Neuropsychology Review
https://doi.org/10.1007/s11065-018-9387-3

REVIEW

Let's Open the Decision-Making Umbrella: A Framework for Conceptualizing and Assessing Features of Impaired Decision Making in Addiction

Lucien Rochat[1] · Pierre Maurage[2,3] · Alexandre Heeren[2,3] · Joël Billieux[4,5,6]

Received: 10 March 2018 / Accepted: 21 September 2018

Abstract
Decision-making impairments play a pivotal role in the emergence and maintenance of addictive disorders. However, a sound conceptualization of decision making as an umbrella construct, encompassing its cognitive, affective, motivational, and physiological subcomponents, is still lacking. This prevents an efficient evaluation of the heterogeneity of decision-making impairments and the development of tailored treatment. This paper thus unfolds the various processes involved in decision making by adopting a critical approach of prominent dual- or triadic-process models, which postulate that decision making is influenced by the interplay of impulsive-automatic, reflective-controlled, and interoceptive processes. Our approach also focuses on social cognition processes, which play a crucial role in decision making and addictive disorders but were largely ignored in previous dual- or triadic-process models. We propose here a theoretical framework in which a range of coordinated processes are first identified on the basis of their theoretical and clinical relevance. Each selected process is then defined before reviewing available results underlining its role in addictive disorders (i.e., substance use, gambling, and gaming disorders). Laboratory tasks for measuring each process are also proposed, initiating a preliminary process-based decision-making assessment battery. This original approach may offer an especially informative view of the constitutive features of decision-making impairments in addiction. As prior research has implicated these features as risk factors for the development and maintenance of addictive disorders, our processual approach sets the scene for novel and transdiagnostic experimental and applied research avenues.

Keywords Decision making · Addiction · Dual-process model · Assessment battery · Transdiagnostic and processual approach · Social cognition

✉ Joël Billieux
Joel.Billieux@uni.lu

1 Cognitive Psychopathology and Neuropsychology Unit, Department of Psychology and Educational Sciences, University of Geneva, Geneva, Switzerland

2 Laboratory for Experimental Psychopathology, Psychological Science Research Institute, UCLouvain, Louvain-la-Neuve, Belgium

3 Clinical Neuroscience Division, Institute of Neuroscience, Université catholique de Louvain, Brussels, Belgium

4 Addictive and Compulsive Behaviours Lab (ACB-Lab), Institute for Health and Behaviour, University of Luxembourg, Esch-sur-Alzette, Luxembourg

5 Centre for Excessive Gambling, Lausanne University Hospitals (CHUV), Lausanne, Switzerland

6 Addiction Division, Department of Mental Health and Psychiatry, University Hospitals of Geneva, Geneva, Switzerland

Introduction

Being regularly confronted with temptations, human beings are constantly forced to make choices, some bad and others good. In view of the importance of decision making, various mechanisms or processes underlying it have been studied for many years from different disciplinary perspectives (e.g., philosophy, psychology, economy, neurosciences, artificial intelligence). Crucially, impairment in decision making has long been established as a hallmark of addictive disorders (Bechara 2005; Bickel et al. 2018; Goudriaan et al. 2005), which are commonly understood as pathologies of "decision-making" (Redish et al. 2008), "choices" (Kalivas and Volkow 2005), or "temporal horizon" (Bickel et al. 2006).

Decision making is often viewed as the result of an active and conscious deliberative process in which individuals

Published online: 06 October 2018

balance the short-term and long-term benefits of a choice in light of the available information (Evans 2003; Figner et al. 2009). In such an approach, decision making is considered a voluntary, and cognitively demanding process. Yet, the cognitive abilities of human beings are naturally limited, and the knowledge available to guide an informed decision largely varies by individual or environmental factors. In accordance with this, economist Herbert Simon theorized the influential limited rationality theory (Simon 1979; see also Gigerenzer and Goldstein 1996), stipulating that individuals are rational agents who generally favor the first satisfying option rather than engaging in a full, comprehensive, and cognitively demanding deliberative process. Thus, adaptive decision making not only relies on cognitive (and contextual factors), but also depends on the influence of affective and physiological processes. Important corroboration of this view is provided by the somatic marker hypothesis (Damasio 1996). According to Damasio, decision making relies on a cost-benefit analysis related to a given action, but is also influenced by "somatic markers," i.e., anticipatory physiological and emotional reactions generated on the basis of the outcomes associated with similar past choices. These somatic markers are especially supposed to guide choices in uncertain contexts, where no detailed cost-benefit analysis is possible. Beyond the involvement of cognitive, affective, and physiological mechanisms, decision making is generally considered to depend on the mutual and conflicting actions of automatic (unconscious) and controlled (voluntary) processes (Epstein 1994; Evans 2003; Strack and Deutsch 2004). The following section addresses the key distinction between "automatic" versus "controlled" determinants of behavior with regard to addictive disorders as assumed in the so-called dual-process models of decision-making (e.g., Bechara 2005; Mukherjee 2010; Schiebener and Brand 2015; Sloman 1996).

Dual-Process Models of Addiction: Origins, Evolution, and Limitations

The dual-process approach has become massively prominent in the field of addictive behaviors, and almost all influential models consider the dichotomy between impulsive-automatic and reflective-controlled determinants of behavior (e.g., Koob and Le Moal 2001; Volkow et al. 2011). In fact, specific dual-process models have been explicitly developed to account for addictive disorders (e.g., Bechara 2005; Evans and Coventry 2006; Fleming and Bartholow 2014; Noël et al. 2013a, 2013b). According to the prominent Bechara's model (Bechara 2005), addiction results from an imbalance between two distinct but interacting cognitive and cerebral systems controlling decision making: an "impulsive" system related to amygdala/striatum activity and driven toward immediate positive reinforcement (e.g., getting high) or negative reinforcement (e.g., reducing withdrawal), and a "reflective" system related to prefrontal activity and focused on future prospects (e.g., the cost and benefits of remaining sober). Such models typically postulate that in addictive disorders, the impulsive-automatic system tends to be overactivated (mainly in reaction to internal or external cues), whereas the mechanisms related to the optimal functioning of the reflective-controlled system are impaired (e.g., inhibitory control deficit). More recently, dual-process approaches have also inspired the development of models accounting for conditions such as gambling and gaming disorders (Brand et al. 2016; Brevers and Noël 2013; Dong and Potenza 2014; Wei et al. 2017), in which the interplay between automatic and reflective processes is, in line with substance-related addictions, postulated to play a pivotal role in the onset and perpetuation of the condition. According to several authors (e.g., McClure and Bickel 2014; Schiebener and Brand 2017), disentangling the various processes involved in impulsive-automatic versus reflective-controlled systems is an important step toward better understanding and treatment of addictive disorders.

In recent years, to better account for specific features of addiction such as craving or urges (Verdejo-Garcia et al. 2012), Noël et al. (2013a, 2013b) extended the dual-process perspective to a "triadic" model integrating a third system related to interoceptive processes. The triadic model exemplifies how dual-process models are currently evolving based on the type of behavior they aim to explain (here addictive disorders). This interoceptive system, which mainly depends on the activity of the insular cortex (in particular its anterior part), promotes addictive behaviors by translating interoceptive signals into subjective experiences, such as feelings of desire, anticipation, urge, or craving (e.g., Naqvi et al. 2007; Verdejo-Garcia et al. 2012). According to Noël et al. (2013a, 2013b), such interoceptive information is susceptible to fostering activity of the impulsive-automatic system while undermining the efficacy of the reflective-controlled system, promoting dysregulated and compulsive drug seeking. Furthermore, it has also been suggested that dysfunction in the interoceptive system engenders poorer self-awareness, which can reinforce denial, reduced perceived need of treatment, or continuous substance abuse despite deleterious health consequences (Goldstein et al. 2009; Goldstein and Volkow 2011). Although this triadic model constitutes an inspiring evolution of previous dual-process models and sophisticates their application to addictive disorders, it still lacks empirical support to confirm the role played by the insular system and its moderating function between limbic and prefrontal areas.

Nevertheless, despite the popularity of these models, experts in the field of decision-making research have recently initiated a dismissive appraisal of the dual-process approach's prospects as a viable and useful model of decision making (e.g., Hommel and Wiers 2017; Keren 2013; Keren and Schul 2009; Newell and Shanks 2014). One serious criticism is the lack of well-defined constructs that renders impossible the generation of testable predictions within the dual-process framework (for extended discussion, see Keren 2013; Keren and Schul 2009). Moreover, the fuzzy conceptual boundaries between the two systems also seemingly challenge the claim that these two systems are extricable (Hommel and Wiers 2017; Keren 2013; Keren and Schul 2009). Likewise, recent research has suggested that most of the processes that are assumed to fall under the label of one of the two systems—at least, according to the dual-process perspective—often involve features of both systems. For instance, although the dual-process perspective conceptualizes attentional biases as a core feature of the "automatic-impulsive system" (e.g., Wiers et al. 2007a; Wiers et al. 2013), the modifications of the very central features of the so-called reflective system, such as via a transient increase in cortical activity within the prefrontal cortex, modulate attentional biases (Heeren et al. 2017). Such a criticism of the dual-process perspective should not come as a surprise, as it is clearly in line with recent empirical and theoretical work in cognitive science defying the arbitrary distinction between controlled and automatic processes, and rather promoting a continuum within a unique functionally integrated cognitive system (Pessoa 2017). Accordingly, because it has become almost impossible to categorize any processes or tasks as specifically pertaining to one of the two systems, recent models of decision making have evolved toward a unitary model of action control, driven by a continuum between intention and automaticity, working as a unique functionally integrated decision-making system (e.g., Hommel and Wiers 2017).

In addition to the aforementioned limitations, by focusing on the imbalance between reflective and automatic systems to explain addictive behaviors, dual-process models, as well as their extension in the triadic model, have neglected other key factors involved in the development and maintenance of addictive disorders, among which are deficits in social cognition processes. This issue is particularly unfortunate because the experimental data available have reported that emotional and interpersonal impairments are widely present among patients presenting addictive disorders. In addition, these socio-cognitive impairments have detrimental consequences on various treatment outcomes such as relapse rate (Gordon and Zrull 1991; Zywiak et al. 2003). Moreover, beyond addiction, many studies have pointed out the critical role of social cognition in decision making (for a review, see Frith and Singer 2008). However, despite recent blooming of this social cognition exploration in psychiatric disorders such as schizophrenia (e.g., Green et al. 2015) and autism (e.g., Leekam and Ramsden 2006), their understanding is still in its infancy in addictive disorders.

Reframing Features of Impaired Decision Making: Implications for Addictive Disorders

Addiction is at its core a decision making problem. Indeed, a large number of case-control studies highlighted that individuals with substance use and addictive disorders (e.g., gambling disorder, gaming disorder) also showed impairment in laboratory measures of decision making (Biernacki et al. 2016; Brevers et al. 2013a; Goudriaan et al. 2004; Schiebener and Brand 2017; Yücel and Lubman 2007). Existing research also emphasized that more pronounced decision-making impairments are linked with more severe addictive disorders (Bechara et al. 2001; Bickel et al. 2014; Krmpotich et al. 2015) and that decision-making performance allows discriminating between individuals exhibiting recreational and those presenting pathological patterns of cocaine use or gambling involvement (Grant et al. 2011; Hulka et al. 2014). A corpus of data also supports the prognosis value of laboratory measures of decision making for various clinical outcomes, such as poorer treatment compliance or increased relapse rates (Álvarez-Moya et al. 2011; Bowden-Jones et al. 2005; Domínguez-Salas et al. 2016; Stevens et al. 2014). Taken together, these data call for the consideration of decision-making-related processes in the diagnosis, treatment, and prevention of addictive disorders (Yücel and Lubman 2007).

Yet, a serious limitation of existing studies is that they often failed to conceptualize decision making as an umbrella construct involving a wide range of distinct cognitive, affective, motivational, and physiological processes. The upshot was that they did not often lead to tailored interventions targeting specific impaired mechanisms (e.g., neurocognitive rehabilitation). Indeed, the classic laboratory tasks generally used to identify decision-making deficits [e.g., Iowa Gambling Task (Bechara et al. 1994), Cambridge Gambling Task (Rogers et al. 1999), Game of Dice Task (Brand et al. 2005), Balloon Analogue Risk Task (Lejuez et al. 2002), delay reward discounting task such as the Monetary Choice Questionnaire (Kirby et al. 1999), Information Sampling Task (Clark et al. 2006)] are "generic" and multidetermined, meaning that performances on these tasks are influenced by many lower order mechanisms, such as inhibitory control, working memory components (e.g., central executive), ability to project oneself in the future, sensitivity to reward, or emotion-laden impulsivity (e.g., Billieux et al. 2010b; Cui et al. 2015; Noël et al. 2007). Consequently, tasks that are considered to measure outcomes of poor decision making provide unspecific information about the nature of decision-making-related deficits presented by patients, which brings into question their clinical usefulness.

Given the aforementioned literature, our objective is to unfold the various processes underlying decision making, capitalizing on recent research in addiction that goes beyond the dual-process perspective by including features of the so-called impulsive-automatic and reflective-controlled processes from this dual-process perspective, as well as interoceptive and social cognition processes. We believe that our approach will also likely contribute to a better understanding of the specific processes involved in the cognitive steps involved in decision making (Verdejo-Garcia et al. 2018), such as (a) preference formation (e.g., developing a preference for a specific option by mentally computing and comparing the subjective value of each available option), (b) choice implementation (e.g., allocating a response to the preferred option), and (c) feedback processing and learning (e.g., shaping behavior and subsequent choices according to the outcomes of previous experiences). Our rationale for the selection of the processes was twofold. First, our decision was based on the relevance of these processes with regard to previous prominent frameworks of decision making in addiction. Second, we also relied on the robustness of the evidence linking these processes to addictive disorders, that is, the processes involved via evidence in the diagnosis, treatment, and prevention of addictive disorders. We considered as eligible all data obtained in substance use disorders and gambling/gaming disorders (American Psychiatric Association 2013; World Health Organization 2018). We first define each selected process before reviewing the available results underlining the role played by this process in addictive disorders, and then we describe a valid task that measures this process, leading to a preliminary comprehensive and process-based decision-making assessment battery.

Proposal for a Taxonomy of Transdiagnostic Features of Decision Making in Addiction and a Related Assessment Battery

Reward Sensitivity: Definition and Role in Addictive Disorders

The reward system is crucial for processing the salience of incoming stimuli and regulating motivational, emotional, and decision-making abilities (Volkow et al. 2010). Efficient reward processing is thus indispensable in healthy humans to initiate and regulate appetitive behaviors, and the proposal that addictive disorders are closely related to changes in reward sensitivity mechanisms is at the heart of the neurobiological models of addiction (Koob and Le Moal 2001; Robinson and Berridge 2003; Volkow et al. 2003). As reward sensitivity is centrally related to limbic structures and associative learning, it is considered part of the impulsive-automatic system from the dual-model process perspective, being related to appetitive associations that cannot be directly controlled by the reflective system. However, recent models support the view that reward processing in fact plays a pivotal role in both automatic and reflective aspects of behavior (see O'Doherty et al. 2017), as it is at the very core of any type of goal-directed behavior. Other psychological models have linked reward sensitivity with impulsivity (Whiteside and Lynam 2001) or sensation-seeking traits (Blum et al. 1996), despite these constructs are theoretically and empirically distinct (e.g., sensation seekers are often characterized as having increased impulsivity toward specific addiction-related stimuli without presenting globally increased reward sensitivity). Reward sensitivity is thus a key concept in addictive disorders, which should be taken into account and validly measured, notably in view of its link with impulsivity and decision making.

While reward sensitivity toward drug-related stimuli has been extensively explored by using attentional biases and implicit attitude paradigms (see related sections), the more general sensitivity to reward and punishment has been far less investigated in addictive disorders. Several tasks have been developed to offer a specific measure of reward/punishment sensitivity [e.g., Reinforcement Learning Task (Frank et al. 2004); see below), but they have not yet been used in addictive disorders. The only currently available data regarding reward sensitivity have been obtained through multidetermined tasks, in particular the Balloon Analogue Risk Task (Lejuez et al. 2002). Results obtained with this task should be taken with caution, as performance on this task can be influenced by factors unrelated to reward sensitivity (e.g., global executive functioning). Moreover, reward sensitivity is merged with risk-taking tendency in this task, despite these two concepts not being considered isomorphic. Nevertheless, increased reward sensitivity (i.e., increased risk taking to obtain higher monetary reward) has been documented to significantly predict heavy alcohol use in young individuals (Fernie et al. 2010). Conversely, long-term alcohol-dependent patients present reduced risk taking in such tasks (Ashenhurst et al. 2011; Campbell et al. 2013), thus suggesting reduced reward sensitivity toward non-alcohol-related rewards. Similar results were found in nicotine-dependence studies, where young adolescent smokers showed increased reward sensitivity (Schepis et al. 2011), whereas adult smokers presented reduced reward-seeking strategies (Lejuez et al. 2005; Ryan et al. 2013). Finally, a recent study showed that individuals characterized by a proneness toward excessive video gaming presented heightened risk taking on the Balloon Analogue Risk Task (Weinstein et al. 2016). While promising, these results have not yet been extended to other addictive disorders, where the exploration of reward sensitivity remains scarce. For example, MDMA users (Hopko et al. 2006) and adolescent gamblers (Cosenza et al. 2017) present increased reward sensitivity; conversely, current opioid (Paydary et al. 2016), cannabis (Gonzalez et al. 2012), or cocaine (Bornovalova et al. 2005) use does not lead to significant reward sensitivity changes. Although the knowledge about substance-related reward sensitivity is thus largely developed, more global reward sensitivity remains to be explored with more specific tasks in addictive disorders.

Measuring Reward Sensitivity A relevant task to measure reward sensitivity is the Reinforcement Learning Task (Frank et al. 2004), which starts with a training phase in which symbols are repeatedly presented in three pairs (A-B; C-D; E-F). For each trial, participants have to choose one of the two symbols, which leads to feedback ("correct"/"incorrect"). While initially choosing randomly, participants progressively learn that each symbol is associated with positive feedback probability (80%–20% for A-B symbols, 70%–30% for C-D, and 60%–40% for E-F). A testing phase then starts with the same symbols but with reorganized pairs (e.g., A-C; B-D); the frequency of A versus B symbol selection shows whether the participant has mostly learned by using negative or positive feedback. Indeed, participants who learn through positive feedback will mostly choose the "A" symbol (related to most positive feedback in the learning phase), indicating high reward sensitivity, whereas participants who learn through negative feedback will mostly avoid choosing the "B" symbol (related to most negative feedback in the learning phase), indicating high punishment sensitivity.

Attentional Biases: Definition and Role in Addictive Disorders Attentional bias can be defined as preferential attentional allocation toward a specific stimuli type. Arguably, most influential models of addiction have proposed that, through associative learning processes, addiction-related cues acquire strong incentive salience that, in turn, gives those cues increased attentional priority—that is, an addiction-related attentional bias (see Anderson 2016; Field et al. 2016 for reviews). In other words, addiction-related conditioned stimuli acquire the ability to hijack one's attention (Field and Duka 2002; Hogarth and Duka 2006; Robinson and Berridge 2008). However, it is worth noting that contemporary perspectives on attentional bias in other clinical fields suggest that attentional bias might result from impairments in the central executive system (e.g., Heeren et al. 2017; Heeren et al. 2013), stressing the fuzzy boundaries of the mechanisms underlying attentional bias.

At the empirical level, a wealth of research indicates that individuals with addictive behaviors exhibit preferential attentional allocation toward addiction-related stimuli (e.g., alcohol-related cues) rather than toward other stimuli. Notably, attentional biases have repeatedly been shown by using various paradigms across different addictive disorders, including severe alcohol use disorders (e.g., Townshend and Duka 2001), tobacco smoking (e.g., Chanon et al. 2010), cannabis use (e.g., Vujanovic et al. 2016), cocaine use (e.g., Mayer et al. 2016), heroin addiction (e.g., Waters et al. 2012), problem gambling (e.g., Hønsi et al. 2013), and problem video gaming (Jeromin et al. 2016). Of note, there is also strong evidence that addiction-related attentional biases might be more than just a by-product of addiction. For instance, across the different addictive disorders, the magnitude of attentional biases has been shown to be strongly predictive of later relapse (Carpenter et al. 2006; Cox et al. 2002; Marissen et al. 2006; Powell et al. 2010; Waters et al. 2003). Moreover, research has shown that reducing attentional biases can, in turn, foster a cascade of downstream benefits, such as the reduction of substance use and the improvement of treatment among individuals with alcohol and nicotine dependence (e.g., Fadardi and Cox 2009; Field et al. 2009; Schoenmakers et al. 2010; but see Christiansen et al. 2015). Together, these observations thus stress the relevance of considering attentional bias as a core transdiagnostic feature of addiction.

Measuring Attentional Bias The Visual Dot-Probe Task appears to be the most commonly used tool to assess attentional biases in contemporary psychopathology research (e.g., Field et al. 2004; Harvey et al. 2004). Notably, most of the eye-tracking studies in addiction research have been performed during a dot-probe task (Field et al. 2006; Marks et al. 2014). In this task, participants view two stimuli (e.g., an alcohol-related word/photograph and a neutral word/photograph) simultaneously presented in two distinct locations (left/right or up/down) on a computer screen for a brief duration (e.g., 500 ms). Immediately thereafter, a probe appears in the location previously occupied by one of the stimuli. In different versions, participants have to indicate the location (right/left or up/down) or identity (e.g., "E" or "F") of the probe as quickly as possible. Attentional bias is demonstrated when participants respond faster to the probe when it replaces an addiction-related stimulus than when it replaces a neutral stimulus, indicating that their attention has been directed to the location occupied by the former stimulus.

Associative Processes: Definition and Role in Addiction Associative processes can be distinguished in accordance with the proxies that they serve, that is, on the one hand, the strength of the associative structure per se, and on the other hand, the automatic tendencies (Gawronski and Bodenhausen 2006; Hofmann et al. 2009; Woud et al. 2016). At a basic level, implicit associations are thought to result from (or be progressively strengthened by) temporal or spatial contiguity with external stimuli, affective reactions, and related behaviors (Sloman 1996). For instance, during the development of an addictive disorder, the related behavior becomes progressively controlled by addiction-associated information that has acquired, via classic and instrumental learning mechanisms, the property of being able to drive addiction-related actions. Moreover, implicit associations and related automatic tendencies are assumed to be independent of whether a person consciously endorses or rejects the implication of an associative link (Aarts et al. 2001; but see O'Doherty et al. 2017). In other words, although someone may be aware of the increasing negative consequences of the execution of an addictive behavior, external stimuli can automatically elicit implicit associations and automatic tendencies (e.g., Wiers et al. 2009; but see Pauli and O'Reilly 2008; Shanks 2009).

In view of the aforementioned literature, researchers have extensively studied the implicit associations and automatic approach-avoidance tendencies in addictive disorders. In particular, several lines of research have led to conceptualizing these associative processes as transdiagnostic features of addiction. First, in nonclinical populations, both implicit associations and automatic tendencies can predict later use of alcohol (Wiers et al. 2002), cigarettes (McCarthy and Thompsen 2006), and cannabis (Ames et al. 2007). Moreover, numerous studies have reported strong implicit associations and automatic tendencies among individuals with addictive behaviors. Positive implicit associations have notably been found among alcoholic patients (Barkby et al. 2012), cigarette smokers (Payne et al. 2007; Woud et al. 2016), cannabis users (Cousijn et al. 2011), cocaine users (Wiers et al. 2007b), heroin users (Wang et al. 2015), problem gamblers (Brevers et al. 2013c), and problem video gamers (Yen et al. 2011). Similarly, approach and avoidance automatic tendencies have been found in alcohol dependence (Barkby et al. 2012; Field et al. 2008), nicotine dependence (Mogg et al. 2005), cannabis use (Beraha et al. 2013), and problem gambling (Boffo et al. 2018).

Of clinical importance, implicit associations and approach-avoidance tendencies are strongly predictive of future addiction-related behaviors, as well as treatment responses among alcohol-dependent individuals (Field et al. 2017; Martin Braunstein et al. 2016; Spruyt et al. 2013; Wiers et al. 2011), smokers (Chassin et al. 2010), and heroin users (Marhe et al. 2013). Moreover, modifying either implicit associations (Tello et al. 2018) or automatic tendencies (Sharbanee et al. 2014) can reduce drinking behaviors in community samples. Preliminary research has revealed similar findings among alcohol-dependent individuals (Manning et al. 2016) and cigarette smokers (Wittekind et al. 2015), stressing the pivotal role of associative processes in the maintenance of addictive disorders.

Measuring Associative Processes Associative processes are typically assessed via implicit measurements (De Houwer 2006). Basically, these measurements can be separated in accordance with the proxies they serve, that is, on the one hand, impulse strength (i.e., the strength of the associative structure per se), and on the other hand, automatic tendencies reflecting the impulse (Hofmann et al. 2009). Two prominent measures of association strength are the Implicit Association Test (Greenwald et al. 1998) and the Affect Misattribution Paradigm (Payne et al. 2005). Regarding automatic tendencies toward the temptation of interest, approach-avoidance paradigms are the most popular measures (e.g., Wiers et al. 2011). Some of these measures involve actual approach-avoidance responses (e.g., Rinck and Becker 2007), whereas others use symbolic responses (e.g., Mogg et al. 2005).

In recent years, the Approach Avoidance Task (Rinck and Becker 2007) has become particularly popular in addiction research. This task involves the execution of approach-avoidance motor responses, requiring participants to respond to stimuli that appear on a computer screen by either pushing (avoidance movement) or pulling (approach movement) a joystick. Given this operationalization, the time participants need to fully execute these valenced movements provides an index of their automatic tendencies for a particular stimulus (e.g., alcohol versus soft drinks). Of note, most of the approach-avoidance paradigms include a task-irrelevant feature so that the push and pull movements are not determined by the content, but by the format or the tilt of the pictures (e.g., push landscape versus pull portrait pictures). As these instructions are stimulus independent, the required response is thus unrelated to the picture's content. As an illustration, it was found that, via this task, hazardous drinkers were faster to pull than to push the joystick in response to alcohol pictures (Wiers et al. 2009). Likewise, automatic approach tendencies were positively associated with past-month expenditures and gambling frequency among problem gamblers (Boffo et al. 2018).

Despite their popularity, implicit measurements have been strongly criticized, especially given their relatively low reliability (e.g., Reinecke et al. 2010). Moreover, uncertainty still abounds regarding whether implicit tasks really measure automatic associations, which are assumed to cause the outcome of the tasks (De Houwer et al. 2009).

Inhibition: Definition and Role in Addictive Disorders Inhibition globally relates to the ability to control one's behaviors, thoughts, or emotions to produce contextually or socially adapted actions. Inhibitory mechanisms are currently conceptualized as a constellation of processes. One of the most influential models (Friedman and Miyake 2004) separates three inhibition-related functions: (1) prepotent response inhibition, the ability to voluntarily stop or defer a dominant or habitual response; (2) resistance to distractor interference, the ability to specifically process a pertinent stimulus while reducing or suppressing the processing of interfering irrelevant stimuli; and (3) resistance to proactive interference, the ability to reduce or avoid the intrusion of previously relevant but now obsolete information in memory, that interferes with the ongoing task.

The loss of control over one's behavior is the hallmark of all addictive disorders, and inhibition is thus at the heart of addictions, which can be defined as the reduction in the ability to inhibit an approach behavior toward a substance or stimulus. In view of this pivotal role, inhibition has been the most deeply explored process in addictive disorders, with recent reviews (Smith et al. 2014; Spechler et al. 2016) underlining that reduced inhibition is a transdiagnostic characteristic of addicted individuals. Hundreds of results from studies that used various tasks and methodologies have extensively shown that the excessive use of alcohol (Stavro et al. 2013), nicotine (Luijten et al. 2013), cannabis (Tapert et al. 2007), cocaine (Morie et al. 2014), and MDMA (Roberts et al. 2013), as well as problem gambling (Moccia et al. 2017) and problem video gaming (Littel et al. 2012), is related to a reduction in the inhibition brain network and reduced performance in inhibition tasks. When separately investigating the three subcomponents mentioned above, studies have shown the following:

1. Prepotent response inhibition is impaired with a medium-large effect size in methamphetamine (Tabibnia et al. 2011) and gambling (Grant et al. 2011) disorders, as well as with a small-medium effect size in cocaine abuse (Colzato et al. 2007; Fillmore and Rush 2002) and severe alcohol use disorders (Goudriaan et al. 2006). Conversely, heterogeneous results have been found for nicotine and cannabis consumption (Billieux et al. 2010a; de Ruiter et al. 2012; Moreno et al. 2012; Ramaekers et al. 2009).
2. Resistance to distractor interference is reduced in alcohol use disorders, with a bidirectional causal link: reduced performance has been reported at the early stages of excessive alcohol use (Lannoy et al. 2017) and might constitute a vulnerability factor (van Hemel-Ruiter et al. 2015), but long-term excessive alcohol use also has a direct negative impact on this ability (Schellekens et al. 2010). Nicotine dependence (Carim-Todd et al. 2016), heroin dependence (Chen et al. 2013), and cannabis use (Maij et al. 2017) do not seem to strongly reduce resistance to distractor interference, whereas cocaine use does (Sokhadze et al. 2008).
3. Resistance to proactive interference has been little studied and related results were inconsistent, as only two studies conducted in recently detoxified alcohol-dependent individuals are available, the first showing a deficit in resistance to proactive interference (Noël et al. 2009) and the second revealing preserved performance (Noël et al. 2013c).

These results suggest that differential patterns of deficits might be present across inhibition subcomponents in addictive disorders. However, as most studies have focused on prepotent response inhibition, the two other subcomponents are still largely underexplored in addictive disorders. Future studies should thus go beyond the measurement of general inhibition skills to promote a separate and specific exploration of each inhibition subcomponent, allowing the establishment of a far more complete profile of inhibitory performance at experimental and clinical levels.

Measuring Inhibition Inhibition abilities constitute subcomponents that might be differentially altered in various addictive states and should thus be measured separately. Prepotent response inhibition can be measured by using the Stop-Signal Task (Verbruggen and Logan 2008), in which participants have to perform a simple binary decision task on targets but refrain from responding when a sound (the stop signal) is presented right after the target (usually in 20–25% of the trials). Stopping the response requires a fast control mechanism to prevent the execution of the already planned motor response. The time needed to stop a response (stop-signal reaction time, or SSRT) is covert, as no behavioral response is given for efficient inhibition. It is thus estimated by varying the time between stimulus presentation and stop-signal occurrence across trials and by computing the probability of the participant stopping at different stop-signal delays. This individual SSRT is the main dependent inhibition measure.

Resistance to distractor interference can be measured by using the Flanker Task (Eriksen and Eriksen 1974), in which participants have to make a binary decision on a central letter while ignoring surrounding and irrelevant letters (i.e., the flankers). This task compares experimental-incongruent conditions (where flankers promote the opposite response to that requested by the central letter) and control-congruent conditions (where flankers promote the identical response to that requested by the central letter). Reduced performance (reduced accuracy or increased reaction times) in the incongruent condition indexes the interference effect from the distractor flankers.

In view of the limited evidence currently available concerning the presence of deficits in the resistance to proactive interference in addictive disorders, no task related to this process has been included in the proposed assessment battery.

Flexibility: Definition and Role in Addictive Disorders Cognitive flexibility relates to the skills needed to rapidly adapt one's thoughts or behaviors following environmental changes. This ability partly relies on other high-level functions (Miyake and Friedman 2012) and has, moreover, been dissociated in several subcomponents according to task requirements, notably leading to the distinction between set shifting, intradimensional flexibility, and extradimensional flexibility (McAlonan and Brown 2003). For the sake of clarity, this executive subcomponent will here be conceptualized as centrally related to shifting abilities, namely, the capacity to switch back and forth between different tasks or mental sets (Monsell 1996).

Addictive disorders are related to flexibility impairments: addicted individuals are constantly using the same behavioral pattern (i.e., addiction-related behavior) and are unable to flexibly adapt their actions according to changing contexts or predicted outcomes. The importance of impairments in flexibility in addictive behaviors has been widely recognized, with reduced task or mental set shifting abilities documented in alcohol-related disorders (Czapla et al. 2016), cocaine users

(Van der Plas et al. 2009; Woicik et al. 2011), and gambling disorder (Leppink et al. 2016). The use of tasks more specifically measuring cognitive flexibility, such as reversal learning paradigms (Cools et al. 2002), showed that patients with severe alcohol use disorders need more time to extinguish previously learned contingencies, indexing reduced flexibility (Vanes et al. 2014). In line with this, cocaine (Verdejo-García et al. 2015) and cannabis (Spronk et al. 2016) users also present increased flexibility errors, which are also found in nicotine-dependent patients currently experiencing craving (Lesage et al. 2017). The use of such specific tasks led to contradictory results in gambling disorders, three studies showing impaired cognitive flexibility (Boog et al. 2014; Choi et al. 2014; de Ruiter et al. 2009) and two studies not reporting such differences with control groups (Torres et al. 2013; Verdejo-García et al. 2015). Finally, Choi et al. (2014) found that problem video gamers present performances that are similar to those of healthy controls in tasks assessing cognitive flexibility. Notably, flexibility deficits play a direct role in the maintenance of disease by constituting a crucial predictor of treatment outcomes in cocaine users (Turner et al. 2009) and alcohol-dependent individuals (Desfosses et al. 2014).

Measuring Flexibility In the Reversal Learning Task (Cools et al. 2002), each trial presents two abstract stimuli and the participant has to make a choice. Feedback is given (“good” or “bad”), and the participant progressively learns which option is good or bad. The predictive value of the stimulus for the outcome is probabilistic (i.e., the feedback is correct in 80% of trials). After efficient learning, a rule is modified (i.e., a reversal) and the participant has to learn the new rule. Dependent measures are the number of trials needed to learn this new rule, indexing cognitive flexibility. While other efficient tasks might be used to measure flexibility in addictive disorders (e.g., Intra/Extra Dimensional Set Shifting Task, Roberts et al. 1988), this task has the central advantage of efficiently measuring cognitive flexibility in an ecological design while allowing dissociation of a shifting component (perseverative errors, responding to the previously reinforced stimuli despite negative feedback) from a negative-feedback component (probabilistic errors, responding correctly but receiving negative feedback).

Updating: Definition and Role in Addictive Disorders Updating refers to the encoding and monitoring of stimulations to modify short-term memory traces according to task requirements (Miyake et al. 2000). It is thus related to working memory (Baddeley 1986; Diamond 2013) but is considered an executive function that goes beyond memory abilities (Friedman and Miyake 2017), as it implies controlled use of encoded stimulations (i.e., manipulating the memorized content).

The effects of drugs on updating efficiency have long been suggested (Fattore and Diana 2016; Stavro et al. 2013): decreased ability to update memory traces reduces everyday life efficiency and could play a role in the persistence of addiction-related habits. A large range of updating paradigms have been used in addictive disorders, indicating strongly reduced performances. In severe alcohol use disorders, updating constitutes a key impairment in the weeks following detoxification, at behavioral (reduced performance) and cerebral (reduced dorsolateral prefrontal cortex activations) levels (Pfefferbaum et al. 2001), whereas heavy consumers without alcohol dependence might present compensatory brain strategies resulting in preserved performance (Wesley et al. 2017). The clinical importance of these brain activations related to updating has been confirmed by results showing that increased prefrontal activations during updating tasks at treatment initiation predict sustained abstinence (Charlet et al. 2014). A long-term impact of drug consumption on updating has also been found in MDMA (Verbaten 2010), cocaine (Verdejo-García and Pérez-García 2007), and heroin (Papageorgiou et al. 2003) dependence, as well as in cannabis consumption, where updating impairments constitute a hallmark of acute (Keles et al. 2017) and chronic (Cohen et al. 2017) use. Regarding nicotine consumption, the results are less clear, as acute nicotine consumption increases updating abilities and long-term dependence is related to impaired updating (Valentine and Sofuoglu 2018), this deficit predicting early relapse (Patterson et al. 2010). Finally, preliminary work shows that updating might be affected in gambling disorder (Ledgerwood et al. 2012), but few reliable results are currently available with regard to behavioral addictions.

Measuring Updating Classic updating tasks all require the active processing of freshly encoded information (Diamond 2013). In particular, the N-Back Task (Kirchner 1958) is considered a reliable tool to measure verbal updating abilities with strong control of working memory load (Friedman and Miyake 2017). This task is usually based on visual stimuli: letters (or numbers) are presented one by one on the screen, and, for each stimulus, the participant has to determine whether it is identical or different from the one presented “n” trials before, “n” varying across conditions and studies between 0 (i.e., detecting the appearance of a prespecified stimulus stored in memory without an updating requirement) and 3 (i.e., deciding whether the presented stimulus is identical to the stimulus presented three trials earlier). Comparing the performances (percentage of correct detections) between control conditions (0-back, 1-back) and experimental conditions (2-back or 3-back) leads to a specific updating index, namely, the ability to monitor, maintain, and modify the information contained in working memory.

Mental Time Travel: Definition and Role in Addictive Disorders Past- and future-oriented mental time travel constitutes a central component of human decision making. Indeed, making appropriate decisions in a specific situation requires both retrieving past similar experiences stored in episodic memory, including their emotional content (see the somatic markers hypothesis; Damasio 1996), and/or temporarily disengaging from the immediate environment to mentally explore possible futures (Boyer 2008; Noël et al. 2017a). For instance, in the case of poor future-oriented mental time travel abilities, short-term rewards (e.g., consuming a drug to relieve negative mood) are given priority over the avoidance of long-term negative consequences of a choice or the accomplishment of future goals associated with a higher reward.

Not only is episodic memory involved in the retrieval and re-experience of past memories, but it also plays a significant role in imagining future events (e.g., Addis et al. 2007). Therefore, both past and future event representations can be episodic, comprising abundant contextual details about events that are specific in time and location (Addis et al. 2007). Mental time travel also involves executive processes and visual-spatial processing (D'Argembeau et al. 2010). Notably, mental time travel is supplemented with "cognitive feelings" (Conway 2009), such as autonoetic consciousness, which is the subjective feeling of re-experiencing past events and the feeling of being brought forward in time to pre-experience a future event (Tulving 2002). Autonoetic consciousness for future events may play an important motivational role in achieving imagined future events (e.g., abstinence), thereby constituting a crucial determinant of change in patients with addictive disorders (Noël et al. 2017a).

Episodic memory as assessed by classic tasks in which participants have to remember a list of words or pictures has been found to be frequently impaired in patients with various addictive behaviors (see Noël et al. 2017a). However, examining mental time travel and associated cognitive feelings requires the use of more specific procedures that assess various dimensions of autobiographical memories and future prospects. In specific procedures that assess past oriented mental time travel, recently detoxified patients with severe alcohol use disorders were impaired in recalling specific autobiographical memories in comparison to matched healthy controls (Cuervo-Lombard et al. 2016). Furthermore, this overgeneralization of autobiographical memories persists for 2 to 6 months of sobriety (Nandrino et al. 2016; Nandrino and Gandolphe 2017). Alcoholics also showed poorer episodic autobiographical performances across several life periods (Nandrino et al. 2016). These reduced performances in alcoholism could be explained by the deleterious effect of alcohol on memory consolidation, by a strategy that decreases distress associated with the retrieval of a memory, or by executive deficits that hamper strategic encoding and retrieval (Noël et al. 2017a).

Regarding episodic future thinking, Mercuri et al. (2015, 2016) showed that opioid users tended to generate fewer episodic details when imagining novel future scenarios in response to either a positive, neutral, or negative cue word than did healthy controls, but did not differ in episodic memory, nor in the scene construction or narrative ability conditions. Preserved episodic memory but impaired episodic foresight ability suggests that intact episodic memory functioning is not sufficient for episodic foresight (Mercuri et al. 2015). In another study, Noël et al. (2017b) showed that problem gamblers' future thoughts contained fewer episodic details (i.e., sensory details and contextual information) and were associated with reduced autonoetic consciousness compared with those of healthy controls. In addition, their mental representations of future events were less differentiated as a function of temporal distance than were those of healthy controls. Indeed, in contrast to healthy controls, problem gamblers did not report more sensory details for closer than distant future events and their subjective sense of the temporal proximity of imagined events was less variable across temporal distances (Noël et al. 2017b).

These results open up a relevant prospect for understanding addiction-related treatment outcomes and symptoms (e.g., relapse, treatment adherence and outcome, readiness to change, craving, or loss of control). In particular, relapse prevention strategies (e.g., developing skills to assertively decline future drug proposals) precisely require abilities to project oneself into the future. Taking into account impairments in episodic future thinking may thus clarify why achieving and maintaining abstinence is frequently so challenging for some patients (Mercuri et al. 2015, 2016).

Measuring Mental Time Travel The Autobiographical Interview (Levine et al. 2002; adapted version by Addis et al. 2008) is a semistructured interview that provides an index of both episodic memory and episodic foresight. More specifically, participants are instructed to describe a previously experienced past event or a novel future event in response to a cue word (neutral, positive, or negative). The events have to refer to a specific time and place, last less than 1 day, and be described from the participant's subjective perspective. The number of episodic details specific to the central events generated for past and future events is the primary measure of episodic memory and episodic future thinking, respectively. Of note, this assessment can be complemented by adding specific questions related to the phenomenological characteristics of the imagined events and to the subjective feelings (autonoetic processes) associated with the events (D'Argembeau and Van der Linden 2006).

Interoception: Definition and Role in Addictive Disorders Interoception refers to a range of processes by which body-relevant signals are transmitted to the brain, allowing the regulation of internal states and maintaining homeostasis (Verdejo-Garcia et al. 2012). Interoception is underlain by multiple processes, including (1) interoceptive accuracy, which typically refers to performance on objective behavioral tests (e.g., heartbeat detection); (2) interoceptive sensibility, which refers to subjective interoception as assessed by self-reports; and (3) interoceptive awareness, which refers to a metacognitive dimension of interoceptive accuracy, as assessed by confidence-accuracy correspondence in a performance task. It thus reflects whether an individual knows if he or she is making good or bad interoceptive decisions with respect to interoceptive behavioral accuracy (Garfinkel et al. 2015).

Neuroimaging studies have consistently stressed that the anterior insula is the critical hub of interoceptive processes (Critchley et al. 2004). According to several authors, disturbances in the prediction or simulation of the body by the insular cortex constitute a key aspect of addiction (Naqvi and Bechara 2010; Naqvi et al. 2007; Paulus et al. 2009; Verdejo-Garcia et al. 2012). Indeed, the insula associated with various regions of the prefrontal cortex (ventromedial and orbital) conveys both the conscious pleasure resulting from the bodily effects of drug taking (e.g., the airway effect after a cigarette puff) and the conscious pain associated with drug withdrawal. In addition, the insula may be involved in the recall and simulation of these bodily effects, which promotes conscious cue-induced urges, desires, or anticipation (e.g., when seeing someone drinking a Belgium beer in a bar), as well as in a cost-benefit analysis of the interoceptive effects of drug consumption. For instance, in the context of failed abstinence, the positive effect of drug taking encoded in the insula (e.g., pleasure) outweighs the negative effects (e.g., aversion). Urge or craving due to heightened insular activity may increase compulsive drug seeking while undermining cognitive resources necessary for adapted decision making (Noël et al. 2013a, 2013b).

Corroborating this view, many studies have stressed the positive correlations between insula activity and self-reported urge for substances such as cigarettes, cocaine, alcohol, or heroin (see Verdejo-Garcia et al. 2012), as well as higher levels of nicotine dependence (Goudriaan et al. 2010). Conversely, damage to the insular cortex tends to dramatically reduce the intensity of craving episodes and provoke immediate smoking cessation (without relapse) in cigarette consumers (Naqvi et al. 2007). However, a decrease in interoceptive function associated with addiction should also be considered (Verdejo-Garcia et al. 2012). Indeed, in such cases, the insular cortex may not appropriately signal the potential aversive outcome of a choice in risky situations (Paulus and Stewart 2014), allowing individuals who are influenced by non-emotional sources such as habits to be guided in their decision making.

By using laboratory tasks that assess interoceptive accuracy, some studies conducted on healthy adults from the community showed that cardiac interoceptive ability critically influences decision making and loss aversion on laboratory decision-making tasks (Dunn et al. 2010; Sokol-Hessner et al. 2015; Werner et al. 2009, 2013). In clinical samples, sober substance use disorder patients (alcohol, heroin, or synthetic cannabinoids) showed significantly lower interoceptive cardiac accuracy than did healthy controls (Ates Cöl et al. 2016; Sönmez et al. 2017). In addition, this poor interoceptive accuracy was significantly associated with greater alcohol craving and greater difficulties in identifying feelings (a dimension of alexithymia), but not with disorder severity. Finally, Schmidt et al. (2013) showed in a sample of in- and outpatients treated for alcohol disorder or multiple substance use disorders (including alcohol) that interoceptive accuracy and tension reduction motives (e.g., negative reinforcement-based expectancies) interacted to predict drinking-related obsessions and compulsions.

Measuring Interoception Most procedures have been developed to assess interoception accuracy in the cardiac domain for pragmatic reasons, inasmuch as heartbeats are distinct and frequent internal events that can be easily measured. The most popular procedures are the Heartbeat Detection Task and the Mental Heart Beat Tracking Method. In a Heartbeat Detection Task (Barrett et al. 2004), during each trial, participants hear a series of 10 tones, each of which is generated by the R-spike in their electrocardiogram. The participants are then asked to report on whether the series of tones are coincident or not with their own heartbeats. On coincident trials, the tones are in general presented 200 ms after each R-spike, whereas they are presented 500 ms after each R-spike on noncoincident trials. In a mental tracking method, participants are asked to count the number of heartbeats experienced in short time intervals (e.g., 25–55 s). The experimenter then compares participants' estimation of their own heartbeats with the actual number of heartbeats recorded on an electrocardiogram trace. Of note, recent data showed that the mental tracking method is strongly affected by expectations and beliefs about one's own heartbeat and should thus be avoided (Ring et al. 2015).

Self-report questionnaire measures of interoception, such as the awareness section of the Body Perception Questionnaire (Porges 1993), are useful in measuring individual differences in perceived sensitivity across a wide range of internal bodily changes, but they do not inform about subjective interoceptive accuracy (Garfinkel et al. 2015). This subscale contains 45 items referring to various bodily sensations (e.g., stomach and gut pains, respiration, heartbeat). For each item, participants indicated their awareness of each sensation on a five-point scale ranging from 1 ("never") to 5 ("always"). Finally, interoceptive awareness can be quantified by measuring the degree to which the accuracy of the performances on a

Heartbeat Detection Task is predicted by subjective confidence in the task judgement (Garfinkel et al. 2015). For this purpose, following each trial on a Heartbeat Detection Task, participants are asked to immediately rate their confidence in the perceived accuracy of their response on a continuous visual analogue scale ranging from "Total guess/No heartbeat awareness" to "Complete confidence/Full perception of heartbeat."

Self-Awareness: Definition and Role in Addictive Disorders It has been proposed that dysfunction of the interoceptive system not only influences the processing of drug-related cues, but that it likely disturbs self-awareness, which may result in underestimation of the severity of a disorder, failure to recognize an illness (or lack of insight), denial, or dissociation between intention and action (Goldstein et al. 2009; Goldstein and Volkow 2011; Verdejo-Garcia et al. 2012) when drug-induced damage to the insula interrupts the interoceptive input signaling the current state of the body. Lack of insight is an important issue in addiction treatment in that some individuals who require treatment probably do not recognize the need for therapeutic support. This reduced perceived need for seeking treatment and/or underestimation of addiction severity may result in poor decision making in the context of continuous substance misuse or addictive behaviors despite repetitive negative outcomes (Brevers and Noël 2013; Goldstein et al. 2009; Goldstein and Volkow 2011).

In the field of addictive disorders, most studies that aimed to examine self-awareness used procedures measuring retrospective metacognitive ability such as rating confidence or wagering on one's own decision, which allows dissociation of metacognition from objective task performance on a trial-by-trial basis. Nevertheless, such procedures examine only one specific aspect of self-awareness, that is, to which point people can monitor their own decision making and discriminate between accurate and inaccurate judgments (Moeller et al. 2016). By using such procedures, dissociations between self-perception of performances and actual behavior have been found in cocaine users, with implications for increased drug-seeking behavior and decreased social-emotional functioning (Moeller et al. 2010, 2012, 2014, 2016); in patients with nicotine dependence (Chiu et al. 2008); in former opium and heroin users who are stable on methadone maintenance treatment (Sadeghi et al. 2017); and in disordered gambling (Brevers et al. 2013b; Brevers et al. 2014). In gambling disorder, this overconfidence in one's bet or decision is also influenced by perceived control, which results in reduced betting performance (Goodie 2005).

Measuring Self-Awareness in Addiction In the Visual-Perception Task developed by Moeller et al. (2016), participants are instructed to make two-choice discrimination judgments about what they have just perceived before providing a confidence rating on their decision. More specifically, on each trial of this task, two circles are presented on the computer for 1 s. A variable number of dots are then displayed inside both circles for 0.7 s. The aim of the task is to guess whether the left or the right circle contained more dots. The difference in the number of dots between the two circles is titrated so that each participant's performance is maintained at a constant level. After an incorrect response, the difference in the number of dots between the two circles is increased by one unit, whereas after two consecutive correct responses, the difference in the number of dots is decreased by one dot. Using a staircase procedure permits one to equate the difficulty of the task between individuals. In total, each participant completes 200 perception trials. To estimate metacognitive efficiency, the investigators compute meta-*d'* (Maniscalco and Lau 2012). In a signal detection theory, meta-*d'* is considered a measure of type 2 sensitivity (i.e., the degree to which individuals can discriminate their own correct judgments from their own incorrect judgments).

Social Cognition: Definition and Role in Addictive Disorders Social cognition is a broad concept encompassing the psychological resources needed to correctly identify interpersonal signals and the skills needed to effectively respond to these signals. This ability is constantly needed in everyday life to efficiently detect, understand, regulate, and react to stimulations emerging from the interpersonal environment (Green et al. 2015). To clarify this field, Green et al. (2008) proposed a classification of social cognition subcomponents, identifying five subcategories: (1) *theory of mind*, the ability to use interpersonal signals to infer others' mental states and to anticipate their behaviors; (2) *social perception*, the aptitude to interpret verbal and nonverbal stimuli to infer individuals' roles and current relationships in equivocal interpersonal contexts; (3) *social knowledge*, the awareness and understanding of social rules and conventions; (4) *attributional bias*, the propensity to consider that interpersonal events are mostly due to individual responsibility, or conversely to others' responsibility or contextual variables; and (5) *emotional processing*, the efficient perception, interpretation, and reaction to the emotional states expressed by others through face, voice, or posture. This typology offers a sound classification to clarify the studies conducted in addictive disorders.

However, as mentioned earlier, the exploration of these social cognition subcomponents is still poor in addictive disorders. Most studies exploring social cognition abilities in addicted populations have focused on severe alcohol use disorders and have led to the proposal of a global social cognition deficit (Bora and Zorlu 2017; Onuoha et al. 2016). Although attribution biases have not yet been explored, theory of mind (Bosco et al. 2014), empathy (Martinotti et al. 2009), social perception (Maurage et al. 2016), social knowledge (Thoma et al. 2013), and emotional processing (Donadon and Osório

2014) are impaired in this population. Conversely, the exploration of social cognition in other substance-related addictive states has been very limited. The only available data suggest that, although nicotine dependence does not impact social cognition (Drusch et al. 2013), reduced theory of mind abilities have been documented in cocaine abusers, this deficit being correlated with craving intensity (Sanvicente-Vieira et al. 2017). Moreover, despite strong interstudy heterogeneity, substance-related addictions are reliably associated with reduced emotion perception abilities (Castellano et al. 2015): individuals who are dependent on cannabis (Bayrakçı et al. 2015), cocaine (Ersche et al. 2015), methamphetamine (Henry et al. 2009), heroin (Contero et al. 2012), or polysubstances (Fernández-Serrano et al. 2010) present reduced emotional facial recognition performances. Finally, social cognition has been explored in only two studies in gambling disorder, which suggested reduced empathy (Tomei et al. 2017) and emotional decoding (Kornreich et al. 2016) abilities. In conclusion, and while only preliminary evidence is available, social cognition deficits may constitute a core characteristic of addictive disorders. Their suggested causal role in the development of addictive disorders (Ernst et al. 2010) and in relapse after detoxification (Zywiak et al. 2003) should urge researchers to develop a theoretically based exploration of these abilities across addicted populations.

Measuring Social Cognition Four tasks can be proposed, each specifically related to a subcomponent of the typology presented above (Green et al. 2015). Because attributional biases have not yet been measured in addictive disorders, we decided not to include a task measuring this process in our battery.

1. *Theory of mind* can be evaluated by using a nonverbal and video-based version of the False Belief Task (Apperly et al. 2004), which measures the ability to infer others' mental states to predict their behaviors. In this task, the participant is asked to make judgments regarding which of the two identical boxes presented in the video contains a green cube by using cues given by actors. In a first subtask ("track-task"), the participant has to determine which box contains the green cube by tracking the actor's perspective and taking into account that this actor has, in some trials, false beliefs about this location (leading him to give erroneous cues). In the second subtask ("inhibit-task"*)*, the participant has to determine which box will be chosen by the actor, which requires the participant, for some trials, to inhibit his/her own correct knowledge about the object's location (self-perspective inhibition) in order to infer the actor's behavior resulting from his false belief. This task is a sound and specific measure of theory of mind, which assesses the ability to understand others' mental states through inhibition of self-perspective.
2. *Social perception* can be evaluated by using the Movie for Assessment of Social Cognition (Dziobek et al. 2006), which ecologically evaluates the perception of social signals by asking the participant to identify the emotions, thoughts, and intentions expressed by characters in 45 short videos depicting real-life social interactions. During each video, social interactions are depicted through characters that express positive or negative emotions, feelings, intentions, and thoughts with different intensities. After each video, a multiple-choice question is asked to evaluate the participant's ability to perceive the affective or cognitive social signals expressed. Each answer corresponds to a response type, related to correct, excessive, reduced, or absent social perception, this task thus measuring the ability to efficiently perceive and interpret social signals.
3. *Social knowledge*, which is centrally related to semantic and rule-based skills, can be evaluated by the Faux-Pas Test (Stone et al. 1998), which requires the participant to identify the breaking of social rules. Twenty written stories are presented, half of them involving an interpersonal mistake. For each story, the participant is asked whether a social faux-pas was present and, if so, which character committed the faux-pas. This task measures the level of social knowledge by measuring the participant's ability to detect interpersonal mistakes in social contexts.
4. *Emotional processing* can be evaluated with the Facial Emotion Recognition Task (Gaudelus et al. 2015), a validated emotion decoding task in which the participant has to identify the emotional state (i.e., anger, contempt, disgust, fear, happiness, sadness) presented by human faces. Faces are morphed (from neutral to full-blown emotion) to evaluate nine levels of intensity (i.e., from 20 to 100%), leading to a total of 54 stimuli (6 emotions × 9 intensities). The accuracy score and detection threshold (intensity at which the emotional content is reliably detected) are computed for each emotion.

Discussion

This paper aimed to describe the core features of decision making in addictive behaviors by proposing a range of processes, with a related measurement task, initiating a comprehensive process-based decision-making assessment battery. Table 1 summarizes the selected processes and the typically related measurement tasks.

The new and innovative processual and transdiagnostic theoretical background proposed here could account for various outcomes related to poor decision making across addictive disorders, but could also, from a transdiagnostic perspective, be applied to other psychopathological disorders. By

Table 1 A process-based decision-making assessment battery

Processes	Measures
Reward sensitivity	Reinforcement Learning Task (Frank et al. 2004)
Attentional bias	Visual Dot-Probe Task (Field et al. 2004)
Associative processes	Implicit Association Test (Greenwald et al. 1998)
	Affect Misattribution Paradigm (Payne et al. 2005)
	Approach Avoidance Task (Wiers et al. 2011)
Inhibition	
Prepotent response inhibition	Stop-Signal Task (Verbruggen and Logan 2008)
Resistance to distractor interference	Flanker Task (Eriksen and Eriksen 1974)
Flexibility	Reversal Learning Task (Cools et al. 2002)
Updating	N-Back Task (Kirchner 1958; Friedman and Miyake 2017)
Mental time travel	Adapted Autobiographical Interview, including assessment of autonoetic consciousness (Addis et al. 2008; D'Argembeau and Van der Linden 2006)
Interoception	
Interoceptive accuracy	Heartbeat Detection Task (Barrett et al. 2004)
Interoceptive sensibility	Awareness section of the Body Perception Questionnaire (Porges 1993)
Interoceptive awareness	Heartbeat Detection Tasks with confidence rating (Garfinkel et al. 2015)
Self-awareness	Visual-Perception Judgement Task with confidence rating (Moeller et al. 2016)
Social cognition	
Theory of mind	False Belief Task (Apperly et al. 2004)
Social perception	Movie for Assessment of Social Cognition (Dziobek et al. 2006)
Social knowledge	Faux-Pas Test (Stone et al. 1998)
Emotional processing	Facial Emotion Recognition Task (Gaudelus et al. 2015)

Note. The measures proposed in this battery should be considered only as exemplars of tasks or self-reports that could be used to assess each process

identifying core processes involved in decision making, the present work thus contributes to enriching the understanding of what constitutes (impaired) decision making, ultimately sophisticating existing system-based (i.e. dual or triadic) models of decision making that still theoretically anchor a large body of experimental and applied research.

According to the conceptual framework proposed, the various processes retained here may contribute to a better understanding of the cognitive steps involved in decision making as conceptualized by Verdejo-Garcia et al. (2018), namely the formation of preferences, choice implementation, and feedback processing and learning. First, preferences formation is likely to be influenced by various processes, including associative processes (susceptible to promoting automatic approach tendencies), attentional bias (toward salient conditioned addiction-related cues), interoceptive factors (susceptible to promoting craving through insular activity), reward sensitivity (preference for rewarding, risky, or stimulating actions), and poor self-awareness (susceptible to preventing one from discriminating between accurate and inaccurate judgments). Second, we propose that choice implementation primarily capitalizes on the efficacy of executive processes (i.e., prepotent response inhibition or flexibility) to restrain and override temptation and to inhibit irrelevant information or actions. Other processes such as mental time travel and self-awareness probably also play a pivotal role in mobilizing motivational resources and proactive pursuit of selected choices. Finally, efficient feedback processing relies on various abilities such as executive functions (e.g., inhibition, updating, and flexibility are necessary to avoid reproducing hazardous or suboptimal choices), sensitivity to reward (resulting in greater attention to gains than to losses), or mental time travel (necessary to take into account past experiences in order to guide further choices).

Another relevant aspect of our approach is that it extends previous work by including up-to-date social cognition processes that have been established as playing a pivotal role in disadvantageous decision making. Indeed, dual- or triadic-process models have largely neglected other relevant systems involved in the emergence and maintenance of substance abuse and addictive disorders. We thus decided to include social cognitive processes, as they also play a critical role in the onset and perpetuation of addictive disorders (Bora and Zorlu 2017; Onuoha et al. 2016). However, further research is needed to disentangle the relations between social cognition-related processes and other processes included in the proposed battery. In particular, not all of these processes can be considered at the same epistemological level. Indeed, on the one hand, interoceptive processes play an important role in emotional processing and executive functions (see Adolfi et al. 2017; Khalsa et al. 2009; Poppa and Bechara 2018). On the other hand, social cognition refers to an overarching category of processes involved in perceiving others and interacting with them that is under the influence of more basic processes (e.g., interoceptive processes, associative processes, executive functions, attentional biases, self-awareness). An in-depth analysis of the potential interactions between social cognition processes and other processes involved in decision making is thus needed to better appraise decision making in social contexts, that is, when the behavior of others affect someone's well-being, when someone has to make a choice in reference to another person, or when the respect of social norms has to be balanced in regard to someone's own interests (Ruff and Fehr 2014).

A central aspect of further elaboration of the theoretical framework proposed would be to investigate the interactions and reciprocal influences of the distinct processes involved in decision making. In particular, to best capture the dynamic interplay among the distinct features (i.e., how they may trigger each other over time), one would need to apply computational methods that characterize the within- and between-person temporal dynamics of intensive intraindividual time series data denoting these systems and their related features (Epskamp et al. 2018). A computational network approach could also help researchers to empirically test whether the distinct features cohere as a large unitary network system of interacting elements (for illustrations, see Beveridge and Shan 2016; Heeren et al. 2018). Finally, techniques from the study of sudden transitions in ecosystems (e.g., Hirota et al. 2011) may also help identify when the dynamic interplay among the distinct features is on the brink of tipping into a disordered state (e.g., disorder, relapse) or returning to a mentally healthy one. The combination of these distinct analytical approaches would ultimately conspire to elucidate the temporal dynamics of the interactions among the distinct features of impaired decision making in addiction and allow one to move beyond the categorical dual- and triadic approaches.

Our paper also opens relevant perspectives at a clinical level. Indeed, deficits in decision making are known to play a crucial role in the onset, maintenance, and relapse of substance use and addictive disorders (e.g., Bechara 2005; Bickel et al. 2018; Goudriaan et al. 2005). However, taking into account the limited efficacy of current treatments, low compliance rate, and high relapse rates observed in addictive disorders (McLellan et al. 2000; Miller 1996; Moos and Moos 2006), there is an urgent need for alternative assessments and individualized, tailored, and transdiagnostic intervention strategies to prevent or diminish the personal, social, and economic burden associated with addiction. In this context, the processual and transdiagnostic battery proposed here, although preliminary, holds relevant prospects for the diagnosis and case conceptualization, prevention, and empirically grounded treatment of decision-making impairments. Indeed, developing such a battery is all the more important because, although poor decision making may result in similar outcomes (e.g., relapse, poor treatment adherence, loss of control), the underlying processes involved in it could be heterogeneous from one person to another. Appraising the heterogeneity of the processes involved in poor decision making enables clinicians to identify individuals at risk of addictive disorders and to provide more efficient prevention strategies. In addition, such an approach supports the development and validation of individualized, tailored, and transdiagnostic treatments targeting specific psychological (or in some cases physiological) processes underlying symptoms and problematic behaviors, as well as claims for abandoning standardized treatments targeting discrete syndromes, which are still largely used in the treatment of addictive disorders (Billieux et al. 2015; Dudley et al. 2011).

As an illustration, and as emphasized earlier, it is generally acknowledged that patients with substance use or gambling disorder present with prepotent response inhibition impairment (Goudriaan et al. 2004; Smith et al. 2014). In such a context, it is tenable to defend the position that the standardized treatment of addiction should comprise a specific module or intervention targeting the improvement of inhibitory control, as most addicted patients are supposed to present this specific deficit. It is worth noting, however, that most supporting evidence in the field has been gathered via case-control studies that by definition focus on group differences and neglect the heterogeneity that potentially characterizes patients. Yet, similar to concerns of other mental conditions such as schizophrenia (Larøi and Van der Linden 2013), it may be that intradiagnostic symptom heterogeneity is more the rule than the exception and that individualized remediation is required. Although few studies have tackled this heterogeneity issue in clinical settings, an interesting observation can be derived from a study that measured impulsivity-related functions (including prepotent response inhibition) in a sample of treatment-seeking patients with gambling disorder (Billieux et al. 2012). Indeed, although this study successfully reproduced classic group-control differences in inhibitory control, it also emphasized that only a subgroup of gambling disorder patients (40%) are characterized by prepotent response impairment when an individual profile analysis is applied, which calls into question the position that inhibitory control is systematically impaired and should be treated in gambling disorder. This kind of data, in line with the process-based approach defended in the current article, supports the crucial need to profile addictive disorder patients with a theoretically grounded assessment battery that allows one to consider the inherent heterogeneity of decision-making impairments as a premise of treatment conceptualization.

The preliminary battery that we proposed thus represents a first attempt to specifically assess decision-making processes, one that goes beyond the use of traditional and multidetermined decision-making laboratory tasks such as the Iowa Gambling Task, the Game of Dice Task, the Balloon Analogue Risk Task, or delay discounting tasks. However, most of the tasks presented here have been generally used for research, and their clinical adaptability/efficiency should be confirmed. In addition, although most of the described tasks efficiently discriminate patients with addictive disorders from healthy controls, the relation to measures of daily life and relevant clinical outcomes (e.g., relapse, abstinence, treatment adherence, quality of life) have not systematically been established. Furthermore, appraising decision-making impairments in addictive disorders requires adoption of a more holistic perspective. Indeed, psychiatric disorders are considered to result from complex interactions between neural systems, psychological states, environmental inputs, and sociocultural determinants (Kendler et al. 2011). In this context, poor decision making, associated with various dysfunctional neurocognitive processes that depend on identified specific neural networks (e.g., insular cortex and interoceptive awareness), has been described in the current paper. However, this perspective on decision making should be integrated in a larger clinical view of addictive disorders, including interactions between the processes described in the inventory of laboratory tasks and emotional factors (e.g., negative mood, anxiety), personal identity (e.g., self-efficacy), or relational factors. In a processual and integrative approach, the interactions between neurobiological factors, social factors, and life events could contribute to poor decision making through their joint effects on various cognitive, affective, and motivational processes identified in the current manuscript (Kinderman and Tai 2007).

Finally, our approach presents some limitations. First, we used a narrative methodology, implying that the information provided was not subject to standardized information selection and specific assessment criteria. Indeed, given the nature of the current article and the vast number of constructs covered (i.e., the range of cognitive, affective, and motivational processes considered in relation to decision making), a systematic and/or meta-analytic approach was not feasible. The selection of constructs retained resulted from a consensus reached by the authors and is thus inherently characterized by a certain degree of subjectivity. An alternative approach could have been to rely on a technique such as the Delphi technique, which is a structured method used to achieve consensus through an iterative process of gathering opinions from a panel of representative experts (Jorm 2015; Yücel et al. 2018). Applying a Delphi approach to the constructs retained (and related assessment tasks) could constitute a relevant further step to test and strengthen the theoretical framework developed in the current paper.

Second, the direction of causality between some processes and addictive features has not always been properly established (e.g., for updating, cognitive flexibility, mental time travel, self-awareness). Consequently, there is suggestive evidence only for the role of various specific processes in the development of addiction.

Conclusion

Addictive disorders constitute a major public health issue and a worldwide economic burden, further increased by the low efficiency of current treatment proposals. It is now acknowledged that poor decision making plays a pivotal role in these disorders, and the precise identification of processes underlying poor decision making in addictive disorders is thus much needed to promote effective prevention approaches and treatment options. In this regard, it is essential to go beyond the use of general and multidetermined decision-making laboratory tasks and to identify specific impairments in decision-making processes to foster psychological interventions that are tailored to the person's specific dysfunctions. This paper, by identifying specific processes involved in poor decision making, constitutes a first step toward a theoretically grounded and experimentally valid evaluation of decision-making impairments and rehabilitation in substance use and addictive disorders.

Acknowledgements We are indebted to Till Lindemann for his support regarding the writing of this manuscript. Pierre Maurage (Research Associate) and Alexandre Heeren (Research Associate) are funded by the Belgian Fund for Scientific Research (F.R.S.-FNRS, Belgium). Alexandre Heeren is also a clinical research fellow of the Helaers Foundation.

References

Aarts, H., Dijksterhuis, A., & De Vries, P. (2001). On the psychology of drinking: Being thirsty and perceptually ready. *British Journal of Psychology, 92*(4), 631–642. https://doi.org/10.1348/000712601162383.

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia, 45*(7), 1363–1377. https://doi.org/10.1016/j.neuropsychologia.2006.10.016.

Addis, D. R., Wong, A. T., & Schacter, D. L. (2008). Age-related changes in the episodic simulation of future events. *Psychological Science, 19*(1), 33–41. https://doi.org/10.1111/j.1467-9280.2008.02043.x.

Adolfi, F., Couto, B., Richter, F., Decety, J., Lopez, J., Sigman, M., et al. (2017). Convergence of interoception, emotion, and social cognition: A twofold fMRI meta-analysis and lesion approach. *Cortex, 88*, 124–142. https://doi.org/10.1016/j.cortex.2016.12.019.

Álvarez-Moya, E. M., Ochoa, C., Jiménez-Murcia, S., Aymamí, M. N., Gómez-Peña, M., Fernández-Aranda, F., & Menchón, J. M. (2011). Effect of executive functioning, decision-making and self-reported impulsivity on the treatment outcome of pathologic gambling. *Journal of Psychiatry & Neuroscience, 36*(3), 165–175. https://doi.org/10.1503/jpn.090095.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington: American Psychiatric Publishing.

Ames, S. L., Grenard, J. L., Thush, C., Sussman, S., Wiers, R. W., & Stacy, A. W. (2007). Comparison of indirect assessments of association as predictors of marijuana use among at-risk adolescents. *Experimental and Clinical Psychopharmacology, 15*(2), 204–218. https://doi.org/10.1037/1064-1297.15.2.218.

Anderson, B. A. (2016). What is abnormal about addiction-related attentional biases? *Drug and Alcohol Dependence, 167*, 8–14. https://doi.org/10.1016/j.drugalcdep.2016.08.002.

Apperly, I. A., Samson, D., Chiavarino, C., & Humphreys, G. W. (2004). Frontal and temporo-parietal lobe contributions to theory of mind: Neuropsychological evidence from a false-belief task with reduced language and executive demands. *Journal of Cognitive Neuroscience, 16*(10), 1773–1784. https://doi.org/10.1162/0898929042947928.

Ashenhurst, J. R., Jentsch, J. D., & Ray, L. A. (2011). Risk-taking and alcohol use disorders symptomatology in a sample of problem drinkers. *Experimental and Clinical Psychopharmacology, 19*(5), 361–370. https://doi.org/10.1037/a0024412.

Ates Cöl, I., Sönmez, M. B., & Vardar, M. E. (2016). Evaluation of interoceptive awareness in alcohol-addicted patients. *Archives of Neuropsychiatry, 53*(1), 17–22. https://doi.org/10.5152/npa.2015.9898.

Baddeley, A. D. (1986). *Working memory*. Oxford: Oxford University Press.

Barkby, H., Dickson, J. M., Roper, L., & Field, M. (2012). To approach or avoid alcohol? Automatic and self-reported motivational tendencies in alcohol dependence. *Alcoholism: Clinical and Experimental Research, 36*(2), 361–368. https://doi.org/10.1111/j.1530-0277.2011.01620.x.

Barrett, L. F., Quigley, K. S., Bliss-Moreau, E., & Aronson, K. R. (2004). Interoceptive sensitivity and self-reports of emotional experience. *Journal of Personality and Social Psychology, 87*(5), 684–697. https://doi.org/10.1037/0022-3514.87.5.684.

Bayrakçı, A., Sert, E., Zorlu, N., Erol, A., Sarıçiçek, A., & Mete, L. (2015). Facial emotion recognition deficits in abstinent cannabis dependent patients. *Comprehensive Psychiatry, 58*, 160–164. https://doi.org/10.1016/j.comppsych.2014.11.008.

Bechara, A. (2005). Decision making, impulse control and loss of willpower to resist drugs: A neurocognitive perspective. *Nature Neuroscience, 8*(11), 1458–1463. https://doi.org/10.1038/nn1584.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*(1–3), 7–15. https://doi.org/10.1016/0010-0277(94)90018-3.

Bechara, A., Dolan, S., Denburg, N., Hindes, A., Anderson, S. W., & Nathan, P. E. (2001). Decision-making deficits, linked to a dysfunctional ventromedial prefrontal cortex, revealed in alcohol and stimulant abusers. *Neuropsychologia, 39*(4), 376–389. https://doi.org/10.1016/S0028-3932(00)00136-6.

Beraha, E. M., Cousijn, J., Hermanides, E., Goudriaan, A. E., & Wiers, R. W. (2013). Implicit associations and explicit expectancies toward cannabis in heavy cannabis users and controls. *Frontiers in Psychiatry, 4*, 59. https://doi.org/10.3389/fpsyt.2013.00059.

Beveridge, A., & Shan, J. (2016). Network of thrones. *Math Horizons, 23*(4), 14–15. https://doi.org/10.4169/mathhorizons.23.4.18.

Bickel, W. K., Koffarnus, M. N., Moody, L., & Wilson, A. G. (2014). The behavioral- and neuro-economic process of temporal discounting: A candidate behavioral marker of addiction. *Neuropharmacology, 76*(Pt B), 518–527. https://doi.org/10.1016/j.neuropharm.2013.06.013.

Bickel, W. K., Kowal, B. P., & Gatchalian, K. M. (2006). Understanding addiction as a pathology of temporal horizon. *The Behavior Analyst Today, 7*(1), 32–47. https://doi.org/10.1037/h0100148.

Bickel, W. K., Mellis, A. M., Snider, S. E., Athamneh, L. N., Stein, J. S., & Pope, D. A. (2018). 21st century neurobehavioral theories of decision making in addiction: Review and evaluation. *Pharmacology, Biochemistry, and Behavior, 164*, 4–21. https://doi.org/10.1016/j.pbb.2017.09.009.

Biernacki, K., McLennan, S. N., Terrett, G., Labuschagne, I., & Rendell, P. G. (2016). Decision-making ability in current and past users of opiates: A meta-analysis. *Neuroscience & Biobehavioral Reviews, 71*, 342–351. https://doi.org/10.1016/j.neubiorev.2016.09.011.

Billieux, J., Gay, P., Rochat, L., Khazaal, Y., Zullino, D., & Van der Linden, M. (2010a). Lack of inhibitory control predicts cigarette smoking dependence: Evidence from a non-deprived sample of light to moderate smokers. *Drug & Alcohol Dependence, 112*(1), 164–167. https://doi.org/10.1016/j.drugalcdep.2010.06.006.

Billieux, J., Gay, P., Rochat, L., & Van der Linden, M. (2010b). The role of urgency and its underlying psychological mechanisms in problematic behaviours. *Behaviour Research and Therapy, 48*(11), 1085–1096. https://doi.org/10.1016/j.brat.2010.07.008.

Billieux, J., Lagrange, G., Van der Linden, M., Lançon, C., Adida, M., & Jeanningros, R. (2012). Investigation of impulsivity in a sample of treatment-seeking pathological gamblers: A multidimensional perspective. *Psychiatry Research, 198*(2), 291–296. https://doi.org/10.1016/j.psychres.2012.01.001.

Billieux, J., Philippot, P., Schmid, C., Maurage, P., De Mol, J., & Van der Linden, M. (2015). Is dysfunctional use of the mobile phone a behavioural addiction? Confronting symptom-based versus process-based approaches. *Clinical Psychology & Psychotherapy, 22*(5), 460–468. https://doi.org/10.1002/cpp.1910.

Blum, K., Sheridan, P. J., Wood, R. C., Braverman, E. R., Chen, T. J., Cull, J. G., & Comings, D. E. (1996). The D2 dopamine receptor gene as a determinant of reward deficiency syndrome. *Journal of the Royal Society of Medicine, 89*(7), 396–400. https://doi.org/10.1177/014107689608900711.

Boffo, M., Smits, R., Salmon, J. P., Cowie, M. E., de Jong, D. T. H. A., Salemink, E., et al. (2018). Luck, come here! Automatic approach tendencies toward gambling cues in moderate- to high-risk gamblers. *Addiction, 113*(2), 289–298. https://doi.org/10.1111/add.14071.

Boog, M., Höppener, P., Wetering, V. D. B. J., Goudriaan, A. E., Boog, M. C., & Franken, I. H. A. (2014). Cognitive inflexibility in gamblers is primarily present in reward-related decision making. *Frontiers in Human Neuroscience, 8*, 569. https://doi.org/10.3389/fnhum.2014.00569.

Bora, E., & Zorlu, N. (2017). Social cognition in alcohol use disorder: A meta-analysis. *Addiction, 112*(1), 40–48. https://doi.org/10.1111/add.13486.

Bornovalova, M. A., Daughters, S. B., Hernandez, G. D., Richards, J. B., & Lejuez, C. W. (2005). Differences in impulsivity and risk-taking propensity between primary users of crack cocaine and primary users of heroin in a residential substance-use program. *Experimental and Clinical Psychopharmacology, 13*(4), 311–318. https://doi.org/10.1037/1064-1297.13.4.311.

Bosco, F. M., Capozzi, F., Colle, L., Marostica, P., & Tirassa, M. (2014). Theory of mind deficit in subjects with alcohol use disorder: An analysis of mindreading processes. *Alcohol and Alcoholism, 49*(3), 299–307. https://doi.org/10.1093/alcalc/agt148.

Bowden-Jones, H., McPhillips, M., Rogers, R., Hutton, S., & Joyce, E. (2005). Risk-taking on tests sensitive to ventromedial prefrontal cortex dysfunction predicts early relapse in alcohol dependency: A pilot study. *Journal of Neuropsychiatry and Clinical Neuroscience, 17*(3), 417–420. https://doi.org/10.1176/jnp.17.3.417.

Boyer, P. (2008). Evolutionary economics of mental time travel? *Trends in Cognitive Sciences, 12*(6), 219–224. https://doi.org/10.1016/j.tics.2008.03.003.

Brand, M., Fujiwara, E., Borsutzky, S., Kalbe, E., Kessler, J., & Markowitsch, H. J. (2005). Decision-making deficits of Korsakoff patients in a new gambling task with explicit rules: Associations with executive functions. *Neuropsychology, 19*(3), 267–277. https://doi.org/10.1037/0894-4105.19.3.267.

Brand, M., Young, K. S., Laier, C., Wölfling, K., & Potenza, M. N. (2016). Integrating psychological and neurobiological considerations regarding the development and maintenance of specific internet-use disorders: An interaction of person-affect-cognition-execution (I-PACE) model. *Neuroscience & Biobehavioral Reviews, 71*, 252–266. https://doi.org/10.1016/j.neubiorev.2016.08.033.

Brevers, D., Bechara, A., Cleeremans, A., & Noel, X. (2013a). Iowa gambling task (IGT): Twenty years after – Gambling disorder and IGT. *Frontiers in Psychology, 4*. https://doi.org/10.3389/fpsyg.2013.00665.

Brevers, D., Cleeremans, A., Bechara, A., Greisen, M., Kornreich, C., Verbanck, P., & Noël, X. (2013b). Impaired self-awareness in pathological gamblers. *Journal of Gambling Studies, 29*(1), 119–129. https://doi.org/10.1007/s10899-012-9292-2.

Brevers, D., Cleeremans, A., Bechara, A., Greisen, M., Kornreich, C., Verbanck, P., & Noël, X. (2014). Impaired metacognitive capacities in individuals with problem gambling. *Journal of Gambling Studies, 30*(1), 141–152. https://doi.org/10.1007/s10899-012-9348-3.

Brevers, D., Cleeremans, A., Hermant, C., Tibboel, H., Kornreich, C., Verbanck, P., & Noël, X. (2013c). Implicit gambling attitudes in problem gamblers: Positive but not negative implicit associations. *Journal of Behavior Therapy and Experimental Psychiatry, 44*(1), 94–97. https://doi.org/10.1016/j.jbtep.2012.07.008.

Brevers, D., & Noël, X. (2013). Pathological gambling and the loss of willpower: A neurocognitive perspective. *Socioaffective Neuroscience & Psychology, 3*, 21592. https://doi.org/10.3402/snp.v3i0.21592.

Campbell, J. A., Samartgis, J. R., & Crowe, S. F. (2013). Impaired decision making on the balloon analogue risk task as a result of long-term alcohol use. *Journal of Clinical and Experimental Neuropsychology, 35*(10), 1071–1081. https://doi.org/10.1080/13803395.2013.856382.

Carim-Todd, L., Mitchell, S. H., & Oken, B. S. (2016). Impulsivity and stress response in nondependent smokers (tobacco chippers) in comparison to heavy smokers and nonsmokers. *Nicotine & Tobacco Research, 18*(5), 547–556. https://doi.org/10.1093/ntr/ntv210.

Carpenter, K. M., Schreiber, E., Church, S., & McDowell, D. (2006). Drug Stroop performance: Relationships with primary substance of use and treatment outcome in a drug-dependent outpatient sample. *Addictive Behaviors, 31*(1), 174–181. https://doi.org/10.1016/j.addbeh.2005.04.012.

Castellano, F., Bartoli, F., Crocamo, C., Gamba, G., Tremolada, M., Santambrogio, J., et al. (2015). Facial emotion recognition in alcohol and substance use disorders: A meta-analysis. *Neuroscience & Biobehavioral Reviews, 59*, 147–154. https://doi.org/10.1016/j.neubiorev.2015.11.001.

Chanon, V. W., Sours, C. R., & Boettiger, C. A. (2010). Attentional bias toward cigarette cues in active smokers. *Psychopharmacology, 212*(3), 309–320. https://doi.org/10.1007/s00213-010-1953-1.

Charlet, K., Beck, A., Jorde, A., Wimmer, L., Vollstädt-Klein, S., Gallinat, J., et al. (2014). Increased neural activity during high working memory load predicts low relapse risk in alcohol dependence. *Addiction Biology, 19*(3), 402–414. https://doi.org/10.1111/adb.12103.

Chassin, L., Presson, C. C., Sherman, S. J., Seo, D.-C., & Macy, J. T. (2010). Implicit and explicit attitudes predict smoking cessation: Moderating effects of experienced failure to control smoking and plans to quit. *Psychology of Addictive Behaviors, 24*(4), 670–679. https://doi.org/10.1037/a0021722.

Chen, H., Jiang, H., Guo, Q., Du, J., Wang, J., & Zhao, M. (2013). Case-control study of error-related negativity among males with heroin dependence undergoing rehabilitation. *Shanghai Archives of Psychiatry, 25*(3), 141–148. https://doi.org/10.3969/j.issn.1002-0829.2013.03.003.

Chiu, P. H., Lohrenz, T. M., & Montague, P. R. (2008). Smokers' brains compute, but ignore, a fictive error signal in a sequential investment task. *Nature Neuroscience, 11*(4), 514–520. https://doi.org/10.1038/nn2067.

Choi, S.-W., Kim, H., Kim, G.-Y., Jeon, Y., Park, S., Lee, J.-Y., et al. (2014). Similarities and differences among internet gaming disorder, gambling disorder and alcohol use disorder: A focus on impulsivity and compulsivity. *Journal of Behavioral Addictions, 3*(4), 246–253. https://doi.org/10.1556/JBA.3.2014.4.6 .

Christiansen, P., Schoenmakers, T. M., & Field, M. (2015). Less than meets the eye: Reappraising the clinical relevance of attentional bias in addiction. *Addictive Behaviors, 44*, 43–50. https://doi.org/10.1016/j.addbeh.2014.10.005.

Clark, L., Robbins, T. W., Ersche, K. D., & Sahakian, B. J. (2006). Reflection impulsivity in current and former substance users. *Biological Psychiatry, 60*(5), 515–522. https://doi.org/10.1016/j.biopsych.2005.11.007.

Cohen, K., Kapitány-Fövény, M., Mama, Y., Arieli, M., Rosca, P., Demetrovics, Z., & Weinstein, A. (2017). The effects of synthetic cannabinoids on executive function. *Psychopharmacology, 234*(7), 1121–1134. https://doi.org/10.1007/s00213-017-4546-4.

Colzato, L. S., van den Wildenberg, W. P., & Hommel, B. (2007). Impaired inhibitory control in recreational cocaine users. *PLoS One, 2*(11), e1143. https://doi.org/10.1371/journal.pone.0001143.

Contero, M., Carmen, M., Secades Vila, R., & Tirapu Ustárroz, J. (2012). Cognición social en adictos a opiáceos. *Revista de Neurologia, 55*, 705–712.

Conway, M. A. (2009). Autobiographical memory and consciousness. In W. P. Banks (Ed.), *Encyclopedia of consciousness* (pp. 77–82). Oxford: Academic.

Cools, R., Clark, L., Owen, A. M., & Robbins, T. W. (2002). Defining the neural mechanisms of probabilistic reversal learning using event-related functional magnetic resonance imaging. *Journal of Neuroscience, 22*(11), 4563–4567. https://doi.org/10.1523/JNEUROSCI.22-11-04563.2002.

Cosenza, M., Griffiths, M. D., Nigro, G., & Ciccarelli, M. (2017). Risk-taking, delay discounting, and time perspective in adolescent gamblers: An experimental study. *Journal of Gambling Studies, 33*(2), 383–395. https://doi.org/10.1007/s10899-016-9623-9.

Cousijn, J., Goudriaan, A. E., & Wiers, R. W. (2011). Reaching out towards cannabis: Approach-bias in heavy cannabis users predicts changes in cannabis use. *Addiction, 106*(9), 1667–1674. https://doi.org/10.1111/j.1360-0443.2011.03475.x.

Cox, W. M., Hogan, L. M., Kristian, M. R., & Race, J. H. (2002). Alcohol attentional bias as a predictor of alcohol abusers' treatment outcome. *Drug and Alcohol Dependence, 68*(3), 237–243. https://doi.org/10.1016/S0376-8716(02)00219-3.

Critchley, H. D., Wiens, S., Rotshtein, P., Öhman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience, 7*(2), 189–195. https://doi.org/10.1038/nn1176.

Cuervo-Lombard, C., Raucher-Chéné, D., Barrière, S., Van der Linden, M., & Kaladjian, A. (2016). Self-defining memories in recently detoxified alcohol-dependent patients. *Psychiatry Research, 246*, 533–538. https://doi.org/10.1016/j.psychres.2016.09.040.

Cui, J.-F., Wang, Y., Shi, H.-S., Liu, L.-L., Chen, X.-J., & Chen, Y.-H. (2015). Effects of working memory load on uncertain decision-making: Evidence from the Iowa gambling task. *Frontiers in Psychology, 6*, 162. https://doi.org/10.3389/fpsyg.2015.00162.

Czapla, M., Simon, J. J., Richter, B., Kluge, M., Friederich, H.-C., Herpertz, S., et al. (2016). The impact of cognitive impairment and impulsivity on relapse of alcohol-dependent patients: Implications for psychotherapeutic treatment. *Addiction Biology, 21*(4), 873–884. https://doi.org/10.1111/adb.12229.

Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 351*(1346), 1413–1420. https://doi.org/10.1098/rstb.1996.0125.

D'Argembeau, A., Ortoleva, C., Jumentier, S., & Van der Linden, M. (2010). Component processes underlying future thinking. *Memory & Cognition, 38*(6), 809–819. https://doi.org/10.3758/MC.38.6.809.

D'Argembeau, A., & Van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition, 15*(2), 342–350. https://doi.org/10.1016/j.concog.2005.09.001.

De Houwer, J. (2006). What are implicit measures and why are we using them. In R. W. Wiers & A. W. Stacy (Eds.), *The handbook of implicit cognition and addiction* (p. 11–28). Thousand Oaks: Sage Publishers.

De Houwer, J., de Teige-Mocigemba, S., Spruyt, A., & Moors, A. (2009). Implicit measures: A normative analysis and review. *Psychological Bulletin, 135*(3), 347–368. https://doi.org/10.3389/fpsyg.2018.00777.

de Ruiter, M. B., Oosterlaan, J., Veltman, D. J., van den Brink, W., & Goudriaan, A. E. (2012). Similar hyporesponsiveness of the dorsomedial prefrontal cortex in problem gamblers and heavy smokers during an inhibitory control task. *Drug & Alcohol Dependence, 121*(1), 81–89. https://doi.org/10.1016/j.drugalcdep.2011.08.010.

de Ruiter, M. B., Veltman, D. J., Goudriaan, A. E., Oosterlaan, J., Sjoerds, Z., & van den Brink, W. (2009). Response perseveration and ventral prefrontal sensitivity to reward and punishment in male problem gamblers and smokers. *Neuropsychopharmacology, 34*(4), 1027–1038. https://doi.org/10.1038/npp.2008.175.

Desfosses, M., Meadows, H., Jackson, M., & Crowe, S. F. (2014). The relationship between neuropsychological functioning and mental health outcomes of chronic alcohol users involved in counselling: Prediction of treatment outcome. *Australian Psychologist, 49*(5), 287–296. https://doi.org/10.1111/ap.12071.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750.

Domínguez-Salas, S., Díaz-Batanero, C., Lozano-Rojas, O. M., & Verdejo-García, A. (2016). Impact of general cognition and executive function deficits on addiction treatment outcomes: Systematic review and discussion of neurocognitive pathways. *Neuroscience & Biobehavioral Reviews, 71*, 772–801. https://doi.org/10.1016/j.neubiorev.2016.09.030.

Donadon, M. F., & Osório, F. L. (2014). Recognition of facial expressions by alcoholic patients: A systematic literature review. *Neuropsychiatric Disease and Treatment, 10*, 1655–1663. https://doi.org/10.2147/NDT.S65376.

Dong, G., & Potenza, M. N. (2014). A cognitive-behavioral model of internet gaming disorder: Theoretical underpinnings and clinical implications. *Journal of Psychiatric Research, 58*, 7–11. https://doi.org/10.1016/j.jpsychires.2014.07.005.

Drusch, K., Lowe, A., Fisahn, K., Brinkmeyer, J., Musso, F., Mobascher, A., et al. (2013). Effects of nicotine on social cognition, social competence and self-reported stress in schizophrenia patients and healthy controls. *European Archives of Psychiatry and Clinical Neuroscience, 263*(6), 519–527. https://doi.org/10.1007/s00406-012-0377-9.

Dudley, R., Kuyken, W., & Padesky, C. A. (2011). Disorder specific and trans-diagnostic case conceptualisation. *Clinical Psychology Review, 31*(2), 213–224. https://doi.org/10.1016/j.cpr.2010.07.005.

Dunn, B. D., Galton, H. C., Morgan, R., Evans, D., Oliver, C., Meyer, M., et al. (2010). Listening to your heart: How interoception shapes emotion experience and intuitive decision making. *Psychological Science, 21*(12), 1835–1844. https://doi.org/10.1177/0956797610389191.

Dziobek, I., Fleck, S., Kalbe, E., Rogers, K., Hassenstab, J., Brand, M., et al. (2006). Introducing MASC: A movie for the assessment of social cognition. *Journal of Autism and Developmental Disorders, 36*(5), 623–636. https://doi.org/10.1007/s10803-006-0107-0.

Epskamp, S., van Borkulo, C. D., van der Veen, D. C., Servaas, M. N., Isvoranu, A.-M., Riese, H., & Cramer, A. O. J. (2018). Personalized network modeling in psychopathology: The importance of contemporaneous and temporal connections. *Clinical Psychological Science, 6*(3), 416–427. https://doi.org/10.1177/2167702617744325.

Epstein, S. (1994). Integration of the cognitive and psychodynamic unconscious. *American Psychologist, 49*, 709–744.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*(1), 143–149. https://doi.org/10.3758/BF03203267.

Ernst, M., Luckenbaugh, D. A., Moolchan, E. T., Temple, V. A., Jenness, J., Korelitz, K. E., et al. (2010). Decision-making and facial emotion recognition as predictors of substance-use initiation among adolescents. *Addictive Behaviors, 35*(3), 286–289. https://doi.org/10.1016/j.addbeh.2009.10.014.

Ersche, K. D., Hagan, C. C., Smith, D. G., Jones, P. S., Calder, A. J., & Williams, G. B. (2015). In the face of threat: Neural and endocrine correlates of impaired facial emotion recognition in cocaine dependence. *Translational Psychiatry, 5*(5), e570. https://doi.org/10.1038/tp.2015.58.

Evans, J. S. B. T. (2003). In two minds: Dual-process accounts of reasoning. *Trends in Cognitive Sciences, 7*(10), 454–459. https://doi.org/10.1016/j.tics.2003.08.012.

Evans, J. S. B. T., & Coventry, K. (2006). A dual-process approach to behavioral addiction: The case of gambling. In R. W. Wiers & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction* (pp. 29–44). Thousand Oaks: SAGE Publications, Inc..

Fadardi, J. S., & Cox, W. M. (2009). Reversing the sequence: Reducing alcohol consumption by overcoming alcohol attentional bias. *Drug and Alcohol Dependence, 101*(3), 137–145. https://doi.org/10.1016/j.drugalcdep.2008.11.015.

Fattore, L., & Diana, M. (2016). Drug addiction: An affective-cognitive disorder in need of a cure. *Neuroscience & Biobehavioral Reviews, 65*, 341–361. https://doi.org/10.1016/j.neubiorev.2016.04.006.

Fernández-Serrano, M. J., Lozano, Ó., Pérez-García, M., & Verdejo-García, A. (2010). Impact of severity of drug use on discrete emotions recognition in polysubstance abusers. *Drug and Alcohol Dependence, 109*(1), 57–64. https://doi.org/10.1016/j.drugalcdep.2009.12.007.

Fernie, G., Cole, J. C., Goudie, A. J., & Field, M. (2010). Risk-taking but not response inhibition or delay discounting predict alcohol consumption in social drinkers. *Drug & Alcohol Dependence, 112*(1), 54–61. https://doi.org/10.1016/j.drugalcdep.2010.05.011.

Field, M., Di Lemma, L., Christiansen, P., & Dickson, J. (2017). Automatic avoidance tendencies for alcohol cues predict drinking after detoxification treatment in alcohol dependence. *Psychology of Addictive Behaviors, 31*(2), 171–179. https://doi.org/10.1037/adb0000232.

Field, M., & Duka, T. (2002). Cues paired with a low dose of alcohol acquire conditioned incentive properties in social drinkers. *Psychopharmacology, 159*(3), 325–334. https://doi.org/10.1007/s00213-001-0923-z.

Field, M., Duka, T., Tyler, E., & Schoenmakers, T. (2009). Attentional bias modification in tobacco smokers. *Nicotine & Tobacco Research, 11*(7), 812–822. https://doi.org/10.1093/ntr/ntp067.

Field, M., Eastwood, B., Bradley, B. P., & Mogg, K. (2006). Selective processing of cannabis cues in regular cannabis users. *Drug and*

Alcohol Dependence, 85(1), 75–82. https://doi.org/10.1016/j.drugalcdep.2006.03.018.

Field, M., Kiernan, A., Eastwood, B., & Child, R. (2008). Rapid approach responses to alcohol cues in heavy drinkers. *Journal of Behavior Therapy and Experimental Psychiatry, 39*(3), 209–218. https://doi.org/10.1016/j.jbtep.2007.06.001.

Field, M., Mogg, K., Zetteler, J., & Bradley, B. P. (2004). Attentional biases for alcohol cues in heavy and light social drinkers: The roles of initial orienting and maintained attention. *Psychopharmacology, 176*(1), 88–93. https://doi.org/10.1007/s00213-004-1855-1.

Field, M., Werthmann, J., Franken, I., Hofmann, W., Hogarth, L., & Roefs, A. (2016). The role of attentional bias in obesity and addiction. *Health Psychology, 35*(8), 767–780. https://doi.org/10.1037/hea0000405.

Figner, B., Mackinlay, R., Wilkening, F., & Weber, E. U. (2009). Affective and deliberative processes in risky choice: Age differences in risk taking in the Columbia card task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*(3), 709–730. https://doi.org/10.1037/a0014983.

Fillmore, M. T., & Rush, C. R. (2002). Impaired inhibitory control of behavior in chronic cocaine users. *Drug & Alcohol Dependence, 66*(3), 265–273. https://doi.org/10.1016/S0376-8716(01)00206-X.

Fleming, K. A., & Bartholow, B. D. (2014). Alcohol cues, approach bias, and inhibitory control: Applying a dual process model of addiction to alcohol sensitivity. *Psychology of Addictive Behaviors, 28*(1), 85–96. https://doi.org/10.1037/a0031565.

Frank, M. J., Seeberger, L. C., & O'Reilly, R. C. (2004). By carrot or by stick: Cognitive reinforcement learning in parkinsonism. *Science, 306*, 1940–1943. https://doi.org/10.1126/science.1102941.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General, 133*(1), 101–135. https://doi.org/10.1037/0096-3445.133.1.101.

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex, 86*, 186–204. https://doi.org/10.1016/j.cortex.2016.04.023.

Frith, C. D., & Singer, T. (2008). The role of social cognition in decision making. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363*(1511), 3875–3886. https://doi.org/10.1098/rstb.2008.0156.

Garfinkel, S. N., Seth, A. K., Barrett, A. B., Suzuki, K., & Critchley, H. D. (2015). Knowing your own heart: Distinguishing interoceptive accuracy from interoceptive awareness. *Biological Psychology, 104*, 65–74. https://doi.org/10.1016/j.biopsycho.2014.11.004.

Gaudelus, B., Virgile, J., Peyroux, E., Leleu, A., Baudouin, J. Y., & Franck, N. (2015). Measuring impairment of facial affects recognition in schizophrenia. Preliminary study of the facial emotions recognition task (TREF). *L'Encephale, 41*(3), 251–259. https://doi.org/10.1016/j.encep.2014.08.013.

Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: An integrative review of implicit and explicit attitude change. *Psychological Bulletin, 132*(5), 692–731. https://doi.org/10.1037/0033-2909.132.5.692.

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: Models of bounded rationality. *Psychological Review, 103*(4), 650–669 https://doi.org/10.1037/0033-295X.103.4.650.

Goldstein, R. Z., Craig, A. D., Bechara, A., Garavan, H., Childress, A. R., Paulus, M. P., & Volkow, N. D. (2009). The neurocircuitry of impaired insight in drug addiction. *Trends in Cognitive Sciences, 13*(9), 372–380. https://doi.org/10.1016/j.tics.2009.06.004.

Goldstein, R. Z., & Volkow, N. D. (2011). Dysfunction of the prefrontal cortex in addiction: Neuroimaging findings and clinical implications. *Nature Reviews Neuroscience, 12*(11), 652–669. https://doi.org/10.1038/nrn3119.

Gonzalez, R., Schuster, R. M., Mermelstein, R. J., Vassileva, J., Martin, E. M., & Diviak, K. R. (2012). Performance of young adult cannabis users on neurocognitive measures of impulsive behavior and their relationship to symptoms of cannabis use disorders. *Journal of Clinical and Experimental Neuropsychology, 34*(9), 962–976. https://doi.org/10.1080/13803395.2012.703642.

Goodie, A. S. (2005). The role of perceived control and overconfidence in pathological gambling. *Journal of Gambling Studies, 21*(4), 481–502. https://doi.org/10.1007/s10899-005-5559-1.

Gordon, A. J., & Zrull, M. (1991). Social networks and recovery: One year after inpatient treatment. *Journal of Substance Abuse Treatment, 8*(3), 143–152. https://doi.org/10.1016/0740-5472(91)90005-U.

Goudriaan, A. E., Oosterlaan, J., de Beurs, E., & Van den Brink, W. (2004). Pathological gambling: A comprehensive review of biobehavioral findings. *Neuroscience & Biobehavioral Reviews, 28*(2), 123–141. https://doi.org/10.1016/j.neubiorev.2004.03.001.

Goudriaan, A. E., de Ruiter, M. B., van den Brink, W., Oosterlaan, J., & Veltman, D. J. (2010). Brain activation patterns associated with cue reactivity and craving in abstinent problem gamblers, heavy smokers and healthy controls: An fMRI study. *Addiction Biology, 15*(4), 491–503. https://doi.org/10.1111/j.1369-1600.2010.00242.x.

Goudriaan, A. E., Oosterlaan, J., de Beurs, E., & van den Brink, W. (2005). Decision making in pathological gambling: A comparison between pathological gamblers, alcohol dependents, persons with Tourette syndrome, and normal controls. Cognitive Brain Research, 23(1), 137–151. https://doi.org/10.1016/j.cogbrainres.2005.01.017.

Goudriaan, A. E., Oosterlaan, J., de Beurs, E., & van den Brink, W. (2006). Neurocognitive functions in pathological gambling: A comparison with alcohol dependence, Tourette syndrome and normal controls. *Addiction, 101*(4), 534–547. https://doi.org/10.1111/j.1360-0443.2006.01380.x.

Grant, J. E., Chamberlain, S. R., Schreiber, L. R. N., Odlaug, B. L., & Kim, S. W. (2011). Selective decision-making deficits in at-risk gamblers. *Psychiatry Research, 189*(1), 115–120. https://doi.org/10.1016/j.psychres.2011.05.034.

Green, M. F., Horan, W. P., & Lee, J. (2015). Social cognition in schizophrenia. *Nature Reviews Neuroscience, 16*(10), 620–631. https://doi.org/10.1038/nrn4005.

Green, M. F., Penn, D. L., Bentall, R., Carpenter, W. T., Gaebel, W., Gur, R. C., et al. (2008). Social cognition in schizophrenia: An NIMH workshop on definitions, assessment, and research opportunities. *Schizophrenia Bulletin, 34*(6), 1211–1220. https://doi.org/10.1093/schbul/sbm145.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology, 74*(6), 1464–1480 https://doi.org/10.1037/0022-3514.74.6.1464.

Harvey, A. G., Watkins, E., & Mansell, W. (2004). *Cognitive behavioural processes across psychological disorders*. New York: Oxford University Press.

Heeren, A., Bernstein, E. E., & McNally, R. J. (2018). Deconstructing trait anxiety: A network perspective. *Anxiety, Stress, and Coping, 31*(3), 262–276. https://doi.org/10.1080/10615806.2018.1439263.

Heeren, A., Billieux, J., Philippot, P., De Raedt, R., Baeken, C., de Timary, P., et al. (2017). Impact of transcranial direct current stimulation on attentional bias for threat: A proof-of-concept study among individuals with social anxiety disorder. *Social Cognitive and Affective Neuroscience, 12*(2), 251–260. https://doi.org/10.1093/scan/nsw119.

Heeren, A., De Raedt, R., Koster, E. H. W., & Philippot, P. (2013). The (neuro)cognitive mechanisms behind attention bias modification in anxiety: Proposals based on theoretical accounts of attentional bias. *Frontiers in Human Neuroscience, 7*, 119. https://doi.org/10.3389/fnhum.2013.00119.

Henry, J. D., Mazur, M., & Rendell, P. G. (2009). Social-cognitive difficulties in former users of methamphetamine. *The British Journal of*

Clinical Psychology, 48(Pt 3), 323–327. https://doi.org/10.1348/000712609X435742.
Hirota, M., Holmgren, M., Van Nes, E. H., & Scheffer, M. (2011). Global resilience of tropical forest and savanna to critical transitions. Science, 334(6053), 232–235. https://doi.org/10.1126/science.1210657.
Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual-systems perspective. *Perspectives on Psychological Science, 4*(2), 162–176. https://doi.org/10.1111/j.1745-6924.2009.01116.x.
Hogarth, L., & Duka, T. (2006). Human nicotine conditioning requires explicit contingency knowledge: Is addictive behaviour cognitively mediated? *Psychopharmacology, 184*(3–4), 553–566. https://doi.org/10.1007/s00213-005-0150-0.
Hommel, B., & Wiers, R. W. (2017). Towards a unitary approach to human action control. *Trends in Cognitive Sciences, 21*(12), 940–949. https://doi.org/10.1016/j.tics.2017.09.009.
Hønsi, A., Mentzoni, R. A., Molde, H., & Pallesen, S. (2013). Attentional bias in problem gambling: A systematic review. *Journal of Gambling Studies, 29*(3), 359–375. https://doi.org/10.1007/s10899-012-9315-z.
Hopko, D. R., Lejuez, C. W., Daughters, S. B., Aklin, W. M., Osborne, A., Simmons, B. L., & Strong, D. R. (2006). Construct validity of the Balloon Analogue Risk Task (BART): Relationship with MDMA use by inner-city drug users in residential treatment. *Journal of Psychopathology and Behavioral Assessment, 28*(2), 95–101. https://doi.org/10.1007/s10862-006-7487-5.
Hulka, L. M., Eisenegger, C., Preller, K. H., Vonmoos, M., Jenni, D., Bendrick, K., et al. (2014). Altered social and non-social decision-making in recreational and dependent cocaine users. *Psychological Medicine, 44*(5), 1015–1028. https://doi.org/10.1017/S0033291713001839.
Jeromin, F., Nyenhuis, N., & Barke, A. (2016). Attentional bias in excessive internet gamers: Experimental investigations using an addiction Stroop and a visual probe. *Journal of Behavioral Addictions, 5*(1), 32–40. https://doi.org/10.1556/2006.5.2016.012.
Jorm, A. F. (2015). Using the Delphi expert consensus method in mental health research. *Australian & New Zealand Journal of Psychiatry, 49*(10), 887–897. https://doi.org/10.1177/0004867415600891.
Kalivas, P. W., & Volkow, N. D. (2005). The neural basis of addiction: A pathology of motivation and choice. *American Journal of Psychiatry, 162*(8), 1403–1413. https://doi.org/10.1176/appi.ajp.162.8.1403.
Keles, H. O., Radoman, M., Pachas, G. N., Evins, A. E., & Gilman, J. M. (2017). Using functional near-infrared spectroscopy to measure effects of delta 9-tetrahydrocannabinol on prefrontal activity and working memory in cannabis users. *Frontiers in Human Neuroscience, 11*, 488. https://doi.org/10.3389/fnhum.2017.00488.
Kendler, K. S., Zachar, P., & Craver, C. (2011). What kinds of things are psychiatric disorders? *Psychological Medicine, 41*(6), 1143–1150. https://doi.org/10.1017/S0033291710001844.
Keren, G. (2013). A tale of two systems: A scientific advance or a theoretical stone soup? Commentary on Evans & Stanovich (2013). *Perspectives on Psychological Science, 8*(3), 257–262. https://doi.org/10.1177/1745691613483474.
Keren, G., & Schul, Y. (2009). Two is not always better than one. A critical evaluation of two-system theories. *Perspectives on Psychological Science, 4*(6), 533–550. https://doi.org/10.1111/j.1745-6924.2009.01164.x.
Khalsa, S. S., Rudrauf, D., Feinstein, J. S., & Tranel, D. (2009). The pathways of interoceptive awareness. *Nature Neuroscience, 12*(12), 1494–1496. https://doi.org/10.1038/nn.2411.
Kinderman, P., & Tai, S. (2007). Empirically grounded clinical interventions clinical: Implications of a psychological model of mental disorder. *Behavioural and Cognitive Psychotherapy, 35*(1), 1–14. https://doi.org/10.1017/S1352465806003274.
Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology: General, 128*(1), 78–87. https://doi.org/10.1037/0096-3445.128.1.78.
Kirchner, W. K. (1958). Age differences in short-term retention of rapidly changing information. *Journal of Experimental Psychology, 55*(4), 352–358. https://doi.org/10.1037/h0043688.
Koob, G. F., & Le Moal, M. (2001). Drug addiction, dysregulation of reward, and allostasis. *Neuropsychopharmacology, 24*(2), 97–129. https://doi.org/10.1016/S0893-133X(00)00195-0.
Kornreich, C., Saeremans, M., Delwarte, J., Noël, X., Campanella, S., Verbanck, P., Ermer, E., & Brevers, D. (2016). Impaired non-verbal emotion processing in pathological gamblers. *Psychiatry Research, 236*(28), 125–129. https://doi.org/10.1016/j.psychres.2015.12.020.
Krmpotich, T., Mikulich-Gilbertson, S., Sakai, J., Thompson, L., Banich, M. T., & Tanabe, J. (2015). Impaired decision-making, higher impulsivity, and drug severity in substance dependence and pathological gambling. *Journal of Addiction Medicine, 9*(4), 273–280. https://doi.org/10.1097/ADM.0000000000000129.
Larøi, F., & Van der Linden, M. (2013). The need for an individualized, everyday life and integrative approach to cognitive remediation in schizophrenia. *Journal of Psychotherapy Integration, 23*(3), 290–304. https://doi.org/10.1037/a0032358.
Lannoy, S., D'Hondt, F., Dormal, V., Billieux, J., & Maurage, P. (2017). Electrophysiological correlates of performance monitoring in binge drinking: Impaired error-related but preserved feedback processing. *Clinical Neurophysiology, 128*(11), 2110–2121. https://doi.org/10.1016/j.clinph.2017.08.005.
Ledgerwood, D. M., Orr, E. S., Kaploun, K. A., Milosevic, A., Frisch, G. R., Rupcich, N., & Lundahl, L. H. (2012). Executive function in pathological gamblers and healthy controls. *Journal of Gambling Studies, 28*(1), 89–103. https://doi.org/10.1007/s10899-010-9237-6.
Leekam, S. R., & Ramsden, C. A. H. (2006). Dyadic orienting and joint attention in preschool children with autism. *Journal of Autism and Developmental Disorders, 36*(2), 185–197. https://doi.org/10.1007/s10803-005-0054-1.
Lejuez, C. W., Aklin, W., Bornovalova, M., & Moolchan, E. T. (2005). Differences in risk-taking propensity across inner-city adolescent ever- and never-smokers. *Nicotine & Tobacco Research, 7*(1), 71–79. https://doi.org/10.1080/14622200412331328484.
Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., et al. (2002). Evaluation of a behavioral measure of risk taking: The balloon analogue risk task (BART). *Journal of Experimental Psychology: Applied, 8*(2), 75–84. https://doi.org/10.1037//1076-898X.8.2.75.
Leppink, E. W., Redden, S. A., Chamberlain, S. R., & Grant, J. E. (2016). Cognitive flexibility correlates with gambling severity in young adults. *Journal of Psychiatric Research, 81*, 9–15. https://doi.org/10.1016/j.jpsychires.2016.06.010.
Lesage, E., Aronson, S. E., Sutherland, M. T., Ross, T. J., Salmeron, B. J., & Stein, E. A. (2017). Neural signatures of cognitive flexibility and reward sensitivity following nicotinic receptor stimulation in dependent smokers: A randomized trial. *JAMA Psychiatry, 74*(6), 632–640. https://doi.org/10.1001/jamapsychiatry.2017.0400.
Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging, 17*(4), 677–689. https://doi.org/10.1037//0882-7974.17.4.677.
Littel, M., van den Berg, I., Luijten, M., van Rooij, A. J., Keemink, L., & Franken, I. H. A. (2012). Error processing and response inhibition in excessive computer game players: An event-related potential study. Addiction Biology, 17(5), 934–947. https://doi.org/10.1111/j.1369-1600.2012.00467.x.
Luijten, M., Veltman, D. J., Hester, R., Smits, M., Nijs, I. M. T., Pepplinkhuizen, L., & Franken, I. H. A. (2013). The role of dopamine in inhibitory control in smokers and non-smokers: A

pharmacological fMRI study. *European Neuropsychopharmacology, 23*(10), 1247–1256. https://doi.org/10.1016/j.euroneuro.2012.10.017.

Maij, D. L., van de Wetering, B. J., & Franken, I. H. (2017). Cognitive control in young adults with cannabis use disorder: An event-related brain potential study. *Journal of Psychopharmacology, 31*(8), 1015–1026. https://doi.org/10.1177/0269881117719262.

Maniscalco, B., & Lau, H. (2012). A signal detection theoretic approach for estimating metacognitive sensitivity from confidence ratings. *Consciousness and Cognition, 21*(1), 422–430. https://doi.org/10.1016/j.concog.2011.09.021.

Manning, V., Staiger, P. K., Hall, K., Garfield, J. B. B., Flaks, G., Leung, D., et al. (2016). Cognitive bias modification training during inpatient alcohol detoxification reduces early relapse: A randomized controlled trial. *Alcoholism, Clinical and Experimental Research, 40*(9), 2011–2019. https://doi.org/10.1111/acer.13163.

Marhe, R., Waters, A. J., van de Wetering, B. J. M., & Franken, I. H. A. (2013). Implicit and explicit drug-related cognitions during detoxification treatment are associated with drug relapse: An ecological momentary assessment study. *Journal of Consulting and Clinical Psychology, 81*(1), 1–12. https://doi.org/10.1037/a0030754.

Marissen, M. A. E., Franken, I. H. A., Waters, A. J., Blanken, P., van den Brink, W., & Hendriks, V. M. (2006). Attentional bias predicts heroin relapse following treatment. *Addiction, 101*(9), 1306–1312. https://doi.org/10.1111/j.1360-0443.2006.01498.x.

Marks, K. R., Roberts, W., Stoops, W. W., Pike, E., Fillmore, M. T., & Rush, C. R. (2014). Fixation time is a sensitive measure of cocaine cue attentional bias. *Addiction, 109*(9), 1501–1508. https://doi.org/10.1111/add.12635.

Martin Braunstein, L., Kuerbis, A., Ochsner, K., & Morgenstern, J. (2016). Implicit alcohol approach and avoidance tendencies predict future drinking in problem drinkers. *Alcoholism, Clinical and Experimental Research, 40*(9), 1945–1952. https://doi.org/10.1111/acer.13151.

Martinotti, G., Di Nicola, M., Tedeschi, D., Cundari, S., & Janiri, L. (2009). Empathy ability is impaired in alcohol-dependent patients. *The American Journal on Addictions, 18*(2), 157–161. https://doi.org/10.1080/10550490802544391.

Maurage, P., D'Hondt, F., de Timary, P., Mary, C., Franck, N., & Peyroux, E. (2016). Dissociating affective and cognitive theory of mind in recently detoxified alcohol-dependent individuals. *Alcoholism, Clinical and Experimental Research, 40*(9), 1926–1934. https://doi.org/10.1111/acer.13155.

Mayer, A. R., Wilcox, C. E., Dodd, A. B., Klimaj, S. D., Dekonenko, C. J., Claus, E. D., & Bogenschutz, M. (2016). The efficacy of attention bias modification therapy in cocaine use disorders. *The American Journal of Drug and Alcohol Abuse, 42*(4), 459–468. https://doi.org/10.3109/00952990.2016.1151523.

McAlonan, K., & Brown, V. J. (2003). Orbital prefrontal cortex mediates reversal learning and not attentional set shifting in the rat. *Behavioral Brain Research, 146*(1–2), 97–103. https://doi.org/10.1016/j.bbr.2003.09.019.

McCarthy, D. M., & Thompsen, D. M. (2006). Implicit and explicit measures of alcohol and smoking cognitions. *Psychology of Addictive Behaviors, 20*(4), 436–444. https://doi.org/10.1037/0893-164X.20.4.436.

McClure, S. M., & Bickel, W. K. (2014). A dual-systems perspective on addiction: Contributions from neuroimaging and cognitive training. *Annals of the New York Academy of Sciences, 1327*, 62–78. https://doi.org/10.1111/nyas.12561.

McLellan, A. T., Lewis, D. C., O'Brien, C. P., & Kleber, H. D. (2000). Drug dependence, a chronic medical illness: Implications for treatment, insurance, and outcomes evaluation. *JAMA, 284*(13), 1689–1695. https://doi.org/10.1001/jama.284.13.1689.

Mercuri, K., Terrett, G., Bailey, P. E., Henry, J. D., Curran, H. V., & Rendell, P. G. (2016). Deconstructing the nature of episodic foresight deficits associated with chronic opiate use. *British Journal of Clinical Psychology, 55*(4), 401–413. https://doi.org/10.1111/bjc.12110.

Mercuri, K., Terrett, G., Henry, J. D., Bailey, P. E., Curran, H. V., & Rendell, P. G. (2015). Episodic foresight deficits in long-term opiate users. *Psychopharmacology, 232*(7), 1337–1345. https://doi.org/10.1007/s00213-014-3772-2.

Miller, W. R. (1996). What is a relapse? Fifty ways to leave the wagon. *Addiction, 91*(12), 15–28. https://doi.org/10.1046/j.1360-0443.91.12s1.6.x.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21*(1), 8–14. https://doi.org/10.1177/0963721411429458.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex « frontal lobe » tasks: A latent variable analysis. *Cognitive Psychology, 41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734.

Moccia, L., Pettorruso, M., De Crescenzo, F., De Risio, L., di Nuzzo, L., Martinotti, G., et al. (2017). Neural correlates of cognitive control in gambling disorder: A systematic review of fMRI studies. *Neuroscience and Biobehavioral Reviews, 78*, 104–116. https://doi.org/10.1016/j.neubiorev.2017.04.025.

Moeller, S. J., Fleming, S. M., Gan, G., Zilverstand, A., Malaker, P., d'Oleire Uquillas, F., et al. (2016). Metacognitive impairment in active cocaine use disorder is associated with individual differences in brain structure. *European Neuropsychopharmacology, 26*(4), 653–662. https://doi.org/10.1016/j.euroneuro.2016.02.009.

Moeller, S. J., Hajcak, G., Parvaz, M. A., Dunning, J. P., Volkow, N. D., & Goldstein, R. Z. (2012). Psychophysiological prediction of choice: Relevance to insight and drug addiction. *Brain, 135*(11), 3481–3494. https://doi.org/10.1093/brain/aws252.

Moeller, S. J., Konova, A. B., Parvaz, M. A., Tomasi, D., Lane, R. D., Fort, C., & Goldstein, R. Z. (2014). Functional, structural, and emotional correlates of impaired insight in cocaine addiction. *JAMA Psychiatry, 71*(1), 61–70. https://doi.org/10.1001/jamapsychiatry.2013.2833.

Moeller, S. J., Maloney, T., Parvaz, M. A., Alia-Klein, N., Woicik, P. A., Telang, F., et al. (2010). Impaired insight in cocaine addiction: Laboratory evidence and effects on cocaine-seeking behaviour. *Brain, 133*(5), 1484–1493. https://doi.org/10.1093/brain/awq066.

Mogg, K., Field, M., & Bradley, B. P. (2005). Attentional and approach biases for smoking cues in smokers: An investigation of competing theoretical views of addiction. *Psychopharmacology, 180*(2), 333–341. https://doi.org/10.1007/s00213-005-2158-x.

Monsell, S. (1996). Control of mental processes. In V. Bruce (Ed.), *Unsolved mysteries of the mind: Tutorial essays in cognition* (pp. 93–148). Hove: Erlbaum.

Moos, R. H., & Moos, B. S. (2006). Rates and predictors of relapse after natural and treated remission from alcohol use disorders. *Addiction, 101*(2), 212–222. https://doi.org/10.1111/j.1360-0443.2006.01310.x.

Moreno, M., Estevez, A. F., Zaldivar, F., Montes, J. M. G., Gutiérrez-Ferre, V. E., Esteban, L., et al. (2012). Impulsivity differences in recreational cannabis users and binge drinkers in a university population. *Drug and Alcohol Dependence, 124*(3), 355–362. https://doi.org/10.1016/j.drugalcdep.2012.02.011.

Morie, K. P., De Sanctis, P., Garavan, H., & Foxe, J. J. (2014). Executive dysfunction and reward dysregulation: A high-density electrical mapping study in cocaine abusers. *Neuropharmacology, 85*, 397–407. https://doi.org/10.1016/j.neuropharm.2014.05.016.

Mukherjee, K. (2010). A dual system model of preferences under risk. *Psychological Review, 117*(1), 243–255. https://doi.org/10.1037/a0017884.

Nandrino, J.-L., & Gandolphe, M.-C. (2017). Characterization of self-defining memories in individuals with severe alcohol use disorders after mid-term abstinence: The impact of the emotional valence of memories. *Alcoholism: Clinical and Experimental Research, 41*(8), 1484–1491. https://doi.org/10.1111/acer.13424.

Nandrino, J.-L., El Haj, M., Torre, J., Naye, D., Douchet, H., Danel, T., & Cottençin, O. (2016). Autobiographical memory deficits in alcohol-dependent patients with short- and long-term abstinence. *Alcoholism: Clinical and Experimental Research, 40*(4), 865–873. https://doi.org/10.1111/acer.13001.

Naqvi, N. H., & Bechara, A. (2010). The insula and drug addiction: An interoceptive view of pleasure, urges, and decision-making. *Brain Structure & Function, 214*(5–6), 435–450. https://doi.org/10.1007/s00429-010-0268-7.

Naqvi, N. H., Rudrauf, D., Damasio, H., & Bechara, A. (2007). Damage to the insula disrupts addiction to cigarette smoking. *Science, 315*(5811), 531–534. https://doi.org/10.1126/science.1135926.

Newell, B., & Shanks, D. (2014). Unconscious influence on decision making: A critical review. *Behavioral and Brain Sciences, 37*(1), 1–19. https://doi.org/10.1017/S0140525X12003214.

Noël, X., Bechara, A., Dan, B., Hanak, C., & Verbanck, P. (2007). Response inhibition deficit is involved in poor decision making under risk in nonamnesic individuals with alcoholism. *Neuropsychology, 21*(6), 778–786. https://doi.org/10.1037/0894-4105.21.6.778.

Noël, X., Billieux, J., Van der Linden, M., Dan, B., de Bournonville, S., Hanak, C., & Verbanck, P. (2009). Impaired inhibition of proactive interference in abstinent individuals with alcoholism. *Journal of Clinical and Experimental Neuropsychology, 31*(1), 57–64. https://doi.org/10.1080/13803390801982726.

Noël, X., Brevers, D., & Bechara, A. (2013a). A neurocognitive approach to understanding the neurobiology of addiction. *Current Opinion in Neurobiology, 23*(4), 632–638. https://doi.org/10.1016/j.conb.2013.01.018.

Noël, X., Brevers, D., & Bechara, A. (2013b). A triadic neurocognitive approach to addiction for clinical interventions. *Frontiers in Psychiatry, 4*, 179. https://doi.org/10.3389/fpsyt.2013.00179.

Noël, X., Van der Linden, M., Brevers, D., Campanella, S., Verbanck, P., Hanak, C., et al. (2013c). Separating intentional inhibition of prepotent responses and resistance to proactive interference in alcohol-dependent individuals. *Drug and Alcohol Dependence, 128*(3), 200–205. https://doi.org/10.1016/j.drugalcdep.2012.08.021.

Noël, X., Jaafari, N., & Bechara, A. (2017a). Addictive behaviors: Why and how impaired mental time matters? *Progress in Brain Research, 235*, 219–237. https://doi.org/10.1016/bs.pbr.2017.07.011.

Noël, X., Saeremans, M., Kornreich, C., Jaafari, N., & D'Argembeau, A. (2017b). Future-oriented mental time travel in individuals with disordered gambling. *Consciousness and Cognition, 49*, 227–236. https://doi.org/10.1016/j.concog.2017.02.006.

O'Doherty, J. P., Cockburn, J., & Pauli, W. M. (2017). Learning, reward, and decision making. *Annual Review of Psychology, 68*(1), 73–100. https://doi.org/10.1146/annurev-psych-010416-044216.

Onuoha, R. C., Quintana, D. S., Lyvers, M., & Guastella, A. J. (2016). A meta-analysis of theory of mind in alcohol use disorders. *Alcohol and Alcoholism, 51*(4), 410–415. https://doi.org/10.1093/alcalc/agv137.

Papageorgiou, C., Rabavilas, A., Liappas, I., & Stefanis, C. (2003). Do obsessive-compulsive patients and abstinent heroin addicts share a common psychophysiological mechanism? *Neuropsychobiology, 47*(1), 1–11. https://doi.org/10.1159/000068868.

Patterson, F., Jepson, C., Loughead, J., Perkins, K., Strasser, A. A., Siegel, S., et al. (2010). Working memory deficits predict short-term smoking resumption following brief abstinence. *Drug and Alcohol Dependence, 106*(1), 61–64. https://doi.org/10.1016/j.drugalcdep.2009.07.020.

Pauli, W. M., & O'Reilly, R. C. (2008). Attentional control of associative learning—A possible role of the central cholinergic system. *Brain Research, 1202*, 43–53. https://doi.org/10.1016/j.brainres.2007.06.097.

Paulus, M. P., & Stewart, J. L. (2014). Interoception and drug addiction. *Neuropharmacology, 76*(Pt B), 342–350. https://doi.org/10.1016/j.neuropharm.2013.07.002.

Paulus, M. P., Tapert, S. F., & Schulteis, G. (2009). The role of interoception and alliesthesia in addiction. *Pharmacology, Biochemistry, and Behavior, 94*(1), 1–7. https://doi.org/10.1016/j.pbb.2009.08.005.

Paydary, K., Mahin Torabi, S., SeyedAlinaghi, S., Noori, M., Noroozi, A., Ameri, S., & Ekhtiari, H. (2016). Impulsivity, sensation seeking, and risk-taking behaviors among HIV-positive and HIV-negative heroin dependent persons. *AIDS Research and Treatment, 2016*, 5323256. https://doi.org/10.1155/2016/5323256.

Payne, B. K., Cheng, C. M., Govorun, O., & Stewart, B. D. (2005). An inkblot for attitudes: Affect misattribution as implicit measurement. *Journal of Personality and Social Psychology, 89*(3), 277–293. https://doi.org/10.1037/0022-3514.89.3.277.

Payne, B. K., McClernon, F. J., & Dobbins, I. G. (2007). Automatic affective responses to smoking cues. *Experimental and Clinical Psychopharmacology, 15*(4), 400–409. https://doi.org/10.1037/1064-1297.15.4.400.

Pessoa, L. (2017). A network model of the emotional brain. *Trends in Cognitive Sciences, 21*(5), 357–371. https://doi.org/10.1016/j.tics.2017.03.002.

Pfefferbaum, A., Desmond, J. E., Galloway, C., Menon, V., Glover, G. H., & Sullivan, E. V. (2001). Reorganization of frontal systems used by alcoholics for spatial working memory: An fMRI study. *NeuroImage, 14*(1), 7–20. https://doi.org/10.1006/nimg.2001.0785.

Poppa, T., & Bechara, A. (2018). The somatic marker hypothesis: Revisiting the role of the 'body-loop' in decision-making. *Current Opinion in Behavioral Sciences, 19*, 61–66. https://doi.org/10.1016/j.cobeha.2017.10.007.

Porges, S. (1993). Body perception questionnaire: Laboratory of development assessment. University of Maryland.

Powell, J., Dawkins, L., West, R., Powell, J., & Pickering, A. (2010). Relapse to smoking during unaided cessation: Clinical, cognitive and motivational predictors. *Psychopharmacology, 212*(4), 537–549. https://doi.org/10.1007/s00213-010-1975-8.

Ramaekers, J. G., Kauert, G., Theunissen, E. L., Toennes, S. W., & Moeller, M. R. (2009). Neurocognitive performance during acute THC intoxication in heavy and occasional cannabis users. *Journal of Psychopharmacology, 23*(3), 266–277. https://doi.org/10.1177/0269881108092393.

Redish, A. D., Jensen, S., & Johnson, A. (2008). Addiction as vulnerabilities in the decision process. *Behavioral and Brain Sciences, 31*(4), 461–487. https://doi.org/10.1017/S0140525X08004986.

Reinecke, A., Becker, E. S., & Rinck, M. (2010). Three indirect tasks assessing implicit threat associations and behavioral response tendencies. *Journal of Psychology, 218*(1), 4–11. https://doi.org/10.1027/0044-3409/a000002.

Rinck, M., & Becker, E. S. (2007). Approach and avoidance in fear of spiders. *Journal of Behavior Therapy and Experimental Psychiatry, 38*(2), 105–120. https://doi.org/10.1016/j.jbtep.2006.10.001.

Ring, C., Brener, J., Knapp, K., & Mailloux, J. (2015). Effects of heartbeat feedback on beliefs about heart rate and heartbeat counting: A cautionary tale about interoceptive awareness. *Biological Psychology, 104*, 193–198. https://doi.org/10.1016/j.biopsycho.2014.12.010.

Roberts, C. A., Fairclough, S., Fisk, J. E., Tames, F. T., & Montgomery, C. (2013). Electrophysiological indices of response inhibition in human polydrug users. *Journal of Psychopharmacology, 27*(9), 779–789. https://doi.org/10.1177/0269881113492899.

Roberts, A. C., Robbins, T. W., & Everitt, B. J. (1988). The effects of intradimensional and extradimensional shifts on visual discrimination learning in humans and non-human primates. *The Quarterly Journal of Experimental Psychology. B, Comparative and Physiological Psychology, 40*(4), 321–341. https://doi.org/10.1080/14640748808402328.

Robinson, T. E., & Berridge, K. C. (2003). Addiction. *Annual Review of Psychology, 54*, 25–53. https://doi.org/10.1146/annurev.psych.54.101601.145237.

Robinson, T. E., & Berridge, K. C. (2008). The incentive sensitization theory of addiction: Some current issues. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 363*(1507), 3137–3146. https://doi.org/10.1098/rstb.2008.0093.

Rogers, R. D., Owen, A. M., Middleton, H. C., Williams, E. J., Pickard, J. D., Sahakian, B. J., & Robbins, T. W. (1999). Choosing between small, likely rewards and large, unlikely rewards activates inferior and orbital prefrontal cortex. *Journal of Neuroscience, 19*(20), 9029–9038. https://doi.org/10.1523/JNEUROSCI.19-20-09029.1999.

Ruff, C. C., & Fehr, E. (2014). The neurobiology of rewards and values in social decision making. *Nature Reviews Neuroscience, 15*(8), 549–562. https://doi.org/10.1038/nrn3776.

Ryan, K. K., Mackillop, J., & Carpenter, M. J. (2013). The relationship between impulsivity, risk-taking propensity and nicotine dependence among older adolescent smokers. *Addictive Behaviors, 38*(1), 1431–1434. https://doi.org/10.1016/j.addbeh.2012.08.013.

Sadeghi, S., Ekhtiari, H., Bahrami, B., & Ahmadabadi, M. N. (2017). Metacognitive deficiency in a perceptual but not a memory task in methadone maintenance patients. *Scientific Reports, 7*(1), 7052. https://doi.org/10.1038/s41598-017-06707-w.

Sanvicente-Vieira, B., Kluwe-Schiavon, B., Corcoran, R., & Grassi-Oliveira, R. (2017). Theory of mind impairments in women with cocaine addiction. *Journal of Studies on Alcohol and Drugs, 78*(2), 258–267. https://doi.org/10.15288/jsad.2017.78.258.

Schellekens, A. F. A., de Bruijn, E. R. A., van Lankveld, C. A. A., Hulstijn, W., Buitelaar, J. K., de Jong, C. A. J., & Verkes, R. J. (2010). Alcohol dependence and anxiety increase error-related brain activity. *Addiction, 105*(11), 1928–1934. https://doi.org/10.1111/j.1360-0443.2010.03065.x.

Schepis, T. S., McFetridge, A., Chaplin, T. M., Sinha, R., & Krishnan-Sarin, S. (2011). A pilot examination of stress-related changes in impulsivity and risk taking as related to smoking status and cessation outcome in adolescents. *Nicotine & Tobacco Research, 13*(7), 611–615. https://doi.org/10.1093/ntr/ntr022.

Schiebener, J., & Brand, M. (2015). Decision making under objective risk conditions - a review of cognitive and emotional correlates, strategies, feedback processing, and external influences. *Neuropsychology Review, 25*(2), 171–198. https://doi.org/10.1007/s11065-015-9285-x.

Schiebener, J., & Brand, M. (2017). Decision making and related processes in internet gaming disorder and other types of internet-use disorders. *Current Addiction Reports, 4*(3), 262–271. https://doi.org/10.1007/s40429-017-0156-9.

Schmidt, A. F., Eulenbruch, T., Langer, C., & Banger, M. (2013). Interoceptive awareness, tension reduction expectancies and self-reported drinking behavior. *Alcohol and Alcoholism, 48*(4), 472–477. https://doi.org/10.1093/alcalc/agt024.

Schoenmakers, T. M., de Bruin, M., Lux, I. F. M., Goertz, A. G., Van Kerkhof, D. H. A. T., & Wiers, R. W. (2010). Clinical effectiveness of attentional bias modification training in abstinent alcoholic patients. *Drug and Alcohol Dependence, 109*, 30–36. https://doi.org/10.1016/j.drugalcdep.2009.11.022.

Shanks, D. R. (2009). The associative nature of human associative learning. *Behavioral and Brain Sciences, 32*(2), 225–226. https://doi.org/10.1017/S0140525X09001149.

Sharbanee, J. M., Hu, L., Stritzke, W. G. K., Wiers, R. W., Rinck, M., & MacLeod, C. (2014). The effect of approach/avoidance training on alcohol consumption is mediated by change in alcohol action tendency. *PLoS One, 9*(1), e85855. https://doi.org/10.1371/journal.pone.0085855.

Simon, H. A. (1979). Rational decision making in business organizations. *The American Economic Review, 69*(4), 493–513.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119*(1), 3–22. https://doi.org/10.1037/0033-2909.119.1.3.

Smith, J. L., Mattick, R. P., Jamadar, S. D., & Iredale, J. M. (2014). Deficits in behavioural inhibition in substance abuse and addiction: A meta-analysis. *Drug and Alcohol Dependence, 145*, 1–33. https://doi.org/10.1016/j.drugalcdep.2014.08.009.

Sokhadze, E., Stewart, C., Hollifield, M., & Tasman, A. (2008). Event-related potential study of executive dysfunctions in a speeded reaction task in cocaine addiction. *Journal of Neurotherapy, 12*(4), 185–204. https://doi.org/10.1080/10874200802502144.

Sokol-Hessner, P., Hartley, C. A., Hamilton, J. R., & Phelps, E. A. (2015). Interoceptive ability predicts aversion to losses. *Cognition and Emotion, 29*(4), 695–701. https://doi.org/10.1080/02699931.2014.925426.

Sönmez, M. B., Kılıç, E. K., Çöl, I. A., Görgülü, Y., & Çınar, R. K. (2017). Decreased interoceptive awareness in patients with substance use disorders. *Journal of Substance Use, 22*(1), 60–65. https://doi.org/10.3109/14659891.2016.1143048.

Spechler, P. A., Chaarani, B., Hudson, K. E., Potter, A., Foxe, J. J., & Garavan, H. (2016). Response inhibition and addiction medicine: From use to abstinence. *Progress in Brain Research, 223*, 143–164. https://doi.org/10.1016/bs.pbr.2015.07.024.

Spronk, D. B., Verkes, R. J., Cools, R., Franke, B., Van Wel, J. H. P., Ramaekers, J. G., & De Bruijn, E. R. A. (2016). Opposite effects of cannabis and cocaine on performance monitoring. *European Neuropsychopharmacology, 26*(7), 1127–1139. https://doi.org/10.1016/j.euroneuro.2016.03.015.

Spruyt, A., De Houwer, J., Tibboel, H., Verschuere, B., Crombez, G., Verbanck, P., et al. (2013). On the predictive validity of automatically activated approach/avoidance tendencies in abstaining alcohol-dependent patients. *Drug and Alcohol Dependence, 127*(1–3), 81–86. https://doi.org/10.1016/j.drugalcdep.2012.06.019.

Stavro, K., Pelletier, J., & Potvin, S. (2013). Widespread and sustained cognitive deficits in alcoholism: A meta-analysis. *Addiction Biology, 18*(2), 203–213. https://doi.org/10.1111/j.1369-1600.2011.00418.x.

Stevens, L., Verdejo-García, A., Goudriaan, A. E., Roeyers, H., Dom, G., & Vanderplasschen, W. (2014). Impulsivity as a vulnerability factor for poor addiction treatment outcomes: A review of neurocognitive findings among individuals with substance use disorders. *Journal of Substance Abuse Treatment, 47*(1), 58–72. https://doi.org/10.1016/j.jsat.2014.01.008.

Stone, V. E., Baron-Cohen, S., & Knight, R. T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience, 10*, 640–656. https://doi.org/10.1162/089892998562942.

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*(3), 220–247. https://doi.org/10.1207/s15327957pspr0803_1.

Tabibnia, G., Monterosso, J. R., Baicy, K., Aron, A. R., Poldrack, R. A., Chakrapani, S., et al. (2011). Different forms of self-control share a neurocognitive substrate. *Journal of Neuroscience, 31*(13), 4805–4810. https://doi.org/10.1523/JNEUROSCI.2859-10.2011.

Tapert, S. F., Schweinsburg, A. D., Drummond, S. P. A., Paulus, M. P., Brown, S. A., Yang, T. T., & Frank, L. R. (2007). Functional MRI of inhibitory processing in abstinent adolescent marijuana users. *Psychopharmacology, 194*(2), 173–183. https://doi.org/10.1007/s00213-007-0823-y.

Tello, N., Bocage-Barthélémy, Y., Dandaba, M., Jaafari, N., & Chatard, A. (2018). Evaluative conditioning: A brief computer-delivered intervention to reduce college student drinking. *Addictive Behaviors, 82*, 14–18. https://doi.org/10.1016/j.addbeh.2018.02.018.

Thoma, P., Winter, N., Juckel, G., & Roser, P. (2013). Mental state decoding and mental state reasoning in recently detoxified alcohol-dependent individuals. *Psychiatry Research, 205*(3), 232–240. https://doi.org/10.1016/j.psychres.2012.08.042.

Tomei, A., Besson, J., & Grivel, J. (2017). Linking empathy to visuospatial perspective-taking in gambling addiction. *Psychiatry Research, 250*, 177–184. https://doi.org/10.1016/j.psychres.2016.12.061.

Torres, A., Catena, A., Cándido, A., Maldonado, A., Megías, A., & Perales, J. C. (2013). Cocaine dependent individuals and gamblers present different associative learning anomalies in feedback-driven decision making: A behavioral and ERP study. *Frontiers in Psychology, 4*, 122. https://doi.org/10.3389/fpsyg.2013.00122.

Townshend, J. M., & Duka, T. (2001). Attentional bias associated with alcohol cues: Differences between heavy and occasional social drinkers. *Psychopharmacology, 157*(1), 67–74. https://doi.org/10.1007/s002130100764.

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53*, 1–25. https://doi.org/10.1146/annurev.psych.53.100901.135114.

Turner, T. H., LaRowe, S., Horner, M. D., Herron, J., & Malcolm, R. (2009). Measures of cognitive functioning as predictors of treatment outcome for cocaine dependence. *Journal of Substance Abuse Treatment, 37*(4), 328–334. https://doi.org/10.1016/j.jsat.2009.03.009.

Valentine, G., & Sofuoglu, M. (2018). Cognitive effects of nicotine: Recent progress. *Current Neuropharmacology, 16*(4), 403–414. https://doi.org/10.2174/1570159X15666171103152136.

van Hemel-Ruiter, M. E., de Jong, P. J., Ostafin, B. D., & Wiers, R. W. (2015). Reward sensitivity, attentional bias, and executive control in early adolescent alcohol use. *Addictive Behaviors, 40*, 84–90. https://doi.org/10.1016/j.addbeh.2014.09.004.

Van der Plas, E. A., Crone, E. A., van den Wildenberg, W. P., Tranel, D., & Bechara, A. (2009). Executive control deficits in substance-dependent individuals: A comparison of alcohol, cocaine, and methamphetamine and of men and women. *Journal of Clinical and Experimental Neuropsychology, 31*(6), 706–719. https://doi.org/10.1080/13803390802484797.

Vanes, L. D., van Holst, R. J., Jansen, J. M., van den Brink, W., Oosterlaan, J., & Goudriaan, A. E. (2014). Contingency learning in alcohol dependence and pathological gambling: Learning and unlearning reward contingencies. *Alcoholism, Clinical and Experimental Research, 38*(6), 1602–1610. https://doi.org/10.1111/acer.12393.

Verbaten, M. N. (2010). Deterioration of executive functioning in chronic ecstasy users: Evidence for multiple drugs effects. *Current Drug Abuse Reviews, 3*(3), 129–138.

Verbruggen, F., & Logan, G. D. (2008). Response inhibition in the stop-signal paradigm. *Trends in Cognitive Sciences, 12*(11), 418–424. https://doi.org/10.1016/j.tics.2008.07.005.

Verdejo-Garcia, A., Chong, T. T.-J., Stout, J. C., Yücel, M., & London, E. D. (2018). Stages of dysfunctional decision-making in addiction. *Pharmacology Biochemistry and Behavior, 164*, 99–105. https://doi.org/10.1016/j.pbb.2017.02.003.

Verdejo-Garcia, A., Clark, L., & Dunn, B. D. (2012). The role of interoception in addiction: A critical review. *Neuroscience and Biobehavioral Reviews, 36*(8), 1857–1869. https://doi.org/10.1016/j.neubiorev.2012.05.007.

Verdejo-García, A., Clark, L., Verdejo-Román, J., Albein-Urios, N., Martinez-Gonzalez, J. M., Gutierrez, B., & Soriano-Mas, C. (2015). Neural substrates of cognitive flexibility in cocaine and gambling addictions. *The British Journal of Psychiatry, 207*(2), 158–164. https://doi.org/10.1192/bjp.bp.114.152223.

Verdejo-García, A., & Pérez-García, M. (2007). Profile of executive deficits in cocaine and heroin polysubstance users: Common and differential effects on separate executive components. *Psychopharmacology, 190*(4), 517–530. https://doi.org/10.1007/s00213-006-0632-8.

Volkow, N. D., Fowler, J. S., & Wang, G.-J. (2003). The addicted human brain: Insights from imaging studies. *Journal of Clinical Investigation, 111*(10), 1444–1451. https://doi.org/10.1172/JCI18533.

Volkow, N. D., Wang, G.-J., Fowler, J. S., Tomasi, D., & Telang, F. (2011). Addiction: Beyond dopamine reward circuitry. *Proceedings of the National Academy of Sciences of the United States of America, 108*(37), 15037–15042. https://doi.org/10.1073/pnas.1010654108.

Volkow, N. D., Wang, G.-J., Fowler, J. S., Tomasi, D., Telang, F., & Baler, R. (2010). Addiction: Decreased reward sensitivity and increased expectation sensitivity conspire to overwhelm the brain's control circuit. *BioEssays, 32*(9), 748–755. https://doi.org/10.1002/bies.201000042.

Vujanovic, A. A., Wardle, M. C., Liu, S., Dias, N. R., & Lane, S. D. (2016). Attentional bias in adults with cannabis use disorders. *Journal of Addictive Diseases, 35*(2), 144–153. https://doi.org/10.1080/10550887.2015.1116354.

Wang, P.-W., Lin, H.-C., Wu, H.-C., Hsu, C.-Y., Chung, K.-S., Ko, C.-H., & Yen, C.-F. (2015). Explicit and implicit heroin-related cognitions and heroin use among patients receiving methadone maintenance treatment. *Comprehensive Psychiatry, 56*, 155–160. https://doi.org/10.1016/j.comppsych.2014.08.047.

Waters, A. J., Marhe, R., & Franken, I. H. A. (2012). Attentional bias to drug cues is elevated before and during temptations to use heroin and cocaine. *Psychopharmacology, 219*(3), 909–921. https://doi.org/10.1007/s00213-011-2424-z.

Waters, A. J., Shiffman, S., Sayette, M. A., Paty, J. A., Gwaltney, C. J., & Balabanis, M. H. (2003). Attentional bias predicts outcome in smoking cessation. *Health Psychology, 22*(4), 378–387. https://doi.org/10.1037/0278-6133.22.4.378.

Wei, L., Zhang, S., Turel, O., Bechara, A., & He, Q. (2017). A tripartite neurocognitive model of internet gaming disorder. *Frontiers in Psychiatry, 8*, 285. https://doi.org/10.3389/fpsyt.2017.00285.

Weinstein, A., Ben Abu, H., Timor, A., & Mama, Y. (2016). Delay discounting, risk-taking, and rejection sensitivity among individuals with internet and video gaming disorders. *Journal of Behavioral Addictions, 5*(4), 674–682. https://doi.org/10.1556/2006.5.2016.081.

Werner, N. S., Jung, K., Duschek, S., & Schandry, R. (2009). Enhanced cardiac perception is associated with benefits in decision-making. *Psychophysiology, 46*(6), 1123–1129. https://doi.org/10.1111/j.1469-8986.2009.00855.x.

Werner, N. S., Schweitzer, N., Meindl, T., Duschek, S., Kambeitz, J., & Schandry, R. (2013). Interoceptive awareness moderates neural activity during decision-making. *Biological Psychology, 94*(3), 498–506. https://doi.org/10.1016/j.biopsycho.2013.09.002.

Wesley, M. J., Lile, J. A., Fillmore, M. T., & Porrino, L. J. (2017). Neurophysiological capacity in a working memory task differentiates dependent from nondependent heavy drinkers and controls. *Drug and Alcohol Dependence, 175*, 24–35. https://doi.org/10.1016/j.drugalcdep.2017.01.029.

Whiteside, S. P., & Lynam, D. R. (2001). The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences, 30*(4), 669–689. https://doi.org/10.1016/S0191-8869(00)00064-7.

Wiers, R. W., van Woerden, N., Smulders, F. T. Y., & de Jong, P. J. (2002). Implicit and explicit alcohol-related cognitions in heavy and light drinkers. *Journal of Abnormal Psychology, 111*(4), 648–658. https://doi.org/10.1037/0021-843X.111.4.648.

Wiers, R. W., Bartholow, B. D., van den Wildenberg, E., Thush, C., Engels, R. C. M. E., Sher, K. J., et al. (2007a). Automatic and controlled processes and the development of addictive behaviors in adolescents: A review and a model. *Pharmacology, Biochemistry, and Behavior, 86*(2), 263–283. https://doi.org/10.1016/j.pbb.2006.09.021.

Wiers, R. W., Houben, K., & de Kraker, J. (2007b). Implicit cocaine associations in active cocaine users and controls. *Addictive Behaviors, 32*(6), 1284–1289. https://doi.org/10.1016/j.addbeh.2006.07.009.

Wiers, R. W., Rinck, M., Dictus, M., & van den Wildenberg, E. (2009). Relatively strong automatic appetitive action-tendencies in male carriers of the OPRM1 G-allele. *Genes, Brain, and Behavior, 8*(1), 101–106. https://doi.org/10.1111/j.1601-183X.2008.00454.x.

Wiers, R. W., Eberl, C., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2011). Retraining automatic action tendencies changes alcoholic patients' approach bias for alcohol and improves treatment outcome. *Psychological Science, 22*(4), 490–497. https://doi.org/10.1177/0956797611400615.

Wiers, R. W., Gladwin, T. E., Hofmann, W., Salemink, E., & Ridderinkhof, K. R. (2013). Cognitive bias modification and cognitive control training in addiction and related psychopathology: Mechanisms, clinical perspectives, and ways forward. *Clinical Psychological Science, 1*(2), 192–212. https://doi.org/10.1177/2167702612466547.

Wittekind, C. E., Feist, A., Schneider, B. C., Moritz, S., & Fritzsche, A. (2015). The approach-avoidance task as an online intervention in cigarette smoking: A pilot study. *Journal of Behavior Therapy and Experimental Psychiatry, 46*, 115–120. https://doi.org/10.1016/j.jbtep.2014.08.006.

Woicik, P. A., Urban, C., Alia-Klein, N., Henry, A., Maloney, T., Telang, F., Wang, G. J., Volkow, N. D., & Goldstein, R. Z. (2011). A pattern of perseveration in cocaine addiction may reveal neurocognitive processes implicit in the Wisconsin card sorting test. *Neuropsychologia, 49*, 1660–1669. https://doi.org/10.1016/j.neuropsychologia.2011.02.037.

World Health Organization (2018). ICD-11 for Mortality and Morbidity Statistics [Internet]. Geneva: World Health Organization; [updated 2018 Jun 18; cited 2018 Jun 19]. Available from: https://icd.who.int/browse11/l-m/en.

Woud, M. L., Maas, J., Wiers, R. W., Becker, E. S., & Rinck, M. (2016). Assessment of tobacco-related approach and attentional biases in smokers, cravers, ex-smokers, and non-smokers. *Frontiers in Psychology, 7*, 172. https://doi.org/10.3389/fpsyg.2016.00172.

Yen, J.-Y., Yen, C. F., Chen, C.-S., Tang, T.-C., Huang, T.-H., & Ko, C.-H. (2011). Cue-induced positive motivational implicit response in young adults with internet gaming addiction. *Psychiatry Research, 190*(2–3), 282–286. https://doi.org/10.1016/j.psychres.2011.07.003.

Yücel, M., & Lubman, D. I. (2007). Neurocognitive and neuroimaging evidence of behavioural dysregulation in human drug addiction: Implications for diagnosis, treatment and prevention. *Drug and Alcohol Review, 26*(1), 33–39. https://doi.org/10.1080/09595230601036978.

Yücel, M., Oldenhof, E., Ahmed, S., Belin, D., Billieux, J., Bowden-Jones, H., et al. (2018). A transdiagnostic dimensional approach towards a neuropsychological assessment for addiction: An international Delphi consensus study. *Addiction*. https://doi.org/10.1111/add.14424.

Zywiak, W. H., Westerberg, V. S., Connors, G. J., & Maisto, S. A. (2003). Exploratory findings from the reasons for drinking questionnaire. *Journal of Substance Abuse Treatment, 25*(4), 287–292. https://doi.org/10.1016/S0740-5472(03)00118-1.