Implicit Cognition and Addiction: A Tool for Explaining Paradoxical Behavior

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Abstract

Research on implicit cognition and addiction has expanded greatly during the past decade. This research area provides new ways to understand why people engage in behaviors that they know are harmful or counterproductive in the long run. Implicit cognition takes a different view from traditional cognitive approaches to addiction by assuming that behavior is often not a result of a reflective decision that takes into account the pros and cons known by the individual. Instead of a cognitive algebra integrating many cognitions relevant to choice, implicit cognition assumes that the influential cognitions are the ones that are spontaneously activated during critical decision points. This selective review highlights many of the consistent findings supporting predictive effects of implicit cognition on substance use and abuse in adolescents and adults; reveals a recent integration with dual-process models; outlines the rapid evolution of different measurement tools; and introduces new routes for intervention.

Contents

INTRODUCTION

The study of implicit processes has much potential for explaining the paradox of addiction. Why do people engage in behaviors they "know" are harmful and potentially life threatening? Rather than assume people weigh pros and cons in an algebraic or reflective model of behavior and then make reasoned choices, implicit cognition approaches assume choices often are influenced by a subset of associations in memory that become spontaneously activated under various conditions. These associations are learned through experience and channel behavior in ways that are not revealed through introspection, self-reflection, or causal attribution. Yet, various indirect methods have become available that reveal these associations and provide hints about the implicit processes that can help explain the paradox. Consistent findings from this research suggest new routes for intervention.

This selective review highlights prominent recent developments and consistent findings in research on implicit cognition and addiction. These developments are then discussed in terms of emerging dual-process theories, which focus on interactions between implicit and executive processes, and in terms of promising intervention approaches. Because implicit cognition concepts in addiction are derived from basic research in memory, cognitive neuroscience, and social cognition, several key findings from these disciplines are also addressed when highly relevant to addiction.

DEFINITIONS AND FOCI

Diversity of Approaches from Basic Cognitive Research

There is no uniformly agreed on definition or approach to implicit cognition or similar concepts of unconscious or automatic processing. Rather, definitions and approaches to implicit cognition have different foci depending on the discipline and sometimes even the subdiscipline or research area. In basic research on episodic memory, the emphasis is on detecting evidence of previous exposure to an event in the absence of conscious or intentional recollection of a previous event (e.g., Graf & Schacter 1985). In research on semantic memory, a concept frequently indistinguishable from implicit cognition is automatic semantic priming, which is focused on effects of one stimulus on the processing of a related stimulus, without the involvement of strategic reflective processes such as expectancy generation or strategic matching (e.g., Hutchison 2003). In recent social psychology, the focus is on uncovering effects of previous experience in the absence of introspective awareness or accurate identification of the source of these effects (Greenwald & Banaji 1995). Bargh & Morsella (2008) have argued that lack of awareness of stimuli (i.e., subliminal processing) is not a necessary or even desirable attribute of unconscious processing, and the same can be said for implicit cognition. The key factor for Bargh & Morsella, as well as many streams of research relevant to clinical psychology, is unawareness of the process, not unawareness of stimuli or content. There is evidence showing that, under some conditions, indirectly assessed (but not self-reported) attitudes influence other psychological processes outside of conscious awareness (Gawronski et al. 2006).

Working Definitions for Addiction Research

The authors have found it useful in addiction research to apply a pragmatic definition, in which implicit cognition is revealed on tests that do not require or encourage the conscious or deliberate recollection of previous events or introspections about the causes of one's behavior. In this view, implicit cognition operates spontaneously, without the need for deliberation, reflection, or awareness of the process responsible for behavior. For example, the perception of a stimulus spontaneously triggers an action, the activation of a concept, a train of thought, or a change in performance on some task. This definition can be considered minimal, a starting point, upon which other features of implicit, automatic or unconscious processing can be added if useful for a given research question or clinical issue. De Houwer, Moors, and colleagues (De Houwer et al. 2009, Moors & De Houwer 2006) have listed a variety of ways in which processes may be classified as implicit or automatic, emphasizing such qualities as goal independence, absence of intentionality, uncontrollability, lack of awareness of one or more aspects of the process (e.g., stimuli, origins, attributes, behavioral effects), efficiency (effectiveness under processing load), and operation even under time constraints. A process is implicit in at least some sense if it can be characterized by one or more of these qualities. Different implicit processes can have different "flavors," featuring different combinations of these qualities, such as the frequent combination of unconscious awareness of the effects of stimuli coupled with conscious awareness of the stimuli themselves (Bargh & Morsella 2008). The lack of a single defining characteristic or all-inclusive concept of implicit cognition is compatible with evidence for multiple implicit processing systems supported in neuropsychological research (see Stacy & Wiers 2006).

Within addiction research, operational definitions and measurement of implicit cognition have varied in accord with the basic literatures. Thus, there has been no single operational definition or measurement paradigm unanimously applied to addiction. Yet, the operational definitions share some common ground, as do the definitions from other literatures. Operational definitions of implicit cognition share the key feature of indirect assessment. The participant is not asked to directly report on the target construct. If the target construct is implicit attitude or associations concerning cues or outcomes of a behavior, the participants are not asked to indicate their feelings or beliefs about an object or behavior but instead perform a task that assesses attitude or associations indirectly. The indirect task may use response latency assessments or other indexes of increased efficiency, word production, or tests of memory performance that include an indirect element. The important assumption is that by measuring cognition indirectly, processes not involving deliberate recollection, self-reflection, self-presentation, or demand characteristics are far less likely to be engaged and may sometimes be avoided altogether. Thus, other important processes documented in extensive basic research are more likely to be revealed, and determinants of behavior usually ignored in most cognitive approaches to addictive behavior may be understood and applied. Sections below illustrate quite different operational definitions that have originated in basic literatures and now lend support to implicit cognition approaches to addictive behavior. The potential value of implicit or indirect measures is that they capture some of the same spontaneous processes that operate when the addictive behavior is triggered spontaneously. Of course, this claim has to be validated by demonstrating that the indirect measure predicts the spontaneously triggered addictive behaviors in the real world.

Old Wine, New Bottle?

Contrary to some reports suggesting that concepts of implicit cognitive processes are derived primarily from contemporary research on social psychology, philosophical and observational work on what today would be classified as implicit memory can be traced back at least to the seventeenth, eighteenth, and nineteenth centuries in work by Descartes, Leibniz, Spinoza, Maine de Biran, Herbart, Carpenter, Schopenhauer, Hering, Binet, Korsakoff, Janet, Freud, and others (for historical review, see Schacter 1987). These philosophers, clinicians, and investigators postulated or observed a form of memory that affects behavior in the absence of recollection. In experimental psychology, the first known use of a test of implicit memory is through the method of savings (Ebbinghaus 1913), though the implicit nature of savings was not fully documented until nearly a century later (Nelson 1978). Implicit memory was not a focus of early twentieth-century psychology, even though Bergson (1911) and Prince (1914) elaborated and extended earlier theorizing on multiple (recollective and unconscious) memory systems, and some learning theorists studied implicit memory (e.g., Thorndike & Rock 1934). Schacter's (1987) review revealed that in 1924, McDougal was the first investigator to use the words "implicit" and "explicit" in terms of multiple forms of memory. Further, a variety of essentially implicit processes were studied within the "new look" era, as well as more recent research in social psychology (Bargh & Morsella 2008).

There are many intriguing and important links between contemporary concepts of implicit processes and earlier work. For example, recent work on illusory memory, which can be explained in part by contemporary theories of implicit processes (e.g., McEvoy et al. 1999), was derived from Deese's (1959) early work on memory intrusions. Theories that support spontaneously activated associations can be traced to rudimentary connectionist models developed by James (1913), with elements apparent in many recent connectionist models in both cognitive (Thomas & McClelland 2008) and social (Monroe & Read 2008) psychology. A variety of models of association through history have avoided reference to conscious or deliberative processing (for review, see Warren 1921) and are relevant to some forms of implicit processes. Recent work in neuroscience demonstrating the distinction between circuits involved in implicit and explicit processes (e.g., Knight et al. 2009, Satpute & Lieberman 2006) received initial impetus from earlier findings revealing forms of implicit memory in amnesic patients in neuropsychological studies of skill learning (Corkin 1968) and priming (Warrington & Weiskrantz 1968). Further, Freud deserves credit for stressing the importance of unconscious processes and internal conflict to predict a wide range of normal and abnormal behavior. However, the fact that he used subjective interpretation rather than objective scientific methods appears to have delayed rather than accelerated the acceptance of implicit processes in psychology (see Wilson 2002).

This brief history merely touches the surface of the many streams of research on implicit process concepts. Clearly, this approach cannot be attributed to one subdiscipline of psychology, and extensive research from multiple areas is quite applicable.

Rather than old wine with a new bottle, we have seen a major resurgence and focus on observed phenomena and processes that have been acknowledged for some time in concept and name. The study of implicit cognition has evolved and continued to progress over a long period: first very slowly, now quite rapidly, and occasionally with differing labels (Wilson 2002). One of the rapid contemporary developments is the availability of new measurement tools that show important predictive effects of implicit cognition on behavior. Other recent developments include the neuroscientific study of implicit or automatic processes, the design of interventions that specifically address these processes, and integration of implicit processes into dual-process theories addressing potential moderators such as executive processes and genetic predispositions. These developments are highlighted below in terms of relevance for clinician psychology. More exhaustive reviews of theoretical and measurement issues are available in earlier work (Wiers & Stacy 2006).

SUMMARY OF SUPPORTIVE FINDINGS IN COLLEGE STUDENTS AND ADULTS

Many findings have revealed important relationships between implicit cognition and addictive behaviors. Most of this research has been conducted in populations of older teenagers and adults, using indirect tests such as the implicit association test (IAT), word production, and several other tasks.

Results from Response Latency Measures

During the past decade, there has been a strong increase in research using different reaction time (RT) paradigms to assess different cognitive processes underlying substance use and misuse. There are different ways to categorize these measures. One way is in relation to the underlying processes the measure is intended to assess. Addiction researchers have attempted to assess three broad classes of cognitive processes, assumed to underlie the development and maintenance of addictive behaviors: (*a*) attentional bias for a substance; (*b*) memory associations related to the substance; and (*c*) action tendencies triggered by the substance (approach or avoidance). Note that there is no one-to-one relationship between processes and measures; for example, varieties of the IAT have been used to assess relatively automatic memory associations with substances (Houben & Wiers 2006b, Wiers et al. 2002) as well as to assess action tendencies, by assessing associations between the substance and approach or avoidance (Ostafin & Palfai 2006, Palfai & Ostafin 2003). Similarly, the addiction-Stroop has often been used as a measure of attentional bias for the addictive substance (Cox et al. 2006), but a primed Stroop has been used to assess memory associations (Stewart et al. 2002).

Regarding attentional bias, most studies have used either a variety of the addiction Stroop or a variety of the visual probe task (for review, see Field & Cox 2008). In the addiction Stroop task, attentional bias is inferred from a slowing in RT when participants name the color of words referring to their substance of abuse, as compared with neutral words. In the visual probe task, two pictures or words are presented simultaneously for a brief period of time, one representing the substance of abuse and the other a matched neutral stimulus. This is followed by the presentation of a probe (e.g., an arrow pointing up or down), to which the participant has to react. Attentional bias is inferred if participants react faster to the probe when it replaces a representation of the substance compared with when it replaces the neutral picture or word. Using these two measures, researchers have fairly consistently found that heavier substance use is related to a stronger attentional bias, both in student and in general population samples (for reviews, see Cox et al. 2006, Field & Cox 2008). Other measures have been used as well, for example, a variety of the change-detection paradigm, where it has been found that substance abusers detect quick changes in a complex visual scene faster when they occur in substance-related stimuli than when they occur in nonsubstance-related stimuli (Jones et al. 2003). Note that these measures do not distinguish well between different components of attention, distinguished in the basic literature on attentional processes: a fast engagement process and a slower disengagement process. For this reason, researchers have started to use methods to register eye movements (Field et al. 2006, Mogg et al. 2003, Schoenmakers et al. 2008). Across different methods and substances of abuse, there is converging evidence that substance abusers show an attentional bias and that this is most pronounced in the relatively slow disengagement component of attention (Cox et al. 2006, Field & Cox 2008). Whether a fast engagement attentional bias is also present in some stages of addiction is more controversial (Leventhal et al. 2008). It is also unclear which role an attentional bias plays in the etiology of addictive behaviors: Does it prelude or follow heavy substance use, and does it play a role in the acceleration from use to problematic use (Field & Cox 2008)? Does it stabilize or decline after long periods of addiction (Loeber et al. 2009, Mogg et al. 2003)? We return to these issues below.

The second class of RT measures attempts to assess memory associations, mostly affective associations, a purpose similar to non-RT memory association measures discussed below. The most often used RT test to assess associations is the IAT, developed by Greenwald and colleagues (Greenwald et al. 1998). The IAT is a reaction-time measure used to probe individual differences in associations between a drug and two attribute categories (e.g., "positive" versus "negative" if one assesses implicit attitudes, or "approach" versus "avoidance" if one assesses action tendencies). The target category (alcohol or another substance in addiction research) also requires a contrast category (often soft drinks or water for alcohol). On each trial of the task, participants rapidly categorize visually presented stimuli (pictures or words) by pressing one of two response keys. For example, they may be instructed to press the left response key when an alcohol-related word or a positive word is presented and to press the right response key in response to alcohol-unrelated or negative words. The rationale for the task is that if participants automatically evaluate alcohol as positive rather than negative, they should be quicker to respond when "alcohol" and "positive" words share the same response key (as in the example) compared to another block of the task where "alcohol" and "negative" words share the same response key. The IAT has a number of strengths, which explain its popularity: it is a flexible tool (different associations can be assessed), easy to use, and much more reliable than many other implicit measures, with test-retest correlations around 0.70 (Hofmann et al. 2005, Wiers et al. 2005). However, the validity of the measure has been criticized, with much ongoing debate (Blanton & Jaccard 2006, Blanton et al. 2009, Greenwald et al. 2005, Nosek & Sriram 2007, Rothermund & Wentura 2004, Rothermund et al. 2005). We discuss the main findings with the IAT in addiction research along with some issues raised by the critics, which are important in view of the interpretation of the findings. First, studies using a classic IAT to assess whether alcohol (or other substances) was more strongly associated with negative than with positive affect consistently found (perhaps surprisingly) stronger associations between alcohol and negative valence than between alcohol and positive valence in light, heavy, and alcoholic drinkers (De Houwer et al. 2004; Houben & Wiers 2008b; Wiers et al. 2002, 2005). Regarding this finding, both criticisms of the IAT may apply: The IAT is a relative measure, and therefore this finding should not be interpreted as indicating that everyone has strong negative associations (despite telling you that they love alcohol, in the case of heavy-drinking students). More relevant is the finding that heavy drinkers demonstrate associations that are somewhat less negative than those of light drinkers (Houben & Wiers 2008b, Wiers et al. 2002). IAT scores of implicit alcohol attitudes also predicted drinking behavior above the variance explained by explicit measures using the same words (Houben & Wiers 2006a, 2007a,b; for meta-analysis, see Rooke et al. 2008).

When positive and negative associations were assessed separately (in two separate IATs contrasting positive with neutral words and negative with neutral words), substance users (undergraduate students) demonstrated both positive and negative associations for alcohol (Houben & Wiers 2006b, 2008a; Jajodia & Earleywine 2003; McCarthy & Thompsen 2006) and smoking (McCarthy & Thompsen 2006). Importantly, positive associations predicted unique variance in drinking and smoking behavior above the variance explained by explicit measures, whereas negative associations were unrelated to drinking and smoking behavior (Houben & Wiers 2006b, 2008a; Jajodia & Earleywine 2003; McCarthy & Thompsen 2006). This suggests that positive associations may be more personally relevant, whereas negative associations may primarily reflect "cultural wisdom" (Houben & Wiers 2007b, Olson & Fazio 2004). In line with this idea, studies using personalized versions of the IAT, which prevent the activation of extrapersonal associations (Olson & Fazio 2004), have also demonstrated positive implicit associations with both alcohol (Houben & Wiers 2007b) and smoking (De Houwer et al. 2006). The strong negative associations for alcohol and other substances may also be partly explained by "figure-ground" asymmetries, indicating that when two salient categories share the same response key, this will result in faster RTs regardless of underlying associations (Rothermund & Wentura 2004). Three studies controlling for figure-ground asymmetries in different ways found that these asymmetries partly but not fully explain the strong negative associations found for alcohol (Houben et al. 2009; Houben & Wiers 2006a,b). Hence, the very strong negative associations with substances found in IAT studies appear to be partly related to the test used (IAT). Other varieties of the test as well as other RT measures, such as the Extrinsic Affective Simon Test (EAST) (De Houwer 2003), found negative associations that were less strong; generally, relatively positive associations were related to drinking (De Houwer & De Bruycker 2007a). However, given the modest reliability of the EAST, the IAT is probably a better measure of interindividual differences (De Houwer & De Bruycker 2007b).

In addition to associations with positive and negative valence, researchers have used the IAT to assess other associations with substances, notably associations with arousal, which were consistently found in heavy drinkers and problem drinkers but not in light drinkers (De Houwer et al. 2004; Houben & Wiers 2006b; Wiers et al. 2002, 2005). Controlling for figure-ground asymmetries did not affect this finding (Houben & Wiers 2006b). Researchers have also recently used an IAT to assess automatically activated coping motives (Hendershot et al. 2009). This is relatively difficult because coping motives refer to drinking for a desirable change in affect, from negative to more positive (Comeau et al. 2001, Cooper et al. 1995, Wiers 2008), and in the associations captured with the IAT, there is no temporal order. In order to assess relatively automatic processes underlying negative reinforcement (Baker et al. 2004), priming measures may be most optimally suited because they include a temporal structure. In this way, it can be investigated to what extent negative affect activates alcohol (or other substances) or the other way around. Using a semantic priming measure in problem drinkers low or high on psychiatric distress, Zack and colleagues found that the activation of alcohol concepts by negative cues correlated with intensity of psychiatric distress and with a tendency to drink in negative states (Zack et al. 1999); findings were similar for young problem drinkers (Zack et al. 2006). Stress has also been found to increase attentional bias for alcohol in coping drinkers (Field & Powell 2007). Positive outcomes of alcohol (e.g., feeling good) also have been found to prime alcohol concepts in semantic priming research, with heavier drinkers showing stronger priming effects (Weingardt et al. 1996). These and other findings in the literature indicate that relatively automatic associations may play an important role in different circumstances: in substance use related to emotional states of positive arousal and in substance use related to the alleviation of negative affect.

The third class of RT measures used in addiction research in the past decade attempts to assess relatively automatic action tendencies of approach or avoidance. This has been done with yet another variety of the flexible IAT (Ostafin & Palfai 2006, Palfai & Ostafin 2003). It was found that heavy drinkers associate drinking more strongly with approach than with avoidance, and this was related to cue-induced craving. A semantic priming measure has also been used to assess action tendencies for approach and avoidance separately and found alcohol problems to be correlated with weak associations between alcohol cues and avoidance motivation but not with strong associations between alcohol cues and approach motivation (Ostafin et al. 2003). Some other paradigms have been developed to assess action tendencies. The first is a paradigm, sometimes referred to with the overly general label "SRC" (stimulus response compatibility), in which participants are instructed in one block to move a manikin (little man) toward pictures of the substance and away from other pictures (approach substance block), and in another block to move the manikin away from the substance and toward other pictures (avoid substance block). Substance use and misuse (alcohol, cigarettes, marijuana) have all been found to be related to relatively fast approach movements in this task (Field et al. 2006, 2008a; Mogg et al. 2003). Recently, a new approach-avoidance task has been developed, which uses a joystick that is pulled (approach) or pushed (avoid) and incorporates a "zooming mechanism": When the joystick is pulled, the picture size increases on the computer screen, and when it is pushed, it decreases (Rinck & Becker 2007). When heavy drinkers were instructed to pull or push in response to the format of the picture (irrespective of the contents), they were found to be faster in pulling than in pushing alcohol pictures, a difference not found for general positive or negative pictures (Wiers et al. 2009b).

Results from Indirect Tests Using Word Production and Memory Testing

Tests of memory associations using word production in addiction typically have used various types of word-association tests. Common tests have used free-word association, in which the participant lists the first word that comes to mind in response to a cue word, phrase, or picture, or a variant termed "controlled association" (Cramer 1968), in which a category of some type (e.g., verb) is requested using similar "top-of-mind" instructions. If such tests do not directly inquire about the target concept (e.g., drug associations), then the tests are indirect and may have the capability of assessing implicit processes. Indeed, consistent evidence across diverse paradigms from basic research shows that word-association tests are capable of detecting implicit conceptual memory (Seger et al. 1999, Vaidya et al. 1995, Zeelenberg et al. 1999), and associations uncovered in these tests predict the spontaneous activation of cognitions across a wide range of experimental procedures (e.g., Hutchison 2003, Nelson et al. 1998, Roediger & McDermott 1995). Consistent findings in cognitive neuroscience support a distinct neural basis of implicit conceptual memory, compared with explicit memory (for review, see Stacy & Wiers 2006). Perhaps the most compelling evidence for the implicit quality of word-association tests comes from studies in amnesic populations. Amnesic participants, with severely impaired explicit memory, have shown no impairments on tests of implicit memory for previous events using word-association tests (e.g., Levy et al. 2004, Shimamura & Squire 1984, Vaidya et al. 1995).

As with any implicit assessment method, it is important to state the specific nature of the implicit process attributed to measurement outcomes (De Houwer et al. 2009). The meaning of implicit processes in the implicit memory literature focuses on memory in the absence of deliberate or conscious recollection of a previous event, not on unconscious activation of the content of associations. Thus, activation or retrieval of associations is spontaneous, but association content must come to mind to detect the associations with these methods. Consistent with Bargh & Morsella's (2008) analysis of unconscious processing of stimuli (i.e., subliminal perception), it is possible that unconscious activation of the content of associations may imply weaker levels of activation or impact than association content that spontaneously pops to mind through indirect testing. However, no data are available to evaluate this contention, and it is possible that some important associations cannot be detected through word association and may require testing through alternative procedures such as those outlined in the previous section.

Addiction research began using word-association methods comprehensively with the work of Szalay and his colleagues (e.g., Szalay et al. 1992), who focused on an associative network approach without invoking implicit cognition concepts. These investigators found different associative structures in drug users versus nonusers (Szalay et al. 1992) and among participants entering versus successfully completing drug treatment (Szalay et al. 1993). Most associative network approaches are quite different from prevailing (deliberative) cognitive theories of health behavior and suggest that associations operate on behavior spontaneously, without the need for reflection. Such networks not only involve associations between affect and behavior, but may also include any type of association that can be represented in memory; for example, associations between situational cues and behavior and concept-to-concept associations. Cue-behavior associations may be more important than affective or outcome associations once habits have begun to be established (e.g., Yin & Knowlton 2006).

Most of Szalay and colleagues' work has used a variant of free-word association classified as continuous association. Continuous association elicits repeated associations to the same cue. For example, "Friday night" is listed 10 times on a page, and participants respond with the first word each instance makes them think of, with the requirement that they try to think of a different response each time. Repeated responses to the same cue can sometimes yield more variation in responses and may more readily produce some clinically relevant associative responses. However, response chaining, in which the previous response rather than the cue influences subsequent responses, is a potential problem. Further, as opposed to strong evidence for single free-word association and controlled association, nothing is known about the implicit status of measurement outcomes using continuous association. However, for clinical purposes, the continued association method may be able to "pull out" some important associations not captured by other methods. Szalay and colleagues' work on ethnic differences has compellingly shown that a response after the first can reveal major differences in associative structures across groups (e.g., Diaz-Guerrero & Szalay 1991); this neglected method may have major implications for both basic and clinical work on addiction. Although continuous-association methods may sometimes lead to more variability and better item-response characteristics than use of single-response methods, there are likely tradeoffs between evidence for the "implicitness" of the measurement outcome and variability using continuous-association methods. However, most of the addiction research using word association conducted after the groundbreaking work of Szalay has relied on more traditional word association, either using free-word association or a form of controlled association termed "verb generation"; verb generation asks for the first action or behavior that comes to mind in response to the cue, which may be a word, picture, or other stimuli. The first use of this technique in addiction to our knowledge was in a study of college students, who were asked to generate the first behavior that came to mind in response to a series of alcohol-related and neutral short phrases (Stacy et al. 1994). The alcohol-related phrases did not explicitly mention alcohol or its synonyms but were obtained from college student norms for likely (perceived) positive outcomes of alcohol use (e.g., having fun, feeling good). Strong correlations were found between the generation of alcohol responses (in response to normatively high-frequency alcohol outcomes) and alcohol consumption, even though nothing was asked about alcohol until after the associations were elicited using this indirect assessment. A number of studies have replicated this finding but have also documented the importance of associations between cues (in addition to affect) and alcohol (for reviews, see Ames et al. 2006, Rooke et al. 2008).

In a recent comprehensive meta-analysis of more than 89 effect sizes from studies sampling nearly 20,0000 participants, word-association tasks demonstrated the best effect sizes/predictive effects among all indirect tests of alcohol or other drug-related associations studied to date (Rooke et al. 2008). Although many studies have found significant effect sizes, one of the more rigorous prediction studies was reported by Kelly et al. (2005). These investigators found that implicit associations measured with word association prospectively predicted alcohol use in college students over a six-month period, adjusting for earlier alcohol use, sensation seeking, and background variables. Prospective effects also have been demonstrated in other studies (Krank et al. 2005, Stacy et al. 1997), also adjusting for some but not all possible confounders.

Although basic research has consistently supported the view that word association is capable of detecting implicit processes, research using association tests in addiction has focused on prediction, not on experimental validation of processes. However, it is likely that the processes leading to responses on such tests run parallel to those uncovered in basic neurocognitive research on implicit conceptual memory using identical test formats. For example, neural imaging work on verb generation has shown clear differences in regions of neural activation depending on the strength of association (e.g., attenuation of activation within the left inferior frontal gyrus when highly associated behaviors are generated; Burton & Martin 2006), previous repetition of responses to cues (e.g., decreased activation in left inferior prefrontal cortex, anterior cingulate gyrus, and right cerebellum; Raichle et al. 1994), and spontaneity of response (Seger et al. 2000). One of the most consistent findings is that activation in left prefrontal regions (Buckner et al. 2000, Seger et al. 2000, Thompson-Schill et al. 1999) decreases with stronger association strength, spontaneity, or repetition. These findings mirror what is generally expected in the transition or switch from processes that are predominantly effortful or control-related to more automatic (or implicit) processing with experience (Chein & Schneider 2005, Schneider & Chein 2003). Based on findings from several lines of research reviewed in a major meta-analysis of neuroimaging results (Chein & Schneider 2005), it has become clear that as experience in a novel behavior increases, (*a*) performance becomes more automatic; and (*b*) dramatic differences in patterns of neural activation occur, with reductions in activity in regions constituting a controlled processing network. Essentially, performance of well-learned (habitual) behaviors in response to strong associations becomes very efficient and does not require much effort or strong involvement of neural regions implicated in control processes. The implications for verb generation and other indirect methods of word association are that they can engage either implicit or more controlled processes. If the participant has at least one strong behavior association for a given cue, then the cue is likely to engage primarily implicit processes. If the participant has only weak associations with the cue, then extensive reflective or controlled processing may be engaged to derive a response.

A variety of additional paradigms validated in basic memory research have major implications for implicit processes, and some of these have been used successfully in addiction research. Methods and strategies applied to addiction have included, for example, process dissociation (Fillmore et al. 1999), illusory memory (Reich et al. 2004, Zack et al. 2009), famous name (Krank & Swift 1994), and extralist cued-recall paradigms (Stacy 1994). One of the interesting features of these procedures is that although memory is tested with direct (explicit) instructions, strategic manipulations of the structure of word lists, of recall cues, instructions, delay intervals, and other features of the procedure often allow for inferences of implicit processes. One example is the illusory memory paradigm, based on the initial work of Deese (1959) and refined by Roediger & McDermott (1995). In what is now called the Deese-Roediger-McDermott (DRM) paradigm, participants are typically provided a list of words. The words have a certain predefined associative or meaning structure, in which different sets of words triangulate on a critical associate or meaning (e.g., glass and view triangulate on window). During a subsequent recall or recognition test, participants falsely remember, with high confidence, having seen or heard the critical (nonpresented) word (window). One explanation is that the critical associate was implicitly activated during the presentation of the study list and thus people remember this activated word as if it had been presented (e.g., McEvoy et al. 1999, Roediger & McDermott 1995). In a clever application of the DRM procedure to addictions, Reich et al. (2004) presented participants with a list of alcohol adjectives. A subsequent recognition test was given either in a neutral or in an alcohol-related context. Heavier, but not lighter, drinkers showed more evidence of false memory for alcohol expectancy words in the alcohol context than in the neutral context. Results were consistent with the authors' expectancy template theory (e.g., Goldman et al. 2006) as well as implicit associative-processing theories of illusory memory (McEvoy et al. 1999).

Examples of Findings Using Other Indirect Tests

Other measures of implicit processes have been developed that do not rely on response latencies, word production, or memory tests. One example involves the affective rating of a neutral stimulus. In the affect misattribution procedure (Payne et al. 2005), an affective prime immediately precedes a neutral stimulus (e.g., a Chinese character), and the participant rates the valence of the stimulus. This strategy has been successfully applied to predict alcohol use and smoking (Payne et al. 2007a,b). Another example is from a study on alcohol consumption (actually placebo beer) during a taste-rating task among female college students (Roehrich & Goldman 1995). Participants engaged in two ostensibly unrelated experiments: a memory study and a consumer study. In the first phase, they were asked to remember materials presented in a television show and were then presented words in a Stroop color-naming task. In a 2 × 2 design during this phase, participants watched an alcohol-related or a neutral show and were presented either alcohol or neutral words in the Stroop task. In the second phase, participants were asked to rate the taste of an ostensibly alcoholic drink (beer), which was actually a nonalcoholic commercial beer. The intriguing result is that both the television show and Stroop prime influenced consumption in the taste-rating task. Extensive debriefing did not reveal any threats to internal validity such as hypothesis guessing. The authors explained the results in terms of an implicit process.

FINDINGS IN YOUNGER ADOLESCENTS: THE DEVELOPMENT OF IMPLICIT ASSOCIATIONS

Relatively few studies have assessed implicit cognitive processes in children and young adolescents. Regarding attentional bias for alcohol, the few studies conducted among adolescents found an attentional bias in those who were heavy but not light drinkers (Field et al. 2007a) and in adolescents who smoked (Zack et al. 2001). Regarding memory associations, Thush & Wiers (2007) used a variety of the IAT in adolescents and found that implicit positive and arousal associations and explicit negative expectancies predicted binge drinking one year later. Two studies in high-risk adolescents compared open-ended and RT-based assessments of substance-use: one alcohol use (Thush et al. 2007) and one marijuana use (Ames et al. 2007). Both studies found that both types of measures predicted unique variance in substance use and misuse, with word-production measures of memory associations demonstrating the largest predictive power. One study examined positive and negative associations with alcohol and cigarettes in alcohol- and cigarette-naive early adolescents (O'Connor et al. 2007), using a sequential mixed-modal priming task. Primes were spoken words (alcohol, nonalcoholic drinks, cigarettes, matched neutral words) followed by visual words (positive or negative) or nonwords. Adolescents of all ages (10–14 years) were faster to respond to positive targets following alcohol drink words compared with nonalcohol drink words. In older adolescents, a similar priming effect was found for smoking, suggesting that during adolescence automatic associations for substances become more positive, most likely as a result of peer influences. In addition, there is emerging evidence that adolescents' implicit attitudes regarding smoking may be related to those of their parents (Chassin et al. 2002, Sherman et al. 2009).

Grenard et al. (2009) longitudinally studied the parallel growth of alcohol-related memory associations (assessed with word association) and alcohol use over three years in several thousand seventh- through ninth-graders. They found a strong correlation (0.80) between the linear growth curves of memory association and alcohol use. Although the study cannot rule out third variable causation, the strength of the correlation and the fact that growth reflects changes over time is at least suggestive of closely linked and possibly causal processes. One plausible interpretation is that memory associations toward alcohol and alcohol consumption feed on each other over time in a reciprocal process. The study also demonstrated that early (seventh-grade) exposure to alcohol advertising predicted both growth trajectories, showing that exposure to media risks can predict changes in memory associations as well as alcohol use over time. In an experimental manipulation of exposure to alcohol commercials in sixth- and tenth-grade self-reported drinkers, Krank & Kreklewetz (2003) found that exposure to alcohol commercials (but not control commercials) increased implicit associations measured with word association. However, the manipulation of commercial type did not affect explicit outcome expectancies for alcohol. Krank & Goldstein (2006) reported a number of strong cross-sectional and longitudinal correlations between similar measures of implicit associations and alcohol and marijuana use among adolescents in grade 7 through 12. Taken together, there is some initial evidence that alcohol advertising may affect implicit alcohol associations in youth, and growing evidence indicates that implicit associations are strongly linked to drug use in youth.

THEORETICAL EXPLANATIONS OF IMPLICIT PROCESSES

A variety of theories from basic memory, automatic or implicit social cognition, and addiction research provide tenable explanations of some of the findings summarized here, but this review does not attempt to summarize all of the many alternatives. Rather, two major frameworks are discussed that are among the most well supported in basic research while also having major implications for addiction.

Connectionist and Associative Memory Frameworks

Connectionist and associative memory theories provide a broad class of theories with dramatically different architectures, levels of analysis (e.g., nodal or elemental), and underlying mathematics but surprisingly similar basic conclusions relevant to addiction and other health behaviors. Further, they each postulate how associations or connections in memory are represented and at least suggest how associations can be developed or changed. Such theories include, for example, distributed connectionist models (Hopfield & Tank 1986, Thomas & McClelland 2008), multiple-trace or instance theories (Hintzman 1986, Logan 1988), and associative memory theories of implicit and explicit processes (Nelson et al. 1998). Each theory, and a number of others in this framework, is buttressed by a long line of empirical evidence, often with strong historical, computational, and experimental routes.

In these approaches, associations or connections are developed and operate through nonreflective processes involving the elements of the association. That is, they do not depend on deliberate or conscious recollection, introspections about one's behavior, or on reasoning efforts. The interconnections or associations among many elements of memory form the potential for many different spontaneous fluctuations in cognition. The common principle that triggers any given fluctuation is essentially a similarity or compatibility effect. The pattern of activation in memory that becomes engaged at one point depends largely on similarity to the immediately preceding pattern of activation or to similarity and association with perceived environmental, social, or affective cues. Specific postulates from theories relevant to the development and activation of implicit associations in addiction are outlined elsewhere (Stacy & Wiers 2006).

Neurological Models of Addiction and Habit

In current neurobiological models of addiction, there are three main models to explain addictive behaviors: incentive salience theory, learning or habit theory, and negative reinforcement or opponent process theories (Robinson & Berridge 2003). Incentive sensitization theory states that the central neuroadaptation in addiction is the development of incentive salience or the development of a hypersensitivity to the incentive motivational effects of drugs and drug-associated stimuli (Robinson & Berridge 2003, 2008). This is thought to produce an attentional bias, pathological motivation to use the drug, and the activation of approach behaviors (Robinson & Berridge 2003, 2008). This perspective is related to one evolutionary account of addictive behavior (Nesse & Berridge 1997), which conceptualizes addiction as the behavioral outcome of drug effects on ancient brain mechanisms that control emotion and behavior. In this perspective, drugs induce a false signal of a fitness benefit, which bypasses higher-order information processing (Nesse & Berridge 1997; see also Newlin 2002 for a model of false fitness and Wiers et al. 2009a for a test of this model in relation to aggression after alcohol). When combined with reduced executive control over motivational impulses, this culminates in addiction. "Sensitized incentive salience can be manifest in behavior either in implicit (as unconscious wanting) or explicit (as conscious craving) processes, depending on circumstances" (Robinson & Berridge 2008, p. 3137). The difference with habit and learning theories is that the core neuroadaptation in addiction is thought to be motivational; learning may modulate the expression of neural sensitization on behavior (e.g., context effects), but learning is not believed to be the core process in addiction. Robinson & Berridge argue that other overlearned habits do not lead to compulsive behaviors (tying shoes), and addicts may engage in complex novel behaviors once motivated to get their drug. They also state that habits may be prominent in animal research owing to the impoverished environment, typically with a single possible response (Robinson & Berridge 2008, p. 3138). In humans, they see the role of habits primarily in rituals involved in drug consumption. In contrast, habit theory emphasizes the compulsive habit-like nature that develops when initial voluntary drug use transforms into compulsive drug use, which has been associated with a progression from ventral to more dorsal domains of the striatum (Everitt et al. 2008). Hence, these authors do not dismiss incentive salience as a contributing mechanism in addiction, but emphasize that habit formation is crucial in the development of compulsive drug use. An important moderating role is further given to impulsivity, both in the onset of addictive behaviors and in the escalation to compulsive drug use (Everitt et al. 2008). Finally, negative reinforcement or opponent process theories emphasize that withdrawal leads to negative motivational states ("the dark side of addiction") and that much drug taking is directed toward alleviating the drug-induced negative affect (Koob & Le Moal 2008a,b). However, as noted by other researchers, addictive negative reinforcement is likely to play a role in withdrawal states, yet addictions typically persist long after withdrawal states dissipate (Robinson & Berridge 2008).

Although these three currently dominant neurobiological theories have been pitted as rivals, they can also be viewed as at least partly complementary, perhaps emphasizing different stages of addiction, with different relative importance for different drugs of abuse and for different individuals, depending on differences in personality. For example, incentive salience appears to develop relatively fast in adolescence (Brenhouse et al. 2008) and is most pronounced in relation to stimulant drugs. Habit theories have been relatively prominent in smoking (Tiffany 1990), which is highly habitual, and habit formation may be especially strong in smoking due to direct effects of nicotine on the habit formation system (Davis & Gould 2008). In addition, habit systems may be especially important in the compulsive aspects of drug addiction, consistent with animal research (Yin & Knowlton 2006). Negative reinforcement has traditionally been linked to opiate addictions but may also play an important role in other addictions, especially in individuals who are vulnerable to negative affect. We can conclude that there are different neurobiological theories emphasizing different neurobiological processes in addiction, which may be more or less relevant in relation to different addictive behaviors in different individuals. The important question from the perspective of this review is to what extent findings on implicit cognition and addiction can be related to these different theories.

The findings discussed above regarding an attentional bias and approach bias for substance-related stimuli are compatible with incentive salience theory (Field & Cox 2008, Franken 2003, Palfai & Ostafin 2003). Moreover, a direct manipulation of dopaminergic function (with an antagonist) in heroin patients demonstrated a reduced attentional bias for drug cues (Franken et al. 2004). Regarding memory associations, both approach associations (Palfai & Ostafin 2003) and arousal associations have been related to incentive sensitization (Wiers et al. 2002). The finding that implicit positive and arousal associations prospectively predicted binge drinking in adolescents (Thush & Wiers 2007) can be interpreted as support for a role of incentive salience in early stages of alcohol abuse (to the extent that these associations represent incentive salience). With respect to habit theory and implicit cognition, it is plausible that implicit associations between cues and behaviors, found to predict drug use (Ames et al. 2007), are equivalent to cue-habit associations that have been differentiated from outcome associations in behavioral neuroscience (Yin & Knowlton 2006). Finally, a recent theory relevant to implicit negative reinforcement in smoking suggests that small dips in mood may trigger the urge to smoke outside conscious awareness (Baker et al. 2004).

DUAL-PROCESS MODELS: EXECUTIVE FUNCTION AND GENETIC MODERATORS

Recently, a number of dual-process models have been formulated to account for the etiology of addictive behaviors (Deutsch & Strack 2006, Evans & Coventry 2006, Stacy et al. 2004, Wiers et al. 2007). Although they differ in detail, they all view addictive behaviors as the joint outcome of two classes of processes: relatively automatic appetitive or impulsive processes and relatively controlled or reflective processes, in line with more general dual-process models in psychology (Kahneman 2003, Smith & DeCoster 2000, Strack & Deutsch 2004). From this perspective, an addiction, once established, is perpetuated by strong appetitive processes, which can be triggered outside awareness and receive little control from reflective processes. However, this relative misbalance between impulsive and reflective processes characterizing addiction may also be partly premorbid to addiction, as witnessed by the fact that impulsivity and related traits such as behavioral undercontrol are among the strongest prospective predictors of later addictive behaviors (de Wit 2009, Sher et al. 2005, Verdejo-Garcia et al. 2008). Note that all current dominant neurobiological theories of addiction also posit a moderating role for impulsivity or relatively weak executive control (Everitt et al.

2008, Koob & Le Moal 2008a, Robinson & Berridge 2008). In addition, engaging in addictive behaviors may result in a fundamental imbalance by increasing the effects of relatively automatic appetitive processes (as witnessed by the stronger implicit cognitive processes in heavy versus light drinkers, for example) and by weakening executive control and motivation to regulate appetitive impulses. These effects may be most pronounced in individuals with relatively weak executive control to begin with (Bechara et al. 2006, de Wit 2009, Volkow et al. 2004, Wiers et al. 2007). A number of recent studies tested a central hypothesis from dual-process models: that the impact of implicit cognitive processes on behavior should be stronger in individuals with relatively weaker executive control compared with individuals with relatively good executive control. Indeed, this hypothesis has been confirmed using different measures to assess memory associations (word production: Grenard et al. 2008; IAT: Houben & Wiers 2009, Thush et al. 2008) and different measures of executive control functions (working memory: Grenard et al. 2008, Thush et al. 2008; classical Stroop interference scores: Houben & Wiers 2009). In individuals with relatively poor scores on executive functions, implicit memory associations were a strong predictor of smoking (Grenard et al. 2008) and alcohol use in high-risk adolescents (Grenard et al. 2008, Thush et al. 2008) and in young adults (Houben & Wiers 2009). Conversely, in adolescents with relatively good executive control, explicit expectancies were the better predictor of alcohol use (Thush et al. 2008). Importantly, this cross-over interaction, showing a fundamental distinction between implicit associations and explicit cognitions (such as outcome expectancies), is not unique to addictive behaviors. It has also been found for candy eating, sexual interest, and aggression (Hofmann et al. 2008) as well as for aggression after drinking alcohol (Wiers et al. 2009a).

A recent dual-process model of alcohol use proposed by Moss & Albery (2009) diverges somewhat from the models just described. In this model, expectancies are applied to both automatic and explicit (or reflective) cognitive effects (Moss & Albery 2009). Although this view is consistent with some previous theorizing about alcohol use (e.g., Goldman et al. 2006), it departs from the concepts and terminology used in basic cognitive research on automatic priming (Hutchison 2003) and with the traditional view of expectancies as explicit, if-then propositions (Wiers & Stacy 2010). In addition to terminology differences, we have argued that expectancy is not necessary for the explanation of automatic or implicit effects within dual-process models in addiction or elsewhere (Wiers & Stacy 2010). Some investigators, primarily studying alcohol use, argue for a more malleable definition of expectancy (Goldman et al. 2006, Moss & Albery 2010).

In addition to individual differences in the relative power of impulsive and reflective processes to predict and explain addictive behavior, there are also relevant state differences. There is emerging evidence that under the acute influence of alcohol, relatively automatic appetitive processes become stronger (Field et al. 2008b, Schoenmakers et al. 2008) while executive control processes become weaker (Fillmore & Vogel-Sprott 2006), and the extent to which this takes place predicts binge drinking (Weafer & Fillmore 2008). Further, in line with more general dual-process models, acute alcohol effects not only predict an increase in subsequent alcohol use, but also can predict other impulsive behaviors involving strong automatic associations. For example, Hofmann & Friese (2008) found that an acute dose of alcohol increased sweet consumption in participants with strong positive associations with candy consumption.

Implicit measures have been shown to be very sensitive to subtle changes in context, as should be expected from measures of relatively spontaneous cognitive processes (Mitchell et al. 2003, Roefs et al. 2006), and a recent study reported context effects for alcohol associations in relation to dating (Lindgren et al. 2009). Another recent study found that alcohol associations as assessed at home (through a Web-based device) were more strongly related to drinking behavior than were associations assessed in a controlled (but sterile) lab (Houben & Wiers 2008b), which could be interpreted as support for context-dependent triggering of drug-relevant associations. A number of other moderators have been studied recently. First, an acute dose of alcohol may not only indirectly increase the impact of impulsive processes (through weakening executive control), but may also enhance substance-related appetitive processes (Field et al. 2008b, Schoenmakers et al. 2008). Interestingly, priming effects have also been found across addictive behaviors, between smoking and drinking (Field et al. 2005, Palfai et al. 2000), and also from amphetamine to gambling (Zack & Poulos 2004). Finally, recent studies have demonstrated genetic moderation of implicit processes in addiction (Hendershot et al. 2009, Wiers et al. 2009b).

INTERVENTION IMPLICATIONS

Implicit cognition has implications for prevention and treatment of addictive behavior. Although prevention of drug use in youth has not yet evaluated implicit cognition approaches, it is possible that prevention could be improved substantially through application of implicit cognition and associative memory principles (e.g., Krank & Goldstein 2006, Stacy et al. 2004). Further, effective programs may already employ, albeit unintentionally, some of these principles. For example, most successful prevention programs repeatedly address peer situations or issues that often precede substance use. Repeatedly tying information and skills learned in a program to the situations in which drugs are likely used takes advantage of similarity postulates pervasive in connectionist and associative memory theories, outlined above. Although drug prevention research has not routinely acknowledged these plausible effects, little is actually known about the critical ingredients of prevention programs. Despite a number of well-conducted randomized trials with some important instances of success, the mechanisms of effects are not well understood, raising questions about construct validity of cause and effect even when internal validity is strong. An implicit cognition approach raises the possibility that programs may have effects through dramatically different processes than the reflective processes of major focus in this intervention arena. Understanding intervention processes helps harness the most effective components of programs, thereby improving prevention outcomes.

With respect to treatment, there are different possible applications of measures of implicit cognitive processes. First, existing measures of these processes can be used to predict treatment outcome, or they may be used to better understand effects on cognitive process mediators. Also, adapted versions may be used to directly target the cognitive processes involved. In a number of recent studies, measures of attentional bias have been used to predict treatment outcome. In alcohol-dependent patients, Cox et al. (2002) found that an increase in attentional bias during treatment predicted dropout. Pretreatment attentional bias has predicted relapse for smoking (Waters et al. 2003), heroin dependency (Marissen et al. 2006), and cocaine dependency (Carpenter et al. 2006). Regarding effects of treatment on implicit cognitive processes, cue exposure did not change attentional bias for heroin (Marissen et al. 2006), and a cognitive behavioral intervention aimed at changing alcohol expectancies was found to change explicit expectancies but to have a minimal effect on implicit alcohol associations (Wiers et al. 2005).

Second, some first attempts have been made to directly interfere with the implicit processes that are thought to play a role in addictive behaviors. This is done for two reasons. First, a direct experimental manipulation of a process is the best way to establish its causal role. Following the seminal study of MacLeod and colleagues in the domain of anxiety (MacLeod et al. 2002), first attempts were made to directly manipulate attentional biases in addictive behaviors (Attwood et al. 2008, Field et al. 2007b, Field & Eastwood 2005, Schoenmakers et al. 2007). All of these studies used varieties of the visual probe test to manipulate attentional bias. In an assessment version of the task, the probe to which participants react equally often replaces the location previously occupied by a representation of the substance or the neutral representation (a bias is inferred when the reaction to the probe is faster if the probe replaces the substance). In a modification paradigm, the contingencies are changed so that most or all probes replace the neutral representations (avoid substance condition) or most probes replace the substance representations (attend substance condition). Results have shown that indeed, this manipulation leads to changes in attentional bias both in heavy drinkers (Field et al. 2007b, Field & Eastwood 2005, Schoenmakers et al. 2007) and in smokers (Attwood et al. 2008, Field et al. 2009). However, unlike findings in anxiety (MacLeod et al. 2002), in all of the studies that tested generalization of the change in attentional bias to new (untrained) pictures, no generalization was found (Field et al. 2007b, 2009; Schoenmakers et al. 2007). All of these studies tested the effect of a single session of attentional retraining. More promising from a clinical perspective are recent findings in which the effects of repeated retraining were tested (Fadardi & Cox 2009, Schoenmakers et al. 2010). Both studies are relatively small but show that repeated attentional retraining results in generalized reductions in attentional bias and to reductions in drinking in a community sample (Fadardi & Cox 2009), and reduced risk of relapse in a clinical sample (Schoenmakers et al. 2010). In addition, first attempts have been made to directly interfere with automatic approach tendencies for alcohol, with promising results (Wiers et al. 2008). Finally, in view of the important moderating roles of executive function and motivation, treatment could not only target relatively automatic appetitive processes, but also increase motivation and ability to control these processes (Wiers et al. 2008). Motivational approaches are common in addiction (Cox et al. 2007, Miller & Rollnick 2002), but initial findings indicate that motivation alone may not always be enough to moderate the impact of impulsive tendencies in addictive behaviors, at least not in adolescents (Thush et al. 2009). An alternative or complementary approach may be to try to increase the ability to control impulses, for which positive outcomes have been reported in children with attention deficit hyperactivity disorder (Klingberg et al. 2005). Clearly, attempts to directly influence implicit cognitive processes in addiction are in their infancy, but we think they are a promising beginning that may anticipate major improvements in intervention in the future. The prediction findings documented across very different methods and designs show that this approach is worthy of increased attention in intervention research.

CONCLUSION AND FUTURE DIRECTIONS

Implicit cognitive processes, measured with a variety of different strategies, have garnered a great deal of support in basic cognitive research across multiple areas of psychology and across distinctly different methods. Further, these processes consistently have been found to predict or correlate with addictive behaviors. Important relations with substance use have been found across cross-sectional, prospective, and experimental designs, in populations varying from older children and young adolescents to adults, and among participants in treatment as well as in nontreatment settings. Implicit processes can be conceptualized and measured in a variety of useful ways as memory associations, attentional biases, or approach-avoidance action tendencies. Measurement of these processes in interventions would help increase the understanding of the nonreflective side of intervention effects. If the automatic, implicit, and associative side of cognition is the "default" in human decision, as Kahneman (2003) suggests, acknowledgment and measurement of these processes could substantially advance intervention research. Although more research is needed on measurement and theory underlying implicit processes, this can also be said about most other useful theoretical and measurement approaches relevant to clinical psychology. As in other areas, the occasional negative criticism should be weighed against the many studies supporting the approach. Overall, the area of implicit cognition as well as its integration into dual-process theory is ripe for much more extensive evaluation in interventions in addiction, either as a tool for understanding intervention effects or as a framework for intervention strategy and design.

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