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A Brief, Critical Review of Research on Impaired Control over Alcohol Use and Suggestions for Future Studies

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Abstract

Impaired control, defined as “a breakdown of an intention to limit consumption” (Heather et al. 1993; p. 701) has historically been considered an important aspect of addiction. Despite recognition of its importance to addiction and potential value as an early indicator of problem drinking risk, we argue that impaired control over alcohol use has not received sufficient research attention. In an effort to spark further research, the present critical review offers brief discussion of the current state of knowledge regarding impaired control and avenues for future research. Three main research areas are addressed: 1) epidemiology, 2) measurement issues and 3) potential mechanisms underlying relationships between impaired control and subsequent problem drinking. Measurement issues include complexities involved in self-report assessment of impaired control, development and validation of human and animal laboratory models, and impaired control’s relationship to other constructs (i.e., impulsivity and other difficulties with self-control; symptoms of dependence such as craving). We discuss briefly two potential mechanisms that may help to explain why some drinkers experience impaired control while others do not: neurobiological dysfunction and family history/genetics. Suggestions for future research are focused on ways in which the impaired control construct may enhance prediction of who might be at particular risk of subsequent problem drinking and to facilitate intervention to reduce problem alcohol use.

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Impaired control over alcohol use involves "a breakdown of an intention to limit consumption" (Heather et al., 1993). Difficulty adhering to limits may be manifested as failure to avoid alcohol use completely (i.e., persistent desire or unsuccessful efforts to cut down or control use ["quit/control"]) or to control alcohol consumption once it has begun (i.e., use in larger amounts or for a longer period of time than intended ["larger/longer"]) (Kahler et al., 1995). Impaired control is not synonymous with heavy drinking (Kahler et al., 1995), nor simply a desire to drink less. Rather, impaired control is a pattern of alcohol use that supersedes conscious intentions to limit use on specific occasions (Heather et al., 1993). Impaired control has been viewed historically as an important aspect of addiction (see Kahler et al., 1995). Its continued clinical relevance is reflected in the fact that two criteria for substance dependence in the 4th edition text revision of the DSM (DSM-IV-TR, APA, 2000) relate to two main facets of impaired control: "larger/longer" (LL) and "quit/control" (QC) (Hasin and Beseler, 2009). More frequent endorsement of LL than QC (e.g., Saha et al., 2007) can be taken as evidence for distinctness of the two main facets of impaired control. However, psychometric findings suggest impaired control is essentially a unitary construct (Heather et al., 1993; Kahler et al. 1995; Read et al., 2006; see Leeman et al. 2012 for discussion).

Evidence suggests impaired control is one of the earliest-developing signs of problem drinking and thus has value as a characteristic of alcohol dependence and potential predictor of more serious problem drinking (see Leeman et al., 2012). Adolescent (Gelhorn et al., 2008; Martin et al., 2006) and young adult (Patock-Peckham et al., 2001; 2011) drinkers frequently endorse impaired control, both on self-report measures and the relevant DSM-IV dependence criteria in diagnostic interviews. Further, alcoholic adults often cite impaired control retrospectively as the dependence symptoms that developed earliest (Langenbucher and Chung, 1995). Limited prospective results show that impaired control predicts subsequent alcohol involvement and related problems. In undergraduates, impaired control self-reported during freshman year predicted self-reported alcohol-related problems during senior year (Leeman et al., 2009). In a short-term prospective study, self-reported impaired control predicted self-reported alcohol use frequency and heavy drinking among undergraduates (Read et al., 2007). A short-term follow-up showed less self-reported alcohol consumption and lower levels of impaired control among college students receiving standard web-based interventions compared to a control condition (Hustad et al., 2010).

Discussion of impaired control as an early-developing dependence characteristic implies progression along a continuum of severity (Heather et al., 1993; Heather 1995). This progression may parallel the impulsivity-to-compulsivity shift that has been described in the addictions (Everitt et al., 2008). People may initially have difficulty adhering to limits because they feel compelled to drink even if negative consequences are possible (i.e., impulsive use), due to rewarding effects of alcohol. After a long period of use, people may shift to a habitual pattern in which they feel incapable of stopping even if serious problems may occur (i.e., compulsive use) (Modell et al., 1993). Severity of impaired control may be assessed most accurately using reliable, valid multiple-item self-report measures (e.g., Heather et al., 1993). Clinical interviews and self-reports typically used in epidemiologic studies yield binary results as to whether or not individuals meet particular dependence criteria and thus do not capture a range of severity.

Impaired control's relationship to other difficulties with self-control has also been a source of uncertainty. An example is impulsivity, a multifaceted construct defined as "a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences" (Moeller et al., 2001). Both constructs involve difficulties maintaining control over behavior and both are likely to result in action despite possible consequences. There are theoretical distinctions between the constructs though. Impaired control is a tendency toward dysregulated patterns of alcohol drinking specifically (Patock-Peckham et al., 2011) and thus one need not necessarily be impulsive in everyday life to experience impaired control (Leeman et al., 2012). Also, impaired control necessarily involves intentions to set limits on alcohol use whereas with impulsivity, there need not be any intention to limit behavior (Bickel and Marsh, 2001). Empirically, correlations between self-reported impaired control and impulsivity have been small-to-moderate (Leeman et al., 2012). Taking these factors into consideration, Leeman et al. (2012) concluded impulsivity and impaired control over alcohol use are related, but distinct constructs.

Despite impaired control's status as a key aspect of addiction and its value as a potential early indicator of more severe problem drinking risk (Leeman et al., 2009), impaired control has not received ample research attention. To spark further research, we offer brief discussion of current knowledge and future directions. We will address three main research areas (Table 1): epidemiology, measurement issues, and possible mechanisms underlying relationships between impaired control and problem drinking.

EPIDEMIOLOGY

Epidemiologic research has provided evidence regarding two DSM-IV dependence criteria (i.e., "larger/longer" [LL] and "quit/control" [QC]) that pertain to impaired control. LL is consistently endorsed at high frequency in adolescent, college and adult samples. QC is consistently endorsed less frequently than LL (e.g., Beseler et al., 2010; Proudfoot et al., 2006; Saha et al., 2007) though the magnitude of differences in LL and QC endorsement varies across studies. Criteria that are endorsed less frequently and begin to be endorsed later in the natural history of drinking are considered more severe. Findings from cross-sectional and prospective studies support the relatively early onset of impaired control.

Cross-sectional studies

Findings from Pollock and Martin (1999) offer an example of the endorsement patterns described above. The most highly endorsed DSM-IV criterion among adolescents was tolerance (41%), followed by LL (33%) and QC (26%). This is consistent with Beseler et al. (2010) who found that tolerance was most frequently endorsed (46%) followed by LL (35%) among undergraduate drinkers. Similar patterns of LL and QC endorsement are seen in large adult community samples (Hasin and Beseler, 2009; Saha et al., 2007). Reflecting the high prevalence of endorsement, item response theory (IRT) analyses have repeatedly found that LL falls in the low severity region of the severity continuum among adolescents (Gelhorn et al., 2008; Martin et al., 2006), undergraduates (Beseler et al., 2010) and adults (Kahler and Strong, 2006; Proudfoot et al., 2006; Saha et al., 2007).

Persistent desire to quit or cut down drinking (QC) is nearly always endorsed less frequently than LL among general population samples (Harford et al., 2005; Proudfoot et al., 2006); those with a family history of alcoholism (Bucholz et al., 1996); international samples (Nelson et al., 1999); current/heavy drinkers (Harford and Muthen, 2001); young adult twins (Lynskey et al., 2005) and adolescents (Gelhorn et al., 2008). A review of these endorsement rates reveals that the gap between endorsing LL and QC is typically larger among adolescents than older drinkers. In an IRT analysis, across community, adjudicated and clinical samples of adolescents, QC showed high severity yet low utility in drawing

distinctions between higher- and lower-risk drinkers (i.e., discrimination) (Gelhorn et al., 2008). Other studies have found high severity and high discrimination for QC in community samples (e.g., Saha et al., 2007). Although QC usually falls in the middle to severe end of the spectrum, an IRT model showed LL to have lowest severity and QC was next lowest in an Australian community sample (Proudfoot et al., 2006). The variability of results may have been due to cultural, measurement and sample (e.g., specific age group versus general community) differences across studies.

Prospective studies

A German longitudinal study found that tolerance, LL and time spent were the first symptoms to appear in adolescent drinkers. Early LL onset was predictive of subsequent alcohol dependence (Behrendt et al., 2008). In another longitudinal study in a high-risk U.S. community sample, LL was more prevalent than tolerance as a first symptom and QC endorsement was indicative of an early stage of alcohol dependence (Buu et al., 2012).

Progression from LL to QC may be indicative of more severe impaired control, possibly paralleling the aforementioned impulsivity-to-compulsivity shift (Everitt et al., 2008). More specifically, impaired control may begin with impulsive choices to drink when one had planned to abstain or to drink to a greater extent than planned (LL). This pattern typically results in negative consequences, which will lead some drinkers to attempt to moderate their drinking. Among those who fail to moderate their drinking despite multiple attempts (QC), some may eventually reach more intense impaired control characterized by compulsive perceived inability to stop drinking.

Population-based, longitudinal epidemiologic research is needed to assess the extent to which this type of progression constitutes a common natural history of problem drinking. Longitudinal epidemiologic studies are also needed to determine whether the two impaired control criteria independently predict subsequent alcohol dependence and whether when assessed together they can be used to predict increased risk of developing an alcohol use disorder. Adolescents who have recently initiated alcohol consumption might be the most appropriate cohort to follow.

In summary, cross-sectional results show that LL is endorsed commonly, compared to other criteria, suggesting lower severity for this criterion and raising the possibility that it is an early indicator of problem drinking. Limited prospective results support this contention. Though usually not endorsed as frequently as LL, QC is nonetheless endorsed relatively commonly, leading to the conclusion that QC is a more severe criterion than LL but still may act as a predictor of more severe future problem drinking.

MEASUREMENT ISSUES

Complexities in self-report assessment

The impaired control construct contains a subjective component, entailing alcohol consumption in violation of an intention to limit use. Thus self-report measures must take into account whether or not individuals set a limit, which presents a challenge (Heather, 1995). Not all problem drinkers set limits on their drinking behavior, making accurate accounting of limit-setting important. For instance, in a small treatment sample, only 36% and 41% of participants endorsed items related to each of the two impaired control criteria and the author reported there were many “not applicable” responses, due to patients reporting no intentions to control their drinking (Chick, 1980). Some adolescents may be unlikely to endorse impaired control-related dependence criteria (particularly QC) due to lack of meaningful attempts at changing their drinking behavior (Martin et al., 2006). Ecological momentary assessment methods may help to capture fluidity and influence of

context in reports of limit setting and alcohol use itself, along with limiting forgetting and recall bias.

Researchers have expressed concerns regarding the validity of endorsement of the impaired control-related dependence criteria in some studies. Endorsement by younger drinkers with relatively short drinking histories and by those who tend not to drink heavily indicates that impaired control endorsement may not consistently reflect compulsive use (e.g., Caetano, 1999). However, lighter drinkers may tend to set relatively low limits that are easily violated, while some heavier drinkers may set inordinately high limits that they will rarely violate. There have also been concerns that for some drinkers, tendencies toward impaired control may relate more closely to social motives or circumstances (i.e., drinking more than intended to facilitate having a good time) than to compulsive use (e.g., Slade et al., in press). While there have been findings that certain drinking motives (e.g., coping) have stronger relationships to alcohol dependence criteria endorsement than others (Beseler et al., 2010), social motives (e.g., inordinately heavy drinking during 21st birthday celebrations [Rutledge et al., 2008]) may also be tied to problematic drinking. Thus, a variety of drinking motives may relate to impaired control and other problematic drinking patterns. For these reasons, patterns of impaired control endorsement that may seem surprising initially do not necessarily indicate poor validity. Further, endorsement of impaired control among non-compulsive drinkers is less of a concern if one views impaired control as being on a continuum of severity (Heather, 1995).

Multi-item self-report measures of impaired control may capture severity and address concerns about validity. Perhaps the best-known measure is the Impaired Control Scale (ICS; Heather et al., 1993): a 3-part measure assessing frequency of recent attempts to limit consumption; past difficulties limiting use and beliefs about future difficulties controlling use. There is also a subscale in a measure of young adult alcohol-related consequences pertaining to impaired control (Read et al., 2006). Current self-report measures do not account for effects of social/environmental context on likelihood of limit setting and likelihood of adherence to limits. For instance, people might be more likely to set limits when at work events where intoxication is inappropriate. Spending time with heavy drinking peers is an example of a context that might make adherence to limits more challenging. Conceivably, those who experience impaired control with less regard to context may be at greatest risk for subsequent physiological dependence as this may be suggestive of a movement toward habitual use (Everitt et al., 2008). Given availability of established, reliable, valid measures, efforts to enhance self-report assessment of impaired control might be most effective through augmentation of existing measures by asking participants to report on tendencies toward impaired control in a variety of contexts.

Measurement issues also pertain to epidemiologic research concerning the prevalence and utility of the impaired control-related dependence criteria. The relative severity of LL has been found to depend to an extent on the items used to measure the construct (Kahler and Strong, 2006). Also, severity of QC has been much lower if assessed as a desire to cut down or stop as opposed to repeated failed attempts to do so (Kahler and Strong, 2006). Thus item selection and precise wording of items requires close attention.

Animal and human laboratory models

Laboratory methods allow investigators to control contingencies presented to subjects and record effects on resulting behaviors, though the artificial nature of these contingencies could be considered a limitation. Essentially, self-report measures assess whether participants believe they have difficulty limiting alcohol use. Laboratory models could be used to assess drinking behavior indicative of impaired control. Considering these differences, it is not surprising that self-report and behavioral measures of self-control-

related constructs have been weakly related (e.g., Krishnan-Sarin et al., 2007). Thus, self-report and behavioral measures of impaired control may provide unique and valuable information in predicting drinking outcomes. Laboratory models could also enable assessment of relationships between impaired control and magnitude/types of cognitive effects resulting from acute or long-term alcohol use as assessed using various behavioral tasks (Fillmore, 2003).

Limits on consumption are critical to impaired control and can be addressed in two non-mutually-exclusive ways in human laboratory models. Intentions to limit consumption and perceived ability to do so could be self-reported by participants prior to and during alcohol administration. Inclinations to limit consumption may also be intuited based on subjects' behaviors in response to contingencies in laboratory paradigms as Leeman et al. (in press) did. Non-naïve human drinkers or animals trained to self-administer alcohol could be provided access to self-administer alcoholic or non-alcoholic beverages *ad-libitum*. The quantity of fluid consumed could be reinforced with alternative rewards (e.g., with food, social stimuli) to limit alcohol intake. Self-administration superseding these levels could be considered indicative of impaired control. While this approach has face validity, it can be challenging to ascertain definitively human participants' intentions to limit their alcohol use and in animal models, there is no direct way to obtain this information.

It is necessary for contingencies to have face validity for modeling impaired control. However, a necessary step in validating any laboratory paradigm is to test whether experimental manipulations result in predictable changes in observable behavior. In this case, the goal would be to observe whether or not patterns of alcohol self-administration believed to be indicative of impaired control increase or decrease among participants randomized to a particular manipulation. For instance, stress-induction may increase alcohol intake above a reinforced limit whereas established or experimental pharmacotherapies may decrease likelihood of alcohol intake above a particular threshold. These types of manipulations could be utilized to learn about possible causes of impaired control (e.g., stress) and to investigate the efficacy of interventions to reduce impaired control on a preliminary basis.

Alcohol self-administration exceeding a limited threshold could also be punished, however it may be advisable for such contingencies to be established separately from limits placed on alcohol self-administration (again perhaps through reinforcement). Alcohol intake despite possible negative consequences is a separate element of addiction and a unique DSM-IV dependence criterion (APA, 2000) though theoretically and empirically related to impaired control (Leeman et al., 2012).

Existing animal models offer guidance regarding possible reinforcement and punishment contingencies that could be incorporated into laboratory models of impaired control. Alcohol drinking can be decreased by scheduling consistent punishment, especially social consequences, as was shown in alcoholics who had self-administered 9–16 drinks per day (Griffiths et al., 1977). Models of continued alcohol self-administration despite punishment have also been developed (0.3–0.7 g/kg/30 min, rats, Vendruscolo et al., 2012). Social stimuli may also make effective rewards (Machado et al., 2011) when attempting to reinforce alcohol self-administration within a pre-determined threshold.

Grant, Helms and colleagues' ongoing work using a well-validated monkey model of alcohol drinking (Grant et al., 2008) is another example of an existing approach that could be utilized to model impaired control. Monkeys required to perform a challenging task for meals greatly decreased their percentage of heavy drinking days (defined as > 3.0 g/kg/day, 0–8%) compared to performing a simple response for meals (fixed-ratio 1, 30%). This

approach could be combined with reinforcement of alcohol self-administration within predetermined limits, perhaps using social stimuli. Animals initially incapable of consuming within these limits could be forced subsequently to earn their food in the challenging task model. For animals who continue to be incapable of consuming within reinforced limits, their patterns of intake are likely indicative of severe, compulsive impaired control. Subsequently, these animals could be re-tested in such a paradigm after having received established or experimental pharmacotherapies, placebo-controlled, in order to determine an effect for these interventions in decreasing self-administration patterns indicative of impaired control.

Prolonged exposure to alcohol vapor leads to some rats self-administering alcohol despite its being mixed with a bitter solution (Vendruscolo et al., 2012). Animals that persist with this pattern, thought to indicate habitual, compulsive responding, could then be introduced to reinforcement for limited alcohol self-administration. Animals that continue to persist with heavy self-administration could also be considered to exhibit impaired control. Similarly, such animals could be re-tested after receiving a pharmacotherapy or placebo to assess its utility for reduction of impaired control. These models could provide valuable basic science data to support subsequent human testing of novel medications that may help to alleviate an early-developing characteristic of alcohol dependence, thus preventing development of more severe alcohol problems.

Relationship to other constructs

Further research is needed to evaluate impaired control's relationships to constructs including risk-taking and specific facets of impulsivity including impulsive response tendencies and decision-making (e.g., delay discounting), assessed via self-reports and behavioral tasks. Behavioral tasks could be utilized to assess how impaired control relates to attentional bias toward alcohol cues; appetitive, approach tendencies; and/or inability to inhibit pre-potent impulses at baseline and following alcohol administration (Field et al., 2010). Basic research suggests impulsivity may predispose organisms to excessive substance use (Everitt et al., 2008), a hypothesis that could be tested prospectively in humans.

Further research is also needed to learn about relationships between impaired control and other symptoms of alcohol dependence (e.g., craving, drinking to alleviate withdrawal). There is evidence suggesting relationships between craving and impaired control. Similar changes over time in self-reports of the two constructs were observed in an alcohol administration paradigm (Modell et al., 1993). In clinical and community samples of adolescents, LL and QC endorsement were found to have mainly small-to-medium significant correlations with craving (Chung and Martin, 2002). However, a key distinction is that craving is a cognitive, motivational state that may or may not lead to actual substance use (Field et al., 2009) whereas there cannot be impaired control without substance use.

In summary, there are several measurement issues regarding impaired control. Issues with self-report include how to account for the crucial subjective, limit-setting element and questions about severity underlying some endorsements of the impaired control-related diagnostic criteria that have led investigators to question the validity of these reports. Use of reliable, valid multi-item self-report measures (e.g., Heather et al., 1993) may be the best approach to addressing these concerns. Laboratory paradigms are promising approaches for research on impaired control that may allow investigators to learn more about precipitants of and interventions to reduce impaired control. Lastly, research is needed to address associations between impaired control and related constructs such as other difficulties with self-control (e.g., impulsivity) and symptoms of alcohol dependence (e.g., craving).

POSSIBLE MECHANISMS

Little is known about why some individuals experience impaired control while others do not, nor is much known about mechanisms underlying relationships between impaired control and subsequent problem drinking. Further research addressing neurobiological dysfunction and family history/genetic risk factors may help address these issues.

Neurobiological dysfunction

With the exception of Modell et al. (1993), who related self-reported impaired control to dopaminergic activity, little prior empirical work has been conducted to relate impaired control directly to neurotransmitter systems or brain function. However, recent studies have related self-reported impaired control to activation in brain regions associated with other difficulties with self-control.

Claus et al. (2011a) conducted an fMRI study of heavy drinkers, with the goal of identifying neural responses to alcohol taste cues. Significant relationships were found between ICS scores (Heather et al., 1993) and enhanced response to alcohol compared to control beverage taste cues in several regions, particularly the insula, precentral gyrus and putamen. Notably, activity in all three regions was associated with riskier task performance in another study (Claus and Hutchison, 2012). Another research group found that alcoholic patients showed decreased activation in the insula and other prefrontal areas in response to fearful facial expressions. Moreover, negative correlations were found between self-reported impaired control and strength of connectivity between the insula and areas of the brain involved in emotion regulation (e.g., inferior frontal cortex) during observation of fearful facial expressions (O'Daly et al., 2012). Taken together, these findings could mean that impaired control is associated with heightened responsiveness to alcohol cues, along with insensitivity to aversive stimuli and these tendencies may be partially mediated by insula dysfunction. Prior findings concerning the insula further support its relevance. The insula has been tied to craving (Naqvi et al., 2007), delay discounting (Claus et al., 2011b) and experience of reward (de Ruiter et al., 2009) among those with problematic addictive behaviors.

The aforementioned impulsivity-to-compulsivity shift that characterizes addiction has been linked to a change in predominance from cortical to striatal activity and within the striatum, from primarily ventral to dorsal activity (Everitt et al., 2008). A relationship between self-reported impaired control and activity in the putamen (located in the dorsal striatum) in the presence of alcohol cues may be suggestive of compulsive alcohol use among some heavy drinkers with impaired control (Claus et al., 2011a). On the other hand, significant positive relationships were found between self-reported impaired control and activity in the left nucleus accumbens (located in the ventral striatum), which may indicate that for some heavy drinkers, alcohol cues are associated with impulsive response or anticipated reward. These relationships could be addressed in future studies using a variety of experimental probes in association with neuroimaging and either self-reported or laboratory models of impaired control. This type of research would be relevant to our understanding of progression of addiction and the role of impaired control in this progression.

Genetics/family history

While progress to identify specific genetic variations associated with increased problem drinking risk has been relatively slow (Claus et al., 2011a), it is well-established that those with a positive family history are at increased risk for developing alcohol use disorders (e.g., Bucholz et al., 1996). There is also precedent for a link with self-control difficulties. Constructs like impulsivity share a common genetic liability with substance use disorders (Kendler et al., 2003). Given this precedent, family history positive individuals may also

tend toward impaired control over alcohol use. Thus far, findings relating family history to impaired control have been limited. Among undergraduates, Leeman et al. (2007) reported a small significant correlation between self-reported impaired control and magnitude of alcohol-related family history.

Relatively slow progress in identifying genes underlying risk of alcohol use disorders may be due partly to use of heterogeneous diagnostic constructs (Claus et al., 2011a). Impaired control may be an example of a specific, clinically-relevant phenotype with value in facilitating identification of novel genetic variants potentially underlying risk of problem drinking or for further validating clinical relevance of known genetic variants. For instance, OPRM1 and DRD2 may be related to impaired control given findings associating variants of these genes with craving and severe alcohol dependence (Connor et al., 2002; van Wildenberg et al., 2007).

In summary, evidence suggests possible relationships between impaired control and neurobiological dysfunction and/or family history/genetics. These factors may contribute to predisposition to impaired control and may also act as mechanisms underlying associations between impaired control and subsequent problem drinking.

CONCLUSIONS

Impaired control has received inadequate research attention given its unique value as a characteristic of alcohol dependence and potential predictor of more serious problem drinking. Viewing impaired control as an early-developing characteristic of dependence implies that impaired control lies along a continuum of severity. As alcohol dependence worsens, a shift from impulsive to compulsive use occurs (Everitt et al., 2008) and impaired control likely becomes pervasive as well (Modell et al., 1993). While there are challenges inherent in self-report measurement of the construct, use of multi-item self-report scales might be the best way to account for varying levels of severity of impaired control. At the same time, laboratory models have potential as novel tools to learn about precipitants of impaired control and interventions that may help to curb difficulties adhering to limits on alcohol consumption. We have also highlighted the need for future research on constructs related to impaired control such as impulsivity and other difficulties with self-control, along with other symptoms of alcohol dependence. Mechanisms underlying relationships between impaired control and risk for more severe problem drinking (e.g., family history/genetics) are also valuable research directions.

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Table 1

Brief overview of five research topics related to impaired control

Research topic	What is currently known	Potential directions for future research
Epidemiology		
Cross-sectional research	Both impaired control related DSM-IV dependence criteria—"larger/ longer" (LL) and "quit/ control" (QC) are endorsed relatively frequently, particularly LL. Research suggests that these criteria are at the low end of the severity spectrum and may be useful in distinguishing between those at higher versus lower risk of subsequent alcohol dependence.	Further research is needed pertaining to relationships between endorsement of the impaired control criteria and endorsement of tolerance given that they each relate to the amount that one drinks. Further qualitative studies may address the meanings people attach to endorsement of the two impaired control criteria, as well as the issue of why lighter drinkers sometimes endorse these criteria.
Prospective research	Limited findings suggest endorsement of 1 of the 2 DSM-IV dependence criteria related to impaired control may predict subsequent alcohol dependence.	More prospective research is needed to assess relationships between the two impaired control-related dependence criteria and to provide definitive evidence of impaired control as a predictor of subsequent alcohol use disorders. Adolescents with recent onset of alcohol use are an appropriate population for this work.
Measurement issues		
Self-report	The limit-setting and violation aspect of impaired control introduces a subjective element, which enhances complexity. Endorsement of LL and QC has been found to depend in part on the items used to assess them and the precise wording of the items.	Self-report measures could be augmented so that they better account for the impact of environmental contexts on impaired control. Close attention should be paid to item selection and wording in epidemiologic research concerning the impaired control-related dependence criteria.
Animal and human laboratory models	Laboratory paradigms have been used to test the preliminary efficacy of interventions and may offer behavioral indices of impaired control. Novel laboratory paradigms must include self-reports of impaired control (human models) and/or face-valid elements to capture the limit setting and violation aspects of impaired control (human or animal models).	Research is needed to develop and validate human laboratory paradigms to model impaired control. Established, validated approaches from the animal literature may have relevance to impaired control and may be incorporated into novel paradigms. These paradigms must be validated further by testing effects of experimental manipulations on self-reports assessed in the laboratory or on alcohol self-administration patterns thought to be indicative of impaired control.
Associations with related constructs	Based on theoretical reasoning and empirical findings, impaired control and impulsivity appear to be related, but distinct constructs. Regarding relationships to other symptoms of alcohol dependence, there is some evidence to support an association between impaired control and craving.	Additional studies are needed to relate impaired control to self-reports and behavioral task measures pertaining to impulsive choice and response, as well as other constructs related to difficulty with self-control, including risk-taking propensity. Further studies are needed to explore a potential relationship between impaired control and craving further, as well as associations with more severe dependence symptoms such as drinking to alleviate withdrawal.
Mechanisms		
Neurobiological dysfunction	Limited neuroimaging results suggest impaired control may relate to activity in multiple brain regions including the precentral gyrus and putamen with early evidence pointing to the insula in particular.	Studies could be conducted to assess the extent to which the shift that has been observed from greater cortical-to-striatal control with growing severity of addiction can also be observed among drinkers reporting increasing intensity of impaired control over alcohol use.
Family history/genetics	Although one would predict that those with a positive family history of alcoholism and with genotypes associated with alcoholism risk would be more likely to endorse impaired control, little is known about this relationship.	New studies to address these relationships or archival data analysis by researchers who have conducted studies including measures of impaired control and self-reported family history and/or genotyping are needed. OPRM1 and DRD2 are examples of genes that may be relevant to impaired control, which could be explored in future studies.