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Performance-Based Contingency Management in Cognitive Remediation Training: A Pilot Study

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ABSTRACT

Impairments in attention, working memory, and executive function are common among substance users and may adversely affect SUD treatment outcomes. The ability of cognitive remediation (CR) interventions to improve these deficits is hindered in part because levels of engagement in CR training may be inadequate to achieve benefit. This pilot study aimed to increase CR engagement and improve outcome by implementing contingency management (CM) procedures that reinforce performance improvements on CR tasks. Participants were forty individuals (50% male; 65% African American) in an outpatient substance use treatment facility with mild cognitive impairment who had ≥30-days of abstinence from alcohol and drugs. They were randomized to standard (CR-S; n = 21) or CM-enhanced (CR-CM; n = 19) cognitive remediation training. CR consisted of 1-hour sessions, three times per week for four weeks (12 sessions). A neuropsychological assessment battery was administered prior to and after the four-week intervention. Both groups had high rates of CR session attendance (mean CR-S = 11.7, CR-CM = 10.9 sessions). Performance on 8 of the 9 CR tasks significantly improved over time for both conditions, with the CR-CM condition demonstrating greater improvement on a CR Sequenced Recall task [$F(1,37) = 5.81$, $p < .05$]. Significant improvement was also evident on 4 of 9 neuropsychological assessment measures, with the CR-CM condition showing differential improvement on the Trail Making Test – Part B [$F(1,37) = 5.34$, $p < .05$]. These findings support the feasibility of using CM procedures to enhance substance users' engagement with CR training and suggest the potential value of more research in this area.

1. Introduction

The effectiveness of treatment for individuals with substance use disorders (SUDs), particularly for cognitively demanding approaches like cognitive behavioral therapy (CBT), may be undermined by diminished cognitive resources associated with chronic substance use (Bolla, Rothman, & Cadet, 1999; Bolla et al., 2004; Verdejo-Garcia, Rivas-Perez, Lopez-Torrecillas, & Perez-Garcia, 2006; Vik, Cellucci, Jarchow, & Hedt, 2004). Impairments with respect to attention, working memory, and executive function among SUD patients have been associated with poorer treatment outcomes such as less abstinence (Passetti, Clark, Mehta, Joyce, & King, 2008), shorter treatment retention (Aharonovich, Nunes, & Hasin, 2003; Aharonovich et al., 2006; Streeter et al., 2008; Turner, LaRowe, Horner, Herron, & Malcolm, 2009; Verdejo-Garcia et al., 2012), lower self-efficacy (Bates, Pawlak, Tonigan, & Buckman, 2006) and poorer coping skills acquisition (Kiluk, Nich, & Carroll, 2011). Cognitive remediation (CR) interventions, typically computer-administered training exercises, are designed to harness the brain's neuroplastic capabilities to enhance or restore these types of impaired cognitive processes (Keshavan, Vinogradov, Rumsey, Sherrill, & Wagner, 2014). Despite the strong evidence base on the effectiveness of CR for improving cognitive impairments among schizophrenic populations (McGurk, Twamley, Sitzer, McHugo, & Mueser, 2007; Medalia & Choi, 2009; Wykes, Huddy, Cellard, McGurk, & Czobor, 2011), tests of CR in individuals with SUDs have yielded mixed results. Some studies have shown training-related improvement in attention and working memory (e.g., Goldstein, Haas, Shemansky, Barnett, & Salmon-Cox, 2005; Rass et al., 2015; Rupp, Kemmler, Kurz, Hinterhuber, & Fleischhacker, 2012), and others limited or no cognitive benefit (e.g., Bickel, Yi, Landes, Hill, & Baxter, 2011; Peterson, Patterson, Pillman, & Battista, 2002).

One potential reason for mixed effects among SUD patients may be their limited motivation to engage in CR. Many CR interventions require participants to complete multiple trials of monotonous tasks. This may lead to boredom and reduced engagement, which in turn impedes task performance (Hawkins, Rae, Nesbitt, & Brown, 2013). Low motivation has been noted as a moderator of CR effects among patients with schizophrenia (Medalia & Choi, 2009; Medalia & Richardson, 2005; Velligan, Kern, & Gold, 2006), yet has received relatively little attention in CR studies with substance users. Although some computer-based CR programs include game-like motivational elements to increase

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engagement and enjoyment (e.g., real-time scoring system, virtual prizes and certificates), the actual effect on participant motivation, engagement, and performance may be relatively limited (Hawkins et al., 2013; Katz, Jaeggi, Buschkuehl, Stegman, & Shah, 2014). Thus, the potential for these cognitive enhancing interventions to serve as a viable adjunct treatment for addictions (Bickel, Moody, & Quisenberry, 2014; Sofuoglu, DeVito, Waters, & Carroll, 2013) may be undermined by the inadequate level of motivation and training engagement within this population.

Contingency management (CM; e.g., voucher or prize-based reinforcement) has strong empirical support for improving treatment retention and increasing abstinence among SUD patients (e.g., Higgins, Alessi, & Dantona, 2002; Higgins et al., 1994; Petry et al., 2006; Prendergast, Podus, Finney, Greenwell, & Roll, 2006), and so might be a useful approach for improving engagement and performance on cognitive tasks in this population. This supposition is supported by studies in which an attention shaping procedure that included monetary rewards for achieving attentiveness duration goals enhanced a conversational skills training program with schizophrenic patients (Silverstein et al., 2005, 2009). A study by Bickel et al. (2011) used performance-based monetary rewards in CR training with individuals diagnosed with stimulant abuse/dependence and demonstrated a positive effect of CR training on a delay discounting measure (although no effect on working memory). This study set a precedent for use of performance-based CM in CR training, but did not provide an evaluation of the approach.

This pilot study was conducted to gather preliminary data on whether a performance-based CM intervention would result in improved performance during computerized CR training, and if so, whether this would translate into improved cognitive function as measured by standard neuropsychological tests.

2. Material and methods

2.1. Overview

This pilot study enrolled individuals with substance use disorders but who had been abstinent for at least 30 days to a 4-week CR intervention. All participants received reinforcement for attending CR sessions; those assigned to the CR-CM condition received reinforcement for improvements on CR tasks. Potential participants were screened for eligibility, then completed pre-training assessments that included neuropsychological assessment prior to being randomized to one of the CR intervention conditions. Following the 4-week CR intervention, participants repeated the neuropsychological assessment battery

2.2. Participants

Participants were recruited from a community outpatient substance use treatment facility as well as through online advertisements. To be eligible, participants had to be between 18–60 years of age, meet DSM-IV criteria for substance dependence within the past year, report no use of alcohol or drugs for the past 30 days (and provide a negative urine drug screen at time of screening), and demonstrate evidence of mild cognitive impairment (score< 26 on Montreal Cognitive Assessment Nasreddine et al., 2005). Individuals were excluded if they met DSM-IV criteria for a current bipolar or psychotic disorder, if they would be unable to complete the 4-week intervention period due to an anticipated event (e.g., planned move out of the area, facing incarceration, etc.), or if they were colorblind (due to inclusion of the Stroop Color Word Test in the assessment battery). The maximum age was set at 60 years, as age has been found to be a predictor of improvement from CR (Kontis, Huddy, Reeder, Landau, & Wykes, 2013; Vita et al., 2013; Wykes et al., 2009). Alcohol and drug abstinence for at least 30 days was required to limit the negative cognitive impact of acute drug withdrawal and/or reduce the potential confound of cognitive recovery associated with short-term abstinence (Pace-Schott et al., 2008; Stavro, Pelletier, & Potvin, 2013). Moreover, there is some evidence that the effectiveness of CR is moderated by initial cognitive function, such that those with greater impairment demonstrate larger effects (Fiszdon, Cardenas, Bryson, & Bell, 2005; Fiszdon, Choi, Bryson, & Bell, 2006).

2.3. Assessments

Pre-training screening included *the Montreal Cognitive Assessment (MoCA)* (Nasreddine et al., 2005), a brief, 10-minute cognitive screening instrument that was used to determine the presence of mild cognitive impairment. It has demonstrated greater sensitivity to subtle cognitive deficits than the Mini-Mental State Examination (MMSE) in a variety of populations (Dong et al., 2010; Hoops et al., 2009; Popovic, Seric, & Demarin, 2007), and has good agreement with the lengthier Neuropsychological Assessment Battery-Screening Module at identifying cognitive impairment in patients with substance use disorders (Copersino et al., 2009). The *Structured Clinical Interview for the DSM-IV* (SCID; First, Spitzer, Gibbon, & Williams, 1995) was used determine diagnostic eligibility, and the Substance Use Calendar (SUC), similar to the Timeline Follow-back (Sobell & Sobell, 1992), was used to assesses self-reported days of substance use in the past calendar month. Urine drug screening (cocaine, marijuana, opioids, benzodiazepines, methamphetamine) was used to confirm recent drug abstinence at the time of screening, as well as weekly during the course of training. Alcohol breathalyzer tests were conducted at each study visit.

Assessments also included: (1) the *Addiction Severity Index* (ASI; McLellan et al., 1992); (2) the *Shipley Institute of Living Scale* (Zachary, 1991) was used to assess general intellectual functioning with scores from the vocabulary and abstract subtests converted to estimated IQ scores; (3) the Patient's Assessment of Own Functioning Inventory (PAOFI; Richardson-Vejlgaard, Dawes, Heaton, & Bell, 2009) was administered at pre- and post-training time points to evaluate patients' self-reported cognitive impairment using a Likert-type response scale from 1 ("almost always") to 6 ("almost never") for a series of items regarding everyday cognitive complaints (e.g., "how often do you lose things or have trouble remembering where they are?"). A higher rating on any item indicates a lesser degree of impairment. The PAOFI includes subscales assessing memory, language and communication, and higher cognitive functions. (4) The Intrinsic Motivation Inventory for Schizophrenia Research (IMI-SR; Choi, Mogami, & Medalia, 2010) is a 21 item self-report, Likert-format measure tapping three domains relating to motivation for treatment: interest/enjoyment, perceived choice, and value/usefulness. The IMI-SR was adapted from the original IMI in order to assess the motivational structures for a learning activity specifically in an experimental setting and has been shown to have good internal consistency and test–retest reliability. Participants indicate how true each of the statements were in regard to completing the computer learning activity (e.g., "I enjoyed doing this activity very much") using a response scale from 1 ("not at all true") to 7 ("very true").

The following seven neuropsychological tests yielding ten measures were administered at pre- and post-training:

Digit Symbol subtest from WAIS-IV – this test consists of nine digit–symbol pairs followed by a list of digits with empty boxes. Participants are asked to write down the corresponding symbol below the correct number as fast as possible, completing as many pairs as possible within 120 seconds. The correct number of pairs is considered a measure of processing speed (Joy, Kaplan, & Fein, 2004).

Trail Making Test (Part A & B) – this timed test requires participants to draw a line connecting a series of targets, either numbers only (trails A) or numbers and letters (trails B), on a sheet of paper. Time to complete the task is a measure of visual attention and cognitive flexibility (Kortte, Horner, & Windham, 2002); separate scores are obtained for part A and B.

Hopkins Verbal Learning Test - Revised (HVLT-R; Brandt & Benedict, 2001) – this is a widely used task of verbal and learning and memory

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