling craving is described as a "temptation" to gamble (Holub et al., 2005) or a motivation to seek for specific objects or feelings (Raylu & Oei, 2004b), or a desire for pleasure, and relief from withdrawal and negative affect (Young & Wohl, 2009). This state perspective is generally studied by eliciting craving with cue exposure, imagery (Ashrafioun et al., 2012), and virtual reality (C.-B. Park et al., 2015) as most of the research on gambling takes place in laboratories (Dickinson et al., 2020). Gambling craving is also conceptualized as a more stable (trait) preoccupation or inclination (Pallanti et al., 2005; Rousseau et al., 2002).

These definitions of a gambling craving have systematically resulted in the development of measurement scales. The authors either define craving with a synonym (i.e., temptation or passion) or are based on instruments developed in the field of substance use, with an a priori transferability. Transposing the conception of substance craving to gambling via a confirmatory approach may neglect its specific aspects and add irrelevant factors in the construct (Billieux et al., 2015; Kardefelt-Winther et al., 2017). This may susceptible to hinder the understanding, the measurement, and the management of gambling craving.

Several experiences are also considered to be part of gambling craving: intrusive thoughts and sensory images, bias toward gambling cues, positive and negative expectations, self-awareness, overt behaviour, and psychophysiological reactions such as heartrate, respiration, muscular tension, brain activity (Ashrafioun & Rosenberg, 2012). Regarding the neurophysiological aspects of gambling craving, Goudriaan et al. (2019) highlight activation of neural substrates similar to those found for substances (i.e., frontal brain and limbic parahippocampal areas, amygdala, and occipital lobe).

Although craving models frequently claim transdiagnostic properties, leading to mechanical transposition to gambling, to date, no theory has been validated to account for gambling craving.

3.2 Assessment

Several procedures have been designed to evaluate gambling craving (or related notions such as urge, temptation, passion, etc.), mainly inspired or adapted from the substance use field (for a review, see Ashrafioun & Rosenberg, 2012).

3.2.1 Non-verbal and proxy measurements

Non-verbal and proxy evaluation of craving allow to avoid potential biases related to self-completion (e.g., social desirability) and are less susceptible to be manipulated. Here is a list of methods that can be considered to evaluate gambling craving

- Psychophysiological measurements:

Physiological reactions, such as heart rate, skin conductance, and electromyography, have been investigated as proxies of gambling craving. The difficulty of determining which type of reactivity makes it possible to distinguish between problem gamblers and non-problematic gamblers and the low practicability of such measures in situ make the use of these techniques uncertain.

Other means to evaluate brain activity were studied as potential measurement of gambling craving. The late positive potential, captured via electroencephalogram, increased during exposure to gambling stimuli, in line with craving (Wölfling et al., 2011). But this inflation was not specific to gambling cues. Regarding the functional magnetic resonance imaging, although used by Potenza et al. (2003), results from this type of study remain difficult to interpret because of the several potential reactions elicited complex stimuli (van Holst et al., 2010b).

- Reaction time tasks

Slower reaction time in tasks involving attention (Stroop, lexical salience, dot-probe) may indicate attentional biases, and gambling craving (e.g., Boyer & Dickerson, 2003; Zack & Poulos, 2004). However, other processes (e.g., emotions or memories intrusion) may also explain the delayed reaction time. Some procedures may also involve what can be considered as subtle cues and elicit gambling craving instead of indicating an experience.

Although these procedures can be used in addition to self-reported questionnaires, they require further investigation and demonstration to be used as gambling craving proxies.

3.2.2 Self-reported questionnaires

Self-report questionnaires are a common way to assess gambling craving. They can be easily and quickly administered, do not require training or specific material, and have good face validity.

3.2.2.1 Single item scales

Gambling craving is frequently assessed using one single item with visual analogue scales (e.g., from 1 = *no urge to gamble* to 5 = *extreme urge to gamble*; Kushner et al., 2008; from 0 = *no urge* to 10 = *extreme urge*; Sodano & Wulfert, 2010). This very handy method allows quick answering and scoring, repeated assessment and sensibility to rapid fluctuations (McCormack et al., 1988). It fails, though, to apprehend the complexity of and the mechanisms (emotions, cognitions, sensations) involved in the gambling craving experience (Ashrafioun & Rosenberg, 2012; Navas et al., 2019; Young & Wohl, 2009).

3.2.2.2 Multi-item scales

In their review, Ashrafioun and Rosenberg (2012) reported the existence of seven multi-item questionnaires that evaluate craving and related constructs (e.g., urge, passion, temptation); they are dispatched into 3 categories: subjective experience of gambling craving (a; four questionnaires), temptation to gamble (b; one questionnaire), and inclination or passion to gamble (c; two questionnaires). These tools, presented in Table 5, are mainly adaptation of scales from the substance use disorder field. The authors also propose four other measurements that include items about the craving experience. Nevertheless, as they were designed for other purposes and as they do not focus on the subjective craving, they will not be introduced in this work.

Based on the Weiss Craving Scale (Weiss et al., 1995), the Gambling Urges questionnaire (Elman et al., 2010) comprises six items about desire in the last 24 hours (e.g., “Please rate how strong your desire was to gambling during the last 24 hours”), resistance today, probability to gamble next week, probability to gamble today if in gambling environment, and cued urge. The variety of timeframes and aspects of this assessment tool makes it a confounding tool, though.

The Penn Gambling Craving Scale (de Castro et al., 2007; Tavares et al., 2005), an adaptation of the PACS (Flannery et al., 1999), was created to compare alcohol and gambling

craving with equivalent scales. This tool includes five items measuring frequency (e.g., “How often have you thought about gambling or about how good gambling would make you feel during the past seven days?”) and intensity (e.g., “How difficult would it have been to resist gambling during this period of time if you had the chance to do so?”).

The Gambling Urge Scale (Raylu & Oei, 2004b) derives from the Alcohol Urge Questionnaire (Bohn et al., 1995). Two items were removed from the initial eight because of factor loadings. The six remaining items (e.g., “All I want to do know is to gamble”) allowed to distinguish between problem and non-problem gamblers and showed good psychometric properties (Ashrafioun, Rosenberg, et al., 2013); they offer a rapid single-score measurement of gambling craving.

These three questionnaires are short and useful in clinical and research frames but their psychometric properties (e.g., predictive validity and construct validity) must be further investigated. Moreover, their monofactorial structure may fail to address underlying components of gambling craving.

The Gambling Craving Scale (GACS; Young & Wohl, 2009) is composed of nine items spread over three subscales: anticipation (e.g., “Gambling would be fun right now”), desire (e.g., “I crave gambling right now”) and relief (e.g., “If I were gambling now, I could think more clearly”). It relies on the same theoretical framework as the QSU (Tiffany & Drobes, 1991) that measures the anticipation of pleasure and relief from withdrawal and negative affect. The scores were related to other gambling constructs (e.g., severity, cognitions), providing evidence for criterion and construct validity of the subscales. However, the validation of this scale was conducted among community gamblers and did not imply gambling craving induction, like previous scales.

The Temptations for Gambling Questionnaire (Holub et al., 2005) is an original scale developed to assess the level of temptation in 21 situations including negative affect (e.g., “feeling angry or frustrated because of my relationship with someone else”), positive mood (e.g., “being in a positive mood), money/chasing (e.g., “wanting to win”), and social factors (e.g., “someone invited me to gamble”). It is unclear though if respondents must evaluate anticipated or recalled temptation. Besides, the item seems to reflect craving triggers rather than craving itself.

The previous questionnaires considered gambling craving as a transient state. The next two measurements address the concept as a more stable (i.e., trait) dimension.

Inspired by the YBOCS (Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989) and the YBOCS-hd (Fedoroff et al., 1999), the Pathological Gambling YBOCS (Pallanti et al., 2005) measure two aspects of craving: obsession (e.g., “How much of your time is occupied by urges/thoughts related to gambling and/or gambling-related activities? How frequently does this occur?”) and compulsion (e.g., “How much of an effort do you make to resist these activities?”). Despite good psychometrical properties, and correlations with gambling symptoms and treatment outcomes, the inclusion of two questions in one item may be confusing for the respondent and can complicate the interpretation.

Table 5. Presentation of multi-item self-report gambling craving questionnaires

Name of scale **Authors (year)**	**Category; derived from**	**Number of items; subscales**	**Timeframe; response format**
Gambling Urges Questionnaire (GUQ) Elman et al. (2010)	Subjective experience; Weiss Craving Questionnaire (Weiss et al., 1995)	6; none	Variable; 11 item-specific choices on a Likert scale from 0 to 10
Temptation for Gambling Questionnaire (TGQ) Holub et al. (2005)	Temptation; Not derived from a substance use disorder scale	21; negative affect, positive mood/impulsivity, seeking wins or money, and social factors	Usual; 6-point Likert scale from 0 *(not at all tempted*) to 5 (*extremely tempted*)
Pathological Gambling-Yale Brown Obsessive-Compulsive Scale (PG-YBOCS) Pallanti et al. (2005)	Inclination or Passion; Yale-Brown Obsessive-Compulsive Scale for heavy drinkers (Fedoroff et al., 1999)	10; gambling thoughts/urge and gambling related behaviours	Set period; 5-point Likert scale from 0 *(*least severe response) to 4 (most severe response)
Gambling Urge Scale (GUS) Raylu & Oei (2004b)	Subjective experience; Alcohol Urge Questionnaire (Bohn et al., 1995)	6; none	Present; 8-point Likert scale from 0 *(completely disagree*) to 7 (*completely agree*)
Gambling Passions Scale (GPS) Rousseau et al. (2002)	Inclination or Passion ; Passions Scale (Vallerand et al., 2003)	10; obsessive passions and harmonious passions	Usual; 7-point Likert scale from 1 (*not agree at all*) to 7 (*very strongly agree*)
Penn Gambling Craving Scale Tavares et al. (2005)	Subjective experience; Penn Alcohol Craving Scale (Flannery et al., 1999)	5; none	Past week; 7 item-specific choices on a Likert scale from 0 to 6
Gambling Craving Scale (GACS) Young & Wohl (2009)	Subjective experience; Questionnaire of Smoking Urges (Tiffany & Drobes, 1991)	9; anticipation, desire, relief	Present; 4-point Likert scale from 1 *(never*) to 4 (*almost always*)

Note: Adapted from Ashrafioun and Rosenberg (2012).

The Passion Scale (Vallerand et al., 2003) is a 14-item assessment tool to evaluate two types of passion: obsessive (i.e., oppressing feeling that forces a person to behave in a certain way) and harmonious (i.e., motivational impulse to freely practice an activity). The Gambling Passion Scale (Rousseau et al., 2002) is an adaptation of this scale to gambling, resulting in a 10-item scale with five obsession statements (e.g., "I am emotionally dependent on this gambling game") and five harmonious statements (e.g., "This gambling game allows me to

live a variety of experiences"). Again, the scale possesses good properties but some studies have questioned the distinction between the two subscales (e.g., Castelda et al., 2007; Skitch & Hodgins, 2005).

The variety of scales again reflects the lack of consensus and the confusion regarding gambling craving, in line with its definition. No questionnaire has shown superiority compared to the others and the choice should depend on the aims of the study. Another possibility would be to create or adapt a scale relying on a validated conceptualization of gambling craving.

3.2.2.3 Other scales measuring gambling disorder that include craving items

Ashrafioun and Rosenbergh (2012) also described four tools related to gambling that include items referring to craving: the Scale of Gambling Choices (three items out of 18; Baron et al., 1995), a questionnaire about gambling (three dichotomous items out of 68; Duvarci & Varan, 2000), the 12-item revised Gambling Symptom Assessment Scale (four items out of 12; S. W. Kim et al., 2001) and the Gambling Related Cognitions Scale (five items out of 23; Raylu & Oei, 2004a). As they were developed for purposes other than measuring gambling craving, these questionnaires are not further presented here.

3.3 Intervention

Craving should also be a treatment target for behavioural addictions, including gambling disorder (Christensen, 2018; Hormes, 2017; S. W. Kim & Grant, 2001). Several methods have been tested specifically to address gambling craving. *Imaginal desensitization* combines relaxation technique with cue-exposure in imagery to reduce gambling craving by habituation and by replacing the urge associated to triggers with a state of relaxation (Blaszczynski & Nower, 2014; Delfabbro, 2014; O'Neill, 2017). Several studies have shown good results on problem gambling, even on the long term (from six months to five years; Dowling et al., 2007; McConaghy et al., 1991). The study conducted by Grant et al. (2009) compared the effect of combined imaginal desensitization and motivational interviewing (to prevent drop out) and gamblers anonymous on gambling urge. They found a significant reduction of urge after the 8-week imaginal desensitization and motivational interviewing program, but not in the gamblers anonymous group. *In vivo desensitization* was developed in order to treat patients unable to use imagery and to prevent avoidance. It decreased problem gambling 6 months after treatment (Battersby et al., 2008) but the drop-out rate was quite important (Delfabbro, 2014). Pharmacotherapy, and more specifically the use of *opioid antagonists*, appears to be effective on gambling disorder by decreasing craving. But the absence of a placebo control group in some studies depleted these results (Christensen, 2018). As in the field of substances, non-invasive *brain stimulation* (i.e., transcranial magnetic stimulation) was tested on cue-induced gambling craving with mixed results on the impact of a single session (Gay et al., 2017; Sauvaget et al., 2018). Based on research conducted among substances, Spagnolo et al. (2019) point interesting perspectives for the use of such techniques on gambling craving and the need for further studies.

In line with the interventions presented in relation with substances (see section 2.4), we present the available information on mindfulness and interference interventions that target gambling craving.

3.3.1 Mindfulness

The investigation of mindfulness-based interventions on gambling is in its infancy but studies have shown promising results on craving. For example, Toneatto et al. (2007) conducted a case study on a patient and added mindfulness meditation to the usual treatment. He became more aware of what was leading him to gamble and adopted a curious attitude toward gambling thoughts, resulting in decreased craving. Similar results were presented in another study (de Lisle et al., 2011) that presented a case of an individual who managed, after a mindfulness training, to refrain from gambling despite craving. Other research found a significant negative relation between gambling craving and mindfulness competences (de Lisle et al., 2014; McKeith et al., 2017), suggesting that this expertise may decrease the intensity of gambling craving. To further evaluate the effect of mindfulness on gambling craving, a group that went through five sessions of mindfulness and cognitive therapy was compared to a group on waiting list (Toneatto et al., 2014). A reduction of gambling severity and craving was noticed in the experimental group and continued after three months. Maynard et al. (2018) conducted a systematic review and meta-analysis on mindfulness-based intervention implemented in the treatment of gambling disorder between 1980 and 2014. They found four studies that included craving as a variable; these indicated positive, moderate, and statistically significant treatment effect. Shead et al. (2019) demonstrated that daily practice of 10-minutes mindfulness for a week significantly decreased gambling craving, contrary to an audiobook listening control condition. Finally, a recent study (Melero Ventola et al., 2020) compared mutual-aid and mindfulness-based cognitive therapy programs successively administered in group. The mindfulness treatment significantly improved mindfulness abilities and diminished craving intensity and frequency with persistence of low scores after six months.

Research about the potential of mindfulness-based interventions on gambling and gambling craving is blooming. All authors agree that more research is needed to understand the processes at stake and to evaluate brief methods and longer programs involving mindfulness.

3.3.2 Interference

To the best of our knowledge and according to O'Neill (2017), no study has yet explored the properties of interference-based methods on gambling craving, despite successful trials on food- and substance-related craving (see section 2.4.2).

4. Aims and research project

Gambling craving has received growing interest in research and clinical practice. However, it was systematically studied by recycling theories developed in the substance use

field using a questionable confirmatory approach. The aim of the current thesis, which uses the EIT as the main theoretical framework, is threefold (see Figure 4): to tackle the *conceptualization* of gambling craving (axis 1), to improve the *assessment* of craving (axis 2), and to test an *intervention* method directly based on the EIT (axis 3).

4.1 Axis 1: Conceptualization (Study 1)

Because the phenomenology of gambling craving was never analysed in relation to dominant gambling craving models, we decided to conduct a mixed methods study (Study 1) among non-clinical gamblers. The qualitative exploration and the thematic analysis of the data allowed to widen our vision of the triggers and the experience of gambling craving, while the quantitative measurements and descriptive analyses identified its most important aspects. These results were put into perspective with the EIT (Kavanagh et al., 2005; May et al., 2015), a cognitive model of craving that is well-established in the field of substances.

4.2 Axis 2: Assessment (Studies 2 and 3)

Several tools have been developed to assess gambling craving. We have adopted a dual approach in order to investigate, on the one hand, the properties of a multi-factorial scale widely used in the field and based on the GACS (Study 2; Young & Wohl, 2009), and, on the other hand, to adapt to gambling and validate a scale developed based on the EIT, the CEQ (Study 3; May et al., 2014). Both tools were completed by community gamblers after a craving induction procedure, which insured that gambling craving was evaluated as a state. Confirmatory (and exploratory for the GACS) factor analyses were used to establish the structure of each questionnaire, and correlations with gambling-related constructs provided information on the construct validity. Their respective measurement target and complementarity were also discussed.

4.3 Axis 3: Intervention (Studies 4 [2 experiments] and 5 [study protocol])

Gambling craving has been identified as an important treatment target for gambling disorder. Interference-based methods are interventions based on the EIT that capture the cognitive resources allocated to craving in order to block the elaboration of intrusive thoughts. Such methods were proven effective to reduce craving in the field of substance and they were, to the best of our knowledge, never tested on gambling craving. As a result, it appeared crucial to probe the impact of interference involving the visuospatial sketchpad on gambling craving. We conducted two experiments (Study 4) to verify the properties of such tasks on induced gambling craving. The superiority of visuospatial tasks compared to interference involving other subcomponents of the working memory (e.g., verbal and auditory; May, Andrade, Panabokke, et al., 2010) was also tested by comparing visuospatial (i.e., mentally picturing a bunch of keys and playing the video game Tetris) to non-visuospatial (i.e., respectively counting cadenced bubble wrap explosion and backwards counting) types of interference. Finally, we described a study protocol related to a multiple single-case study (Study 5 in preparation) that aims to investigate interference-based

techniques in a sample of clinical gamblers, using ecological momentary assessment and intervention, in order to explore their effect in a real clinical setting.

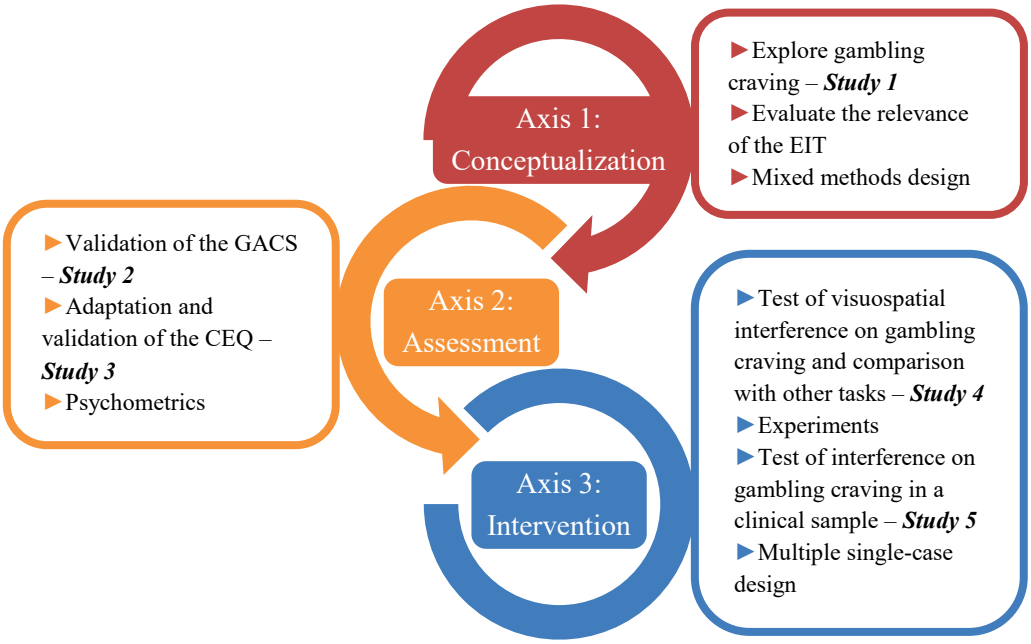

Figure 4. Summary of the research plan of the present PhD thesis

Chapter 2

Exploring gambling craving through the Elaborated Intrusion Theory of desire: A mixed methods approach

Gambling disorder is a well-established behavioural addiction, which was classified with substance-related disorders in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders. Although craving was introduced as a new diagnostic criterion for substance-related disorders, it was not included for gambling disorder. This study aimed to explore the experience of gambling craving and to evaluate whether the elaborated intrusion theory of desire (EIT), a cognitive model of craving, fits gambling craving. A mixed methods study was conducted among 31 non-clinical gamblers. The qualitative part consisted of open-ended questions targeting the components of the EIT. The quantitative part consisted of a questionnaire designed to assess triggers and descriptions of gambling craving. Qualitative analysis revealed six distinct conceptual categories related to gambling craving: positive and negative affect, external cues, mental imageries, thoughts and physiological sensations. The quantitative analysis highlighted the most relevant triggers (e.g., spontaneous thoughts) and experiential characteristics (e.g., visual imagery) of gambling craving. The present study allowed the authors to support the relevance of the EIT as it applies to gambling craving by disentangling its core features. Findings from this study suggest that the use of interventions derived from the EIT may be relevant for problem gambling treatment.

Reference : Cornil, A., Lopez-Fernandez, O., Devos, G., de Timary, P., Goudriaan, A. E., & Billieux, J. (2018). Exploring gambling craving through the elaborated intrusion theory of desire: A mixed methods approach. *International Gambling Studies*, *18*(1), 1-21. https://doi.org/10.1080/14459795.2017.1368686

Exploring gambling craving through the Elaborated Intrusion Theory of desire: A mixed methods approach

1. Introduction

Gambling disorder is a well-established behavioural addiction and nowadays constitutes a recognized public health issue. Gambling disorder has an estimated prevalence around 1.5% in the adult population (Gowing et al., 2015; Williams, Volberg, et al., 2012), yet important national differences exist (Hodgins et al., 2011). Originally, pathological gambling was included as an impulse control disorder in previous editions of the Diagnostic and Statistical Manual of Mental Disorders (3rd ed., DSM-III, and 4th ed., text rev., DSM-IV-TR; American Psychiatric Association, 1980, 2000). It was renamed as gambling disorder in the fifth edition of the manual (DSM-5; American Psychiatric Association, 2013) and aligned with the substance-related and addictive disorder category. This amendment was due to the accumulation of evidence emphasizing similarities with substance use disorders, such as similar neurobiological and cognitive impairments and shared psychosocial risk factors (e.g., Clark, 2010; Goudriaan et al., 2006; Potenza, 2006). Craving as a diagnostic criterion was for the first time included in the DSM-5 to define substance-related disorders (Romanczuk-Seiferth et al., 2014) on the basis of behavioural, imaging, pharmacological, and genetic evidence (Hasin et al., 2013). Craving was not included as a criterion of gambling disorder, which constitutes a striking difference from substance-related disorders, because the question of whether craving is central to the diagnosis of gambling disorder remains to date unanswered (Rash et al., 2016).

1.1 Gambling Craving

In past years, the study of gambling craving has received a growing interest. Initial evidence was gathered by adapting questionnaires developed to assess alcohol craving for gambling craving (de Castro et al., 2007; Tavares et al., 2005). Using this approach, these studies demonstrated that both alcohol and gambling craving correlate with negative affect, whereas only gambling craving was found to be associated with positive affect. The relation between negative affect and gambling craving is in accordance with the cognitive behavioural model of gambling disorder formulated by Sharpe (2002), which posits that gamblers characterized by maladaptive coping strategies are more prone to experience adverse emotional states promoting craving episodes. It has also been suggested by Ladouceur et al. (2007) that gambling craving persists over time and has a long-term impact, based on data highlighting that the majority of a sample of self-excluded casino gamblers still felt craving 6 months after being excluded from gambling. Another study by de Castro and colleagues (2007) found that the self-reported subjective intensity of craving was equivalent, and in certain cases even more pronounced, in pathological gamblers versus patients with an alcohol

use disorder. Along the same lines, recent studies have demonstrated that the cerebral activity observed during substance and gambling craving episodes (provoked via cue exposure) presented striking similarities (van Holst et al., 2010a).

Several instruments have been developed in recent years to assess gambling craving, most of them being inspired or adapted from questionnaires measuring craving for psychoactive substances. Among existing measures, some are unidimensional (e.g., Gambling Urge Questionnaire; Elman et al., 2010; Gambling Urge Scale; Raylu & Oei, 2004b; Penn Gambling Craving Scale; Tavares et al., 2005), whereas others comprise different subscales and distinguish between various dimensions of craving. For example, the Gambling Craving Scale (Young & Wohl, 2009) separately assesses Desire (urgent desire), Anticipation (of positive affect) and Relief (from negative affect). Considering gambling disorder as a condition within the spectrum of obsessive and compulsive disorders, Pallanti and colleagues (2005) adapted the Yale-Brown Obsessive-Compulsive Scale to measure, on the one hand, gambling-related thoughts and craving and, on the other hand, gambling-related behaviours.

According to Grant et al. (2010), a core characteristic of behavioural addictions consists in the inability to inhibit harmful behaviours (such as gambling) that are triggered by craving episodes. This assumption is in line with theoretical (Blaszczynski & Nower, 2002; Sharpe, 2002) and empirical (e.g., Ashrafioun, Kostek, et al., 2013; Raylu & Oei, 2004b; Young & Wohl, 2009) evidence that craving is a key factor involved in the development, maintenance, and relapse of gambling disorder, similar to what was demonstrated in relation to substance use disorders. Furthermore, Hormes (2017) recently advocated for retaining craving as a diagnostic criterion in behavioural addictions, on the basis of a corpus of data emphasizing that craving is a reliable index to differentiate between normal and pathological appetitive behaviours and that intensity of craving correlates with functional impairment in the context of gambling disorder. Nonetheless, most existing gambling craving research is anchored within the biomedical approach of addiction and thus focuses on the physiological and cerebral similarities between gambling and substance-related disorders, rather than on the potential unique features of gambling craving (e.g., van Holst et al., 2010a). Thus, studies offering an in-depth exploration of the psychological processes (e.g., cognitive, affective or motivational) involved in the onset and continuation of gambling craving are lacking. Actually, it appears that most research conducted in the field a priori transposes what is known about substance craving and applies this to gambling craving, from scale development to hypothesis testing (for a critical discussion, see Billieux et al., 2015; Kardefelt-Winther et al., 2017). A consequence of this "confirmatory bias" is that qualitative studies aiming at exploring the core features of gambling craving and related subjective experiences are lacking. This is unfortunate, as such studies could inform the field on potential unique aspects of gambling craving and thus participate in the refinement of gambling craving assessment and treatment.

1.2 The Elaborated Intrusion Theory of desire

Traditional models of craving define it as a motivational state characterized by an intense "urge to consume" a psychoactive substance (e.g., Baker et al., 1986; Marlatt, 1985b).

Cognitive models of craving challenged these theories. Among them, the elaborated intrusion theory of desire (EIT; Figure 5; Kavanagh et al., 2005) conceptualizes episodes of craving as high-level cognitive processes – or elaborations – recruiting mental imagery and executive (controlled) mechanisms. According to the EIT, craving and desire are not qualitatively distinct phenomena; rather, they constitute subjective psychological experiences of various intensity aligned on the same continuum, which can be linked to any potential hedonic or reinforcing activity or behaviour. Within the EIT, desire – or craving – is the result of an emotion-laden cognitive elaboration where a specific behaviour (e.g., eating, consuming a psychoactive substance), together with its anticipated consequences (e.g., pleasure, relief), overwhelm one's attentional focus (Kavanagh et al., 2005, 2013).

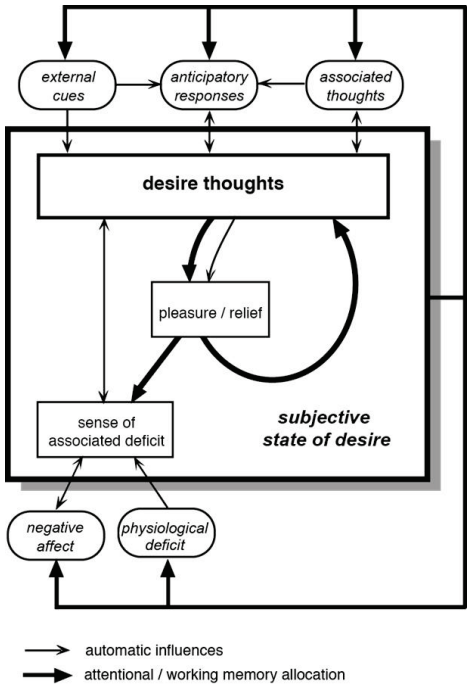

Figure 5. The elaborated intrusion theory of desire

Note. Adapted from "Imaginary Relish and Exquisite Torture: The Elaborated Intrusion Theory of Desire," by D. J. Kavanagh, J. Andrade and J. May, 2005, Psychological Review, 112(2), p. 448. Copyright 2005 by the American Psychological Association. Adapted with permission.

The EIT identifies five types of triggers that are susceptible to promote a subjective state of craving. External cues (1) are elements from the environment that have been associated (conditioned) with an implicated behaviour. Anticipatory responses (2) are physiological sensations (e.g., saliva, rumbling of stomach) that are not necessarily related to the incriminated behaviour, but that are interpreted in this way. Associated thoughts (3) are thoughts unrelated to the incriminated behaviour (e.g., task-unrelated intrusive thoughts, mind wandering, or episodic memory retrieval) that are prone to, attract the attention on the

incriminated behaviour through associative processes. According to the EIT, these three types of triggers promote desire thoughts, which consist in multi-sensorial cognitive elaborations about the desired object composed of mental imageries (e.g., mentally picturing a casino), thoughts (e.g., thinking how good it would be to gamble right now), and plans related to the satisfaction of the desire (e.g., planning to get money out of the cash point to gamble). The last two types of triggers, namely physiological deficits (4) and negative affect (5), are postulated to cause desire/craving through the mediation of a sense of associated deficit (i.e., the awareness of discomfort or a withdrawal state). Based on the EIT, desire thoughts allow one to voluntary and mentally feel the desired object, and thus have the function to either generate pleasure or relieve the discomfort caused by the sense of associated deficit. This however comes at a cost, as the cognitive elaborations sustaining desire thoughts are demanding in terms of cognitive resources (attentional processes and working memory).

Importantly, the EIT posits that a double retroactive loop (or vicious circle) is responsible for the acute subjective experience of desire – or craving – which ultimately promotes the compulsive/impulsive satisfaction of the desired object. The first vicious circle is explained by the positive and negative reinforcement value of the desire thoughts, whereas the second vicious circle is sustained by the fact that the object of desire is only fulfilled to a lesser extent (i.e., through mental imagery), which, through a counterfactual process (i.e., a comparison between the desired versus actual state), strengthens the sense of associated deficit and perpetuates desire thoughts, as previously described. The EIT is now a well-established theory in the field of substance use disorders (Caselli & Spada, 2015; May et al., 2015; Tiggemann & Kemps, 2005), which allows to disentangle the various psychological processes involved in craving episodes.

1.3 Current Study

Despite growing evidence suggesting that gambling and substance craving show physiological similarities and similarities in underlying brain functions (de Castro et al., 2007; Romanczuk-Seiferth et al., 2014; Tavares et al., 2005) craving was not retained in the DSM-5 to define gambling disorder. Research on the psychological aspects of gambling craving is thus warranted. Importantly, this research must be explorative in nature, because most previous studies adopted a confirmatory approach, following what is known about substance craving. To the best of our knowledge, no qualitative study has been conducted previously to explore the experience of gambling craving and consider it in the light of existing theoretical models of craving.

The first objective of the current study, therefore, was to provide a content analysis of the core features and characteristics of gambling craving, based on the framework of the EIT, which constitutes a sound theoretical rationale to account for the complexity and multi-determined nature of the psychological processes implicated. The second aim of this research was to further investigate the relevance of the EIT by assessing the weight of its components regarding gambling craving.

To reach these objectives, we recruited a sample of non-clinical gamblers from the community and conducted a mixed methods study with complementary purposes (Greene et al., 1989). This study had a sequential triangulation design (Creswell & Plano Clark, 2011; Morse, 1991) composed of two standalone data sets, one qualitative and one quantitative, that are analysed separately. In this approach, the results are combined for discussion in order to address one specific research topic. We adopted this research design because it allowed us to investigate gambling craving via two different and independent approaches, thus combining their strengths. In the present study, the qualitative part was conducted first and comprised open-ended questions covering the various components of the EIT in order to meet the first goal of this research and to examine gamblers' subjective representation of their craving experiences. Second, we collected the quantitative questions using a questionnaire developed by May and colleagues (2004) in order to assess triggers and components of gambling craving, the second objective of this research. This step consisted of the adaptation of a questionnaire that was created to measure the components of substance craving within the rationale provided by the EIT (May et al., 2004). Third, we crosschecked the qualitative results with the quantitative ones. In the final step, qualitative and quantitative data were conjointly considered to explore and describe the phenomenon of gambling craving.

2. Methods

2.1 Participants and Procedure

The study consisted of an online self-reported survey (hosted by Qualtrics) and was composed of three distinct sections: (1) the assessment of demographic and gambling related variables (type and frequency of gambling, symptoms of disordered gambling); (2) a set of qualitative questions developed to investigate the relevance of the EIT applied to gambling craving; and (3) a set of items (quantitative questions) targeting gambling craving. The sections were administered separately, in the mentioned order, and were parts of a broader longitudinal study. Other data not related to the current project are presented elsewhere.

Participants were regular gamblers from the community who volunteered to participate. Inclusion criteria were being aged 18 years and older, being fluent in French, and being involved in some form of gambling (at least twice a week at the moment of the study). Participants were recruited through advertisements (gambling houses in Brussels, news shops and other public places at the UCLouvain), snowballing techniques, and through distribution in social networks (e.g., research-related groups on Facebook).

Confidentiality of the participants was guaranteed, and no personal data was collected. Participants were identified by a personalized code of two letters and four numbers, signed an informed consent, and were paid 20€ for their participation. The study protocol was approved by the ethical committee of the Psychological Sciences Research Institute of the UCLouvain. This study is part of a larger longitudinal research project on gambling, and other data not related to the current project are presented elsewhere.

A total of 31 regular gamblers (21 males), aged from 19 to 37 years (M = 22.65, SD = 3.31), took part in the study. Most of the participants were students at the time of the experiment (n = 28). All but one participant indicated being involved in more than one gambling activity. The gambling activities reported were the following: scratch cards (n = 28), lotteries (n = 25), poker (n = 17), bets (n = 14), online poker (n = 8), slot machines (n = 5) and others (roulette, casino, electronic gambling machines; n = 5). Symptoms of disordered gambling were assessed via the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001), which is a widely used screening test composed of nine continuous items based on experiences of the past 12 months. This questionnaire allows classification of gamblers into categories related to the severity of their symptoms, according to defined cut-offs. Twenty-one (68% of the sample) had a score equal or higher than 3 on the PGSI, indicating probable at-risk gambling associated with negative consequences to some extent. Among them, eleven participants (35% of the sample) had a score equal or higher than 8, indicating probable gambling disorder. It is worth noting that the elevated proportion of at-risk gamblers identified in the study sample is not surprising given that all recruited participants were highly involved gamblers.

2.2 Qualitative section

Nine questions were generated to explore the core features and characteristics of gambling craving (see Table 6) on the basis of the EIT. Themes covered by the questions mainly focused on craving triggers (e.g., external cues, physical sensations, emotional states) and related cognitive elaborations (e.g., mental imageries). Temporality was also considered, as some questions referred to emotional states and physical sensations that generally precede gambling (i.e., during the craving episode), whereas others referred to emotional states and physical sensations taking place while gambling or after having gambled. This approach was used to distinguish between craving versus gambling-related emotional states and physical sensations. In order to cover aspects that previous questions might have neglected, we added an additional non-mandatory question for participants who wanted to add or specify some elements or details regarding their gambling craving.

2.3 Quantitative section

The quantitative section consisted of the adaptation of a questionnaire developed to assess the component of the EIT related to substance craving (May et al., 2004)[1]. The questionnaire was adjusted to gambling and measured triggers (12 items) and characteristics (10 items) of gambling-related craving (see Table 7 for the specific items). In the current study, this questionnaire was used to determine whether the descriptors of gambling craving refute or support the EIT.

[1] The study by May et al. (2004) was conducted to compare the EIT to another theory explaining substance craving, the Cognitive Processing Model (Tiffany, 1990). The comparison of these theories was not relevant to our objectives in the present study. However, all items of the initial questionnaire were adapted in order to assess the components related to the EIT, as well as to challenge this model on aspects that it does not cover.

Table 6. Qualitative part of the study

Internal and external triggers
1. What are the thoughts and/or mental imageries that come to your mind and promote your desire to gamble? How do they appear?
2. When the desire to gamble occurs (before gambling), what emotions do you experience?
3. When the desire to gamble occurs (before gambling), what are the related body sensations or physical reactions?
4. Do environmental elements promote your desire to gamble or generate gambling-related thoughts? For example, an advertisement, a smell, the sound of coins…
Temporal aspects
5. What emotions do you experience while involved in gambling?
6. What types of body sensations or physical reactions do you experience while gambling?
7. What emotions do you experience after having been involved in gambling?
8. What types of body sensations or physical reactions do you experience after having been involved in gambling?
Additional question
9. What further information would you like to give us about your gambling craving? It might be a deepening of a question that has been asked or an element on which no question was raised but that you find interesting to mention.

Note. The open-ended questions were presented in the following order: 1, 2, 5, 6, 3, 7, 8, 4, 9.

The scale was translated to French as follows: (1) Two authors of this manuscript (AC and JB) translated the 22 items into French; (2) an English-French bilingual person translated the French version back into English; and (3) all discrepancies identified between the original English scale and the back translation were discussed until a satisfactory solution was found. Several items were adapted to target gambling rather than substance craving. First, three items that relate to smell and taste, relevant in the context of substance use but probably not in the context of gambling, were replaced by items related to the sense of touch, which we hypothesized is more relevant in the context of gambling (e.g., manipulating cards, dices, slot machines). Second, one item which originally addressed the availability of the substance was adapted to refer to the availability of gambling (see Table 7). All items were scored on a 5-point Likert scale ranging from 1 ("not at all") to 5 ("absolutely"). Due to technical failure, two participants did not complete the quantitative section of the study.

2.4 Data analytic strategy

2.4.1 Qualitative data analysis

Thematic analysis was used to create categories of answers by identifying 'themes which capture the most important patterns of meaning contained within the data (Willig, 2013, p. 57). Qualitative transcripts were indexed via NVivo 10 computer software and initial thematic analysis was conducted by the principal investigator (AC). Another author (OLF) verified and validated the findings and a third author (JB) supervised the whole process and added a layer of consensus. Regular discussions between AC and OLF resulted in the identification of themes based on data obtained with the open-ended questions (see Table 6). We relied on an in-depth analysis conducted by two distinct authors to reduce potential bias and overstatements. All qualitative data were classified into 44 themes (see Table 8: e.g., excitement, stress, advertisement, wealth/win, tension, activities), and a conceptual network

was created based on the occurrence (i.e., presence of a specific theme in the answers of a participant) of each identified theme (Hsieh & Shannon, 2005). In our qualitative analysis, we decided to focus on the occurrence rather than on the frequency (i.e., the number of times a specific theme is mentioned by a participant) of the themes. The rationale for this choice is that in qualitative research, frequency is generally considered a potentially biased variable, especially influenced by the participant's pre-existing knowledge about the phenomenon under investigation, and not necessarily representative of its importance for the participant (Willig, 2013). To support our qualitative data analysis, we systematically illustrated each identified theme with participant's quotes (see Table 8).

Table 7. Participant's answers on the quantitative questions, based on an adaptation of the questionnaire developed by May et al. (2004)

	Mean rating	Agreement percentage				
		1	2	3	4	5
What in general triggers your gambling craving?						
I suddenly think about it – spontaneous thoughts	3.3	3	14	41	28	14
I have nothing else to do / I am bored – boredom	3.1	17	3	38	38	3
I picture myself gambling – visual imagery	2.7	24	21	21	34	0
I feel happy – positive affect	2.5	24	28	21	28	0
Other things I am thinking about remind me of it – associated thoughts	2.4	24	31	24	21	0
I see the game / touch the game / hear sounds related to the game – external cues	2.1	38	28	21	10	3
I imagine the sensation of touching objects related to gambling – tactile imagery	1.9	62	3	21	10	3
I imagine the sounds related to the game – auditory imagery	1.7	66	14	10	7	3
I always gamble at a certain time / place – habit	1.7	59	21	17	3	0
I feel stressed / anxious / sad – negative affect	1.6	66	14	14	7	0
I am really busy – being busy	1.5	66	21	10	3	0
I feel hungry / thirsty / tired / physical discomfort – physiological deficit	1.3	79	14	3	3	0
Please describe your gambling craving when it occurs						
If I don't think about gambling, my craving will go away – distraction	2.7	31	10	21	31	7
I am visualising it – visual imagery	2.4	34	17	21	24	3
I am in a place where it is possible to gamble – context	2.4	31	21	24	21	3
Gambling would feel very comforting at that time – comfort expectation	2.2	38	24	24	10	3
I am imagining the touch sensations related to gambling – tactile imagery	2.1	48	10	21	21	0
I am thinking of how much better I will feel after I have gambled – thoughts about mood improvement	2.0	45	24	17	14	0
I am trying to resist gambling – self-control	2.0	45	24	21	10	0
I would feel more relaxed if I gambled – expectation of relaxation	1.9	52	17	17	14	0
I can hear myself gambling – auditory imagery	1.7	55	24	14	7	0
I want to gamble because I am hungry / thirsty or I feel tiredness / a physical discomfort – physiological deficit	1.2	79	17	3	0	0

Note. The items highlighted in grey do not fit with the Elaborated Intrusion Theory, according to the initial conceptualization by May et al. (2004). The Likert scale used for all items ranged from 1 ("not at all") to 5 ("absolutely"). The bold dashed lines represent the cut-off to consider an item as relevant.

Table 8. Qualitative thematic analysis of gambling craving triggers

Themes	Quotes	Percentage (n = 31)
Affect		**97%**
Positive		*81%*
Excitement	"I feel excitement" (06 M 20)	61%
Joy	"I feel euphoria and joy because I'm gonna win" (05 F 26)	39%
Confidence	"confidence" (01 M 22); "safety" (25 F 21)	6%
Negative		*48%*
Stress	"stress that I cannot get over till I've lost […] money" (02 M 23)	32%
Others [a]	"doubt" (26 M 22); "feeling of smallness" (15 M 23)	13%
Boredom	"boredom plays also a part in it" (28 M 21)	6%
Irritation	"I feel irritated towards the equipment [i.e., the computer]" (19 F 21)	6%
External Cues		**94%**
Advertisement	"the advertisement for sports betting sites" (01 M 22)	55%
Cues related to gambling/sport	"casino token" (15 M 23); "a football match" (11 M 23)	42%
Cues related to wealth	"the sight of the price of some things" (17 M 21)	26%
Sounds	"the sound of coins" (05 F 26); "casino sounds" (03 F 26)	19%
Hearing gambling-related words	"words specific to poker […] (raise, shove, fold, creep…)" (28 M 21)	19%
Gambling locations	"the places leading to gambling" (31 M 19)	16%
Others[b]	"the hour that the online poker tournament begin" (19 F 21)	16%
Specific events	"Friday 13th" (06 M 20); "big sport events" (12 M 21)	13%
TV shows	"poker television programs" (21 M 22)	6%
Images		**74%**
Wealth / Win	"I imagine the amount of money I could have" (08 M 24)	35%
Dream, realization, projection	"image of what I could do, live" (14 F 24)	26%
Gambling stuff	"the images are: cards, dices […] colours" (30 F 25)	23%
Others [c]	"about images, I'd say […] a glass of alcohol, men" (23 F 21)	13%
Gambling locations	"the image of a casino" (31 M 19)	10%
Thoughts		**65%**
Wealth / Win	"to be rich" (25 F 21); "thoughts of money" (18 M 20)	39%
Dream, realization, projection	"dreams coming true through money" (06 M 20)	23%
People	"the thought of this person" (02 M 23)	10%
Others [d]	'thoughts of victory, surpassing oneself' (04 M 37)	10%
Justification	"better spend money on it than on cigarettes" (07 M 21)	6%
Physiological Sensations		**48%**
No physiological sensation	*"I don't remember any specific body sensation" (15 M 23)*	*39%*
Tension	"clenched fist" (10 M 19)	19%
Twitch	"finger tapping on the table" (04 M 37)	16%
Body temperature change	"I feel like warmth" (05 F 26)	13%
Sweat	"sweat, hands a bit wet" (30 F 25)	10%
Heart rate acceleration	"palpitation" (23 F 21)	6%

Note. For each quote, the following information is reported in brackets: (1) identification number of the participant; (2) gender; and (3) age. Percentages reported concerned the entire sample.
[a] Smallness, Fear, Doubt; [b] Being with Friends, a Computer Screen, a Smell, the Hour; [c] Flash, Images of Joy, Colours, a Glass of Alcohol, a Specific Atmosphere; [d] Imprecise Thoughts, Victory.

2.4.2 Quantitative data analysis

The analysis of the answers obtained via the quantitative items was performed in accordance with the descriptive data analytic strategy proposed by May et al. (2004) to examine the relevance of various craving descriptors according to the EIT. Using the same analysis as May et al. (2004) is also necessary for comparison purposes. To this end, a cut-off was used to define relevant versus non-relevant descriptors, based on the 5-point Likert scale. More precisely, an item was considered non-relevant if (1) the lowest point of the Likert scale (answer = "not at all") was selected by at least 50% of the participants, and (2) the mean response score for that item was lower than 2. All items that passed this threshold were considered relevant.

3. Results

3.1 Qualitative results

3.1.1 Core features and characteristics of gambling craving

The qualitative data analytic process conducted highlighted the existence of five main themes that emerged from the analysis of the four questions addressing gambling craving triggers (questions 1 to 4) and the additional non-mandatory supplementary question (question 9). These themes were the following: (1) affect, (2) external cues, (3) mental imageries, (4) thoughts and (5) physiological sensations. It is worth noting that all answers were taken into account in the qualitative analysis process, even when a reply to one question (e.g., a participant reported 'boredom' in the space dedicated to the answer to question 4 about external cues) better fit another question ('boredom' was a better answer to question 2 about emotions). Figure 6 illustrates the proportion of participants who reported each main theme and Table 8 provides a comprehensive and exhaustive description of the themes and sub-themes identified, alongside with supportive quotes extracted from participant's responses. We created categories named "other" to group unique answers that cannot be linked to the identified sub-themes in order to ensure that the analysis was exhaustive.

As reported in Table 8, the qualitative data analysis revealed that affect is the most prevalent theme identified by the participants (97%), with positive affect being more frequently identified (81%) than negative affect (48%). Positive affect was generally related to constructs such as arousal, joy, or confidence, whereas negative affect was related to constructs such as stress, boredom or irritation. Another major theme identified pertains to external cues (94%), such as advertisement or gambling-related cues or words, wealth-related cues, gambling locations, or special events and TV shows. The majority of the participants also described that their gambling craving was associated with mental imageries (74%) or thoughts (65%) that largely concerned the same types of contents, such as wealth or wins, dream or realization, or gambling locations. Finally, physiological sensations were reported by almost half of the participants (48%), and included physical tension, twitch, body temperature fluctuation, sweat or heart rate acceleration. It is worth noting that a considerable

part of the sample (39%) indicated that physiological sensations were not present in gambling craving experiences.

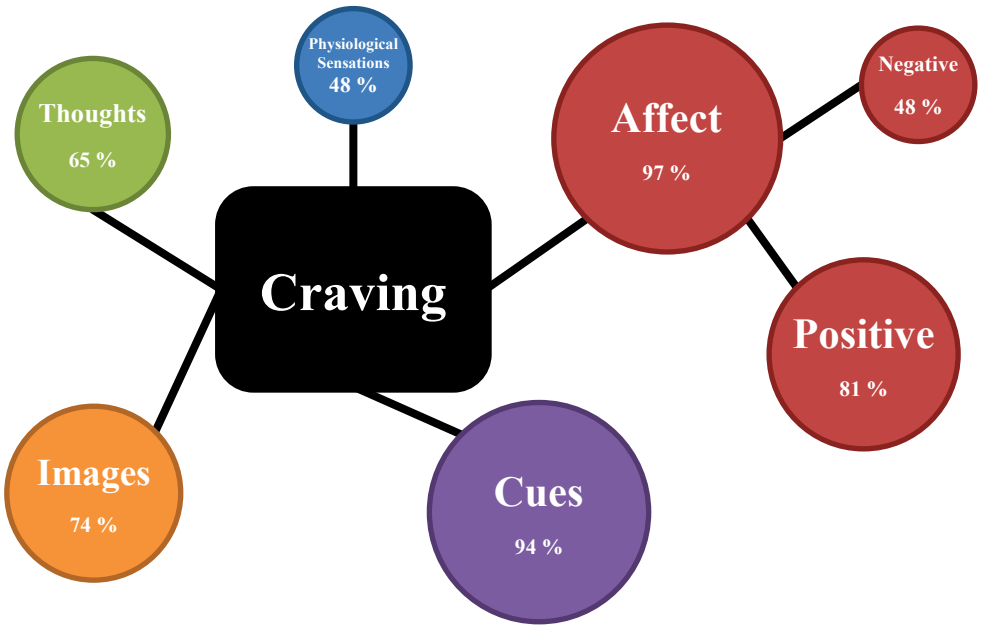

Figure 6. The core features of gambling craving

Note: The macro-themes generated from participants' answers to open-ended questions are reported in the circles. The size of the circles is proportional to the percentage of participants who mentioned each theme.

3.1.2 Temporality of emotional states and physiological sensations

The qualitative analysis revealed differential emotional states and physiological sensations before gambling (i.e., while experiencing craving), during gambling, and post-gambling (questions 2, 3 and 5 to 8, see Table 9).

Regarding emotional states, it appears first that positive affect is reported by the great majority of the participants before gambling (81%) and post-gambling (84%) but is slightly less prevalent during gambling (61%). Interestingly, an in-depth consideration of the type of affect reported revealed the special status of "excitement", which is generally reported before gambling (61%), diminished during gambling (26%), and quasi-absent post-gambling (6%). In contrast, joy seems more frequent post-gambling (65%) than before gambling (39%) or when actually gambling (26%). When it comes to negative affect, it appeared that approximately half of the participants (48%) reported negative affect before gambling, while this proportion increases during gambling (65%) and culminates post-gambling (84%). When looking at the type of negative affect reported, it appears that stress is frequently reported during gambling (52%), whereas irritation (35%) and disappointment (39%) are the most frequently reported negative affect characterizing post-gambling.

As described earlier, physiological sensations were not reported as frequently as other themes (e.g., affect, cues) by the participants. Nonetheless, an analysis of their temporality showed that physical sensations are less often reported by the participants pre-gambling (i.e., when the craving occurs; 48%) than when being involved in gambling (77%) or post-gambling (65%). An in-depth analysis of sub-themes highlighted more specific variations. Both tension and twitch are reported before gambling (respectively 19% and 16%) and increase in similar proportion during gambling (respectively 32% and 29%). In contrast, twitch totally disappears after gambling, whereas tension remains mentioned by a subpart of the participants (16%). Eventually, relaxation does not appear before or during gambling but only afterwards, and is frequently related to wins ("wellbeing and relaxation if win").

3.2 Quantitative results

According to the statistical approach applied by May et al. (2004), and as described earlier, an item was considered non-relevant if the lowest point of the Likert scale was selected by at least half of the sample and if the mean response score for that item was lower than 2 on the 5-point Likert scale. Each item that did not match these two conditions were considered relevant. Six triggers for craving were classified as relevant (external cues, associated thoughts, positive affect, visual imagery, boredom and spontaneous thoughts) and six triggers were classified as non-relevant (physiological deficit, being busy, negative affect, habit, auditory imagery and tactile imagery), see Table 7. Regarding craving characteristics, seven descriptors were classified as relevant (self-control, thoughts about mood improvement, tactile imagery, comfort expectation, context, visual imagery and distraction) and three descriptors were classified as non-relevant (physiological deficit, auditory imagery and expectation of relaxation). The results of the quantitative analysis are summarized in Table 7.

4. Discussion

Although gambling disorder has been aligned with substance-related and addictive disorders in the DSM-5 (American Psychiatric Association, 2013), a craving criterion was not included to define the condition. Research is thus warranted in order to test the relevance of established craving models in relation to gambling craving. The current study consists of a first qualitative and quantitative endeavour to explore the core features of gambling craving and to determine whether it can be conceptualized within the framework of the EIT, an empirically supported cognitive model of craving. On the whole, although the EIT was initially conceptualized to account for desire and craving related to psychoactive substances and food, the current study supports its relevance within the context of gambling as well. In addition, in consistency with previous findings by May and colleagues (2004), the EIT appears to be a valid cognitive model to account for craving episodes. In the next sections, we discuss the key themes identified (see Figure 6) based on the EIT (see Figure 5) and point out the arguments pro and con the suitability of the EIT to account for the subjective experience of gambling craving. The discussion conducted will also be fuelled by the cross-

checking of the qualitative and quantitative results. We also discuss how our findings open up promising avenues in terms of process-based psychological treatment.

Table 9. Temporality of emotional states and physical sensations

	Percentage (n = 31)		
	Before	During	After
Affect	**97%**	**90%**	**97%**
Positive	*81%*	*61%*	*84%*
Excitement	61%	26%	6%
Joy	39%	26%	65%
Confidence	6%	0%	0%
Pleasure	0%	13%	0%
Others	0%	6% [a]	6% [b]
Satisfaction	0%	0%	16%
Relief	0%	0%	10%
Relaxation	0%	0%	6%
Negative	*48%*	*65%*	*84%*
Stress	32%	52%	6%
Others	6% [c]	0%	13% [d]
Boredom	6%	3%	0%
Irritation	6%	23%	35%
Doubt	3%	6%	0%
Disappointment	0%	10%	39%
Despair - Sadness	0%	3%	13%
Guilt - Remorse	0%	0%	6%
Neutral	*0%*	*16%*	*0%*
Physiological Sensations	**48%**	**77%**	**65%**
No physiological sensation	*39%*	*16%*	*19%*
Tension	19%	32%	16%
Twitch	16%	29%	0%
Body temperature change	13%	6%	10%
Sweat	10%	6%	3%
Heart rate acceleration	6%	19%	3%
Others	0%	10% [e]	6% [f]
Headache	0%	6%	0%
Relaxation	0%	0%	26%
Tiredness	0%	0%	19%

Note. The themes in bold constitutes the main categories, those in italic, intermediate or alternate categories, and, in regular form, the detailed categories. Percentages reported concerned the entire sample (one individual represents 3.2% of the sample). The sub-themes highlighted in grey show noticeable report variations (at least 13%) of sub-themes mentioned by at least 25% of the sample either before, during, or after gambling.
[a] Feeling Well, Hope; [b] Feeling Well, Optimistic; [c] Smallness, Fear; [d] Disgust, Lost, Failure, Void Feelings; [e] Blurred Vision, Hunger, Bristly Hairs; [f] Shiver, Dynamic or Slow Activity

4.1 Affect

In accordance with the EIT theory, which posits the central role of affective states in triggering and perpetuating craving episodes (Kavanagh et al., 2005), our study identifies affect-related contents as being the most frequently reported theme. Similar to what is described in previous studies (e.g., de Castro et al., 2007; Schlauch et al., 2013), positive

affect seems an inherent feature of gambling craving. Indeed, the majority of the participants described that feelings of joy and excitement act as triggers with regard to their subjective experiences of gambling craving. This phenomenon is compatible with the EIT, which stipulates that pleasure and relief participate in reinforcing the cognitive elaborations underlying craving episodes (Kavanagh et al., 2005). Importantly, our analysis supports the view that positive affect per se can trigger gambling craving, which is not mentioned as such in the initial formulation of the EIT (see Figure 5). Indeed, the participants reported, both in the qualitative and quantitative questions, that positive affect (e.g., excitement, joy, feeling happy) is important in triggering their gambling craving.

In contrast, negative affect is described by less than half of the participants in the qualitative questions; in addition, from the quantitative analysis conducted, negative affect cannot be considered an important trigger of gambling craving in the current sample of recreational gamblers. Given the massive evidence supporting the role of negative affect in triggering gambling behaviours (Raylu & Oei, 2004b), this finding might seem counter-intuitive and could be attributed – at least in part – to the non-clinical nature of the study sample. Indeed, the participants in our study included recreational or at-risk gamblers, who probably did not fulfil many of the criteria for disordered gambling or display clinically relevant symptoms. Notably, however, when reconsidering the responses provided to the qualitative questions, recreational and at-risk gamblers both appear to have reported negative affect as a potential trigger of craving, confirming the continuum between desire and craving postulated by the EIT. Nonetheless, and very interestingly, it appears that “boredom”, which can be considered a non-clinical index of negative affect, is the second most pervasive trigger reported in the quantitative questions (see Table 7). Accordingly, our findings are not necessarily in contradiction with the cumulating body of research emphasizing the role of negative affect in triggering craving states. Moreover, boredom might be regarded as a state in which cognitive resources could be available for the elaboration of desire thoughts, which is compatible with the EIT even if this particular factor is not directly addressed in this very theory (May et al., 2004).

4.2 External Cues

The importance of conditioned external (i.e., environmental) cues in triggering gambling craving (Potenza et al., 2003; Sharpe, 2002; Smith, Pols, et al., 2013) is confirmed in our sample of gamblers from the community, as external cues was the second most prominent theme identified by the participants (see Figure 6 and Table 8). The importance of external cues in promoting gambling craving is also supported by the quantitative items analysis (see Table 7). An in-depth content analysis reveals that the types of external cues reported by the participants included gambling-related advertisements and areas in which gambling opportunities were available. These findings are in line with recent studies emphasizing that young problem gamblers are more sensitive to gambling advertising (Hanss et al., 2015) and that the availability of gambling (context) has to be considered a risk factor for disordered gambling (Jacques et al., 2000; Phillips et al., 2013). Interestingly, the qualitative data analysis conducted also reveals that external cues can be related to differential sensory

modalities (i.e., seeing, hearing, and touching; see Table 8 for concrete examples). Regarding the findings that are in line with our theoretical rationale, it appears that the importance of external cues in triggering gambling craving (second most frequent theme reported) supports the relevance of the EIT, as the availability of the desired product, through confrontation with salient external cues, is susceptible to promoting the occurrence of desire thoughts and thus craving.

4.3 Mental imageries and thoughts

Mental imagery plays a core role in perpetuating desire thoughts and craving according to the EIT (Kavanagh et al., 2005), whether the craving is induced in laboratory (Tiffany & Drobes, 1991) or occurs naturally (May et al., 2004). Moreover, it is shown that the vividness of mental imageries is related to the intensity and overwhelming nature of the craving (K. Harvey et al., 2005). In our sample, both the quantitative and the qualitative analyses highlight that mental imagery is a core aspect of the gambling craving experience (see Table 8), whereas the quantitative analysis emphasizes it can also constitute a trigger for gambling craving (see Table 7). On the whole, the various analyses conducted emphasize that visual imagery can act as a trigger for gambling craving, whereas the subjective experience of craving itself is associated with both visual imagery (e.g., visualizing a gambling session) and tactile imagery (e.g., imaging the sensation of manipulating tokens). It is worth mentioning that albeit gambling-related sounds (e.g., the sound of the coins dropping when a slots player cashes out) are known to play a key role in the initiation and perpetuation of gambling behaviours (Brevers & Noël, 2013), auditory imagery per se was not described by the participants as an important aspect of the features of gambling craving.

According to the EIT, the thoughts related to the desired product constitute a fundamental feature of the subjective experience of craving (Kavanagh et al., 2005). Our sample confirms the importance of thoughts, although less prominently than mental imageries. Although the qualitative analysis conducted does not allow us to distinguish between thoughts triggering craving through classical conditioning from thoughts related to (spontaneous) recollection of gambling-related memories (Kavanagh et al., 2005), the quantitative analysis points out that spontaneous or associated thoughts are prone to trigger gambling craving. Importantly, the comprehensive analysis conducted shows that it is actually complicated to differentiate between mental imageries and thoughts, as they are often related to similar subthemes (e.g., wealth, win, dream, realization, future mental projection). However, this superposition actually makes sense because both mental imageries and thoughts related to the desired product are postulated to interact in promoting the craving experience in the EIT (Kavanagh et al., 2005; Salkovskis & Reynolds, 1994).

4.4 Physiological Sensations

Within the EIT, physiological sensations are referred to as anticipatory responses on the one hand, which can trigger desire thoughts and as physiological deficits on the other hand, promoting craving through the focus on the subjective state of deprivation, as for example in the case of a withdrawal syndrome (see Figure 6). In the present study, “physiological

sensations" is a less prominent theme and related descriptions are limited to anticipatory physiological responses. This is not surprising as gambling behaviours are not associated with the ingestion of a substance (e.g., a drug or an aliment) influencing physiological homeostasis. Yet, the qualitative analyses conducted reveals that physiological sensations (e.g., muscular tension, twitch, heart rate acceleration) are part of the gambling craving experience for a subpart of the participants (see Table 8). Interestingly, in the qualitative part, both recreational and at-risk gamblers reported physiological sensations or the absence of such sensations, confirming, as for negative affect, the continuum hypothesis of the EIT. The temporal analysis conducted further illustrates that reported physiological sensations increase during the game and decrease afterwards. Coming back to the EIT, this observation tentatively supports the view that the cognitive elaborations underlying desire thoughts already provide satisfaction and/or relief, but to a lesser extent than the actual involvement in the object of desire or craving (Kavanagh et al., 2005).

4.5 Clinical implications, limitations, and perspectives

The present study confirms the relevance of the EIT to account for the gambling craving experience, which opens up avenues for clinical management of gambling craving. Yet, some limitations of the studies have to be acknowledged. First, the current study consists of an online study using open-ended questions, which on the one hand limits the influence of social desirability bias, but on the other hand might result in less rich or sophisticated qualitative material than what would be obtained using in-depth interviews or focus groups. Second, our study was conducted in a small sample of non-clinical gamblers with heterogeneous gambling habits and preferred game types (the most frequent gambling activities reported were scratch cards and lotteries). Accordingly, although the tenets of the EIT conceptualized healthy desire and obsessive craving as two extremes of the same continuum (Kavanagh et al., 2005), further research on clinical gamblers and/or research that takes into account gambling preferences is warranted to confirm and extend the findings of the present study. Inclusion of clinical gamblers is also necessary to disentangle which types of triggers are more frequently related to dysfunctional gambling habits. Another important limitation is the self-reported and retrospective nature of our measures, which might result in partly distorted or stereotypical rather than accurate or spontaneous answers. Nonetheless, the study design was adapted to reach the objectives formulated (i.e., to measure the subjective experience of gambling craving and analyse it in relation to a specific theoretical framework). Future studies should, however, be conducted with experimental designs or real-world settings (e.g., laboratory-induced craving, craving monitoring via mobile apps).

Despite its limitations, the current study supports the use of interventions derived from the EIT to target craving in gambling disorder. In particular, a promising psychological intervention directly resulting from the EIT consists in recruiting the cognitive resources necessary for the elaboration of mental imageries and thoughts sustaining craving through a competing task, which diminishes their vividness and overwhelming nature. Interference-based psychological interventions thus aim to block or reduce craving by switching the cognitive resources (e.g., attentional processes, visuospatial sketchpad of the working

memory) allocated to the elaboration of desire thoughts to another competing task that recruits the same type of resources (May, Andrade, Panabokke, et al., 2010; May et al., 2008; Steel et al., 2006). Growing evidence supports the usefulness of interference-based interventions (e.g., as diverse as clay modeling, playing the video game Tetris, guided imagery) to interfere with psychoactive substance-related craving (May, Andrade, Panabokke, et al., 2010; Skorka-Brown et al., 2014, 2015) or food-related craving (Andrade, Pears, et al., 2012; Hamilton et al., 2013). However, to date, interference-based techniques have not been tested in relation to gambling craving, implying that further research on this very topic is warranted. According to May et al. (2015), other psychological interventions targeting central aspects involved in experiencing craving are worth considering to reduce the frequency and/or vividness of craving. This could include techniques designed to reduce the influence of external or environmental cues (cognitive bias modification) or interventions which are related to improving emotion regulation skills (e.g., mindfulness-based interventions).

Chapter 3

Probing gambling urge as a state construct: Evidence from a sample of community gamblers

Little effort has been made to systematically test the psychometric properties of the Gambling Craving Scale (GACS; Young & Wohl, 2009). The GACS is adapted from the Questionnaire on Smoking Urges (Tiffany & Drobes, 1991) and thus measures gambling-related urge. Crucially, the validation of scales assessing gambling urge is complex because this construct is better conceptualized as a state (a transient and context-determined phenomenon). In the present study, we tested the psychometric properties of the French version of the GACS with 2 independent samples of community gamblers following an induction procedure delivered through an audio-guided imagery sequence aimed at promoting gambling urge. This procedure was specifically used to ensure the assessment of gambling urge as a state variable. Participants also completed measures of gambling severity, gambling cognitions and motives, impulsivity, and affect. Confirmatory factor analysis showed that the original three-factor solution (anticipation, desire, relief) did not fit the data well. Additional exploratory factor analysis suggested instead a two-factor solution: an intention and desire to gamble dimension and a relief dimension. The factorial structure resulting from the exploratory factor analysis was tested with confirmatory factor analysis in a second independent sample, resulting in an acceptable fit. The two dimensions presented good internal reliability and correlated differentially with the other study's variables. The current study showed that, similar to what has been reported for substance-related urge, gambling urge are adequately probed with a bidimensional model. The findings suggest that the French GACS has good psychometric properties, legitimizing its use in research and clinical practice.

Reference: Canale, N., Cornil, A., Giroux, I., Bouchard, S., & Billieux, J. (2019). Probing gambling urge as a state construct: Evidence from a sample of community gamblers. *Psychology of Addictive Behaviors*, *33*(2), 154–161. https://doi.org/10.1037/adb0000438

Probing gambling urge as a state construct: Evidence from a sample of community gamblers

1. Introduction

Influential models posit craving as a central construct to explain the maintenance and exacerbation of gambling disorder (Blaszczynski & Nower, 2002; Brevers & Noël, 2013; Sharpe, 2002). Craving also has a pivotal role in gambling disorder relapse (Oei & Gordon, 2008) and treatment attrition (Smith et al., 2010). Recent evidence supports the natural course of gambling craving (before treatment, during treatment, after treatment) as a relevant clinical outcome in assessing treatment effectiveness (Caler et al., 2016; Pickering et al., 2018). Although research findings converge to highlight that craving is not unique to drugs and plays a pivotal role in gambling disorder (e.g., J. E. Grant & Kim, 2003b; Robert Ladouceur et al., 2003; Wood & Griffiths, 2007), research conducted in the gambling field has often used terms such as craving, urge, or desire interchangeably (e.g., Ashrafioun & Rosenberg, 2012; Young et al., 2008). Such conceptual confusion was in particular favored by the fact that influential models, such as that by Tiffany and Conklin (2000), define craving as the desire or urge for positive reinforcement (e.g., feeling high) and/or for negative reinforcement (e.g., feeling relieved), thereby equating constructs such as craving, desire, and urge. Crucially, recent cognitive approaches of craving provided a theoretical background that allows for distinguishing these constructs and for assuming their specificity (the elaborated intrusion theory of desire; see Kavanagh et al., 2005; May et al., 2004). According to these models, craving constitutes an elaborate and obsessive cognitive experience that encompasses other complex and multisensorial mental imagery processes, whereas urge can be considered the immediate perspective of positive and/or negative reinforcement (Cornil et al., 2018; Kavanagh et al., 2005). From such a perspective, urge plays an important role in the broader craving experience but does not at all constitute the craving experience per se.

The inconsistency in the labels used to describe the craving experience has also impacted its assessment, resulting in a situation in which scales that use various labels (e.g., urge, craving, desire, obsession) are generally postulated as measuring a similar underlying construct (i.e., gambling craving). Several scales have thus been developed to assess constructs such as gambling urge and craving, most inspired by or transposed from instruments developed in the substance use disorder field (for recent reviews, see Ashrafioun & Rosenberg, 2012; Caler et al., 2016). Early instruments consisted of single-item rating scales assessing the intensity of an urge or desire to gamble, but successive refinement of these instruments revealed the importance of assessing a variety of specific emotional, cognitive, and physiological experiences that characterize gambling urge and/or craving. The need for valid multidimensional assessment measures led to the development of the

Gambling Craving Scale (GACS; Young & Wohl, 2009). The GACS is a nine-item self-report measure of gambling craving adapted from the Questionnaire on Smoking Urges (QSU; Tiffany & Drobes, 1991), which is largely used to measure two dimensions of cigarette craving, namely intention and desire to smoke (expectation of positive reinforcement) and relief from negative affect (expectation of negative reinforcement; e.g., L. S. Cox et al., 2001; Dethier et al., 2014) The GACS is to date considered the main and most used measure of gambling craving (Ashrafioun & Rosenberg, 2012; Caler et al., 2016), especially when it comes to experimental studies aiming to induce or mitigate gambling craving (e.g., cue reactivity or intervention studies). Notably, despite being generally thought to measure craving and being named after this construct, the GACS was developed by adapting the QSU and in fact measures gambling urge.

The GACS was validated by Young and Wohl (2009) through a classic two-step strategy in which they used exploratory factor analyses (EFAs) and confirmatory factor analyses (CFAs) in two independent samples of gamblers. EFAs with a Promax oblique rotation suggested a three-factor solution (anticipation, desire, relief; Study 1 with undergraduate gambler students), which was further supported by a CFA (Study 2 with community gamblers). Thus, as measured by the GACS, gambling urge encompasses both (a) the anticipation of the consequences of gambling (i.e., expectations of fun and enjoyment and/or relief from negative subjective experiences) and (b) the desire to gamble to obtain these consequences (i.e., reinforcements).

An important limitation of these previous psychometric studies is that they failed to ensure that participants completing the scale actually experienced a gambling urge, and at the same time, the scale included only state-based items (e.g., Item 1: “Gambling would be fun right now”). A potential consequence of such an approach is that it is likely that most undergraduate students included in the original validation (Young & Wohl, 2009; Study 1) did not experience a gambling urge when they were asked to respond to the items, which could have affected their answers and thus the proposed factor structure of the GACS. Indeed, craving and/or urge consists of transient and context-dependent subjective states (Drummond, 2001; Sayette et al., 2000); it is thus questionable whether asking undergraduate students to respond to items that measure current urge without having elicited it is likely to result in a reliable factor model. This issue is particularly critical because the GACS is often used as a state measure in experimental cue reactivity or intervention studies inducing or targeting craving and/or urge episodes (Bouchard et al., 2017; Brevers et al., 2018; Ciccarelli et al., 2016). To capitalize on a multidimensional measurement of gambling urge (such as that proposed for the GACS), researchers should therefore validate such a model in participants who have undergone an urge induction procedure. Moreover, although some studies used translated versions of the GACS (e.g., French version: Bouchard et al., 2017; Brevers et al., 2018), the only available psychometric study on the scale is the initial paper by Young and Wohl (2009). Accordingly, further psychometric studies are required to establish the psychometric properties of the GACS, which is the most commonly used scale to measure gambling urge.

The present study was designed to address these limitations by testing the psychometric properties of the GACS following an induction procedure to confirm or reject the proposed three-factor model of gambling urge obtained in a sample of undergraduate students (Young et al., 2009). More precisely, the present study tested the psychometric properties of the French version of the GACS in two independent samples of community gamblers following an induction procedure delivered through an audio-guided imagery sequence. This procedure was specifically used to ensure that the measure of gambling urge is conceptualized as a state variable. Construct validity of the French version of the GACS was also tested by considering its relation with gambling-related constructs (gambling cognitions and gambling motives) and constructs known to have an influence on gambling urge and related craving experiences (impulsivity traits and affect).

2. Methods

2.1 Participants

This study was conducted by using a cross-sectional online survey. Two independent samples of community gamblers were recruited through online advertisements on research-related websites and Facebook groups. Inclusion criteria were being at least 18 years old, being a fluent French speaker, and having gambled at least once in the past year. The independence of the two samples was guaranteed by using the personal data collected (i.e., Internet protocol address and e-mail address) to remove participants from Sample 2 who had already completed the online survey (in Sample 1). These data were dissociated from the data set before the analyses to ensure confidentiality. All participants provided online consent prior to starting the survey. The Ethical Committee of the Psychological Sciences Research Institute at the UCLouvain (Belgium) approved the study protocol.

2.2 Procedure

The online survey consisted of three sections. The first concerned the central variables of the study (e.g., the French GACS, gambling-related information, affective states). The second comprised additional trait measures (e.g., impulsivity traits, gambling cognitions) used to support the validity of the GACS. The last section of the survey (optional in Sample 1 and mandatory in Sample 2)[1] consisted of an induction procedure (aimed at promoting gambling urge) followed by the completion of the GACS. The first section of the online survey contained demographic items, the Positive and Negative Affect Schedule (Watson et al., 1988; French version: Gaudreau et al., 2006), items assessing gambling preferences, the French GACS (Young & Wohl, 2009),[2] and the Problem Gambling Severity Index (PGSI; French items: Ferris & Wynne, 2001). The second section of the online survey consisted of

[1] After the large majority of participants agreed to undergo the craving induction in Sample 1 and to limit the number of non-usable data (only participants having completed the three sections were retained for analyses), we decided to make the craving induction procedure mandatory for Sample 2.

[2] The craving induction procedure was efficient in Sample 1 (see *Results* section), so we decided not to administer the GACS two times in Sample 2 for time-saving purposes.

additional questionnaires presented in random order: the short UPPS-P Impulsive Behavior Scale (Billieux et al., 2012), the Gambling Motives Questionnaire–Financial (Schellenberg et al., 2016; French version: Devos et al., 2017), and the Gambling-Related Cognitions Scale (Raylu & Oei, 2004a; French version: M. Grall-Bronnec et al., 2012). Participants were next asked whether they agreed to participate in the third section of the survey. On agreement, the induction procedure was delivered through an audio-guided imagery sequence based on the imagery script described by Ashrafioun et al. (2012). The induction lasted 156 s, and the script was read with an enthusiastic tone. Relaxation was first induced, after which

Table 10. Characteristics and Reliability for the Scales

Author (year)	Questionnaire	Number and Type of Items	Response Format	Reliability (Sample 2)[a]
Young and Wohl (2009)	Gambling Craving Scale (GACS)	9 items distributed on 3 subscales (anticipation, desire, and relief)	7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*)	Subscale αs ranging from .78 to .87[b]
Ferris and Wynne (2001)	Problem Gambling Severity Index (PGSI)	9 items	4-point Likert scale: 0 (*never*), 1 (*sometimes*), 2 (*most of the time*), 3 (*almost always*)	Total score α = .84
Billieux et al. (2012a)	Short UPPS-P Impulsive Behavior Scale (S-UPPS-P)	20 items distributed on 5 subscales (negative urgency, positive urgency, lack of premeditation, lack of perseverance, and sensation seeking)	4-point Likert scale: 1 (*I agree strongly*), 2 (*I agree somewhat*), 3 (*I disagree somewhat*), 4 (*I disagree strongly*)	Subscale αs ranging from .77 to .84
Grall-Bronnec et al. (2012)	Gambling-Related Cognitions Scale (GRCS)	23 items distributed on 5 subscales (interpretative bias, illusion of control, predictive control, gambling expectancies, and perceived inability to stop gambling)	7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*)	Subscale αs ranging from .75 to .90
Devos et al. (2017)	Gambling Motives Questionnaire-Financial (GMQ-F)	15 items distributed on 4 subscales (coping, enhancement, social, and financial)	4-point Likert scale: 1 (*never or almost never*), 2 (*sometimes*), 3 (*often*), 4 (*almost always or always*)	Subscale αs ranging from .74 to .84
Gaudreau, Sanchez, and Blondin (2006)	Positive and Negative Affect Schedule (PANAS)	20 items distributed on 2 subscales (positive affect and negative affect)	5-point Likert scale: 1 (*not at all or very slightly*), 2 (*a little*), 3 (*moderately*), 4 (*quite a bit*), 5 (*extremely*)	Subscale αs .81 and .90, respectively

[a] Reliability values (Cronbach's alpha) were presented for Sample 2, given that all the measures were used for the convergent validity analysis (assessed by using Sample 2).
[b] These values concern the original three-factor solution (anticipation, desire, relief)

Table 11. Sample Characteristics

Characteristic	Sample 1 (N = 165)	Sample 2 (N = 256)	Statistical test
Mean age (*SD*)	29.94 (11.85)	27.67 (10.34)	p = .04
Sex (%)			*ns*
Male	41.2	44.5	
Female	58.8	55.5	
Nationality (%)			p = .001
Canadian[a]	.6	0	
Belgian[b]	16.4	29.7	
French[b]	78.8	66.4	
Swiss[a]	2.4	0	
Other[a]	1.8	3.9	
Mother tongue (%)			*ns*
French	98.2	95.3	
Other	1.8	4.7	
Education (%)			*ns*
None	.6	0	
Primary	0	.8	
Secondary	11.5	20.7	
Diploma of collegial studies (Canada)	0	.8	
Bachelor	48.5	48.0	
Master	32.1	25.4	
Ph.D.	2.4	2.3	
Other	4.8	2.0	
Gambling frequency (%)			*ns*
At least a few times a year	38.2	44.1	
At least once a month	18.2	19.9	
A few times a month	15.2	14.8	
Once a week	13.9	8.6	
A few times a week	13.3	11.7	
Every day	1.2	.8	
Mean PGSI (*SD*)	3.41 (4.23)	2.81 (3.20)	*ns*
PGSI score (%)			*ns*
Non-problem gamblers [PGSI = 0]	30.9	28.8	
Low-risk gamblers [PGSI = 1–2]	25.5	30.5	
Moderate-risk gamblers [PGSI = 3–7]	29.1	30.5	
Problem gamblers [PGSI = ≥8]	14.5	10.2	

Note. PGSI = Problem Gambling Severity Index. *ns* = not significant. Sample characteristics were compared with analysis of variance for continuous variables and chi-square tests for categorical variables. Groups with different superscripts differ significantly (p < .05) from one another in post hoc tests.

participants were instructed to picture themselves, as vividly as possible, discussing gambling wins with friends. Several gambling types were mentioned, including bets, lottery tickets, casino games, slot machines, dice, poker, and blackjack. Participants were asked to think about their favourite ways to gamble and to mentally picture themselves gambling for 15 s. Finally, they were instructed to open their eyes. Participants then completed the GACS a final time (Young & Wohl, 2009). In Sample 2, the GACS was administered only after the induction procedure. A short recorded audio-guided mindfulness session was proposed to avoid carryover effects related to the experiment. The GACS (Young & Wohl, 2009) was translated from English into French and then backtranslated to English to establish

consistency with the original English version. The total score ($\alpha = .87$ before induction; $\alpha = .89$ after induction) was used to confirm the effect of the induction procedure. Details about the scales used are presented in Table 10.

Two independent samples were used in the current study. Three respondents (one in Sample 1; two in Sample 2) were excluded based on outliers or extreme responses (age > 90 years). In Sample 1, 187 participants started and completed the online survey, but 22 did not agree to take part in the third section of the online survey. Therefore, 165 participants between ages 18 and 68 years were used for data analysis. Sample 2 comprised 256 participants between ages 18 and 74 years (see Table 11 for the demographic details of both samples), who all underwent the induction procedure. Participants had the opportunity to receive compensation (5 Euros) by providing their e-mail at the end of the survey (45.5% of Sample 1 and 53.5% of Sample 2 required compensation). For both samples, there were no differences between participants requiring compensation or not in terms of demographics (age and gender) or problem-gambling symptoms (Problem Gambling Severity Index score). The first sample was used in the initial analyses to test the structural validity of the French GACS based on the model validated by the authors of the GACS (Young & Wohl, 2009), whereas the second sample was used for cross-validation.

3. Results

Descriptive statistics for gambling behaviours (frequency and severity) are outlined in Table 11. The results of the repeated-measures analysis of variance conducted on the GACS (total score precraving and postcraving induction) showed a significant main effect of time, $F(1, 164) = 42.92$, $p < .001$, $\eta^2 = .21$. Post hoc tests showed that the two time points differed significantly (T0 [preinduction] < T1 [postinduction], $p < .001$) in the expected direction (higher global urge following the induction procedure): T0: $M = 27.08$, $SD = 10.22$; T1: $M = 31.04$, $SD = 11.62$; mean change from T0 = 3.96 (7.76). Such analysis ensured the efficacy of the induction procedure and supported the relevance of subsequent analyses to establish the structural validity of the GACS as a scale measuring a state construct. We also tested whether different levels of problem gambling based on the PGSI scores (nonproblem gamblers, low-risk gamblers, moderate-risk gamblers, problem gamblers) impacted the efficacy of the induction procedure, which was not the case ($p = .80$).

The first step of our psychometric investigation, conducted in Sample 1, consisted of testing the expected three-factor structure of the GACS (Young & Wohl, 2009) with a CFA. Because the induction procedure proved efficient, data on the GACS completed postinduction were used for these analyses. As suggested by Rhemtulla et al. (2012), given that the data were ordinal (e.g., Likert scale), the weighted least squares mean and variance robust estimator was used in all CFAs. Four widely accepted fit indices with established cutoffs were used to determine the acceptability of model fit (Kline, 2011): (a) χ^2 test, (b) Bentler's comparative fit index (CFI; values above .90 suggest acceptable fit); (c) root mean square error of approximation (RMSEA; values less than .07 indicate acceptable fit); and (d) standardized root-mean-square residual (SRMR; values less than .08 suggest acceptable fit).

The CFA of the three-factor GACS presented a poor fit of the data ($\chi^2 = 151.41$, $df = 24$, $p < .001$; RMSEA = 0.18 [0.15–0.21], CFI = .99, SRMR = 0.11).

In accordance with this initial result and considering that the structural validity of the GACS was tested only in a unique study (Young & Wohl, 2009) that presented several limitations (e.g., absence of an induction procedure), we decided to conduct an additional EFA to identify a potential alternative model to be compared with the original three-factor model. An EFA with principal axis factoring was thus performed to explore the structure of the scale. Oblique rotation (Promax) was used to allow factors to correlate and to increase their interpretability, which is similar to the strategy generally used for multidimensional craving and/or urge scales (e.g., Chauchard et al., 2015; Young & Wohl, 2009). Two widely used criteria were applied to determine the number of nontrivial factors to be retained: (a) eigenvalues greater than 1.00 and (b) the scree test (Cattell, 1966). The Kaiser-Meyer-Olkin measure of sampling adequacy (.86) and Bartlett's test of sphericity ($\chi^2 = 1286.91$, $df = 36$, $p < .001$) indicated that the correlation matrix was appropriate for conducting the analysis. Both the eigenvalue criterion and the scree test suggested the presence of two nontrivial factors. More specifically, EFA produced two factors with eigenvalues greater than 1.00 (5.01, 1.96) that explained 77.43% of the variance, exceeding the 50% recommended for a meaningful factor solution (Floyd & Widaman, 1995). Two items (4 and 6) loading similarly and heavily (> 49) on both factors were removed, and the EFA was performed again. The subsequent EFA produced two factors with eigenvalues greater than 1.00 (3.66, 1.72) that explained 76.87% of the variance. All items exceeded factor loadings of .40 (see Table 12). The items loading on the first factor reflected an intention to gamble characterized by planning and expectation of positive effects (fun, excitement, enjoyable); therefore, the first extracted factor was labeled Intention and desire to gamble. Items loading on the second factor reflected relief from negative affect expected from gambling; consequently, the second extracted factor was labeled Relief from negative affect. The two factors were moderately intercorrelated ($r = .29$; $p < .001$), suggesting that the GACS comprised two related but specific factors related to gambling urge. The factors were renamed according to the QSU labels because the GACS was developed after this scale.

A new series of CFAs were conducted in an independent sample (Sample 2) to test the derived two-factor structure of the French GACS from the results in Sample 1. Several models were tested and compared: the initial three-factor model (Model A) by Young et al. (2009), the two-factor model resulting from the EFA conducted in Sample 1 (Model B), and a one-factor model (Model C), because most recent published studies with the GACS rely only on the global score (see e.g., Caselli & Spada, 2015; Fernie et al., 2014; Harrison et al., 2018; Takeuchi et al., 2016) Among the three models (see Table 13 for the fit indices), the CFA showed that the two-factor model produced an acceptable fit, $\chi^2(13) = 25.02$, $p = .023$; RMSEA = 0.06 [0.02–0.09], CFI = .99, SRMR = 0.05. As expected, the indicators all showed significant positive factor loadings, with standardized coefficients ranging from .47 to .94 (see Table 12). Finally, the model that allows covariances between the two latent craving factors fits the data significantly better than does the model that treats the latent factors as independent, $\chi^2(1) = 198.93$, $p < .001$.

Table 12. Factor Loadings on the Two Factors of the Gambling Craving Scale (GACS)-French Version

Items		EFA (Sample 1; *n* = 165) rotated factor loadings		CFA (Sample 2; *n* = 256) standardized factor loadings	
		Factor 2	Factor 1	Factor 2	Factor 1
Item 1:	"Gambling would be fun right now."		.87		.92
Item 2:	"If I had an opportunity to gamble right now, I probably would take it."		.92		.85
Item 3[a]:	"I would not enjoy gambling right now."		.41		.47
Item 5:	"I need to gamble right now."	.75		.87	
Item 7:	"If I were gambling now, I could think more clearly."	.92		.94	
Item 8:	"I could control things better right now if I could gamble."	.94		.90	
Item 9:	"Gambling would make me less depressed."	.83		.70	
Explained variance (R^2)		52.29	24.58		

Note. EFA = exploratory factor analysis; CFA = confirmatory factor analysis. Factor 1: Intention and desire to gamble; Factor 2: Relief from negative affect. [a] Reverse-coded item.

Table 13. Fit Statistics for the CFA Models (Sample 2, n = 256)

Model	χ^2	*df*	*p*	CFI	SRMR	RMSEA (90% CI)
Model A	95.27	24	<.001	0.99	0.08	0.11 (0.09-0.14)
Model B	25.02	13	.023	0.99	0.05	0.06 (0.02-0.09)
Model C	192.61	14	<.001	0.97	0.13	0.22 (0.20-0.25)

Note. Model A = three-factor model proposed by Young and Wohl (2009); Model B = two-factor model resulting from the exploratory factor analysis conducted in Sample 1; Model C = one-factor model; CI = confidence interval; CFI = comparative fit index (>0.90); SRMR = standardized root mean square residual (<0.08); RMSEA = root mean square error of approximation (<0.07).

Internal consistency was examined by computing Cronbach's alpha and composite reliability (Raykov, 1997) on the basis of the identified factors. Composite reliability was computed with an online calculator (Colwell, 2016). Both values were good to excellent for the two subscales: Intention and desire to gamble (α = .78; composite reliability = .81) and Relief from negative affect (α = .86; composite reliability = .92). There was also a significant positive correlation between the two factors, r = .40, p < .001.

In the last step of our data analyses, convergent validity was assessed by examining the correlations between GACS scores and measures of gambling participation (gambling frequency and problem gambling symptoms), other gambling-related variables (gambling cognitions and gambling motives), and addiction and urge-related constructs (impulsivity and affect). A series of correlation comparisons were conducted by using Eid et al.'s (2010) calculations via the Psychometrica online calculator (Lenhard & Lenhard, 2014). Pearson correlation analyses revealed significant relationships between the Relief from negative

affect factor and gambling frequency and problem gambling symptoms (see Table 14). In contrast, the Intention and desire to gamble factor presented a lower correlation with problem gambling symptoms (comparison of correlations test, $p < .001$). To determine how the two GACS subscales were associated with gambling motives, problematic gambling-related cognitions, impulsivity traits, and affect, we examined the simple correlations between each GACS subscale (see Table 14). The correlations between Relief from negative affect and two subscales of the GMQ (social and coping) and the five GRCS subscales ($r = .44–.60$) were statistically significantly higher than those between Intention and desire to gamble and both subscales of the GMQ and the five GRCS subscales ($r = .14–.41$; all comparisons of correlations test, $p < .05$).

Table 14. Pearson Correlations between the Two Factors of the GACS (Pleasure and Relief) and Demographic Characteristics, Gambling Related Variables, Impulsivity Traits, and Affect

Variables	Factor 1	Factor 2	z
Gender (1 = male; 2 = female)	.11	.04	
Age	-.04	.03	
Gambling frequency	.05	.14*	
PGSI total score	.18**	.45***	-4.24***
GMQ-Social	.14*	.44***	-4.67***
GMQ-Coping	.22***	.54***	-5.24***
GMQ-Enhancement	.35***	.36***	-0.16
GMQ-Financial	.21**	.16*	0.74
GRCS-Gambling expectancies	.41***	.56***	-2.63**
GRCS-Illusion of control	.26***	.53***	-4.45***
GRCS-Predictive control	.34***	.47***	-2.13*
GRCS-Inability to stop gambling	.22***	.60***	-6.41***
GRCS-Interpretative bias	.36***	.47***	-1.82*
Negative urgency	.17**	.23***	-0.89
Positive urgency	.04	.11	
Lack of premeditation	.05	.05	
Lack of perseverance	.05	.07	
Sensation seeking	.04	.19**	
Positive affect	.15*	.12*	0.44
Negative affect	-.10	.12*	

Note. The z column refers to the comparisons of correlations. GACS = Gambling Craving Scale; PGSI = Problem Gambling Severity Index; GMQ = Gambling Motives Questionnaire; GRCS = Gambling-Related Cognitions Scale. Factor 1: Intention and desire to gamble; Factor 2: Relief from negative affect. ***$p < .001$. **$p < .01$. *$p < .05$.

4. Discussion

This study aimed to test the psychometric properties of the French GACS following an induction procedure in community gamblers. The main results are that, although the original three-factor model of the GACS had a poor fit, a two-factor model derived from the combined use of EFAs and CFAs in two independent samples adjusted well to the data (after two of the original items were removed). Crucially, our study tested the structural validity of the GACS following an induction procedure because the items assessed gambling urge as a state, that is, a fluctuant and transient phenomenon. The first factor, which corresponds to Intention and

desire to gamble, consisted of three items (Items 1, 2, and 3), all part of the original GACS factor anticipation of positive affect. The second factor corresponds to Relief from negative affect, consisting of four items. Three (Items 7, 8, and 9) were part of the original GACS factor, relief, and one (Item 5) was part of the original GACS factor, desire (Young & Wohl, 2009). Notably, these two factors, Intention and desire to gamble and Relief from negative affect, are consistent with those previously reported in studies that used the QSU (Tiffany & Drobes, 1991) in samples of cigarette smokers (e.g., Toll et al., 2006) and marijuana consumers (Chauchard et al., 2015). This consistency in results between the present study and these studies is important because the GACS items are directly inspired from the QSU items. For example, the two-factor model of the GACS in the present study is aligned with the 10-item QSU-Brief (L. S. Cox et al., 2001).

The inconsistency between our results and those of the original study may be due to a crucial difference in methodological approaches because, for theoretical reasons, we decided to test the psychometric structure of the GACS following an induction procedure. Such a procedure in our view better reflects the experiences of gamblers in the real context of gambling in comparison with the previous measurement approach, and it allowed us to model a semiecological situation in which gambling urge is prompted by external gambling-related cues. Beyond this important methodological point, it is worth noting that some differences between our samples and those of Young and Wohl (2009) could have contributed to the differences in results (e.g., demographic differences, cultural differences, or language differences related to the craving term; see Hormes & Rozin, 2010). To overcome these language differences, further studies must be undertaken to investigate the structure of the English GACS following an induction procedure.

This study also provided additional evidence regarding the convergent validity of the French version of the GACS by highlighting that the Intention and desire to gamble and the Relief from negative affect factors were positively associated with problem gambling symptoms and problematic gambling-related cognitive distortions (e.g., Young & Wohl, 2009). An additional point was that these two subtypes of gambling urge were positively associated with gambling motives, affect, and impulsivity traits. More specifically, Relief from negative affect was more strongly associated with cognitive distortions and gambling motives than was Intention and desire to gamble. This result can be linked to emotional vulnerabilities of the gamblers that led to their repeated inability to restrain themselves from urge to gamble (see the pathways model of problem and pathological gambling; Blaszczynski & Nower, 2002). In addition, these results are in line with the studies reviewed by Brevers et al. (2013) showing that comparable sensitization to addiction-related cues happens in pathological gambling, which encompasses the presence of gambling-related urge during gambling cue reactivity and higher activity in the brain reward system in the course of anticipating and expecting gambling outcomes.

Several limitations of the study have to be acknowledged. First, the current study was conducted in nonclinical gamblers; further examination of the GACS in patients with gambling disorder is thus required for this reason as well as because in our study, disordered gambling symptoms (assessed with the PGSI) did not moderate the effect of the induction

procedure. Second, the study involved only self-reported measures, which are known to be flawed by social desirability or lack of introspection biases. Third, the study did not include a no-exposure control group. Consequently, it is not possible to ascertain that the increase in urge could result, at least partly, from completing the GACS on two separate occasions within a short period and not necessarily from the induction procedure used. Further studies should also consider concurrent measures of gambling urge (e.g., Gambling Urge Scale; Raylu & Oei, 2004b), craving (e.g., Craving Experience Questionnaire; May et al., 2014), or related constructs such as gambling dark flow (i.e., a pathological absorption or dissociative state that can be assessed with the Game Experiences Questionnaire; Dixon et al., 2018) to establish convergent validity.

Despite these limitations, the present research is the first to examine the factor structure of the GACS by using data obtained after an induction procedure. The results suggest that gambling urge is a construct composed of the expected consequences of gambling (Relief from negative affect–Intention and desire to gamble). The French GACS presents good psychometric properties and can be considered a reliable instrument to measure gambling urge as a state construct in experimental research devoted to the manipulation of such a state as well as in clinical practice. Ultimately, although we decided not to rename the scale investigated in the current study to avoid complicated comparisons with previous research, it is crucial to bear in mind that the GACS, in line with the scales from which it was inspired (i.e., the QSU), is adapted to measure the relatively narrow construct of gambling urge and not the broader and multidetermined construct of gambling craving.

Chapter 4

The gambling Craving Experience Questionnaire: Psychometric properties of a new scale based on the elaborated intrusion theory of desire

Both research and clinical practice acknowledge the importance of craving as a maintenance and relapse factor in gambling disorder. The elaborated intrusion theory (EIT; Kavanagh et al., 2005) of desire has been extensively investigated in relation to psychoactive substance or food craving but, to date, has scarcely been studied in relation to gambling. In such a context, developing an assessment tool of gambling craving based on the EIT is warranted. To fill this gap in the literature, we aimed to develop and test the psychometric properties of a gambling-adapted version of the Craving Experience Questionnaire (CEQ; May et al., 2014), which is the best established measure of craving theoretically anchored in the EIT. An online survey that included the gambling CEQ (g-CEQ) and a craving induction procedure was administered to 274 community participants involved in gambling at least a few times a year. Concurrent and convergent validity were explored through correlations with a scale that measured gambling urge and with a series of questionnaires that measured disordered gambling symptoms, gambling cognitions, and gambling motives. The confirmatory factor analyses supported the validity of the expected three-factor model of the "strength" and "frequency" forms of the g-CEQ and showed better model fit than a one-factor solution, corroborating the initial structure of the CEQ. Furthermore, the scale has good internal consistency and its validity is supported by correlations with gambling-related constructs. The g-CEQ is thus a theoretically and psychometrically sound instrument to measure gambling craving based on the EIT.

Reference: Cornil, A., Long, J., Rothen, S., Perales, J. C., de Timary, P., & Billieux, J. (2019). The gambling craving experience questionnaire: Psychometric properties of a new scale based on the elaborated intrusion theory of desire. *Addictive Behaviors*, *95*, 110–117. https://doi.org/10.1016/j.addbeh.2019.02.023

The gambling Craving Experience Questionnaire: Psychometric properties of a new scale based on the elaborated intrusion theory of desire

1. Introduction

Gambling disorder is a mental condition associated with severe personal and public consequences (Blaszczynski & Nower, 2002; Lorains et al., 2011). Its prevalence is estimated at 1.5% in the worldwide adult population (Gowing et al., 2015; Williams, West, et al., 2012) but it ranges from 0.2% in Norway to 5.3% in Hong Kong, highlighting important national differences (Hodgins et al., 2011). Gambling disorder was aligned with substance use disorders in the last version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) and in the recently released eleventh International Classification of Diseases (World Health Organization, 2018). This new classification (the condition was previously conceptualized as an impulse control disorder) was supported by a large body of evidence that highlighted important similarities between substance use and gambling disorder (e.g., Clark, 2010; Goudriaan et al., 2006; Potenza, 2006). Nevertheless, although craving is now a recognized diagnostic criterion for substance use disorder in the DSM-5, it has not been retained to define gambling disorder (American Psychiatric Association, 2013). In such a context, further research on the phenomenology, etiology, and assessment of gambling craving is warranted.

Gambling craving (and related constructs such as urge, drive, temptation, and desire; Young et al., 2008) has been increasingly investigated over the past 20 years, and influential models in the field, as well as research, have considered craving to play a pivotal role in the development, maintenance and relapse of gambling disorder (Hodgins & el-Guebaly, 2004; Oei & Gordon, 2008; Sharpe, 2002; Smith, Battersby, et al., 2013). Research also showed that gambling-like reinforcement schedules seem to trigger the same incentive-sensitization mechanisms that underlie craving in substance use disorders (Anselme et al., 2013; Rømer Thomsen et al., 2014). Moreover, neurobiological evidence has been gathered that shows clear similarities between craving for psychoactive substances and for gambling (van Holst et al., 2010a). Initial studies that relied on questionnaires adapted from the substance use field showed, somewhat surprisingly, that pathological gamblers tend to report stronger craving than cocaine addicts or alcoholics do (Castellani & Rugle, 1995; de Castro et al., 2007; Tavares et al., 2005), highlighting the relevance of craving as a significant symptom not only for substance use disorder but also for gambling disorder.

According to Ashrafioun and Rosenberg (2012), gambling craving has mainly been measured through visual analogue scales with one single item (e.g., rating current gambling

craving on a scale from 1 = “no urge” to 10 = “extreme urge”; Sodano & Wulfert, 2010). Although convenient for quick and repeated measurement, this method fails to capture the complexity and multifactorial nature of the gambling craving experience (Navas et al., 2019; Young & Wohl, 2009). Several authors have developed multi-item unidimensional questionnaires such as the Gambling Urge Scale (Raylu & Oei, 2004b) or the Penn Gambling Craving Scale (Tavares et al., 2005). Furthermore, questionnaires with subscales were also developed: the Pathological Gambling Yale-Brown Obsessive-Compulsive Scale (measuring thoughts/urge and compulsions separately; Pallanti et al., 2005) or the Gambling Craving Scale (measuring gambling urge related to positive and negative reinforcement; Canale et al., 2019). These questionnaires were based on traditional motivational and reinforcement-based (reward versus punishment sensitivity) models of craving (for conceptual comparisons of these models, see Canale et al., 2019; May et al., 2004; Skinner & Aubin, 2010). More recently, a cognitive model emerged that paved the way for new fundamental and clinical research: the elaborated intrusion theory of desire (EIT; Kavanagh et al., 2005; May et al., 2015). The EIT defines craving (or desire) as an emotionally laden subjective state in which attention remains focused on the object of the desire. According to the EIT, and in line with previous influential models of craving, the craving experience initially results from confrontation with specific internal and external cues that triggers intrusive desire thoughts (verbal or imaginal) related to the object of craving. In a second step, which constitutes the more central and original feature of the EIT, cognitive elaboration of these intrusive thoughts is induced through a double vicious spiral process. First, the desire-related thoughts generate pleasure and relief as the object of craving is reached through imagery (Weber et al., 2017). This positive reinforcement is postulated to contribute to the perpetuation of the elaborated desire-related thoughts. Second, the consciousness of a discrepancy between the desired imagery and reality (i.e., the craving is not actually fulfilled) elicits a sense of associated deficit that fosters elaboration of desire thoughts in order to cope with this perceived deficit- and relief-associated negative affect. The inner tension for the desired object that results from this cognitive elaboration represents the subjective state of craving.

To assess the subjective state of craving (or desire) as conceptualized by the EIT, investigators developed two scales. The first is the Alcohol Craving Experience questionnaire (ACE; Coates et al., 2017; Statham et al., 2011). The ACE consists of two forms: one assessing the strength of craving episodes (ACE-S) and the other assessing the frequency of craving episodes over a specific time frame (ACE-F). Each form is composed of three distinct subscales (examples provided are related to the strength and frequency forms, respectively): (1) intensity (e.g., “How strongly did you want a drink?” and “How often did you want a drink?”), imagery (e.g., “How vividly did you picture alcohol or drinking?” and “How often did you picture alcohol or drinking?”), and intrusiveness (e.g., “How intrusive were the thoughts?” and “How often were the thoughts intrusive?”). Also grounded on the EIT, the Craving Experience Questionnaire (CEQ; May et al., 2014) is an adapted version of the ACE designed to assess craving for psychoactive substances (e.g., alcohol, cigarettes) and food. The EIT was validated in a heterogeneous sample of participants (e.g., patients with substance use disorders; community participants deprived of food) through a combination of exploratory factor analysis and confirmatory factor analysis (CFA) that highlighted a similar

structure for the ACE and the CEQ (see Figure 7). This factor structure was initially found for the ACE (only one item of the ACE, referring to body feelings, was not adapted to all substances and was removed from the scale).

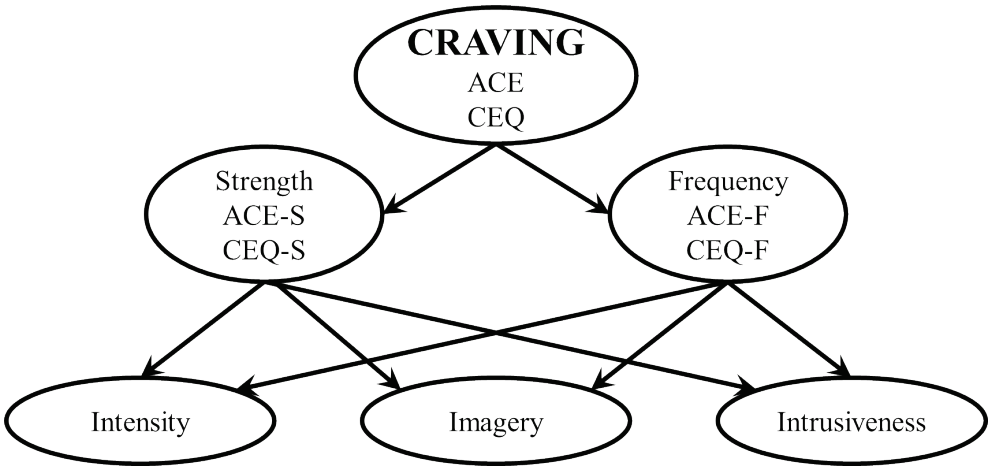

Figure 7. Structure of the Alcohol Craving Experience questionnaire (ACE) and the Craving Experience Questionnaire (CEQ)

1.1 Current study

To date, no instrument grounded in the EIT exists to measure gambling craving. Yet, a previous study by Cornil et al. (2018) supported the validity of the EIT to account for gambling craving, showing through a mixed-method and phenomenological approach that this very theory might constitute a promising theoretical framework for gambling research. In such a context, developing an assessment tool for gambling craving based on the EIT is warranted for both research and clinical purposes. To fill this gap in the literature, we aimed in the present study to develop and test the psychometric properties of a gambling-adapted version of the CEQ (i.e., the g-CEQ) that measures the strength of a specific craving, as well as the frequency of craving over a time frame. To this end, community gamblers were recruited and completed an online experiment. Our study capitalized on an induction procedure (audio-guided imagery session), as some items of the g-CEQ assess state constructs (craving states are fluctuant and triggered by specific cues). Concurrent and convergent validities were established by considering relations with (1) a gambling urge scale, (2) gambling and problem gambling-related factors (i.e., gambling cognitions, gambling motives, and problem gambling symptoms), and (3) psychological dimensions known to affect craving experiences (affective states and impulsivity traits).

2. Materials and methods

2.1 Participants

Recreational gamblers were recruited from the general community through online advertisements on research-related Facebook groups and websites. Participants had to be at least 18 years old, fluent French speakers, and involved in gambling at least a few times a year. Prior to their inclusion; participants were informed that the study focused on the desire to gamble. A total of 401 participants answered the online questionnaire. Among them, 290 (72.32%) completed the entire questionnaire. Sixteen respondents were removed because of an exaggeratedly speedy completion time (< 10 min), or because of age (> 90 years old), duplicate answers (determined by cross-examination of IP addresses, age, sex and emails), or contradictory answers to a scale with a reversed item (participants who systematically responded with the lowest score on all items of the scale, including a reversed item, were excluded). The final sample was composed of 274 participants (152 women) with an age range of 18 to 74 years ($M = 28.54$, $SD = 11.10$). Nationality, mother tongue, level of education, and gambling frequency are reported in Table 15, and gambling frequency and preferences are presented in Table 16. According to the cut-off generally used with the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001), our sample of gamblers

Table 15. Sample Description

	Sample % (n = 274)
Nationality	
Belgian	28.83%
French	67.15%
Other[a]	4.01%
Mother Tongue	
French	95.62%
Other[b]	4.38%
Education	
Primary	0.73%
Secondary	20.44%
Diploma of Collegial Studies (Canada)	0.73%
Bachelor	49.27%
Master	24.45%
Ph.D.	2.19%
Other	2.19%
Gambling Frequency	
At least a few times a year	42.70%
At least once a month	20.07%
At least a few times a month	14.23%
Once a week	9.12%
A few times a week	13.14%
Every day	0.73%

[a]Participants reporting another nationality were Algerian, Burundian, Congolese, Hungarian, Iranian, Moroccan, Polish, or Spanish.
[b]Participants reporting another mother tongue were all fluent French speakers.

included *non-problem* (28.83%), *low-risk* (31.38%), *moderate-risk* (29.20%), and *problem* (10.58%) gamblers.

Table 16. Gambling Habits

	Gambling Frequency %	Favorite Gambling %
Scratch cards	72.99%	36.86%
Lottery	53.65%	18.61%
Betting (online)	28.10%	15.69%
Slot machines	23.36%	6.57%
Poker (offline)	20.80%	7.30%
Betting (offline)	17.15%	5.84%
Poker (online)	16.48%	4.38%
Stock exchange	5.47%	1.46%
Other	3.28%	3.28%

Note. The gambling activities are sorted according to gambling frequency.

2.2 Measures and procedure

The g-CEQ is a gambling-adapted version of the CEQ (May et al., 2014). The scale was created by having the CEQ items translated from English into French and then having another bilingual translator back-translate them into English, as required when adapting scales previously published in another language. When necessary, wording was adapted to the gambling context. The items pertaining to the imagery subscales of each form (i.e., strength and frequency) were also modified: the four items covering picture, smell, taste, and mouth imagery in the CEQ were adapted into three items covering picture, auditory, and tactile imagery in the g-CEQ. These modalities are indeed better adapted for gambling according to a previous study that explored the phenomenology of the gambling craving experience (Cornil et al., 2018). The final scale consisted of 18 items (nine for each form) rated on a scale ranging from 0 (“not at all”) to 10 (“extremely” for CEQ-S and “constantly” for CEQ-F). All items are reported (in French and in English) in the Appendix D.

The study sequence is depicted in Figure 8 and the questionnaires that were administered online are described in Table 17. After having signed informed consent, participants completed demographic information. The Positive and Negative Affect Schedule (PANAS; Gaudreau et al., 2006) was then administered to control affective state prior to the beginning of the study. Participants then filled in a series of items that assessed gambling habits and completed the PGSI (Ferris & Wynne, 2001) and the gambling Craving Experience Questionnaire – Frequency (g-CEQ-F) which evaluated the occurrence of gambling craving over the past week. Afterwards, an induction procedure was administered to participants through an audio-guided imagery scenario that was based on an experimental procedure (Ashrafioun et al., 2012) and adapted into French. Participants were asked to imagine themselves discussing wins and positive aspects of different gambling types (bets, lottery tickets, and several casino games) with their friends. They were then instructed to picture themselves practicing their favorite gambling activity. This procedure showed efficacy in

another sample (Canale et al., 2019; Sample 1). Following the craving induction, participants were assessed with the gambling Craving Experience Questionnaire – Strength (g-CEQ-S) for current gambling craving and with another scale assessing current gambling urge: the Gambling Craving Scale (GACS; Young & Wohl, 2009; French version: Canale et al., 2019). The GACS, which measures gambling urge as a state, was included to assess concurrent validity. To evaluate convergent validity, we randomized three questionnaires that measure gambling-related constructs and administered them to assess impulsivity traits (short UPPS-P Impulsive Behavior Scale; S-UPPS-P; Billieux et al., 2012), gambling motives (Gambling Motives Questionnaire - Financial; GMQ-F; Schellenberg et al., 2016; French version: Devos et al., 2017), and gambling cognitions (Gambling Related Cognitions Questionnaire; GRCS; Raylu & Oei, 2004a; French version: M. Grall-Bronnec et al., 2012). Finally, a short audio-guided mindfulness session was systematically offered to participants to avoid any experiment-related carryover effect.

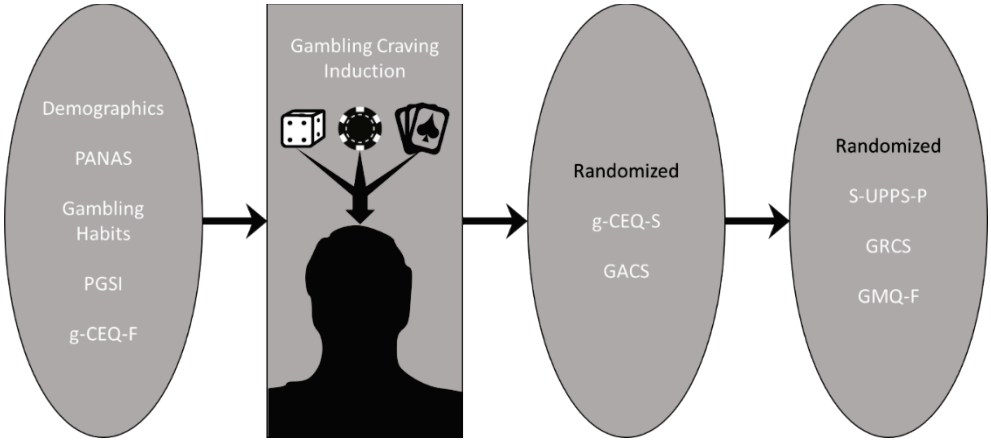

Figure 8. Study design

Note. g-CEQ-S = gambling Craving Experience Questionnaire – Strength form; g-CEQ-F = gambling Craving Experience Questionnaire – Frequency form; GACS = Gambling Craving Scale; PGSI = Problem Gambling Severity Index; GMQ-F = Gambling Motives Questionnaire; GRCS = Gambling-Related Cognitions Scale; S-UPPS-P = short UPPS-P Impulsive Behavior Scale. All 274 participants completed each questionnaire of the survey.

Participants who entirely completed the survey were invited to provide an email address if they were interested in receiving compensation (5 euros; 54.71% of the sample requested the compensation). Participants' bank details or PayPal account were requested by mail to perform the transfer. There were no differences between participants accepting the compensation or not in terms of demographics (age, gender), gambling frequency, or problem gambling symptoms.

The study protocol was approved by the ethical committee of the psychological Sciences Research Institute (IPSY) at the UCLouvain (Louvain-la-Neuve, Belgium). Some of the data set described here is part of Sample 2 in the study by Canale et al. (2019).

Table 17. Characteristics and Reliability for the Scales.

Questionnaire	Author (year)	Number and Type of Items	Response Format	Composite Reliability in Current Study (CR)
Positive and Negative Affect Schedule (PANAS; state version)	Gaudreau, Sanchez, & Blondin (2006)	20 items distributed on 2 subscales (positive affect and negative affect)	5-point Likert scale: 1 (*not at all or very slightly*), 2 (*a little*), 3 (*moderately*), 4 (*quite a bit*), 5 (*extremely*)	Subscale CR .83 and .90, respectively
Problem Gambling Severity Index (PGSI)	Ferris & Wynne (2001)	9 items	4-point Likert scale: 0 (*never*), 1 (*sometimes*), 2 (*most of the time*), 3 (*almost always*)	Total score CR = .80
Gambling Craving Scale (GACS)	Canale et al. (2019)	7 items distributed on 2 subscales (pleasure and relief)	7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*)	Subscale CR .80 and .88, respectively
Short UPPS-P Impulsive Behavior Scale (S-UPPS-P)	Billieux et al. (2012)	20 items distributed on 5 subscales (negative urgency, positive urgency, lack of premeditation, lack of perseverance, and sensation seeking)	4-point Likert scale: 1 (*I agree strongly*), 2 (*I agree somewhat*), 3 (*I disagree somewhat*), 4 (*I disagree strongly*)	Subscale CR ranging from .77 to .85
Gambling-Related Cognitions Scale (GRCS)	Grall-Bronnec et al. (2012)	23 items distributed on 5 subscales (interpretative bias, illusion of control, predictive control, gambling expectancies, and perceived inability to stop gambling)	7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*)	Subscale CR ranging from .73 to .86
Gambling Motives Questionnaire-Financial (GMQ-F)	Devos et al. (2017)	15 items distributed on 4 subscales (coping, enhancement, social, and financial)	4-point Likert scale: 1 (*never or almost never*), 2 (*sometimes*), 3 (*often*), 4 (*almost always or always*)	Subscale CR ranging from .74 to .81

2.3 Data analytic strategy

Preliminary analysis of the distribution of variables with a graphical approach and skewness and kurtosis tests indicated that most of the data were not normally distributed and were right-skewed. Consequently, non-parametric tests were preferred. As the factor structure of the CEQ had already been established (May et al., 2014), each form (i.e., g-CEQ-S and g-CEQ-F) was investigated through a CFA by using maximum likelihood with the Satorra-Bentler correction (MLM) as estimator. This robust version of the maximum likelihood estimator is recommended for smaller samples and non-normal data with outliers, and it requires no missing values (Schumacker & Lomax, 2016). A one-factor solution for each form was also tested and compared with the expected three-factor model. The reliability was evaluated with a composite reliability (CR) test.

Spearman's ρ was used to evaluate the correlations. Effect sizes of correlation were discussed according to Cohen's (1988) guidelines. The concurrent validity of the g-CEQ-S was assessed from correlations with the GACS (Canale et al., 2019). Convergent validity was estimated by investigating the correlations of each subscale of both forms of the g-CEQ with gambling frequency and gambling-related constructs: disordered gambling symptoms (PGSI), gambling motives (GMQ-F), gambling cognitions (GRCS), and impulsivity traits (S-UPPS-P). Correlations of the g-CEQ-S subscales and emotional states (PANAS) were also considered, as affect is known to influence craving (de Castro et al., 2007; Schlauch et al., 2013; Sharpe, 2002; Tiffany & Kassel, 2010).

3. Results

3.1 Factor structure

The CFA and the CR were computed with the lavaan R Package (Rosseel, 2012) in RStudio (RStudio Team, 2016). Schumacker and Lomax (2016) suggest systematically reporting three fit indices for the CFA: the chi square, the root mean square error of approximation (RMSEA; value of .05 to .08 indicates a close fit), and the standardized root mean square residual (SRMR; value of < .05 indicates a good model fit). Additional commonly used fit indices were also considered, namely, Bentler's comparative fit index (CFI; value close to .90 or .95 reflects a good fit) and the goodness-of-fit index (GFI; value close to .90 or .95 reflects a good fit). The CFA for the g-CEQ-S showed that a three-factor solution produced an acceptable fit ($\chi^2 = 44.52$; $df = 24$; $p < 0.01$); RMSEA = .07 (.04–.10), SRMR = .03, CFI = .99, GFI = .97. The factor loadings (see Figure 9) were all positive and significant ($p < .001$) and ranged from .76 to .95. The CR indices were good to excellent for the three subscales: intensity (.91), imagery (.86), and intrusiveness (.91). The one-factor solution produced a poorer fit ($\chi^2 = 242.36$; $df = 27$; $p < .01$); RMSEA = .22 (.19–.24), SRMR = .08, CFI = .82, GFI = .82. The CFA for the g-CEQ-F showed that a three-factor solution also produced an acceptable fit ($\chi^2 = 47.63$; $df = 24$; $p < .01$); RMSEA = .08 (.05–.12), SRMR = .04, CFI = .96, GFI = .95. The factor loadings (see Figure 9) were all positive and significant ($p < .001$) and ranged from .72 to .92. The CR indices were good for the three

subscales: intensity (.86), imagery (.83), and intrusiveness (.89). The one-factor solution again produced an inferior fit ($\chi^2 = 114.26$; $df = 27$; $p < 0.01$); RMSEA = .17 (.13–.19), SRMR = .06, CFI = .89, GFI = .86.

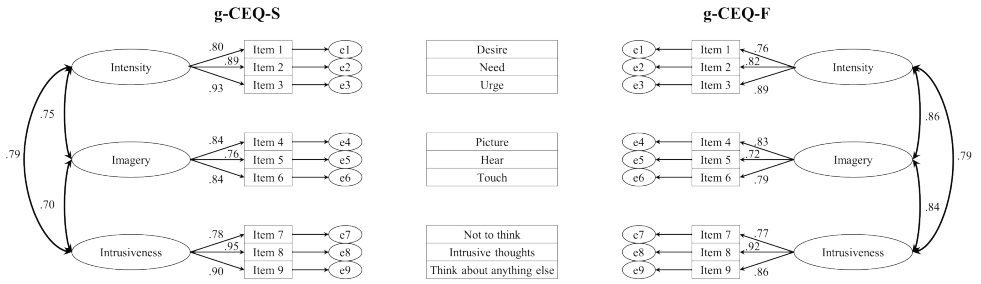

Figure 9. Factorial structure of the strength and frequency forms of the gambling Craving Experience Questionnaire (g-CEQ)

3.2 Correlation analyses

Spearman's ρ was evaluated with IBM SPSS Statistics (IBM Corp, 2016). Correlations of interest for the purpose of the study are reported in Table 18. The significance threshold was lowered, according to the Bonferroni correction, in terms of the number of correlations (.05/108 = .00046). The three subscales of both forms showed moderate to strong significant correlations between each other. There were also moderate to strong correlations between the g-CEQ-S and the GACS. All subscales of both versions of the g-CEQ significantly correlated with problem gambling symptoms, gambling motives (except financial motives), and gambling cognitions. Regarding the impulsivity facets assessed by the S-UPPS-P, only the sensation seeking subscale correlated with the imagery subscale of the g-CEQ-F. With regard to affect, the intensity subscale of the g-CEQ-S showed significant correlation with positive affect. Finally, gambling frequency was found to correlate with the various subscales of the g-CEQ-F.

4. Discussion

This research was designed to test the psychometric properties of the two forms of the g-CEQ (strength and frequency), a scale grounded in the EIT and adapted from the CEQ (May et al., 2014). Crucially, the current study represents the first attempt to adapt the CEQ to gambling, whose pathological form (gambling disorder) is to date the only accepted behavioural addiction in the DSM (American Psychiatric Association, 2013). The various analyses conducted showed that this new scale has adequate psychometric properties and thus constitutes a promising tool for future research and clinical practice.

The computed CFA supported the validity of the expected three-factor model of the strength and frequency forms of the g-CEQ, and it showed better model fit than a one-factor solution, corroborating the initial structure of the CEQ (May et al., 2014; Statham et al., 2011). Moreover, similarly to what was done by May et al. (2014), the current study tested the

structure of the g-CEQ-S following an induction procedure, which is theoretically sound for measuring craving as a state construct (Canale et al., 2019). The three factors – intensity, imagery, and intrusiveness – of both forms (g-CEQ-F and g-CEQ-S) are composed of three items. These results suggest that the modifications made to adapt the scale (e.g., suppression of one sensorial item, slight modifications in the wording to match the gambling context) were relevant and did not affect the scale's structural validity.

Table 18. Spearman's Correlations of the g-CEQ-S and g-CEQ-F Subscales for Concurrent and Convergent Validity

	g-CEQ-S			g-CEQ-F		
	Intensity	Imagery	Intrusiveness	Intensity	Imagery	Intrusiveness
g-CEQ-F Intensity	.55*					
g-CEQ-F Imagery		.49*				
g-CEQ-F Intrusiveness			.61*			
GACS Pleasure	.67*	.53*	.46*			
GACS Relief	.69*	.57*	.68*			
PGSI	.42*	.34*	.44*	.49*	.48*	.49*
GMQ-F Social	.31*	.33*	.33*	.24*	.38*	.31*
GMQ-F Coping	.47*	.37*	.49*	.49*	.50*	.51*
GMQ-F Enhancement	.40*	.38*	.35*	.33*	.32*	.27*
GMQ-F Financial	.19	.11	.17	.24*	.14	.23*
GRCS Gambling Expectancies	.58*	.42*	.52*	.53*	.54*	.48*
GRCS Illusion of Control	.52*	.37*	.43*	.37*	.43*	.45*
GRCS Predictive Control	.52*	.40*	.45*	.44*	.44*	.50*
GRCS Inability to Stop Gambling	.57*	.36*	.57*	.55*	.52*	.56*
GRCS Interpretative Bias	.50*	.49*	.46*	.44*	.47*	.44*
Negative Urgency	.11	.01	.12	.10	.11	.08
Positive Urgency	.11	.12	.12	.06	.02	.06
Lack of Premeditation	.03	-.02	.02	.06	.06	.03
Lack of Perseverance	.00	.01	.09	.02	.01	.04
Sensation Seeking	.15	.16	.15	.20	.24*	.17
Positive Affect	.21*	.17	.11			
Negative Affect	.03	.01	.12			
Gambling Frequency				.47*	.28*	.30*

Note. g-CEQ-S = gambling Craving Experience Questionnaire – Strength form; g-CEQ-F = gambling Craving Experience Questionnaire – Frequency form; GACS = Gambling Craving Scale; PGSI = Problem Gambling Severity Index; GMQ-F = Gambling Motives Questionnaire; GRCS = Gambling-Related Cognitions Scale.
*$p < .00046$.

The moderate-to-strong correlations observed between the subscales of the g-CEQ-S and the GACS support its construct validity. Indeed, the relief- and pleasure-related thoughts and imagery constitute the craving experience according to the EIT (Kavanagh et al., 2005), which explains the relation with the GACS, which assesses gambling urge from a positive and negative reinforcement perspective (e.g., feeling high/stimulated, reduce anxiety or sadness). However, and contrary to the GACS, the g-CEQ measures cognitive rather than motivational processes, implying that these two scales are more complementary than competitive.

Convergent validity was supported by the correlations (reported in Table 18) with problem gambling symptoms, gambling motives (except for the financial facet), and gambling cognitions, implying a close relation between problem gambling severity and risk factors for problem gambling with the strength and frequency of gambling craving. The differential links observed with impulsivity traits warrant further discussion. Unexpectedly, all correlations of the g-CEQ subscales with the impulsivity facets were of small amplitude and non-significant. Indeed, previous studies generally observed moderate and positive correlations between impulsivity facets (especially negative urgency) and cigarette (Billieux et al., 2007; Doran et al., 2007), mobile phone (De-Sola et al., 2017), or pornography (Rømer Thomsen et al., 2018) craving. Nevertheless, as previously explained, the scales used in these previous studies measured gambling urge (e.g., anticipation of pleasure or relief) rather than gambling craving (for a more comprehensive account of the distinctions between these two constructs, see Canale et al., 2019), explaining their close link with impulsive traits and behaviors (Gray, 1994; Rochat et al., 2018). In contrast, craving as assessed by the CEQ is more linked with cognitive constructs (e.g., mental imagery), implying that they will more likely correlate with measures that assess, for instance, intrusive or obsessive thoughts. Only sensation seeking was correlated with the imagery subscale of the g-CEQ-F, suggesting that participants with higher sensation seeking more frequently elaborate images related to the object of desire in order to potentially feel, to a lesser extent, the excitement or pleasure provided by gambling.

Some limitations of the study need to be mentioned. First, although appropriate for the analyses conducted, the sample size of our study was relatively modest and mainly composed of occasional gamblers from the community. Future studies should thus replicate the findings in a larger sample and in clinical gamblers. Second, the study relied on self-reported measures, which are known to be influenced by different types of biases (e.g., lack of introspection, social desirability). To this end, further validation of the g-CEQ could capitalize on a combination of self-reported measures and physiological measures, as is often the case in craving research, although more research is needed in the field of gambling (Ashrafioun & Rosenberg, 2012). Third, the induction procedure involved a guided imagery approach, which may have inflated imagery-related features of the triggered craving. However, this procedure was necessary to ensure the measurement of craving as a state construct (for a related discussion, see Canale et al., 2019). Fourth, our design can be considered semi-ecological, as we induced a craving state rather than analyzing naturally occurring craving. Yet, past research has shown that the use of relevant cues (such as those

present in the guided imagery) allows triggering of real craving episodes (Erblich et al., 2009; Wölfling et al., 2011). Despite these limitations, the g-CEQ is a promising tool for assessing gambling craving based on the EIT, a cognitive model of craving that has grown in popularity in recent years. The g-CEQ allows for the development of theoretically founded, process-based clinical interventions, such as interference-based techniques known to interfere with the vividness of craving experiences (e.g., May, Andrade, Panabokke, et al., 2010; Steel et al., 2006) and mindfulness-based approaches that help people to accept and cope with the intrusive nature of some craving experiences (Sancho et al., 2018).

Chapter 5

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

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

Reference: Cornil, A., Rothen, S., de Timary, P., & Billieux, J. (2021). Interference-based methods to mitigate gambling craving: A proof-of-principle pilot study. *International Gambling Studies*. Advance online publication. https://doi.org/10.1080/14459795.2021.1903063

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

1. Introduction

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

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

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

1.1 The Elaborated Intrusion Theory of Desire

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

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

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

1.2 Interference-Based Psychological Interventions

According to the EIT, attentional and working memory allocation plays a pivotal role in the elaboration of desire thoughts and the persistence and vividness of the craving experience (Kavanagh et al., 2005; May et al., 2004). Several studies have shown that inducing craving decreases cognitive performance, thus confirming that the craving process is underpinned by cognitive resources (Green et al., 2000; Kemps, Tiggemann, & Grigg, 2008; Tiggemann et

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

In recent years, an increasing number of experiments have been conducted to test the potential of different types of interference-based methods in reducing craving. A non-exhaustive yet representative selection of such studies is detailed in Table 19. These studies were selected to exemplify the variety and specificities of interference-based methods that have been used across different populations, settings (induced, naturally occurring, real world), and types of craving (e.g., food, tobacco, alcohol, caffeine). Existing studies suggest, on the one hand, that interference-based methods can reduce or interrupt craving, and, on the other, that methods involving visual imagery are the most effective. A limitation of some of the techniques used (e.g., modelling geometric forms with clay) is that they are not easily transferable to everyday life, thus limiting their potential clinical utility. A notable exception is the video game Tetris, which can easily be installed on a variety of portable technological devices used in daily life (e.g., tablets and smartphones). Tetris is characterized by a heavy load on visuospatial working memory and can thus be considered a relevant interference-based method (Skorka-Brown et al., 2014, 2015). Indeed, this video game decreased attentional biases towards food and reduced experimentally induced craving. It also helped participants who were sensitive to hedonic food cues not to respond to high-calorie food after a craving induction (van Dillen & Andrade, 2016). Tetris also showed efficacy in diminishing naturally occurring craving strength and the vividness of related mental images (Skorka-Brown et al., 2014). Finally, playing Tetris for 3 minutes in a real-life setting helped to reduce the intensity of craving for psychoactive substances and food, as well as for a variety of appetitive behaviours such as sex, video gaming, and physical exercise (Skorka-Brown et al., 2015).

Table 19. Selection of studies that use interference-based methods

Study	Target	Participants	Interference-based tasks and control conditions (CC)	Results
Kemps et al. (2005)	Induced **chocolate** craving	Chocolate cravers or not cravers, female university students	• Dynamic visual noise • Irrelevant speech	**Reduction** of craving and vividness ***Dynamic visual noise more effective than irrelevant speech***
Steel et al. (2006)	Induced **food** craving	Food deprived or not-deprived female University students	• Dynamic visual noise	**Reduction** of vividness and intensity of craving
May et al. (2010) *4 experiments*	Induced **cigarette craving**	Smokers (>10 cigarettes/day) recruited in a University (staff and students)	• Auditory mental imagery • Visual mental imagery	**Reduction** of craving in visual condition but not in auditory condition
			• Auditory mental imagery and dynamic visual noise • Visual mental imagery	**Reduction** of craving in both conditions among deprived individuals
			• Auditory mental imagery • Visual mental imagery	**Interruption** of the increase of craving in visual imagery condition but not in auditory imagery condition
			• Clay modelling • Backwards counting (CC)	**Interruption** of the increase of craving in clay modelling condition but not in backwards counting condition

Study	Target	Participants	Interference-based tasks and control conditions (CC)	Results
Knäuper et al. (2011)	Naturally occurring **food** or **drink** craving	University staff and students	• Pleasant imagery • Backwards alphabet (CC)	**Reduction** of craving Pleasant imagery more effective than reciting the backwards alphabet condition
Andrade et al. (2012) *2 experiments*	Induced **chocolate** craving	Chocolate lovers recruited from university staff and students	• Clay modelling • Backwards counting (CC)	**Reduction** of craving in clay modelling Clay modelling as effective as backwards counting
			• Clay modelling	**Reduction** of the strength and the vividness of craving in Clay modelling condition
			• Backwards counting (CC)	Clay modelling more effective than backwards counting
Kemps & Tiggemann (2013)	Naturally occurring **food** craving	Female university students with food craving (7/week)	• Dynamic visual noise • No task (CC)	**Reduction** of the intensity of food craving Dynamic visual noise more effective than no intervention

Study	Target	Participants	Interference-based tasks and control conditions (CC)	Results
Skorka-Brown et al. (2014)	Naturally occurring **food**, **drink**, **caffeine**, or **nicotine** craving	University students	• Puzzle video game Tetris • Load screen (CC)	**Reduction** of the strength and vividness of craving in Tetris condition Tetris more effective than load screen
Skorka-Brown et al. (2015)	In real world, **drugs**, **drink**, **food**, or **activities** craving	University students	• Puzzle video game Tetris • No task (CC)	**Reduction** of the strength and vividness of craving in Tetris condition Tetris more effective than simple monitoring
Schumacher et al. (2018)	Naturally occurring **food** craving	Female university students with food craving (1/day)	• Mental imagery • Cognitive defusion (CC)	**Reduction** of the frequency and intensity of craving Mental imagery as effective as cognitive defusion
Dodds et al. (2019) *2 experiments*	Naturally occurring **food**, **drink**, **caffeine**, **nicotine**, **alcohol**, or **unspecified** craving	University students and the nearby city dwellers	• Puzzle video game Tetris • Corsi block task • Digit span task (CC)	**Reduction** of intensity, vividness, and intrusiveness but no difference across tasks
			• Corsi block task • Video watching (CC)	**Reduction** of intensity, vividness and intrusiveness more important in the task involving working memory (Corsi block)

Note. The lines separate experiments from one study.

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

1.3 Current study

Given the central role of craving in the maintenance and relapse of gambling disorder, the development of specific interventions that target the implicated processes is an important step towards the improvement of psychological treatment for this condition. In this vein, the EIT provides a sound theoretical framework to account for the gambling craving and interference-based methods inspired from this model that have substantiated their effectiveness in mitigating substance and food-related craving (see Table 19). In such a context, the present investigation aimed to test, for the first time (O'Neill, 2017), the efficacy of visuospatial interference methods in the context of experimentally induced gambling craving via two distinct experiments. Gamblers from the general population were recruited for this proof-of-principle study. In Experiment 1, we tested an intervention in which participants were asked to form a vivid mental image of a bunch of keys while manipulating them without seeing them. The target mental image of this interference-based method was chosen because keys are a common item that everyone carries, and because the task involves visuospatial and tactile senses that are relevant in the context of gambling craving (Cornil et al., 2018). In Experiment 2, we tested another type of interference-based method, which consists in playing the video game Tetris. This choice was based on recent studies suggesting that suggested that this video game, which has a heavy load on visuospatial working memory interferes with visual imagery involved in the elaboration of craving, can be successfully used to mitigate substance craving (see Table 19 for more details; Skorka-Brown et al., 2014, 2015).

2. Experiment 1

2.1 Methods

2.1.1 Participants and recruitment

The sample comprised 38 community individuals (16 males and 22 females; mean age 29 years old, age range 18-59 years old) who gamble at least once a month. To be included in the experiment, participants had to be 18 years or older, fluent in French, and not in the process of quitting or reducing gambling. Education, occupation, and gambling preferences are reported in Table 20. Participants were recruited through flyers at gambling venues, advertisements on university campus, and social media. Participants who completed the

whole experiment received 5 euros in compensation which could also be handed out in the form of scratch cards (see Experimental Design).

Table 20. Demographics and gambling preferences

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

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

2.1.2 Questionnaires

Craving (i.e., the dependent variable) was measured with the g-CEQ, which has two forms: The frequency version (g-CEQ-F) is used to evaluate the rate of craving in a certain period (e.g., last week) and the strength version (g-CEQ-S) is used to assess a specific craving episode (here, the craving measured at baseline, post-induction but pre-intervention, and post-intervention; see below and Figure 10). Each form contains three subscales (intensity, imagery, and intrusiveness).

Table 21. Characteristics and reliability of scales used

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

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

Other questionnaires were used as control variables:

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

The questionnaires used in this study and their properties are presented in Table 21[1].

2.1.3 Experimental design

Participants were informed about the topic of the study and general procedure, financial compensation, confidentiality, and the possibility of withdrawing from the study at any time. After reading the presentation, they answered an initial online questionnaire that was administered with the online platform Qualtrics, so that we could identify eligible participants. The inclusion criteria were gambling at least once a month, being over the age of majority (18 years in Belgium), speaking French, and not being involved in a gambling-related treatment. After having signed the informed consent document, participants completed demographics information and had to provide a valid email address for the second part of the experiment. They also completed the following randomized questionnaires used as control variables: the short Psi-Q, g-CEQ-F, PGSI, and short UPPS-P. The participants who met the inclusion criteria were then contacted by email to set up an appointment for the experimental phase. Participants completed the experiment individually in a laboratory with a trained and supervised master student (one per experiment) who installed them in front of a computer to start filling in questionnaires that were also hosted by Qualtrics. After a reminder about the experiment, the participants started by filling in the DASS-21. They then had to evaluate their current gambling craving with their baseline on the g-CEQ-S (g-CEQ-S_{Base}). A craving was then experimentally induced through the combination of an audio-guided imagery scenario and a gambling task (both available at https://osf.io/cmzgr/). The scenario was based on the work of Ashrafioun, McCarthy, and Rosenberg (2012), and recent research showing its efficiency (Canale et al., 2019). The gambling task, designed with E-Prime 2.0, consisted in playing a slot machine with two dice (see Figure 10). Participants were told that they had three chances to obtain a total of 7 by summing the two dice to win

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

five scratch cards of Win for Life (maximum win is 500€/month for life; worth 1€ each). The first trial was a miss (between 2 and 5 or between 9 and 12) as was the second (6 or 8). The third trial was a win, announced with a jingle and "jackpot" mentions in the corners of the screen. The five tickets were placed on the desk, but participants were told not to scratch the cards yet. Before the intervention, they again completed the g-CEQ-S_{Pre} and were randomly assigned to the experimental or control conditions. Following the conditions described below (see Conditions section), craving was assessed a final time post intervention with the g-CEQ-S_{Post}. The participants were then debriefed, and a short mindfulness session (audio file available at https://osf.io/cmzgr/) was offered to avoid carryover effects. They could also choose to keep the five scratch cards or exchange them for €5.

All study data are available from the Open Science Framework repository (https://osf.io/cmzgr/).

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

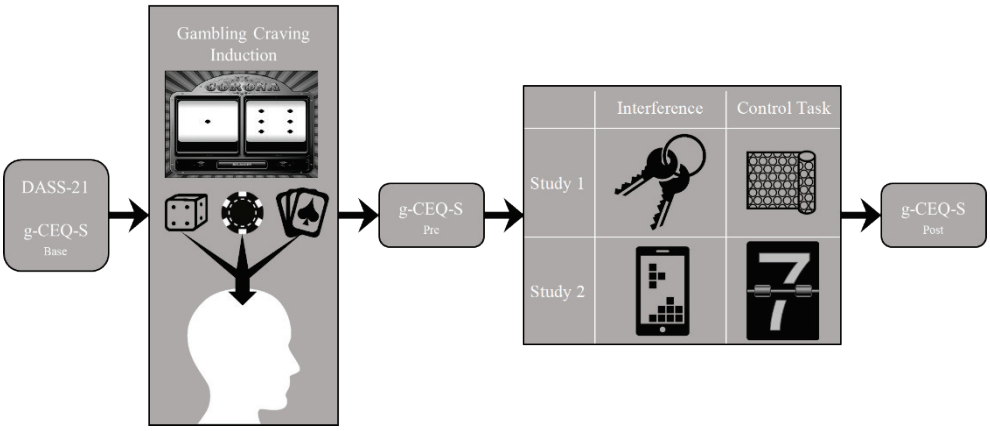

Figure 10. Experimental design for both experiments

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

2.1.4 Conditions

In the experimental condition, the interference method consisted in manipulating with one's dominant hand a bunch of keys (one car key, one flat key, and one deadlock key tied on a keyring with a plastic fidelity card from a supermarket) in an opaque bag. During a 322-second recorded session (audio file available at https://osf.io/cmzgr/), participants were instructed to mentally picture the keyring (shape, texture, colour, size) and each key one by one, and then to create a mental image of the entire bunch of keys as vividly as possible. This task was chosen because imagining a bunch of keys requires cognitive resources (working

memory, visual sketchpad, and attention). Moreover, from a clinical utility viewpoint, this method is easily implementable in daily life. In the control condition, participants had to pop bubble wrap and count each bubble with the rhythm of a metronome (25 BPM; audio file available at https://osf.io/cmzgr/). Exploding bubble wrap is often used as a source of amusement and can be used as art therapy (Durrani, 2014) but we postulated that this task did not involve the visual cognitive resources that are essential in the elaboration of a craving (May, Andrade, Panabokke, et al., 2010).

2.2 Results

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

2.2.1 Induction of gambling craving and intervention efficacy

Gambling craving was induced with audio-guided imagery and a short gambling task. To ensure that the induction worked properly, we performed paired samples *t*-tests to compare the subscales of the g-CEQ-S_{Base} and g-CEQ-S_{Pre} (intensity, imagery, and intrusiveness).

Table 22. Paired samples t-tests between g-CEQ-S subscales at T1 (baseline) and at T2 (post-induction) and between g-CEQ-S subscales at T2 and at T3 (post-intervention)

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

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

Results presented in Table 22 show a significant increase ($p < .001$) between baseline (T1) and pre-intervention (T2) for the three subscales of the g-CEQ-S with large effect sizes ($d > .80$), except for intrusiveness where a medium effect size ($d > .50$) occurred (Cohen, 1988). To evaluate the impact of the interventions on induced gambling craving, we used paired samples *t*-tests to compare the subscales of the g-CEQ-S_{Pre} and g-CEQ-S_{Post}. Results

presented in Table 22 show significant decreases ($p < .001$) between T2 and post-intervention (T3) for the three subscales of the g-CEQ-S with large effect sizes ($d > .80$), except for a medium effect size ($d > .50$) for intrusiveness.

2.2.2 Condition differences

Independent sample *t*-tests were performed to evaluate the difference between experimental and control conditions for sex, age, and the following scales and their subscales: PGSI, short Psi-Q, S-UPPS-P, DASS-21, g-CEQ-F and g-CEQ-S_{Base}. We used a False Discovery Rate procedure (Benjamini & Hochberg, 1995) via an online calculator (Carbocation Corporation, 2016) to determine adjusted *p*-values with a false discovery rate of 5% for the 24 *t*-tests computed. No significant difference between conditions was found (see Table 23).

2.2.3 Effect of interference methods

Three repeated measures analyses of covariance (ANCOVA; one for each g-CEQ-S subscale) were performed with time (T2 and T3) as a within-subject factor, task as a between-subject factor (experimental and control), and PGSI as a covariate (in order to take into account individual differences in disordered gambling symptoms). In both the experimental and control conditions, the various craving subscales (intensity, imagery, and intrusiveness) decreased significantly over time (see Figure 11).

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

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

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

Table 23. Independent samples t-tests between experimental and control conditions

	Experiment 1			Experiment 2		
	Statistic	Mean difference	Benjamini-Hochberg Adjusted *p*	Statistic	Mean difference	Benjamini-Hochberg Adjusted *p*
Sex	1.73		.99	.00		.57
Age	1.24	4.89	.88	-1.79	-6.58	.48
short Psi-Q Vision	.44	.63	.88	1.23	2.79	.61
short Psi-Q Sound	-.37	-1.11	.86	1.43	2.47	.55
short Psi-Q Smell	.75	1.42	.79	1.02	2.58	.55
short Psi-Q Taste	.56	1.32	.82	1.21	3.16	.61
short Psi-Q Touch	-.40	-.79	.87	.55	1.16	.75
short Psi-Q Body	-.94	-1.58	.84	1.49	2.21	.56
short Psi-Q Emotion	.09	.16	.97	.67	.95	.71
g-CEQ-F Intensity	.11	.26	1.00	-.50	-1.11	.74
g-CEQ-F Imagery	.06	.11	.96	-.94	-1.95	.70
g-CEQ-F Intrusiveness	.91	1.68	.74	-2.19	-3.68	.48
PGSI	.11	.11	1.00	-.90	-1.37	.68
Negative Urgency	1.58	1.53	.72	.61	.53	.73
Positive Urgency	2.35	1.74	.24	-.30	-.21	.77
Lack of Premeditation	-.56	-.42	.87	-.34	-.26	.81
Lack of Perseverance	-.91	-.68	.81	.39	.32	.80
Sensation Seeking	-.69	-.74	.80	1.50	.74	.67
DASS-21 Depression	1.41	1.95	.82	-2.37	-2.05	.56
DASS-21 Anxiety	1.73	2.37	.72	-.72	-3.21	.48
DASS-21 Stress	2.72	4.11	.24	-.72	-.79	.72
g-CEQ-S_{Base} Intensity	.84	2.16	.75	-1.75	-3.00	.43
g-CEQ-S_{Base} Imagery	1.01	2.58	1.00	-.90	.79	.77
g-CEQ-S_{Base} Intrusiveness	1.00	2.11	.88	-.90	-2.00	.65

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

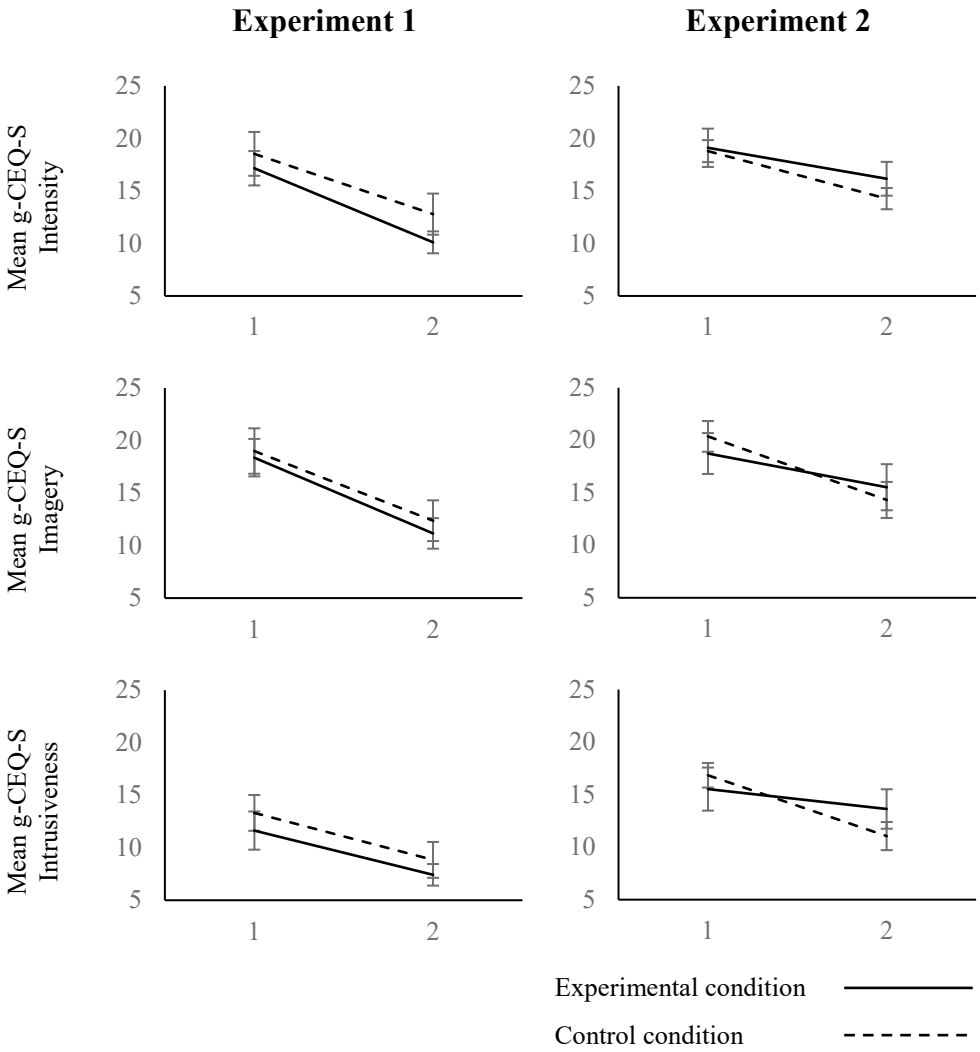

Figure 11. Mean ratings of each g-CEQ-S subscale at T2 (post-induction) and T3 (post-intervention) for Experiment 1 and Experiment 2

Note. Error bars represent standard error of the mean. g-CEQ-S = gambling Craving Experience Questionnaire – Strength form.

2.3 Discussion of experiment 1

In this first experiment, we found that both tasks reduced gambling craving intensity, the vividness of mental images, and the intrusiveness of desire thoughts. Yet, contrary to our expectations, both task types similarly mitigated craving, indicating that our "control" tactile task had the same effect on craving as did the method involving visual mental imagery. Our findings are not consistent with previous evidence showing that craving mainly depends on

visuospatial processes (e.g., Andrade, May, et al., 2012; Knäuper et al., 2011; May, Andrade, Panabokke, et al., 2010). However, these results might be explained by the involvement of working memory in the control condition (participants had to remember to explode the bubbles with the rhythm of a metronome and simultaneously to count the bubbles exploded), which is also a cognitive function postulated to underlie the craving process according to the EIT (Kavanagh et al., 2005; May et al., 2015). Such a view is consistent with the findings obtained by Dodds et al. (2019), who showed that a task that required verbal working memory (Digit Span) was as effective as other tasks focused on visuospatial cognitive resources (Tetris and Corsi Block) in order to reduce naturally occurring substance-related craving. Moreover, we cannot exclude the possibility that some participants in the control condition used different strategies during the bubbles task (e.g., some participants used patterns to explode bubbles that may have involved visuospatial capacities). For this reason, our control condition might have been not optimal nor pure enough in terms of the cognitive mechanisms involved. We thus decided to use another control task in Experiment 2, namely backwards counting. Indeed, this task has been successfully used as a control condition in other interference-based studies and mobilizes verbal working memory but not visuospatial abilities (e.g., Andrade, Pears, et al., 2012; May, Andrade, Panabokke, et al., 2010; Versland & Rosenberg, 2007).

3. Experiment 2

3.1 Methods

3.1.1 Participants and recruitment

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

3.1.2 Questionnaires and experimental design

The design replicates Experiment 1 with the same questionnaires and other tasks described in the Conditions section below (see Figure 10). The data from this experiment is also available at https://osf.io/cmzgr/.

3.1.3 Conditions

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

participants had to count backwards by 7 starting from 500 during the same length of time as in the interference condition (i.e., 3 minutes).

3.2 Results

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

3.2.1 Induction of gambling craving and intervention efficacy

Gambling craving was induced as in Experiment 1. The efficacy of the gambling craving induction was checked by computing paired samples *t*-tests between the g-CEQ-S_{Base} and the g-CEQ-S_{Pre} (intensity, imagery, and intrusiveness). Results presented in Table 22 show significant increases ($p < .001$) between T1 and T2 for the three subscales of the g-CEQ-S with large effect sizes ($d > .80$) according to Cohen's guidelines (1988). The effect of both tasks of was evaluated by paired samples *t*-tests between the g-CEQ-S_{Pre} and the g-CEQ-S_{Post}. Results presented in Table 22 show significant decreases ($p < .001$) between T2 and T3 for the three subscales of the g-CEQ-S with large effect sizes ($d > .80$), except for a medium effect size ($d > .50$) for intrusiveness.

3.2.2 Condition differences

Independent samples *t*-tests were performed to evaluate the difference between both conditions on all variables tested in Experiment 1 and following the same Benjamini-Hochberg procedure to determine adjusted *p*-values. No significant difference between conditions was found (see Table 23).

3.2.3 Effect of interference methods

As in Experiment 1, three repeated measures ANCOVAs (one for each g-CEQ-S subscale) were performed with time (pre and post) as the within-subjects factor, task as the between-subject factor (experimental and control), and PGSI as a covariate. In both experimental and control conditions, craving subscales (intensity, imagery, and intrusiveness) decreased significantly over time (see Figure 11).

g-CEQ-S Intensity. There was a significant effect of time, $F(1,35) = 4.79$, $p = .035$, partial $\eta^2 = .120$, but no significant effect of condition, $F(1,35) = 0.01$, $p = .918$, partial $\eta^2 < .001$. The analyses revealed no significant interaction between time and condition, $F(1,35) = 2.41$, $p = .130$, partial $\eta^{22} = .064$, but they showed a significant interaction between time and PGSI, $F(1,35) = 4.18$, $p = .048$, partial $\eta^2 = .107$. Given the sample size, a graphical approach was favoured to further investigate this interaction (Figure 12). Participants who presented more gambling disorder symptoms reported a higher intensity of craving at T2, which decreased more sharply than it did among those who presented fewer gambling disorder symptoms. No significant difference was found between experimental and control conditions for the g-CEQ-S intensity subscale at T2, $t(36) = -0.15$, $p = .882$, and at T3, $t(36) = -1.00$, $p = .326$.

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

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

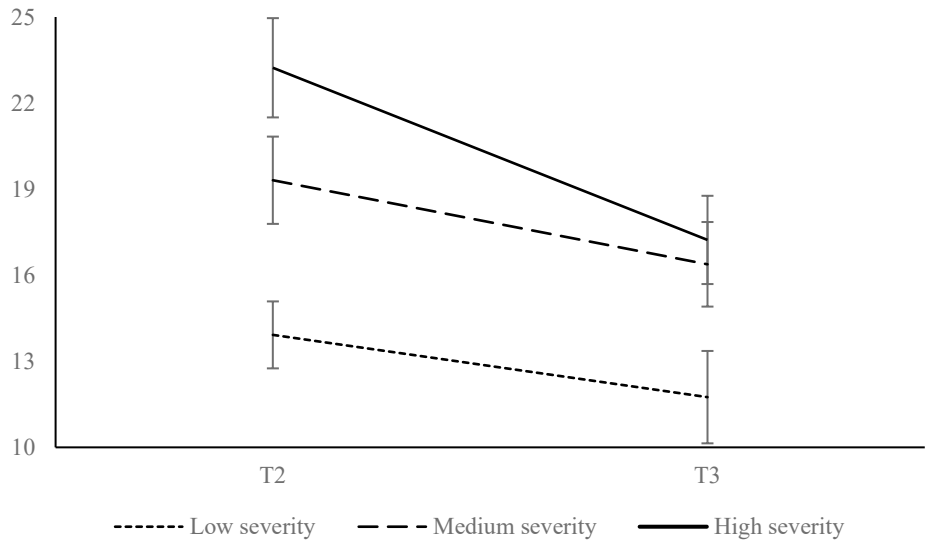

Figure 12. Mean ratings of the intensity subscale of the g-CEQ-S at T2 (pre-intervention) and T3 (post-intervention) for Experiment 2 across three categories of gambling severity

Note. Error bars represent standard error of the mean. The sample was divided into three categories according to the Problem Gambling Severity Index scores: low severity (0-2; n = 12), medium severity (3-7; n = 13) and high severity (8-21; n = 13). g-CEQ-S = gambling Craving Experience Questionnaire – Strength form.

3.3 Discussion of experiment 2

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

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

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

4. General discussion

The two experiments presented in this paper tested, for the first time, the mitigating effect of two interference methods on laboratory-induced gambling craving that are easily implementable in daily life. The first method involved creating a multi-sensorial mental image (picturing a bunch of keys while manipulating them) and the second method involved playing a video game that mobilized visuospatial working memory. In both experiments, gambling craving intensity, imagery, and intrusiveness decreased as the result of the tasks used. These outcomes are broadly consistent with previous research that shows the usefulness of methods that tax working memory resources in reducing craving (e.g., Kemps et al., 2005; May, Andrade, Panabokke, et al., 2010; Skorka-Brown et al., 2015). Given the prominent role of craving in gambling disorder, the current findings have concrete clinical implications. Although derived from a community sample of gamblers among whom only a minority presented with gambling disorder symptoms, the present results provide preliminary support for the clinical utility of interference-based techniques in the clinical context.

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

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

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

The present study has some limitations to consider. Firstly, the control tasks of each study were not strictly equivalent, preventing the comparison of experimental tasks. However, as the control task from the first experiment might have involved visuospatial resources, we decided to use another "purer" verbal task in Experiment 2. Secondly, our samples are composed of community gamblers and our results should be replicated in a clinical population. Thirdly, our sample size is relatively small. Nevertheless, we determined sample size in our experiments based on previous studies with similar aims (i.e., testing the effect of interference methods) and procedures (e.g., Kemps & Tiggemann, 2013c; May, Andrade, Panabokke, et al., 2010; Skorka-Brown et al., 2015). Fourthly, as a decrease in craving was observed with all tasks used (experimental and control tasks), we cannot exclude that the diminution of craving was explained by a distraction or cognitive load effect, rather than by the effect of sensory imagery per se. Moreover, it remains difficult to determine whether the tasks involved other working memory slave-systems. Future research could use tasks that focus on a specific sensorial modality (i.e., "pure" tasks) in order to compare, for instance, auditory to visuospatial interference, such as span (recalling a series of numbers or letters

that are read or heard) or go/no-go (responding or inhibiting response to auditory or visual stimuli) tasks. Finally, one could argue that the results observed could be due to a natural decrease of craving rather than an effect of the interference methods per se. Yet, previous research that used comparable craving induction procedures and interference methods successfully showed differences in post-task self-reported craving across experimental conditions (e.g., Andrade, Pears, et al., 2012; Kemps & Tiggemann, 2007; May, Andrade, Panabokke, et al., 2010). This was the case, for example, for studies showing the superiority of interference methods in comparison to "mind wandering" or "no-task" conditions (e.g., Kemps, Tiggemann, & Christianson, 2008; May, Andrade, Willoughby, et al., 2012; Schumacher et al., 2018). This observation suggests that the effects obtained in the current study, which followed a similar experimental design to those of the previous studies, can reasonably be attributed to the interference methods and not to the spontaneous reduction of induced craving.

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

Chapter 6

Tackling naturally occurring gambling craving with interference among clinical gamblers: Study Protocol

Gambling craving is an important factor of maintenance and relapse of gambling disorder. A growing body of literature tested interventions targeting substance-related craving and, to a lesser extent, gambling-related craving. Among those methods, interference-based techniques aim at moving resources allocated to the elaboration of craving-related thoughts to a competing task recruiting similar cognitive resources, thus reducing the vividness and overwhelming nature of craving. Despite promising results in laboratory experiments, few studies have investigated the relevance of such techniques in real clinical settings. This pilot study aims to test the efficacy of interference-based techniques on gambling craving in a realistic clinical setting. A multiple single-case design, easily implementable in treatment, will be used to test interference-based intervention among a small number of adult outpatients with a gambling disorder. They will be recruited by clinicians at the Center for Excessive Gambling in Lausanne, Switzerland. A web-app specifically designed for this study will allow for the assessment of naturally occurring gambling craving and the administration of the techniques through three consecutive phases (one week each): baseline, intervention, and three-month follow-up. Potentially confounding variables will also be measured (e.g. cognitive distortions, impulsivity traits). Data collection has been delayed, due to the pandemic situation. The data analytic strategy will include both visual analyses and inferential tests. Non-overlap of all pairs and slope and level change will be used to estimate the effect-size, and Cohen's d will be used to summarize treatment effects in each patient.

Reference: Cornil, A., S., de Timary, P., Khazaal, Y., Rochat, L., Simon, O., Walentynowicz, M., Zumwald, C., & Billieux, J. (2020). Tackling naturally occurring gambling craving among problem gamblers with interference [Manuscript in preparation]. Psychological Sciences Research Institute, Université catholique de Louvain.

Tackling naturally occurring gambling craving with interference among clinical gamblers: Study Protocol

1. Introduction

Gambling craving is involved in the development, maintenance, and relapse of gambling disorder (e.g., Oei & Gordon, 2008; Young & Wohl, 2009). Yet, there is a lack of research regarding evidence-based interventions available to mitigate craving in patients displaying a gambling disorder. The elaborated intrusion theory of desire (EIT; Kavanagh et al., 2005) is a cognitive model of craving which offers important avenues for the development of psychological interventions, as it clearly describes the processes at play in craving experiences (e.g., mental imageries, working memory). Recently, Cornil et al. (2018) evidenced that the elaborated intrusion theory is relevant to account for gambling craving experiences. According to this model, craving (and desire) is the result of an elaboration process where "desire thoughts" (mental images and thoughts), induced by internal (e.g., frustration) and/or external (e.g., advertisement) triggers, require attentional and cognitive resources (i.e., working memory). The principle of interference-based techniques is to move the resources allocated to the elaboration of intrusive desire thoughts towards a competing task (e.g., clay modelling, competitive mental imagery, Tetris), thus preventing the craving elaboration and reducing its vividness and overwhelming nature. Several studies (e.g., Andrade, Pears, et al., 2012; May, Andrade, Panabokke, et al., 2010; Skorka-Brown et al., 2015) have shown the efficacy of such techniques in reducing substance-related craving, with a superior effect of visuospatial interference. Yet, data obtained on clinical samples remain scarce.

To investigate the relevance of interference-based techniques, a study including two experiments (Cornil et al., 2021) was conducted in community gamblers. In two conditions (19 gamblers per condition), gambling craving was first induced via a short mental imagery session and a computer-generated gambling simulation task. Then, the experimental group was asked to perform a visuospatial interference task consisting of creating a vivid mental image of a bunch of keys (experiment 1) or of playing the videogame Tetris on a smartphone (experiment 2). The control group completed a task requiring other cognitive resources: pop and count bubble wrap (experiment 1) or to count backwards by seven (experiment 2). The analyses revealed that induced craving decreases significantly in both conditions of the two experiments, replicating the findings by Dodds et al. (2019) who question the superiority of visuospatial interference to reduce craving. Although the design of this study does not demonstrate that interference is more effective than a simple effect of time, this "proof of principle" study encourages to further investigate the potential of interference-based techniques to reduce craving in a clinical population of gamblers.

To overcome the limitations of previous research (i.e., sound control condition, clinical sample, and long-term effect investigation), we designed a new study that aimed to take place in the clinical context (i.e., the Center for Excessive Gambling, Lausanne University Hospitals). Unfortunately, we were not able to carry out this new study during the time of this doctoral thesis as a combination of factors prevented us to do so; namely an extremely lengthy ethical clearing process and the Covid-19 pandemic[1].

2. Methodology

In this project, we aim to adopt a multiple single-case design, as this methodology is ideal to understand the whole process of an interference-based intervention among a small number of outpatients (5 to 10) with a gambling disorder, given that recruitment is a major problem for research in this field (Toneatto, 2005). Besides being easily implementable in a clinical setting, this design will provide enough evidence to further validate these techniques using a randomized-control trial, with the involvement of multiple sites to maximise recruitment potential. Ecological momentary assessment and intervention via smartphone were favoured, as these methods are suitable to assess and target naturally occurring gambling craving (Merkouris et al., 2020).

2.1 Questionnaires

In the present study, several questionnaires will be used to evaluate gambling-related constructs:

- Gambling *symptomatology*: Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001)
- This questionnaire was initially created to assess Gambling Symptoms based on the previous year. We will use the previous week as timeframe (PGSI-w).
- Gambling *motivations*: Gambling Motives Questionnaire (French GMQ-f; Devos et al., 2017)
- Gambling *cognitions*: Gambling Related Cognitions Scale (GRCS; Marie Grall-Bronnec et al., 2012)

The following scales will assess gambling craving and associated concepts.

- Gambling craving: Gambling Craving Experience Questionnaire (g-CEQ; Cornil, Long, et al., 2019; May et al., 2014) Strength form (g-CEQ-S) and Frequency form (g-CEQ-F)[2]
  - 3 versions of the g-CEQ-S will be used: g-CEQ-S-*p* (*present* – current level of craving) and g-CEQ-S-*d* (strongest craving this *day*), g-CEQ-S-*w* (strongest craving this *week*)

[1] Note that the study described in this section will be conducted in 2021.

[2] Due to previous results showing the relevance of tasks involving verbal cognitive resources to reduce craving (Cornil et al., in press; Dodds et al., 2019), a tenth item on verbal thoughts was added to both forms of the g-CEQ: "Right now/at that time, how much does/did your mind expressed thoughts that are/were encouraging you to gamble?" or "Over the last week/day, how often did your mind expressed thoughts that were encouraging you to gamble?"

  - 2 version of the g-CEQ-F will be used: g-CEQ-F-*d* (frequency during the *day*) and g-CEQ-F-*w* (frequency during the *week*)
- Gambling craving *triggers*: gambling Transaddiction Craving Triggers Questionnaire (g-TCTQ; Cornil, Rothen, et al., 2019; von Hammerstein et al., 2019)
- Desire thoughts: Desire Thinking Questionnaire (DTQ; Chakroun-Baggioni et al., 2017)

Other questionnaires will serve as control variables:

- Impulsivity: Short UPPS-P Impulsive Behavior Scale (S-UPPS-P; Billieux et al., 2012)
- Imagery abilities: Short Plymouth Sensory Imagery Questionnaire (short Psi-Q; Andrade et al., 2014)
- Depression: Beck Depression Inventory 2 (BDI-2; Beck et al., 1998)
- Anxiety: State-Trait-Anxiety Inventory-Trait (STAI-T; Gauthier & Bouchard, 1993; Spielberger et al., 1993)
- Use of the app, Self-efficacy, Importance of managing gambling craving, and treatment Adherence (USIA)

2.2 Design

The study will be divided into five phases (Figure 13). The recruitment (1) will collect the demographics answers to the g-CEQ-S-w, g-CEQ-F-w and to the following randomized questionnaires: PGSI-w, GMQ-f, GRCS, g-TCTQ, DTQ, S-UPPS-P, short Psi-Q, BDI-2, and STAI-T. To create a baseline (2; maximum one week after the initial assessment), participants will be asked to use a webapp (a shortcut to a webpage that presents questionnaires and interventions) for seven days, as soon as they feel a naturally-occurring gambling craving. At that stage, the app will first ask participants if, following the previous completion, they have gambled, in order to collect information about gambling behaviours following craving. Then, it will measure instant gambling craving strength (g-CEQ-S-p), ask them to let their mind wander for three minutes, and finally measure gambling craving strength again. At the end of each day, a prompt will request them to fulfil the g-CEQ-S-d and the g-CEQ-F-d and ask them to rate their implication in the study with the USIA. The intervention phase (3), which also last 7 days, slightly differs from the previous one (Table 24): instead of mind-wandering, interference-based methods (see below) will be proposed to participants. At the end of that week, the following randomized questionnaires will be sent to them for control purposes: PGSI-w, g-TCTQ, DTQ, BDI-2 and STAI-T. Then, they will have the app at their disposal for free use (4) for three months. Reminders of the app will be sent once a month. Finally, the long-term effect will be assessed with a seven-day follow-up phase (5) that is identical to the intervention phase, with the same assessment at the end of the week.

Figure 13. The five phases of the study

The app proposes several types of interference-based methods to allow different experience and favour compliance. The first three are audio-guided. The manipulation a *bunch of keys* was already tested in the frame of this PhD thesis. It consists in creating a vivid and complete image of a bunch of keys, an object that one often carries in their pocket. The *fidget* is a complex object composed of 12 facets with different stimuli (Figure 14). As for the keys, they must be manipulated to create a realistic mental image. Both methods involve the senses of sight and touch – audition may be involved but to a lesser extent. The last guided method consists in imagining oneself in a past or expected pleasant situation. The attention of the participants is oriented towards several sensorial modalities during the *imagery* session. Once the participants have acquired some experience, they can decide to choose to do the previous tasks without instructions or to do *another task* that they want to try during the same amount of time as in the guided ones. Afterwards, they simply report what they did during the lapse of time. This possibility was added to reflect clinical reality and to allow outpatients to adapt the interference principle to their own preferences, thus creating tailor-made solutions. There is also an option to skip the exercise if they are not in the right conditions to practice.

This study was approved by the cantonal ethics commission of Vaud (Switzerland; 2018-00363).

Table 24. Baseline, intervention, and follow-up steps for naturally occurring gambling craving

Baseline	**Intervention and follow-up**
g-CEQ-S (present craving)	g-CEQ-S (present craving)
3 minutes task: **mind wandering**	*3 minutes task (possibility to skip)*: **interference**: bunch of keys, fidget, imagery, chosen task
g-CEQ-S (present craving)	g-CEQ-S (present craving; not administered if interference was skipped)

2.3 Population

Five to ten participants will be recruited among the outpatients from the Centre for Excessive Gambling, (Lausanne University Hospitals). They should be over 18, speak French, and report episodes of strong gambling craving (assessed by the therapist). Although frequent comorbidities (e.g., depression, anxiety) are no exclusion criteria, more severe conditions (e.g., psychosis, acute manic or depressive phase) are incompatible with the study.

Figure 14. The 12-face fidget

2.4 Data analytic strategy

Graphical and descriptive approaches will help getting a broad view of the results. The data will then be analysed per participant with non-overlap of all pairs and slope and change level methods (Manolov et al., 2011). A *d*-statistic for single-case studies (Shadish et al., 2014) will allow to compute a global effect size index of the intervention across the sample.

3. Potential implications

This study has the potential to provide important pilot results that may potentially lead to randomized control trials, and, more importantly, to the implementation of interference in gambling disorder treatment.

Chapter 7

General discussion

General discussion

Gambling craving plays a pervasive role in the maintenance and relapse of gambling disorder. Accordingly, the goals of this PhD thesis were to better understand gambling craving, to improve its measurement, and to test the potential efficacy of interference-based intervention in mitigating craving episodes. Indeed, research on gambling craving has developed in recent years, even if no consensus has emerged regarding its conceptualization and measurement. Even more concerning, a substantial portion of related research was built on substance-related craving (e.g., alcohol, drug, food) with an a priori transferability hypothesis (Billieux et al., 2015; Kardefelt-Winther et al., 2017). Instead of following this path, the current PhD thesis dug into the roots of gambling craving by investigating first its phenomenology. Indeed, in *Study 1*, a qualitative analysis allowed for an in-depth examination of the components of gambling craving, before a quantitative analysis was conducted in order to determine the most relevant triggers and aspects of the craving experience. The results from both approaches supported the validity of the elaborated intrusion theory of desire (EIT; Kavanagh et al., 2005; May et al., 2004) in the context of gambling craving. Studies 2 and 3 focused on the improvement of gambling craving assessment. *Study 2* validated a widely used craving instrument in French (the Gambling Craving Scale; GACS; Young & Wohl, 2009), while *Study 3* validated an EIT-based instrument (the Craving Experience Questionnaire; CEQ; May et al., 2014). In these two studies, we overcame the main limitation of previous validation attempts of gambling craving scales as we experimentally induced craving (through an audio-guided imagery script) before asking our participants to complete the gambling craving items. Finally, and based on the theoretical framework provided by the EIT, *Study 4* tested the efficacy of different types of interference-based methods on gambling craving.

The next sections present the main findings of the four studies included in the present PhD thesis (for a summary, see Figure 15). The theoretical and clinical implications of these studies are then discussed, along with their strengths and limitations. Finally, perspectives of our work are proposed for future research and treatment.

1. Summary of main findings

Axis 1: Gambling craving conceptualization

1.1 Exploring gambling craving through the elaborated intrusion theory of desire: a mixed methods approach

A sample of 31 non-problem regular gamblers (gambling at least twice a week) from the community were recruited and answered open-ended questions about their experience of gambling craving. This study aimed to question the traditional substance-based conception

of gambling craving and to understand its process. A mixed-method approach was used to combine in-depth investigation of the construct with a qualitative approach, and an evaluation of its most important aspects with a quantitative method. The thematic analysis of the qualitative data allowed to draw six main categories of answers: positive and negative affect, external cues, images, thoughts, and physiological sensations. The quantitative part highlighted relevant triggers (e.g., spontaneous thoughts, boredom) and descriptions (e.g., susceptibility to distraction, visual imagery) of the craving experience. Overall, *Study 1* supports the relevance of the EIT to summarise gambling craving, offering assessment and intervention perspectives. However, the data also suggests a role of positive affective states as a trigger for gambling craving, which is not included in the original EIT. The study also failed to demonstrate the presence of a physiological deficit to elicit gambling craving, but it might be due to the fact our study was conducted in non-clinical gamblers and/or to potential irrelevance of physical withdrawal symptoms in the context of behavioural (non-substance-related) addictive behaviours.

Axis 2: Gambling craving assessment

1.2 Probing gambling urge as a state construct: Evidence from a sample of community gamblers

The original GACS (Young & Wohl, 2009) is a highly used scale composed of nine items spread over three subscales: *anticipation* of pleasure, urgent *desire* to gamble, and expectation of *relief*. Because the initial validation study of this scale did not ensure that participants were actually experiencing a gambling craving, we addressed this validity issue in our *Study 2* by applying an experimental gambling induction procedure prior the participants are asked to complete the scale. Confirmatory factor analyses did not support the initial three-factor structure of the scale. Instead, a combination of exploratory and confirmatory factor analyses supported a psychometrically sound two-factor solution for the seven retained items (two items were discarded as they loaded on both factors, thus violating the unidimensional assumption of each subscale), which is in line with other craving measures using similar items, (e.g., the Questionnaire of Smoking Urges; QSU; Tiffany & Drobes, 1991): (a) intention and desire to gamble and (b) relief from negative affect. Importantly, these results allowed us to propose that the GACS measures gambling *urge*[1] as the motivational component of the craving experience (pleasure and relief in the EIT), but not craving itself.

[1]While both urge and craving can be considered as states that drive towards gambling from a motivation perspective, gambling urge (or expectations of gambling, in line with its conception by Tiffany & Drobes, 1991) fuels the elaboration of gambling craving, sustaining the view of the urge as a motivational component of craving. Eventually, we consider gambling motives as stable factors, as measured by the Gambling Motives Questionnaire (Schellenberg et al., 2016; S. H. Stewart & Zack, 2008).

1.3 The gambling craving experience questionnaire: Psychometric properties of a new scale based on the elaborated intrusion theory of desire

The CEQ (May et al., 2014) is based on the EIT and has two forms: strength to evaluate a specific craving (e.g., current) and frequency to estimate the occurrence of craving over a period of time (e.g., last week). Each form is composed of 10 items that covers intensity, imagery, and intrusiveness. In *Study* 3, the questionnaire was adapted to gambling (g-CEQ) by removing three non-relevant imagery items (about taste, smell, and throat sensation) and by including two imagery items (about sound and touch feeling), in line with results from a previous study (Cornil et al., 2018). The items were phrased in order to be gambling specific and the same induction procedure as in Study 2 was used to ensure the assessment of an occurring gambling craving experience and support construct validity. The convergent validity was confirmed by correlations with gambling symptoms, motives and cognitions. Results from the confirmatory factor analyses supported the postulated structure and the scale showed good psychometric properties. As the g-CEQ evaluates the intensity and the frequency of the craving cognitive processes, it complements the GACS rather than replaces it. Accordingly, both tools can be used conjointly for a fine-grained assessment of gambling craving.

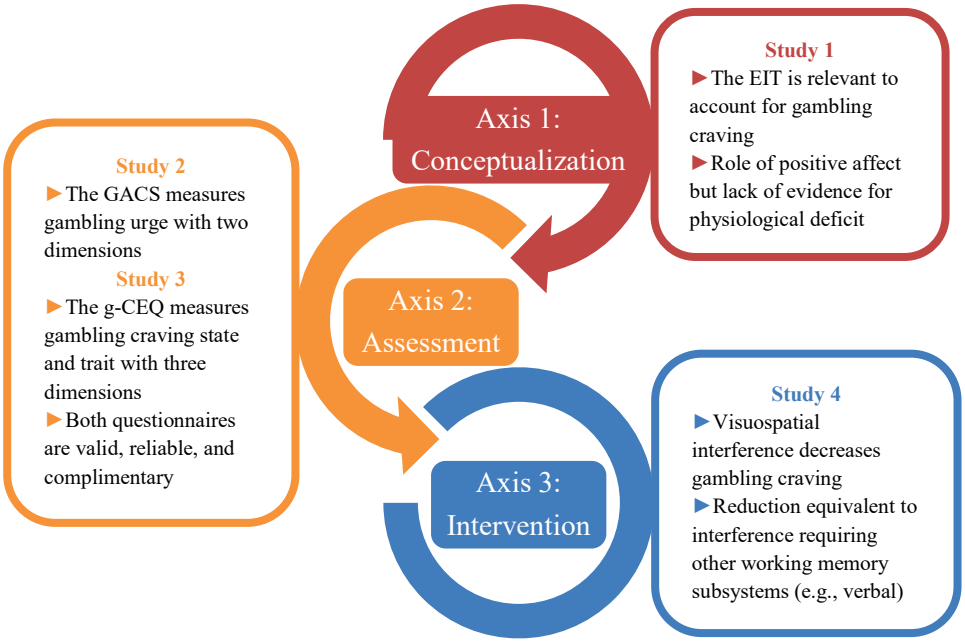

Figure 15. Summary of the main findings

Axis 3: Gambling craving intervention

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

While interference-based methods (tasks monopolizing resources involved in the deployment and perpetuation of craving) are anchored in the EIT and were found efficient to reduce substance and food-related craving, no experiment has ever tested the relevance of such interventions in the context of gambling craving. *Study 4* addressed this gap through two distinct experiments. The study globally showed that, among community gamblers, methods involving visuospatial resources decreased cue-induced craving but were considered equivalent to other tasks recruiting different working memory subsystems. Despite the small sample of non-clinical gamblers, this research showed that interference-based methods, which can be easily used in clinical practices and implemented in daily life, constitute interventions with interesting perspectives for the treatment of people suffering from gambling disorder.

1.5 Tackling naturally occurring gambling craving among clinical gamblers with interference: Study protocol

Although we will not further discuss *Study 5* in this section because it has not yet been conducted, this particular study offers some perspective for future research on gambling craving in a clinical sample. The ecological momentary assessment and intervention also allow to target *real* gambling craving. Moreover, the multiple single-case design overcome the difficulty to recruit a large sample of clinical gamblers and the results will provide leads for potential randomized control trials.

2. Conceptualization of gambling craving through the elaborated intrusion theory of desire

Numerous studies have supported the relevance of the EIT to account for substance and food related craving (see May et al., 2015). Our Study 1 provides initial support to its applicability in the gambling context. Indeed, qualitative and quantitative data corroborates the role of *external cues* as elicitors of gambling craving, via associative processes, in line with previous researches (e.g., Hanss et al., 2015; Potenza et al., 2003; Smith, Pols, et al., 2013). Our study also confirmed that *mental imagery* and *thoughts* play a pivotal role in the occurrence of gambling craving, which is coherent with the EIT that regroups them under “associated thoughts” and “desire thoughts”. Those two constituents of the EIT were difficult to distinguish in our qualitative data due to their similar nature (thoughts and images). Yet, the quantitative part confirmed that thoughts are also identified as gambling craving triggers, upholding the relevance of both constructs in the theory, despite partial overlap. Physiological sensations, even though less prominent than other components, were also identified as *anticipatory responses* susceptible to promote gambling craving.

Beyond the elements that justify the relevance of the EIT in the field of gambling, Study 1 also requires to reconsider the status of affect and physiological deficit in the context of gambling craving.

2.1 Affect

In line with previous research (de Castro et al., 2007; Schlauch et al., 2013), Study 1 highlighted the importance of *positive affect* (an element not included in the initial EIT, see section 2.1.5 of the general introduction) as a trigger of gambling craving and not only as being part of the subjective craving experience. Although the relationships between variables remains to be investigated, positive affect was clearly and widely identified as an initiator of gambling. Caselli and Spada (2010) also support the importance of positive emotions as craving triggers. By investigating desire thinking among 24 participants seeking treatment for desire related problems (disorders related to alcohol, food, gambling or smoking), they found that the majority of their sample elaborated desire thoughts to reduce unpleasant states, but also to enhance pleasant feelings. Furthermore, a recent research examined a pool of 43 items susceptible to trigger craving (transaddiction craving triggers questionnaire; TCTQ) in a sample of 111 outpatients with an alcohol use disorder (von Hammerstein et al., 2019). After removing items with a floor-effect or low factor loadings, this study showed that a 25-item version of the scale composed of three subscales fits the data well. The subscales include (a) external cues and related thoughts, (b) unpleasant affect, and (c) *pleasant affect*. Likewise, an unpublished study (Cornil, Rothen, et al., 2019) tested the same items and reproduced a similar structure for gambling (g-TCTQ). Both studies further emphasize the importance of positive affect as a potential trigger for craving.

Even though the role of *negative affect* in the elicitation of gambling craving is well documented in the literature (e.g., de Castro et al., 2007; Sharpe, 2002; Tavares et al., 2005), negative emotions were less frequently reported by participants in both qualitative and quantitative datasets. However, “boredom” was rated as the second most important trigger for gambling craving.

These results may be partially due to the non-clinical origin of the sample. Indeed, individuals with a problematic engagement could rather gamble to reduce negative affect than to enhance positive affect. Future research should investigate if a distinction exists between problem and non-problem gamblers regarding positive and negative affective states as gambling craving triggers. Indeed, for recreational gamblers and gamblers that do not seek for help, as in Study 1 sample, desire thoughts may rather be generated by positive emotions and kindle pleasure than respectively negative affect and relief because gambling is mostly considered an enjoyable activity, with no or few deleterious consequences. While for problematic gamblers, desire thoughts may be more related to negative affect and relief, even if still linked to positive states. Study 2 sustains this assumption through the correlations between problem gambling symptoms and the GACS subscales; the correlation with relief from negative affect (r = .45) being stronger than the correlation taking place with intention and desire to gamble (r = .18). This is in line with the dualistic model of passion by Vallerand (2015). This model distinguishes between harmonious passions (i.e., commitment to an

activity that occupies a significant place in daily life without interfering with other areas of life) and obsessive passions (i.e., commitment that is experienced as oppressive and leads to the disregarding of important areas of life); both aspects may co-occur but one is expected to prevail. A recent review (Morvannou et al., 2018) found that obsessive passion was associated to gambling problems while results were less clear for harmonious passion. This further fuels the necessity to test our hypothesis that negative affect is more related to craving among problem gamblers presenting an obsessive passion whereas positive affect may be more present in harmonious gambling involvement.

2.2 Physiological deficit

The mixed-method approach endorsed in Study 1 did not find physiological deficit to play a role in the context of gambling craving. It could be attributed to a lack of body awareness of participants, but the greater mention of physiological sensations and the decrease in the report of "no sensation" while gambling tend to refute this hypothesis. The absence of substance ingestion, which might modify the physiological homeostasis, may also explain that gamblers do not suffer from physiological deficits. However, Blaszczynski et al. (2008) have reported that gamblers, as frequently as alcohol users, may experience withdrawal symptoms such as depression, irritability/agitation, restlessness, anxiety, general discomfort and headaches. Contrary to our participants who were regular gamblers (at least twice a week) with no prospect of change (no withdrawal), their study sample was composed of pathological gamblers – and alcoholics.

Although it cannot be excluded that gambling craving is provoked by physiological deficits among people with more severe gambling problematic, this factor should be further investigated to avoid that, by a confirmatory approach, substance use criteria would be transferred towards behavioural addictions without further testing (Billieux et al., 2015; Kardefelt-Winther et al., 2017). Tolerance and withdrawal symptoms are often questioned in the literature regarding their relevance in the context of behavioural addictions. Indeed, an increased involvement or the need to bet more money is not necessarily imputable to the tolerance phenomenon per se but can be related to efforts to train and develop skills. Moreover, Starcevic (2016) argues that no study to date has shown that severe withdrawal symptoms were present in behavioural addictions. Through their papers, these experts draw attention on the need to examine behavioural addictions in an exploratory rather than confirmatory approach, an approach that we adopted for gambling craving. Such an approach would help in identifying the unique features of gambling craving and contribute to improve its assessment and treatment.

2.3 The gambling elaborated intrusion theory of desire

Given the findings from Study 1, we propose to adapt the EIT to the gambling craving context (see Figure 16). Besides the original factors, it now includes positive affect as a trigger of desire thoughts. For instance, the excitement induced by new perspectives of research could elicit gambling desire thoughts via similar associative process as for other

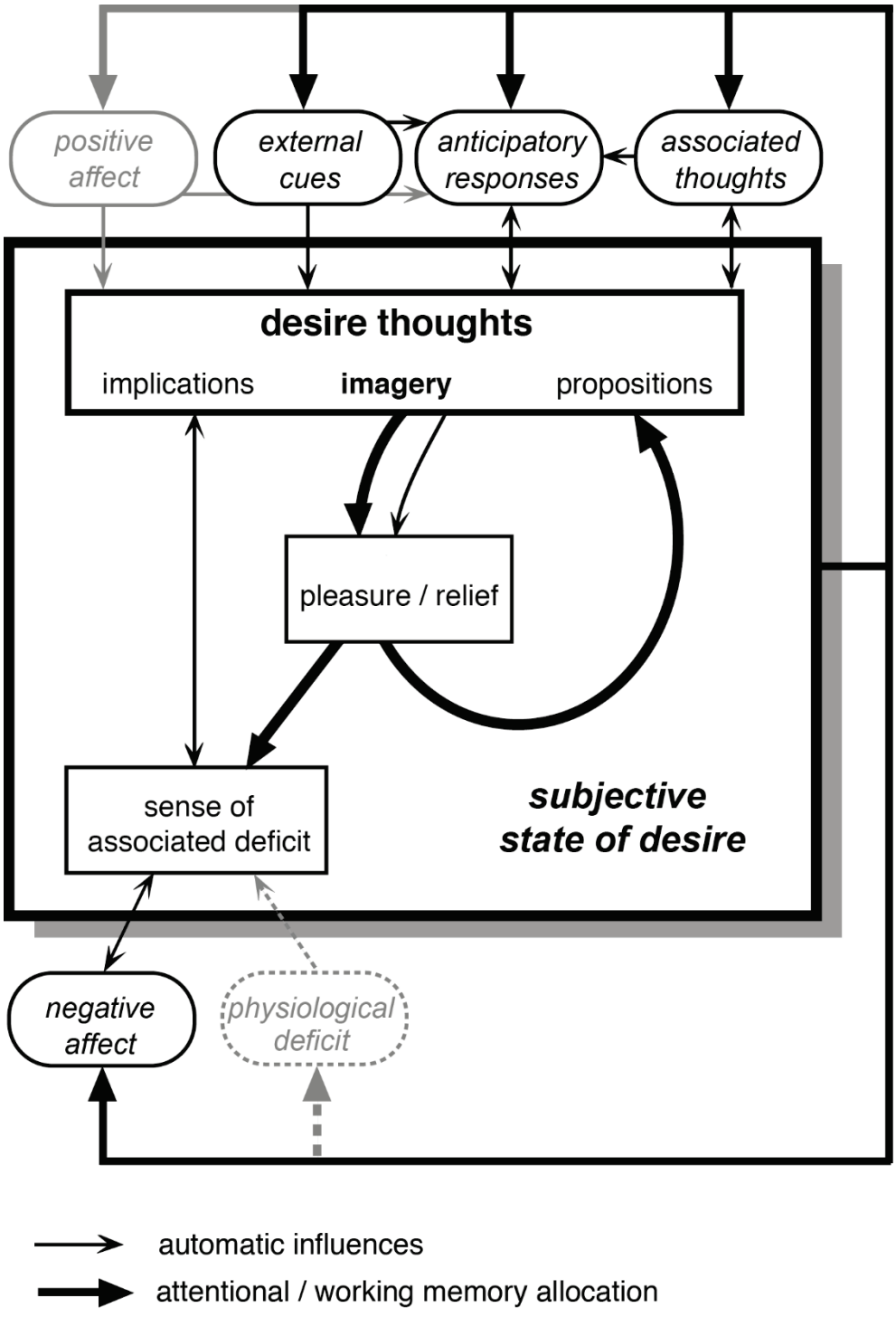

Figure 16. The gambling elaborated intrusion theory of desire

Note. Elements in grey tint arise from our research on gambling craving. The dashed components were not found relevant in this study.

triggers. It could directly activate intrusive memories of risky bets that resulted in big wins. Positive emotions are also susceptible to generate gambling craving via anticipatory responses (e.g., tension).

Physiological deficit is indicated in a dashed box but was not removed from the gambling EIT as future research in clinical samples must test if it actually triggers gambling craving among people with clinical gambling patterns.

It is also important to note that the initial definition of desire, proposed by Kavanagh et al. (2005, p. 447) and based on the EIT, also suits gambling craving: "an affectively charged cognitive event in which an object or activity that is associated with pleasure or relief of discomfort is in focal attention". The authors make no qualitative difference between craving and desire. However, in line with the dualistic model of passion (Vallerand, 2015) that distinguishes between harmonious and obsessive passions, and with Brandtner et al. (2020) who found that desire thinking – considered a normal process – may be deleterious when its focus is somehow prohibited, we propose to use the term craving as a desire that leads to dysfunctional behaviour, which is in conflict with important personal values and goals, but not imperatively related to addictions (e.g., tan; Ashrafioun & Bonar, 2015; rock-climbing; Roderique-Davies et al., 2018). Such a clarification would allow to target problematic desire without pathologizing normal behaviour.

2.4 Note of Caution

Before pursuing our discussion, several limitations inherent to our first study on gambling craving conceptualization are worth mentioning. First, the configuration of our survey (i.e., written open-ended questions) did not allow to provide feedbacks to the participants, for example, in order to better investigate the participants' representations of their gambling craving experience or to understand the links between the various EIT components (i.e., the arrows in Figure 16). This could have been addressed by individual interviews or via a focus group approach. However, the online survey format used had the merit to potentially reduce the influence of social desirability and provided initial evidence of the relevance of the EIT for gambling craving. Second, our sample size was modest, reported various types of gambling activities, and only included non-clinical gamblers who nonetheless included several participants showing risky or problematic gambling patterns. Although the EIT considers that craving experiences do not differ qualitatively (i.e., on a continuum of strength; Kavanagh et al., 2005), future studies should take gambling habits into account and use a larger sample that includes participants diagnosed with gambling disorder

Despite these limitations, our initial analysis of the adequacy of the EIT to account for gambling craving has several implications for assessment and treatment (further discussed in the corresponding sections below). Besides drawing attention on positive affect as potential elicitor, it allows targeting craving itself – avoidance or management of all potential triggers may not be conceivable – for assessment and treatment in order to prevent problematic gambling behaviours. Indeed, gambling craving is not considered an epiphenomenon but a cognitive process, which can be evaluated with questionnaires and targeted with specific

interventions. On the one hand, the detailed description of the gambling craving mechanisms involving several components (i.e., desire thoughts, pleasure/relief, and sense of deficit) supports the use of multi-factorial instruments, instead of globally measuring craving with a single item or with one-factor scales. This fuels the need to further investigate the psychometric properties of the GACS, a multi-factorial tool that is widely used in the literature, and to adapt the CEQ (May et al., 2014), a tool anchored in the EIT that offers a rich assessment of substance and food craving, to gambling. On the other hand, our study paved the way for testing the efficacy of methods derived from the (gambling) EIT. Interference-based interventions aim to capture the cognitive resources (attention and working memory) allocated to the elaboration of craving and to move them towards another competing task. Previous studies have shown its potential to reduce substance and food craving, with a superiority of visuospatial methods (e.g., May, Andrade, Panabokke, et al., 2010; Skorka-Brown et al., 2015; Steel et al., 2006). In line with Study 1 results and the gambling EIT, and because no study has investigated such interventions in the field of gambling (O'Neill, 2017), the impact of interference-based methods on gambling craving has been investigated in the subsequent steps of the thesis.

3. Assessment of gambling craving and urge

In the context of the current doctoral thesis, two instruments were investigated: the GACS that measures the gambling urge, as the motivational component of gambling craving, and the g-CEQ that measures the gambling craving experience, which is based on the model that theoretically anchors our work: the EIT.

3.1 The gambling craving scale (GACS)

The GACS is a commonly used tool that was validated to measure gambling craving; however, its psychometric properties were explored in only one study that did not rely on a craving induction method (Young & Wohl, 2009), which questions the validity of the psychometric validation realized. The study conducted in our work used an induction procedure to examine the psychometric properties of the GACS and found a two-factor solution similar to other existing tools in the substance field (e.g., Questionnaire of Smoking Urges; QSU; Tiffany & Drobes, 1991): *intention and desire to gamble*, which addresses the possibility to get pleasure; and *relief from negative affect*, which refers to the use of gambling as a coping strategy to get out of a negative emotional state. In line with other questionnaires that target identical processes, the focus of the GACS was redefined as gambling urge – instead of craving – which is defined as the immediate motivation towards positive and/or negative reinforcement. The subscales can be used to clarify the expectations of the gambling involved in the instant craving experience.

3.2 The gambling craving experience questionnaire (g-CEQ)

The validation of the g-CEQ demonstrated the same three-factor structure as the original CEQ (May et al., 2014). The *frequency* form (g-CEQ-F) evaluates the occurrence of gambling craving on a specific timeframe. The validated version relates to the previous week, but other periods were tested for the CEQ and could be used in research and for clinical purposes. The *strength* form (g-CEQ-S) focusses on a definite craving episode. Each form of the g-CEQ includes three subscales. The *intensity* subscale measures the magnitude of the craving. The *imagery* subscale evaluates the vividness of mental images on three sensorial modalities that were found relevant for gambling: sight, hearing, and touch. The *intrusiveness* subscale estimates the oppression caused by the thoughts.

3.3 Implications for gambling craving assessment

The validation study of the GACS contributed to disentangle the concepts of urge and craving. These terms are often used interchangeably in the literature (Young et al., 2008) contributing to the "conceptual chaos" surrounding these constructs. In line with the QSU (Tiffany & Drobes, 1991) and the numerous subsequent questionnaires (see Rosenberg, 2009), the GACS measures the urge, which is the motivational part of craving and which covers the *pleasure / relief* factor in the experience of craving; the urge and its measurement by the GACS are then compatible and integrated in the gambling EIT. Importantly, the urge is considered a transient state and the two subscales of the GACS, intention and desire to gamble (1) and relief from negative affect (2), are distinct from respectively the enhancement and coping facets of the Gambling Motives Questionnaire that assesses traits (S. H. Stewart & Zack, 2008)

While the GACS measures the gambling urge, the g-CEQ-S concentrates on gambling craving, a multifactorial and transient experience that involves cognitive resources and emotions, with a cognitive rather than motivational approach. Indeed, besides the intensity of the subjective experience, it targets the vividness of mental images and the intrusiveness of thoughts, reflecting the process involved in the subjective state of desire or craving described by the EIT. Both questionnaires may then be viewed as complimentary; researchers and clinicians should be cautious to use them for the right purposes. Guidance for administration is presented in the perspectives section (see 5.1.2).

The g-CEQ-F completes the evaluation of gambling craving with a focus on their rate. As explained by May et al. (2014) for substance and food craving, the combination of both g-CEQ forms helps determining to what extent the frequency and the strength of craving episodes precipitates gambling behaviour and relapse.

The identical factor structure of the CEQ and the g-CEQ confirms the transaddiction potential of the questionnaire. This could mean that, following appropriate adaptation (i.e., a priori phenomenological and qualitative exploration), this questionnaire could be adapted in the context of other behaviours (e.g., sexual behaviours, gaming). In such future adaptation, a particular attention should be paid to the imagery subscale, as senses involved in craving

imagery may change across targets (May et al., 2014). This would allow comparisons of behavioural and substance related craving to highlight specific features of craving through behaviours, or to question the relevance of including craving as a diagnostic criterion for behavioural addictions and to support (or disprove) the alignment of gambling disorder with the substance-related and addictive disorders category in DSM-5 (American Psychiatric Association, 2013).

The main limitation of both studies concerns the sample that was relatively modest and that was composed of non-clinical gamblers from the community. Even though future studies should replicate the findings in larger samples of participants with gambling disorder, the samples also included frequent (a few times a week or every day) and symptomatic (moderate-risk and problematic) gamblers. The use of self-reported questionnaires only also constitutes a limitation as they may be impacted by lack of introspection or social desirability. The use of physiological measures may improve the next validations studies of the scales, although it may create a burden (e.g., need for specific material, necessity to meet the subjects) for the completion of the study and increase the difficulty to recruit participants. Finally, the induction may have not been effective in eliciting gambling craving among all the participants. However, the imagery script mentioned different gambling activities to ensure that relevant cues were presented to participants.

Despite these limitations, the assessment tool validated in the current thesis allow for a fine-grained assessment of gambling craving in the clinical and research contexts, as it will be described in more details in a subsequent section of the discussion.

4. Intervention: mitigating gambling craving

4.1 Interfering with gambling craving

Because craving plays a pervasive role in the prognosis of gambling disorder, research has tested several methods to prevent or reduce it (see section 3.3 of the general introduction). Interference-based methods are anchored in the EIT and coherent with the gambling EIT. They involve the shifting of cognitive resources implicated in the elaboration of desire thoughts (thick arrows in Figures 3 and 13) towards other demanding and competing tasks. It is, to the best of our knowledge, the only type of intervention to straightforwardly target the craving process, as opposed to other methods that indirectly impact craving by influencing proxy constructs. The fourth study of this work found that such techniques were efficient to reduce induced gambling craving. However, it failed to prove the hypothesized superiority of a visuospatial tasks compared to other exercises requiring verbal or other sensorial resources.

4.2 Implications for psychological interventions targeting gambling craving

In Study 4, we found that the various tasks used (including those initially postulated to act as “control tasks”) were able to mitigate laboratory induced gambling. The absence of

difference between the tasks indicates either that monopolizing any type of working memory is enough to reduce craving, or that several slave systems of the working memory are used in the elaboration process of craving. In the first case, it would imply that psychological intervention should focus on identifying the methods that are suitable for each individual to maximize treatment adherence. The task should be sufficiently demanding to be optimal. Indeed, mere distraction is susceptible to reduce craving but to a lesser extent than interference (Dodds et al., 2019). However, the clinician should adjust the difficulty to each patient abilities to avoid excessive cognitive challenges that would favour dropouts. If several types of working memory are involved, then the interference should be tailored according to the subjective experience of craving, which may be described by the items from the imagery subscale of the g-CEQ, and by the verbal items that were suggested to be implemented in the g-CEQ. Interference methods could then be visuospatial, verbal, auditory, etc. or even a combination of the different aspects of the experience to increase effectiveness.

The potential of interference-based methods on the g-CEQ-F subscales scores remains unknown as long-term effect of interference is still questioned (Dodds et al., 2019; Kemps & Tiggemann, 2015; van Dillen & Andrade, 2016). In the same vein, interference would not necessarily modify the nature (as a trait) of desire thoughts (verbal thoughts and mental images on one or several sensorial modalities) but would interrupt their elaboration. Longitudinal studies should thus address the lasting effects of such interventions. The impact of interference is however more corroborated on the scores of the g-CEQ-S subscale, leading to a global reduction of present gambling craving. This kind of methods can be directly applied when a gambling craving of any intensity occurs, as opposed to techniques that rather aim at preventing craving to be overwhelming. The absence of a proper control task (e.g., mind wandering or no task) may weaken the attribution of this reduction to the interventions, as spontaneous reduction of gambling craving was not tested. Even though future studies should include a neutral control condition in their design, previous studies in the field of substance use have shown superiority of interference over such conditions, leading to the reasonable assumption that interference was also more efficient than “doing nothing” to reduce gambling craving. The lack of clinical sample may also be pointed out as a limitation of our study. However, several participants showed risky and problematic gambling patterns and this research can be considered a sound proof of principle.

5. General limitations

Several studies carried out for this PhD thesis have two transversal limitations that must be acknowledged.

First, from Study 1 to 4, the samples recruited were not clinical. As such, it remains uncertain whether our research may be relevant to treat individuals with a gambling disorder. Future research should specifically target clinical samples, and the psychometric properties of the developed tools confirmed in clinical samples, even though our participants sometimes reported heavy symptomatology according to the Canadian Problem Gambling Index (Ferris & Wynne, 2001). Regarding the relevance of interference-based interventions for individuals

with a gambling disorder, Study 5, which has not yet been conducted due to the pandemic, is intended to address this issue with a multiple single-case design and ecological momentary interventions and assessments. If this pilot study is conclusive, further randomised controlled trials should be carried out in large clinical samples to allow the use of interference by clinicians.

Second, we used an imagery script to induce gambling craving, which may have inflated the scores of participants on the (visual) imagery subscale. Other media such as pictures (Miedl et al., 2014) or virtual reality (Bouchard et al., 2017) could have been used as they do not require mental imagery. However, Ashrafioun et al. (2012) have found that an imagery script (the one used in this work) was more effective than pictures to induce gambling craving (measured with the Gambling Urge Scale; Raylu & Oei, 2004b). Virtual reality involves material (hardware and software), cannot be administered remotely, and does not elicit stronger craving than imagery (Bouchard et al., 2017). Overall, this technique satisfied our effectiveness and ecological requirements. Study 2 provided further arguments for its relevance with increased scores of gambling urge following the script. It was also combined with a simulated environment in Study 4 to maximize its potential. Although past research supported this induction procedure, we acknowledge the potential inflation of the imagery items of the g-CEQ. To test the potential impact of the induction procedure, May et al. (2010) propose to compare the effect of visual (e.g., pictures of a casino) versus auditory (e.g., sound of a slot-machine) cues, but an auditory elicitation does not necessarily exclude visual representations. Eventually, the use of naturally occurring gambling craving should prevent potential biases related to the induction, and the trigger(s) could be controlled with the g-TCTQ (Cornil, Rothen, et al., 2019).

6. Perspectives

The following sections first propose perspectives of research that will allow to deepen and extend the work conducted in this PhD thesis on gambling craving. Then, to go beyond the scope of this work, we present propositions for improving the conceptualization, assessment, and intervention on craving across food, substances, and behaviours, with the intention of also considering the proximal variables of craving, from the triggers to the behaviour.

6.1 Gambling craving perspectives

6.1.1 Testing the connections of the gambling EIT components

As pointed out in the limitation of our mixed-method study (see section 2.4), the data did not allow the evaluation of the causal links between the factors of the EIT identified as relevant for gambling craving (arrows in Figure 16). Moreover, the open-ended questions were not the ideal format to elicit elaboration on answers and to deeply investigate the representation of gambling craving mechanisms among participants in a two-step qualitative study. The sample should be composed of occasional to clinical gamblers, in a dimensional perspective, that would be involved in various gambling activities. (e.g., lottery, bets, poker,

etc.). The first step would consist of focus groups from six to eight participants (Willig, 2013, p. 123) to generate models (one per group) of gambling craving. The moderator would first ask the participants to describe their gambling craving with broad questions about the triggers and experience of craving. Then, questions will progressively focus on more specific aspects: cognitions, emotions, physiological sensations and behaviours. Finally, the moderator would build a consensual graphical model that summarises the discussion and that includes causal relationships between factors. To avoid potential biases in the questions and in the construction of the models, they could be novice in the field of craving but should be trained to lead such groups; another researcher with more expertise could be present to assist the main moderator with an attention on non-verbal data (e.g., disapproval) and to take notes. Thematic analysis of the transcripts (audio recordings and notes) would be used to fuel and/or nuance the results from our mixed-methods study and could also bring insights for potential variability on the model created in each group. Individual interviews would allow each participant to be confronted to the different models (from all the groups) and their potential variations, along with the gambling EIT in order to provide feedback. The analyses of the results would corroborate and/or question the entire gambling EIT. Crucially, it would also help to consider the potential specificities of craving related to different types of gambling activities by grouping the feedbacks of participants accordingly.

6.1.2 Recommendations for assessment

Despite its good psychometric properties, we make some recommendations for the use and the improvement of the CEQ. Although statistically grouped in one factor, the clinician should consider the responses to the imagery items of the g-CEQ-S separately in order to determine which sense prevails in the experience, as it might have repercussion on the treatment. The subscale could also benefit from the addition of a broader question on imaging experience, without the specification of a sense (e.g., “Right now/at that time, how vividly do/did you imagine gambling?” or “Over the last [time-frame] how often did you imagine gambling?”). The fourth study of this thesis, in line with the findings by Dodds et al. (2019), revealed that verbal tasks were susceptible to interfere with gambling craving. Besides the imagery component of desire thoughts, which is included in the g-CEQ, several items about the internal verbal speech (e.g., “Right now/at that time, how much does/did your mind express thoughts that are/were encouraging you to gamble?” or “Over the last [time-frame] how often did your mind express thoughts that were encouraging you to gamble?”) could then be added in the scale. Structural factor analysis could help determining if these items should be regrouped with the imagery items to create a desire thoughts subscale or if they constitute a full verbal subscale. Finally, while the name of the frequency form evidently indicates what it evaluates, the strength form name could benefit of a change. Indeed, it does not clearly express that it measures a specific craving. Moreover, it can be confusing regarding the intensity subscale. The word “state” would elucidate the focus of this form.

Our studies validated a “current” version of the GACS and the g-CEQ-S, following an induction procedure. The questionnaires could, for example, assess craving and urge retrospectively: the strongest of the week, the last on or the average estimation of the previous day. Different timeframes could also be considered for the g-CEQ-F (e.g., previous day).

However, this retrospective approach involves limitations (e.g., biased memory). The ideal of measurement in clinical context would imply to evaluate naturally occurring craving and urge, via ecological momentary assessment, on smartphone for instance. A regular measurement should be implemented before the intervention to create a baseline, to help noticing the transient aspect of gambling craving and urge, and to raise awareness on these experiences. The occurrence of gambling sessions following the craving and urge should also be taken into account in relation to the GACS and the g-CEQ, with questions such as "After having answered the questionnaires, do you intend to gamble?" or, retrospectively, "Did the last craving or urge that you evaluated led you to gamble?". Combining these inputs (questionnaires and gambling activity) will allow to determine what aspect of the craving experience is promoting relapse: the frequent occurrence of craving, intense craving episodes, vivid mental images (visual, auditory, or tactile), intrusive thoughts, and/or gambling urge (expectations of pleasure and relief). Such information will be crucial in order to individualize treatment. In such a perspective, regular assessment of gambling craving should be used to document the treatment efficacy. Once the reduction of the vividness and overwhelming nature of craving is successfully implemented and consolidated, the frequency of measurements may gradually decrease. At this point, retrospective measures (e.g., estimation of an average score per day or week) could be favoured. During periods identified as being more at risk, or when the patient notices a rebound, the assessment of gambling craving and urge should be re-implemented.

The perspective of using ecological momentary assessment to measure naturally occurring gambling craving and urge could also be used for research. Indeed, even if the semi-ecological procedure involving induction definitively constitute a strength in the research design used to validate the GACS and the g-CEQ, investigating the psychometric properties of both scales when the participants experience gambling craving and urge would allow to capture their subjective experience in a more realistic setting.

6.1.3 Interference to mitigate gambling craving: Recommendations for clinical use

As mentioned in the assessment-related recommendations (section 5.1.2), the imagery subscale of both forms of the g-CEQ, enhanced with items assessing the internal verbal speech, helps to determine what kind of task will be more relevant. Examples of tasks in relation to specific and combined aspects of desire thinking are presented in Table 25. Interventions that were tested on food and substance craving (see section 2.4.2 of the general introduction) are also included; their effect remains yet to be explored. No "pure" tactile task was tested in previous research, but this sense is included in the examples of more complex methods. The choice of the methods should also be guided by the patient preferences and possibilities (e.g., not owning a smartphone, task adapted to the patient cognitive abilities). Moreover, the clinician should not propose tasks relying on cues associated to gambling (e.g., colours and sounds of Tetris could be associated with slot machines, or the smartphone could be the main gambling platform). We also recommend proposing and testing various activities for comparison in order to identify the most effective ones and for the establishment of suitable tasks in different contexts (e.g., key manipulation instead of mental imagery in social

context), identified through collaborative empiricism and guided problem-solving (Dattilio & Hanna, 2012). Each method should be first administered in clinical setting and debriefing should be conducted afterwards to assess difficulties and to adjust the methods. Audio-files with instructions should be provided for training between the sessions. The patient should progressively develop knowledge of the acquired methods, making the recordings unnecessary. The therapist should be creative in developing methods based on the principle of interference and the needs and preferences of the patient. Anchored in a collaborative empiricism approach, and to promote self-efficacy (Bandura, 1978), the patient is encouraged to share their own ideas with regard to potential interference-based techniques.

Table 25. Examples of methods susceptible to target the modalities involved in gambling craving

Dominant modality involved in desire thoughts	**Examples of tasks**
Visuospatial	Tetris, *dynamic visual noise*, *visual imagery*
Auditory	*Auditory imagery*
Verbal	Backwards counting, *backward alphabet*, *digit span*
Combined	Key manipulation (eyes closed), counting and exploding bubble wrap (following patterns), *clay modeling*

Note. Interventions in italics were not tested on gambling craving.

The effect of the tasks (described in this work or original) should be assessed through regular measurements of craving with the g-CEQ. Personalized feedbacks will allow for more qualitative inputs regarding the interventions. The clinician should also pay attention to treatment compliance and should monitor the motivation of the patient to improve how they handle gambling craving.

6.2 Perspectives on the conceptualization of craving

6.2.1 The need for a consensual definition of craving

Research on craving has bloomed in the recent years. However, there is still no consensus on an operational definition and on a theory that would allow coherent developments in research and in clinical practice. In the present work, we relied on a sound cognitive theory of craving (the EIT) and, in line with substance use research, we found it relevant to account for gambling craving, allowing to elaborate assessment (GACS and g-CEQ) and interventions (interference) with theoretical validity. Nevertheless, our conceptualization of craving is not global.

Although attempts to reach an agreement have already been conducted in the past (for instance at a consensus development conference on craving organised in February 1991; Pickens & Johanson, 1992), a study relying on a Delphi methods involving experts (clinicians and researchers) from the field across substances and behaviours could bring a solution to finally define the components of craving, and to constitute a solid basis for future research. Indeed, such an approach allows to reach an agreement through a rigorous methodology (Jones & Hunter, 1995) involving the a-priori definition of key methodologic criteria

(Diamond et al., 2014). The *selection* (or exclusion) *of experts* should be detailed to allow reproducibility. In addition, we should cautiously choose the participants in a balanced way (Jorm, 2015) to avoid favouring a specific view of craving (i.e., recruiting scholars from the same laboratory). The purpose of reaching a *consensus* should be explicit and defined (e.g., a threshold of 75% to certify agreement). Criteria should also be defined for the *interruption* of the Delphi process (number of rounds or level of consensus) and regarding the *dropping of items*.

Jones and Hunter (1995) divides the Delphi process into three iterative rounds, with intermediate analyses; accordingly, we propose a potential design to define craving. First, the experts would answer to open-ended questions about craving from more general (e.g., "What are the components of craving?") to more specific ones (e.g., "What cognitive resources are involved in craving?"). The thematic analysis should provide with a list of definitions, components, and mechanisms that describes craving. This list would be converted into a quantitative questionnaire asking, in a second step, the expert to report their level of agreement for each proposition. Finally, in a third round, the participants would have the opportunity to rerate the items and to potentially change the scores by having a summary of the round 2 results at their disposal. Several key factors involved in craving should emerge from the results to establish a consensual definition. Although other rounds may be set until the reach of a consensus, we will rather consider ambiguous results in the light existing research and/or put into perspective for further investigation.

6.2.2 Craving from a processual and transdiagnostic approach

Although the syndrome-based approach is widely used in treatment and research, especially in the context of addictive behaviours, there is growing evidence that points to its limitations (for further details, see Barlow, 2004; Nef et al., 2012). The transdiagnostic approach (Mansell et al., 2008) emerged as a promising alternative in clinical psychology research and treatment. According to this approach evoked in the general introduction (section 1.1), mental disorders results from the disturbance of psychological processes which mediate the relation between, on the one hand, biological, social, and circumstantial factors, and mental health (problems) on the other hand (Kinderman, 2005, 2019; Kinderman & Tai, 2007). A (dysfunctional) process is defined as "an aspect of cognition (e.g., attention, memory, thought, reasoning) or behaviour (e.g., overt or subtle avoidance) that may contribute to the maintenance of a psychological disorder" (A. G. Harvey et al., 2004, p. 14).

This thesis clearly states that craving is transdiagnostic and the EIT explains this phenomenon across addictive and food-related disorders. The underlying components, the intrusive thoughts and images, can also be identified in other mental diseases such as post-traumatic stress disorder, obsessive compulsive disorder, depression and anxiety (Ceschi & Pictet, 2018). Experiential avoidance is an important process involved in the elaboration of spontaneous thoughts and images because it consists in the escape from the sense of associated deficit by the seek for relief (and pleasure) provided by the desire thoughts. In the frame of the EIT, craving can be considered a cognitive avoidance, along with rumination, mental compulsion, and thought suppression (Nef et al., 2012). This avoiding process of

elaboration generates subjective craving (i.e., emotionally charge mental state) that will eventually be avoided as well by indulging it, leading to problematic behaviour. In this processual approach, interventions to reduce cognitive avoidance (e.g., exposure, acceptance, cognitive defusion) can be considered relevant to handle craving on the long term.

6.2.3 Confrontation of the EIT with other contemporary models

The *elaborated intrusion theory of desire* served as framework in this thesis because it explains the craving processes in detail. However, other models could be considered to challenge or complement the EIT.

May et al. (2004) pointed out that both *cognitive processing model* (CPM; Tiffany, 1990) and the EIT conceptualize craving as emerging from the awareness of cognitive activity. Yet the EIT details the processes involved in craving and includes imagery as part of the experience (Panabokke, 2004). Hofman and van Dillen (2012) went one step further by proposing a *dynamic model of desire* that integrates both the CPM and the EIT. Instead of seeing both theories as contradictory, the authors consider them as complimentary. In a first pathway, automatic affective processing of triggers results in a "mindless" behaviour, and the automatic and habitual response of consumption or addictive behaviour. This operation is facilitated when the object of desire is immediately available or when few processing resources are usable. Under opposite conditions, the second pathway is triggered; it involves the emergence of a conscious experience and access to working memory. The craving initiates at the very moment when one becomes aware of intrusive thoughts and their subsequent elaboration.

Based on neurocognitive research, the *metacognitive hub model* (Flaudias et al., 2019), another recent model of craving, divides the construct into three interactive subcomponents which each contain implicit (unconscious and automatic) and explicit (accessible to awareness) sides. The cognitive craving (1) impedes cognitive resources and may be related to the elaboration process in the EIT, which monopolize the attentional and working memory systems. The automatic craving (2) refers to the automatic mechanisms (e.g., attentional biases or cue reactivity) and can be found as the automatic influences in the EIT. This type of craving also includes the automatic path from the CPM and the appetitive and aversive conditioning factors in the EIT. (i.e., pleasure / relief). Finally, the physiological craving[2] (3) describes the interpretation of body sensations, such as withdrawal symptoms, or unpleasant psychological states, which are part of or triggers of the sense of associated deficit of the EIT. In addition to these assumptions, which are compatible with the EIT, the metacognitive hub model highlights the importance of metacognitions that can be defined as "knowledge and cognitive processes that are involved in the appraisal, control, or monitoring of thinking" (Spada, Caselli, et al., 2015, p. 9). The authors suggest that metacognitive abilities allow implicit signals from the three subsystems to be made explicit. Theses abilities may enhance

[2] This aspect of craving refers to underlying physiological mechanisms of the subjective experience of craving, but not the subjective experience of craving itself.

or reduce the salience of one or several types of craving, creating subjective variations in the experience.

Spada, Caselli et al. (2015; 2013) adapted the *self-regulatory executive function model* (Wells & Matthews, 1996) to addictive behaviours with a *triphasic metacognitive formulation*, which also draws attention on the role of metacognitions in craving. This transformed model distinguishes between two types of metacognitive beliefs that are also susceptible to lead to gambling behaviours (Spada, Giustina, et al., 2015). The positive ones favour dysfunctional processes (e.g., "Gambling allows me to escape from my problems and my worry"), while the negative ones relate to significance, uncontrollability, and hazard of cognitions (e.g., "I cannot control my gambling"). Those metacognitions influence the addictive process before, during, and after the engagement in the problematic behaviour. They are postulated to facilitate desire thinking and craving, but also to influence their behavioural outcome and the recurrence of gambling episodes. Caselli and Spada (2013) created a specific questionnaire on metacognitions about desire thinking (see section 5.2.4.2. The metacognitions about desire thinking questionnaire). They hypothesize that positive metacognitions are involved in the initiation of desire thinking, while negative metacognitions may impact the sense of deficit. Caselli et al. (2018) also developed a questionnaire on metacognitions about gambling (for a review and meta-analysis on the topic, see Rogier et al., 2021). They reported good psychometric properties and significant relations with gambling severity, reinforcing the importance of metacognitions in the modelling. However, its link with gambling craving (or desire thinking) was not investigated.

6.2.4 From trigger to behaviour: The holistic elaborated intrusion theory of desire

Given the factors presented in the general introduction (see section 2.1.5.3) and the models and research presented in the previous section, we propose an attempt to update the EIT to include aspects from the triggers to the behaviour with two pathways. (see Figure 17).

The first automatic or "mindless" path (dashed lines in Figure 17) is inspired from the CPM and the dynamic model of desire. The acquired automatized schema is activated by triggers, without consciousness. A retroaction reinforces the association between triggers and behaviours and strengthens the habitual mechanism. The triggers (orange frame) are the same as in the EIT with the addition of positive affect, which is susceptible to elicit anticipatory responses, like external cues and associated thoughts.

If awareness of the state emerges from the experience, the process must go through a second conscious path (continuous lines in Figure 17) involving craving and the related cognitive resources. The trigger mechanisms and the subjective craving process (blue frame) are the same as in the EIT, with the same characteristic difference between automatic (thin lines) and attentional and working memory (thick lines) mechanisms. Triggers induce an initial intrusive desire thought (yellow frame), either directly or through a sense of associated deficit. Those verbal and imagery thoughts elicit pleasure and relief (green frame) leading to two vicious spirals. The first one directly reinforces the elaboration of desire thoughts; the other increases the sense of associated deficit with a contrast between real and imagined

experience, requiring further elaboration to overcome this sensation. Attention and working memory also focus on handling triggers that may fuel the elaborative process. The holistic EIT, in line with the EIT (Kavanagh et al., 2005) and the dynamic model (Hofmann & van Dillen, 2012) of craving, predicts that craving will increase when more cognitive resources are allocated to its elaboration and the process of related cues. The perceived importance of the obstacle is not considered of primary influence, as opposed to the CPM (Tiffany, 1990) postulates; the obstacle, no matter how insurmountable, only helps to break from the mindless pathway and to experience craving, through awareness.

The outcome of the subjective state of desire, even if explained by the authors, was not integrated in the graphic modelling. To describe the whole process with parsimony, Figure 17 includes the two potential types of response to gambling craving (i.e., gambling and restrain or other behaviour) and the cognitive regulation factors. The present section has highlighted the influence of metacognitions (red frame; explicitly mentioned on Figure 17 as related to a questionnaire; see section 5.2.4.2) on the subjective state of desire and on the decision process (e.g., Caselli & Spada, 2013; Spada, Caselli, et al., 2015). Functional coping strategies may help mitigating the craving (e.g., interference-based methods) or impact the choice of behaviour (e.g., meditation to promote acceptance), while some dysfunctional strategies (e.g., avoidance) may lead to gambling. Self-efficacy and appraisal processes related to goals and standards are also postulated to moderate the result of craving. Those factors may also influence each other (e.g., more coping strategies may improve self-efficacy) but are of importance in the decision process. Eventually, the reaction or response (i.e., gambling or not) to gambling craving may reinforce or mitigate the conditioned associations between the triggers and the behavioural response in both pathways.

Such holistic update of the EIT, if proven relevant, could also lead to an enhanced assessment and intervention by comprehensively addressing the factors involved in craving. But crucially, it also changes our view of craving; instead of considering craving as a personal weakness or as a consumption and relapse promoter, it can also be conceptualized as a sign of change and part of the recovery process (Marlatt & Parks, 1982). Indeed, the craving experience comes with the awareness that enables conscious decisions and a way out of the problematic “mindless” pattern.

6.2.5 A broader evaluation of craving and proximal factors

Other questionnaires assessing constructs related to the craving – but not targeting it directly – have been developed with the EIT as reference (May et al., 2015). The desire thinking questionnaire (DTQ; Caselli & Spada, 2011) aims to evaluate the nature of desire thoughts. The metacognitions about desire thinking questionnaire (MDTQ; Caselli & Spada, 2013) measures the metacognitions that specifically target the desire thinking process. Eventually, the transaddiction craving triggers questionnaire, which has been validated for alcohol (von Hammerstein et al., 2019) and gambling (Cornil, Rothen, et al., 2019) measures the extent to which stimuli are likely to trigger craving. The constructs evaluated by these three scales are mentioned by coloured frames in Figure 17. The current section discusses the

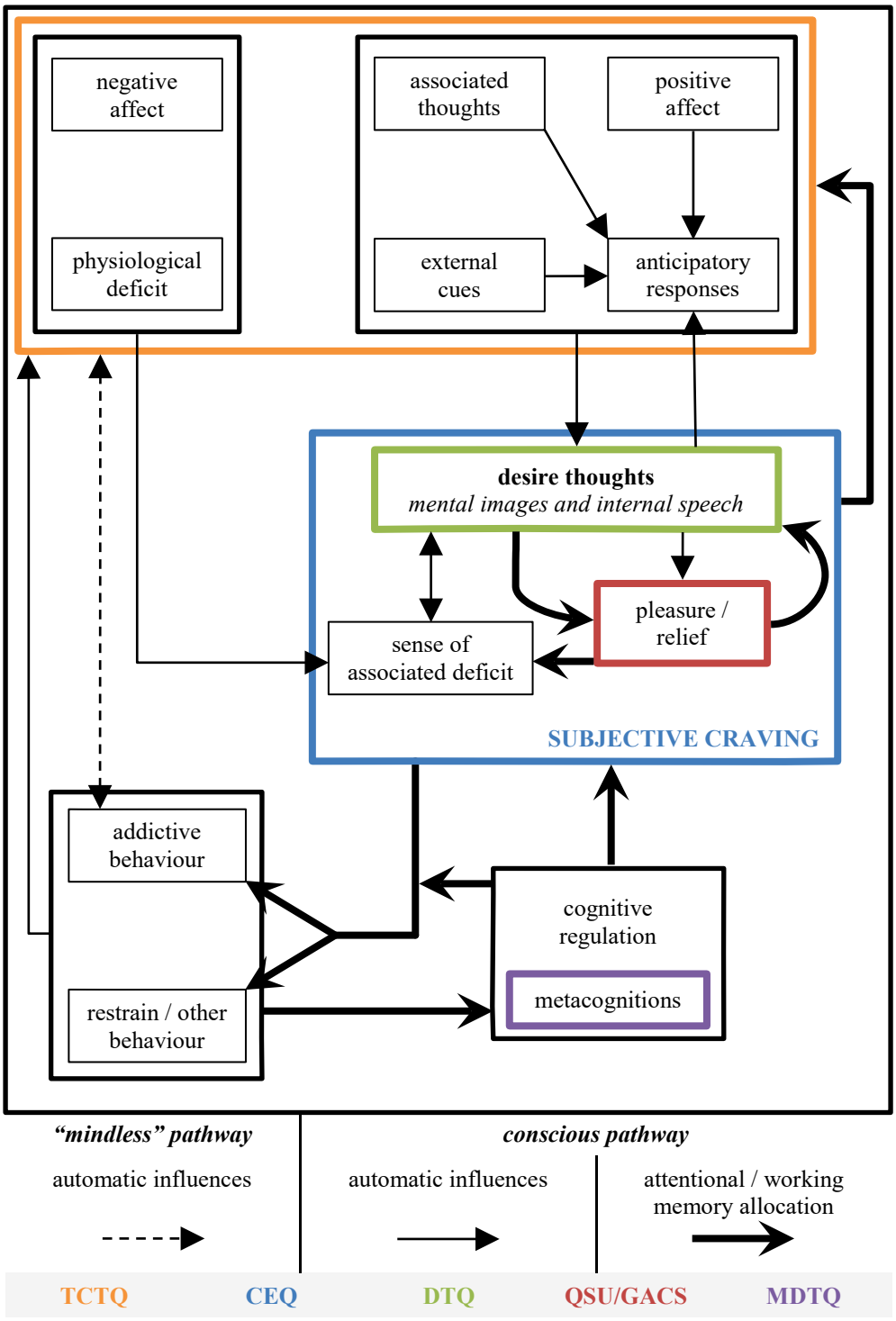

Figure 17. The holistic EIT: a two-pathway model of addictive behaviour

Note. Assessment of constructs in coloured boxes are mentioned below the figure.

different questionnaires and their usefulness for a comprehensive evaluation of craving, in line with the holistic EIT. Scales and subscales are presented in Table 26, along with potential specific interventions discussed in section 5.3.

6.2.5.1 The desire thinking questionnaire (DTQ)

Desire thinking is considered a controlled cognitive mechanism which includes verbal and imaginal elaboration of the desired object and it is the central process of the EIT. Caselli and Spada (2011) developed the DTQ to evaluate the two components of desire thoughts. The *verbal perseveration* (5 items; e.g., "When I begin to think about the desired activity I continue until I manage to do engage in it") encompasses the repetitive thoughts while the *imaginal prefiguration* (5 items; e.g., "I begin to imagine the desired activity every time it comes to my mind") contains mental images about one's own experience of the desired activity. Participants rate their agreement with items on a 4-point Likert scale (1 = *almost never*, 2 = *sometimes*, 3 = *often*, and 4 = *almost always*). The scale showed good psychometric properties and correlated with craving measured by the Penn Alcohol Craving Scale (Flannery et al., 1999) among participants seeking treatment for alcohol issues.

The DTQ allows to rapidly measure the nature of desire thinking as a trait with an acceptable test-retest reliability. The subscales offer various items about verbal and imaginal aspects of the construct that are associated with substance use disorders (e.g., alcohol, nicotine) and behavioural addictions (e.g., gambling, internet use) in community and clinical samples (Mansueto et al., 2019). The scale has initially no timeframe specified, but Chakroun et al. (2017) have used the scale with the last week as period of reference. They found significant correlations of both subscales with craving. However, the latter was measured with a single item retrospectively measuring the average alcohol craving of the previous week. Given the timeframe, the imaginal prefiguration subscale should be compared to the imagery factor of g-CEQ-F applied on the same period. This form of the CEQ is shorter and explicitly covers several sensorial modalities, unlike the corresponding DTQ subscale that is more general (except one item about the visual modality). One study (Markus et al., 2019) found a significant strong correlation between both subscales[3] related to alcohol use in a normative sample ($r = .64$; $p < .01$) and in an inpatient sample ($r = .61$; $p < .01$), suggesting a potential overlap. However, moderate to strong correlations were also found with the other subscales of the CEQ in its two forms, challenging its complementarity with the DTQ. Further research is needed to clarify this potential overlap.

6.2.5.2 The metacognitions about desire thinking questionnaire (MDTQ)

Several studies (for reviews, see Hamonniere & Varescon, 2018; Rogier et al., 2021) and models (e.g., Flaudias et al., 2019; Spada, Caselli, et al., 2015) attribute an important role to

[3] The scale used to measure the alcohol craving was the alcohol experience questionnaire (Statham et al., 2011) which is based on the EIT and which has a factor-structure similar to the CEQ.

metacognitions in addictions and, a fortiori, in gambling disorder[4]. Following a study that indicates preliminary evidence of the role played by metacognitions on desire thinking (Caselli & Spada, 2010), Caselli and Spada (2013) created the MDTQ to evaluate these specific metacognitions, which designates the subjective considerations about desire related thoughts. This questionnaire is composed of three subscales: *positive metacognitions* about desire thinking (i.e., desire thinking is effective to improve motivation and to distract from unpleasant thoughts; e.g., "Imagining what I desire helps me to have greater control over my choices"), *negative metacognitions* about desire thinking (i.e., desire thinking is uncontrollable and deplete control on behaviour; e.g., "The more I imagine a desired activity/object the harder I find it to resist the impulse of doing it"), and *need to control* desire-related thoughts (i.e., desire thinking impacts self-image and must be controlled; e.g., "Not being able to control my thoughts about what I desire is a sign of weakness"). The two latter factors cover similar control related content and they were expected to be regrouped. Confirmatory factor analyses confirmed though that a three-factor solution better fit the data. This questionnaire and its subscales have adequate internal consistency, acceptable external and test-retest reliability. The positive and negative metacognitions subscales positively correlated with craving and desire thinking, but not with the need to control factor whose role remains uncertain. Positive metacognitions about desire thinking are supposed to play a part in the initiation of desire thoughts while negative metacognitions may fuel the escalation of craving. Despite the four experiments included in the study (also in a sample of participants with alcohol abuse), further research are expected to investigate the MDTQ properties in clinical samples across substances and behaviours, and to examine the potential causal role of metacognitions about desire thinking on craving and addictive behaviours with longitudinal designs.

6.2.5.3 The transaddiction craving triggers questionnaire (TCTQ)

The transaddiction craving triggers questionnaire (TCTQ) emerged from the lack of a tool to assess the triggers of craving, based on the EIT. It was developed as a side project of this PhD thesis in which it has not been included as an empirical study. However, in the perspective of a holistic assessment of craving anchored in the EIT, it seemed relevant to discuss it in this section.

Based on previous research (Cornil et al., 2018; May et al., 2004), 43 items susceptible to elicit craving were generated in order to cover factors considered stable over time: external cues (8 items), anticipatory responses (5 items), associated thoughts (5 items), negative affect (9 items), physiological deficit (5 items), sense of associated deficit (3 items), and positive affect (8 items). They were administered to 111 alcohol use disorder outpatients (von Hammerstein et al., 2019) that rated the items on a scale from 1 (*not at all*) to 6 (*absolutely*).

[4] The metacognitions about gambling questionnaire (Caselli et al., 2018) also helps assessing metacognitions that might impact gambling severity. Although it has good psychometric properties and significant relations with gambling, its link with craving (or desire thinking) was not investigated; it is then not further discussed in this work.

Table 26. Interventions to implement according to significant scores on the dimensions of the scales

Name of scale **Authors (year)**	**Subscales (number of items)**		**Interventions**
Transaddiction Craving Triggers Questionnaire (TCTQ) von Hammerstein et al. (2019) ; Cornil et al. (2019)	unpleasant emotions and associated thoughts (5)		emotion management
	pleasant emotions and arousal (8)		
	internal and external cues (6)		pharmacotherapy, cue exposure, attention retraining, desensitization
Craving Experience Questionnaire (CEQ) May et al. (2014) ; Cornil et al. (2019)	frequency	intensity (3)	interference
		imagery (3)	
		intrusiveness (3)	
	strength	intensity (3)	
		imagery (3)	
		intrusiveness (3)	
Desire Thinking Questionnaire (DTQ) Caselli & Spada (2011)	verbal perseveration (5)		
	imaginal prefiguration (5)		
Questionnaires on Urge (e.g., QSU/GACS) Tiffany & Drobes (1991) ; Canale et al. (2019)	intention and desire to gamble (3)		emotion management, relaxation techniques (as part of imaginal desensitization)
	relief from negative affect (4)		
Metacognitions about Desire Thinking Questionnaire (MDTQ) Caselli & Spada (2013)	positive metacognitions about desire thinking (8)		detached mindfulness, worry and rumination postponement techniques (based on metacognitive therapy)
	negative metacognitions about desire thinking (6)		
	need to control desire-related thoughts (4)		

Note. Mindfulness-based interventions can theoretically be considered effective on roughly all the factors involved in the holistic EIT. It was not mentioned as such for clarity except for metacognitions on which a specific type of intervention (i.e., detached mindfulness) was tested.
QSU = Questionnaire of Smoking Urges; GACS = Gambling Craving Scale

A floor effect (≥ .50) was found for 16 items that were removed, except for one covering visual cues, for theoretical reasons. Three other items were eliminated because of low loadings on the factors in the exploratory factor analysis. The 25 remaining items were distributed over three subscales: (a) unpleasant affect (e.g., stress), (b) pleasant affect (e.g., joy), and (c) cues and related thoughts (e.g., thoughts about locations where you drink alcohol). The scale showed good psychometric properties and construct validity. The same analyses were conducted in a sample of at-risk gamblers (problem gambling severity index ≥ 3; Ferris & Wynne, 2001) from the general population (Cornil, Rothen, et al., 2019). A total of 24 items were discarded due to floor effect or low factor loadings. The final 19-item

solution was divided into three similar subscales: (a) *unpleasant emotions and associated thoughts*, (b) *pleasant emotions and arousal*, and (c) *internal and external cues*. Cronbach's α ranging from .78 to .87 proved good reliability and moderate correlations were found with gambling variables and gambling craving. This questionnaire allows tailored intervention and can be used both in research and clinical practice. In the latter, we suggest using all the items without floor-effect (28 items for alcohol use and 22 items for gambling) as the supplementary items might provide relevant data for intervention. The g-TCTQ should also be tested in clinical population, although only risky gamblers were included in the analyses.

6.3 Interventions in the frame of the holistic elaborated intrusion theory of desire

In this section, interventions presented as methods that decrease craving (see section 2.4 of the general introduction) and gambling craving (see section 3.3 of the general introduction) are placed in the frame of the holistic EIT, along with new leads on interventions targeting metacognitions (Figure 17). The reader must keep in mind that further studies are required to evaluate the impact of those methods on craving and that the association with the holistic EIT components are mainly at the hypothesis stage. Then, the probable effects of mindfulness-based interventions on craving are also examined through the same theory. Interference methods have been discussed extensively in the previous sections and will therefore not be discussed here. The scores of treatment-seeking persons or research participants on the scales related to the holistic EIT (see section 5.2.4) are likely to guide the choice of intervention. An attempt to link high scores in the scales and subscales examined with these interventions is shown in Table 26.

To address the triggers of gambling craving, and more specifically the emotional aspects (affect factors in the TCTQ), the improvement of emotion management seems to be the ideal target. Gross (2015) propose several types of emotions regulation (e.g., situation selection, situation modification, attentional deployment, cognitive change, response modulation) that can be implemented at three stages of the regulation cycle (identification, selection, and implementation). Those could help to better cope with negative emotions, but also with positive ones. Although research has mainly focused on negative affect, research also indicates that positive affect can indeed be a relevant treatment target (for a review, see Carl et al., 2013). Emotion regulation may also influence craving, decreasing the obligation to elaborate desire thoughts to feel pleasure and get relieved from negative affect. The urge would decrease, reducing the motivational part of craving.

Studies have tested several methods regarding cue reactivity (cues factor in the TCTQ and g-TCTQ). Pharmacotherapy (opioid antagonists), cue exposure, attention retraining and desensitization (in imagery and in vivo) have showed promising results to reduce the salience of conditioned stimuli. The relaxation component of imaginal desensitization may also reduce to need for relief, which is a motive to elaborate desire thoughts measured by the relief from negative affect factor of the GACS.

The methods involving motivation enhancement, and more specifically implementation intentions, may help coping with the "mindless" pathway. Indeed, new automatisms may be introduced in daily life to create more functional reactions to the triggers.

The recent highlights of the role of metacognitions on craving request development and probation of methods to modify those metacognitions or reduce their detrimental effects. In their review of metacognitive beliefs in addictive behaviours, Hamonniere and Varescon (2018) emphasize the need for more research on interventions that focus on metacognitions such as metacognitive therapy (Wells, 2013), which includes worry and rumination postponement techniques and detached mindfulness (i.e., meta-awareness and distancing). The latter was compared to a brief exposure to alcohol cues and was found more effective on metacognitive beliefs and to reduce urge[5] in a sample of eight patients with an alcohol use disorder (Caselli et al., 2016). A pilot study on the potential of metacognitive training (Gehlenborg et al., 2020) initiated the investigation of this type of interventions on problem and pathological gambling. Four of their eight modules specifically aimed at changing metacognitions with psychoeducation. However, their focus was the feasibility of the intervention and their sample size was too small to generalize the results. The authors plan to test their program in a randomized control trial.

Mindfulness-based interventions are receiving a lot of enthusiasm and interest in the recent years. Although more research is still required in the field of addiction, mindfulness may reduce craving through several mechanisms. Raising awareness on its triggers can allow the detection of cues and the installation of appropriate responses. The acceptance and non-judgemental experience of emotions should prevent the immediate need to escape and avoid them by an addictive behaviour such as alcohol use or gambling. The consciousness of the present moment is also supposed to prevent from going through the "mindless" pathway, leading to the possibility to influence the operations at stake. But it can also improve the cognitive regulation, leading to a conscious choice. Kindness towards oneself may help dealing with self-efficacy issues and the identification of own values can enrich the appraisal process. Mindfulness-based interventions (e.g., detached mindfulness) are also supposed to work on metacognitions by favouring awareness and distancing. Cognitive defusion in the acceptance and commitment therapy may also be effective on such cognitions.

As highlighted by May et al. (2015), mindfulness strategies (e.g., decentering strategy, defusion and acceptance exercises, body scanning, "urge surfing") help coping with intrusive desire thoughts and reducing craving (see sections 2.4.1 and 3.3.1 of the general introduction). Indeed, meditative practice and related trainings target the attention and the working memory that are involved in the double vicious spiral of the elaboration. The aim of mindfulness is to stop fighting with spontaneous thoughts and to gain flexibility on the allocation of cognitive resources, facilitating, for instance, interference methods. So, while interference reduces craving when it happens, mindfulness-based techniques may, with a more distal approach, enhance flexibility and facilitate the effectiveness of interference. This

[5] The term "urge" was used in the research, although it targeted craving as defined in this work. It was measured with a single item.

would help disengage from intrusive thoughts and reduce the g-CEQ-S subscales scores, but it would also allow to reduce the DTQ subscales scores by stopping the elaboration of desire thought related to addictive behaviours (i.e., no more verbal perseveration nor imaginal prefiguration). Mindfulness also promotes the pursuit of the experience, as opposed to avoidance, in order to observe the transience of mental events, such as craving. The awareness of this ephemerality may decrease the g-CEQ-F subscales scores in the long run, through the progressive modification of metacognitive beliefs (e.g., "If I don't yield into my craving, it won't stop") and craving self-efficacy (i.e., the feeling of competence to overcome craving). The occurrence of craving would not necessarily be altered at the beginning but, because it would not be perceived as threatening, it would become less salient, and subjectively less noticed.

Mindfulness-based interventions are promising, but the gold standard seems to be 8-week programs such as mindfulness based relapse prevention (Bowen et al., 2010). This type of treatment is quite demanding and englobes a range of learnings and practices, making it difficult to understand what the effective processes are. Without denying the benefits of such coherent treatments, future research should continue to investigate how components of mindfulness or techniques from acceptance and commitment therapy (e.g., cognitive defusion, experience acceptance, focus on the present instant) influence craving. Although limits between separated targets of interventions may be blurry (e.g., non-judgemental approach involves acceptance), it might be the best way to understand the underlying mechanisms of mindfulness that are susceptible to reduce craving. Researchers and clinicians could also work on combining the beneficial aspects of mindfulness and interference in a coherent and effective treatment for gambling craving.

7. Conclusion

Previous studies on gambling craving have used cognitive approaches inspired from the substance use field with an a priori transferability hypothesis. The present PhD thesis got back to the roots of the gambling craving experience in order to establish a sound conceptualization and definition. The proposed distinction between desire and craving depending on their target (respectively functional and dysfunctional) may prevent strong desire from being considered deleterious if both were considered qualitatively similar. The gambling EIT has implications for the assessment of and intervention on gambling craving, but also potentially for other types of craving, with the inclusion of positive affect. The measurement of gambling craving is complex, like its mechanisms, and the use of multifactorial scales such as the GACS and the g-CEQ helps understanding its various aspects. Eventually, the outcomes of the questionnaires should guide researchers and therapists towards tailored interference-based interventions.

If this PhD research shows evidence and perspective for the transaddiction character of craving and the related conceptualization, assessment, and intervention, those should not be transferred to other harmful behaviours without proper research. A lot of work remains to be

done regarding current and emerging addictions, with an effort to avoid pathologizing non-problematic gambling behaviours (e.g., a healthy passion for gambling).

Finally, it is urgent to stop the scattering of scientific work on craving and to start building a research that craves for convergence.

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Appendices

Appendices

Appendix A – Scientific communications

Journal articles (peer-reviewed)

Published

Cornil, A., Rothen, S., de Timary, P., & Billieux, J. (2021). Interference-based methods to mitigate gambling craving: A proof-of-principle pilot study. *International Gambling Studies*. Advance online publication. https://doi.org/10.1080/14459795.2021.1903063

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In preparation

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Book

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Appendix B – Conference Organisation

The Big Adventure: Create your own journey. Second edition of TEDxUCLouvain. 9th May 2017. [Curator, Speaker Management]

YOUxTOPIA: Share your visions of tomorrow. First edition of TEDxUCLouvain. 21st April 2016. [Curator, Speaker Management]

Appendix C – Gambling Craving Scale (GACS)

Veuillez répondre aux 7 questions suivantes sur une échelle allant de 1 (fortement en désaccord) à 7 (fortement en accord), en encerclant la réponse qui décrit le mieux comment vous vous sentez *à l'instant présent*.

Please answer the 7 following questions on a scale from 1 (strongly disagree) to 7 (strongly agree), by circling the answer that best describes how you feel right now

	Fortement en désaccord **Strongly disagree**						Fortement en accord **Strongly agree**
1. Il serait plaisant de pouvoir jouer à un jeu de hasard en ce moment. **Gambling would be fun right now.**	1	2	3	4	5	6	7
2. Si j'avais l'opportunité de jouer à un jeu de hasard à l'instant présent, je le ferais probablement. **If I had an opportunity to gamble right now, I probably would take it.**	1	2	3	4	5	6	7
3. Je n'aurais pas de plaisir à jouer à un jeu de hasard à l'instant présent.* **I would not enjoy gambling right now.***	1	2	3	4	5	6	7
4. J'ai besoin de jouer à un jeu de hasard à l'instant présent. **I need to gamble right now.**	1	2	3	4	5	6	7
5. J'aurais les idées plus claires si je jouais à un jeu de hasard à l'instant présent. **If I were gambling now, I could think more clearly.**	1	2	3	4	5	6	7
6. J'aurais un meilleur contrôle de la situation si je pouvais jouer à un jeu de hasard en ce moment. **I could control things better right now if I could gamble.**	1	2	3	4	5	6	7
7. Si je jouais à un jeu de hasard, je me sentirais moins déprimé(e). **Gambling would make me less depressed.**	1	2	3	4	5	6	7

* Item à cotation renversée. **Reverse-coded item**.

Appendix D – gambling Craving Experience Questionnaire (g-CEQ)

Sous-échelle Sévérité (Force) – Subscale Strength, g-CEQ-S

Veuillez répondre aux questions suivantes par rapport à votre envie de jouer à un jeu d'argent à l'instant présent

Please answer the following questions in relation to your current craving to gamble

	Pas du tout **Not at all**										Extrêmement **Extremely**
1. À l'instant présent, à quel point désirez-vous jouer ? **Right now, how much do you want to gamble?**	0	1	2	3	4	5	6	7	8	9	10
2. À l'instant présent, à quel point avez-vous besoin de jouer ? **Right now, how much do you need to gamble?**	0	1	2	3	4	5	6	7	8	9	10
3. À l'instant présent, à quel point votre envie de jouer est-elle forte/pressante ? **Right now, how strong is the urge to gamble?**	0	1	2	3	4	5	6	7	8	9	10
4. À l'instant présent, à quel point vous représentez-vous mentalement le jeu de manière détaillée ? **Right now, how vividly do you picture the game?**	0	1	2	3	4	5	6	7	8	9	10
5. À l'instant présent, à quel point imaginez-vous les sons qui sont associés au jeu de manière détaillée ? **Right now, how vividly do you imagine the sounds related to the game?**	0	1	2	3	4	5	6	7	8	9	10
6. À l'instant présent, à quel point imaginez-vous la sensation de toucher ou de manipuler des objets liés au jeu de manière détaillée ? **Right now, how vividly do you imagine the feeling of touching or manipulating objects related to the game?**	0	1	2	3	4	5	6	7	8	9	10
7. À l'instant présent, à quel point essayez-vous de ne pas penser au jeu ? **Right now, how hard are you trying not to think about the game?**	0	1	2	3	4	5	6	7	8	9	10
8. À l'instant présent, à quel point vos pensées sont-elles intrusives ? **Right now, how intrusive are your thoughts?**	0	1	2	3	4	5	6	7	8	9	10
9. À l'instant présent, à quel point est-ce difficile de penser à quelque chose d'autre ? **Right now, how hard is it to think about anything else?**	0	1	2	3	4	5	6	7	8	9	10

Sous-échelle Fréquence – Subscale Frequency, CEQ-F

Veuillez répondre aux questions suivantes par rapport à vos envies de jouer de cette dernière semaine.

Please answer the following questions in relation to your craving to gamble during the last week.

	Pas du tout **Not at all**										Constamment **Constantly**
1. Durant la semaine dernière, à quelle fréquence avez-vous désiré jouer ? **During the last week, how often did you want to gamble?**	0	1	2	3	4	5	6	7	8	9	10
2. Durant la semaine dernière, à quelle fréquence en avez-vous eu besoin de jouer ? **During the last week, how often did you need to gamble?**	0	1	2	3	4	5	6	7	8	9	10
3. Durant la semaine dernière, à quelle fréquence avez-vous eu envie de jouer fortement/de manière pressante ? **During the last week, how often did you have a strong urge to gamble?**	0	1	2	3	4	5	6	7	8	9	10
4. Durant la semaine dernière, à quelle fréquence vous êtes-vous mentalement représenté le jeu de manière détaillée ? **During the last week, how often did you picture the game?**	0	1	2	3	4	5	6	7	8	9	10
5. Durant la semaine dernière, à quelle fréquence avez-vous imaginé les sons qui sont associés au jeu de manière détaillée ? **During the last week, how often did you imagine the sounds related to the game?**	0	1	2	3	4	5	6	7	8	9	10
6. Durant la semaine dernière, à quelle fréquence avez-vous imaginé la sensation de toucher ou de manipuler des objets liés au jeu de manière détaillée ? **During the last week, how often did you imagine the feeling of touching or manipulating objects related to the game?**	0	1	2	3	4	5	6	7	8	9	10
7. Durant la semaine dernière, à quelle fréquence avez-vous essayé de ne pas penser au jeu ? **During the last week, how often did you try not to think about the game?**	0	1	2	3	4	5	6	7	8	9	10
8. Durant la semaine dernière, à quelle fréquence vos pensées ont-elles été intrusives ? **During the last week, how often were your thoughts intrusive?**	0	1	2	3	4	5	6	7	8	9	10
9. Durant la semaine dernière, à quelle fréquence a-t-il été difficile de penser à quelque chose d'autre ? **During the last week, how often was it hard to think about anything else?**	0	1	2	3	4	5	6	7	8	9	10

Appendix E – Mean and Standard Deviation of g-CEQ-S and g-CEQ-F Items

	g-CEQ-S *M* (*SD*)	g-CEQ-F *M* (*SD*)
Item 1 – Desire	4.02 (2.52)	2.63 (2.35)
Item 2 – Need	1..90 (2.28)	1.49 (1.96)
Item 3 – Urge	2.29 (2.43)	1.26 (2.04)
Item 4 – Picture	3.49 (2.83)	1.62 (2.12)
Item 5 – Hear	2.19 (2.63)	0.73 (1.41)
Item 6 – Touch	2.60 (2.81)	1.04 (1.77)
Item 7 – Not to think	1.91 (2.39)	1.08 (1.92)
Item 8 – Intrusive thoughts	2.25 (2.62)	1.05 (1.85)
Item 9 – Think about anything else	2.12 (2.71)	0.78 (1.72)

Appendix F – Transdiagnostic Craving Triggers Questionnaire (TCTQ)

Ce questionnaire a pour objectif d'évaluer ce qui, pour vous, *déclenche* un désir / une envie / un besoin de consommer de l'alcool / de fumer / de jouer à des jeux de hasard et d'argent. Veuillez tout d'abord entourer l'activité sur laquelle porte ce questionnaire :

This questionnaire aims to evaluate what, for you, *triggers* a craving / an urge to drink alcohol / to smoke / to gamble. Please, let us know which activity this questionnaire focuses on:

Boire de l'alcool	Fumer	Jouer à des jeux d'argent	Jouer à des jeux vidéo en ligne
Drink alcohol	**Smoke**	**Gamble**	**Play Online Video-Games**

Veuillez indiquer dans quelle mesure les éléments suivants peuvent *déclencher*, pour vous, un désir / une envie / un besoin de vous adonner à cette activité.

Please, indicate how much the following elements can *trigger*, for you, a craving / an urge to indulge in the pleasure of this activity.

	Pas du tout **Not at all**					Tout à fait **Absolutely**
1. De l'ennui **Boredom**	1	2	3	4	5	6
2. Des choses que vous voyez autour de vous (par ex. publicités, ordinateur, objets associés à l'alcool / à la cigarette / aux jeux…) **Things you see around you (e.g., advertisement, objects associated to alcohol / cigarette / gambling / video games...)**	1	2	3	4	5	6
3. Du plaisir **Pleasure**	1	2	3	4	5	6
4. Une accélération du rythme cardiaque **Heart rate increase**	1	2	3	4	5	6
5. Des pensées de contrôle (« je peux m'arrêter quand je le décide ») **Thoughts of control ("I can stop whenever I decide")**	1	2	3	4	5	6
6. Certains sons (par ex. bruits de verres, d'un briquet, de l'argent, d'un clavier…) **Some sounds (e.g., noises of glasses, a lighter, money, a keyboard…)**	1	2	3	4	5	6
7. Du stress **Stress**	1	2	3	4	5	6
8. Du soulagement **Relief**	1	2	3	4	5	6
9. Un mal de tête **Headache**	1	2	3	4	5	6
10. L'impression que vous vous sentez mal **The impression you feel bad**	1	2	3	4	5	6
11. Une odeur particulière (par ex. odeur d'alcool / de cigarette / un parfum…) **A specific smell (e.g., smell of alcohol / cigarette / a perfume)**	1	2	3	4	5	6

	Pas du tout **Not at all**					Tout à fait **Absolutely**
12. De la satisfaction **Satisfaction**	1	2	3	4	5	6
13. Une salivation accrue **An increased salivation**	1	2	3	4	5	6
14. De la honte **Shame**	1	2	3	4	5	6
15. La sensation de toucher certains objets (par ex. un verre, un cendrier, des cartes, une souris…) **The sensation of touching some objects (e.g., a glass, an ashtray, cards, a mouse…)**	1	2	3	4	5	6
16. Des pensées relatives aux personnes avec qui vous buvez / fumez / jouez **Thoughts related to people with whom you drink / smoke / gamble / play video games**	1	2	3	4	5	6
17. Des besoins physiologiques (par ex. faim ou soif) **Physiological needs (e.g., hunger or thirst)**	1	2	3	4	5	6
18. De l'excitation **Arousal**	1	2	3	4	5	6
19. De la déception **Disappointment**	1	2	3	4	5	6
20. Un goût spécifique (par ex. une boisson, un chewing-gum, des biscuits apéritifs, de pizza…) **A specific taste (e.g., a drink, a chewing gum, salted biscuit, pizza…)**	1	2	3	4	5	6
21. Une variation de la température du corps (par ex. chaleur ou fraîcheur) **A body temperature change (e.g., heat or cool)**	1	2	3	4	5	6
22. Des pensées par rapport à des problèmes (par ex. travail, finances, une discussion sérieuse…) **Thoughts related to problems (e.g., work, finances, a serious talk)**	1	2	3	4	5	6
23. De la peur ou de l'angoisse **Fear or anxiety**	1	2	3	4	5	6
24. De la joie **Joy**	1	2	3	4	5	6
25. Des contextes particuliers (par ex. conflit, attente, à une fête, suite à une invitation, un jour de paie…) **Specific contexts (e.g., conflict, wait, at a party, after an invitation, a payday)**	1	2	3	4	5	6
26. De la fatigue physique ou un manque d'énergie **Physical tiredness or a lack of energy**	1	2	3	4	5	6
27. De la solitude **Loneliness**	1	2	3	4	5	6
28. La conscience que vous n'êtes pas bien **The awareness that you are not well**	1	2	3	4	5	6
29. De la fierté ou de la confiance **Pride or confidence**	1	2	3	4	5	6

	Pas du tout **Not at all**					Tout à fait **Absolutely**
30. Des pensées portant sur l'alcool, les cigarettes, les jeux **Thoughts about alcohol, cigarettes, gambling, video games**	1	2	3	4	5	6
31. De la transpiration **Sweat**	1	2	3	4	5	6
32. Une discussion portant sur l'alcool, la cigarette ou les jeux **A talk about alcohol, cigarettes, gambling, video games**	1	2	3	4	5	6
33. De la frustration ou de la colère **Frustration or anger**	1	2	3	4	5	6
34. Une tension musculaire **Muscular tension**	1	2	3	4	5	6
35. De la détente **Relaxation**	1	2	3	4	5	6
36. Des pensées à propos de lieux où vous buvez / fumez / jouez **Thoughts about locations where you drink / smoke / gamble / play video games**	1	2	3	4	5	6
37. Des tremblements **Shivers**	1	2	3	4	5	6
38. De la tristesse ou du désespoir **Sadness or despair**	1	2	3	4	5	6
39. Des endroits particuliers (par ex. dans un bar, un casino, un bureau …) **Specific locations (e.g., in a bar, a casino, an office…)**	1	2	3	4	5	6
40. Un tic nerveux ou un mouvement rapide et répété (par ex. tapotement, jambe qui tremble…) **A tic or a twitch (e.g., tapping, shaking leg)**	1	2	3	4	5	6
41. De l'euphorie **Euphoria**	1	2	3	4	5	6
42. De la culpabilité **Guilt**	1	2	3	4	5	6
43. Un sentiment de mal être **A feeling of unease**	1	2	3	4	5	6

Indices Externes – **External Cues** → 2, 6, 11, 15, 20, 25, 32, 39
Réponses Anticipatrices – **Anticipatory Responses** → 4, 13, 21, 34, 40
Pensées Associées – **Associated Thoughts** → 5, 16, 22, 30, 36
Affects Négatifs – **Negative Affect** → 1, 7, 14, 19, 23, 27 33, 38, 42
Déficits Physiologiques – **Physiological Deficit** → 9, 17, 26, 31, 37
Affects Positifs – **Positive Affect** → 3, 8, 12, 18, 24, 29, 35, 41
Sentiment de manque – **Sense of Associated Deficit** → 10, 28, 43

Alcohol TCTQ (von Hammerstein et al., 2019)

1. Émotion désagréables – **Unpleasant affect**: 1, 7, 10, 14, 19, 22, 23, 25, 27, 28, 33, 38, 42, 43
2. Émotions agréables – **Pleasant affect**: 3, 8, 12, 18, 24, 35, 41
3. Indices et pensées associées – **Cues and associated thoughts**: 2, 30, 36, 29

Gambling TCTQ (Cornil, Rothen, et al., 2019)

1. Émotions désagréables et pensées associées – **Unpleasant emotions and associated thoughts**: 1, 7, 19, 22, 27
2. Émotions agréables et activation – **Pleasant emotions and arousal**: 3, 4, 12, 18, 24, 29, 35, 41
3. Indices internes et externes – **Internal and external cues**: 16, 25, 30,32, 36, 39