Motivation, Working Memory, and Decision Making: A Cognitive-Motivational Theory of Personality Vulnerability to Alcoholism

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This article presents a cognitive-motivational theory (CMT) of the mechanisms associated with three basic dimensions of personality vulnerability to alcoholism, impulsivity/novelty seeking, harm avoidance, and excitement seeking. CMT describes the interrelationships between activity in basic motivational systems and attentional, decision making, and working memory processes as the mechanisms associated with variation in each personality trait. Impulsivity/novelty seeking reflects activity in both appetitive and inhibitory motivational systems, greater attention to reward cues, and increased emotional reactivity to reward and frustration. Harm avoidance reflects individual differences in fearfulness and activity in specific inhibitory systems. Excitement seeking reflects the need to engage in appetitive behaviors in less predictable environments to experience positive affect. CMT also describes the impact of working memory and the specific motivational processes underlying each trait dimension on the dynamics of decision making from the perspective of decision field theory.

Key words: alcoholism, cognition, decision making, personality, working memory

BEHAVIORAL REGULATION AND ALCOHOL USE DISORDERS

Poor behavioral regulation is a fundamental feature of alcohol use disorders. Not only is alcohol abuse and dependence a reflection of poorly regulated behavior, but excessive alcohol use also affects and, in many cases, disrupts the cognitive and motivational processes that serve critical roles in the adaptive regulation of behavior (Finn, 2000; Finn, Sharkansky, Brandt, & Turcotte, 2000; Iacono, Carlson, Taylor, Elkins, & McGue, 1999; Vogel-Sprott, Easdon, Fillmore, Finn, & Justus, 2001). Disrupted behavioral regulation in alcohol use disorders is evident in four broad categories of processes and sources of vulnerability: (a) preexisting personality and behavioral traits, (b) attempts to self-regulate mood, (c) individual differences in response to alcohol, and (d) the effects of alcohol on homeostatic regulatory systems. For instance, alcohol abuse is typically seen as one of many manifestations of poor self-control or disinhibitory processes in general (Brown, 1998; Finn et al., 1997; Finn, Kessler, & Hussong, 1994, Finn, Mazas, Justus, & Steinmetz, 2002; Gorenstein & Newman, 1980). Alcohol abuse also is associated with maladaptive attempts to use alcohol to regulate emotions and cope with stress (Cooper, Frone, Russell, & Mudar, 1995; Finn, Earleywine, & Pihl, 1992; Stewart & Zeitlin, 1995). Vulnerability to alcohol abuse has been associated with increased sensitivity to the reinforcing effects of alcohol (Finn, Zeitouni, & Pihl, 1990; Finn et al., 1992) and decreased sensitivity to the impairing effects of alcohol (Schuckit, 1994), both of which can promote increased alcohol intake (Finn & Justus, 1997). Finally, the acute and long-term effects of alcohol consumption influence homeostatic regulatory systems and can promote excessive drinking and poorly regulated, impulsive behavior (Fillmore, Vogel-Sprott, & Gavrilescu, 1999; Finn, Justus, Mazas, & Steinmetz, 1999; Mucha, Geier, Stuhlinger, & Mundle, 2000; Vogel-Sprott et al., 2001). This article presents a cognitive-motivational theory (CMT) of the personality mechanisms that

contribute to a vulnerability to alcoholism. CMT describes the interrelationships between motivational, working memory, and decision-making processes that make up the major mechanisms that contribute to individual differences in the personality traits that predispose to alcoholism and other externalizing behavior. Although it is well established that specific temperamental, personality, and behavioral traits are associated with the early development of alcohol abuse, considerably less is known about the mechanisms involved in this process, and in many cases, this process is oversimplified in the literature as being due to a single, broad process labeled "poor self-control," "poor self-regulation," or "undercontrolled behavior."

PERSONALITY AND VULNERABILITY TO ALCOHOLISM

A substantial body of research suggests that a range of personality and temperamental traits that reflect disinhibitory and/or strong appetitive processes play a major role in the development of alcohol use disorders (Chassin, Pitts, DeLucia, & Todd, 1999; Cloninger, Sigvardsson, & Bohman, 1988; Finn et al., 2000; Sher, Walitzer, Wood, & Brent, 1991; Wills, Sandy, & Yaeger, 2000). Longitudinal data suggest that these types of traits reflect fundamental etiological mechanisms in the development of early onset substance abuse and antisocial behavior. Temperamental traits, such as impulsivity, overactivity, distractibleness, and irritability, assessed at 3 years of age predict the development of alcohol abuse in early adulthood (Caspi, Moffitt, Newman, & Silva, 1996). Early onset alcohol use and abuse also is predicted by high novelty seeking and low harm avoidance in childhood (Cloninger et al., 1988; Masse & Tremblay, 1997) and adolescence (Wills, Vaccaro, & McNamara, 1994) and conduct problems in early adolescence (Chassin et al., 1999). Young adults with alcoholism tend to show high levels of disinhibited and appetitive personality traits, such as impulsivity, boredom susceptibility, thrill and adventure seeking, excitement seeking (Finn, Mazas, Justus, et al., 2002; Sullivan et al., 1990; A. L. von Knorring, Bohman, von Knorring, & Oreland, 1985; L. von Knorring, von Knorring, Smigan, Lindberg, & Edholm, 1987); novelty seeking (Ball, 1996; Ball, Kranzler, Tennen, Poling, & Rounsaville, 1998; Finn, Mazas, Justus, et al., 2002; Sullivan et al., 1990; Yoshino, Kato, Takeuchi, Ono, & Kitamura, 1994); and aggressiveness (Babor et al., 1992; L. von Knorring et al., 1987). Longitudinal studies also show that externalizing, delinquent, and aggressive behavior is predicted by impulsivity, low harm avoidance, and other disinhibited, traits in early childhood (Caspi et al., 1996; Raine, Reynolds, Venables, Mednick, & Farrington, 1998) and

in late childhood and early adolescence (Loeber, Farrington, Stouthamer-Loeber, Moffitt, & Caspi, 1998). A history of antisocial behavior in young adults also is associated with personality traits such as impulsivity/ novelty seeking, low harm avoidance, and excitement seeking (Finn, Mazas, Justus, et al., 2002; Krueger, Hicks, & McGue, 2001). Novelty seeking, which is highly correlated with impulsivity and aggressivity (Finn, Mazas, Justus, et al., 2002; Nagoshi, Walter, Muntaner, & Haertzen, 1992; Wills, DuHamel, & Vaccaro, 1995; Wills et al., 1994), also is associated with higher rates of treatment dropout and relapse in alcoholics (Meszaros et al., 1999). In summary, the evidence is overwhelming that the childhood temperament traits and adolescent personality traits that reflect disinhibitory and/or strong appetitive tendencies predispose to the development of alcohol use disorders. Three major questions that need further research are as follows: (a) What are the fundamental dimensions of the personality traits associated with this type of vulnerability? (b) What are the key mechanisms that contribute to variation in these traits? and (c) What are the mechanisms that account for the association between these traits and alcohol use disorders?

Substantial progress has been made in outlining the interrelationships among temperament, personality traits, and the other factors considered to be important in the development of alcohol problems. For instance, poor control, risk taking, and novelty seeking have been associated with affiliating with substance-abusing peers, maladaptive coping, more negative life events, and current substance use levels in young adolescents (Wills et al., 1995, 2000). Disinhibited traits also have been associated with positive alcohol expectancies and motives to drink to cope with stress or enhance positive emotions (Cooper et al., 2000; Finn et al., 2000; Sher et al., 1991). Poor impulse control and externalizing, disruptive behavior have been associated with increased anger proneness, low frustration tolerance (Cole, Michel, & Teti, 1994; Eisenberg et al., 2001; Keltner, Moffitt, & Stouthamer-Loeber, 1995), and low parental involvement (Wills et al., 1995, 2000). However, the specific cognitive, emotive, and motivational mechanisms underlying the association between different personality traits and alcohol use disorders are not well characterized. One issue that hampers research into specific personality mechanisms of risk is the wide range of different personality traits and measures used across studies. Some studies describe personality risk as a single construct, such as behavioral undercontrol (Sher et al., 1991; Sher & Gotham, 1999), which groups the entire range of interrelated traits into one global phenotype. This approach has some value in describing broad-based trends in the types of vulnerability to alcoholism (cf.

Sher & Gotham, 1999), but it has no utility in aiding the search for specific mechanisms associated with a personality vulnerability. Other researchers focus on the role of a limited range of specific traits, such as impulsivity, surgency, and neuroticism (e.g., Cooper, Agocha, & Sheldon, 2000), but the theory guiding the choice of traits is often not clear, and key dimensions of personality are frequently excluded. CMT describes three fundamental personality dimensions that are distinguished in terms of the motivational, emotional, and cognitive processes that mediate or moderate vulnerability to alcohol use disorders. Our factor analytic studies (Finn, Mazas, Justus, et al., 2002; Justus, Finn, & Steinmetz, 2001) suggest that three basic personality traits, impulsivity/novelty seeking, low harm avoidance, and excitement seeking, assessed using multiple measures, characterize the main dimensions of disinhibited personality and reflect different mechanisms (Finn, Mazas, Justus, et al., 2002; Finn, Lin, Mazas, & Busemeyer, 2002; Justus et al., 2001). The theory and research on these different personality dimensions is presented below.

There is considerable consensus that the personality traits that predispose to alcohol abuse reflect a vulnerability to externalizing behavioral in general, such as conduct problems, antisocial behavior, alcohol abuse, and risky sexual behavior, rather than being specific to risk for alcoholism (Finn, Mazas, Justus, et al., 2002; Gorenstein & Newman, 1980; Justus, Finn, & Steinmetz, 2000; Iacono et al., 1999). A popular conception is that a deficit in self-regulation or generalized self-control is the core feature of this disinhibitory vulnerability (Brown, 1998; Miller & Brown, 1991; Tarter, 1988; Wills et al., 2000). This idea has many merits. First of all, alcohol abuse itself reflects a fundamental breakdown in the self-regulation of alcohol consumption. Furthermore, a number of traits that predict the later development of alcoholism, such as impulsivity, aggression, and overactivity, are marked by or defined in terms of poor self-control. However, other traits, such as low harm avoidance and excitement seeking, are not specific manifestations of poor self-control per se. For instance, the association between excitement seeking and excessive alcohol use probably is not the result of an inability to control alcohol intake. Those high in excitement seeking might intentionally drink to excess for the specific effects of alcohol and the specific sequelae of intoxication. Likewise, harm avoidance reflects a dimension of variation in the processes associated with fearfulness and risk aversion (Finn, Mazas, Justus, et al., 2002; Waller, Lilienfeld, Tellegen, & Lykken, 1991), where both extremes can be adaptive in certain situations. Low harm avoidance does not reflect a specific deficit in self-regulation. Low harm avoidance may dispose some to engage in risky behavior, which might be adaptive in some circumstances or maladaptive in other circumstances. So rather than focusing on the concept of deficit, CMT takes a broader perspective. CMT conceptualizes a personality vulnerability to alcoholism in terms of specific variations in the motivational, emotive, and cognitive processes that predispose to specific styles of self-regulation that promote drinking alcohol to excess or losing control over alcohol intake in certain circumstances.

WORKING MEMORY, DECISION MAKING, AND ALCOHOLISM

A key hypothesis in CMT is that working memory capacity moderates specific aspects of vulnerability through its effect on the maintenance of activation of low salient signals in the decision-making process. Central roles for cognitive processes, such as working memory and attention, in mediating and moderating temperament, behavioral and emotional regulation, and disinhibited psychopathology have been proposed by many (e.g., Barkley, 1997, 2001; Eisenberg et al., 2000; Rothbart, Derryberry, & Posner, 1994). Attentional control, attention shifting, and vigilance are thought to play key roles in the regulation of behavior by modulating approach and emotional responses (Eisenberg et al., 2000; Rothbart et al., 1994). Most models of working memory include attentional processes, such as attentional control and attentional shifting, as central processes that serve, in part, the maintenance and manipulation of representations in working memory (Baddeley & Logie, 1999; Cowan, 1999; Finn, Mazas, Justus, et al., 2002; Kimberg & Farah, 1993). Barkley (1997, 2001) points out that working memory provides the space and capacity for activating self-directed speech, sensory images, and representations for the purpose of problem solving, hypothesis generation, self-reflection, and rule application to guide socially adaptive behavior. CMT builds on these theoretical formulations by elaborating on the specific mechanisms involved at the interface between signal processing and the activation or inhibition of behavior, their association with dynamic decision-making processes, and the specific mechanisms by which working memory capacity modulates personality vulnerability to alcohol use disorders.

A Three-Dimensional Model of Working Memory Capacity

Although working memory is thought to play an important role in behavioral regulation (Goldman-Rakic, 1987; Kimberg & Farah, 1993), the precise mechanisms by which it influences behavior inhibition or activation are not well articulated. There is considerable evidence implicating working memory and other executive

functions in dysregulated, antisocial behavior (Barkley, 1997; Moffitt, 1993). Working memory is thought to play a central role in behavioral regulation (Barkley, 1997; Fuster, 1995; Kimberg & Farah, 1993), and deficits in working memory have been associated with dysregulated behavior such as attention deficit hyperactivity disorder (Barkley, 1997) and alcoholism (Ambrose, Bowden, & Whelan, 2001). Although there are a variety of conceptions of working memory, it is generally considered to be a limited capacity process (Engle, Conway, Tuholski, & Shisler, 1995) of keeping activated in mind representations of the world (stimuli) so that they may be effectively used to guide behavior (Baddeley, 1986; Finn, Mazas, Justus, et al., 2002; Kimberg, D'Esposito, & Farah, 1998). Working memory processes are involved in the temporary storage and manipulation of information that supports the ongoing regulation of behavior and are critical in decision-making and problem-solving contexts (Baddeley & Logie, 1999, Goldman-Rakic, 1987). The following simple examples illustrates the role of working memory in guiding behavior.

> John is sitting at his desk and finds that he is quite thirsty. He decides that a cold Coke will satisfy his thirst. He gets up from his desk and begins walking to the cold drink vending machine to buy a Coke. He keeps in mind his goal of getting a Coke, arrives at the vending machine, puts his money in the machine, pushes the button for a Coke, and gets his cold Coke to slake his thirst.

To get the Coke, it was necessary for John to maintain his goals (i.e., go to the machine, get a Coke, slake his thirst) in working memory between the time of formulating his plan and pressing the button for Coke on the vending machine. If John's working memory capacity had been overextended by having other very important matters on his mind, he might not have been able to keep in mind the simple goal of getting a Coke in the drink machine. Other factors might also compromise John's ability to keep is goals in mind are distractions, having poor short-term memory capacity, being unable to maintain items in working memory over an extended period of time, or being unable to think of more than one thing at a time. Another simple example of working memory in action is illustrated in the following scenario.

> Mary is sitting at her desk and finds that she is quite thirsty. She decides that a cold drink will satisfy her thirst. She gets up from her desk and walks to the soft drink vending machine to find a cold drink. When she arrives at the vending machine, she tries to decide what drink to get. She really wants a Coke, but she recalls that she is trying to eat a healthy diet and wants to avoid a lot of sugar. She also recalls that people had been losing their money in the machine for some specific choices, such as orange juice or perhaps apple juice. Mary considers buying a Coke, apple juice, spring water, or 7-UP. In the process, she thinks about her current attitude about healthy eating, about how many calories she had consumed that day, the high cost of bottled water, whether she will lose her money if she chooses the apple juice option, and the great taste of Coke. A coworker, Roger, arrives right when she is considering her options and asks Mary about an important project. Mary gets distracted in the process and chooses a Coke.

In this example, Mary's working memory capacity was being taxed by the many different options and concerns that she was considering in the decision making process. To thoroughly consider her decision, Mary had to keep a number of things in mind, resist distraction from other stimuli (Roger), engage in some mental manipulation (thinking about different options, her priorities, whether the machine was malfunctioning), and shift her attention between different options, outcomes, and priorities. Roger distracted and perhaps rushed Mary, which seemed to affect her decision. Rather than choosing the healthy option, Mary went against her healthy eating plan and chose the Coke. In this example, Mary's initial desire to drink a Coke and the immediate enjoyment associated with drinking Coke would make the Coke option highly salient and very activated in working memory. The potential long-term consequences of increased calories and violation of her healthy eating priorities associated with drinking Coke were somewhat less salient, because Mary had to shift her attention to think carefully about them before making a decision. Roger's question about the important project interfered with the decision process by introducing additional items about an important task into working memory. Because working memory has a limited activation capacity, Mary would retain only those drinking decision items that were most salient (i.e., Coke is tasty) in working memory, and those more salient items would drive the decision about what option to choose.

The task of maintaining representations in mind involves a number of processes that serve the working memory system, such as encoding processes, the activation capacity of the short-term store, the capacity for mental manipulation, the active maintenance of information in over time, resistance to distraction, cognitive inhibition, and attentional processes, such as controlled shifting of attention (Baddeley & Logie, 1999; Cowan, 1999; Engle, Tuholski, Laughlin, & Conway, 1999; K. L. Shapiro & Luck, 1999; Vogel, Luck, & Shapiro, 1998). CMT focuses on working memory capacity defined as the activation capacity for the short-term store, the capacity to resist distraction and mentally manipulate information in working memory, and the capacity to maintain the activation of items in working memory over

time and engage in dual tasking (Finn, 2002). The activation capacity of the short-term store refers to the maximum number of items that can be kept in short-term memory at one time. Items are conceptualized as having a certain degree of activation in short-term memory. High-activation items are easily retrieved. Items with low activation are less reliably maintained in working memory and more difficult to retrieve. CMT proposes a threshold function for activation level, whereby items with activation levels above threshold are reliably maintained and retrieved to guide behavior. The capacity to resist distraction and mentally manipulate items in working memory refers to the capacity to inhibit extraneous items from attaining sufficient activation to displace current items in working memory and the capacity to manipulate the activation of specific items in working memory as one shifts attention to specific options in a process of making a decision. Finally, the capacity to maintain activation refers to the process by which the activation of specific items is maintained above threshold over time, perhaps via mechanisms that are similar in reverberating circuits. Dual-task capacities involve inhibitory processes that allow for the maintenance of separate sets of items that are related to different tasks in working memory. Confirmatory factor analysis of data (Finn, 2002) obtained from 300 participants tested on a number of tasks that assess working memory capacity, such as the letter-number sequencing task (Wechsler, 1997), the dual-verbal working memory task (Hale, Bronik, & Fry, 1997), the operation-word span task (Engle et al., 1995, 1999), the digit span task (Wechsler, 1981), and other working memory tasks, support this three-dimensional model of working memory capacity, which is illustrated in Figure 1.

Working Memory Capacity and Decision Making

Working memory capacity is relevant in decision contexts that involve the consideration of a number of cues, behavioral options, and their consequences. CMT draws on the idea, proposed in decision field theory (Busemeyer & Townsend, 1993), that decision making is a dynamic process affected by the interplay of signal salience, preference for specific outcomes, estimates of outcome probabilities, and the use of rules to guide decisions, all of which can change during the process of making a decision. The basic idea is that the processes underlying working memory capacity facilitate the shifting of influence on behavior from the initially highly salient, expected, immediate consequences of behavior to the initially less salient future expected consequences of behavior. Generally speaking, behavior is more likely to be adaptive when hypothetical future consequences exert significant influence on behavior (Barkley, 2001; Finn, Mazas, Justus, et al., 2002). Failing to account for
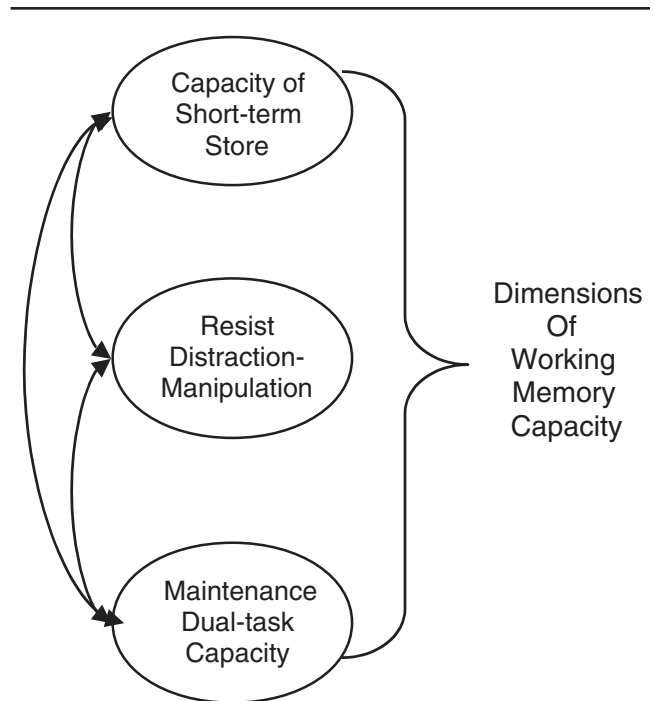

Figure 1: Theoretical Model of the Primary Dimensions of Working Memory Capacity That Play Central Roles in Decision Making.

NOTE: Each dimension is assessed as a latent variable using a range of standard tests of working memory capacity (refer to text).

future outcomes of behavior is associated with impulsive choices that result in significant interpersonal, health, financial, and legal problems. Working memory capacity is associated with the processes involved in maintaining items at activation levels sufficient to be used to effectively guide behavior and sufficient for the process of reflectivity (considering options and outcomes and choosing an appropriate response) in decision making. Greater capacity allows for more items to be reliably retained, more capacity for reflection, and more capacity to resist distraction. In the end, the greater the working memory capacity, the more likely the less salient, future-oriented information about the consequences of behavior can be kept in mind, become the focus of attention, and influence decision making. Less salient signals are more difficult to keep in mind than highly salient signals because the low salient signals are less activated in working memory (Kimberg & Farah, 1993). Participants with low working memory capacity will have greater difficulty keeping in mind the less salient stimuli, rendering them less influential on behavior (Finn, Mazas, Justus, et al., 2002). Research shows that high salient stimuli are more influential in decision making under memory loads, when the various aspects of working memory capacity are compromised (Shiv & Fedorikhim, 1999).

Signal salience in decision contexts is influenced by the proximity (immediate/amount of delay), the estimated probability (high/low), and the attention paid to (importance) the consequences of behavior (Busemeyer & Townsend, 1993; Finn, Mazas, Justus, et al., 2002). In general, higher salience signals have a greater influence on behavior than low salience signals (Busemeyer & Townsend, 1993), which is illustrated by the fact that delayed rewards are discounted (are less influential) relative to immediate rewards as a function of the amount of delay (Rachlin, 1989).

The capacity to reflect is associated with the capacity to mentally manipulate items in memory (e.g., "If I do A, then B might occur now; if I do C, then D might occur now"), whereby less salient signals may increase in saliency, if they become the focus of reflection ("If I do E, then G might happen in tomorrow, but if I do F, then H might happen in 2 weeks"). Greater capacity to resist distraction and maintain the activation of items in working memory over time should allow for a greater capacity to reflect. Research on the dynamic processes in decision making (decision field theory) shows that longer deliberation times are associated with a shift in influence from the initially more salient, proximal consequences of behavior to the initially less salient, distal consequences (Busemeyer & Townsend, 1993; Busemeyer, Townsend, & Stout, in press).

Working Memory Capacity and Alcohol Use and Abuse

How might working memory capacity be relevant to alcohol abuse? Take, for example, a young college student faced with a decision either to go out drinking with his friends or to spend time studying alone for an upcoming test. This decision involves considering, at one time, a number of options and their immediate and future positive and negative consequences. The relative salience of the options and consequences are influenced by their temporal proximity (e.g., immediate are more salient), their subjective importance or value, and expectedness (Busemeyer & Townsend, 1993; Finn, Mazas, Justus, et al., 2002). Often, the most salient signals in this type of decision context are those associated with the immediate rewards of drinking, such as the fun, social acceptance, and stimulation of college drinking events. An individual with a low working memory capacity will be less able to consider the less salient signals, which are often associated with the delayed negative consequences of drinking or the delayed positive consequences of studying and, in many cases, would be more likely to go drinking (less likely to inhibit). However, signal salience is influenced both by objective factors (e.g., proximity in time, probability) as well as subjective factors, such as relative importance of or value placed on

the specific consequences of behavior. CMT holds that impulsivity/novelty seeking is associated with paying more attention to rewards, experiencing increased exhilaration to rewards, and taking less time deliberating decisions, all of which results in rewards being more salient and influential than punishments and should lead to greater difficulties inhibiting behavior. Impulsive/novelty seeking subjects with low working memory capacity are likely to be even more disinhibited because they have greater difficulty keeping in mind the less salient punishment cues. Theoretically, impulsive/novelty-seeking subjects with high working memory capacity also focus more attention on reward cues, but they still should have enough reserve working memory capacity to keep in mind the less salient punishment cues and counteract, to some degree, their disinhibitory tendencies. Thus, a low working memory capacity should exacerbate disinhibitory tendencies for impulsive/novelty-seeking subjects. Working memory mechanisms in alcoholism are discussed further below.

Summary

Working memory capacity has an important influence on decision making and may serve to moderate risk for alcoholism. Increased working memory capacity provides (a) greater activation capacity of the short-term store, increasing the likelihood that lower salient stimuli can be influential on behavior; (b) greater capacity for mental manipulation, which should facilitate reflectivity during the deliberations of decisions; and (c) increased active maintenance and dual-tasking capability, which should allow for representations to be maintained for longer periods of time (i.e., longer deliberation times).

A CMT OF PERSONALITY VULNERABILITY

As noted above, the evidence that personality traits predispose to alcoholism and other externalizing behavior is overwhelming. However, the wide range of different measures and types of traits used across studies makes it difficult to identify the critical etiological mechanisms associated with these traits. Furthermore, most studies of personality and alcoholism are not based in a well-articulated theory of the mechanisms by which specific personality dimensions predispose to alcoholism. Many are based on the broad notion that personality traits are associated with a disinhibitory vulnerability to alcoholism, but the precise disinhibitory mechanisms are not specified. Cloninger's (1987a) tridimensional theory of personality vulnerability to alcoholism has been very influential and has inspired many studies of personality and alcoholism. However, almost all of this work has been directed toward addressing questions such as "Do these personality traits characterize alcohol-

ics in terms of the profiles suggested by the theory?", "Are these personality traits predictive of the onset of alcohol problems or the early onset of alcohol use?" "What are the psychosocial and familial correlates of these traits?" and "Do genetic factors account for significant portions of the variance in these personality traits?" None of these questions deals with issues of etiological mechanisms. Only a very few studies have directly investigated the behavioral and biological mechanisms associated with Cloninger's traits, and the results of some of these studies are difficult to interpret because of the measurement problems of Cloninger's personality tests, the Tridimensional Personality Questionnaire (TPQ) (Cloninger, 1987b) and the Temperament and Character Inventory (TCI) (Cloninger, Pryzbeck, Svrakic, & Wetzel, 1994). A major problem with the TPQ and TCI is that the harm avoidance scale is a better measure of negative affectivity than harm avoidance (Finn, Mazas, Justus, et al., 2002; Meszaros et al, 1999; Nagoshi et al., 1992; Peirson & Heuchert, 2001; Yoshino et al., 1998). Harm avoidance is supposed to reflect a proclivity to behavioral inhibition and avoidance of dangerous activity, which is distinct from the broader construct of negative affectivity (Finn, Mazas, Justus, et al., 2002; Nagoshi et al., 1992; Waller et al., 1991). This makes it difficult to determine whether studies that use the TCI or TPQ to investigate mechanisms in harm avoidance are uncovering mechanisms associated with negative affectivity in general or harm avoidance in particular (e.g., Corr et al., 1995; Corr, Kumari, Wilson, Checkley, & Gray, 1997). CMT takes a multivariate approach to assessing the key dimensions of personality associated with a vulnerability to alcoholism. Using multiple measures that tap the key constructs of impulsivity, novelty seeking, harm avoidance, sensation seeking, and excitement seeking, CMT proposes a number of mechanisms that represent major processes associated with these traits and a vulnerability to alcoholism.

Dimensions of Personality Vulnerability to Alcohol Abuse

Initially, Finn et al. (2000) postulated a model with two major personality-mediated pathways to alcohol abuse. This model hypothesized that personality risk for alcohol abuse was mediated by (a) a social deviance proneness pathway, which reflected antisocial qualities and problems regulating behavior in accordance with social norms, interpersonal or other contextual cues for appropriate behavior, or the likelihood of future negative consequences, and (b) an excitement seeking pathway, a subset of sensation-seeking traits, which reflected preferences for exciting, pleasurable activity and an inability to tolerate boredom. Finn et al. studied the association between a family history of alcoholism, personal-

ity, and alcohol use and abuse in a sample of 435 young adults. A positive family history of alcoholism was significantly associated with high levels of social deviance (antisociality), excitement seeking, and higher rates of alcohol abuse and dependence (Finn et al., 2000). Most of the association between familial alcoholism and alcohol problems was mediated by social deviance and excitement seeking. Social deviance was assessed as a latent variable with measures of low socialization, antisocial traits, and childhood behavioral problems. Excitement seeking also was assessed as a latent variable with the disinhibition and boredom susceptibility scales of the sensation seeking scale (Zuckerman, 1979), which have common genetic origins and represent a dimension of sensation seeking distinct from thrill seeking and experience seeking (Finn et al., 2000). Structural equation modeling revealed that social deviance directly promoted alcohol abuse, whereas excitement seeking promoted excessive alcohol intake, which in turn led to increased alcohol problems (Finn et al., 2000). Individuals who were high in social deviance and drank significant amounts of alcohol had more problems (probably due to difficulties regulating their use) than those who were lower in social deviance and drank equivalent amounts of alcohol (Finn et al., 2000). Social deviance is likely the result of a number of different mechanisms associated with impulsivity, novelty seeking, and low harm avoidance, such as difficulties inhibiting behavior that is associated with strong rewards, difficulties avoiding significant punishments, and a preference for immediate rewards. Excitement seeking was thought to reflect a need to engage in appetitive, hedonistic activities and a susceptibility to boredom when unstimulated, which fosters excessive drinking and attitudes that highlight alcohol's pleasurable effects (Finn et al., 2000). A recent twin study replicated these findings in a large epidemiological sample of Finnish twins and found evidence that these two paths were largely independent and primarily genetic in origin (Mustanski, Viken, Kaprio, & Rose, 2002).

CMT postulates three major dimensions of vulnerability to alcohol abuse—impulsivity/novelty seeking, harm avoidance, and excitement seeking—illustrated in the latent variable model depicted in Figure 2. The original two-path model in Finn et al. (2000) was revised by replacing the social deviance proneness dimension with the personality dimensions of impulsivity/novelty seeking and harm avoidance, because impulsivity/novelty seeking and harm avoidance represent personality phenotypes that more directly reflect specific bio-behavioral mechanisms (Finn, Mazas, Justus, et al., 2002). Rather than reflecting a single personality dimension, social deviance proneness reflects a broader phenotype that is influenced of a number of personality traits, interper-

sonal characteristics, and socialization influences. Impulsivity and novelty seeking are combined into one dimension because they are highly correlated and confirmatory factor analyses suggest that they reflect the same general dimension of personality (Finn, Mazas, Justus, et al., 2002; Finn & Steinmetz, 2002; Wills et al., 1994, 1995). In addition, observational measures of novelty seeking in children (Cloninger et al., 1988; Masse & Tremblay, 1997) actually assess characteristics of impulsivity, such as inattentiveness, aggressiveness, overactivity, disorganization, poor behavioral control, excitableness, and restlessness (Evenden, 1999a). Our confirmatory factor analytic studies that include the range of personality scales typically used to assess personality risk for alcoholism indicate that a model with three personality factors (impulsivity/novelty seeking, harm avoidance, and excitement seeking) is the best fitting model of disinhibited personality (Finn, Mazas, Justus, et al., 2002; Finn & Steinmetz, 2002).

The model illustrated in Figure 2 is based on data from 307 young adult male and female participants who were recruited using advertisements designed to attract responses from a sample with a range of disinhibited traits (cf. Finn, Mazas, Justus, et al., 2002; Justus et al., 2001, for recruitment information). Approximately 40% of the sample had significant problems with alcohol. This three-factor model, χ^2(17, N = 307) = 72.0, $p < .001$ (Goodness of Fit Index = .94, Non-Normed Fit Index = .94) fit the data better than all competing models (one- and two-factor models) using difference χ^2 model comparisons. Difference χ^2 values varied from 33.7 (df = 2, $p < .0001$) to 305 .3 (df = 3, $p < .00001$). As expected, each personality dimension was significantly associated with excessive alcohol use, alcohol abuse, and antisocial behavior. Figure 3 illustrates the univariate structural paths between each dimension and alcohol use and abuse. Figure 4 illustrates the univariate structural paths between each dimension and a measure of antisocial symptoms (a checklist of a lifetime history of antisocial symptoms).

Although the three-factor model is the best fitting model, the factors are significantly intercorrelated with one another (cf. Figure 2). The significant intercorrelations reflect the interrelatedness of these traits, the overlap in behavioral phenotypes, and the method variance associated with self-report measures. However, research suggests that there are unique mechanisms associated with each trait dimension (Finn et al., 2000; Finn, Mazas, Justus, et al., 2002; Koopmans, Boomsma, Heath, & van Doornen, 1995; Mustanski et al., 2002). For instance, behavior genetic studies indicate that the measures of excitement seeking have distinct genetic origins from the thrill and adventure seeking aspects of low harm avoidance (Koopmans et al., 1995) and from social devi-
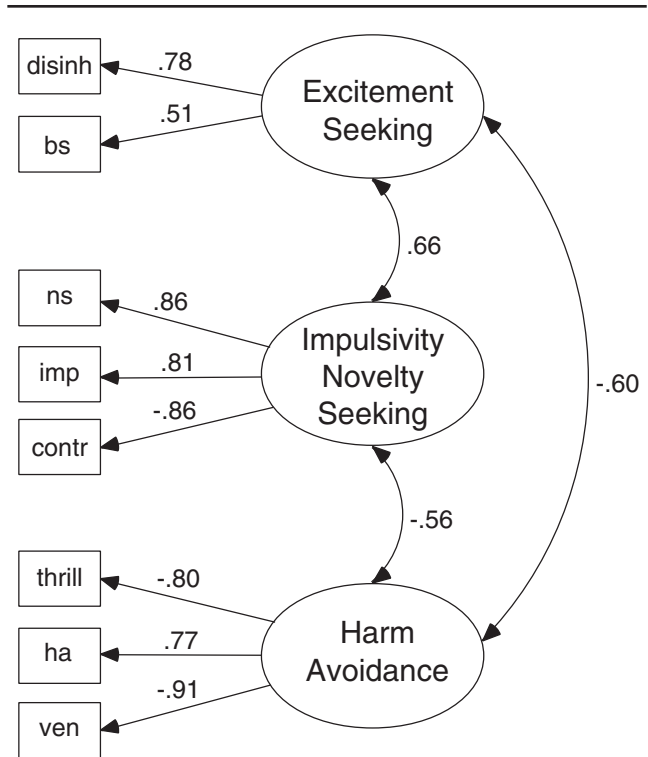

Figure 2:   Three-Factor Model of the Primary Dimensions of Personality Vulnerability to Alcoholism.
NOTE: Comparisons with competing models indicated that this was the best fitting latent variable model; disinh = Disinhibition scale of the Sensation Seeking Scale (SSS); bs = SSS Boredom Susceptibility scale; ns = Novelty Seeking scale of the Tridimensional Character Inventory; imp = Eysenck and Eysenck's (1978) Impulsivity scale; contr = Control scale from the Multidimensional Personality Questionnaire (MPQ); thrill = SSS Thrill and Adventure Seeking scale; ha = MPQ Harm Avoidance scale; ven = Eysenck and Eysenck's (1978) Venturesomeness scale. Rectangles depict observed variables. Ellipses depict latent variables. Single-direction arrows depict regression paths (standardized factor loadings). Bidirectional arrows depict correlations.
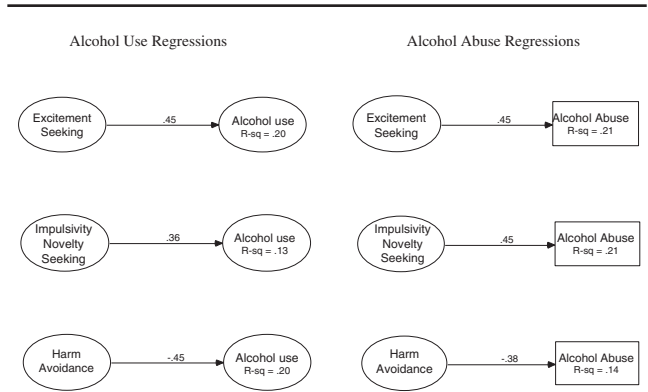

Figure 3:   Structural Equation Models of Regressions of Alcohol Use (left side) and Alcohol Abuse (right side) on Each Personality Dimension.
NOTE: Indicator measures for personality scales are shown in Figure 2. Indicators for alcohol use are the average quantity, frequency, and density (most consumed on 1 occasion) in the past 6 months. Alcohol abuse is a measure of lifetime alcohol symptoms. Standardized regression coefficients are depicted.
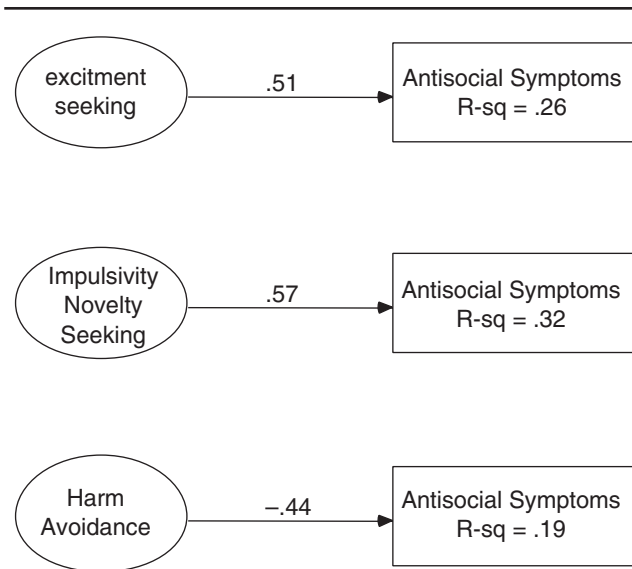
Figure 4: Structural Equation Models of Regressions of Antisocial Symptoms (lifetime history) on Personality Latent Variables.
NOTE: Indicator measures for personality scales are shown in Figure 2. Standardized regression coefficients are depicted.

ance proneness (Mustanski et al., 2002), which is strongly associated with impulsivity. Although there is phenotypic overlap among these traits, the theory holds that there are specific mechanisms associated with each trait. For example, high levels of activity (a broad behavioral phenotype) is associated with both impulsivity/novelty seeking and excitement-seeking traits. High activity levels can be the result of a number of different processes, such as poor impulse control (impulsivity/novelty seeking) or a need to be engaged in appetitive behaviors to experience positive affect (excitement seeking). The challenge for researchers is to refine these broad behavioral phenotypes by identifying the endophenotypes that more directly reflect the specific mechanisms that contribute to variation in a specific trait (Iacono et al., 1999). Thus, it is important that all three trait dimensions be included in most models to identify the specific processes that are unique to each trait.

In CMT, each personality dimension is associated with a specific pattern of activity in one or more bio-behavioral motivational systems and with a specific emotional states or processes. The idea that personality traits reflect activity in specific bio-behavioral motivational systems and specific emotional states and processes has been proposed by others (Bates, 2000; Collins & Depue, 1992; Depue & Spoont, 1986; Fowles, 1987; Gray, 1987; Kagan, Snidman, & Arcus, 1998; Rothbart, Ahadi, & Evans, 2000; Rothbart et al., 1994). In fact, many point out that emotions reflect a fundamental facet of temperament and personality (Bates, 2000). CMT includes roles for

motivational systems such as the behavioral facilitation-activation systems (Depue & Spoont, 1986; Fowles, 1987) and the behavioral inhibition systems described by Gray (1987) and Kagan and colleagues (Kagan, Resnick, & Snidman, 1990; Kagan et al., 1998), although the nature of the association between traits and motivational systems differ in some cases from what has been proposed by others.

A central idea in CMT is that inhibitory influences on behavior reflect multiple mechanisms and, in some contexts, distinct motivational systems (Finn, Mazas, Justus, et al., 2002; Kagan et al., 1998; Nigg, 2000) rather than a single underlying behavioral inhibition system (Gray, 1987). For instance, research suggests that behavioral inhibition to threatening, aversive stimuli involves somewhat different mechanisms than behavioral inhibition to nonreward or nonaversive punishments encountered in approach contexts (Finn, Mazas, Justus, et al., 2002). Using a large sample ($N = 351$), Finn Mazas, Justus, and colleagues (2002) studied behavioral inhibition on two types of go/no-go learning tasks in alcoholic subjects with and without conduct disorder, controls, and subjects with conduct disorder and no alcoholism. Both tasks involved modest monetary rewards (win $0.17/trial) for each correct response to a go stimulus (a hit). One task, called the nonaversive task, involved monetary punishment (loss of $0.17) for failing to inhibit responses (false alarms on no-go trials). The other task, called the aversive task, involved electric shock punishment (3mA shock to the inside of the arm) for failing to inhibit responses (false alarms on no-go trials). Hit rates were not correlated across the two tasks. Inhibition learning (false alarm rates) was only modestly correlated across tasks ($r = .28$), suggesting that unique mechanisms on these two types of tasks are more influential than common mechanisms. Finn, Mazas, Justus, et al. (2002) found that different personality traits were associated with inhibition on the two tasks, which also suggests that different mechanisms are associated with behavioral inhibition on the two tasks. Low harm avoidance was associated with poor inhibition on the aversive task, and impulsivity/novelty seeking was associated with poor inhibition on the nonaversive task.

Another key idea in CMT is that specific traits and motivational processes are associated with individual differences in the manner in which individuals process information about the environment. For instance, novel environments represent complex stimuli that include cues that signal the potential for rewarding, positive experiences and cues that signal the potential for punishing, aversive experiences. Those who pay more attention to the potential (cues) for threat or judge the probability of negative outcomes to be higher than positive outcomes may be more inhibited in novel environments

(Busemeyer & Townsend, 1993; Finn, Mazas, Justus, et al., 2002). On the other hand, those who focus more on reward cues may be less inhibited and more exploratory (novelty seeking) in new environments. Furthermore, rather than being a dichotomous category describing either new or familiar environments, novelty is considered to be a continuous variable reflecting the degree to which a particular environment is new or uncertain and individual differences in the perception of familiarity and uncertainty. What follows is a description of each of the three personality constructs, the measures of each construct, the hypothetical mechanisms underlying their variation and association with alcohol use disorders, and the evidence in support of the validity of these constructs as indicators of a vulnerability to alcoholism. Each personality dimension represents the complex interplay of a number of processes. The theory outlined below focuses only on major mechanisms in each trait that involve the interrelationships between motivational and cognitive processes.

IMPULSIVITY/NOVELTY SEEKING

The phenotypic features of impulsivity/novelty seeking are poor control of appetitive and aggressive impulses, difficulties delaying gratification, acting without thinking, increased activity, and increased emotional reactivity to both positive, rewarding experiences and frustrative, provocative experiences. Individuals with high scores on this trait have greater difficulty inhibiting or modulating their behavior once they are in an approach mode (Finn, Mazas, Justus, et al., 2002; Newman, 1987; Newman & Schmidt, 1998; Patterson & Newman, 1993). Likewise, when frustrated, hassled, or provoked, individuals with high levels of impulsivity are more likely to react with increased hostility and aggression (Barratt, 1994). Thus, poor self-regulation is a core feature of impulsivity/novelty seeking and contributes to the overlap between impulsivity and social deviance proneness. Although not well studied, CMT also proposes that high levels of impulsivity/novelty seeking are associated with greater exhilaration, vigor, and positive affect in response to significant rewarding experiences. In terms of emotional processes, CMT hypothesizes that impulsivity/novelty seeking is associated with increased emotional reactivity to events thought to be associated with activity in the behavioral facilitation system described by Depue and colleagues (Collins & Depue, 1992; Depue & Spoont, 1986).

In CMT, not only do impulsive individuals drink more alcohol (see Figure 3), but they do so in a manner that is more likely to lead to problems (Finn et al., 2000; Finn, Mazas, Justus, et al., 2002). For instance, some young adults with low levels of impulsivity drink excessive amounts of alcohol; however, they are more likely to
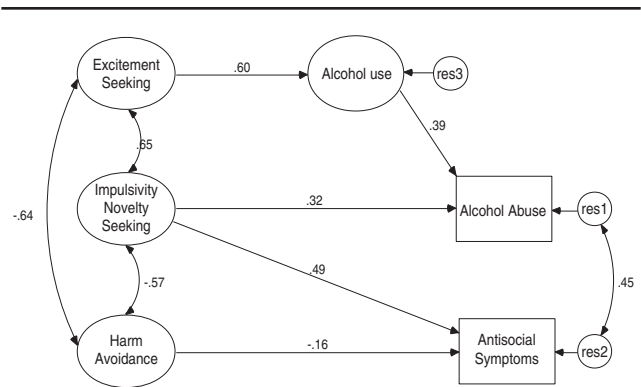

Figure 5: **Structural Equation Model of the Association Between Personality Vulnerability Dimensions and Alcohol Use, Alcohol Abuse, and Antisocial Symptoms.**
NOTE: Indicators are not shown. Res1, res2, and res3 depict residual variables for each dependent measure. Rectangles depict observed variables. Ellipses depict latent variables. Single-direction arrows depict regression paths (standardized regression coefficients). Bidirectional arrows depict correlations. Only those statistically significant paths are depicted.

drink in contexts that are planned and controlled, such as with specific friends, at specific events, when it will not interfere with responsibilities, or when does not involve driving a vehicle. On the other hand, impulsive individuals are more likely to "party" spontaneously, without specific plans, when it could interfere with responsibilities, and in contexts where unexpected problems are more likely to arise. In addition, once they have started drinking and are in an approach (appetitive) mode, impulsive individuals have more difficulty controlling or moderating their drinking. The structural path model displayed in Figure 5 is consistent with this perspective. In this model, impulsivity/novelty seeking has direct paths to alcohol abuse and antisocial behavior but not to alcohol use. This suggests that when controlling for the overlap with excitement seeking and low harm avoidance, impulsivity/novelty seeking is specifically associated with evidence of poor self-regulation (alcohol problems and antisocial behavior).

Self-report measures of impulsivity/novelty seeking. The indicator measures for novelty seeking/impulsivity used in the confirmatory factor analysis and structural models described in this article were the Novelty Seeking scale from the TCI (Cloninger et al., 1994), the Impulsivity scale from the Eysenck Impulsivity-Venturesomeness test (Eysenck & Eysenck, 1978), and the Control scale of the Multidimensional Personality Questionnaire (MPQ) (Tellegen, 1982). These widely used, psychometrically sound, self-report inventories capture the key phenotypic components of impulsivity and novelty seeking (Kirby, Petry, & Bickel, 1999; Krueger, Caspi, Moffitt, Silva, & McGee, 1996; Luengo, Carrillo de la Pena, &

Otero, 1991). Low scores on the MPQ control scale, high TCI novelty-seeking scores, and high impulsivity scores reflect low self-control, spontaneous exploratory behavior, the experiencing of strong impulses to respond to appetitive stimuli recklessness, and a lack of planning and foresight (Cloninger et al., 1994; Luengo et al., 1991; Tellegen & Waller, in press). These scales are all highly correlated with one another (rs = –.74, –.70, and .70, ps < .0001). The Barratt Impulsivity Scale (Barratt, 1985) also is a commonly used, psychometrically sound, self-report measure of impulsivity. Although not included in the factor analytic study reported in this article, Finn, Mazas, and Justice (2002) observed high correlations between the total score on the Barratt measure and the three measures noted above (rs = .68, .70, and –.75, ps < .0001) in a current, ongoing study.

Mechanisms in impulsivity/novelty seeking. CMT postulates two major processes associated with impulsivity/ novelty seeking: (a) strong appetitive/approach tendencies and (b) difficulties controlling or inhibiting these strong appetitive urges. Each process is thought to involve a number of interrelated mechanisms. The strong appetitive tendencies are hypothesized to be associated with heightened sensitivity to rewards and increased responsivity to aggression by others (unconditioned responses) as well as increased responsivity to cues for reward and provocation. These processes have been linked to the construct of the behavioral facilitation system (Depue & Spoont, 1986) and have some features in common with Fowles's (1987) behavioral activation system. The difficulties inhibiting approach are hypothesized to be due to weak inhibition in response to cues for nonreward (Depue & Spoont, 1986; Gray, 1987) or nonaversive punishment (Finn, Mazas, Justus, et al., 2002), with insensitivity to future negative consequences when immediate gains are probable (Mazas, Finn, & Steinmetz, 2000), and with weak inhibition of prepotent response tendencies (Logan, Schachar, & Tannock, 1997). Although some theories emphasize a primary role for strong approach tendencies (strong behavioral activation system) in impulsivity/novelty seeking (Cloninger, 1987a; Quay, 1965; Scerbo et al., 1990; S. K. Shapiro, Quay, Hogan, & Schwartz, 1988), many point out that impulsivity is likely due to an interaction between strong behavioral facilitation-activation and weak behavioral inhibition as the motivational processes underlying impulsivity (Fowles, 1987; Gray, 1987). For instance, Mazas et al. (2000) studied the effects of the magnitude of immediate gains and long-term losses on decision making in young adults with alcoholism and or antisocial personality using the card-playing task developed by Bechara, Damasio, Damasio, and Anderson (1994). Participants were allowed to choose cards from any one of four decks of cards. Each card choice won an immediate sum of money, either 50 cents or $1.00, 100% of the time. Some cards also resulted in losing a sum of money that varied from 50 cents to $12.50. Choices from two of the decks resulted in winning 50 cents on each card and losing a total of $2.50 for every 10 cards chosen (for a net gain of $2.50 per 10 card selections). Loses occurred either 50% or 10% of the time, depending on the deck. Choices from the other two decks resulted in winning $1.00 on every card; however, the participants lost a total of $12.50 for every 10 cards chosen from these decks (for a net loss of $2.50 per 10 card selections). Participants with antisocial personality chose more cards from the decks that had higher immediate winnings ($1.00), even though such choices resulted in greater losses in the long term. Participants without antisocial personality chose more cards from the small immediate gain decks (50-cent reward) compared with the large immediate gain decks and learned to optimize their long-term gains over the course of the task. The overall pattern of results suggested that antisocial subjects were more initially responsive to the immediate larger rewards and were unable to inhibit their inclination to choose from the large immediate reward decks, because they were insensitive or unresponsive to the long-term punishments associated with such choices. A subsequent analysis of these data revealed that the personality trait of impulsivity accounted for a significant portion of the association between antisocial personality and a preference for the immediate, large reward decks (Finn, Lin, et al., 2002).

CMT associates the strong appetitive processes observed in impulsive/novelty seeking individuals with a strong behavioral facilitation system (BFS) rather than the behavioral activation system (BAS) because the BFS construct appears to reflect the kinds of patterns of behavior associated with impulsivity and novelty seeking. Readers are referred to work by Depue and colleagues (Collins & Depue, 1992; Depue & Spoont, 1986) for detailed discussions of the BFS and to work by Fowles (1980, 1983, 1987) and Gray (1975, 1987) for a discussion of the BAS. The BFS and BAS are both thought to be associated with increased response to (conditioned) signals for reward and nonpunishment, which facilitates approach and active avoidance. However, increased BFS activity also is thought to mediate unconditioned responses (e.g., responses to actual rewards) and hostile and irritative aggressive responses to events that frustrate efforts to obtain rewards, which closely reflects CMT's conceptualization of impulsivity/novelty seeking. Increased BFS activity would be associated with greater exhilaration, vigor, and positive affect in response to reward, a greater likelihood to respond with hostile or aggressive responses to aggressive provocations (i.e., being the object of another's aggression), increased

spontaneous exploratory behavior in response to novelty, increased approach responses to reward cues, and increased aggressive and/or hostile responses to frustrations arising from being blocked from reward (Collins & Depue, 1992; Depue & Spoont, 1986), all of which are typical of individuals high in impulsivity/novelty seeking. The mesolimbic and mesocortical dopaminergic projections from the ventral tegmental area are thought to form the neural basis for the BFS (Collins & Depue, 1992; Depue & Spoont, 1986). Dopamine activity also has been shown to enhance glutamate-induced excitations in the nucleus accumbens and neostriatum, which increases signal to noise ratio for behaviorally relevant information, such as cues for rewards, and may serve to facilitate approach behavior (Kiyatkin & Rebec, 1996, 1999). Thus, increased dopamine activity may serve, in part, to increase the salience of reward cues, which is considered by CMT to be a central mechanism in impulsivity.

Weak inhibition is associated with a number of neurophysiological systems, such as the septo-hippocampal system (Depue & Spoont, 1986; Gray, 1987) and orbital-prefrontal circuitry (Bechara et al., 1994; Casey et al., 1997). There is ample evidence that a significant role in behavioral inhibition is played by serotoninergic pathways involving the interconnections between the median raphe nuclei and the septo-hippocampal complex and mesolimbic dopaminergic projections to nucleus accumbens (Depue & Spoont, 1986; Spoont, 1992). Low serotonin activity has been associated with impulsivity, impulsive aggression, and hostility in both animals (Evenden, 1999b; Higley et al., 1996) and humans (Coccaro & Kavoussi, 1997; Fishbein, Lozovsky & Jaffe, 1989; Linnoila & Virkkunen, 1992). The potential mechanisms by which serotonin is involved in behavioral regulation are many. There is evidence that decreased serotonin is associated with an increase in dopamine-mediated exploratory behavior in novel environments, increased behavioral reactivity to sensory input, disinhibition of previously punished behavior, and exaggeration of the saliency of conditioned signals (Spoont, 1992). Studies also suggest that low 5-HT is associated with a decreased ability to tolerate delay of reward (Bizot, Le Bihan, Puech, Hamon, & Thiebot, 1999), a decreased ability to pause to prepare to choose an appropriate response (Evenden, 1999b), and decreased salience of delayed rewards (Ho, Mobini, Chaing, Bradshaw, & Szabadi, 1999), all of which are associated with impulsivity/novelty seeking. There is also strong evidence linking the orbital-prefrontal cortex with poor inhibition of behavior that is rewarded in the short-term but results in significant long-term punishment (e.g., Bechara et al., 1994) and poor inhibition of prepotent response tendencies, such as those primed

in no/no-go or stop-signal tasks (Casey et al., 1997). Studies of the cortical event-related potential also provide evidence for the role of the prefrontal cortex in impulsivity, antisocial behavior, and alcohol problems (Bauer, 1997; Bauer, O'Connor, & Hesselbrock, 1994; Justus et al., 2001).

CMT proposes six interrelated mechanisms related to strong BFS activity and weak inhibition in impulsive/novelty seeking individuals: (a) increased attention paid to (or salience of) cues for reward; (b) difficulties learning to modulate approach behavior in response to changing circumstances; (c) strong emotional responses to reward and frustration; (d) more rapid development of learned-conditioned responses to cues for reward and aggressive provocation; (e) less time deliberating decisions to approach; and (f) and interactions between low working memory capacity, increased attention to reward cues, and behavioral inhibition.

The idea that cues for reward have higher salience for those with high levels of impulsivity/novelty seeking is suggested from studies of delayed discounting of future rewards (Kirby et al., 1999), studies of children's ability to delay gratification (Mischel, Ebbeson, & Zeiss, 1972; Mischel, Shoda, & Rodriguez, 1989; Shoda, Mischel, & Peake, 1990), and studies of the modulating role of working memory capacity on response inhibition (Finn, Mazas, Justus, et al., 2002, discussed in more depth below). It appears that impulsive/novelty seeking individuals pay more attention to reward, and once focused on reward, they have difficulty inhibiting their approach or modulating their responses to account for new information or changes in the consequences of behavior (Newman & Schmidt, 1998; Patterson & Newman, 1993). Drinking alcohol is associated with highly salient immediate reward cues, such as good taste, pleasant emotions, reduced stress, and social facilitation. The negative consequences of drinking are typically delayed and less probable and therefore less salient. Impulsive/novelty-seeking individuals are thought to pay more attention to immediate rewards associated with drinking, less attention to the longer term negative outcomes of drinking, and are more likely to drink to excess (Mazas et al., 2000). Impulsivity is defined by some as the tendency to discount to a larger degree the value of a larger future reward relative to an immediate smaller reward (Rachlin, 1989). Impulsivity is associated with higher discounting rates of future rewards relative to immediate rewards (Kirby et al., 1999), suggesting that the immediate reward is more salient for impulsive individuals. For instance, in the Mazas et al. (2000) study of decision making, impulsivity was associated with decisions that initially favored larger immediate rewards even though they were associated with large losses and decisions that displayed low aversion to potential losses

(Finn, Lin, et al., 2002). Studies also have shown that children who pay more attention to a potential, immediate reward (a food reward) have greater difficulties delaying gratification (Mischel et al., 1972, 1989). Four-year old children, who failed to divert their attention away from rewards in delay of gratification tasks, were more impulsive, less able to deal with frustrations, and more distractible at age 17 (Shoda et al., 1990). Finally, impulsive/novelty-seeking individuals respond to novel environments with strong approach tendencies (Caspi et al., 1996; Cloninger et al., 1988), when novelty is typically thought to elicit behavioral inhibition (Gray, 1975; Kagan et al., 1990; 1998). It may be that impulsive/novelty-seeking individuals pay more attention to the cues for reward in novel environments and are less inhibited by the unfamiliar nature of novelty, which leads them to respond to novelty as a potential reward. On the other hand, more behaviorally inhibited individuals may pay less attention to reward cues and more attention to cues that signal the potential for punishment or uncertainty in novel environments, leading them to respond to novelty as a potential threat. In decision field theory, this parameter is called attention weight and reflects the degree to which a decision is based on attention to either rewards or punishments (Busemeyer et al., in press; Busemeyer & Townsend, 1993). Impulsive/novelty-seeking individuals appear to give more weight to the potential for rewards and less weight to the potential for punishments when making decisions.

Impulsivity has been consistently associated with strong tendencies to experience anger more readily (Keltner et al., 1995) and to react to frustrations, hassles, or provocations with hostility and aggression (Barratt, 1994; Cole et al., 1994; Eisenberg et al., 2001). CMT also proposes that impulsivity is associated with stronger positive emotional responses to rewards, such as sexual stimuli, obtaining a desired goal, being in love, and the effects of psychoactive drugs or alcohol. Increased responsivity to rewards, aggressive stimuli, and frustrations can have three important consequences that compromise behavioral regulation. First, greater emotional, unconditioned responses may serve to facilitate development of conditioned emotional and behavioral responses to cues for reward and aggressive provocation, making approach behaviors, such as drinking, more reflexive and less amenable to effortful (thoughtful) control and making it difficult to learn how to modulate emotional expression. Impulsive individuals are likely to develop conditioned positive responses to drinking cues, which should further encourage engaging in drinking behavior. Second, strong conditioned emotional responses to approach or aggressive/frustrative cues put a load on working memory capacity, compromising the capacity to kind keep all relevant information

in mind when making a decision. In other words, when one experiences strong emotions, it is difficult to think of anything except the focus of one's emotions. As noted above, when a significant load is put on working memory, the high salient cues are the most likely to affect decisions and behavior (Shiv & Fedorikhim, 1999). In many cases, the high salient cues are those associated with immediate gratification. In drinking decision contexts, the most salient cues are those associated with the immediate, positive effects of alcohol. Less salient are the longer term effects, such as feeling hung over or sluggish the next day. Thus, impulsive individuals are hypothesized to be more likely to experience stronger positive emotions when faced with the prospect of drinking (i.e., more enthusiastic and upbeat), which biases them to think mainly about the highly salient cues associated with drinking and to have less working memory capacity resources to think of the less salient, future consequences of drinking. Third, greater emotional responses may affect specific decision-making processes that are involved in reaching a choice preference threshold (cf. decision field theory by Busemeyer & Townsend, 1993). When making decisions, individuals consider two or more options. During deliberations, which may be very brief, the relative preference for each option changes as the individual considers each choice. The option that passes a particular preference threshold first is the option that is chosen. A preference threshold is the level of preference for an option such that the person considers that option to be preferable over other competing options (Busemeyer & Townsend, 1993). For instance, consider the example of the young college student faced with a decision to go out drinking with his friends or to spend time studying alone for an upcoming test. Ideally, this individual will consider each option and weigh his preferences for each behavior and outcome. After a certain point of time, he will come to subjectively prefer one option to a sufficient degree that he takes that course of action. At that point, he is thought to have reached a preference threshold, where he prefers one option enough to make that choice (Busemeyer & Townsend, 1993). However, if he is particularly excited about seeing his friends, enthusiastic about the possibility of seeing someone for whom he has romantic interest, and thinks beer would really taste good, then this emotional state will augment his initial preference state for drinking, creating a momentum in favor of the drinking option and pushing his preference for drinking closer to threshold levels. Such would be the case for impulsive individuals, who are likely to experience more positive emotion about the prospects of having fun and take less time before they decide that drinking and partying is what they want to do.

Impulsivity also is associated with shorter deliberation times or a lack of reflectivity (Barratt, 1994; Evenden, 1999a; Patterson & Newman, 1993). This may be partly due to overestimating time intervals (van den Broek, Bradshaw, & Szabadi, 1992) and being unable to delay responding to obtain a reward (van den Broek, Bradshaw, & Szabadi, 1987). Shorter deliberation times may also be an effect of increased emotional responses or increased attention paid to reward cues, which augment the relative preference for approach behaviors such that preference passes a threshold value faster for impulsive subjects. Decision-making research has shown that stronger initial preferences are associated with shorter deliberation times (Busemeyer & Townsend, 1993). Studies of the dynamic processes in decision making also suggest that longer deliberation times increase the likelihood that influence will shift from the initially more salient information to the initially less salient, distal information concerning a specific choice (Busemeyer et al., 2002; Busemeyer & Townsend, 1993). In addition, impulsive individuals may have a lower overall preference threshold, which would result in shorter deliberation times. Impulsive individuals may choose quickly because they are more likely to act on a whim (low preference threshold) rather than on strong convictions or preferences for one or another outcome. Finally, shorter deliberation times may also be due to a lack of cognitive sophistication, executive cognitive ability, or simple practice in taking the time to think decisions through.

The interaction between low working memory capacity and increased attention paid to reward cues is hypothesized by CMT to exacerbate inhibitory problems in impulsive/novelty-seeking subjects. As noted above, Finn, Mazas, Justus, et al. (2002) assessed behavioral inhibition on an aversive (shock) and nonaversive (loss of money) go/no-go learning tasks in alcoholics with and without conduct disorder. The study also examined the interrelationships between go/no-go learning, working memory capacity, and the personality traits of impulsivity/novelty seeking, low harm avoidance, and excitement seeking and tested the theory that working memory capacity would modulate inhibition learning when no-go signals were less salient than go signals. Impulsive/novelty-seeking subjects with low working memory capacity showed greater difficulty learning to inhibit their responses to less salient cues for punishment on the go/no-go task with nonaversive, monetary punishment. Figure 6 displays these data. Impulsivity/ novelty seeking was significantly associated with poor inhibition for low working memory subjects but not for high working memory subjects. As noted above, CMT holds that impulsivity/novelty seeking is associated with paying more attention to reward cues. Those with low

working memory capacity have a greater difficulty holding the lower salient punishment cues in mind, which leads to greater difficulties learning to inhibit behavior and more problems with alcohol. Impulsive subjects with high working memory have sufficient working memory capacity to hold the lower salient cues in mind and can effectively learn to inhibit their behavior in this kind of go/no-go task. Low working memory capacity is thought to exacerbate problems in behavioral regulation and increase vulnerability to alcohol abuse (Finn, Mazas, Justus, et al., 2002; Finn & Steinmetz, 2002). Two recent studies support this notion. Hall and Finn (2002) found that social deviance proneness was associated with more alcohol problems for subjects with low working memory capacity, even after controlling for IQ. Social deviance proneness reflects poor behavioral regulation associated with impulsivity and other antisocial characteristics. Finn and Steinmetz (2002) found that low working memory capacity was associated with a stronger relationship between impulsivity/novelty seeking and both drug and alcohol abuse.

In summary, CMT holds that a number of mechanisms bias impulsive/novelty-seeking individuals toward quick, reflexive (impulsive) decisions that are influenced more by proximal, highly salient reward cues, which predispose toward making choices to drink alcohol excessively and failing to moderate drinking once it has been initiated, even when negative consequences are probable. The theory highlights the roles that signal saliency, working memory capacity, and dynamic decision-making processes play in a predisposition to alcohol problems.

HARM AVOIDANCE

Low harm avoidance is associated with the early onset of alcohol use and abuse (Cloninger et al. 1988; Finn, Mazas, Justus, et al., 2002; Masse & Tremblay, 1997) and antisocial, delinquent behavior (Krueger et al., 1996; Raine et al., 1998). The phenotypic features of low harm avoidance are fearlessness, a daring disregard for danger, an enjoyment of risky and dangerous activities, and seeking out, rather than avoiding, situations that have a significant potential for physical harm. The primary processes underlying low harm avoidance are thought to be an insensitivity to aversive events, which fosters fearlessness, and difficulties inhibiting behaviors that lead to aversive punishment (Finn, Justus, Mazas, Rorick, & Steinmetz, 2001; Lykken, 1995). Although low harm avoidance is associated with increased alcohol use and abuse (see Figure 3), the data suggest that its association with alcohol use and abuse is mediated by impulsivity/ novelty seeking and excitement seeking (see Figure 5). Figure 5 indicates that harm avoidance is uniquely associated with antisocial behavior when controlling for the
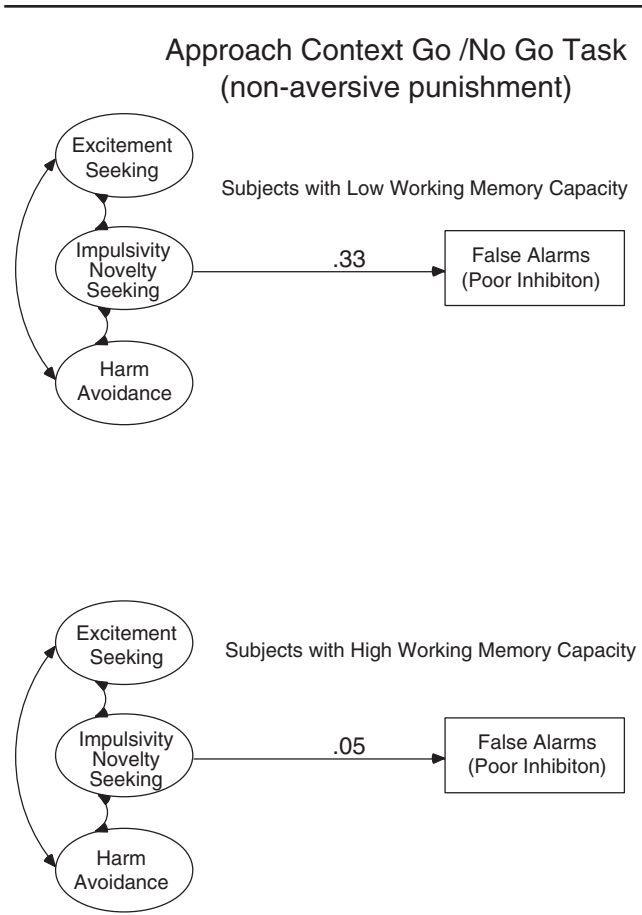
Figure 6: **Structural Equation Models of the Association Between Personality Vulnerability Dimensions and Poor Inhibition on a Go/No-Go Task With Monetary Rewards and Monetary (Nonaversive) Punishments in Subjects With High and Low Working Memory Capacity.**
NOTE: The data are from Finn, Mazas, Justus, and Steinmetz (2002). The path from impulsivity/novelty seeking to poor inhibition is significant for low working memory capacity but not for high working memory capacity subjects.

Figure 7: **Structural Equation Model of the Associations Between Harm Avoidance, Antisocial Symptoms, Alcohol Use, and Alcohol Abuse.**
NOTE: Only significant paths are depicted.

influence of impulsivity/novelty seeking and excitement seeking. However, the association between low harm avoidance and excessive alcohol intake is large and equivalent to excitement seeking in the univariate analyses (see Figure 3). Figure 7 illustrates the covariance among harm avoidance, antisocial behavior, and alcohol use and abuse. This model indicates that low harm avoidance is strongly associated with excessive alcohol use, which is independent of its association with antisocial symptoms. This association between low harm avoidance and drinking is likely to be mediated by excitement seeking (note Figure 5). In summary, low harm avoidance appears to predispose to excessive alcohol use; however, the mechanisms underlying this association are likely to be associated with excitement seeking. Low harm avoid-
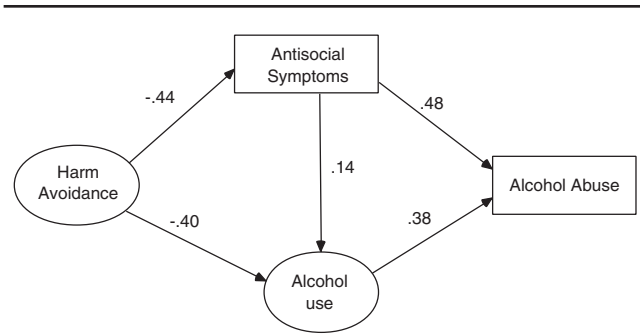
ance is associated with increased alcohol problems, but this effect appears to be mediated through its association with antisocial behavior and impulsivity/novelty seeking.

Self-report measures of harm avoidance. The indicator measures of harm avoidance used in the confirmatory factor analyses and structural models reported in this article were the MPQ Harm Avoidance scale (Tellegen, 1982), Eysenck's Venturesomeness scale (Eysenck & Eysenck, 1978), and the Thrill and Adventure Seeking scale of the Sensation Seeking Scale (Zuckerman, 1979). Venturesomeness and thrill and adventure seeking were negatively loaded on this scale, reflecting their association with low harm avoidance. The MPQ Harm Avoidance scale assesses the tendency toward behavioral inhibition and the avoidance of dangerous or risky activities (Waller et al., 1991). The Venturesomeness scale and Thrill and Adventure Seeking scale assesses the tendency to be daring and to seek out activities that have a high potential for harm (Eysenck & Eysenck, 1978; Zuckerman, 1979). These three measures were strongly correlated with one another ($rs = -.71, -.62, .73, ps < .0001$), suggesting that they all reflect a common personality dimension. Cloninger et al.'s (1994) TCI Harm Avoidance scale is more strongly associated with negative affectivity ($rs = .6$) than MPQ harm avoidance, TAS, and venturesomeness ($rs = .30, -.23,$ and $-.37$), suggesting that TCI harm avoidance reflects negative affectivity and is not a good measure of harm avoidance (Finn, Mazas, Justus, et al., 2002).

Mechanisms in low harm avoidance. Low harm avoidance is associated with two interrelated mechanisms, (a) weak behavioral inhibition to aversive punishment and (b) emotion-information processing characteristics that result in a relative insensitivity to aversive events that results in fearlessness and the enjoyment of dangerous activities. Harm avoidance probably involves individual differences in activity of the septo-hippocampal

complex that underlies the poor behavioral inhibition associated with low harm avoidance (Depue & Spoont, 1986; Gray, 1975, 1987; Spoont, 1992). Individual differences in activity of the central nucleus of the amygdala (Davis, 1992; LeDoux, 1992), with its interconnections with orbitofrontal cortex, lateral hypothalamus, and central gray region, are likely to be involved in the processing of information about aversive events thought to be associated with a proneness to fear (Heimer, De Olmous, Alheid, & Zaborszky, 1991; Morgan & LeDoux, 1995). Evidence linking the central nucleus of the amygdala in the processing of information about threat comes from studies of the role of the amygdala in fear conditioning and startle responsivity. For example, lesions of the amygdala block fear conditioning in rats (LeDoux, 1992). Also, the amygdala is critical for the learning of the fear-potentiated startle response (Davis, 1992) and has been implicated in fear and anxiety processing in humans (Charney, Deutch, Krystal, Southwick, & Davis, 1993). The medial prefrontal cortex also has been implicated in aspects of fear conditioning (Morgan & LeDoux, 1995).

Research suggests that low harm avoidance is the personality dimension associated with poor behavioral inhibition in response to aversive punishments (Finn, Mazas, Justus, et al., 2002; Lykken, 1957, 1995). Early research by Lykken (1957) showed that difficulties inhibiting behavior to avoid an aversive, shock punishment characterized psychopaths and was associated with a trait measure of fearlessness that was an early version of the Harm Avoidance scale of the MPQ (Lykken, 1995). The research by Finn, Mazas, Justus, et al. (2002) noted above showed that low harm avoidance was specifically associated with difficulties inhibiting behavior in response to aversive (shock) punishments on a go/no-go task (see Figure 8) but not to nonaversive punishments (compare Figure 8 with Figure 6). The association between low harm avoidance and poor inhibition to aversive punishment was specifically related to a history of conduct disorder (Finn, Mazas, Justus, et al., 2002) rather than alcoholism. Finally, working memory capacity was not associated with a modulation of inhibition in subjects with low harm avoidance. Low harm avoidance was associated with poor inhibition for both high and low working memory capacity subjects (Finn, Mazas, Justus, et al., 2002). In terms of the dynamics of decision making, the data suggest that subjects low in harm avoidance are aware of the potential for aversive consequences in risky decisions, but they simply do not put much weight to those consequences when making decisions. Finn, Mazas, Justus, et al. suggested that subjects with low harm avoidance were well aware of the possibility of receiving the aversive electric shock on the go/no-go task (Figure 8), but they just did not care as much.
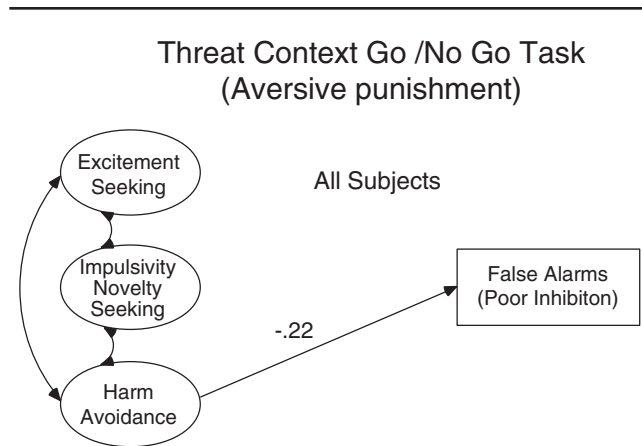

Figure 8: Structural Model of the Association Between Personality Vulnerability Dimensions and Poor Inhibition on a Go/No-Go Task With Monetary Rewards and Shock (aversive) punishments.

NOTE: The data are from Finn, Mazas, Justus, and Steinmetz (2002). The standardized regression coefficient from harm avoidance to poor inhibition is statistically significant.

Low harm avoidance has been associated with smaller anticipatory electrodermal responses to threatening, aversive stimuli (Finn, Justus, Mazas, & Steinmetz, 1998), reduced electrodermal response to mismatch novelty (Finn et al., 2001), and reduced potentiation of startle by aversive affective states (Corr et al., 1995, 1997). These studies suggest that low harm avoidance is associated with processing information about potential threat in a manner that might de-emphasize the threatening aspects of aversive or unknown stimuli. Phasic electrodermal responses just prior to receiving a shock are associated with increased orienting to the impending shock and increased anxiety. Finn et al. (1998) showed that low harm avoidance, but not impulsivity or excitement seeking, was associated with smaller anticipatory skin conductance responses prior to shock delivery. Electrodermal responses to mismatch novelty (tones differing in pitch and duration) reflect specific orienting processes thought to be associated with the allocation of attentional resources to unexpected or novel events (Ohman, 1979). Finn et al. (2001) observed that the personality trait of constraint was associated with larger electrodermal responses to mismatch novelty. Analyses of the association between MPQ harm avoidance and phasic electrodermal responses to mismatch novelty (not reported in Finn et al., 2001) revealed that low harm avoidance was associated with smaller electrodermal responses to novelty ($r = .36$, $p < .01$). Novelty is considered by some to be a stimulus that elicits activity in behavioral inhibition systems (Gray, 1975; Kagan et al., 1998), because new events have the potential for harm and require inhibition of

behavior to allow for the allocation of attention and the assessment of harm potential. The low electrodermal responses to novelty in the low harm avoidant subjects suggest that they do not allocate as many resources to assess the potential for threat in novel situations.

Fear potentiates the startle response in both humans (Globisch, Hamm, Esteves, & Ohman, 1999) and animals (Davis, 1992). The acoustic eye blink startle response is typically potentiated when processing aversive stimuli and attenuated when processing information associated with pleasant affect (Bradley & Lang, 1999; Lang, 1995). Research indicates that individuals who report high levels of fearfulness show greater potentiation of the startle response while viewing aversive photographs (Bradley & Lang, 1999). Corr and colleagues reported an association between Cloninger's TCI harm avoidance measure and potentiation of startle when viewing aversive pictures (Corr et al., 1995, 1997); however, because TCI harm avoidance is associated more with negative affectivity than the specific processes associated with harm avoidance, it is difficult to interpret the nature of this effect. Research indicates that psychopaths do not demonstrate the typical potentiation of startle when viewing aversive stimuli (Patrick, 1994). The lack of potentiation of startle by aversive stimuli in psychopaths appears to be due to their superficial and detached emotional qualities (Patrick, 1994), which are related to low levels of fear and anxiety (Lykken, 1995). Together, these results suggest that subjects low in harm avoidance may not be processing aspects of aversive stimuli in a manner that elicits activation of aversive motivational systems.

A recent study found that psychopaths showed significant attenuation of the startle response when viewing pictures of thrilling activities (e.g., cliff diving), whereas nonpsychopaths showed potentiation of responses to these pictures (Levenston, Patrick, Bradley, & Lang, 2000). Levenston et al. (2000) suggested the higher levels of sensation seeking in psychopaths may lead them to view dangerous activities as pleasant, which would result in an attenuation of the startle. The attenuation of the startle when viewing pictures of thrilling and dangerous activities is probably most strongly correlated with thrill and adventure seeking, a specific indicator of low harm avoidance. The results of Levenston et al. suggest the intriguing possibility that individuals with low harm avoidance may process information about threat as if it were associated with positive affect and appetitive motivation rather than fear and aversive motivation. This would be consistent with the behavioral phenotype of seeking out dangerous activity and enjoying such activities (Zuckerman, 1994).

In summary, low harm avoidance is thought to be associated with weak behavioral inhibition to aversive

punishment, fearlessness, and an informational processing style that de-emphasizes the threatening aspects of dangerous situations. Harm avoidance as a specific personality trait has not been studied extensively in terms of the mechanisms associated with its variation. Clearly, more work is needed to understand the cognitive, emotive, and motivational processes underlying harm avoidance and its association with disinhibited behavior.

EXCITEMENT SEEKING

People high in excitement seeking prefer activities that are very pleasurable or hedonistic in nature, such as partying, drinking to excess, flirting, having many sexual experiences with different sexual partners, and viewing pornographic or sexually explicit material. High excitement seeking also is associated with a tendency to get bored when inactive or when engaging in predictable or very familiar activities. Research shows that excitement seekers have higher levels of alcohol use (Finn et al., 2000; Justus et al., 2000; Mustanski et al., 2002), drug use (Finn & Steinmetz, 2002), and promiscuous sexual activity (Justus et al., 2000). Excitement seeking also is associated with more alcohol problems (see Figure 3), but this effect is mediated by its association with excessive alcohol use (see Figure 5). In Finn et al.'s (2000) study of the association between a familial alcoholism, personality, and alcohol use and abuse, excitement seeking was specifically associated with increased alcohol use and greater expectations that drinking is pleasurable and facilitates social interactions. Finn et al. concluded that excitement seeking reflects strong approach tendencies that predispose to excessive alcohol consumption, which in turn leads to more alcohol problems. The immediate effects of alcohol are pleasurable, and alcohol intoxication opens the door to other appetitive behaviors, exciting or stimulating experiences, and less predictable events, making alcohol consumption an attractive behavior for excitement seekers.

Self-report measures of excitement seeking. The indicator measures for excitement seeking used in the confirmatory factor analysis and structural models reported in this and other articles (e.g., Finn et al., 2000; Justus et al., 2000) are the Disinhibition and Boredom Susceptibility scales from the Sensation Seeking Scale (Zuckerman, 1979). The items directly related to drinking alcohol or getting high are dropped from the Disinhibition scale (Finn et al., 2000). Research (Finn et al., 2000; Koopmans et al., 1995) indicates that the Disinhibition and Boredeom Susceptibility scales reflect a sensation-seeking subfactor associated with pleasure and excitement seeking, whereas the Thrill and Adventure Seeking scale reflects low harm avoidance (Watson & Clark, 1984).

Mechanisms in excitement seeking. Excitement seeking reflects an interrelationship between affect, level of stimulation, and engagement in appetitive behaviors. For excitement seekers, affect is more strongly influenced by the degree of engagement with appetitive stimuli and unpredictable contexts. Two processes are thought to be associated with excitement seeking: (a) a need for more variety of appetitive stimulation and greater intensity of engagement of the appetitive motivation system to experience significant positive affect and (b) reduced activity or familiar or repetitive activity resulting in increases in specific aspects of negative affect associated with boredom (bored, edgy, restless, uninterested, dull, unstimulated, weary) and decreases in positive affect associated with engagement (interested, enthusiastic, excited, inspired, stimulated, motivated, happy, attentive, pleasure).

Those high in excitement seeking are thought to experience more positive affect in contexts where events are somewhat less predictable and where there are opportunities for engaging in a range of appetitive behaviors, such as sexual activities (flirtation, sexual contact), drug or alcohol consumption, and social activities that are fun, exciting, and less predictable (risky humor, wild parties, party games). Consistent with this idea, excitement seeking is associated with expectations that alcohol will be pleasurable, fun, and exciting (Finn et al., 2000). A recent study of decision making in alcoholics (Finn, Lin, et al., 2002) suggested that excitement seeking was associated with a decision strategy that was associated with being less responsive to recent effects (i.e., recent wins and losses) and learning to optimize gains at a slower rate. Participants with and without alcoholism and antisocial personality engaged in a version of the Bechara et al. (1994) decision-making task that involved choosing to draw cards that could result in winning or losing money from four different card decks (original results reported in Mazas et al., 2000). Finn, Lin et al. (2002) reanalyzed the results of this study using mathematical models that estimate parameters associated with the dynamic, stochastic processes that influence decision making. Rather than looking at summary results (as in Mazas et al., 2000), these mathematical models estimate parameters that index the influences on the patterns of decisions across time, such as general learning (the degree to which decisions are associated with learning due to recent events), the degree of aversive to risk when choices are likely to result in winning or losing (called utility functions), the weight (valence) given to reward or punishments (the degree to which attention to reward or punishment across trials affects decisions), and sensitivity (the degree to which decisions are based on rules associated with learned probabilities versus random choices). A number of different competing mathe-

matical models of the decision process are fitted to the data for each participant and then compared. Parameters from the best fitting model, which was an expectancy-utility model, are then treated as individual difference measures of decision making. Excitement seeking was significantly associated with lower learning rate parameters, indicating that excitement seekers tended not to base their decisions on recent events (loses and wins) and therefore did not learn to avoid losing money. Excitement seeking appeared to be associated with engaging in a pattern of choices that was based on some strategy unrelated to whether they were winning or losing rather than using their recent experience to adjust their decisions. One interpretation of these results is that the choices of excitement seekers reflected a specific strategy to seek out variety rather than the predictable effects of choices based on recent events, even though that strategy resulted in winning less money overall. Measures of affect were not assessed in this study, so a test of the hypothesis concerning the association between affect and patterns of decisions was not possible. There are no studies in the literature that examine the covariance between affect and appetitive activity in individuals varying in excitement seeking. In the studies by Finn and colleagues (Finn et al., 1998, 2001; Finn, Mazas, Justus, et al., 2002; Finn, Mazas, & Justus, 2002), excitement seeking has not been associated with any measures of behavioral inhibition or activation measures of EEG activity (Finn & Justus, 1999) or amplitude of the cortical evoked potential (Justus et al., 2001).

The biological mechanisms underlying excitement seeking are not clear. There is a large number of studies of the biological and psychophysiological correlates of sensation seeking (Zuckerman, 1979, 1994); however, many of these do not attempt to separate excitement seeking from other aspects of sensation seeking, and many of the results are inconsistent (cf. Zuckerman, 1994). It would seem obvious that appetitive motivational systems, such as the BFS, are implicated in excitement seeking. One hypothesis worth investigating is that the BFS requires more input stimulation to achieve adequate activity to engender positive affect in those high in excitement seeking. This hypothesis suggests that reduced activity or sensitivity of the BFS may be associated with excitement seeking. Decreased activity in mesolimbic or mesocortical dopamine pathways, decreased sensitivity of postsynaptic dopamine receptors, or increased dopamine autoreceptor sensitivity in mesolimbic and mesocortical dopamine pathways may be associated with excitement seeking. There is some suggestion that decreased platelet monoamine oxydase activity is associated with sensation seeking (Zuckerman, 1994), which would be associated with lower overall dopamine activity. Another possibility is that excitement

seeking is associated with reduced activity in glutamate projections from prefrontal cortex to nucleus accumbens, which would result in reduced dopamine activity. Glutamate projections from prefrontal cortex modulate dopamine system responsivity in an excitatory fashion (Grace, 1991). Increased glutamate activity stimulates dopamine release in nucleus accumbens (Grace, 1991; Jones, Snell, & Johnson, 1987). This would suggest a role for hypoactivity in prefrontal glutamate circuits in excitement seeking.

Excitement-seeking traits may also develop as a consequence of early exposure to alcohol and drugs. Early exposure to the pleasurable effects of drugs and alcohol may decrease the sensitivity of appetitive systems to pleasurable stimuli or reduce the overall psychological quality of the pleasure associated with normal activities that are not as hedonistic in quality (a kind of psychological habituation). Whatever the case, it seems likely that the association between excitement seeking and substance use may result from an interaction between temperament and the developmental impact of early exposure to alcohol and drugs. Next to nothing is known about these kinds of mechanisms.

In summary, excitement seeking is associated with a preference for exciting, pleasurable experiences and a tendency to get bored when not engaging in appetitive behaviors. It is hypothesized that people high in excitement seeking need to be actively engaged in appetitive behavior to experience significant positive affect, which will predispose them to drink alcohol for its pleasurable effects and potential for excitement that it engenders. Very little is known about the bio-behavioral mechanisms associated with excitement seeking. It is suggested that reduced sensitivity of appetitive motivational systems may be associated with excitement seeking; however, there are no data in support of this or other viable competing hypotheses at this time. Advances in our knowledge of the bio-behavioral mechanisms in excitement seeking should result from using more sophisticated behavioral paradigms that tap key facets of excitement seeking in combination with some of the current technology available in brain imaging and electrophysiology.

CONCLUSIONS

CMT postulates that a vulnerability to alcoholism is associated with three dimensions of personality that are related to different motivational and cognitive decision-making processes. Factor analysis suggests that three dimensions of personality, impulsivity/novelty seeking, harm avoidance, and excitement seeking, account for most of the variation in personality risk for alcoholism. Impulsivity/novelty seeking reflects a single personality dimension associated with activity in both appetitive (behavioral facilitation) and inhibitory motivational systems, greater attention to reward cues, and increased emotional reactivity to reward and frustration. Harm avoidance reflects individual differences in fearfulness and activity in inhibitory systems. Excitement seeking reflects the need to engage in appetitive behaviors and experience less predictable environments to experience positive affect. CMT also postulates a central role for working memory capacity in the moderation of personality vulnerability and in the dynamic process of decision making. Evidence suggests that working memory capacity moderates the association between impulsivity and poor behavioral regulation. Increased working memory capacity provides (a) greater activation capacity of the short-term store, increasing the likelihood that lower salient stimuli can be influential on behavior; (b) greater capacity for mental manipulation, which should facilitate reflectivity during the deliberations of decisions; and (c) increased active maintenance and dual-tasking capability, which should allow for representations to be maintained for longer periods of time (longer deliberation times). Working memory capacity has implications for the effects of attention, signal salience, and emotional reactivity on the dynamics of decision making. Finally, CMT describes the unique influence of each trait dimension on the dynamics of decision making, from the perspective of decision field theory (Busemeyer & Townsend, 1993). Research into the motivational, working memory, and decision-making processes associated with a vulnerability to alcoholism and other externalizing disorders should provide important insights into the mechanisms of risk.

REFERENCES

Ambrose, M. L., Bowden, S. C., & Whelan, G. (2001). Working memory impairments in alcohol-dependent participants without clinical amnesia. *Alcoholism: Clinical and Experimental Research, 25*, 185-191.

Babor, T. F., Hofmann, M. DelBoca, F. K., Hesselbrock, V., Meyer, R. E., Dolinsky, Z. S., & Rounsaville, B. (1992). Types of alcoholics I: Evidence for an empirically derived typology based on indicators of vulnerability and severity. *Archive of General Psychiatry, 49*, 599-608.

Baddeley, A. D. (1986). *Working memory.* Oxford, UK: Oxford University Press.

Baddeley, A. D., & Logie, R. (1999). Working memory: The multicomponent model. In A. Mijake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 28-61). Cambridge, UK: Cambridge University Press.

Ball, S. A. (1996). Type A and Type B alcoholism: Applicability across sub-populations and treatment settings. *Alcohol Health & Research World, 20*, 30 -35.

Ball, S. A., Kranzler, H. R., Tennen, H., Poling, J. C., & Rounsaville, B. J. (1998). Personality disorder and dimension of differences between Type A and Type B substance abusers. *Journal of Personality Disorders, 12*, 1-12.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory or ADHD. *Psycholgical Bulletin, 121*, 65-94.

Barkley, R. A. (2001). The executive functions and self-regulation: An evolutionary neuropsychological perspective. *Neuropsychology Review, 11*, 1-29.

Barratt, E. S. (1985). Impulsiveness defined within a systems model of personality. In C. D. Speilberger & J. N. Butcher (Eds.), *Advances in personality assessment* (Vol. 5, pp. 113-132). Hillsdale, NJ: Erlbaum.

Barratt, E. S. (1994). Impulsiveness and aggression. In J. Monahan & H. J. Steadman (Eds.), *Violence and mental disorder: Developments in risk assessment* (pp. 61-79). Chicago: University of Chicago Press.

Bates, J. E. (2000). Temperament as an emotion construct: Theoretical and practical issues. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (pp. 382-396). New York: Guilford.

Bauer, L. O. (1997). Frontal P300 decrements, childhood conduct disorder, and the prediction of relapse among abstinent cocaine abusers. *Drug and Alcohol Dependence, 44*, 1-10.

Bauer, L. O., O'Connor, S., & Hesselbrock, V. M. (1994). Frontal P300 decrements in antisocial personality disorder. *Alcoholism: Clinical and Experimental Research, 18*, 1300-1305.

Bechara, A., Damasio, A., Damasio, H., & Anderson, S. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*, 7-15.

Bizot, J -C., Le Bihan, C., Puech, A. J., Hamon, M., & Thiebot, M -H. (1999). Serotonin and tolerance of delay of reward in rats. *Psychopharmacology, 146*, 400-412.

Bradley, M. M., & Lang, P. J. (1999). Fearfulness and affective evaluations of pictures. *Motivation and Emotion, 23*, 1-13.

Brown, J. M. (1998). Self-regulation and the addictive behaviors. In W. R. Miller & N. Heather (Eds.), *Treating addictive behaviors* (pp. 61-73). New York: Plenum.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: A dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review, 100*, 432-459.

Busemeyer, J. R., Townsend, J. T., & Stout, J. C. (in press). Motivational underpinnings of utility in decision making: Decision field theory analysis of deprivation and satiation. Manuscript submitted for publication. In S. Moore (Ed.), *Emotional cognition.* Amsterdam: Johns Benjamins.

Casey, B. J., Trainor, R. J., Oriendi, J. L., Schubert, A. B., Nystrom, L. E., Giedd, J. N., Castellanos, F. X., Haxby, J. V., Noll, D. C., Cojen, J. D., Forman, S. D., Dahl, R. E., & Rapoport, J. L. (1997). A developmental functional MRI study of prefrontal activation during performance of The go/no go task. *Journal of Cognitive Neuroscience, 9*, 835-847.

Caspi, A., Moffitt, T. E., Newman, D. L., & Silva, P. A. (1996). Behavioral observations at age 3 years predict adult psychiaric disorders. *Archives of General Psychiatry, 53*, 1033-1039.

Charney, D. S., Deutch, A. Y., Krystal, J. H., Southwick, S. M., & Davis, M. (1993). Psychobiologic mechanisms of posttraumatic stress disorder. *Archives of General Psychiatry, 50*, 292-305.

Chassin, L., Pitts, S. C., DeLucia, C., & Todd, M. (1999). A longitudinal study of children of alcoholics: Predicting young adult substance abuse disorders, anxiety, and depression. *Journal of Abnormal Psychology, 108*, 106-119.

Cloninger, C. R. (1987a). Neurogenetic adaptive mechanisms in alcoholism. *Science, 236*, 410-416.

Cloninger, C. R. (1987b). *Tridimensional personality questionnaire* (Version 4). St. Louis, MO: Washington University Medical School.

Cloninger, C. R., Pryzbeck, T. R., Svrakic, D. M., & Wetzel, R. D. (1994). *The Temperament and Character Inventory (TCI): A guide to its development and use.* St. Louis, MO: Washington University, Center for the Psychobiology of Personality.

Cloninger, C. R., Sigvardsson, S., & Bohman, M. (1988). Childhood personality predict alcohol abuse in young adults. *Alcoholism: Clinical and Experimental Research, 12*, 494-505.

Coccaro, E. F., & Kavoussi, R. J. (1997). Fluoxetine and impulsive aggressive behavior in personality-disordered subjects. *Archives of General Psychiatry, 54*, 1081-1088.

Cole, P. M., Michel, M. K., & Teti, L. O. (1994). The development of emotion regulation and dysregulation: A clinical perspective (Society for Research in Child Development Monograph No. 240). *The Development of Emotion Regulation: Biological and Behavioral Considerations, 59*, 73-100.

Collins, P. F., & Depue, R. A. (1992). A neurobehavioral systems approach to developmental psychopathology: Implications for disorders of affect. In D. Cicchetti & S. L. Toth (Ed.), *Developmental perspectives on depression* (pp. 29-101). Rochester, NY: University of Rochester Press.

Cooper, M. L., Agocha, V. B., & Sheldon, M. S. (2000). A motivational perspective on risky behaviors: The role of personality and affect regulatory processes. *Journal of Personality, 68*, 1059-1088.

Cooper, M. L., Frone, M. R., Russell, M., & Mudar, P. (1995). Drinking to regulate positive and negative emotions: A motivational model of alcohol use. *Journal of Perssonality and Social Psychology, 69*, 990-1005.

Corr, P. J., Kumari, V., Wilson, G. D., Checkley, S., & Gray, J. A. (1997). Harm avoidance and affective modulation of the startle reflex: A replication. *Personality and Individual Differences, 22*, 591-593.

Corr, P. J., Wilson, G. D., Fotiadou, M., Kumari, V., Gray, N. S., Checkley, S., et al. (1995). Personality and affective modulation of the startle reflex. *Personality and Individual Differences, 19*, 543-553.

Cowan, N. (1999). An embedded-process model of working memory. In A. Mijake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 62-101). Cambridge, UK: Cambridge University Press.

Davis, M. (1992). The role of the amygdala in fear and anxiety. *Annual Review of Neuroscience, 15*, 353-375.

Depue, R. A., & Spoont, M. R. (1986). Conceptualizing a serotonin trait: A behavioral dimension of constraint. *Annals of the New York Academy of Sciences, 487*, 47-62.

Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., et al. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Development, 72*, 1112-1134.

Eisenberg, N., Guthrie, I. K., Fabes, R. A., Shepard, S. A., Losoya, S. H., Murphy, B. C., et al. (2000). Prediction of elementary school children's externalizing problem behaviors from attentional and behavioral regulation and negative emotionality. *Child Development, 71*, 1367-1382.

Engle, R. W., Conway, A.R.A., Tuholski, S. W., & Shisler, R. J. (1995). A resource account of inhibition. *Psychological Science, 6*, 122-125.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A.R.A. (1999). Working memory, short-term memory, and general fluid intelligence: A latent variable approach. *Journal of Experimental Psychology: General, 128*, 309-331.

Evenden, J. (1999a). Varieties of impulsivity. *Psychopharmacology, 146*, 348-361.

Evenden, J. (1999b). The pharmacology of impulsive behavior in rats VII: The effects of serotonergic agonist and antagonists on responding under a discrimination task using unreliable visual stimuli. *Psychopharmacology, 146*, 422-431.

Eysenck, S.B.G., & Eysenck, H. J. (1978). Impulsiveness and venturesomeness: Their position in a dimensional system of personality description. *Psychological Reports, 43*, 1247-1255.

Fillmore, M. T., Vogel-Sprott, M., & Gavrilescu, D. (1999). Alcohol effects on intentional behavior: Dissociating controlled and automatic influences. *Experimental and Clinical Psychopharmacology, 7*, 372-378.

Finn, P. R. (2000). Studies of the acute effects of alcohol on cognition and impulsive-disinhibited behavior. In A. Norona, M. Eckardt, & K. Warrant (Eds.), *Review of NIAAA's neuroscience and behavioral research portfolio* (pp. 337-356) (Monograph No. 34). Bethesda, MD: National Institute of Alcohol Abuse and Alcoholism Research.

Finn, P. R. (2002). *Dimensions of working memory capacity: Short-term, maintenance, and resistance to distraction capacities.* Unpublished manuscript.

Finn, P. R., Earleywine, M., & Pihl, R. O. (1992). Sensation seeking, stress reactivity and alcohol dampening discriminate the density of a family history of alcoholism. *Alcoholism: Clinical and Experimental Research, 16*, 585-590.

Finn, P. R., & Justus, A. (1997). Physiological responses in the children of alcoholics. *Alcohol Health & Research World, 21*, 227-231.

Finn, P. R., & Justus, A. (1999). Reduced EEG alpha power in the male and female offspring of alcoholics. *Alcoholism: Clinical & Experimental Research, 23,* 256-262

Finn, P. R., Justus, A., Mazas, C., Rorick, L., & Steinmetz, J. E. (2001). Constraint, alcoholism, and electrodermal response in aversive classical conditioning and mismatch novelty paradigms. *Integrative Physiological and Behavioral Science, 36,* 154-167.

Finn, P. R., Justus, A., Mazas. C., & Steinmetz, J. E. (1998). *Electrodermal response to threat: The effects of sex, risk taking, and antisocial traits.* Paper presented at the annual meeting of the Society for Psychophysiological Research, Denver, CO.

Finn, P. R., Justus A., Mazas C., & Steinmetz, J. E. (1999). Working memory, executive processes and the effects of alcohol on go/no go learning: Testing a model of behavioral regulation and impulsivity. *Psychopharmacology, 146,* 465-472.

Finn, P. R., Kessler, D. N., & Hussong, A. M. (1994). Risk for alcoholism and classical conditioning to signals for punishment: Evidence for a weak behavioral inhibition system. *Journal of Abnormal Psychology, 103,* 293-301.

Finn, P. R., Lin, A., Mazas, C., & Busemeyer, J. (2002). *Dynamic processes in decision making in individuals with alcohol abuse and antisocial personality.* Unpublished manuscript.

Finn, P. R., Mazas, C. A., & Justus, A. (2002). *Personality and measures of behavioral inhibition in the young adult children of alcoholics.* Unpublished manuscript.

Finn, P. R., Mazas, C. A., Justus, A., & Steinmetz, J. E. (2002). Early-onset antisocial alcoholism with a history of conduct disorder: Go/no go learning deficits, personality, and working memory capacity. *Alcoholism: Clinical & Experimental Research, 26,* 186-206.

Finn, P. R., Sharkansky, E., Brandt, K., & Turcotte N (2000). The effects of family history, personality and expectancies on alcohol use and abuse. *Journal of Abnormal Psychology, 109,* 122-133.

Finn, P. R., Sharkansky, E., Viken, R., West, T. L., Sandy, J., & Bufferd, G. (1997). Heterogeneity in the families of sons of alcoholics: The impact of familial vulnerability type on offspring characteristics. *Journal of Abnormal Psychology, 106,* 26-36.

Finn, P. R., & Steinmetz, J. E. (2002). *Dimensions of disinhibited personality in substance use and abuse.* Unpublished manuscript.

Finn, P. R., Zeitouni, N., & Pihl, R. O. (1990). The effects of alcohol on psychophysiological hyper-reactivity to non-aversive and aversive stimuli in men at high-risk for alcoholism. *Journal of Abnormal Psychology, 99,* 79-85.

Fisbein, D. H., Lozovsky, D., & Jaffe, J. H. (1989). Impulsivity, aggression, and neuroendocrine responses to serotoninergic stimulation in substance abusers. *Biological Psychiatry, 25,* 1049-1066.

Fowles, D. C. (1980). The three arousal model: Implications of Gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. *Psychophysiology, 17,* 87-104.

Fowles, D. C. (1983). Motivational effects on heart rate and electrodermal activity: Implications for research on personality and psychopathology. *Journal of Research on Personality, 17,* 48-71.

Fowles, D. C. (1987). Application of a behavioral theory of motivation to the concepts of anxiety and impulsivity. *Journal of Research on Personality, 21,* 417-435

Fuster, J. M. (1995). Memory and planning: Two temporal persectives of frontal lobe function. In H. H. Jasper, P. S. Riggio, & P. S. Goldman-Rakic (Eds.), *Epilepsy and the functional anatomy of the frontal lobe* (pp. 9-18). New York: Raven Press.

Globisch, J., Hamm, A. O., Esteves, F., & Ohman, A. (1999). Fear appears fast: Temporal course of startle reflex potentiation in animal fearful subjects. *Psychophysiology, 36,* 66-75.

Goldman-Rakic, P. S. (1987). Circuitry of primate prefrontal cortex and regulation of behavior by representational knowledge. In F. Plum & V. Mountcastle (Eds.), *Handbook of physiology* (Vol. 5, pp. 373-417). Bethesda, MD: American Physiological Society.

Gorenstein, E. E., & Newman J. P. (1980). Disinhibitory psychopathology: A new perspective and a model for research. *Psychological Review, 87,* 301-315.

Grace, A. A. (1991). Phasic versus tonic dopamine release and the modulation of dopamine system responsivity: A hypothesis for the etiology of schizophrenia. *Neuroscience, 41,* 1-24.

Gray, J. A. (1975). *Elements of a two-process theory of learning.* London: Academic Press.

Gray, J. A. (1987). Perspectives on anxiety and impulsivity: a commentary. *Journal of Research in Personality, 21,* 493-509.

Hale, S., Bronik, M. D., & Fry, A. F. (1997). Verbal and spatial working memory in school age children. *Developmental Psychology, 33,* 364-371.

Hall, J., & Finn, P. R. (2002). *The role of working memory capacity in modulating vulnerability to alcohol abuse in the young adult children of alcoholics.* Unpublished manuscript.

Heimer, L., De Olmous, J., Alheid, G. F., & Zaborszky, L. (1991). "Perestroika" in the basal forebrain: Opening the border between neurology and psychiatry. In G. Holstege (Ed.), *Progress in brain research: Vol 87. Role of the forebrain in sensation and behavior* (pp. 109-165). Amsterdam: Elsevier.

Higley, J. D., King, S. T., Hasert, M. F., Champoux, M., Soumi, S. J., & Linnoila, M. (1996). Stability of interindividual differences in serotonin function and its relationship to aggressive wounding and competent social behavior in rhesus macaque females. *Neuropsychopharmacology, 14,* 67-76.

Ho, M -Y., Mobini, S., Chaing, T -J., Bradshaw, C. M., & Szabadi, E. (1999). Theory and method in the quantitative analysis of "impulsive choice" behavior: Implications for psychopharmacology. *Psychopharmacology, 146,* 362-372.

Iacono, W. G., Carlson, S. R., Taylor, J., Elkins, I. J., & McGue, M. (1999) Behavioral disinhibition and the development of substance abuse disorders: Findings from the Minnesota Twin Family Study. *Development and Psychopathology, 11,* 869-900.

Jones, S. M., Snell, L. D., & Johnson, K. M. (1987). Inhibition by phencyclidine of excitatory amino acid-stimulated release of neurotransmitter in the nucleus accumbens. *Neuropsychopharmacology, 26,* 173-179.

Justus, A., Finn, P. R., & Steinmetz, J. E. (2000). The influence of disinhibited personality traits on the association between alcohol use and risky sexual behavior. *Alcoholism: Clinical & Experimental Research, 24,* 1028-1035.

Justus, A., Finn, P. R., & Steinmetz, J. (2001). P300 decrements are associated with disinhibited personality and early-onset alcohol problems. *Alcoholism: Clinical & Experimental Research, 25,* 1457-1466.

Kagan, J., Resnick, J. S., & Snidman, N. (1990). The temperamental qualities of inhibition and lack of inhibition. In M. Lewis & S. M. Miller (Eds.), *Handbook of developmental psycho-pathology* (pp. 219-226). New York: Plenum.

Kagan, J., Snidman, N., & Arcus, D. (1998). Childhood derivatives of high and low reactivity in infancy. *Child Development, 69,* 1483-1493.

Keltner, D., Moffitt, T. E., & Stouthamer-Loeber, M. (1995). Facial expressions of emotion and psychopathology in adolescent boys. *Journal of Abnormal Psychology, 104,* 644-652.

Kimberg, D. Y., D'Esposito, M., & Farah, M. J. (1998). Cognitive functions in the prefrontal cortex - working memory and executive control. *Current Directions in Psychological Science, 7,* 185-194.

Kimberg, D. Y., & Farah, M. J. (1993). A unified account of cognitive impairments following frontal lobe damage: The role of working memory in complex, organized behavior. *Journal of Experimental Psychology: General, 122,* 411-428.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug using controls. *Journal of Experimental Psychology: General, 128,* 78-87.

Kiyatkin E. A., & Rebec, G. V. (1996). Dopaminergic modulation of glutamate-induced excitations of neurons in the neostriatum and nucleus accumbens of awake, unrestrained rats. *Journal of Neurophysiology, 75,* 142-153.

Kiyatkin, E. A., & Rebec, G. V. (1999). Striatal neuronal activity and responsiveness to dopamine and glutamate after selective blockade of D1 and D2 dopamine receptors in freely moving rats. *Journal of Neuroscience, 19,* 3594-3609.

Koopmans, J. R., Boomsma, D. I., Heath, A. C., & van Doornen, L.J.P. (1995). A multivariate genetic analysis of sensation seeking. *Behavior Genetics, 25,* 349-356.

Krueger, R. F., Caspi, A., Moffitt, T. E., Silva, P. A., & McGee, R. (1996). Personality traits are differentially linked to mental disorders: A multitrait-multidiagnosis study of an adolescent birth cohort. *Journal of Abnormal Psychology, 105*, 299-312.

Krueger, R. F., Hicks, B. M., & McGue, M. (2001). Altruism and antisocial behavior: Independent tendencies, unique personality correlates, distinct etiologies *Psychological Science, 12*, 397-402.

Lang, P. J. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist, 50*, 372-385.

LeDoux, J. E. (1992). Brain mechanisms of emotion and emotional learning. *Current Opinions in Neurobiology, 2*, 191-197.

Levenston, G. K., Patrick, C. J., Bradley, M. M., & Lang, P. J. (2000). The psychopath as observer: Emotion and attention in picture processing. *Journal of Abnormal Psychology, 109*, 373-385.

Linnoila, V.M.I, & Virrkunen, M. (1992). Aggression, suicidality, and serotonin. *Journal of Clinical Psychiatry, 53*(10, Suppl.), 46-51.

Loeber, R., Farrington, D. P., Stouthamer-Loeber, M., Moffitt, T. E., & Caspi, A. (1998). The development of male offending: Key findings from the first decade of the Pittsburgh Youth Study. *Studies on Crime & Crime Prevention, 7*, 141-171.

Logan, G. D., Schachar, R. J., & Tannock, R. (1997). Impulsivity and inhibitory control. *Psychological Science, 8*, 60-64.

Luengo, M. A., Carrillo de la Pena, M. T., & Otero, J. M. (1991). The components of impulsiveness: A comparison of the I-7 Impulsiveness questionnaire and the Barratt Impulsivity Scale. *Personality and Individual Difference, 12*, 657-667.

Lykken, D. T. (1957). A study of anxiety in the sociopathic personality. *Journal of Abnormal and Social Psychology, 55*, 6-10.

Lykken, D. T. (1995). *The antisocial personalities.* Englewood Cliffs, NJ: Lawerence Erlbaum.

Masse, L. C., & Tremblay, R. E. (1997). Behavior of boys in kindergarten and the onset of substance use during adolescence. *Archives of General Psychiatry, 54*, 62-68.

Mazas, C., Finn, P. R., & Steinmetz, J. E. (2000). Decision making biases, antisocial personality, and early-onset alcoholism. *Alcoholism: Clinical and Experimental Research, 24*, 1036-1040.

Meszaros, K., Lenzinger, E., Hornik, K., Fureder, T., Willinger, U., Fischer, G., Schonbeck, G., & Aschauer, H. N. (1999). The Tridimensional Personality Questionnaire as a predictor of relapse in detoxified alcohol dependents. *Alcoholism: Clinical and Experimental Research, 23*, 483-486.

Miller, W. R., & Brown J. M. (1991) Self-regulation as a conceptual basis for the prevention of addictive behaviors. In N. Heather, W. R. Miller, & J. Greeley (Eds.), *Self control and the addictive behaviors* (pp. 3-79). Sydney, Australia: Maxwell Macmillan.

Mischel, W., Ebbeson, E. B., & Zeiss, A. R. (1972). Cognitive and attentional mechanisms in delay of gratification. *Journal of Personality and Social Psychology, 21*, 204-218.

Mischel, W., Shoda, Y., & Rodriguez, M. L. (1989). Delay of gratification in children. *Science, 244*, 933-938.

Moffitt, T.E. (1993). The neuropsychology of conduct disorder. *Developmental Psychopathology 5*, 135-151.

Morgan, M. A., & LeDoux, J. E. (1995). Differential contribution of dorsal and ventral medial prefrontal cortex to the acquisition and extinction of conditioned fear in rats. *Behavioral Neuroscience, 109*, 681-688.

Mucha, R. F., Geier, A., Stuhlinger, M., & Mundle, G. (2000). Appetitive effects of drug cues modeled by pictures of the intake ritual: Generality of cue-modulated startle examined with inpatient alcoholics. *Psychopharmacology, 151*, 428-432.

Mustanski, B. S., Viken, R. J., Kaprio, J., & Rose, R. J. (2002). *Genetic factors account for the differential association between two personality risk factors with alcohol use and abuse.* Unpublished manuscript.

Nagoshi, C. T., Walter, D., Muntaner, C., & Haertzen, C. A. (1992). Validation of the Tridimensional Personality Questionnaire in a sample of male drug users. *Personality and Individual Differences, 13*, 401-409.

Newman, J. P. (1987). Reaction to punishment in extraverts and psychopaths: Implications for the impulsive behavior of disinhibited individuals. *Journal of Research on Personality, 21*, 464-480.

Newman, J. P., & Schmitt, W. A. (1998). Passive avoidance in psychopathic offenders: A replication and extension. *Journal of Abnormal Psychology, 95*, 252-256.

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and working inhibition taxonomy. *Psychological Bulletin, 126*, 220-246.

Ohman, A. (1979). The orienting response, attention, and learning: An information-processing perspective. In H. D. Kimmel, E. H., van Orst, & J. F. Orlebeke (Eds.), *The orienting reflex in humans* (pp. 443-471). Hillsdale, NJ: Lawrence Erlbaum.

Patrick, C. J. (1994). Emotion and psychopathy: Startling new insights. *Psychophysiology, 31*, 319-330.

Patterson, C. M., & Newman, J. P. (1993). Reflectivity and learning from aversive events: Toward a psychological mechanism for the syndromes of disinhibition. *Psychological Review, 100*, 716-736.

Peirson, A. R., & Heuchert, J. W. (2001). The relationship between personality and mood: Comparison of the BDI and the TCI. *Personality and Individual Differences, 30*, 391-399.

Quay, H. C. (1965). Psychopathic personality as pathological stimulation-seeking. *American Journal of Psychiatry, 122*, 180-183.

Rachlin, H. (1989). *Judgement, decision and choice: A cognitive and behavioral synthesis.* New York: Raven Press.

Raine, A., Reynolds, C. Venables, P. H., Mednick, S. A., & Farrington, D. P. (1998). Fearlessness, stimulation-seeking, and large body size at age 3 years as early predispositions to childhood aggression at age 11 years. *Archives of General Psychiatry, 55*, 745-751.

Rothbart, M. K., Ahadi, S. A., & Evans, D. E. (2000). Temperament and personality: Origins and outcomes. *Journal of Personality and Social Psychology, 78*, 122-135.

Rothbart, M. K., Derryberry, D., & Posner, M. I. (1994). A psychobiological approach to the development of temperament. In I. E. Bates & T. D. Wachs (Eds.), *Temperament: Individual differences at the interface between biology and behavior* (pp. 83-116). Washington, DC: American Psychological Association.

Scerbo, A., Raine, A., O'Brien, M., Chan, C. J., Rhee, C., & Smiley, N. (1990) Reward dominance and passive avoidance learning in adolescent psychopaths. *Journal of Abnormal Child Psychology, 18*, 451-463.

Schuckit, M. A. (1994). Low level of response to alcohol as a predictor of future alcoholism. *American Journal of Psychiatry, 151*, 184-189.

Shapiro, K. L., & Luck, S. J. (1999). The attentional blink: A front-end mechanism for fleeting memories. In. V. Coltheart (Ed.), *Fleeting memories: Cognition of brief visual stimuli* (pp. 95-118). Cambridge, MA: MIT Press.

Shapiro, S. K., Quay, H. C., Hogan, A. E., & Schwartz, K. P. (1988). Response perseveration and delayed responding in undersocialized aggressive conduct disorder. *Journal of Abnormal Psychology, 97*, 371-373.

Sher, K. J., & Gotham, H. (1999), Pathological alcohol involvement: A developmental disorder of young adulthood. *Development and Psychopathology, 11*, 933-956.

Sher, K. J., Walitzer, K. S., Wood, P. K., & Brent, E. E. (1991). Characteristics of children of alcoholics: Putative risk factors, substance use and abuse and psychopathology. *Journal of Abnormal Psychology, 100*, 427-448.

Shiv, B., & Fedorikhim, A. (1999). Heart and mind in conflict: The interplay of affect and cognition in consumer decision making. *Journal of Consumer Research, 26*, 278-292.

Shoda, Y., Mischel, W., & Peake, P. K. (1990). Predicting adolescent cognitive and self-regulatory competencies from preschool delay of gratification: Identifying diagnostic conditions. *Developmental Psychology, 26*, 978-986.

Spoont, M. R. (1992). Modulatory role of serotonin in neural information processing: Implications for human psychopathology. *Psychological Bulletin, 112*, 330-350.

Stewart, S. H., & Zeitlin, S. B. (1995). Anxiety sensitivity and alcohol use motives. *Journal of Anxiety Disorders, 9*, 229-240.

Sullivan, J. L., Baenziger, J. C., Wagner, D. L., Rauscher, F. P., Nurnberger, J. I., & Holmes, J. S. (1990). Platelet MAO in subtypes of alcoholics. *Biological Psychiatry, 27*, 911-922.

Tarter, R. E. (1988). Are there inherited behavioral traits that predispose to substance abuse? *Journal of Consulting and Clinical Psychology*, *56*, 189-196.

Tellegen, A. (1982). *Brief manual of the Multi-Dimensional Personality Questionnaire*. Unpublished manuscript, University of Minnesota.

Tellegen, A., & Waller, N. G. (in press). Exploring personality through test construction: Development of the Multidimensional Personality Questionnaire. In S. R. Briggs & J. M. Cheek (Eds.), *Personality measures: Development and evaluation* (Vol. 1). Greenwich, CT: JAI.

van den Broek, M. D., Bradshaw, C. M., & Szabadi, E. (1987). Behavior of "impulsive" and "non-impulsive" humans in a temporal differentiation of schedule of reinforcement. *Personality and Individual Differences*, *8*, 233-239.

van den Broek, M. D., Bradshaw, C. M., & Szabadi, E. (1992). Performance of impulsive and non-impulsive subjects on two temporal differentiation tasks. *Personality and Individual Differences*, *8*, 233-239.

Vogel, E. K., Luck, S. J., & Shapiro, K. L. (1998). Electrophysiological evidence for a postperceptual locus of suppression during the attentional blink. *Journal of Experimental Psychology: Human Perception & Performance*, *24*, 1656-1674.

Vogel-Sprott, M., Easdon, C., Fillmore, M., Finn, P. R., & Justus A. (2001). Alcohol and behavioral control: Cognitive and neural mechanisms. *Alcoholism: Clinical & Experimental Research*, *25*, 117-121.

von Knorring, A. L., Bohman, M., von Knorring, L., & Oreland, L. (1985). Platelet MAO activity as a biological marker in subgroups of alcoholism. *Acta Psychiatrica Scandinavica*, *72*, 51-58.

von Knorring, L., von Knorring, A. L., Smigan, L., Lindberg, U., & Edholm, M. (1987). Personality traits in subtypes of alcoholics. *Journal of Studies on Alcohol*, *48*, 523-527.

Waller, N. G., Lilienfeld, S. O., Tellegen, A., & Lykken, D. T. (1991). The Tridimensional Personality Questionnaire: Structural Validity and comparison with the Multidimensional Personality Questionnaire. *Multivariate Behavioral Research*, *26*, 1-23.

Wechsler, D. (1981). *Wechsler Adult Intelligence Test–R*. New York: Psychological Corporation.

Wechsler, D. (1997). *Wechsler Adult Intelligence Test–III*. New York: Psychological Corporation.

Wills, T. A., DuHamel, K., & Vaccaro, D. (1995). Activity and mood temperament as predictors of adolescent substance use: Test of a self-regulation mediational model. *Journal of Personality and Social Psychology*, *68*, 910-916.

Wills, T. A., Sandy, J. M., & Yaeger A. (2000). Temperament and adolescent substance abuse: An epigenetic approach to risk and protection. *Journal of Research on Personality*, *68*, 1127-1151.

Wills, T. A., Vaccaro, D., & McNamara, G. (1994). Novelty seeking, risk taking, and related constructs as predictors of adolescent substance use. An application of Cloninger's theory. *Journal of Substance Abuse*, *6*, 1-20.

Yoshino, A., Kato, M., Takeuchi, M., Ono, Y., & Kitamura, T. (1994). Examination of the tridimensional personality hypothesis of alcoholism using empirically multivariate typology. *Alcoholism: Clinical and Experimental Research*, *18*, 1121-1124.

Zuckerman, M. (1979). *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, NJ: Lawrence Erlbaum.

Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. Cambridge, UK: Cambridge University Press.