Published in final edited form as:

Addict Behav. 2015 May ; 44: 23–28. doi:10.1016/j.addbeh.2014.12.001.

Decision Making about Alcohol Use: The Case for Scientific Convergence

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Abstract

Research on cognitive processes related to the decision to drink alcohol has yielded assessment tools that predict drinking as well or better than any other predictor. Although largely overlapping in content, some of these tools have issued from different theoretical perspectives and consequently have been named to reflect separate cognitive constructs. This article describes a single theme that may be shared by what now appear to be separate constructs: anticipatory information processing. These anticipatory processes are reviewed at multiple levels of analysis, from neurobiology, to learning and memory, and finally to behavioral choice. Evidence supporting anticipatory processing as a causal influence on drinking also is reviewed, along with evidence that these ideas may be usefully applied to prevention/treatment efforts.

Keywords

Alcohol; Cognition; Alcohol Expectancies; Motivation; Anticipation

For over three decades the decision to drink alcohol has been studied in the context of cognition (see Donovan & Marlatt, 1980; Brown, Goldman, Inn, & Anderson, 1980). Since then, indices of alcohol-related cognition have been as predictive of drinking patterns as any variables researched. Numerous terms have been used to describe these “thought processes” involved in drinking including “expectancies,” “beliefs,” “reasons,” “attitudes,” “motives,” “associations,” “evaluations,” or the generic “cognitions,” among others. Using statistical techniques that can parse out variance explained by different variables, researchers have demonstrated that they all predict drinking to some extent, and that when included within the same models, they may show some degree of independence in predicting drinking outcomes such as frequency, quantity, or alcohol problems. For example, regression models predicting drinking may have both “expectancies” and “motives” contributing unique explanatory

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variance (Read, Wood, Kahler, Maddock, & Palfai, 2003). Despite the incremental variance explained, and their potentially distinct theoretical origins, however, considerable quantitative and qualitative overlap in content exists between seemingly different cognitive constructs. Quantitatively, measures of these constructs tend to have statistically significant correlations with one another (as high as .56; Cooper, Frone, Russell, & Mudar, 1995). Qualitatively, items including words reflecting a behavioral or affective sentiment such as “sociable,” “pleasant,” “fun,” “bad,” or “relaxed,” may be found on many measures of what have been offered as indicators of *different* alcohol-related thought processes. The array of approaches to this domain have advanced our understanding of how alcohol behavior is influenced, while the quantitative and qualitative overlap presents a number of empirical and theoretical questions that have yet to be resolved. Some of these issues will be discussed later in this review. We start with a brief review of exemplars of these measures.

Conventional paper and pencil self-report measures have yielded a great deal of information about how humans conceive of drinking behavior. They include measures such as the Alcohol Expectancy Questionnaire (Brown, Christiansen, & Goldman, 1987), the Drinking Motives Questionnaire (Cooper, 1994), and the Reasons for Drinking Questionnaire (Westerberg, Miller, & Heather, 1996). Using measures such as these, alcohol-related cognitions have demonstrated strong correlations with drinking, predicting up to half of the drinking variance in error attenuated models, prediction of the onset and level of drinking in children/adolescents, mediation of the relationship between known antecedents of drinking (e.g., family, peer, or cultural factors) and drinking, and increases and decreases that parallel drinking in experimental designs (see Goldman, Reich, & Darkes, 2006, for a more detailed summary of this research).

It is important to keep in mind that although the phrase “thought processes” (used above) implies a degree of conscious deliberation, dozens of studies have shown that alcohol-related behavior can be influenced by cognitive stimuli in the absence of awareness of the governing processes (i.e., implicitly). These studies have used tasks developed by cognitive psychologists to test memory activation following implicit primes. Because initiation and pursuit of goals may be largely non-conscious (Custers & Aarts, 2010), approaches that tap these non-conscious processes are quite applicable to the investigation of alcohol-related goals. In addition, the use of implicit methods reduces demand characteristics associated with explicit assessment (which may indirectly encourage participants to provide the results that the experimenter “wants”). A final advantage of using implicit measures is their sensitivity to very subtle contextual shifts. Similar words to those used in the paper and pencil measures mentioned above often have been used in these measures, including the Implicit Association Test (e.g., Wiers, van Woerden, Smulders, & de Jong, 2002; McCarthy & Thompson, 2006), the Stroop Task (Kramer & Goldman, 2003), primed recall tasks (Reich, Noll, & Goldman, 2005), and free association tasks (e.g., Stacy, 1997; Palfai & Wood, 2001), among several others. Consistent with responses to the explicit tasks, in each of these studies’ responses to implicit tasks were contingent on the typical drinking level of the participants. In other words, alcohol-related cognitions measured implicitly repeatedly have been correlated with drinking.

A view that, in part, drove the use of implicit measures in all of these studies was that implicit measures accessed psychological processes that were somehow more central to decision-making, or at least provided additional statistical explanation for the decision to drink, than those processes that could be accessed by explicit measurement approaches. To examine these suppositions, Reich, Below, and Goldman (2010) conducted a meta-analysis of studies that included both kinds of measures within a single study. Results of this meta-analysis provided support for the notion that implicit measures offered added statistical information, but were not necessarily more central to the decision to drink: in thirteen of the sixteen studies that met the inclusion criteria, explicit measures accounted for more drinking variance than did implicit measures (in 12 out of 13 studies accounting for unique variance). Meta-analysis of the relative mean effect sizes confirmed the observed differences. Notably, one study of participants with cognitive impairment (not included in the meta-analysis) did show an advantage of using an implicit measure over an explicit measure (Grenard et al., 2008). In summary, therefore, these results showed that explicit techniques typically predicted more outcome variance than did implicit techniques, but that thoroughgoing approaches to prediction might best use both explicit and implicit measures of alcohol-related cognition to predict drinking.

To summarize the current state of science in alcohol-related cognition: whether they are called expectancies, motives, cognitions, or reasons for drinking (or other characterizations), and whether they are measured explicitly or implicitly, alcohol-related cognitions have been empirically shown to play a role in the decision-making processes that influence drinking. To advance this field in the direction of scientific explanation, however, it would be useful to go beyond just having an array of measures with different names, which are presented as though they represent different constructs/mechanisms that drive drinking, and which are rarely considered in concert. That is, it may be useful to consider the possibility that common psychological processes underlie all the measures in this domain. We will consider these possible common processes below. Clear consideration of the possibility that common processes are in play necessitates that we first address a few of the (primarily) methodological issues that may obscure our capacity to see the psychological processes common to all these measures/theoretical approaches.

Although space considerations do not allow a thorough review of all the issues involved, a few central points are worth noting. First, psychological/decision-making processes rooted in the neurobiology of the brain can be only imperfectly accessed by psychometric approaches to instrument development, and analyzed by regression/structural equation approaches aimed at evaluating operational/causal pathways. For example, when instruments include items that are highly overlapping, but also have instructional sets that differ to some degree, it should come as no surprise that they might demonstrate both overlapping and unique predictive variance. Statistical non-overlap can, in fact, be useful in prediction models; uniqueness suggests that scales could be used together to maximize prediction (increased accounted for variance in the outcome measures). Statistical uniqueness is less informative with regard to process, however; in deciphering the underlying processes/mechanisms that actually drive behavior. Uniqueness can derive from method variance and not from distinct psychological processes; i.e., from somewhat differing sets of items included in a scale, differing instructions, differing wording or

ordering of items, differing scoring systems based on different factor solutions, etc. While it is true that some configurations of items, scales, etc., may predict uniquely, it is not necessarily true that these item arrangements are more informative about controlling processes.

Given the substantial overlap among all these scales in variances accounted for, it also should come as no surprise that statistical models can be constructed that purport to show that the variance accounted for by one instrument might mediate the influence of the other; in fact, in the absence of competing models, it remains likely that in any pairing of these measures (or scales) either could mediate the influence of the other. A quintessential example is the case of “expectancies” and “motivations.” Previous reports have indicated that “motivations” mediate the influence of “expectancies” (Cooper et al., 1995). These reports, however, should not be considered a definitive representation of the operation of underlying processes. For example, given the overlap of variances accounted for in the case above, it remains possible that expectancies could have been shown to mediate motivations. Other than theoretical preference, there is no reason at the process level to regard either construct as more proximal to drinking decisions. Although it has been argued to the contrary, it could easily be argued that expectancies, conceived as information (memory) networks are more proximal. Following experimental manipulation, expectancies have been shown to activate in-the-moment in certain contexts and to influence behavior immediately (e.g., Roehrich & Goldman, 1995; Carter, McNair, Corbin, & Black, 1998). These findings readily support expectancies as a very proximal influence on behavior. In fact, outside the alcohol/substance abuse field, motivation explanations have often relied on expectancy formulations as the actual operational components that drive behavior (Bolles, 1967; 1972).

Second, all methods based on administration of questionnaires or on verbal reports may possibly be assessing epiphenomena. It is without question that (as with all behavioral outputs), behavior predicts behavior. Alcohol use is no exception. If scores on assessment instruments are correlated with the target behaviors, it may just be that these scores are useful for prediction because of their correlations with the behaviors in question, but not necessarily because what the instruments purport to assess are the actual drivers of the behavior. Unlike some of the approaches noted above, evidence for expectancies as real causal processes is available. Expectancies measured in children before drinking begins have been shown to predict later drinking (precluding their interpretation as an epiphenomenon; Christiansen et al., 1989), and the experimental manipulation of expectancies through “expectancy challenge” has been shown to alter drinking behavior (Scott-Sheldon, Terry, Carey, Garry, & Carey, 2012). Evidence of this kind for other constructs in this domain is less available.

Lastly, we would argue for parsimony and consilience as guideposts toward better understanding of actual controlling forces in the highly important domain of alcohol and drug use. Rather than making ever-finer distinctions between constructs, we support theoretical accounts that converge with processes that have emerged in many fields (not just alcohol abuse research), and from entirely separate lines of research. Although these processes include what is often called cognition, they certainly go beyond the limitations associated with consciously available cognitions, or even implicit cognitions. The concept of

anticipatory responding is one such set of processes, and we argue that it is the fundamental driver of behavior represented by all the constructs noted above.

Anticipation

Anticipation is a fundamental neurobiological process, probably carried out by a number of systems in the brain. Framing the neurobiological basis of anticipation recently in the New York Times, Andy Clark (2012) said: "...the brain is complex, and builds new solutions upon old, perhaps resulting in a rather messy and hard-to-unravel edifice. Nonetheless, there can be fundamental processing ploys at work even in superficially much "messier" systems and the claim is indeed that the use of multilayer predictive routines is one such fundamental ploy." Clark is not alone in identifying "multilayer predictive routines" as central to neurobehavioral functioning. The noted philosopher Daniel Dennett (1991) articulated this idea when he characterized the brain as an "anticipatory machine." Even more recently, the "generation of predictions" was identified as a viable universal principle for organizing the multidisciplinary study of the brain and behavior (Bar, 2011). The central purpose for the remainder of this article is to provide support for the anticipatory influence on the decision to drink alcohol. In this characterization, alcohol related cognition represents the linkage between the opportunity for reinforcement (context), the learned behavioral template for obtaining that reinforcement, and an anticipated outcome.

A Broad Perspective on Anticipation

Because time always moves forward, if organisms' behavior were solely reactions to external circumstances as they were unfolding, the next moment would have already happened as the organism was responding to the previous moment. This inevitable response delay clearly would be an evolutionary disadvantage. As a result, organisms have been shaped by evolution to be ready for not yet encountered situations. In this vein, the brain and nervous system of higher organisms have evolved to use information about past experiences to prepare for upcoming circumstances. In psychology, we refer to this capacity as memory, which as it turns out is better understood as a means of looking forward than of re-examining the past. That is, memory is best understood as a means of applying information garnered from prior circumstances to continually adjust to the "stream" of environments/circumstances that we encounter as our lives progress. And, as we know from memory research, this information is not a precise recording of experience. As Calvin and Bickerton (2000, p. 34) point out, "We...make generalizations on inadequate evidence at very short notice, because that works better, in terms of evolutionary fitness, than making 100% correct generalization after a long period of cogitation."

In general, anticipatory decision-making seeks rewards and avoids adversity. It is critical to recognize, however, that rewards are not limited to the satisfaction of basic biological needs, but include outcomes that enhance evolutionary fitness (Glimcher, 2002). For example, jockeying for status in the social hierarchy is inherent to the motivational systems of social animals, because social status makes reproductive success more likely. The critical significance of social positioning has been underscored by the discovery of biological mechanisms of vicarious social learning such as mirror cells and brain regions that support

mentalizing (taking the perspective of others). These discoveries provide mounting evidence that social information achieves privileged status in the brain (Mitchell, 2008). Not surprisingly, the pursuit of social reward seems to be a key component across many types of alcohol-related cognition (Fairbairn & Sayette, 2014).

Evidence of Anticipatory Processes in Brain Reward Systems

Anticipatory processes of the kind noted above have been extensively implicated in the neurobiology of animal and human reward and reinforcement (Breiter, Kahneman, & Shizgal, 2001; Kupfermann, Kandel, & Iversen, 2000; McClure, Laibson, & Loewenstein, 2004; Schultz, 2004; Schultz, Dayan, & Montague, 1997). Previous research even has revealed brain circuitry that is differentially active in anticipation, rather than in response to rewards (Glimcher & Lau, 2005; Minamimoto, Hori, & Kimura, 2005; McClure et al., 2004; Tobler, Fiorillo, & Schultz, 2005). In a relatively recent advance, Alexander and Brown (2011, p. 1338) computationally modeled the multiple decision-making functions of the dorsal anterior cortex and surrounding medial prefrontal cortex as based on “forming expectations about actions and detecting surprising outcomes.” This advance was anticipated by Kupfermann et al., who noted in earlier work (2000, p. 1010) that, “...dopaminergic neurons encode *expectations* (ital. added) about external rewards.”

One pathway that uses contextual signals to anticipate that reward is imminent is embodied by dopaminergic neurons running from the striatum to the nucleus accumbens and on to the frontal lobes, and has been described as converting “...an event or stimulus from a neutral ‘cold’ representation (mere information) into an attractive and ‘wanted’ incentive that can ‘grab’ attention” (i.e., incentive salience; Berridge & Robinson, 1998, p. 313). Montague and Berns (2002) also described this system’s function as reward prediction, contending specifically that the level of dopamine pathway activity signals, in advance of consummatory behaviors, that rewards available in a particular context differ from rewards anticipated. Such a mechanism would serve to adjust ongoing behavior toward the most beneficial expected outcomes.

Apart from signaling reward availability, another means of identifying reward stimuli centers on the amygdaloid complex, an important area in the expression of emotion (Holland & Gallagher, 2004; Iversen, Kupfermann, & Kandel, 2000). Obviously, a neural system supporting the experience of emotion (pleasure or aversion) would be instrumental in encouraging certain behaviors and discouraging others. This emotion makes certain sensed patterns of information more salient, and therefore more likely to be attended to, stored and acted upon (Holland & Gallagher, 2004; Phelps, 2004; Schultz, 2004). The linkage between neural processing of information and motivation/emotion is suggested by connections observed between areas such as the nucleus accumbens and amygdala, and information-processing areas such as the hippocampus and frontal cortex (Cardinal & Everitt, 2004; Phelps, 2004).

To fully validate the role of anticipatory brain processes, brain reward systems must eventually be tied to behavior. Work by Matsumoto and Tanaka (2004, p. 178) indicates that the prefrontal cortex (anterior cingulate cortex) links signals of biologically important inputs

with actions "...based on goal expectation and memory of action—outcome contingency." Given the conceptualization presented in these pages, memory of action—outcome contingency would be, of course, the essence of all alcohol-related cognition and its orientation would be anticipatory. It is this "memory" that is reenacted in anticipation that the action will again lead to reward.

Anticipation as Embodied in Complex Psychological Systems

Described at a different level (scale), these brain systems manifest themselves in terms we commonly refer to as psychological processes; e.g., perception, learning, memory, and language (among others). Although psychology has a history of separating these processes for study, it is important to appreciate that they are not distinct; each of these processes is thoroughly integrated with the others.

Perception

The human sensory system is constantly receiving a vast amount of sensory input. Not only is detailed information received by multiple senses in parallel, but incoming information is changing from moment to moment. It has been estimated that potentially billions of bits of information impinge on the human senses every second, whereas, after processing, no more than 50 bits of information per second are available to consciousness (Norretranders, 1991). Even allowing for substantial additional capacity to process information outside of consciousness, organisms must use selection processes to eliminate insignificant information, while remaining responsive to information that matters for survival and adaptation.

One of the central purposes of a memory system may be to filter incoming stimuli. The choice of information to which the organism is biased (selectively responsive) is governed by the nature of our sensory systems as honed over evolutionary time, and by the encoding of past sensory–perceptual configurations collected throughout the life experience of that organism. As one example, the human visual system has receptive elements configured to be sensitive to particular stimulus arrays (e.g., lines in various orientations, patterns, movement; Maunsell, 1995). But a good deal of perceptual selectivity in humans is based on past experience because complex adaptations require plasticity. Many receptive elements, once thought to be hardwired, have been found to be adaptable (plastic; Grossberg, 1995; Singer 1995; Tsodyks & Gilbert 2004). In addition, perceptual integration is not passive; perceptual systems actively identify, process, and compare information to create whole perceptions from available information. Grossberg (1995, 439; credited to Richard Warren) offered an interesting example: Suppose you hear a noise followed immediately by the words "eel is on the..." If that string of words is followed by the word "orange," you hear "peel is on the orange." If the word "wagon" completes the sentence, you hear "wheel is on the wagon." If the final word is "shoe," you hear "heel is on the shoe." In this example, Grossberg suggests that expectations activated by the final word in the sequence provide a means to fill in incomplete data and influence perception of the first word. It has been suggested (Miyashita 2004, 436) that because "the configuration of environmental stimuli and their behavioral context in daily life are unique and rarely repeated exactly," the brain must be able to recover a complete memory from stimulus conditions that supply only

partial cues. Anticipatory processes occur not just with perception of visual or auditory stimuli, but with perception of motion (Kerzel, 2005), time perception (Correa, Lupiáñez, & Tudela, 2005), orienting behavior in early infancy (Haith, Hazan, & Goodman, 1988), and the perception of music (Huron, 2006).

Learning/Memory

Associationist principles (e.g., Nelson, McEvoy, & Pointer 2003) provide an effective starting point for understanding how initially disconnected information may be “bonded” into a larger whole in the appropriate context. Such bonding assures that relevant information can be reassembled efficiently, and effectively repeated as needed. Because associations, long understood as central to memory encoding and retrieval, may “serve as the building blocks of prediction,” association-based memory models should not only be seen as consistent with anticipatory models, but instead as their foundation (both for explicit and implicit processing; Bar, 2011, p. 17). Anticipatory processes have been used to describe operant (Dragoi & Staddon, 1999) and classical conditioning (Kirsch, Lynn, Vigorito, & Miller, 2004; Van Hamme & Wasserman, 1994), comparative judgment (Heekeren, Marrett, Bandettini, & Ungerleider, 2004; Ritov, 2000), models of memory (Bower, 2000), and the learning of complex motor skills (e.g., Wulf & Prinz, 2001).

Emotion/motivation

A full explanation of the control of behavior in the real world requires additional theoretical elements that encourage the translation of pure associational information into overt behavior. That is, associational principles provide the foundation for memory, but do not determine what will be selected for remembering. As evolution progressed, selection pressures (e.g., adaptation, survival) influenced development of mechanisms that serve as signals for monitoring evolutionary success (fitness). We refer to these mechanisms when we discuss emotion, motivation, reward, incentive, reinforcement (positive and negative), and punishment. To govern real-world behavior, information that is accessed by associational search at some point must be integrated with information about reward and punishment (Schultz, 2004). It is this final, critical information that specifies what searches will be undertaken and what behaviors will be carried out to consummate reward via approach or avoidance. Such information also can be used to create novel mental scenarios about not-yet-experienced situations from combinations of previous experiences to guide decisions (Bar, 2011). The conceptual framework of behavioral economics taps into a possible processing algorithm which allows the value of drinking related outcomes to be compared with alternative behaviors. Such algorithms might be one way by which individuals create future scenarios in which differing decisional outcomes are possible (e.g., MacKillop et al., 2010). This construction of possible future events based on reconstruction of previous events is consistent with what has been termed “mental time travel” (Suddendorf & Corballis, 1997).

The essence of this anticipatory model is that context activates memories of objects/events that lead to prediction of payoffs. These associations also are integrated with memories of neural and somatic reactions that give them emotional and motivational value (Barrett & Bar, 2011; Bechara, 2011), along with the behaviors that are likely to lead to those rewards.

In this way, anticipation serves as the theoretical piece linking motivation/emotion with cognition (association). As noted by Holland and Gallagher (2004, p. 148), “Recently, conventional associative learning paradigms have been adapted to allow systematic study of anticipation and action in a range of species, including humans... ‘expectancy’ refers to the associative activation of such reinforcer representations by the events that predict them, before the delivery of the reinforcer itself.”

Conclusion and Future Directions

It is, of course, a complex cascade of the multiple influences described above that influences the decision to drink. As with all decisions, neural processing pathways use various kinds of information collected in the past, and interwoven with current contextual circumstances, to set up a competition between “go” signals, “stop” signals, and “do something else” signals. Three-plus decades of alcohol-related cognition research have suggested that it is possible to probe at least some aspects of this cascade with both conventional paper and pencil (e.g., Brown et al., 1980; Cooper et al., 1995) and implicit psychological measures (e.g., Roehrich & Goldman, 1995; Wiers et al., 2002). That is, cognition, to some extent, can be seen as the coming together of the above anticipatory processes as they bear upon the control of drinking decisions. Further, that alcohol-related cognition can be measured in children before drinking ever begins (Bekman, Goldman, Worley, & Anderson, 2011; Christiansen et al., 1989) is most critical to the logic model presented here, because these findings show that alcohol-related cognitions are not just a byproduct (an epiphenomenon) of already accumulated drinking patterns. Furthermore, anticipation as a governing influence on drinking behavior is not confined to the period before drinking begins. It has been shown that during a drinking episode, alcohol-related behavior may be influenced by expectancies (placebo effects) carried by the drinker in anticipation of alcohol effects on the brain, and then by the combined psychological and pharmacological effects after alcohol begins to affect neurotransmission in the brain (e.g., Moss and Albery, 2009).

This anticipatory model is also transdisciplinary in the sense that it ties together multilevel neurobiological systems with behavioral decision-making. Although the research that most directly would connect the cognitive variables discussed earlier with these neurobiological systems has yet to be extensively undertaken, overlap in the existing research base (recall the Grossberg example; i.e., hearing “peel,” “wheel,” and “heel,” depending on the sentence ending) leaves little doubt that these response domains are associated. For obvious reasons, it is difficult to carry out the research that would assess the degree to which verbal indices of anticipatory processes correspond to the neurobiological networks that underpin these processes. Word-based responses come from living humans, and anticipatory neurobiological networks mostly have been accessed with biological probes that could not be used in humans. Some initial probes of this kind have been supportive (e.g., Fishman, Goldman, & Donchin, 2008), but more work needs to be done using other neuroimaging methods. If sufficient correspondence between neurobiological probes and cognitive measurement tools can be demonstrated, we may be able to increase our array of targets for prevention research. To this point these targets have been focused on the alteration of anticipatory memory associations. For example, the research base supporting expectancy challenge approaches is already established (Scott-Sheldon et al., 2012), but has suggested

mostly short-term effects. Given the intention of this paper to highlight a possible convergence upon the theme of anticipation from all angles of alcohol-related cognition, other intervention approaches might also be considered within this same framework. For instance, approaches to modify alcohol-related cognitions from “go”-biased to “stop”-biased have emerged with some signs of promise (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). These kinds of behavioral biases also represent anticipatory rules that minimize the need for slow, conscious decision-making in the face of immediate environmental demands.

Acknowledgments

This paper was supported in part by National Institute on Alcohol and Alcoholism Grants R01 AA08333 and R01 AA016091.

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Highlights

- Cognitive processes predict drinking as well or better than any other predictor.
- One theme may be shared by seemingly separate cognitive constructs: anticipation.
- Anticipatory processes are evident at many neurobiological and behavioral levels.
- Anticipatory processes seem to have a causal influence on drinking.
- Anticipatory processes should be considered as a target for prevention efforts.