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Predictors of decision-making on the Iowa Gambling Task: Independent effects of lifetime history of substance use disorders and performance on the Trail Making Test

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Abstract

Poor decision-making and executive function deficits are frequently observed in individuals with substance use disorders (SUDs), and executive deficits may contribute to poor decision-making in this population. This study examined the influence of lifetime history of an alcohol, cocaine, heroin, or polysubstance use disorder on decision-making as measured by the Iowa Gambling Task (IGT) after controlling for executive ability, demographic characteristics, and current substance use. Participants (131 with lifetime history of SUD and 37 controls) completed the IGT and two neuropsychological tests: the Trail Making Test and the Controlled Oral Word Association Test. Control participants performed significantly better than those with a lifetime SUD history on the IGT, but performance on the neuropsychological tests was comparable for the two groups. A lifetime SUD diagnosis was associated with performance on the IGT after controlling for covariates, and Trail Making Test performance was associated with IGT performance in both SUD and control participants.

Keywords: Decision-making; Substance use disorder; Executive ability; Neuropsychological tests; Iowa Gambling Task; Trail Making Test; Controlled Oral Word Association Test

1. Introduction

Poor decision-making is a characteristic associated with substance use disorders (Allen, Moeller, Rhoades, & Cherek, 1998; Mitchell, Fields, D'Esposito, & Boettiger, 2005). Maladaptive substance use could arise from poor decision-making skills that lead individuals with substance use disorders (SUDs) to ignore long-term negative consequences in the interest of immediate gratification or relief of uncomfortable states (Bechara, 2005). Alcohol and other abused drugs may also contribute to impaired decision-making through acute effects on the nervous system and chronic negative impact on neurotransmitters (Jentsch & Taylor, 1999).

The Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994) is a sensitive measure of decision-making that simulates a real-world decision-making situation requiring evaluation of the magnitude and timing of rewards and punishments under uncertain conditions. Higher short-term rewards are associated with larger punishments, making the choice of lower short-term rewards more advantageous in the long-term (Bechara et al., 1994). SUDs are consistently associated with poor performance on the IGT. For instance, poorer performance relative to controls has been observed in patients with dependence on alcohol or stimulants (Bechara et al., 2001), heroin (Petry, Bickel, & Arnett, 1998), marijuana (Whitlow et al., 2004), and polydrugs (Grant, Contoreggi, & London, 2000). The tendency to favor short-term rewards in spite of punishment on the IGT persists in long-term abstinent alcoholics (Fein, Klein, & Finn, 2004). Adverse real life consequences of substance use,

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including medical and legal problems, and greater severity of alcohol use are associated with poor performance on the IGT among SUD treatment patients (Dom, D'haene, Hulstijn, & Sabbe, 2006; Verdejo-Garcia, Bechara, Recknor, & Perez-Garcia, 2006).

SUDs are also associated with deficits on neuropsychological tests of executive functions (Bates, Bowden, & Barry, 2002; Fals-Stewart & Bates, 2003; Goldstein et al., 2004; Verdejo-Garcia & Perez-Garcia, 2007). Executive functions are cognitive processes that govern and regulate other abilities and include working memory, alternating and selective attention, self-monitoring, inhibition, cognitive flexibility, novel problem solving, organization, and abstract reasoning. Many of the negative characteristics often attributed to substance abusers, such as low motivation, denial or minimization of problem severity, and poor impulse control, may actually arise in part from executive cognitive deficits (Fals-Stewart, Shanahan, & Brown, 1995; Goldman, 1995). Decision-making can be viewed as a behavioral manifestation of executive cognitive ability. To date, however, empirical research regarding the relationship between performance on the increasingly popular IGT and standard measures of executive function among individuals with SUDs has been limited. They have primarily relied on a single measure, the Wisconsin Card Sorting Test (WCST), and results have been inconsistent, as outlined below.

Bechara et al. (2001) examined group differences on the IGT and three neuropsychological tests among patients with substance (alcohol or stimulant) dependence, patients with lesions to the ventromedial prefrontal cortex (VM), and normal controls. Substance dependent patients performed more poorly than controls, and their performance as a group did not differ from that of patients with VM lesions, who generally exhibit decision-making deficits on the IGT. Substance dependent patients made more perseverative errors on the WCST than either comparison group, suggesting an inability to adapt to changing contingencies. Performance on two other tests of executive ability, the Stroop and Tower of Hanoi, did not differ among groups, and there were no significant correlations among the IGT and the three neuropsychological tests of executive ability (Bechara et al., 2001).

Other studies examined performance on the IGT and the WCST in individuals with SUDs with conflicting results. Some SUD samples perform relatively worse than controls on both the IGT and the WCST (Piratsu et al., 2006), while others perform worse on the IGT but comparably on the WCST (Grant et al., 2000) or vice versa (Piratsu et al., 2006).

Verdejo-Garcia and Perez-Garcia (2007) administered an array of executive tests including the WCST, Stroop, verbal fluency (FAS), Ruff Figural Fluency Test, Letter-Number Sequencing, Arithmetic, Spatial Span, and Similarities from the Wechsler scales, the Category Test, Go/No Go test, and two other interference tests, as well as the IGT and another decision-making test called the Cognitive Bias Task, to abstinent polysubstance users and controls. Factor analysis revealed four factors that the authors described as updating, inhibition, shifting, and decision-making. The IGT was the only test that loaded on the decision-making factor; the other decision-making test loaded on the same factor as tests of fluency, working memory, and reasoning. However, the IGT shared a substantial proportion of variance with other executive tests, suggesting that executive ability may contribute to but not fully account for IGT performance. Abstinent substance users performed more poorly than controls on all four categories of executive ability identified by the factor analysis.

The WCST is considered a test of abstract reasoning and set shifting (Lezak, Howieson, & Loring, 2004). With the exception of the studies by Bechara et al. (2001) and Verdejo-Garcia and Perez-Garcia (2007) described above, studies of individuals with SUDs have not examined relationships between the IGT and tests purported to measure other aspects of executive ability. The purpose of this study was to examine whether executive ability as measured by two popular and easily administered tests (Trail Making Test and Controlled Oral Word Association Test) contributes to the relationship between SUDs and decision-making deficits as assessed by performance on the IGT. The Trail Making Test and Controlled Oral Word Association Test (COWA) have been used extensively in studies examining relationships between executive cognitive abilities and SUDs, and SUDs are consistently associated with poorer performance on both tests (e.g., Jovanovski, Erb, & Zakzanis, 2005; Tapert, Granholm, Leedy, & Brown, 2002; Verdejo-Garcia & Perez-Garcia, 2007). The Trail Making Test measures cognitive flexibility, alternating attention, and response inhibition (Kortte, Horner, & Windham, 2002; Strauss, Sherman, & Spreen, 2006), while the COWA is used to assess novel problem solving, organization, and self-monitoring (Strauss et al., 2006). We know of no studies examining how the specific executive abilities measured by the Trail Making Test and COWA might contribute to IGT performance in substance users. Decision-making on the IGT relies on multiple cognitive processes, including the ability to respond flexibly to changing contingencies, inhibit a dominant response, identify the solution to a novel problem, and monitor prior responses and their outcomes, processes that are also tapped by the Trail Making Test and COWA. We therefore chose these two tests as our measures of executive ability.

Potential contributions of age, gender, and education were also examined to control for their influence on IGT performance. We predicted that SUDs would be associated with poorer performance on the IGT and that executive ability would contribute to that association.

2. Method

2.1. Participants

Participants were recruited using newspaper advertisements and flyers distributed at substance abuse treatment