



Review

Free will in addictive behaviors: A matter of definition

W. Miles Cox^{a,*}, Eric Klinger^b, Javad Salehi Fadardi^{a,c}^a Bangor University, Bangor, Wales, United Kingdom^b University of Minnesota, Morris, MN, United States^c Ferdowsi University of Mashhad, Mashhad, Iran

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ABSTRACT

Certain people are at risk for using alcohol or other drugs excessively and for developing problems with their use. Their susceptibility might arise from a variety of factors, including their genetic make-up, brain chemistry, family background, personality and other psychological variables, and environmental and sociocultural variables. Moreover, after substance use has become established, there are additional cognitive-motivational variables (e.g., substance-related attentional bias) that contribute to enacting behaviors consistent with the person's motivation to acquire and use the substance. People who are at such risk are likely to choose to use addictive substances even though doing so entails negative consequences. In the sense of complete freedom from being determined by causal factors, we believe that there is no such thing as free will, but defined as ability to make choices from among multiple options, even though the choices are ultimately governed by natural processes, addicted individuals are free to choose. Although they might appear unable to exercise this kind of free will in decisions about their substance use, addictive behaviors are ultimately always goal-directed and voluntary. Such goal pursuits manifest considerable flexibility. Even some severely addicted individuals can cease their use when the value of continuing the use abruptly declines or when the subjective cost of continuing the use is too great with respect to the incentives in other areas of their lives. Formal treatment strategies (e.g., contingency management, Systematic Motivational Counseling, cognitive training) can also be used to facilitate this reversal.

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Free will can be characterized in a number of different ways. According to Baumeister's (2014) definition, resting on that of Haggard, Mele, O'Connor, and Vohs (2010), free will is "the capacity for free action [which means] that the person could do different things in the same situation" (p. 236). This definition is susceptible to varying interpretations.

First, one could take "could do" to mean that nothing in the physical environment or range of the person's physical capabilities could prevent the alternative actions and that there are no other constraints. A second interpretation of "could do" might focus on the process of choosing and rule out self-destructive choices that run strongly contrary to the chooser's values, such as drawing a gun on police officers (assuming that suicide is not valued positively) or publicly engaging in behavior that would inevitably be viewed by others as offensive, such as violating

* Corresponding author.

E-mail address: m.cox@bangor.ac.uk (W.M. Cox).

one's society's strict codes of dress or conduct (assuming that the person positively values social acceptance).

The distinction between these two interpretations is between free will in the sense of choosing according to one's preferences without regard to situational constraints, such as social pressure, versus in the sense of choosing according to one's preferences *realistically*, that is, in light of the foreseeable consequences, given the situational opportunities and constraints, if any. In other words, the exercise of *free will* is construed in the present article as choosing from among actions that are feasible given the existing physical limitations or insuperable social constraints. The physical constraints include those imposed by the limitations of brain functions, including brain pathologies (Fenton & Wiers, 2016) but also by the “balance between impulsive and reflective processes” (Wiers, Field, & Stacy, 2014, p. 39) that may be the result of the addictive substance itself. Otherwise, however, choices are determined by additional causal factors, such as reward sensitivity (Jonker et al., 2016; van Hemel-Ruiter, de Jong, Ostafin, & Wiers, 2015), executive processes such as goal inhibition (Goldstein, Volkow, Wang, Fowler, & Rajaram, 2001; van Hemel-Ruiter et al., 2015; Wiers, Boelema, Nikolaou, & Gladwin, 2015), goal motivation, goal value, and even goal prediction and availability (Volkow, Fowler, & Wang, 2004), memory associations (Ames et al., 2014) for the addictive behavior relative to associations for alternative goals to choose from, and, the alternative goals' values (Kalivas & Volkow, 2005), availability, and levels of automaticity. Ambivalence attributable to conflicts between foreseeable outcomes of a decision, for example between brief strong enjoyment and subsequent loss of an alternative opportunity, may render a decision difficult to make. It is nevertheless made “freely” in the sense of free will employed here.

A third possibility might be to interpret “could do” as making choices free from psychological determinants of action. Such determinants would include genetic determinants of neural and hormonal functions and situational elicitors of behavioral responses that have been previously shaped by environmental influences. This interpretation of free will would, however, deny a role for causality. It would accordingly be inconsistent with scientific understanding of human behavior (see also Baer, Kaufman, & Baumeister, 2008). In this latter sense, free will would not, from a conventionally deterministic scientific viewpoint, exist.

A critic might point to the human capacity for originality, for thinking of creative solutions, even surprising ones, including circumventing seemingly daunting obstacles to a goal pursuit. Having created a solution, the person then continues the goal pursuit in the newly indicated direction. From a scientific perspective, such solutions would result from previously established associative pathways in the brain, perhaps along with quasi-random confluences of stimuli that might lead to experiencing those associations in new ways. That is, the original or creative insights would still have been determined by the flow of prior events. In what sense, then, does this portray *freely* willed action?

Baumeister (2014) also noted that causality takes place at a variety of levels, from the atomic to the social; that the path from one level to another is often hard to trace; and that there is often a probabilistic factor that defies precise prediction of outcomes. None of these considerations, however, seems determinative regarding the existence of free will. The fact that at this time the relationships between levels are poorly understood cannot demonstrate the existence of free will. Neither can the existence of unexplainable probabilistic variation, inasmuch as will presumably directs behavior stably at particular outcomes that have certain properties of value and probability of attainability, as described briefly in a subsequent section. Does it make sense to equate “free” with irreducibly unexplainable?

In considering the role of free will in addiction, it is necessary to make some important distinctions. One of these is between free will and conscious choice, or conscious will, as Wegner (2002) puts it. It is entirely possible to view the causal chain that leads to actions, such as imbibing addictive substances, as either determined by concrete, predictive precursors or as freely chosen, unpredictable courses of action,

without committing to a position regarding the role of consciousness. Therefore, the very useful discussions regarding the causal role of consciousness in choice or will (e.g., Baumeister, Masicampo, & Vohs, 2011, 2015) are not necessarily relevant to the consideration of *free* will.

It should also be noted, however, that individuals' preferences to engage in one behavior versus another will have been shaped by their genetic endowment in interaction with their past experiences. As discussed in the next section, scientific advances now permit specifying physiological, psychological, and cultural differences among individuals, which together shape their preferences regarding their use of addictive substances. Whether one wishes to characterize the resulting choices as truly “free” depends on how one understands such freedom. Yes, people generally have a number of possible choices before them, in which case their choices are made freely, but in our view their ultimate choices are formed by the various physical and experiential determinants that we later describe.

In any event, to say that their choices have been predetermined is in no way inconsistent with the view that people can think critically and can often devise creative, even surprising solutions for reaching their goals. After all, individuals' patterns of thought, including their associative pathways that affect their creative solutions, rest on a foundation of brain functions and previous experiences that enable them to envision and map out their futures.

To obtain a sense of how free will is experienced in everyday life, Stillman, Baumeister, and Mele (2011) asked undergraduate student volunteers to describe instances in which their actions reflected the exercise of free will and other instances in which free will was not a factor, as, for instance, when the action was perceived as completed under duress. Raters then assessed the narratives with regard to a set of dimensions. The characteristic that best distinguished the two classes of action was described as goal attainment, which was rated much higher in narratives of freely chosen actions than in narratives of more constrained actions. This finding meshes nicely with the goal theory of current concerns (e.g., Klinger & Cox, 2011), which avoids pondering the concept of freedom of will but recognizes the centrality of goal pursuits in the brain's architecture and more broadly in the capacity for survival of members of the animal kingdom.

The sections that follow explore what is known about the motivational factors and constraints regarding alcohol use. It does so in order to assess the extent to which excessive alcohol consumption can be considered a free choice versus one over which the drinker lacks control.

1. The value of drinking alcohol

Cox and Klinger (1988, 1990, 2004, 2011a) have proposed a motivational model of alcohol use. The model summarizes the major variables that contribute to—or detract from—the value of drinking alcohol, and it shows how these variables pass through a motivational track that culminates in a person's decision to drink—or not to drink—alcohol. The decision to drink, or not to do so, is voluntary in the sense that the drinker can exercise control over it. Nevertheless, the nature of the control is itself predictable and determined. That is, for example, insofar as variables that increase the value of drinking alcohol apply to a particular individual, weight will be added to that person's decisions to drink alcohol as opposed to not doing so. Conversely, if variables that detract from the value of drinking alcohol apply to an individual, weight will be added to this person's decisions not to drink.

It is important to clarify how *value* is defined in the science of motivation. *Incentives* are the objects, events, or situations that have positive or negative value, in the sense that a person would like to get, obtain, or retain them (in the case of positive incentives), or the person would like to prevent, avoid, or be free of them (in the case of negative incentives). The value attributed to an incentive is, therefore, the expectation that a desirable change in the person's feeling—i.e., his or her *affect*—will occur if he or she acquires a positive incentive or gets rid of a negative incentive. Drinking alcohol might be a positive incentive for one person; it

might be a negative incentive for another person; or it more likely might have both positive and negative value for the same individual.

In the following sections, we discuss the major categories of variables that contribute to the positive or negative value of drinking alcohol. These variables include biological, sociocultural, environmental, and psychological factors. When, as a result of the influence of these variables, a person highly values drinking alcohol, there is a strong likelihood that he or she will choose to drink. In our view, this person will have freely (in the limited sense described above) decided to drink, even though the decision might be neither prudent nor healthy.

On a terminological note, it is important to recognize that the term *addiction* is descriptive and predictive but not explanatory. It labels a likelihood of repeated behaviors of a certain kind, typically behaviors disapproved of by the user of the term and most likely carrying serious disadvantages for the addicted individual, at least in the view of the person using the term *addicted*. The addictive behavior is commonly also ascribed to the addict's *inability* to cease use, but addiction reflects likelihood of choices, not lack of capability to act.

2. Drinking alcohol tends to run in families

It has long been recognized that excessive drinking and alcohol problems tend to run in families (Orford, 1984). However, the similarity in drinking patterns among family members could be due to (a) various environmental factors within the family context (Orford, 1984) that help to define the value of drinking for a particular family, (b) genetic factors that help to determine the extent to which drinking alcohol is pleasurable or aversive, or (c) the interaction between environmental and genetic factors. In an effort to separate the relative contribution of environmental and genetic factors to the development of alcohol use disorders (AUDs), studies have compared the prevalence of AUDs in monozygotic and dizygotic twins who were reared by their biological parents with those who were reared by adoptive parents. In a meta-analysis of these studies, Verhulst, Neale, and Kendler (2015) concluded that the heritability of AUDs is substantially greater than the proportion of shared environmental variance (0.49 versus 0.10).

But what is transmitted genetically that could cause an AUD to develop? Efforts are under way to identify the specific variations on the human genome that contribute to the genetic risk for AUDs (e.g., Juraeva et al., 2015; Yan et al., 2014; Ystrom, Kendler, & Reichborn-Kjennerud, 2014). Although progress has been made, the exact determinants of genetic risk for AUDs are not yet fully understood. Nevertheless, some conclusions can be drawn. For instance, the degree to which alcohol affects the neurotransmitters in the brain seems to be partly genetically determined (Tabakoff & Hoffman, 2013). For some individuals, alcohol might strongly reduce anxiety through the release of gamma-aminobutyric acid (GABA). For other people, drinking alcohol might strongly enhance reward-related stimuli through the release of dopamine (Berridge, 2007). Another reaction to alcohol that is likely genetically determined is the alcohol flush reaction (Dickson, James, Heath, et al., 2006). It includes a variety of unpleasant bodily reactions in people with a deficiency in aldehyde dehydrogenase—the enzyme that metabolizes acetaldehyde (the toxic first metabolite of alcohol)—when they drink alcohol. The alcohol flush reaction seems to be genetically determined in that deficits in aldehyde dehydrogenase are common among people of East Asian ancestry, unlike those of European ancestry (Dickson et al., 2006).

The various biochemical reactions to alcohol described here affect the value that individual drinkers place on drinking alcohol, either increasing or decreasing the degree of reward that a person derives from drinking alcohol. Again, when an individual attributes great value to drinking alcohol, that person will likely choose to drink. It is a decision that is freely made (in the limited sense described above) on the basis of the payoff that this person expects to derive from drinking.

3. Sociocultural and environmental influences

The value that a person attributes to drinking alcohol is also strongly influenced by the society in which the person lives (Greenfield & Room, 1997; Orford, 2001; Room, 2013; Wild, 2002). For instance, the society helps to define the circumstances in which it is appropriate to drink and how much alcohol should be drunk. Individuals within a society are explicitly and implicitly reinforced when their drinking corresponds to the societal norms, and they are explicitly and implicitly censured when their own drinking deviates from societal norms. These societal reactions to an individual's drinking help to solidify the value that each person places on drinking alcohol.

The differences in societal views about drinking are reflected in the patterns of alcohol consumption within particular countries. For example, an international study of heavy drinking among university students (Dantzer, Wardle, Fuller, Pampalona, & Steptoe, 2006) found that university students in some southern European countries (e.g., Italy, France, Greece) had low rates of heavy episodic drinking compared to students in some of the northern European countries (viz., Belgium, Ireland, Poland, Netherlands, Slovakia) and in North America (e.g., United States) and South America (e.g., Columbia). There were, however, exceptions to the general conclusion about the difference between northern and southern European countries in the rates of heavy drinking. For example, students in Germany, like those in Italy, had a low rate. Similar to the results of other studies, in school-based surveys from 13 European countries, Kuntsche et al. (2015) found that adolescents from southern and central Europe drank more frequently than those from northern Europe, but adolescents from northern European countries reported being intoxicated more frequently. The cultural differences in drinking seemed to be due to stronger social (e.g., “because it helps you enjoy a party”), enhancement (e.g., “because you like the feeling”), and coping (e.g., “because it helps you when you feel depressed or nervous”) motives for drinking in northern Europe than in southern and central Europe.

In addition to cultural attitudes about drinking within a society, environmental influences also affect the value that individuals place on drinking alcohol. Taxes and advertisements of alcohol are two such influences. For instance, it has been demonstrated that within particular countries, increases in taxes on alcohol lead to reductions in alcohol consumption generally and reductions specifically in binge and other kinds of excessive drinking that carry negative health-related consequences (Staras, Livingston, Christou, Jernigan, & Wagenaar, 2014; Xuan et al., 2015). Presumably, raising taxes on alcoholic beverages reduces money that might otherwise be used to purchase other positively valued goods and services or requiring additional negatively valued work to purchase them, thus increasing drinkers' ambivalence about drinking. Reductions in taxes, on the other hand, are associated with increases in consumption and consequent increases in alcohol-related morbidity and mortality (Zatoński, Sulowska, Zatoński, Herbec, & Muszyńska, 2015). In other words, tax increases lower the net value of drinking alcohol, thereby making it more likely that individuals will control their drinking; reductions in taxes have the opposite effect.

The goal of alcohol advertisements is, of course, to increase the attractiveness of drinking alcohol (i.e., its value), thereby increasing the amount of alcohol that people consume. Various research studies have clearly demonstrated that there is, in fact, a direct relationship between the amount of alcohol that people consume and their exposure to alcohol advertisements. This relationship, for example, has been demonstrated among underage drinkers with regard both to the amount of alcohol and the particular brands that they consume (Morgenstern, Isensee, Sargent, & Hanewinkel, 2011; Ross et al., 2014; Ross et al., 2015; Siegel et al. cited by Barry [2], 2015; Siegel et al., 2016), and it has also been shown that alcohol advertisements influence young people's perceptions of the normativeness of drinking (Martino et al., 2016). Conversely, restrictions on alcohol advertisements have been found to be inversely associated with the prevalence of hazardous drinking (Bosque-Prous et al., 2014).

Any of these sociocultural and environmental influences that add weight to the positive value that a person expects to derive from drinking alcohol will make it more likely that the person will actually decide to drink. Again, however, we emphasize that the decision is made voluntarily in the sense that nothing in the environment coerces it (Cox & Klinger, 1988, 1990, 2004, 2011a). This view is consistent with the view that addiction is a special case of—rather than an exception to—normal motivational processes (Köpetz, Lejuez, Wiers, & Kruglanski, 2013; Lewis, 2017; Orford, 2001), even in the case that the resulting behavior appears to be self-destructive (Köpetz et al., 2013).

4. Personality and other psychological factors

A personality characteristic that has often been identified as a risk factor for alcohol and other substance misuse is behavioral disinhibition (Bogg & Finn, 2010)—particularly in the form of impulsivity (Harnett, Lynch, Gullo, Dawe, & Loxton, 2013; Loxton, Bunker, Dingle, & Wong, 2015; Mackinnon, Kehayes, Clark, Sherry, & Stewart, 2014; Mikheeva & Tragesser, 2016; Thompson, Roemer, & Leadbeater, 2015; Wood, Dawe, & Gullo, 2013). Another such characteristic is negative emotionality (Mackinnon et al., 2014; Mikheeva & Tragesser, 2016). Impulsive individuals value drinking alcohol for the enhancement that it brings; depressed and anxious individuals value drinking because they perceive that it will alleviate their negative emotions.

Another factor that determines the value that drinking alcohol has for a particular individual is the other incentives in the person's life that are available, or potentially available, for the person to pursue and enjoy. Excessive drinkers, including those who develop an AUD, seem explicitly or implicitly to compare the value that they attribute to drinking alcohol with the value that they can derive from incentives in other areas of their lives (Cox & Klinger, 2011a). The chemical effects that drinkers seek to achieve from drinking alcohol occur rapidly, and the satisfaction that could be achieved from more distant goals might seem relatively unattractive, especially to drinkers who exhibit delay discounting, i.e., those who disproportionately devalue delayed rewards (Moody, Franck, Hatz, & Bickel, 2016). In fact, it has been demonstrated that as perceived access to other incentives decreases, people's motivation to drink alcohol increases (e.g., Vuchinich & Tucker, 1996, 1998). Additionally, it has been shown that problematic drinkers are more likely to resolve their drinking problem if they have a satisfying life and adequate resources for coping with frustrations (Cox, Schippers, Klinger, et al., 2002; Moos & Moos, 2007; Murphy, Correia, Colby, & Vuchinich, 2005; Tucker, Roth, Vignolo, & Westfall, 2009; Tucker, Vuchinich, Black, & Rippens, 2006). In short, drinkers who previously had a drinking problem have been able to resolve it if they perceive that they have access to sufficiently compelling competing incentives. Their decision to give up drinking would have been made in the same voluntary manner as their earlier decisions to imbibe. Specifically, it would have been made when drinkers came to view the downside of drinking alcohol as outweighing the value of continuing to drink. Such a decision might be made even among people who are severely addicted.

5. Are addictive behaviors motivated or automatic? A false dichotomy¹

One property frequently attributed to addiction is automaticity. That is, the behavior, such as alcohol consumption, follows uncontrollably from given circumstances. That property would appear to abrogate free will. What follows examines this idea as it applies to alcohol use.

To begin with, addictive behaviors are malleable with regard to both their forms and probability of occurrence. They are, like other behaviors beyond simple reflexes, goal-directed, and voluntary (see also, e.g., Heyman, 2009). That is, addicted individuals can voluntarily modify

their instrumental acts to accord with what is needed to obtain addictive substances in particular circumstances. Notwithstanding contrary opinions in the field that addictive behaviors, or at least some of their components, are *automatic* and beyond voluntary control, the evidence indicates that they are modifiable.

Automatic suggests that under given conditions a response has a high probability of occurring. It may also include acts that originate through unconscious processes (Huang & Bargh, 2014). Some authors (e.g., Feil et al., 2010) use the term “compulsive” to describe addictive instrumental (e.g., “seeking”) and consummatory (e.g., “taking”; Vanderschuren & Everitt, 2005) actions.

Such terms imply mechanical rigidity, but the literature indicates that behaviors associated with addiction are nevertheless modifiable. For example, automaticity is perhaps most often attributed to attentional biases. Yet such alcohol-related behaviors, though viewed as automatic action tendencies, can be changed through *cognitive bias modification* (Cox, Fadardi, Hosier, & Pothos, 2015; Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011) and mindfulness treatment (e.g., Witkiewitz, Lustyk, & Bowen, 2013). Evidence also indicates that most people who change their substance use do so on their own without formal treatment (e.g., Bischof, Rumpf, & John, 2012).

This is not to deny that ending or even moderating substance use may be difficult, often excruciatingly so. There is evidence of brain properties associated with addiction that may deepen the difficulty (Holton & Berridge, 2013; Koob, 2006). Repeated consumption of the addictive substance appears to shift value from consumption to procurement of the addictive substance and to reduce the subjective value of more natural kinds of rewards, such as food and social interaction (Kalivas & Volkow, 2005).

Nevertheless, in other respects addictions result from processes of the kind that produce strivings for high-value goals in general. That they are so highly valued gives at least the persistence and intensity of these goal pursuits the appearance of automaticity. However, goal-directedness is particularly characterized by responding to obstacles by altering one's responses, whether by increasing sheer forcefulness or trying novel approaches to circumvent the obstacles. Pioneer researcher Wolfgang Köhler (1925) labeled this response flexibility *Umweg* (detour) behavior.

The goal theory of current concerns, from its first formulations, recognized this principle by labeling the first stage following an encounter with an obstacle the invigoration stage (Klinger, 1975, 1977). When in need, addicts regularly display such detour behavior in the sometimes ingenious ways they find for obtaining or concealing their substances, such as diverting them from hospital stores and patients.

One route to apparent automaticity is repetition of goal-directed behavioral sequences. Frequently repeating sequences of initially separate actions integrates their action units into longer, relatively seamless action streams that require little conscious control to unfold, as in skilled playing of a musical instrument. However, opposing this kind of automatization (i.e., response integration, Klinger, 1971) to goal-directedness creates a false dichotomy. Even integrated action sequences are subject to modification according to circumstances, as when a violinist in a public performance voluntarily changes fingering to compensate for a suddenly broken string. Of course, such flexibility depends on a degree of practice and knowledge, but the point here is that the behavior is ruled by the desire to optimize attainment of goals and is not simply mechanical.

Another general principle is that having chosen to pursue a goal alters cognitive processing, beginning with changes in the individual's priorities for processing stimuli (Klinger, 1978, 2013). People become more attentive to all kinds of goal-related cues and are more likely to recall them and to think about them spontaneously. Consistent with this principle, alcohol addicts give processing priority to alcohol-related cues (Cox, Fadardi, & Pothos, 2006). These in turn further whet appetites for alcohol consumption (Cox et al., 2006; Field & Cox, 2008; Field, Duka, Tyler, & Schoenmakers, 2009a; Field, Munafo, & Franken, 2009b). A similar process operates with regard to food. Importantly from the standpoint of

¹ For an extended discussion of this topic, see Cox, Klinger, and Fadardi (2017).

modifiability, interfering with goal-related imagery reduces consumption (May, Kavanagh, & Andrade, 2015). Addicts also display heightened delay discounting, in which rewards of ostensibly equal general value for the individual are treated as if more valuable the sooner that they can be obtained. In the case of alcohol use, delay of potentially rewarding alternative activities thus discounts their value (see Cox et al., 2002; Noël, Bechara, Brevers, Verbanck, & Campanella, 2010).

The theory presented here shares some features with dual-process models of addiction (e.g., Moss & Albery, 2009; Wiers, Cox, Field, et al., 2006) in which automatic processes such as addiction-related attentional bias and controlled processes (deliberate responses) are both involved in addictive behaviors. Although both kinds of processes play a role in decisions about using an addictive substance, the decision, however conflicted and difficult, is in our view always ultimately under the person's voluntary control and remains goal-directed. The evidence suggests only that the drug-seeking behavior can become repetitive. Seeking a target (i.e., a goal object or event) such as an addictive substance remains under conscious control even if it is a habitual, seemingly automatized behavioral sequence triggered by internal or external cues.

As we have argued, addiction reflects a major shift in the relative incentive values of the substances that have attained the status of an individual's goal objects, both substance-related and other ones. In accordance with Expectancy X Value decision theory (Van Eerde & Thierry, 1996), this shift changes decisions and renders it more difficult (i.e., less likely) for a person to stop pursuing the addictive goal. As incentives and goals change in potency and nature (e.g., Kalivas & Volkow, 2005), the direction of decision-making also changes. Nevertheless, although values affect voluntary choices, the addictive behaviors are directly controlled by those voluntary choices rather than being purely pharmacologically, quasi-robotically controlled acts (see also Heyman, 1996, 2013; Russell & Davies, 2009). It is of interest that the extent to which interviewed drug users subsequently reduce their use is predicted by the extent to which they express commitment to such change in their interviews (Amrhein, Miller, Yahne, Palmer, & Fulcher, 2003).

Consistent with this view, even severely addicted individuals may undergo natural remission when further changes in values and expectancies produce the decision that the benefits of changing their addictive behavior outweigh the emotional costs of continuing the consumption of the addictive substance (Bischof et al., 2012). Addictive behaviors can, therefore, also succumb to the behavior-shaping administration of rewards and punishments as, for example, by applying contingency management treatments (Stitzer & Petry, 2006). Another approach that works on modifying the value and expectancy components of goal choices, Systematic Motivational Counseling (Cox & Klinger, 2011b), has also been found to generate changes in patterns of use (Cox et al., 2003; Fuhrmann, Schroer, & Jong-Meyer, 2011). The section that follows reviews the research on addiction-related cognitive biases and their modification, with resulting changes in consumption of substances.

6. Cognitive automaticity and free choice

The previous sections discussed how choices are intertwined with goal setting, goal management, and goal pursuits. Usually, even if people wish to, they cannot simply copy and paste ways of doing things. It is, however, also true that the majority of the daily activities that people undertake, even those involving preferences for food, art, sports, movies, and so on, follow an algorithm that has been established in the brain. The more often one repeats the behavior, the more established it becomes. This section discusses selective evidence on automatic cognitive processes that are not under conscious control and how they are related to decision-making and goal-seeking behaviors. The evidence described here challenges people's desire to implement their free will, especially with regard to well-established addictive behaviors, which entail strong emotions.

The emotionality that is associated with goal pursuits (referred to as *value*) has a great impact on the cognitive system, and the relationship is

reciprocal. In fact, theories and research suggest that sometimes decisions are totally intuitive or based on nonconscious inner (*visceral*) desires (see Dunn, Evans, Makarova, White, & Clark, 2012; M. J. Robinson, Fischer, Ahuja, Lesser, & Maniates, 2016).

With reference to one variety of apparent automatization, T. E. Robinson and colleagues (Robinson & Berridge, 1993, 2000, 2001, 2008) explained how repeating drug-use behaviors leads to alterations in the brain's reward circuits. They coined the term *incentive sensitization* to refer to these goal-specific brain pathways. M. J. Robinson et al. (2016) also argued that when incentive sensitization develops into *wanting* an object, i.e., experiencing a visceral desire for it (i.e., a nonconscious, inner desire), this initiates a behavioral chain of goal pursuits even in the absence of *liking* the object of the goal. Such visceral wanting can be triggered by sheer exposure to cues that are associated with the goal, which in the case of addictive behaviors might be stimuli related to alcohol, drugs, or forbidden food. This view is consistent with Tiffany's (1999) conclusion from reviewing cue-reactivity studies that cues can actually elicit visceral reactions, and that conscious feelings of *craving* are not a necessary part of substance use or of relapse (Wray, Gass, & Tiffany, 2013).

Executive cognitive functioning (ECF) is also important in emotion regulation and goal-related behaviors. Within ECF, two subsystems have been identified, each with distinctive, but to some extent overlapping, neural substrates that are involved in decision-making and motivated behavior. One is a so-called *hot* cognitive system, which is responsible for regulating affect, emotions, and behavior that is motivated toward achieving a valued goal (i.e., an incentive). The other is a so-called *cold* cognitive system, which is responsible for regulating less affective, abstract, and non-contextual tasks and problem solving (Dolcos & McCarthy, 2006; Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Jordan, Dolcos, & Dolcos, 2013).

There is evidence that overlapping brain regions are involved in both of these systems, but hot ECF has been found to be more strongly associated with the orbitofrontal cortex and ventromedial regions, both of which are connected to limbic areas that are associated with emotional and social processing. Cold ECF, on the other hand, is more strongly associated with dorsolateral prefrontal areas (Tsermentseli & Poland, 2016). There is evidence from neurocognitive research that people with a history of alcohol or other substance abuse have poorer cognitive and brain functioning related to both hot and cool ECF (Moreno-Lopez et al., 2012). Insofar as this suggests a possible causal connection, it indicates that alcohol and other drug abuse may impair the brain's loci that are responsible for a wide range of ECF, including inhibition, task switching, sustained attention, decision making, and planning (de la Monte & Kril, 2014; Smith, Simon Jones, Bullmore, Robbins, & Ersche, 2014; Terrett et al., 2014; Vonmoos et al., 2014). Such impairment may reduce the individual's ability to voluntarily inhibit or deflect particular goal pursuits.

Surprisingly, evidence suggests that the adverse effects of chemicals on the brain's executive functions can be traced to embryonic life. In one study, six-to-nine-year-old children whose mothers smoked during their pregnancy showed poorer performance on a task measuring hot ECF than children whose mothers were also smokers but who refrained from smoking during their pregnancy (Huijbregts, Warren, de Sonneville, & Swaab-Barneveld, 2008). These authors also observed a dose-response relationship in the children's performance. However, as far as impulsivity and disinhibition are concerned, a genetic factor could also be implicated in view of the fact that the mothers of children with better ECF were able to successfully refrain from smoking during their pregnancy.

It is interesting that anticipation of goal-related outcomes is mainly processed in amygdala in interaction with orbital prefrontal and anterior cingulate cortex. Moreover, the interactions among these structures affect one's cue reactivity, attentional bias, and response selections (Baxter, Parker, Lindner, Izquierdo, & Murray, 2000; Murray, 2007). Therefore, a mixture of habit development and adverse effects of the

abused chemicals on the brain contribute subtly to cognitive processes that underlie making decisions about whether to consume an addictive substance. Such nonconscious cognitive processes have been classified into two major types of biases: (a) attentional bias, and (b) interpretive bias. Both of these can be construed as a kind of automatization. However, as indicated later, this does not necessarily indicate that they are unmodifiable.

7. Attentional bias

Attentional bias for substance-related stimuli is one's tendency to readily perceive and attend to stimuli in the environment that are related to the person's substance use. It also can be construed as an automatized phenomenon, but, again, it turns out to be malleable. Furthermore, it parallels, and can be considered a particular instance of, attentional bias toward cues associated with any significant personal goal (Cox et al., 2006).

Attentional bias tasks are based on either facilitation or interference effects. Facilitation refers to easier detection of salient stimuli (e.g., a bottle of wine) among other kinds of stimuli (e.g., a bottle of a nonalcoholic beverage). Interference, by contrast, refers to difficulty in turning one's attention away from a salient stimulus (e.g., a bottle of wine) and paying attention to another kind of stimulus. For instance, in the emotional Stroop task, the participant's task is to ignore the meaning of a series of words (e.g., wine, table) and respond as quickly and accurately as possible to the color (e.g., red, blue, green, yellow) in which each word is presented. Each participant's interference score is calculated by subtracting the mean reaction time for naming the color of the neutral words (e.g., table) from the mean reaction time for naming the color of salient words (e.g., wine). Presumably, the semantic meaning of the salient word takes processing priority over the focus prescribed by the task, the color of the word's font, thus delaying identification of the color. The interference score is a measure of the person's attentional bias for the salient category (e.g., alcohol).

Studies suggest that indicants of individuals' cold ECF, such as impulsivity or poor inhibitory control, are correlated with their performance on attentional bias tasks (e.g., Liu et al., 2011). Therefore, it is important to establish whether (a) longer response times on measures of attentional bias can be attributed to the substance-related characteristics of the stimuli, or (b) longer response times simply result from participants' impaired ECF. Fardard and Cox (2006) used a regression model to control for alcohol abusers' impaired ECF and concluded that the attentional bias for alcohol-related stimuli was not an artifact of the abusers' poorer cognitive ability. In a study testing the relationship between drinking motives and drinking-related interpretation biases, Woud, Becker, Rinck, and Salemin (2015) reported that ECF did not mediate the relationship between drinking expectancies and drinking-related interpretation biases.

Using various measurement techniques, such as the visual probe (Field et al., 2007; Schoenmakers, Wiers, Jones, Bruce, & Jansen, 2007), flicker (Jones, Bruce, Livingstone, & Reed, 2006; Jones, Jones, Smith, & Copley, 2003; Schoenmakers et al., 2007), dual-task (Waters & Green, 2003), and Stroop (Cox et al., 2006) paradigms; eye-tracking technology (Friese, Bargas-Avila, Hofmann, & Wiers, 2010); and functional magnetic resonance imaging (fMRI; Vollstadt-Klein et al., 2012), researchers have documented attentional bias across a wide range of addictive behaviors, including alcohol abuse (Fardard, 2003; Fardard & Cox, 2008; Roy-Charland et al., 2016; Sharma, Albery, & Cook, 2001; Vollstadt-Klein et al., 2012; Wilcockson & Pothos, 2015; Zettler, Stollery, Weinstein, & Lingford-Hughes, 2006), heroin addiction (Bearre, Sturt, Bruce, & Jones, 2007; Waters, Marhe, & Franken, 2012), cocaine addiction (Castillo et al., 2010; Copersino et al., 2004; Hester, Dixon, & Garavan, 2006; Kilts et al., 2014; Sokhadze et al., 2008; Waters et al., 2012), marijuana use (Cousijn et al., 2013; Field, 2005; van Hemel-Ruiter, Wiers, Brook, & de Jong, 2016; Vujanovic, Wardle, Liu, Dias, & Lane, 2016), and obesity (Doolan, Breslin, Hanna, & Gallagher, 2015; Fardard & Bazzaz, 2011; Freijy, Mullan, & Sharpe,

2014; Lattimore & Mead, 2015; Nathan et al., 2012; Schmitz, Naumann, Trentowska, & Svaldi, 2014; Werthmann et al., 2015).

In an fMRI study, Ihssen, Cox, Wiggert, Fardard, and Linden (2011) exposed heavy drinkers to alcohol-related pictures and to pictures related to healthy goal pursuits. They found that the parts of the brain that are involved in emotional processing (i.e., insular cortex) and reward circuitry (i.e., ventral striatum) showed greater activation in heavy drinkers than light drinkers during exposure to the alcohol-related pictures. When presented with the stimuli related to higher-order goals (such as those related to family, health, and finances), the heavy drinkers showed weaker responses in frontal areas than the light drinkers.

What does increased activity in certain loci of the brain in response to addiction-related stimuli indicate? Ihssen et al.'s (2011) findings suggest that heavy drinkers have difficulty forming healthy goals as an alternative to drinking alcohol. For them, alcohol serves as a major source of emotional regulation, which means an increased likelihood of relapse after they attempt to control their drinking. Franken (2003) argued that when habitual substance users encounter a conditioned drug stimulus, their brain's dopamine level in the corticostriatal circuit increases, particularly in the anterior cingulate gyrus, amygdala, and nucleus accumbens. The increase serves two purposes: (a) it draws the person's attention toward a drug-related stimulus, and (b) it results in motor preparation and hyperattentiveness to drug-related stimuli. Together, the activation promotes substance craving and perhaps relapse. In fact, several studies have concluded that drug-related attentional bias predicts post-treatment relapse among drug-abusers (Field & Cox, 2008; Goldstein, Woicik, Lukasik, Maloney, & Volkow, 2007; Marissen et al., 2006).

Evidence on the relationship between attentional bias and substance abuse and relapse suggests that one's willpower proportionately suffers from the strength of one's attentional bias for substance-related stimuli. However, despite extensive literature discussing the importance of attentional bias and its relationship to continued substance use and relapse (Field & Cox, 2008; Field, Munafo, & Franken, 2009), the evidence for this conclusion is not entirely consistent (Field, Marhe, & Franken, 2014). It should be noted that such results are based on group averages; usually the mean score of one group (e.g., heavy drinkers) was compared with the mean score of another group. In other words, it is not possible to predict whether individual substance users will show an attentional bias, and, even if they do, there is no guarantee that their outcome will be determined by their degree of attentional bias (e.g., Flaudias et al., 2013; van Hemel-Ruiter et al., 2016). Attentional bias apparently interacts with a variety of circumstantial variables in its relation to subsequent variables, such as substance use (Field et al., 2016). Nevertheless, studies have shown that attentional bias training can help substance users reduce their attentional bias for addiction-related stimuli (Attwood, O'Sullivan, Leonards, Mackintosh, & Munafo, 2008; Bazzaz, Fardard, & Parkinson, 2016; Cox et al., 2015; Field, Duka, Tyler, & Schoenmakers, 2009; Hester et al., 2006; Wiers et al., 2015a, 2015b; Ziaee, Fardard, Cox, & Yazdi, 2016).

To conclude, attentional bias can exacerbate an addiction; however, there are ways to reduce its effects, the simplest of which is to avoid situations and stimuli that are related to the substance use. Another way is to practice overcoming the attentional bias using one of the attention retraining programs that have been specifically developed for this purpose. There is no study to suggest that substance-related attentional bias can excuse substance users' inability to control their harmful behavior. As, however, we show in the subsequent sections, the contribution of nonconscious processes to addictive behaviors is not limited to substance-related attentional bias.

8. Interpretation bias

"When you were talking, he started..." How could one complete this sentence? Would one say something such as "laughing at you" or perhaps "looking at you"? What about these sentences: "When we want to hang out, we go to a supermarket to buy..." "It was late, and she

came home...”? People's tendency to immediately appraise an ambiguous situation in a given way (whether positive or negative) constitutes their interpretation bias, but an interpretation bias does not normally reflect reality (Butler & Mathews, 1983). Like attentional bias, it also can be modified; this means that it is not completely automatized.

Studying implicit substance-related interpretation biases relies on implicit paradigms such as *word association* tasks (e.g., Stacy, Ames, & Grenard, 2006). Single ambiguous words can be used to study implicit associations, whereby participants are asked to report their first spontaneous response to a given ambiguous cue (e.g., “bar”); alternatively, ambiguous phrases containing affective components (e.g., “What a spirit!”) or open-ended ambiguous scenarios can be used (Woud, Fitzgerald, Wiers, Rinck, & Becker, 2012; Woud, Hutschemaekers, Rinck, & Becker, 2015a; Woud et al., 2014; Woud et al., 2015b). The common finding from this line of research is that people with more alcohol-related associations tend to drink more heavily than those with fewer alcohol-related associations. It seems that the facilitation effect in alcohol-related associations is a product of both one's history of procuring alcohol and an eliciting factor that promotes craving and future alcohol use (Woud et al., 2015b, 2015a).

Actually, there have been only a few studies that have tested the relationship between interpretation biases and alcohol or other drug use. Woud et al. (2012) reported that, compared to light drinkers, excessive drinkers generated more alcohol-related completions of the sentences. In Woud et al.'s (2014) study, alcohol-dependent patients showed greater alcohol-related interpretation bias and extended the bias to emotionally vague contexts (i.e., potentially related to fear or depression) than did control patients who had either a clinically diagnosed mood disorder or an anxiety disorder. Woud et al. (2015a, 2015b) found that drinkers' motives for reducing their negative affect (i.e., coping motives) were the sole predictor of their interpretation bias in favor of drinking alcohol when they were exposed to an ambiguous negative context. An example of such a scenario is: “Your study loan piles up, you failed an exam, and now you lost your wallet. You just want to forget all your problems.” Two choices were provided for overcoming the problems: drinking alcohol or going for a long walk. The participants' bias toward drinking alcohol was a significant predictor of their future drinking.

In summary, excessive drinkers tend more often than light drinkers to interpret ambiguous, potentially alcohol-related scenarios in an alcohol-related manner. And there is evidence with alcohol abusers (Woud, Hutschemaekers, Rinck, & Becker, 2015) that a single session of Cognitive Bias Modification-Interpretation (CBM-I) can produce changes in alcohol-related interpretation biases. Motivated by the strong evidence for a relationship between negative affect, frustration intolerance, and substance use (Bitsakou, Antrop, Wiersema, & Sonuga-Barke, 2006; Ko, Yen, Yen, Chen, & Wang, 2008; Kraemer, McLeish, & O'Bryan, 2015; McHugh & Otto, 2012), Samifard, Fadardi, and Shamloo (2016) compared drug-users in a treatment program with non-abusers on explicit and implicit measures of frustration intolerance. On both measures, the drug users scored higher than the non-users. Examples of the scenarios that were used in the study are as follows: “Occasionally, you join your friends for walking in the wilderness. In the past, sometimes you have used drugs with your friends. You are on your way to meet your friends for the hike. On your way, you think of...” A negative target interpretation was “On your way, you think of past experiences and want to use drugs”. A positive target interpretation was “On your way, you think of your bad experiences with drugs, and you decide to stop using them”.

Next, drug-users who scored high on the temptation to use drugs and low on frustration tolerance were randomly allocated to a sham intervention or to an experimental group that received three sessions of CBM-I in order to alter their frustration-related negative bias. At post-test and a one-month follow-up, participants again completed the baseline measures. The results indicated that, compared to the sham intervention group, the experimental group showed increases in positive, drug-unrelated interpretations of ambiguous scenarios and in frustration tolerance, which were accompanied by reductions in the temptation to use drugs.

The findings suggest that the use of CBM-I to promote positive interpretations can have clinical implications in the treatment of drug use. In other words, cognitive bias modification programs are a means of helping substance users to facilitate their motivation to control their harmful habit; however, making such a decision is a matter of their own choice.

9. Conclusions regarding cognitive automaticity and free choice

Due not only to the adverse effects of substance use but also to the development of various types of cognitive biases, a substance abuser's brain suffers from a distortion in the flow of higher-order cognitive processes, including concentration and working memory, which might reduce the person's ability to exercise reflective processes over impulsive processes, hence disrupting controlled patterns of substance use. When executive cognitive functions that are responsible for reflective processes are impaired, the effects of various types of cognitive biases on drinking-related decisions can be multiplied. A cognitive bias, therefore, can lead a substance user to make decisions in favor of substance use despite the person's conscious vows to refrain from the use. Factors that strengthen implicit processes contribute to the person's choosing immediate goals over more long-term goals (Lewis, 2011).

Although implicit processes, such as those described here, can outweigh the impact of reflective processes in substance-related decisions and behaviors, substance use is not necessarily ruled predominantly by implicit processes. In fact, there is a general consensus among addiction researchers that if an individual has the necessary motivation and cognitive resources, the impact of implicit processes can be regulated (Becker et al., 2016; Belackova, Maalste, Zabransky, & Grund, 2015; Petry, 2005; Woud et al., 2015b, 2015a). The resulting decisions would exemplify the exercise of free will as this article defines it.

10. Conclusions

We take the view that the natural course of events entails causes and effects. Although, within the present state of our knowledge, there will be some unpredictable, seemingly random variation in behavior, this random variation cannot be meaningfully equated with human free will. People can, however, make choices from among an assortment of possibilities that are unconstrained by physical limits or significant social pressures. Making a choice from among such options might, in this limited sense, be viewed as having been made freely, even though the choice was predictable.

Within the present theory, the value component of decision-making depends on immediate or anticipated affective responses to the alternatives, regardless of whether these are to anticipated physical pleasures, to the conditioned inner consequences of obeying or violating moral principles, or to some other source of affective arousal. Various kinds of brain impairments, psychopathologies, and personality traits such as impulsiveness also affect decision processes. Repeated substance use itself risks physical, emotional, and social changes that may weight decision processes against cessation of use, even when the addict recognizes that cessation would carry benefits, although possibly just not enough to outweigh the experiential benefits of continued use. The present review of choices that are available to an individual about whether to use an addictive substance makes it clear that once a person has become addicted, ceasing to use the substance constitutes an often extremely difficult and improbable choice; nevertheless, cessation of the use is not impossible. The present review also makes it clear that the behaviors entailed in obtaining and consuming an addictive substance cannot be construed as entirely automatic or quasi-mechanical, in that they are to some extent flexible and sometimes even creative. Furthermore, the evidence indicates that the components involved in seeking an addictive substance and wanting to use it can at least to some extent be modified by appropriate treatment techniques.

The component that is most difficult to change is the goal to use the addictive substance, once it has become firmly established. It, in turn,

guides the motivational, cognitive, and emotional components of the subsequent substance-seeking behavior. Despite their recalcitrance, addiction-related goals can be changed, or at least suppressed and superceded by other goals, often without any formal treatment but also within an empirically validated treatment program. In this limited sense, people indeed are free to choose whether or not to use an addictive substance.

References

- Ames, S. L., Grenard, J. L., He, Q., Stacy, A. W., Wong, S. W., Xiao, L., ... Bechara, A. (2014). Functional imaging of an alcohol-implicit association test (IAT). *Addiction Biology*, 19(3), 467–481.
- Amrhein, P. C., Miller, W. R., Yahne, C. E., Palmer, M., & Fulcher, L. (2003). Client commitment language during motivational interviewing predicts drug use outcomes. *Journal of Consulting and Clinical Psychology*, 71(5), 862–878.
- Attwood, A. S., O'Sullivan, H., Leonards, U., Mackintosh, B., & Munafo, M. R. (2008). Attentional bias training and cue reactivity in cigarette smokers. *Addiction*, 103(11), 1875–1882.
- Baer, J., Kaufman, J. C., & Baumeister, R. F. (2008). Introduction: Psychology and free will. In J. Baer, J. C. Kaufman, & R. F. Baumeister (Eds.), *Are we free? Psychology and free will* (pp. 3–9). New York, NY: Oxford University Press.
- Baumeister, R. F. (2014). Constructing a scientific theory of free will. In W. Sinnott-Armstrong (Ed.), *Moral psychology. Free will and moral responsibility*, Vol. 4. (pp. 237–255). Cambridge, Massachusetts, USA: MIT Press.
- Baumeister, R. F., Masicampo, E. J., & Vohs, K. D. (2011). Do conscious thoughts cause behavior? *Annual Review of Psychology*, 62, 331–361.
- Baumeister, R. F., Masicampo, E. J., & Vohs, K. D. (2015). Conscious thoughts and the causation of behavior. In M. Mikulincer, P. R. Shaver, E. Borgida, & J. A. Bargh (Eds.), *APA handbook of personality and social psychology, volume 1: Attitudes and social cognition* (pp. 231–250). Washington, DC: American Psychological Association.
- Baxter, M. G., Parker, A., Lindner, C. C., Izquierdo, A. D., & Murray, E. A. (2000). Control of response selection by reinforcer value requires interaction of amygdala and orbital prefrontal cortex. *Journal of Neuroscience*, 20(11), 4311–4319.
- Bazzaz, M. M., Fardadi, J. S., & Parkinson, J. (2016). Efficacy of the attention control training program on reducing attentional bias in obese and overweight dieters. *Appetite*, 108, 1–11.
- Bearre, L., Sturt, P., Bruce, G., & Jones, B. T. (2007). Heroin-related attentional bias and monthly frequency of heroin use are positively associated in attenders of a harm reduction service. *Addictive Behaviors*, 32(4), 784–792.
- Becker, S. J., Squires, D. D., Strong, D. R., Barnett, N. P., Monti, P. M., & Petry, N. M. (2016). Training opioid addiction treatment providers to adopt contingency management: A prospective pilot trial of a comprehensive implementation science approach. *Substance Abuse*, 37(1), 134–140.
- Belackova, V., Maalste, N., Zabransky, T., & Grund, J. P. (2015). "Should I buy or should I grow?" How drug policy institutions and drug market transaction costs shape the decision to self-supply with cannabis in the Netherlands and the Czech Republic. *The International Journal on Drug Policy*, 26(3), 296–310.
- Berridge, K. C. (2007). The debate over dopamine's role in reward: The case for incentive salience. *Psychopharmacology*, 191, 391–431.
- Bischof, G., Rumpf, H. J., & John, U. (2012). Natural recovery from addiction. In H. J. Shaffer, D. A. LaPlante, & S. E. Nelson (Eds.), *APA addiction syndrome handbook. Recovery, prevention, and other issues*, Vol 2. (pp. 133–155). Washington, D.C.: American Psychological Association.
- Bitsakou, P., Antrop, I., Wiersma, J. R., & Sonuga-Barke, E. J. (2006). Probing the limits of delay intolerance: Preliminary young adult data from the delay frustration task (DeFT). *Journal of Neuroscience Methods*, 151(1), 38–44.
- Bogg, T., & Finn, P. R. (2010). A self-regulatory model of behavioral disinhibition in late adolescence: Integrating personality traits, externalizing psychopathology, and cognitive capacity. *Journal of Personality*, 78(2), 441–470.
- Bosque-Prous, M., Espelt, A., Guitart, A. M., Bartoli, M., Villalbi, J. R., & Brugal, M. T. (2014). Association between stricter alcohol advertising regulations and lower hazardous drinking across European countries. *Addiction*, 109(10), 1634–1643.
- Butler, G., & Mathews, A. (1983). Cognitive processes in anxiety. *Advances in Behaviour Research and Therapy*, 5(1), 51–62.
- Castillo, C., Martinez, D., Martinez, R., Rossi, P., Fonseca, E., Astals, M., ... Torrens, M. (2010). Attentional bias towards cocaine cues using a dot-probe detection task. *European Neuropsychopharmacology*, 20, S584–S585.
- Copersino, M. L., Serper, M. R., Vadhan, N., Goldberg, B. R., Richarme, D., Chou, J. C., ... Cancro, R. (2004). Cocaine craving and attentional bias in cocaine-dependent schizophrenic patients. *Psychiatry Research*, 128(3), 209–218.
- Cousijn, J., Watson, P., Koenders, L., Vingerhoets, W. A., Goudriaan, A. E., & Wiers, R. W. (2013). Cannabis dependence, cognitive control and attentional bias for cannabis words. *Addictive Behaviors*, 38(12), 2825–2832.
- Cox, W. M., & Klinger, E. (1988). A motivational model of alcohol use. *Journal of Abnormal Psychology*, 97, 168–180.
- Cox, W. M., & Klinger, E. (1990). Incentive motivation, affective change, and alcohol use: A model. In W. M. Cox (Ed.), *Why people drink: Parameters of alcohol as a reinforcer* (pp. 291–314). New York: Amereon Press.
- Cox, W. M., & Klinger, E. (2004). A motivational model of alcohol use: Determinants of use and change. In W. M. Cox, & E. Klinger (Eds.), *Handbook of motivational counseling: Concepts, approaches, and assessment* (pp. 121–138). Chichester, United Kingdom: Wiley.
- Cox, W. M., & Klinger, E. (2011a). A motivational model of alcohol use: Determinants of use and change. In W. M. Cox, & E. Klinger (Eds.), *Handbook of motivational counseling: Goal-based approaches to assessment and intervention with addiction and other problems* (pp. 131–158). Chichester, United Kingdom: Wiley-Blackwell.
- Cox, W. M., & Klinger, E. (2011b). Systematic motivational counseling: From motivational assessment to motivational change. In W. M. Cox, & E. Klinger (Eds.), *Handbook of motivational counseling* (pp. 276–302) (2nd ed.). Chichester, United Kingdom: Wiley-Blackwell.
- Cox, W. M., Schippers, G. M., Klinger, E., et al. (2002). Motivational structure and alcohol use of university students with consistency across four nations. *Journal of Studies on Alcohol*, 63(3), 280–285.
- Cox, W. M., Heinemann, A. W., Miranti, S. V., Schmidt, M., Klinger, E., & Blount, J. (2003). Outcomes of systematic motivational counseling for substance use following traumatic brain injury. *Journal of Addictive Diseases*, 22, 93–110.
- Cox, W. M., Fardadi, J. S., & Pothos, E. M. (2006). The addiction-Stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin*, 132(3), 443–476.
- Cox, W. M., Fardadi, J. S., Hosier, S. G., & Pothos, E. M. (2015). Differential effects and temporal course of attentional and motivational training on excessive drinking. *Experimental and Clinical Psychopharmacology*, 23(6), 445–454.
- Cox, W. M., Klinger, E., & Fardadi, J. S. (2017). Nonconscious motivational influences on cognitive processes in addictive behaviors. In N. Heather, & G. Segal (Eds.), *Addiction and choice: Rethinking the relationship* (pp. 259–285). Oxford, UK: Oxford University Press.
- Dantzer, C., Wardle, J., Fuller, R., Pampalona, S. Z., & Steptoe, A. (2006). International study of heavy drinking: Attitudes and sociodemographic factors in university students. *Journal of American College Health*, 55, 83–89.
- Dickson, P. A., James, M. R., Heath, A. C., et al. (2006). Effects of variation at the ALDH2 locus on alcohol metabolism, sensitivity, consumption, and dependence in Europeans. *Alcoholism: Clinical and Experimental Research*, 30(7), 1093–1100.
- Dolcos, F., & McCarthy, G. (2006). Brain systems mediating cognitive interference by emotional distraction. *Journal of Neuroscience*, 26(7), 2072–2079.
- Doolan, K. J., Breslin, G., Hanna, D., & Gallagher, A. M. (2015). Attentional bias to food-related visual cues: Is there a role in obesity? *Proceedings of the Nutrition Society*, 74(1), 37–45.
- Dunn, B. D., Evans, D., Makarova, D., White, J., & Clark, L. (2012). Gut feelings and the reaction to perceived inequity: The interplay between bodily responses, regulation, and perception shapes the rejection of unfair offers on the ultimatum game. *Cognitive, Affective, & Behavioral Neuroscience*, 12(3), 419–429.
- Fardadi, J. S. (2003). *Cognitive-motivational determinants of attentional bias for alcohol-related stimuli: Implications for a new attentional-training intervention*. Unpublished doctoral dissertation Bangor, United Kingdom: University of Wales, Bangor.
- Fardadi, J. S., & Bazzaz, M. M. (2011). A combi-Stroop test for measuring food-related attentional bias. *Experimental and Clinical Psychopharmacology*, 19(5), 371–377.
- Fardadi, J. S., & Cox, W. M. (2006). Alcohol attentional bias: Drinking salience or cognitive impairment? *Psychopharmacology (Berlin)*, 185(2), 169–178.
- Fardadi, J. S., & Cox, W. M. (2008). Alcohol-attentional bias and motivational structure as independent predictors of social drinkers' alcohol consumption. *Drug and Alcohol Dependence*, 97(3), 247–256.
- Feil, J., Sheppard, D., Fitzgerald, P. B., Yücel, M., Lubman, D. I., & Bradshaw, J. L. (2010). Addiction, compulsive drug seeking, and the role of frontostriatal mechanisms in regulating inhibitory control. *Neuroscience and Biobehavioral Reviews*, 35(2), 248–275.
- Fenton, T., & Wiers, R. W. (2016). Free will, black swans and addiction. *Neuroethics*. <http://dx.doi.org/10.1007/s12152-016-9290-7>.
- Field, M. (2005). Cannabis 'dependence' and attentional bias for cannabis-related words. *Behavioral Pharmacology*, 16(5–6), 473–476.
- Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence*, 97(1–2), 1–20.
- Field, M., Duka, T., Eastwood, B., Child, R., Santarcangelo, M., & Gayton, M. (2007). Experimental manipulation of attentional biases in heavy drinkers: Do the effects generalise? *Psychopharmacology (Berlin)*, 192(4), 593–608.
- Field, M., Duka, T., Tyler, E., & Schoenmakers, T. (2009a). Attentional bias modification in tobacco smokers. *Nicotine & Tobacco Research*, 11(7), 812–822.
- Field, M., Munafo, M. R., & Franken, I. H. A. (2009b). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin*, 135(4), 589–607.
- Field, M., Marhe, R., & Franken, I. H. (2014). The clinical relevance of attentional bias in substance use disorders. *CNS Spectrums*, 19(3), 225–230.
- 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.
- Flaudias, V., Brousse, G., de Chazeron, I., Planche, F., Brun, J., & Llorca, P. M. (2013). Treatment in hospital for alcohol-dependent patients decreases attentional bias. *Neuropsychiatric Disease and Treatment*, 9, 773–779.
- Franken, I. H. (2003). Drug craving and addiction: Integrating psychological and neuropsychopharmacological approaches. *Progress in Neuropsychopharmacology and Biological Psychiatry*, 27(4), 563–579.
- Freijy, T., Mullan, B., & Sharpe, L. (2014). Food-related attentional bias. Word versus pictorial stimuli and the importance of stimuli caloric value in the dot probe task. *Appetite*, 83, 202–208.
- Friese, M., Bargas-Avila, J., Hofmann, W., & Wiers, R. W. (2010). Here's looking at you, bud: Alcohol-related memory structures predict eye movements for social drinkers with low executive control. *Social Psychological and Personality Science*, 1(2), 143–151.
- Fuhrmann, A., Schroer, B. M., & Jong-Meyer, R. (2011). Systematic motivational counseling in groups: Promoting therapeutic change through client interaction. In W. M.

- Cox, & E. Klinger (Eds.), *Handbook of motivational counseling: Goal-based approaches to assessment and intervention with addiction and other problems* (pp. 303–327) (2nd ed.). Chichester, United Kingdom: Wiley-Blackwell.
- Goldstein, R. Z., Volkow, N. D., Wang, G. J., Fowler, J. S., & Rajaram, S. (2001). Addiction changes orbitofrontal gyrus function: Involvement in response inhibition. *Neuroreport*, 12(11), 2595–2599.
- Goldstein, R. Z., Woicik, P. A., Lukasik, T., Maloney, T., & Volkow, N. D. (2007). Drug fluency: A potential marker for cocaine use disorders. *Drug and Alcohol Dependence*, 89(1), 97–101.
- Greenfield, T. K., & Room, R. (1997). Situational norms for drinking and drunkenness: Trends in the US adult population, 1979–1990. *Addiction*, 92(1), 347.
- Haggard, P., Mele, A., O'Connor, T., & Vohs, K. (2010). Lexicon of key terms. Big questions in free will project. Published online at <http://www.freewillandscience.com/wp/?pageid=63>
- Harnett, P. H., Lynch, S. J., Gullo, M. J., Dawe, S., & Loxton, N. (2013). Personality, cognition, and hazardous drinking: Support for the 2-component approach to reinforcing substances model. *Addictive Behaviors*, 38(12), 2945–2948.
- 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.
- van Hemel-Ruiter, M. E., Wiers, R. W., Brook, F. G., & de Jong, P. J. (2016). Attentional bias and executive control in treatment-seeking substance-dependent adolescents: A cross-sectional and follow-up study. *Drug and Alcohol Dependence*, 159, 133–141.
- Hester, R., Dixon, V., & Garavan, H. (2006). A consistent attentional bias for drug-related material in active cocaine users across word and picture versions of the emotional Stroop task. *Drug and Alcohol Dependence*, 81(3), 251–257.
- Heyman, G. (1996). Resolving the contradictions of addiction. *Behavioral and Brain Sciences*, 19(4), 561–574.
- Heyman, G. M. (2009). *Addiction: A disorder of choice*. Cambridge, MA: Harvard University Press.
- Heyman, G. (2013). Addiction and choice: Theory and new data. *Frontiers in Psychiatry*, 4, 31.
- Holton, R., & Berridge, K. (2013). Addiction between compulsion and choice. In N. Levy (Ed.), *Addiction and self-control: Perspectives from philosophy, psychology, and neuroscience* (pp. 239–268). New York, NY: Oxford University Press.
- Hongwanishkul, D., Happaney, K. R., Lee, W. S., & Zelazo, P. D. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology*, 28(2), 617–644.
- Huang, J. Y., & Bargh, J. A. (2014). The selfish goal: Autonomously operating motivational structures as the proximate cause of human judgment and behavior. *Behavioral and Brain Sciences*, 37, 121–135.
- Huijbregts, S. C. J., Warren, A. J., de Sonnevile, L. M. J., & Swaab-Barneveld, H. (2008). Hot and cool forms of inhibitory control and externalizing behavior in children of mothers who smoked during pregnancy: An exploratory study. *Journal of Abnormal Child Psychology*, 36(3), 323–333.
- Ihssen, N., Cox, W. M., Wiggert, A., Fadardi, J. S., & Linden, D. E. (2011). Differentiating heavy from light drinkers by neural responses to visual alcohol cues and other motivational stimuli. *Cerebral Cortex*, 21(6), 1408–1415.
- Iordan, A. D., Dolcos, S., & Dolcos, F. (2013). Neural signatures of the response to emotional distraction: A review of evidence from brain imaging investigations. *Frontiers in Human Neuroscience*, 7, 200.
- Jones, B. T., Jones, B. C., Smith, H., & Copley, N. (2003). A flicker paradigm for inducing change blindness reveals alcohol and cannabis information processing biases in social users. *Addiction*, 98(2), 235–244.
- Jones, B. T., Bruce, G., Livingstone, S., & Reed, E. (2006). Alcohol-related attentional bias in problem drinkers with the flicker change blindness paradigm. *Psychology of Addictive Behaviors*, 20(2), 171–177.
- Jonker, N. C., Glashouwer, K. A., Ostafin, B. D., van Hemel-Ruiter, M. E., Smink, F. R., Hoek, H. W., & de Jong, P. J. (2016). Attentional bias for reward and punishment in overweight and obesity: The TRAILS study. *PLoS One*, 11(7), e0157573. <http://dx.doi.org/10.1371/journal.pone.0157573>.
- Juraeva, D., Treutlein, J., Scholz, H., Frank, J., Degenhardt, F., Cichon, S., ... Rietschel, M. (2015). XRCC5 as a risk gene for alcohol dependence: Evidence from a genome-wide gene-set-based analysis and follow-up studies in drosophila and humans. *Neuropsychopharmacology*, 40(2), 361–371.
- 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.
- Kilts, C. D., Kennedy, A., Elton, A. L., Tripathi, S. P., Young, J., Cisler, J. M., & James, G. A. (2014). Individual differences in attentional bias associated with cocaine dependence are related to varying engagement of neural processing networks. *Neuropsychopharmacology*, 39(5), 1135–1147.
- Klinger, E. (1971). *Structure and functions of fantasy*. N.Y.: Wiley.
- Klinger, E. (1975). Consequences of commitment to and disengagement from incentives. *Psychological Review*, 82, 1–25.
- Klinger, E. (1977). *Meaning and void: Inner experience and the incentives in people's lives*. Minneapolis: University of Minnesota Press.
- Klinger, E. (1978). Modes of normal conscious flow. In K. S. Pope, & J. L. Singer (Eds.), *The stream of consciousness: Scientific investigations into the flow of human experience* (pp. 225–258). New York: Plenum.
- Klinger, E. (2013). Goal commitments and the content of thoughts and dreams: Basic principles. *Frontiers in Psychology*, 4, 415.
- Klinger, E., & Cox, W. M. (2011). Motivation and the goal theory of current concerns. In W. M. Cox, & E. Klinger (Eds.), *Handbook of motivational counseling* (pp. 3–47) (2nd ed.). Chichester, United Kingdom: Wiley-Blackwell.
- Ko, C. H., Yen, J. Y., Yen, C. F., Chen, C. S., & Wang, S. Y. (2008). The association between Internet addiction and belief of frustration intolerance: The gender difference. *Cyberpsychology & Behavior*, 11(3), 273–278.
- Köhler, W. (1925). *The mentality of apes*. New York: Harcourt, Brace.
- Koob, G. F. (2006). The neurobiology of addiction: A hedonic Calvinist view. In W. R. Miller, & K. M. Carroll (Eds.), *Rethinking substance abuse: What the science shows, and what we should do about it* (pp. 25–45). New York, NY: Guilford Press.
- Köpetz, C. E., Lejuez, C. W., Wiers, R. W., & Kruglanski, A. W. (2013). Motivation and self-regulation in addiction: A call for convergence. *Perspectives on Psychological Science*, 8(1), 3–24.
- Kraemer, K. M., McLeish, A. C., & O'Bryan, E. M. (2015). The role of intolerance of uncertainty in terms of alcohol use motives among college students. *Addictive Behaviors*, 42, 162–166.
- Kuntsche, E., Wicki, M., Windlin, B., Roberts, C., Gabbainn, S. N., van der Sluijs, W., & Demetrovics, Z. (2015). Drinking motives mediate cultural differences but not gender differences in adolescent alcohol use. *Journal of Adolescent Health*, 56(3), 323–329.
- Lattimore, P., & Mead, B. R. (2015). See it, grab it, or STOP! Relationships between trait impulsivity, attentional bias for pictorial food cues and associated response inhibition following in-vivo food cue exposure. *Appetite*, 90, 248–253.
- Lewis, M. D. (2011). Dopamine and the neural “now”: Essay and review of addiction: A disorder of choice. *Perspectives on Psychological Science*, 6(2), 150–155.
- Lewis, M. (2017). Addiction and the brain: Development, not disease. *Neuroethics*. <http://dx.doi.org/10.1007/s12152-016-9293-4>.
- Liu, S., Lane, S. D., Schmitz, J. M., Waters, A. J., Cunningham, K. A., & Moeller, F. G. (2011). Relationship between attentional bias to cocaine-related stimuli and impulsivity in cocaine-dependent subjects. *American Journal of Drug and Alcohol Abuse*, 37(2), 117–122.
- Loxton, N. J., Bunker, R. J., Dingle, G. A., & Wong, V. (2015). Drinking not thinking: A prospective study of personality traits and drinking motives on alcohol consumption across the first year of university. *Personality and Individual Differences*, 79, 134–139.
- Mackinnon, S. P., Kehayes, I. L., Clark, R., Sherry, S. B., & Stewart, S. H. (2014). Testing the four-factor model of personality vulnerability to alcohol misuse: A three-wave, one-year longitudinal study. *Psychology of Addictive Behaviors*, 28(4), 1000–1012.
- 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.
- Martino, S. C., Kovalchik, S. A., Collins, R. L., Becker, K. M., Shadel, W. G., & D'Amico, E. J. (2016). Ecological momentary assessment of the association between exposure to alcohol advertising and early adolescents' beliefs about alcohol. *Journal of Adolescent Health*, 58(1), 85–91.
- May, J., Kavanagh, D. J., & Andrade, J. (2015). The elaborated intrusion theory of desire: A 10-year retrospective and implications for addiction treatments. *Addictive Behaviors*, 44, 29–34.
- McHugh, R. K., & Otto, M. W. (2012). Profiles of distress intolerance in a substance-dependent sample. *American Journal of Drug and Alcohol Abuse*, 38(2), 161–165.
- Mikhieva, O. V., & Trageser, S. L. (2016). Personality features, disordered eating, and alcohol use among college students: A latent profile analysis. *Personality and Individual Differences*, 94, 360–365.
- de la Monte, S. M., & Kril, J. J. (2014). Human alcohol-related neuropathology. *Acta Neuropathologica*, 127(1), 71–90.
- Moody, L., Franck, C., Hatz, L., & Bickel, W. K. (2016). Comorbid depression, antisocial personality, and substance dependence: Relationship with delay discounting. *Drug and Alcohol Dependence*, 160, 190–196.
- Moos, R. H., & Moos, B. S. (2007). Treated and untreated alcohol-use disorders: Course and predictors of remission and relapse. *Evaluation Review*, 31(6), 564–584.
- Moreno-Lopez, L., Stamatakis, E. A., Fernandez-Serrano, M. J., Gomez-Rio, M., Rodriguez-Fernandez, A., Perez-Garcia, M., & Verdejo-Garcia, A. (2012). Neural correlates of hot and cold executive functions in polysubstance addiction: Association between neuropsychological performance and resting brain metabolism as measured by positron emission tomography. *Psychiatry Research*, 203(2–3), 214–221.
- Morgenstern, M., Isensee, B., Sargent, J. D., & Hanewinkel, R. (2011). Exposure to alcohol advertising and teen drinking. *Preventive Medicine*, 52(2), 146–151.
- Moss, A. C., & Albery, I. P. (2009). A dual-process model of the alcohol-behavior link for social drinking. *Psychological Bulletin*, 135(4), 516–530.
- Murphy, J. G., Correia, C. J., Colby, S. M., & Vuchinich, R. E. (2005). Using behavioral theories of choice to predict drinking outcomes following a brief intervention. *Experimental and Clinical Psychopharmacology*, 13(2), 93–101.
- Murray, E. A. (2007). The amygdala, reward and emotion. *Trends in Cognitive Sciences*, 11(11), 489–497.
- Nathan, P. J., O'Neill, B. V., Mogg, K., Bradley, B. P., Beaver, J., Bani, M., ... Bullmore, E. T. (2012). The effects of the dopamine D(3) receptor antagonist GSK598809 on attentional bias to palatable food cues in overweight and obese subjects. *The International Journal of Neuropsychopharmacology*, 15(2), 149–161.
- Noël, X., Bechara, A., Brevers, D., Verbanck, P., & Campanella, S. (2010). Alcoholism and the loss of willpower: A neurocognitive perspective. *Journal of Psychophysiology*, 24, 240–248.
- Orford, J. (1984). The prevention and management of alcohol problems in the family setting: A review of work carried out in English-speaking countries. *Alcohol and Alcoholism*, 19(2), 109–122.
- Orford, J. (2001). Addiction as excessive appetite. *Addiction*, 96(1), 15–31.
- Petry, N. M. (2005). Methadone plus contingency management or performance feedback reduces cocaine and opiate use in people with drug addiction. *Evidence-Based Mental Health*, 8(4), 112.
- Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Research Reviews*, 18(3), 247–291.
- Robinson, T. E., & Berridge, K. C. (2000). The psychology and neurobiology of addiction: An incentive-sensitization view. *Addiction*, 95(Suppl. 2), S91–117.
- Robinson, T. E., & Berridge, K. C. (2001). Incentive-sensitization and addiction. *Addiction*, 96(1), 103–114.

- Robinson, T. E., & Berridge, K. C. (2008). Review. The incentive sensitization theory of addiction: Some current issues. *Philosophical Transactions of the Royal Society, B: Biological Sciences*, 363(1507), 3137–3146.
- Robinson, M. J., Fischer, A. M., Ahuja, A., Lesser, E. N., & Maniates, H. (2016). Roles of “wanting” and “liking” in motivating behavior: Gambling, food, and drug addictions. *Current Topics in Behavioral Neurosciences*, 27, 105–136.
- Room, R. (2013). Sociocultural aspects of alcohol consumption. In P. Boyle, P. Boffetta, A. B. Lowenfels, H. Burns, O. Brawley, W. Zatonski, & J. Rehm (Eds.), *Alcohol: Science, policy, and public health* (pp. 38–45). New York, NY: Oxford University Press.
- Ross, C. S., Maple, E., Siegel, M., DeJong, W., Naimi, T. S., Ostroff, J., ... Jernigan, D. H. (2014). The relationship between brand-specific alcohol advertising on television and brand-specific consumption among underage youth. *Alcoholism: Clinical and Experimental Research*, 38(8), 2234–2242.
- Ross, C. S., Maple, E., Siegel, M., DeJong, W., Naimi, T. S., Padon, A. A., ... Jernigan, D. H. (2015). The relationship between population-level exposure to alcohol advertising on television and brand-specific consumption among underage youth in the US. *Alcohol and Alcoholism*, 50(3), 358–364.
- Roy-Charland, A., Plamondon, A., Homeniuk, A. S., Fleisch, C. A., Klein, R. M., & Stewart, S. H. (2016). Attentional bias toward alcohol-related stimuli in heavy drinkers: evidence from dynamic eye movement recording. *American Journal of Drug and Alcohol Abuse*, 1–9.
- Russell, C., & Davies, J. B. (2009). Empirical, logical and philosophical arguments against cigarette smoking as a pharmacologically compelled act. *Current Psychology*, 28(3), 147–168.
- Samifard, M., Fardari, J. S., & Shamloo, S. Z. (2016). *Effectiveness of a cognitive bias modification-interpretation (CBM-I) on reducing frustration-related negative interpretation bias and temptation to use substances*. Unpublished master's thesis Mashhad, Iran: Faculty of Education and Psychology, Ferdowsi University of Mashhad.
- Schmitz, F., Naumann, E., Trentowska, M., & Svaldi, J. (2014). Attentional bias for food cues in binge eating disorder. *Appetite*, 80, 70–80.
- Schoenmakers, T., Wiers, R. W., Jones, B. T., Bruce, G., & Jansen, A. T. (2007). Attentional retraining decreases attentional bias in heavy drinkers without generalization. *Addiction*, 102(3), 399–405.
- Sharma, D., Albery, I. P., & Cook, C. (2001). Selective attentional bias to alcohol related stimuli in problem drinkers and non-problem drinkers. *Addiction*, 96(2), 285–295.
- Siegel, M., Ross, C. S., Albers, A. B., DeJong, W., King, C., Naimi, T. S., & Jernigan, D. H. (2016). The relationship between exposure to brand-specific alcohol advertising and brand-specific consumption among underage drinkers—United States, 2011–2012. *American Journal of Drug and Alcohol Abuse*, 42(1), 4–14.
- Smith, D. G., Simon Jones, P., Bullmore, E. T., Robbins, T. W., & Ersche, K. D. (2014). Enhanced orbitofrontal cortex function and lack of attentional bias to cocaine cues in recreational stimulant users. *Biological Psychiatry*, 75(2), 124–131.
- Sokhadze, E., Singh, S., Stewart, C., Hollifield, M., El-Baz, A., & Tasman, A. (2008). Attentional bias to drug- and stress-related pictorial cues in cocaine addiction comorbid with PTSD. *Journal of Neurotherapy*, 12(4), 205–225.
- Stacy, A. W., Ames, S. L., & Grenard, J. L. (2006). Word association tests of associative memory and implicit processes: Theoretical and assessment issues. In R. W. Wiers, & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction*. Thousand Oaks, CA: SAGE.
- Staras, S. A. S., Livingston, M. D., Christou, A. M., Jernigan, D. H., & Wagenaar, A. C. (2014). Heterogeneous population effects of an alcohol excise tax increase on sexually transmitted infections morbidity. *Addiction*, 109(6), 904–912.
- Stillman, T. F., Baumeister, R. F., & Mele, A. R. (2011). Free will in everyday life: Autobiographical accounts of free and unfree actions. *Philosophical Psychology*, 24(3), 381–394.
- Stitzer, M., & Petry, N. (2006). Contingency management for treatment of substance abuse. *Annual Review of Clinical Psychology*, 2, 411–434.
- Tabakoff, B., & Hoffman, P. L. (2013). The neurobiology of alcohol consumption and alcoholism: An integrative history. *Pharmacology, Biochemistry and Behavior*, 113, 20–37.
- Terrett, G., McLennan, S. N., Henry, J. D., Biernacki, K., Mercuri, K., Curran, H. V., & Rendell, P. G. (2014). Prospective memory impairment in long-term opiate users. *Psychopharmacology (Berlin)*, 231(13), 2623–2632.
- Thompson, K., Roemer, A., & Leadbeater, B. (2015). Impulsive personality, parental monitoring, and alcohol outcomes from adolescence through young adulthood. *Journal of Adolescent Health*, 57(3), 320–326.
- Tiffany, S. T. (1999). Cognitive concepts of craving. *Alcohol Research & Health*, 23(3), 215–224.
- Tsermentseli, S., & Poland, S. (2016). Cool versus hot executive function: A new approach to executive function. *Encephalos*, 53, 11–14.
- Tucker, J. A., Vuchinich, R. E., Black, B. C., & Rippens, P. D. (2006). Significance of a behavioral economic index of reward value in predicting drinking problem resolution. *Journal of Consulting and Clinical Psychology*, 74(2), 317–326.
- Tucker, J. A., Roth, D. L., Vignolo, M. J., & Westfall, A. O. (2009). A behavioral economic reward index predicts drinking resolutions: Moderation revisited and compared with other outcomes. *Journal of Consulting and Clinical Psychology*, 77(2), 219–228.
- Van Eerde, W., & Thierry, H. (1996). Vroom's expectancy models and work-related criteria: A meta-analysis. *Journal of Applied Psychology*, 81, 575–586.
- Vanderschuren, L. J., & Everitt, B. J. (2005). Behavioral and neural mechanisms of compulsive drug seeking. *European Journal of Pharmacology*, 526, 77–88.
- Verhulst, B., Neale, M. C., & Kendler, K. S. (2015). The heritability of alcohol use disorders: A meta-analysis of twin and adoption studies. *Psychological Medicine*, 45(5), 1061–1072.
- Volkow, N. D., Fowler, J. S., & Wang, G. J. (2004). The addicted human brain viewed in the light of imaging studies: Brain circuits and treatment strategies. *Neuropharmacology*, 47(Suppl 1), 3–13. <http://dx.doi.org/10.1016/j.neuropharm.2004.07.019>.
- Vollstadt-Klein, S., Loeber, S., Richter, A., Kirsch, M., Bach, P., von der Goltz, C., ... Kiefer, F. (2012). Validating incentive salience with functional magnetic resonance imaging: Association between mesolimbic cue reactivity and attentional bias in alcohol-dependent patients. *Addiction Biology*, 17(4), 807–816.
- Vonmoos, M., Hulka, L. M., Preller, K. H., Minder, F., Baumgartner, M. R., & Quednow, B. B. (2014). Cognitive impairment in cocaine users is drug-induced but partially reversible: Evidence from a longitudinal study. *Neuropsychopharmacology*, 39(9), 2200–2210.
- Vuchinich, R. E., & Tucker, J. A. (1996). Alcoholic relapse, life events, and behavioral theories of choice: A prospective analysis. *Experimental and Clinical Psychopharmacology*, 4(1), 19–28.
- Vuchinich, R. E., & Tucker, J. A. (1998). Choice, behavioral economics, and addictive behavior patterns. In W. R. Miller, & N. Heather (Eds.), *Treating addictive behaviors* (pp. 93–104) (2nd ed.). New York: Plenum Press.
- 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.
- Waters, H., & Green, M. W. (2003). A demonstration of attentional bias, using a novel dual task paradigm, towards clinically salient material in recovering alcohol abuse patients? *Psychological Medicine*, 33(3), 491–498.
- Waters, A. J., Marhe, R., & Franken, I. H. (2012). Attentional bias to drug cues is elevated before and during temptations to use heroin and cocaine. *Psychopharmacology (Berlin)*, 219(3), 909–921.
- Wegner, D. M. (2002). *The illusion of conscious will*. Cambridge, MA, USA: MIT Press.
- Werthmann, J., Jansen, A., Vreugdenhil, A. C., Nederkoorn, C., Schyns, G., & Roefs, A. (2015). Food through the child's eye: An eye-tracking study on attentional bias for food in healthy-weight children and children with obesity. *Health Psychology*, 34(12), 1123–1132.
- Wiers, R. W., Cox, W. M., Field, M., et al. (2006). The search for new ways to change implicit alcohol-related cognitions in heavy drinkers. *Alcoholism: Clinical and Experimental Research*, 30(2), 320–331.
- 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, 490–497.
- Wiers, R. W., Field, M., & Stacy, A. W. (2014). Passion's Slave?: Conscious and Unconscious Cognitive Processes in Alcohol and Drug Abuse. In K. J. Sher (Ed.), *The Oxford handbook of substance use and substance use disorders. Vol. 1* (pp. 311–350). Oxford: Oxford library of psychology.
- Wiers, R. W., Houben, K., Fardari, J. S., van Beek, P., Rhemtulla, M., & Cox, W. M. (2015a). Alcohol cognitive bias modification training for problem drinkers over the web. *Addictive Behaviors*, 40, 21–26.
- Wiers, R. W., Boelema, S. R., Nikolaou, K., & Gladwin, T. E. (2015b). On the development of implicit and control processes in relation to substance use in adolescence. *Current Addiction Reports*, 2(2), 141–155.
- Wilcockson, T. D., & Pothos, E. M. (2015). Measuring inhibitory processes for alcohol-related attentional biases: Introducing a novel attentional bias measure. *Addictive Behaviors*, 44, 88–93.
- Wild, T. C. (2002). Personal drinking and sociocultural drinking norms: A representative population study. *Journal of Studies on Alcohol*, 63(4), 469–475.
- Witkiewitz, K., Lustyk, M. K., & Bowen, S. (2013). Retraining the addicted brain: A review of hypothesized neurobiological mechanisms of mindfulness-based relapse prevention. *Psychology of Addictive Behaviors*, 27, 351–365.
- Wood, A. P., Dawe, S., & Gullo, M. J. (2013). The role of personality, family influences, and prosocial risk-taking behavior on substance use in early adolescence. *Journal of Adolescence*, 36(5), 871–881.
- Woud, M. L., Fitzgerald, D. A., Wiers, R. W., Rinck, M., & Becker, E. S. (2012). 'Getting into the spirit': Alcohol-related interpretation bias in heavy-drinking students. *Psychology of Addictive Behaviors*, 26(3), 627–632.
- Woud, M. L., Pawelczak, S., Rinck, M., Lindenmeyer, J., Souren, P., Wiers, R. W., & Becker, E. S. (2014). Alcohol-related interpretation bias in alcohol-dependent patients. *Alcoholism: Clinical and Experimental Research*, 38(4), 1151–1159.
- Woud, M. L., Hutschmaekers, M. H., Rinck, M., & Becker, E. S. (2015a). The manipulation of alcohol-related interpretation biases by means of Cognitive Bias Modification-Interpretation (CBM-I). *Journal of Behavior Therapy and Experimental Psychiatry*, 49(Pt A), 61–68.
- Woud, M. L., Becker, E. S., Rinck, M., & Salemink, E. (2015b). The relationship between drinking motives and alcohol-related interpretation biases. *Journal of Behavior Therapy and Experimental Psychiatry*, 47, 102–110.
- Wray, J. M., Gass, J. C., & Tiffany, S. T. (2013). A systematic review of the relationships between craving and smoking cessation. *Nicotine & Tobacco Research*, 15(7), 1167–1182.
- Xuan, Z., Chaloupka, F. J., Blanchette, J. G., Nguyen, T. H., Heeren, T. C., Nelson, T. F., & Naimi, T. S. (2015). The relationship between alcohol taxes and binge drinking: Evaluating new tax measures incorporating multiple tax and beverage types. *Addiction*, 110(3), 441–450.
- Yan, J., Aliev, F., Webb, B. T., Kendler, K. S., Williamson, V. S., Edenberg, H. J., ... Dick, D. M. (2014). Using genetic information from candidate gene and genome-wide association studies in risk prediction for alcohol dependence. *Addiction Biology*, 19(4), 708–721.
- Ystrom, E., Kendler, K. S., & Reichborn-Kjennerud, T. (2014). Early age of alcohol initiation is not the cause of alcohol use disorders in adulthood, but is a major indicator of genetic risk. A population-based twin study. *Addiction*, 109(11), 1824–1832.
- Zatoński, W. A., Sulikowska, U., Zatoński, M. Z., Herbec, A. A., & Muszyńska, M. M. (2015). Alcohol taxation and premature mortality in Europe. *Lancet*, 385(9974), 1181.
- Zetteler, J. I., Stollery, B. T., Weinstein, A. M., & Lingford-Hughes, A. R. (2006). Attentional bias for alcohol-related information in adolescents with alcohol-dependent parents. *Alcohol and Alcoholism*, 41(4), 426–430.
- Ziaee, S. S., Fardari, J. S., Cox, W. M., & Yazdi, S. A. (2016). Effects of attention control training on drug abusers' attentional bias and treatment outcome. *Journal of Consulting and Clinical Psychology*, 84(10), 861–873.