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Understanding the construct of impulsivity and its relationship to alcohol use disorders

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Abstract

There are well-established links between impulsivity and alcohol use in humans and other model organisms; however, the etiological nature of these associations remains unclear. This is likely due, in part, to the heterogeneous nature of the construct of impulsivity. Many different measures of impulsivity have been employed in human studies, using both questionnaire and laboratory-based tasks. Animal studies also use multiple tasks to assess the construct of impulsivity. In both human and animal studies, different measures of impulsivity often show little correlation and are differentially related to outcome, suggesting that the impulsivity construct may actually consist of a number of more homogeneous (and potentially more meaningful) subfacets. Here, we provide an overview of the different measures of impulsivity used across human and animal studies, evidence that the construct of impulsivity may be better studied in the context of more meaningful subfacets, and recommendations for how research in this direction may provide for better consilience between human and animal studies of the connection between impulsivity and alcohol use.

Keywords

Behavioral disinhibition; behavioral undercontrol; delay aversion; impulsivity; response inhibition; sensation-seeking

The Relationship Between Impulsivity and Alcohol Use

Human studies

There is an extensive literature linking impulsivity to alcohol use and alcohol problems in human studies, as has been reviewed previously (e.g. Sher & Trull 1994; Congdon & Canli 2005; Verdejo-Garcia, Lawrence & Clark 2008). It is also well known that heavy alcohol use can trigger impulsive behavior (Jentsch & Taylor 1999; Goldstein & Volkow 2002). For

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example, Marczinski *et al.* (2005) reported that following alcohol administration in a challenge paradigm, commission errors in response engagement (i.e. key press responses) increased relative to placebo. In addition, studies of the development of the dependence process suggest that chronic, heavy alcohol consumption can lead to homeostatic dysregulation that could be expected to induce negative affect and weaken self-regulation (Koob & LeMoal 1997). That is, increasing levels of dependence can lead to decreasing levels of self-control. Thus, not only can alcohol act acutely to induce or magnify impulsive behavior, but it can also act chronically to increase the likelihood of impulsivity via the adaptive burden of what is termed allostasis.

The converse has also been demonstrated: impulsivity as measured in prospective studies has been shown to predict the development of alcohol use disorders (e.g. Dawes, Tarter & Kirisci 1997; Clark, Vanyukov & Cornelius 2002), and to mediate the relationship between parental substance use disorders and the eventual development of substance use disorders in offspring (Tarter *et al.* 2004). The fact that impulsivity is elevated in offspring who are at high risk for substance use disorders based on a parental history of substance use disorders suggests that impulsivity may be a reflection of a genetic vulnerability for substance use problems. This hypothesis is further supported by twin data that indicate that a variety of different disorders that are characterized by impulsive behavior, including alcohol dependence, drug abuse/ dependence, childhood conduct disorder and adult antisocial behavior overlap largely due to an underlying shared genetic liability (Kendler *et al.* 2003). Personality traits related to impulsivity also load on this latent genetic factor (Young *et al.* 2000; Krueger *et al.* 2002). In fact, twin studies suggest that genetic factors contributing to variation in dimensions of personality, particularly behavioral undercontrol, account for a substantial proportion of the genetic diathesis for alcohol dependence and most of the common genetic diathesis for alcohol dependence and conduct disorder (Slutske *et al.* 2002). In addition, there are electrophysiological abnormalities observed in alcohol dependent individuals that are also associated with other forms of substance dependence, childhood externalizing disorders and adult antisocial personality disorder (Iacono *et al.* 1999; Porjesz *et al.* 2005), again suggesting that an underlying vulnerability toward disinhibition may contribute to a number of different externalizing disorders, of which alcohol dependence is one. Together, these literatures indicate that impulsivity may be a general risk factor for a number of conditions broadly termed the externalizing spectrum (Krueger *et al.* 2002), and that alcohol use disorders may represent one specific manifestation of this spectrum.

It remains unclear whether impulsivity actually contributes to an enhanced risk for alcohol problems, or whether it simply reflects a manifestation of the same predisposition that contributes to alcohol use/problems. This underscores the importance of using a developmental context to understand the impulsivity/alcohol use relationship. Although personality has traditionally been viewed as a ‘stable’ characteristic, longitudinal research clearly demonstrates very large changes across the life course (e.g. Roberts, Walton & Viechtbauer 2006). Developmentally related decline in impulsivity may represent an important reason why drinking problems tend to wane with maturity (Littlefield, Sher & Wood 2009).

Animal studies

The observation of a connection between impulsivity and alcohol use/problems is not unique to human populations. It has also been observed in studies with non-human primates, rats and mice. As in humans, pre-existing differences in impulsivity have been correlated with differences in alcohol-related behavior. For example, mice exhibiting greater impulsivity, as measured by a delay discounting task, exhibit significantly less locomotor stimulation on their initial ethanol exposure, suggesting reduced alcohol sensitivity (Mitchell *et al.* 2006).

A second line of research has examined the effects of alcohol on impulsivity. Several studies have examined the effects of alcohol on impulsivity as measured by delay aversion (Poulos, Parker & Le 1998; Tomie *et al.* 1998; Evenden & Ryan 1999; Olmstead, Hellemans & Paine 2006). All used acute dosing procedures, with doses ranging from 0.25 to 1.8 g/kg, and the general consensus was that rats show heightened delay aversion following the ethanol treatment. Similarly, acute intragastric administration impairs performance in a differential reinforcement of low-rate (DRL) responding task that measures aspects of response inhibition and timing (Popke, Allen & Paule 2000). This impairment of DRL responding was observed at lower doses (1.5–3.0 g/kg) than other aspects of instrumental performance, and it was suggested that mechanisms underlying response inhibition may be particularly sensitive to the effects of acute alcohol (Popke *et al.* 2000). Alcohol also lowers response inhibition in several other experimental procedures, such as the Geller–Seifter conflict test and the elevated plus-maze. An anticonflict effect in these models may reflect behavioral disinhibition, but it may also be related to a reduced salience of the aversive or anxiogenic stimulus properties through the anxiolytic or analgesic properties of ethanol, making interpretations complicated. However, across a variety of procedures, a pattern has emerged indicating that alcohol acutely reduces response inhibition.

As in human data, there is also suggestion from animal studies that the links between impulsivity and alcohol use may be genetically mediated. One research strategy that has been used to demonstrate this in animals is to study impulsivity measures in animal lines selectively bred for differences in alcohol consumption. One pair of rat lines used to study genetic influences on alcohol-related traits is the alcohol preferring (P) and non-preferring (NP) rats. These lines were created by selective breeding of rats from the high and low extremes of alcohol consumption and preference as assessed by a two-bottle preference test procedure. After approximately 15 generations, the P and NP rats showed stable, highly differentiated alcohol preference. In addition, it has been suggested that P rats show behavioral disinhibition, as they evidence difficulties learning behaviors that require response inhibition across multiple tasks. P rats showed deficits in a passive avoidance learning task, in which the rats had to learn to inhibit stepping down from a platform to avoid a shock. In addition, they showed deficits on a DRL task, in which they had to learn to suppress bar pressing when training was shifted to require a delay in bar pressing to receive a sugar pellet reward. This led the researchers to suggest that P rats are ‘a good model of disinhibitory processes associated with familial and personality-risk for alcoholism’ (Steinmetz *et al.* 2000). Research using the high alcohol drinking (HAD1 and HAD2) and low alcohol drinking (LAD1 and LAD2) rat lines indicate that animals selected for high alcohol consumption also exhibit higher levels of delay aversion measured using a delay discounting task (Wilhelm & Mitchell 2008). Conversely, rat and mouse strains have been selectively bred for divergence in novelty seeking, as measured based on levels of exploratory locomotion in a novel environment, which provides evidence that this is a heritable trait (Kliethermes & Crabbe 2006). However, selective breeding for delay aversion or response inhibition has not occurred, presumably due to the complex nature of the tasks used to generate these behaviors and the possibility that impulsive behavior can occur through multiple mechanisms. Accordingly, the literature on selective breeding for ‘impulsivity’ phenotypes is more limited than that on animals selectively bred for differences in alcohol consumption.

Another strategy that has suggested a genetic correlation between impulsivity and alcohol use is to correlate these measures across inbred strains. For example, Logue, Swartz & Wehner (1998) found that the ability to withhold nosepoking until signaled, which they used as ‘a measure of behavioral control or impulsivity’, was negatively correlated with ethanol consumption across 13 inbred mouse strains. Strains that were better able to control their behavioral responding (i.e. less impulsive) consumed less ethanol and vice versa.

In summary, there are multiple lines of evidence from human and animal studies connecting impulsivity and alcohol use disorders. Across species, there is data that alcohol use increases impulsivity acutely. There is suggestion from human studies that chronic alcohol use may lead to long-term decreases in self-control, although this is an area of research that merits additional study in both human and animal paradigms. The converse has also been demonstrated across species: differences in impulsivity have been correlated with differences in alcohol use. Furthermore, there is suggestion across human and animal studies that the observed phenotypic correlations likely reflect, in part, a genetic correlation between impulsivity and alcohol-related phenotypes. However, what also becomes apparent across human and animal studies is that the measurement of 'impulsivity' varies dramatically from one study to the next. Different studies that purport to study impulsivity may be using very different measures of the construct. Is the same construct really targeted in studies with humans and animals? When we discuss 'impulsivity', what exactly are we talking about?

The Measurement of Impulsivity in Human Studies

Questionnaire-based measures

Impulsivity is a loose construct, and is often used interchangeably with behavioral disinhibition or behavioral undercontrol. The variable terminology may result from the fact that several different personality processes have been identified that lead to rash or impulsive acts. Historically, there has been no consistent, agreed-on understanding of the nature of the underlying disposition(s). As Depue & Collins (1999) put it, 'impulsivity comprises a heterogeneous cluster of lower-order traits that includes terms such as impulsivity, sensation seeking, risk-taking, novelty seeking, boldness, adventuresomeness, boredom susceptibility, unreliability, and unorderliness' (p. 495). There is a growing data-based consensus that there is no single personality trait that underlies the disposition to rash or impulsive action (Whiteside & Lynam 2001; Smith *et al.* 2007). Instead, recent models have described five different dispositions to rash action that are only moderately related to each other; the median inter-correlation among the five traits (which are described below) was 0.25 in a recent study (Cyders & Smith 2007; Cyders *et al.* 2007). Two of the five dispositions are emotion-based: *positive urgency* is the tendency to act rashly when experiencing extremely positive mood, and *negative urgency* is the tendency to act rashly when experiencing extremely negative mood. Two are based on deficits in conscientiousness: *lack of planning* is the tendency to act without forethought, and *lack of perseverance* reflects a failure to tolerate boredom or to remain focused despite distraction. The fifth is *sensation seeking*, or the tendency to seek out novel or thrilling stimulation (Zuckerman 1994; Whiteside & Lynam 2001, 2003; Whiteside *et al.* 2005; Cyders & Smith 2007; Smith *et al.* 2007).

The identification of these different dispositions has several advantages for impulsivity researchers in general and for alcohol researchers in particular. First, it was developed through empirical organization of the many existing measures of impulsivity, so early measures of impulsivity can be placed along one of the five dimensions (Whiteside & Lynam 2001). Table 1 provides an overview of these relationships. Second, it clarifies the types of processes that lead to rash action. Distinctions among emotion-based, conscientiousness-based and sensation seeking-based dispositions are of obvious clinical importance and likely reflect differences in etiology. Third, the five traits are easily integrated with existing comprehensive models of personality (Costa & McCrae 1992; Whiteside & Lynam 2001). Fourth, there is some evidence that there are distinct heritable contributions to them (Jang, Livesley & Vernon 1996). Fifth, the different dispositions have different concurrent and prospective external correlates (Whiteside *et al.* 2005; Anestis *et al.* 2007; Billieux *et al.* 2007; Cyders *et al.* 2007; Cyders & Smith 2007, 2008; Smith *et al.* 2007; Fried, Cyders & Smith 2008; Gay *et al.* 2008). With respect to alcohol use, the urgency traits predict problem drinking, whereas sensation seeking predicts the frequency of drinking (Smith *et al.* 2007; Fischer & Smith 2008; Cyders *et al.* 2009). Sixth, distinguishing among the different processes leads to more homogeneous measures of personality risk for impulsive action. When a single score is used to represent multiple processes that correlate only modestly with each other, the meaning of individual differences in such scores is unclear; the result is theoretical imprecision and scientific uncertainty (Smith & Combs in press). Also, the assessment of homogeneous dimensions of personality risk is essential for the effort to identify specific gene polymorphisms of relevance to that risk (Smith, McCarthy & Zapolski 2009).

Performance-based measures

Laboratory tasks are understood to measure variability in cognitive processes that can contribute to impulsive behavior. Parallel to the questionnaire-based literature, these efforts are complicated by the use of several different tasks that gauge different aspects of impulsivity. Organizational schemes provided by Friedman & Miyake (2004) and Dougherty and his colleagues (Dougherty, Marsh & Mathias 2002; Marsh *et al.* 2002; Dougherty *et al.* 2005a,b) suggest five different types of cognitive tasks. First, *prepotent response inhibition*, or the *inability to inhibit an already initiated response*, refer to 'the ability to suppress dominant, automatic or prepotent responses.' Second, *resistance to distractor interference* involves avoiding interference from task-irrelevant information in the external environment (Friedman & Miyake 2004), and third, *resistance to proactive interference* involves resisting memory intrusions of information previously, but no longer relevant to the task (Friedman & Miyake 2004). Fourth is the tendency not to delay responding in order to obtain a larger reward (Dougherty *et al.* 2005b). A tendency to prefer immediate over delayed rewards is considered to be an aspect of impulsivity that is potentially important to addiction, since addictive disorders are typified by a choice of the use of a substance in the present, often at the expense of concern about future outcomes. Accordingly, alcohol-dependent and other addicted individuals tend to discount future rewards more steeply than non-addicted individuals (Bickel *et al.* 2007). The fifth type of task involves distorted judgments of elapsed time (Dougherty *et al.* 2005b).

A number of different tasks have been developed to index these various cognitive processes; a non-exhaustive list of examples of these tasks is presented in Table 2. Similar to the questionnaire-based literature, different tasks show varying degrees of correlation. For example, Friedman & Miyake (2004) found that prepotent response inhibition and resistance to distractor interference correlated highly ($r = 0.67$), and neither correlated with resistance to proactive interference. Furthermore, they found some evidence supporting the validity of the distinction between the first two tasks and the third task, in that they had different external correlates. In fact, different cognitive tasks have been related to a number of different relevant external criteria. For example, both adolescents with disruptive behavior disorders and suicidal individuals demonstrate difficulties inhibiting already initiated responses. In addition, adolescents with disruptive behavior disorders, psychopaths and aggressive/suicidal individuals all tend to choose more immediate, smaller rewards rather than wait for larger rewards (Dougherty *et al.* 2005b). These individuals also show state-level increases in some impulsive behaviors as a function of alcohol consumption, whereby alcohol consumption leads to more errors of commission (failure to inhibit a response one should have inhibited) in a laboratory task (Dougherty *et al.* 2002). Because this type of error may reflect urgent responding, it is possible that some individuals act based on high trait levels of urgency that are compounded by alcohol-induced state increases in urgency, again suggesting multiple links between impulsivity and alcohol use.

Relations between performance (state) and questionnaire based (trait) measures

There are several issues involved in the effort to relate laboratory performance tasks to questionnaire-based trait measures. First, personality traits and the behaviors measured by laboratory tasks are far from isomorphic. The former refer to stable characteristic individual differences in ways of perceiving the world and responding to it; in all likelihood, traits reflect combinations of affective and cognitive processes. In contrast, laboratory tasks typically refer to relatively specific cognitive processes. Thus, it is not clear that measures of the two types of processes should necessarily relate strongly. Along these lines, Reynolds *et al.* (2006) found that self-report measures of impulsivity did not correlate strongly with behavioral tasks assessing aspects of impulsive behavior.

Second, the disaggregation of trait measures of impulsivity into five separate constructs is quite recent. Attempts to relate the five trait constructs to laboratory task performance are just now underway (Gay *et al.* 2008). There will probably be important new developments relating the traits and tasks in the coming years. One initial attempt to relate the cognitive tasks to personality traits is that of Bechara & Van der Linden (2005). They suggested that urgency may relate to prepotent response inhibition (or, in Dougherty's terms, difficulty inhibiting already initiated responses), whereas lack of perseverance may relate to resistance to proactive interference. Consistent with their view, McCarthy, Kroll & Smith (2001) found that errors in a go/no-go task correlated with neurotic extraversion; go/no-go errors of commission are thought to reflect failures to inhibit prepotent responses. Most recently, Gay *et al.* (2008) provided more direct empirical support for their contention. Gay *et al.* (2008) found that negative urgency did in fact correlate with errors in a go/no-go task, and that lack of perseverance did relate to difficulties in overcoming proactive interference and to intrusion of task unrelated thoughts.

It is likely that progress defining the cognitive functions measured by different tasks will continue to accrue, as will information relating personality traits to task performance. The difficulties in these domains do, of course, pose difficulties in efforts to relate human and animal measures of impulsivity.

Measures of Impulsivity in Animal Studies

The measures used in animal studies have parallels with performance tasks described in human research, but are more narrowly defined and are almost exclusively focused on response inhibition and delay aversion. Tasks that measure the inability to withhold responses are characterized by periods during which responding is reinforced, coupled with periods in which either (1) the absence of responding is explicitly reinforced or (2) the occurrence of responding is neither reinforced nor punished. In some procedures, the different periods are signaled by unique cues (e.g. a go/no-go procedure in which a light indicates responding will be reinforced and a tone signals responses will be accompanied by foot shock). In other procedures, only the period in which responding is reinforced is signaled (e.g. responding in a location signaled by a light in the five choice serial reaction time task; Robbins 2002). In yet other procedures, only internal signals indicate when responses will be reinforced (e.g. internal signals that indicate the passage of time in a differential reinforcement of low-rate responding procedure; DRL). Tasks that measure delay aversion (delay discounting) are characterized by choices between small rewards available immediately or with a minimal delay, and larger rewards available after a delay. To quantify sensitivity to delay, some procedures vary the length of the delay to the larger reward and examine changes in preference (adjusting delay procedure, e.g. Perry *et al.* 2005; the within sessions procedure, e g., Evenden & Ryan 1999; the between session procedure, e.g. Poulos, Le & Parker 1995), while others vary the size of the small reward (adjusting amount procedure, e.g. Richards *et al.* 1997).

Even with the more limited measures of impulsivity used across animal studies, there is evidence that these tasks may tap into different aspects of impulsivity. Research has shown that response inhibition and delay aversion are mediated by different neurobiological and neurochemical substrates, implicating dissociable cortico-limbic-striatal circuits and mechanisms. For example, different brain manipulations affect response inhibition and delay discounting (Evenden 1999; Dalley *et al.* 2007a). Additionally, the difference observed between HAD and LAD rats on a delay discounting task, described above (Wilhelm & Mitchell 2008), was not observed in short-term selected lines of mice, bred to voluntarily drink either high (STDRHI2) or low (STDRLO2) amounts of 10% ethanol. However, in a Go/No-go task, STDRHI2 mice showed significant impairments in ability to inhibit nose-poking in response to specific cues (Wilhelm *et al.* 2007). On this basis, the authors suggested that delay aversion and response inhibition are different forms of impulsivity (see also Evenden 1999; Winstanley *et al.* 2005; Dalley *et al.* 2007b; Winstanley 2007), and that future studies should examine 'the link between genetics and specific subcomponents of impulsivity associated with alcohol consumption' (Wilhelm *et al.* 2007). Another question that remains to be answered is whether different aspects of impulsive behavior influence different aspects of alcohol-motivated behavior and consumption. In a recent study, Diergaarde *et al.* (2008) demonstrated that impulsive action (i.e. response inhibition) and impulsive choice (i.e. delay aversion) predict vulnerability to distinct stages of nicotine-seeking behavior in rats. Impulsive action was associated with a greater motivation for nicotine, whereas impulsive choice was associated with nicotine seeking during abstinence and cue-induced relapse. It remains to be determined whether a similar dissociation exists between different varieties of impulsivity and subdomains of alcohol self-administration.

Future Directions

Research clearly establishes a link between impulsivity and alcohol use in both humans and animals, with data indicating bidirectional relationships: alcohol consumption increases impulsive acts, and organisms that differ on impulsivity also differ in their alcohol consumption. Furthermore, there is evidence that these phenotypic correlations may be genetically mediated.

Progress in understanding the relationship between impulsivity and alcohol use has likely been slowed by the imprecise use of the term 'impulsivity' and the plethora of measures that have been used to index this construct. Indeed, there is now good evidence, from both human and animal studies, that impulsivity is not a unitary construct. In human studies, different measures that have all been referred to as measures of 'impulsivity' are not highly correlated and do not load on a single factor; this is true of both questionnaire-based and laboratory-based measures of impulsivity. It is crucial for researchers to appreciate the distinctions among the different personality bases for rash action, the distinctions among different cognitive tasks thought to relate to rash action, and the distinctions between trait and laboratory task-based operationalizations of impulsivity/inhibition. Researchers should specify the precise cognitive or trait process in which they are interested in order to maximize the validity of the inferences they draw from their studies. Recent years have seen progress in attempting to identify more homogeneous subfacets of impulsivity, with some of these efforts described here. Importantly, these different aspects of impulsivity appear to be differentially related to different aspects of alcohol use and may help advance our understanding of different pathways of risk to the development of alcohol problems. For example, one of the important distinctions that has emerged when comparing the different dispositions with rash action is that the urgency traits predict problem drinking, whereas sensation seeking predicts the frequency of drinking. Although the necessary research has not yet been conducted, it may be the case that urgency-inspired drinking is more often associated with bad choices, both because of affect-based depletion of cognitive resources (Muraven & Baumeister 2000), and because there may be additive effects of trait urgency and alcohol-induced disinhibition.

With efforts underway to identify more homogenous dispositions to rash action, the next critical step will be to delineate how these different dispositions relate to the different laboratory tasks measuring aspects of behavioral disinhibition. Initial efforts toward this goal are underway, with some preliminary but converging evidence that urgency may relate to prepotent response inhibition, whereas lack of perseverance may relate to resistance to proactive interference. An additional step may be to continue to pursue the development of laboratory tasks that relate to the more recently identified personality processes. For example, is there benefit to developing new, additional laboratory tasks for humans or animals that might reflect emotion-based rash action? The final critical step will be to identify how these questionnaire and laboratory based measures from human studies relate to the tasks used to measure impulsivity in animal studies. We note that even though the most obvious parallels are between human laboratory-based tests of impulsivity and animal measures of impulsivity, performance on laboratory tasks in humans is more readily discussed as reflecting both 'trait-based' personality facets, as well as cognitive function and a variety of other 'state-based' factors that influence task performance. However, these issues and distinctions have received less explicit attention in the animal literature. Questions will need to be addressed, such as, are genetic findings that emerge with a particular paradigm in animal studies also related to the hypothesized analogous paradigm in human laboratory-based measures? Knowing that the two predominant methods of measuring impulsivity in animals (through response inhibition and delay aversion) show different external correlates, we might expect that similar differences would be found using response inhibition tasks and delay discounting paradigms in human laboratory studies. Experimental paradigms suitable for animals do exist to examine dimensions of rash action identified by research in human subjects, such as impact of task-irrelevant stimuli (e.g. Pavlovian examinations of context effects) and distorted estimates of elapsed time (e.g. the peak procedure for timing). However, individual differences in these measures have not been a primary focus of interest for researchers, nor have data been interpreted in an impulsivity context. In addition, there is very little work in the animal literature (or human literature for that matter) on how chronic alcohol use and dependence influence impulsivity. Future work in this area would be highly valuable.

Table 3 represents a first attempt to synthesize these literatures. It lists primary dimensions of impulsivity that have been identified/studied across the personality and laboratory-based human studies and animal studies. Facets of impulsivity that have shown consistent relationships with alcohol use/problems (as reviewed early in this paper) are indicated with a shared superscript, and measures that show some preliminary evidence of tapping into the same facets of impulsivity are indicated together in a shaded or nonshaded box. This table is by no means exhaustive or complete; it only represents a starting point that we hope will generate hypotheses to guide future research. We are certain that many researchers would argue for additional tasks/measures for inclusion in various boxes in the table; this is exactly the point —to begin a dialogue, and hopefully to inspire studies to collect the requisite data to expand and solidify this table. Research of this sort, which attempts to relate measures of different facets of impulsivity across tasks and across species, is in its infancy. Many unresolved questions remain to be answered. For example, initial studies suggest that positive and negative urgency and sensation seeking are most readily associated with aspects of alcohol use; are the constructs of lack of planning and lack of perserverance of little relevance to the field of alcohol research, or are they perhaps related to components of the dependence process that have yet to be studied? Or, are these low conscientiousness traits most relevant to problem drinking for only a subset of the population, such as individuals with attention deficit-hyperactivity disorder? More broadly, are there moderators of the influence of each of the traits that merit investigation? Are there laboratory tasks or animal paradigms that tap into the construct of human sensation seeking, which has been associated with alcohol use and problems across multiple independent studies? Is it possible to develop tasks that differentiate positive and negative urgency? And finally, research will be needed to identify how these different facets and measures of impulsivity may be related to different components of the dependence process. Although this represents a challenging task, it will be necessary to understand how pathways of risk for alcohol dependence unfold and what role(s) aspects of impulsivity play in those pathways.

In conclusion, studying the relationship between impulsivity and alcohol use is a challenge that has been magnified by the wealth of different measures used to index a heterogeneous construct. In order to advance our understanding of how rash action is related to alcohol use/ problems, we need (1) better delineation of the impulsivity construct into more homogeneous facets in the personality literature; (2) systematic efforts to relate these facets to the different aspects of impulsivity measured via different laboratory tasks; and (3) research aimed at characterizing how these different aspects of impulsivity, as measured in human questionnaires and laboratory tasks, relate to the different animal models of impulsivity.

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Table 1

Scales from previous measures of impulsivity that load on each of the five dispositions identified in Whiteside & Lynam (2001).

Disposition	Measure	Reference
Negative urgency	Inhibitory control	Buss & Plomin (1975)
	NEO-PI-R impulsiveness scale	Costa & McCrae (1992)
	Barratt's attentional impulsivity	Patton, Stanford & Barratt (1995)
Sensation seeking	Buss and Plomin's sensation seeking scale	Buss & Plomin (1975)
	Eysenck's venturesomeness scale	Eysenck *et al.* (1985)
	NEO-PI-R excitement seeking scale	Costa & McCrae (1992)
	Dickman's functional impulsivity scale	Dickman (1990)
Lack of planning	NEO-PI-R deliberation scale (negatively)	Costa & McCrae (1992)
	Multidimensional Personality Questionnaire control scale	Tellegen (in press)
	Personality Research Form impulsivity scale	Jackson (1984)
	Eysenck's I-7 impulsivity scale	Eysenck *et al.* (1985)
	Temperament and Character Inventory impulsivity scale	Cloninger (1987)
	Buss and Plomin's decision time scale	Buss & Plomin (1975)
	Barratt's lack of planning and motor impulsivity scales	Patton *et al.* (1995)
	Barratt's attentional impulsivity	Patton *et al.* (1995)
Lack of perseverance	NEO-PI-R self-discipline scale (negatively)	Costa & McCrae (1992)
	Sensation Seeking Scale disinhibition and boredom susceptibility scales	Zuckerman (1994)
	Buss and Plomin's persistence scale.	Buss & Plomin (1975)
Positive urgency	—	

NEO-PI-R = NEO Personality Inventory-Revised.

Table 2

Examples of laboratory tasks used to measure different cognitive constructs related to impulsivity.

Construct	Example tasks	Brief description	Reference
Prepotent response inhibition	Go/no-go tasks	Suppress an inclination to provide a previously reinforced response	Marczinski & Fillmore (2003)
	Stop-signal task	Learn to categorize words, try to withhold learned response on some trials	Logan (1994)
	Continuous performance task	Respond as quickly as possible to target stimulus, refrain response on rarer nontarget	Conners & MHS Staff (2000)
	Antisaccade task	Suppress a reflexive saccade toward a cue	Friedman & Miyake (2004)
Resistance to distractor interference	Eriksen Flanker task	Identify target letter presented by itself or flanked by incompatible letters	Eriksen & Eriksen (1974)
	Word naming task	Name target word, presented in green, alone or with distractor red word	Kane *et al.* (1994)
	Shape matching task	Same as above, but with shapes instead of words	DeSchepper & Treisman (1996)
Resistance to proactive Interference	Brown–Peterson task	Learn and later recall successive lists made up of words taken from same category	Kane & Engle (2000)
	Cued recall task	View one of two lists of words, then recall word on most recent list, ignoring previous list words	Tolan & Tehan (1999)
Delay response	Two choice impulsivity paradigm	Choices between smaller reward more quickly, and larger reward with delay	Dougherty *et al.* (2005b)
	Single key impulsivity paradigm	Respond as desired, size of reward related to length of delay between responses	Dougherty *et al.* (2005b)
Distortions in elapsed time	TIME paradigm	Estimate how much time has elapsed	Dougherty *et al.* (2005b)

Table 3

Different facets of impulsivity identified in human and animal studies.

Human		
Personality literature[a]	**Laboratory tasks**	**Animal**
Positive urgency[b]	Prepotent response inhibition[b]	Response inhibition[b]
Negative urgency[b]		
Lack of perseverance	Resistance to distractor interference	
	Resistance to proactive interference	
	Delay aversion[b]	Delay aversion[b]
Lack of planning		
Sensation seeking[b]		
	Judgment of time elapse	

Note: measures that show some preliminary evidence of tapping into the same facets of impulsivity are indicated together in a shaded or nonshaded box.

[a]Subscales in UPPS Impulsive Behavior Scale; Whiteside & Lynam (2001); Cyders *et al.* (2007).

[b]Indicates facets of impulsivity that have shown consistent relationships with alcohol use/problems, as reviewed in text.