



Effects of working memory load, a history of conduct disorder, and sex on decision making in substance dependent individuals



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ABSTRACT

Background: Substance dependence and antisocial psychopathology, such as a history of childhood conduct disorder (HCCD), are associated with impulsive or disadvantageous decision making and reduced working memory capacity (WMC). Reducing WMC via a working memory load increases disadvantageous decision making in healthy adults, but no previous studies have examined this effect in young adults with substance dependence and HCCD.

Method: Young adults with substance dependence (SubDep; $n = 158$, 71 female), substance dependence and HCCD (SubDep + HCCD; $n = 72$, 24 female), and control participants ($n = 152$, 84 female) completed a test of decision making (the Iowa Gambling Task; IGT) with or without a concurrent working memory load intended to tax WMC. Outcomes were (i) net advantageous decisions on the IGT, and (ii) preferences for infrequent- versus frequent-punishment decks.

Results: SubDep + HCCD men made fewer advantageous decisions on the IGT than control men without a load, but there were no group differences among women in that condition. Load was associated with fewer advantageous decisions for SubDep + HCCD women and control men, but not for men or women in the other groups. Participants showed greater preference for infrequent-punishment, advantageous decks under load as well.

Conclusions: There are gender differences in the effects of substance dependence, HCCD, and working memory load on decision making on the IGT. Decision making by control men and SubDep + HCCD women suffered the most under load. Load increases preferences for less-frequent punishments, similar to a delay discounting effect. Future research should clarify the cognitive and neural mechanisms underlying these effects.

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1. Introduction

Drug and alcohol dependence are highly comorbid with antisocial psychopathology, such as a history of childhood conduct disorder (HCCD; Hasin et al., 2007; Krueger et al., 2002). Comorbid HCCD or antisociality is associated with more severe symptomatology and course of substance dependence (Finn et al., 2002; Sher and Gotham, 1999; Zucker, 1987). Impulsive decision making is a core feature of substance dependence and HCCD (Bechara et al., 2001; Bobova et al., 2009; Cantrell et al., 2008; Ernst et al., 2003; Grant et al., 2000; Kim et al., 2006; Mazas et al., 2000). Furthermore, both substance dependence and HCCD are associated with reduced working memory capacity (WMC; Bechara and Martin, 2004; Bogg and Finn, 2010; Finn et al., 2009). Lower WMC is associated with impulsive decision-making (Bechara and Martin, 2004; Endres et al., 2011; Finn et al., 2002; van der Plas et al., 2009),

and reducing WMC via a working memory load increases impulsive decision making in healthy adults (Hinson et al., 2002, 2003; Hofmann et al., 2009; Ward and Mann, 2000). However, little is known about the effects of compromising WMC in those with substance dependence and HCCD. The current study was designed to investigate the associations among substance dependence, HCCD, WMC, and decision making in young adults on a version of the Iowa Gambling Task (IGT; Bechara et al., 1994) that was modified to manipulate WMC.

1.1. Assessing decision making with the Iowa Gambling Task (IGT)

The IGT is a card-playing task which assesses decision making under uncertainty and risk (Buelow and Suhr, 2009; see Section 2). For the IGT, a disadvantageous decision bias is reflected in a preference for card decks associated with high immediate wins but long-term losses. Disadvantageous decision making on the IGT has been reported in individuals with substance dependence (Bechara and Damasio, 2002; Cantrell et al., 2008; Dom et al., 2006; Fein et al., 2004) and alcohol dependence with comorbid antisocial

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psychopathology (Mazas et al., 2000) or HCCD (Kim et al., 2006), and may reflect a general tendency to pursue immediate rewards despite long-term negative consequences. This could contribute to the type of poor behavioral control often exhibited by individuals with substance dependence or antisocial psychopathology, such as continuing to abuse substances or engage in other risky antisocial behavior despite threats to health or freedom (Bechara, 2005; Finn, 2002).

Recent research has noted that participants generally prefer infrequent-punishment decks over the frequent-punishment ones on the IGT (infrequent punishment bias) (Chiu et al., 2008; Fridberg et al., 2010; Goudriaan et al., 2007, 2005; Upton et al., 2012). This may be related to the finding that decision-makers tend to prefer options which have been associated most frequently with positive outcomes (Barron and Erev, 2003; Erev and Barron, 2005; Hertwig et al., 2004; Yechiam et al., 2005a), and may discount infrequent punishments similar to a delay discounting effect (e.g., Weller et al., 2010). No previous studies have examined infrequent punishment bias on the IGT in the context of substance dependence, HCCD, and WMC.

1.2. Working memory (WM), decision making, and behavioral control

Working memory (WM) is an executive attention system which facilitates the ability to maintain or suppress information and resist distraction (Engle, 2002; Finn, 2002; Kane and Engle, 2002). Increased WMC is associated with a greater capacity to shifting of attention from highly salient, immediate outcomes to less-salient, long-term consequences (Finn, 2002; Finn et al., 2002). Both substance dependence and HCCD are associated with lower WMC in young adults, which could contribute to poorer decision making in those individuals (Bogg and Finn, 2010; Endres et al., 2011; Finn and Hall, 2004; Finn et al., 2009) and problems such as impulsivity and poor behavioral control (Finn, 2002; Finn et al., 2002; Hinson et al., 2003).

Dual-process models of self-control (Hofmann et al., 2009; Wiers et al., 2010) posit that compromising control processes, such as a WMC, leads to problems with self-control in vulnerable individuals, such as those with stronger impulsivity. For instance, a WM load resulted in excessive eating only in restrained eaters (Boon et al., 2002; Ward and Mann, 2000). However, other studies suggest that this effect is more generalized and observable in healthy adults, as evidenced by less advantageous decision making on the IGT under working memory load (Hinson et al., 2002; Jameson et al., 2004; Pecchinenda et al., 2006). Those studies employed a dual-task design in which participants performed a secondary task during each decision trial, which places additional demands on the WM system (Kane and Engle, 2002). No previous studies have examined decision making under WM load in individuals with substance dependence or HCCD. Because those with substance dependence and/or HCCD are inclined toward disadvantageous decisions (i.e., vulnerable), we hypothesize that a WM load would result in larger decreases in advantageous decision making in these individuals.

1.3. Sex and decision making on the IGT

Some data suggest that healthy men choose more advantageously than women on the IGT (Bechara and Martin, 2004; Bolla et al., 2004; Reavis and Overman, 2001; Stout et al., 2005). A number of studies indicate that substance dependent men, especially those with comorbid antisocial psychopathology, make fewer advantageous decisions relative to control men (Grant et al., 2000; Kim et al., 2006; Mazas et al., 2000; Stout et al., 2005). Decision making among substance-dependent women has received less attention, and previous studies have produced mixed results (Bechara and

Martin, 2004; Stout et al., 2005; van der Plas et al., 2009). Prior studies have not compared substance dependent women with and without comorbid HCCD in terms of decision making on the IGT.

1.4. The present study

The purpose of the present study was to investigate the associations among substance dependence, HCCD, WMC, and decision making in young adults. Healthy control participants and participants with substance dependence with or without HCCD completed a version of the IGT modified to manipulate WMC. We differentiate between substance dependence with and without HCCD because HCCD is associated with increased behavioral disinhibition (Finn et al., 2002) and more severe course and complications (Del Boca and Hesselbrock, 1996; Sher and Gotham, 1999; Zucker, 1987).

There were three primary hypotheses. First, substance dependence would be associated with greater preference for disadvantageous decks on the IGT. Second, based on dual process models of self-control (Hofmann et al., 2009; Wiers et al., 2010) we hypothesized that a WM load would increase disadvantageous decision-making the most in those with substance dependence and HCCD. Third, we also hypothesized that WM load would enhance the salience of frequent punishments (increasing their inhibitory influences) resulting in more choices from infrequent punishment decks (Finn, 2002). We also expected this effect to be most pronounced among participants with substance dependence and HCCD. With regard to sex differences, we hypothesized that men with substance dependence and HCCD would make less advantageous decisions compared with control men without a WM load (Grant et al., 2000; Kim et al., 2006; Mazas et al., 2000). We also expected that control men would make more advantageous decisions than control women on the IGT overall (Bechara and Martin, 2004; Bolla et al., 2004; Reavis and Overman, 2001; Stout et al., 2005).

2. Method

2.1. Participants

Participants who varied according to substance use levels and disinhibited behavioral characteristics were recruited via flyers posted around the community, as described in previous reports (Bobova et al., 2009; Cantrell et al., 2008; Finn et al., 2009). Table 1 presents the inclusion and exclusion criteria. Eligible participants were between the ages 18 and 30. The age range of 18–30 years was used because substance use disorders have the highest prevalence in this age range (Hall et al., 1999; Kessler et al., 2005) and older cohorts are more likely to be biased by morbidity and the effects of long-term chronic substance abuse on cognition. Upon arriving at the laboratory, participants provided written informed consent, were given a breath alcohol test, and were asked about their alcohol and drug use over the past 24 h. Participants were rescheduled if their breath alcohol level was greater than 0.0%, if they reported consuming any drug within the past 12 h, if they reported feeling hung-over, or if they appeared impaired, high, overly sleepy, or were unable to attend to questions. Most participants were white (77.2%), followed by black (8.4%), Asian (7.6%), Hispanic (6.1%), and Native American (0.3%), 44% were employed and 80% were students. Participants received \$10.00 per hour for their participation in addition to any money won on the IGT. The local institutional review board approved all study procedures.

2.2. Assessment

2.2.1. Diagnostic interview. Participants were interviewed using the alcohol and other drug abuse/dependence, childhood conduct disorder, and adult antisocial behavior portions of the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz et al., 1994) which is based on diagnostic criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (APA, 1994). Participants in the present study were placed in one of three groups based upon the SSAGA: no current or past diagnosis (control; $n = 152$), current substance dependence without HCCD (SubDep; $n = 158$), and current substance dependence with HCCD (SubDep+HCCD; $n = 72$). Demographic and diagnostic information for each of the three groups is presented in Table 2.

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