HHS Public Access

Author manuscript

Exp Clin Psychopharmacol. Author manuscript; available in PMC 2017 October 01.

Published in final edited form as:

Exp Clin Psychopharmacol. 2016 October ; 24(5): 390–399. doi:10.1037/pha0000091.

Initial Feasibility and Validity of a Prospective Memory Training Program in a Substance Use Treatment Population

Mary M. Sweeney, Ph.D.[1,*], **Olga Rass, Ph.D.**[1], **Patrick S. Johnson, Ph.D.**[1], **Eric C. Strain, M.D.**[1], **Meredith S. Berry, Ph.D.**[1], **Hoa T. Vo, Ph.D.**[2], **Marc J. Fishman, M.D.**[1,2], **Cynthia A. Munro, Ph.D.**[1], **George W. Rebok, Ph.D.**[3], **Miriam Z. Mintzer, Ph.D.**[1], and **Matthew W. Johnson, Ph.D.**[1,*]

[1]Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA

[2]Mountain Manor Treatment Center, Baltimore, Maryland, USA

[3]Department of Mental Health, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, Maryland, USA

Abstract

Individuals with substance use disorders have shown deficits in the ability to implement future intentions, called prospective memory. Deficits in prospective memory and working memory, a critical underlying component of prospective memory, likely contribute to substance use treatment failures. Thus, improvement of prospective memory and working memory in substance use patients is an innovative target for intervention. We sought to develop a feasible and valid prospective memory training program that incorporates working memory training and may serve as a useful adjunct to substance use disorder treatment. We administered a single session of the novel prospective memory and working memory training program to participants (*n* = 22; 13 male; 9 female) enrolled in outpatient substance use disorder treatment and correlated performance to existing measures of prospective memory and working memory. Generally accurate prospective

*Correspondence concerning this article prior to publication should be addressed to Mary M. Sweeney, Behavioral Pharmacology Research Unit, Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, 5510 Nathan Shock Drive, Baltimore, Maryland, USA 21224. marymsweeney@jhmi.edu. Telephone: 410-550-3076. Fax: 410-550-0030. After publication, correspondence should be addressed to Matthew W. Johnson, Behavioral Pharmacology Research Unit, Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, 5510 Nathan Shock Drive, Baltimore, Maryland, USA 21224. mwj@jhu.edu. Telephone: 410-550-0056. Fax: 410-550-0030.

Disclosures

This research was supported by National Institute on Drug Abuse grant R01DA035277 (MWJ) and K24DA023186 (ECS). Support for MMS, OR, PSJ, and MSB was provided by National Institute on Drug Abuse Grant T32DA07209. The funding source had no role other than financial support.

Work related to this research was conducted while OR, PSJ, and MZM were employed at Johns Hopkins University. OR is now at the U.S. Food and Drug Administration/Center for Tobacco Products (FDA/CTP), PSJ is now at California State University, Chico, and MZM is now at the National Institutes of Health. All authors contributed in a significant way to the manuscript and all authors have read and approved the final manuscript.

Although OR is a FDA/CTP employee, this work was not done as part of her official duties. This publication reflects the views of the authors and should not be construed to reflect the views or policies of FDA/CTP, the National Institutes of Health, the Department of Health and Human Services, or the United States government. MJF is the Medical Director of Mountain Manor Treatment Center (MMTC) where some of the patients enrolled in the study described in this article were treated. MJF is a part-time faculty member of the Johns Hopkins University. He is the beneficiary of the trust which owns MMTC. MJF also serves on the governing board of the trust and the Board of Directors of MMTC. This arrangement has been reviewed and approved by the Johns Hopkins University in accordance with its conflict of interest policies. The authors have no other conflicts of interest.

memory performance in a single session suggests feasibility in a substance use treatment population. However, training difficulty should be increased to avoid ceiling effects across repeated sessions. Consistent with existing literature, we observed superior performance on event-based relative to time-based prospective memory tasks. Performance on the prospective memory and working memory training components correlated with validated assessments of prospective memory and working memory, respectively. Correlations between novel memory training program performance and established measures suggest that our training engages appropriate cognitive processes. Further, differential event- and time-based prospective memory task performance suggests internal validity of our training. These data support development of this intervention as an adjunctive therapy for substance use disorders.

Keywords

prospective memory; working memory; cognitive training; substance use disorder; addiction

Prospective memory is memory for actions to be performed in the future, such as remembering to call a doctor to schedule an exam, take a daily medication, or check on food in the oven (Brandimonte, Einstein, & McDaniel, 2014; Einstein & McDaniel, 1990; Zogg, Woods, Sauceda, Wiebe, & Simoni, 2012). Prospective memory is important in day-to-day functioning, and prospective memory deficits are associated with functional impairment in clinical populations, such as unemployment and lack of independence in those living with HIV (Woods et al., 2008; Woods et al., 2011). Individuals with a history of substance use also show impairment in prospective memory. This is true across a wide range of substances and populations including opioids (Terrett et al., 2014), methamphetamine (Rendell, Mazur, & Henry, 2009), MDMA (3,4-methylenedioxy-methamphetamine; (Heffernan, Jarvis, Rodgers, Scholey, & Ling, 2001; Rendell, Gray, Henry, & Tolan, 2007; Rodgers et al., 2001), alcohol (Griffiths et al., 2012; Heffernan, Clark, Bartholomew, Ling, & Stephens, 2010; Heffernan, 2008; Heffernan et al., 2006), cannabis (Bartholomew, Holroyd, & Heffernan, 2010; McHale & Hunt, 2008; Montgomery, Seddon, Fisk, Murphy, & Jansari, 2012; Rodgers et al., 2001), and substance dependent individuals living with HIV (Martin et al., 2007). In substance-dependent HIV-seropositive individuals, prospective memory deficits predict self-reported risky sexual and injection practices (Martin et al., 2007). Taken together, these data suggest that improvement of prospective memory may be a valuable target for intervention in patients with substance use disorders, particularly those who engage in HIV risk behaviors.

Prospective memory may play an integral role in successful substance use treatment. Substance use disorder treatment requires implementation of future intentions such as attending group therapy sessions, taking medications (e.g., an antidepressant or opioid pharmacotherapy), and avoiding situations that are known to trigger drug use. Because the patient may fail to remember to implement these strategies, prospective memory deficits may contribute to treatment failure. Thus, an innovative training program that improves prospective memory could benefit patients enrolled in a substance use treatment program. Existing prospective memory interventions include direct training of prospective memory processes and/or compensatory strategies to overcome deficits (see Hering, Rendell, Rose, Schnitzspahn, & Kliegel, 2014, for review). An unpublished study with older adults (Rose et al., 2012, described in Hering et al., 2014) suggests a benefit of directly training prospective memory processes. A study is currently being conducted to address the common problem of cognitive impairment in heart failure patients that directly trains prospective memory processes (Cameron et al., 2015). Although not yet applied to substance use treatment populations, these studies are promising for direct training of prospective memory processes.

No existing prospective memory intervention involves explicit training of working memory, a critical underlying component of prospective memory. Because intentions for future action must be held in mind prior to performing the action, prospective memory is dependent on working memory. Working memory is the ability to hold in mind and manipulate information over short periods of time, such as holding in mind a question while giving the answer, or performing mental arithmetic (Baddeley, 1992). Greater working memory function predicts greater prospective memory function, and increasing working memory load worsens prospective memory performance (Smith, 2003; Smith & Bayen, 2005). As such, improvement in working memory may improve prospective memory (Richter, Modden, Eling, & Hildebrandt, 2015). Like prospective memory, working memory is impaired in substance-using populations (Crean, Crane, & Mason, 2011; Jovanovski, Erb, & Zakzanis, 2005; Martin et al., 2003; Mintzer & Stitzer, 2002; Murphy, Wareing, Fisk, & Montgomery, 2009; Ornstein et al., 2000; Rendell et al., 2009). Working memory training programs have shown improvements in working memory, decision making, or drug-related outcomes in substance-using populations (Bickel, Yi, Landes, Hill, & Baxter, 2011; Houben, Wiers, & Jansen, 2011; Rass et al., 2015). Given the importance of working memory for implementation of intentions and for deficits in substance users, a prospective memory intervention would benefit from incorporating working memory training.

A prospective memory training intervention should also provide training on both event- and time-based prospective memory tasks. Event-based prospective memory tasks have salient, external cues that signal the appropriateness of the action to be performed (Einstein & McDaniel, 1990). For example, seeing a colleague at work serves as an external cue to ask about setting up a meeting. Time-based prospective memory tasks, on the other hand, have only the passage of time to indicate the appropriateness of the action (Einstein & McDaniel, 1990; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). For example, if a meeting is set for 10:00 AM, one must monitor the time until the start of the meeting. Prospective memory tasks requiring greater self-initiated monitoring (i.e., time-based tasks) tend to be more difficult than event-based tasks (Einstein et al., 1995; Sellen, Louie, Harris, & Wilkins, 1997). Including both types of tasks in a training intervention is important because some experimental manipulations or individual differences may affect time-based, but not event-based prospective memory (Cheung et al., 2015; Dawkins, Turner, & Crowe, 2013; Einstein et al., 1995; Kliegel, Martin, McDaniel, & Einstein, 2001; McHale & Hunt, 2008). The inclusion of both time- and event-based tasks also provides an initial assessment of an intervention's internal validity. Because time-based prospective memory tasks require greater self-initiated monitoring relative to event-based tasks, performance on a prospective memory training program is expected to show higher accuracy on event-based prospective memory tasks relative to time-based prospective memory tasks.

A feasible training program would involve brief, computerized training sessions within an appropriate level of difficulty. To increase the likelihood that memory training could be adopted as an adjunctive therapy, brief training sessions would minimize the time commitment for patients and treatment providers while maximizing the amount of time for other aspects of treatment. Automation via computer minimizes the burden on treatment staff to receive specialized training, minimizes human error or prompting, and ensures fidelity. An appropriately difficult training program would allow room for improvement, but not be so difficult as to result in frustration or promote non-adherence. As a consequence of limited education or income, patients in some community substance use treatment settings may have limited experience with or access to computers (McClure, Acquavita, Harding, & Stitzer, 2013). Therefore, it is important to demonstrate that a computerized program does not serve as an obstacle to training in a low-income treatment population. With these goals in mind, we developed a novel prospective memory training program to be administered in a community substance use treatment setting.

The computerized program uses innovative immersive technology to simulate everyday prospective memory challenges that occur in the context of ongoing demand. Prospective memory tasks (e.g., take medication; pay bills) are completed while the participant is engaged in a commercially available working memory training program framed as a "work-at-home" job. The working memory training program provides measurable, ongoing demand while potentially improving working memory. In the present study, we administered a single prospective memory training session to a community substance use treatment population. It is important to initially assess the validity and feasibility of this program as a first step in the development of an intervention that would be implemented over repeated sessions, and ensure that the appropriate cognitive processes are engaged. Validity and feasibility of the training program were assessed based on the distribution of scores for proportion correct on prospective memory tasks, the relationship of performance on prospective memory tasks to an existing computerized assessment of prospective memory, and the relationship of working memory training performance to an existing assessment of working memory.

Method

Participants

We recruited participants from urban community treatment programs for substance use disorders in Baltimore, Maryland using flyers and word of mouth referral. We conducted a preliminary screening via telephone or in-person and confirmed eligibility at a subsequent 2 hr screening session. Eligible participants were aged 18–55 and enrolled in a substance use treatment program. So that participants were a relevant group for HIV risk behavior interventions in future research, participants must have had sexual intercourse without a condom at least once in the last year and/or had sexual intercourse with at least two partners (with or without a condom) in the last 30 days. Participants were excluded if they were taking a benzodiazepine or reported significant daytime sedation associated with antidepressants. Participants with unstable psychiatric conditions, a history of any severe psychiatric condition associated with psychosis, or a medical condition associated with significant cognitive impairment were also excluded. Of the 27 participants who were screened using these criteria, five were excluded. All participants who qualified after the full screening completed the entire study (*n* = 22; 13 male; 9 female). Participants continued to receive treatment-as-usual, which was not contingent on study participation.

Prospective Memory Training Program

Our program used an immersive computer interface to simulate real life prospective memory challenges that occur in the context of ongoing working memory demands. Headphones were used to mask external noise and present sound accompanying the software. The computer program displayed a living-room environment with a clock, door, desk, computer monitor and phone (see Figure 1 for a screen shot) on a 27-in. 2560 x 1440 pixel LED monitor.

During the 32-min session, participants were asked to complete six prospective memory tasks, three of which were event-based and three of which were time-based. Event-based tasks required the participant to type a response when a person called on the phone (e.g., "When Joy calls, ask her for a ride"; "When Trey calls, ask him about school") or when a person arrived at the door (e.g., "When you see Ann, return her wrench"; "When you see Matt, show him the broken window"). A ringing sound and a name on the phone accompanied phone tasks, while a knocking sound and a person at the door (name shown above the door) accompanied door tasks (see Figure 1). For the three time-based tasks, the participant monitored the clock to complete the task at the appropriate time (e.g., At 8:05, take out trash; At 8:30, pay bills). There was no stimulus other than the correct time on the clock to indicate the task should be completed. Regardless of the actual session start time, the clock on the screen of the prospective memory training program initially displayed 8:00 AM and minutes incremented in real-time thereafter. Two event-based distractors appeared during the session and consisted of someone who was not on the trained task list arriving at the door or calling on the phone. Fifty-two possible character names (26 male, 26 female; all monosyllabic) and accompanying distinct images were randomly assigned by the program to accompany event-based tasks and distractors. To approximate the anticipated demographics of the treatment population, 17 of each sex were illustrated as Black/African American and nine were illustrated as White/Caucasian. Prior to beginning the session, a research assistant performed a visualization exercise with the participant for each prospective memory task. Then, a computerized encoding quiz asked the participant to type the appropriate response to the program stimuli. If the participant gave an incorrect response as judged by the research assistant, the visualization for the missed item and all quiz questions were repeated until correct.

The participant used the mouse to click on the phone, door, or clock when appropriate. A text box appeared and participants had one minute (signaled; see Figure 1) to type and submit a response. If the participant clicked on any inactive stimulus in the environment or clicked on the phone, door, or clock when it was not appropriate, no text entry was allowed. Neither researchers nor the computer program provided feedback regarding task accuracy. Ignoring the distractor stimuli or typing a response such as "ignore" were counted as correctly dismissing the distractor. The stimuli/events occurred randomly in time, with the constraint that the inter-stimulus interval was no shorter than 2 min 30 s and no longer than 5 min 30 s.

Working Memory Training

Participants performed working memory tasks via a commercially available, Internet-based working memory training program within an inset screen (826 x 610 pixels), framed as a "work-at-home" job (Cogmed QM 3.0, Pearson Inc.). The working memory training included a series of eight exercises requiring maintenance and manipulation of visual or auditory sequences. The program adjusted difficulty within the session by increasing the number of items in the sequence when performance was good and decreasing the number of items if performance was poor. All exercises began with two-item sequences, and the number of items at session completion varied with performance. When a prospective memory stimulus occurred, the program required the participant to complete the working memory trial before interacting with the prospective memory stimulus. Working memory training lasted beyond the 32-min prospective memory training session until all exercises were completed (approximately 50 min), during which time the prospective memory interface and display remained on but no further stimuli appeared. Data from the prospective and working memory training program were excluded for one participant due to repeated difficulties accessing these programs via the Internet.

Virtual Week

We used the Virtual Week © (Peter Rendell, 1997) to assess the relationship of performance on our prospective memory training program to performance on an existing computerized measure of prospective memory. The Virtual Week is a validated behavioral measure of prospective memory (Rendell & Craik, 2000; Rendell & Henry, 2009) that has shown poorer performance in substance-using populations (Griffiths et al., 2012; Henry, Mazur, & Rendell, 2009; Rendell et al., 2007; Rendell et al., 2009; Terrett et al., 2014). We used the computerized, brief version of the Virtual Week, which includes one practice day and two virtual days[1]. The screen illustrates a board game in which the squares on the board represent times of the day. Each virtual day required completion of eight prospective memory tasks, which were categorized as regular or irregular, and as event- or time-based. Regular tasks were performed every day and irregular tasks were a response to events that arose during the day. An event-based task required the user to perform a virtual task in response to an event card, whereas a time-based task required the participant to monitor the time indicated by the token's position on the board. No accuracy feedback was provided during or after the Virtual Week. Performance of a prospective memory task in the Virtual Week was coded as correct, miss, late, early, little late, or little early according to previously described criteria (Terrett et al., 2014). Upon completion of the game, the program administered a recognition quiz to test the participants' knowledge of the prospective memory tasks. Due to experimenter error, six participants experienced Virtual Week under

[1]Because this study took place in a treatment population with some individuals with a history of problematic alcohol use, in a few instances we removed references to alcohol (or ambiguous references to "drink") in the Virtual Week. For example, we changed "You have had a glass or two of wine," to be "You have had a cup or two of tea," and changed the photo for this event to show tea rather than wine.

incorrect settings. Data from these participants were excluded from the analyses of Virtual Week task performance and inter-task correlations.

Additional Measures

We assessed history of drug abuse and dependence according to a DSM-IV checklist (Hudziak et al., 1993; Johnson, Johnson, Herrmann, & Sweeney, 2015) for opioids, cocaine, cannabis, alcohol, and sedative/hypnotics. We assessed past-month HIV risk behaviors (e.g., unprotected sexual intercourse, intravenous drug use) using the HIV Risk-Taking Behavior Scale (Darke, Hall, Heather, Ward, & Wodak, 1991). Participants' performance on the Shipley Institute of Living Scale (Shipley, 1940) was used to estimate age-adjusted WAIS-IQ score (Zachary, Crumpton, & Spiegel, 1985). To measure verbal working memory, we administered the digit span forward and backward (Wechsler, 1981; Wechsler, 2008). We administered a self-report measure of prospective memory (Prospective Memory Questionnaire, PMQ; (Hannon, Adams, Harrington, Fries-Dias, & Gipson, 1995), which examines prospective memory failures according to endorsement of items on subscales relating to long-term episodic (e.g., I missed appointments I had scheduled), short-term habitual (e.g., I forgot to shower or bathe), and internally cued (e.g., I forgot what I came into a room to get) aspects of prospective memory, as well as compensatory strategies (e.g., I write myself reminder notes). Drug users have reported poorer prospective memory on the PMQ (Heffernan et al., 2001; Heffernan, Moss, & Ling, 2002). Staff probed participants regarding the previous night's sleep quality. Although no participant's sleep quality required rescheduling the session, study staff would have rescheduled if the previous night's sleep quality been unusually poor.

Procedure

The Johns Hopkins University Institutional Review Board approved this study, and all procedures were performed in accordance with the ethical standards of the Declaration of Helsinki. The study consisted of three parts termed screening, pre-training, and training. During screening, a breathalyzer test confirmed .000 blood alcohol concentration (BAC) prior to obtaining written informed consent. We determined eligibility according to criteria described above. Qualified participants completed pre-training and training sessions. Participants turned off their cell phones prior to pre-training and training. During pre-training, participants completed the Shipley Institute of Living Scale, digit span forward and backward, PMQ, and the Virtual Week. During training, participants completed our combined prospective memory and working memory training program. Urine tests for drugs of abuse and sleep questionnaires were conducted at each visit. Breathalyzer results were required to be .000 prior to each visit. Participants completed the study parts across three visits ($n = 20$), two visits ($n = 1$), or one visit ($n = 1$) based on scheduling needs and clinic preference. Critical components of our prospective memory training program always took place in one visit. Participants received $30 for screening, $35 for pre-training, $35 for training and a $50 bonus for study completion.

Data Analysis

In order to describe the sample, we summarized participant demographic information, substance use disorder history, and mean scores on the HIV Risk-Taking Behavior Scale and the Shipley Institute of Living Scale (estimated WAIS-IQ). We described performance on the prospective memory training program and the Virtual Week in terms of overall mean proportion correct prospective memory tasks and mean proportion correct for both event- and time-based tasks. We compared mean performance for event- and time-based tasks using paired samples *t* tests. We examined Pearson correlations between performance on the prospective memory training program and the Virtual Week and examined whether performance on our prospective memory program or the Virtual Week correlated with any subscale of the Prospective Memory Questionnaire. To examine working memory performance, we measured the correlations between mean highest number of items in a sequence in the working memory component of our training program and the longest digit span forward and longest digit span backward. We also examined how performance on primary prospective memory and working memory outcomes may differ as a function of participant sex using independent samples *t* tests.

Results

Participants

Table 1 shows basic demographic characteristics of the sample (n = 22) as well as smoking status, history of substance abuse or dependence, HIV Risk-Taking Behavior Scale scores, and estimated WAIS-IQ. All participants except one (who was in treatment for cannabis dependence) met lifetime DSM-IV diagnostic criteria for opioid abuse or dependence. In addition, lifetime prevalence of abuse or dependence on cocaine (72.7%), cannabis (63.6%), alcohol (54.5%), and sedative/hypnotics (31.8%) was common. In total, 20 participants (90.9%) met lifetime diagnostic criteria for abuse or dependence on more than one substance. Most participants were maintained on an opioid pharmacotherapy such as buprenorphine/naloxone (n = 15; 68.2%), buprenorphine (n = 1; 4.5%), or methadone (n = 3; 13.6%). Some participants were prescribed naltrexone (n = 2; 9.1%) and/or disulfiram (n = 3; 13.6%) in addition to buprenorphine/naloxone or alone. It was common for participants to be prescribed at least one additional psychiatric medication (n = 13; 59.1%) such as atypical antipsychotics (n = 8; 36.4%), SSRIs (n = 5; 22.7%), or bupropion (n = 4; 18.2%).

Prospective Memory Training Program

Overall mean proportion correct on assigned tasks for our prospective memory training program was .75 (SD = .31). Mean proportion correct for event-based tasks (M = .84; SD = .29) was significantly higher than mean proportion correct for time-based tasks (M = .67; SD = .38; t(20) = 3.20, p = .004). Mean proportion of distractors correctly ignored was .98 (SD = .11). Table 2 shows the performance distribution for prospective memory tasks. Performance tended to be very accurate, such that 18 out of 21 participants (excludes one participant, see Method) missed no more than one event-based task and 14 missed no more than one time-based task. Females had significantly greater proportion correct for event-based prospective memory tasks (M = 1.00, SD = 0, n = 9) relative to males (M = .72, SD = .34, n = 12; t(11) = 2.80, p = .02, equal variances not assumed), but not for time-based prospective memory tasks (Females: M = .78, SD = .29; Males: M = .58, SD = .43; t(19) = 1.17, p = .26). Upon further examination, females in the sample were significantly younger than males (Females: M = 35.89, SD = 10.13, N = 9; Males: M = 45.15, SD = 6.84, N = 13;

t(20) = 2.57, $p = .02$), but were not significantly different according to other demographic variables of race (Females: $n = 3$ White, $n = 6$ non-White; Males: $n = 1$ White, $n = 12$ non-White; Fisher's Exact Test $p = .26$), education in years (Females: $M = 11.67$, $SD = 2.5$; Males: $M = 11.38$, $SD = 1.26$; $t(20) = .35$, $p = .73$), or monthly income in USD (Females: $M = 613.88$, $SD = 790.24$; Males: $M = 399.77$, $SD = 358.19$; $t(20) = .86$, $p = .40$).

Virtual Week

Figure 2 displays proportion correct overall and for event-and time-based tasks for Virtual Week alongside performance on our prospective memory training program. There was no significant difference between proportion correct on event-based tasks ($M = .60$; $SD = .38$) and time-based tasks ($M = .54$; $SD = .34$) on the Virtual Week ($t(15) = 1.33$, $p = .20$). As was the case with the novel prospective memory training program, females had significantly greater proportion correct for event-based prospective memory tasks on the Virtual Week ($M = .88$, SD = .23, $n = 7$) relative to males ($M = .39$, $SD = .33$, $n = 9$; $t(14) = 3.30$, $p = .01$), but not for time-based tasks (Females: $M = .68$, $SD = .31$; Males: $M = .43$, $SD = .34$; $t(14) = 1.50$, $p = .16$). Table 3 describes performance on the Virtual Week in more detail with proportion of responses in the Virtual Week that correspond to each response category (correct, miss, late, early, little late, little early) across each prospective memory task type (regular, irregular, event, time). Mean proportion correct on the retrospective quiz for Virtual Week tasks was .81 ($SD = .22$).

Overall proportion correct on prospective memory tasks for our prospective memory training program was significantly correlated with overall proportion correct on the Virtual Week ($r(13) = .54$, $p = .04$). Proportion correct on event-based tasks for our prospective memory training program was significantly correlated with proportion correct for both event- ($r(13) = .65$, $p = .009$) and time-based ($r(13) = .57$, $p = .03$) tasks on the Virtual Week. Proportion correct on time-based tasks for our prospective memory training program was not significantly correlated with time- ($r(13) = .34$, $p = .22$) or event-based ($r(13) = .47$, $p = .07$) tasks on the Virtual Week.

Self-Reported Prospective Memory

We examined correlations between self-reported prospective memory failures on the Prospective Memory Questionnaire (PMQ; overall and for each subscale; higher scores represent worse prospective memory), and each of two other variables: 1) overall proportion correct on our prospective memory training program; and 2) overall proportion correct on Virtual Week. Only the correlation between overall proportion correct on Virtual Week and score on the short-term habitual subscale of the PMQ was significant ($r(14) = -.65$, $p = .007$; for all other correlations $p \geq .24$).

Working Memory Training

Mean highest number of items in a sequence across all working memory exercises was 5.22 ($SD = .88$). Mean highest number of items on the working memory training program was not significantly different for males and females (Females: $M = 5.08$, $SD = 1.02$, $n = 9$; Males: $M = 5.32$, $SD = .79$, $n = 13$; $t(20) = .61$, $p = .55$). Mean highest number of items in a sequence was significantly correlated with longest digit span forward ($r(20) = .56$, $p = .007$) and backward ($r(20) = .47$, $p = .03$). Performance on the digit span forward was not significantly different for males ($M = 6.31$, $SD = 1.44$, $n = 13$) and females ($M = 6.22$, $SD = .83$, $n = 9$; $t(20) = .16$, $p = .87$) and neither was the digit span backward (Females: $M = 4.00$, $SD = .87$; Males: $M = 3.92$, $SD = 1.32$; $t(20) = .15$, $p = .88$).

Discussion

We successfully administered one session of our novel prospective memory training program in a community substance use treatment sample. The distribution of performance on the prospective memory tasks suggests the program is feasible for administration in this population, but may not be sufficiently challenging. As predicted, significantly superior performance on event-based relative to time-based prospective memory tasks indicates the program was successful in differentiating between tasks requiring low or high degrees of self-initiated monitoring (Einstein et al., 1995; Sellen et al., 1997). The overall proportion correct on our prospective memory training program was significantly positively related to overall proportion correct on an established assessment of prospective memory, the Virtual Week. Working memory performance on the training tasks was significantly positively associated with standard measures of working memory. These findings suggest the prospective memory training program is valid and should be further developed for substance use treatment.

Our results suggest a computerized prospective memory training program is potentially feasible and acceptable in a community treatment population with varied educational histories (i.e., on average less than a high school education) and mean income well below the poverty line. Total time for a single session of training was approximately 50 minutes, which was not overly burdensome to participants or their ongoing treatment. Further, participants generally found the program to be engaging. Future research should increase the difficulty of the training program (i.e., increase number of prospective memory tasks) to allow for improvement in prospective memory performance across repeated sessions, and formally assess treatment acceptability for clinicians and patients (e.g., Mitchell, Monico, Gryczynski, O'Grady, & Schwartz, 2015; Sanchez & Bartel, 2015). Successful implementation of the program for a single session is promising for further development of this intervention, especially in a repeatedly administered protocol.

Performance on our prospective memory training program was significantly and positively correlated with performance on the Virtual Week, which has consistently shown poorer performance in populations with a history of drug use relative to control populations (Griffiths et al., 2012; Henry et al., 2009; Rendell et al., 2007; Rendell et al., 2009; Terrett et al., 2014). We found significant correlations between performance on event-based tasks with our program and event-and time-based tasks on the Virtual Week, but not between time-based tasks on our training program and time-based tasks with the Virtual Week. Differences in the strength of these correlations may be a function of our limited sample size, but may also reflect differences in the time-based tasks. For our training program, time-based tasks depended on the passage of real-time. In the Virtual Week, passing squares on the board according to dice rolls indicated time. Consequently, time-based tasks in the brief version of Virtual Week used here may be more event-like. The full version of Virtual Week includes "time-check" tasks that require the participant to break from the activity of the board game, which may be more comparable to our time-based tasks. Correlation between our prospective memory training program and the Virtual Week does not necessarily indicate that our training would improve performance on the Virtual Week, but these data suggest that the Virtual Week is a good candidate for tests of near-transfer of prospective memory improvement following repeated training sessions, possibly with the inclusion of time-check tasks (see Barnett & Ceci, 2002 for a discussion of transfer).

Accuracy on the Virtual Week, but not our prospective memory training program, was significantly negatively associated with self-reported memory failures on the short-term habitual subscale of the Prospective Memory Questionnaire. Virtual Week includes short-term, habitual tasks that are repeated on each virtual day (e.g., take your medication at breakfast and dinner), which may relate more strongly to this subscale relative to our program. Neither overall self-reported prospective memory, nor self-reported prospective memory on the long-term episodic, internally-cued, or strategies subscales were correlated with performance on the Virtual Week or our prospective memory training program. Objective laboratory measures of prospective memory may assess different aspects of prospective memory than self-report measures (see Uttl & Kibreab, 2011 for discussion). The relationship between self-reported prospective memory failures and objective laboratory measures may be better explored in a larger sample size with sufficient power to detect such a relationship.

A distinguishing feature of our prospective memory training program is that we target working memory for intervention alongside explicit prospective memory training. Working memory training programs have shown improvements in cognitive, decision-making, and drug related outcomes (Bickel et al., 2011; Houben et al., 2011; Rass et al., 2015), and therefore, training working memory in addition to prospective memory may be a critical component for increasingly successful drug treatments. Currently available prospective memory assessments such as the Memory for Intentions Screening Test (Raskin, 2009) or the Virtual Week are designed for assessment of prospective memory rather than intervention, and none explicitly include working memory training. Training multiple memory components has been associated with improved training outcomes through various means that can enhance plasticity as well as specific memory functions such as encoding and retrieval (Gross et al., 2012; Hertzog et al., 2008). The working memory training aspect of our program simulates the ongoing demand in which day-to-day prospective memory tasks occur while aiming to improve processes critical to prospective memory. We found that performance on the working memory training during the session was significantly positively associated with performance on the digit span forward and backward. This suggests the training targets the appropriate working memory processes and that the digit span is a good candidate for assessing near-transfer training effects.

This study established the internal and external validity of a novel prospective memory training program through demonstrated differential performance for time- and event-based prospective memory tasks, as well as significant correlations with performance on the existing memory assessment, the Virtual Week. Future research should examine the generality of the observed effects. For example, females in this sample performed significantly better than males on event-based prospective memory tasks in the novel prospective memory training program and the Virtual Week. These data are consistent with previous research suggesting that females tend to outperform males on prospective memory tasks (Maylor & Logie, 2010). On the other hand, females in the present study were significantly younger than males. Younger adults tend to outperform older adults on laboratory prospective memory tasks (e.g., Henry et al., 2004), and thus the sex differences observed here must be interpreted cautiously. Our sample was predominately opioid maintained, but commonly reported lifetime abuse or dependence on other substances. Thus, it is also necessary to examine whether our results generalize to substance use treatment populations without a history of opioid use or polydrug use. Overall, findings from this study show the prospective memory training program is a good candidate for further development as a multiple-session adjunctive therapy for substance use treatment.

Acknowledgments

We acknowledge Peter Rendell for developing Virtual Week and providing access. We thank Len Onyiah for computer programming. We thank Lisa Mitchell for her assistance in conducting this research. This work was presented in part at the 3rd Annual Collaborative Perspectives on Addiction Conference of the American Psychological Association and at the 77th Annual Meeting of the College on Problems of Drug Dependence. Initial findings were described in an abstract published in Drug and Alcohol Dependence (i.e., Sweeney et al., 2015, *Drug and Alcohol Dependence, 156,* e217–e218).

References

Baddeley A. Working memory. Science (New York, NY). 1992; 255(5044):556–559.

Barnett SM, Ceci SJ. When and where do we apply what we learn? A taxonomy for far transfer. Psychological Bulletin. 2002; 128(4):612–637. [PubMed: 12081085]

Bartholomew J, Holroyd S, Heffernan TM. Does cannabis use affect prospective memory in young adults? Journal of Psychopharmacology (Oxford, England). 2010; 24(2):241–246. DOI: 10.1177/0269881109106909

Bickel WK, Yi R, Landes RD, Hill PF, Baxter C. Remember the future: Working memory training decreases delay discounting among stimulant addicts. Biological Psychiatry. 2011; 69(3):260–265. DOI: 10.1016/j.biopsych.2010.08.017 [PubMed: 20965498]

Brandimonte, MA.; Einstein, GO.; McDaniel, MA. Prospective memory: Theory and applications. London: Taylor and Francis; 2014.

Cameron J, Rendell PG, Ski CF, Kure CE, McLennan SN, Rose NS, … Thompson DR. PROspective MEmory training to improve HEart failUre self-care (PROMETHEUS): Study protocol for a randomised controlled trial. Trials. 2015; 16:196-015-0721-2.doi: 10.1186/s13063-015-0721-2 [PubMed: 25927718]

Cheung EF, Lui SS, Wang Y, Yang TX, Shum DH, Chan RC. Time-based but not event-based prospective memory remains impaired one year after the onset of schizophrenia: A prospective study. Schizophrenia Research. 2015; 169(1–3):147–152. DOI: 10.1016/j.schres.2015.09.015 [PubMed: 26404040]

Crean RD, Crane NA, Mason BJ. An evidence based review of acute and long-term effects of cannabis use on executive cognitive functions. Journal of Addiction Medicine. 2011; 5(1):1–8. DOI: 10.1097/ADM.0b013e31820c23fa [PubMed: 21321675]

Darke S, Hall W, Heather N, Ward J, Wodak A. The reliability and validity of a scale to measure HIV risk-taking behaviour among intravenous drug users. AIDS (London, England). 1991; 5(2):181–185.

Dawkins L, Turner J, Crowe E. Nicotine derived from the electronic cigarette improves time-based prospective memory in abstinent smokers. Psychopharmacology. 2013; 227(3):377–384. DOI: 10.1007/s00213-013-2983-2 [PubMed: 23344557]

Einstein GO, McDaniel MA. Normal aging and prospective memory. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1990; 16(4):717–726.

Einstein GO, McDaniel MA, Richardson SL, Guynn MJ, Cunfer AR. Aging and prospective memory: Examining the influences of self-initiated retrieval processes. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1995; 21(4):996–1007.

Griffiths A, Hill R, Morgan C, Rendell PG, Karimi K, Wanagaratne S, Curran HV. Prospective memory and future event simulation in individuals with alcohol dependence. Addiction (Abingdon, England). 2012; 107(10):1809–1816. DOI: 10.1111/j.1360-0443.2012.03941.x

Hannon R, Adams P, Harrington S, Fries-Dias C, Gipson MT. Effects of brain injury and age on prospective memory self-rating and performance. Rehabilitation Psychology. 1995; 40(4):289–298. DOI: 10.1037/0090-5550.40.4.289

Heffernan T, Clark R, Bartholomew J, Ling J, Stephens R. Does binge drinking in teenagers affect their everyday prospective memory? Drug and Alcohol Dependence. 2010; 109(1–3):73–78. DOI: 10.1016/j.drugalcdep.2009.12.013 [PubMed: 20071106]

Heffernan TM. The impact of excessive alcohol use on prospective memory: A brief review. Current Drug Abuse Reviews. 2008; 1(1):36–41. [PubMed: 19630703]

Heffernan TM, Jarvis H, Rodgers J, Scholey AB, Ling J. Prospective memory, everyday cognitive failure and central executive function in recreational users of ecstasy. Human Psychopharmacology. 2001; 16(8):607–612. DOI: 10.1002/hup.349 [PubMed: 12404540]

Heffernan TM, Moss M, Ling J. Subjective ratings of prospective memory deficits in chronic heavy alcohol users. Alcohol and Alcoholism (Oxford, Oxfordshire). 2002; 37(3):269–271.

Heffernan T, O'Neill T, Ling J, Holroyd S, Bartholomew J, Betney G. Does excessive alcohol use in teenagers affect their everyday prospective memory? Clinical Effectiveness in Nursing. 2006; 9(Supplement 3):e302–e307. DOI: 10.1016/j.cein.2006.05.003

Henry JD, MacLeod MS, Phillips LH, Crawford JR. A meta-analytic review of prospective memory and aging. Psychology and Aging. 2004; 19(1):27–39. DOI: 10.1037/0882-7974.19.1.27 [PubMed: 15065929]

Henry JD, Mazur M, Rendell PG. Social-cognitive difficulties in former users of methamphetamine. The British Journal of Clinical Psychology/the British Psychological Society. 2009; 48(Pt 3):323–327. DOI: 10.1348/000712609X435742

Hering A, Rendell PG, Rose NS, Schnitzspahn KM, Kliegel M. Prospective memory training in older adults and its relevance for successful aging. Psychological Research. 2014; 78(6):892–904. DOI: 10.1007/s00426-014-0566-4 [PubMed: 24744122]

Houben K, Wiers RW, Jansen A. Getting a grip on drinking behavior: Training working memory to reduce alcohol abuse. Psychological Science. 2011; 22(7):968–975. DOI: 10.1177/0956797611412392 [PubMed: 21685380]

Hudziak JJ, Helzer JE, Wetzel MW, Kessel KB, McGee B, Janca A, Przybeck T. The use of the DSM-III-R checklist for initial diagnostic assessments. Comprehensive Psychiatry. 1993; 34(6):375–383. [PubMed: 8131381]

Johnson MW, Johnson PS, Herrmann ES, Sweeney MM. Delay and probability discounting of sexual and monetary outcomes in individuals with cocaine use disorders and matched controls. PloS One. 2015; 10(5):e0128641.doi: 10.1371/journal.pone.0128641 [PubMed: 26017273]

Jovanovski D, Erb S, Zakzanis KK. Neurocognitive deficits in cocaine users: A quantitative review of the evidence. Journal of Clinical and Experimental Neuropsychology. 2005; 27(2):189–204. DOI: 10.1080/13803390490515694 [PubMed: 15903150]

Kliegel M, Martin M, McDaniel MA, Einstein GO. Varying the importance of a prospective memory task: Differential effects across time- and event-based prospective memory. Memory (Hove, England). 2001; 9(1):1–11. DOI: 10.1080/09658210042000003

Martin EM, Nixon H, Pitrak DL, Weddington W, Rains NA, Nunnally G, … Bechara A. Characteristics of prospective memory deficits in HIV-seropositive substance-dependent individuals: Preliminary observations. Journal of Clinical and Experimental Neuropsychology. 2007; 29(5):496–504. DOI: 10.1080/13803390600800970 [PubMed: 17564915]

Martin EM, Pitrak DL, Rains N, Grbesic S, Pursell K, Nunnally G, Bechara A. Delayed nonmatch-to-sample performance in HIV-seropositive and HIV-seronegative polydrug abusers. Neuropsychology. 2003; 17(2):283–288. [PubMed: 12803434]

Maylor EA, Logie RH. A large-scale comparison of prospective and retrospective memory development from childhood to middle age. The Quarterly Journal of Experimental Psychology. 2010; 63(3):442–451. DOI: 10.1080/1747021090346872 [PubMed: 20043274]

McClure EA, Acquavita SP, Harding E, Stitzer ML. Utilization of communication technology by patients enrolled in substance abuse treatment. Drug and Alcohol Dependence. 2013; 129(1–2): 145–150. DOI: 10.1016/j.drugalcdep.2012.10.003 [PubMed: 23107600]

McHale S, Hunt N. Executive function deficits in short-term abstinent cannabis users. Human Psychopharmacology. 2008; 23(5):409–415. DOI: 10.1002/hup.941 [PubMed: 18421794]

Mintzer MZ, Stitzer ML. Cognitive impairment in methadone maintenance patients. Drug and Alcohol Dependence. 2002; 67(1):41–51. S0376871602000133. [PubMed: 12062778]

Mitchell SG, Monico LB, Gryczynski J, O'Grady KE, Schwartz RP. Staff views of acceptability and appropriateness of a computer-delivered brief intervention for moderate drug and alcohol use. Journal of Psychoactive Drugs. 2015; 47(4):301–307. DOI: 10.1080/02791072.2015.1075631 [PubMed: 26375411]

Montgomery C, Seddon AL, Fisk JE, Murphy PN, Jansari A. Cannabis-related deficits in real-world memory. Human Psychopharmacology. 2012; 27(2):217–225. DOI: 10.1002/hup.1273 [PubMed: 22389086]

Murphy PN, Wareing M, Fisk JE, Montgomery C. Executive working memory deficits in abstinent ecstasy/MDMA users: A critical review. Neuropsychobiology. 2009; 60(3–4):159–175. DOI: 10.1159/000253552 [PubMed: 19893333]

Ornstein TJ, Iddon JL, Baldacchino AM, Sahakian BJ, London M, Everitt BJ, Robbins TW. Profiles of cognitive dysfunction in chronic amphetamine and heroin abusers. Neuropsychopharmacology : Official Publication of the American College of Neuropsychopharmacology. 2000; 23(2):113–126. S0893-133X(00)00097-X [pii]. [PubMed: 10882838]

Raskin SA. Memory for intentions screening test: Psychometric properties and clinical evidence. Brain Impairment. 2009; 10(1):23–33. DOI: 10.1375/brim.10.1.23

Rass O, Schacht RL, Buckheit K, Johnson MW, Strain EC, Mintzer MZ. A randomized controlled trial of the effects of working memory training in methadone maintenance patients. Drug and Alcohol Dependence. 2015; 156:38–46. DOI: 10.1016/j.drugalcdep.2015.08.012 [PubMed: 26404954]

Rendell PG, Gray TJ, Henry JD, Tolan A. Prospective memory impairment in "ecstasy" (MDMA) users. Psychopharmacology. 2007; 194(4):497–504. DOI: 10.1007/s00213-007-0859-z [PubMed: 17619860]

Rendell PG, Mazur M, Henry JD. Prospective memory impairment in former users of methamphetamine. Psychopharmacology. 2009; 203(3):609–616. DOI: 10.1007/s00213-008-1408-0 [PubMed: 19037633]

Rendell PG, Craik FIM. Virtual week and actual week: Age-related differences in prospective memory. Applied Cognitive Psychology. 2000; 14(7):S43–S62.

Rendell PG, Henry JD. A review of virtual week for prospective memory assessment: Clinical implications. Brain Impairment. 2009; 10(1):14–22. DOI: 10.1375/brim.10.1.14

Richter KM, Modden C, Eling P, Hildebrandt H. Working memory training and semantic structuring improves remembering future events, not past events. Neurorehabilitation and Neural Repair. 2015; 29(1):33–40. DOI: 10.1177/1545968314527352 [PubMed: 24699430]

Rodgers J, Buchanan T, Scholey AB, Heffernan TM, Ling J, Parrott A. Differential effects of ecstasy and cannabis on self-reports of memory ability: A web-based study. Human Psychopharmacology. 2001; 16(8):619–625. DOI: 10.1002/hup.345 [PubMed: 12404542]

Rose, NS.; Craik, FIM.; Hering, A.; Rendell, P.; Moreno, S.; Bidelman, G.; Kliegel, M. Training older adults' prospective memory with the virtual week video game. Poster Presented at the Cognitive Aging Conference; Atlanta, GA. 2012.

Sanchez RP, Bartel CM. The feasibility and acceptability of "arise": An online substance abuse relapse prevention program. Games for Health Journal. 2015; 4(2):136–144. DOI: 10.1089/g4h.2014.0015 [PubMed: 26181807]

Sellen AJ, Louie G, Harris JE, Wilkins AJ. What brings intentions to mind? an in situ study of prospective memory. Memory (Hove, England). 1997; 5(4):483–507. DOI: 10.1080/741941433

Shipley WC. A self-administering scale for measuring intellectual impairment and deterioration. Journal of Psychology. 1940; 10:371.

Smith RE. The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2003; 29(3):347–361.

Smith RE, Bayen UJ. The effects of working memory resource availability on prospective memory: A formal modeling approach. Experimental Psychology. 2005; 52(4):243–256. DOI: 10.1027/1618-3169.52.4.243 [PubMed: 16304724]

Terrett G, McLennan SN, Henry JD, Biernacki K, Mercuri K, Curran HV, Rendell PG. Prospective memory impairment in long-term opiate users. Psychopharmacology. 2014; 231(13):2623–2632. DOI: 10.1007/s00213-014-3432-6 [PubMed: 24448901]

Uttl B, Kibreab M. Self-report measures of prospective memory are reliable but not valid. Canadian Journal of Experimental Psychology = Revue Canadienne De Psychologie Experimentale. 2011; 65(1):57–68. DOI: 10.1037/a0022843 [PubMed: 21443331]

Wechsler, D. WAIS-R manual: Wechsler adult intelligence scale-revised. Psychological Corporation; 1981.

Wechsler, D. Wechsler adult intelligence scale. 4. San Antonio, TX: Pearson; 2008.

Woods SP, Iudicello JE, Moran LM, Carey CL, Dawson MS, Grant I. HIV Neurobehavioral Research Center Group. HIV-associated prospective memory impairment increases risk of dependence in everyday functioning. Neuropsychology. 2008; 22(1):110–117. DOI: 10.1037/0894-4105.22.1.110 [PubMed: 18211160]

Woods SP, Weber E, Weisz BM, Twamley EW, Grant I. HIV Neurobehavioral Research Programs Group. Prospective memory deficits are associated with unemployment in persons living with HIV infection. Rehabilitation Psychology. 2011; 56(1):77–84. DOI: 10.1037/a0022753 [PubMed: 21401289]

Zachary RA, Crumpton E, Spiegel DE. Estimating WAIS-R IQ from the shipley institute of living scale. Journal of Clinical Psychology. 1985; 41(4):532–540.

Zogg JB, Woods SP, Sauceda JA, Wiebe JS, Simoni JM. The role of prospective memory in medication adherence: A review of an emerging literature. Journal of Behavioral Medicine. 2012; 35(1):47–62. DOI: 10.1007/s10865-011-9341-9 [PubMed: 21487722]

Author Manuscript

Author Manuscript

Author Manuscript

Public Significance Statement

Individuals with substance use problems tend to have poorer memory for future intentions and poorer memory for short-term maintenance and manipulation of information. We developed and implemented a single session of a novel memory training program in substance use patients. Results suggest the training program engages the appropriate memory processes, and is feasible in substance use patients.

Figure 1.
Screen shot of the novel prospective memory training program. Participants completed the prospective memory tasks by clicking on the door, the phone, or the clock with the mouse and typing a response in the textbox that appeared. Working memory training (Cogmed QM 3.0, Pearson Inc.) was completed on the inset "computer monitor"

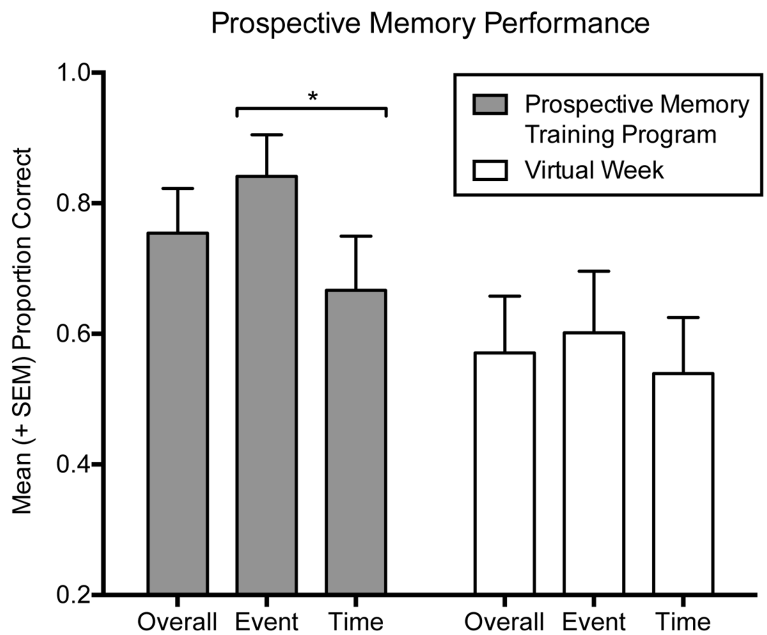

Figure 2.

Mean proportion correct and standard error for the prospective memory training program alongside mean proportion correct and standard error for the Virtual Week. Proportions reflect overall proportion correct as well as proportion correct on event- and time-based tasks. * indicates significant difference between proportion correct for event- and time-based tasks for our prospective memory training program ($t(20) = 3.20$, $p = .004$)

Table 1

Participant Demographic Characteristics and Drug Use History

	n	%
Total	22	100 %
Sex		
Male	13	59.1 %
Female	9	40.9 %
Racial Background[1]		
Black/African American	15	68.2 %
White/Caucasian	4	18.2 %
More than one race[2]	2	9.1 %
American Indian/Alaska Native	1	4.5 %
Tobacco Smoking Status		
Smoker	19	86.4 %
Non-Smoker	3	13.6 %
Met DSM-IV Substance Use Criteria (Lifetime)[3]		
Opioids	21	95.5 %
Cocaine	16	72.7 %
Cannabis[4]	14	63.6 %
Alcohol	12	54.5 %
Sedative/hypnotic	7	31.8 %
	Mean	*SD*
Age (years)	41.4	9.4
Education (years)	11.5	1.8
Monthly Income	$487.36	$568.17
HIV Risk-Taking Behavior Scale Total Score[5]	6.27	4.22
Shipley Institute of Living Scale (Estimated WAIS-IQ)	90.8	11.4

Note.

[1] All participants identified as non-Hispanic.

[2] The two participants who identified as more than one race both identified as White/Caucasian and American Indian/Alaska Native.

[3] *n* represents the number of participants who met DSM-IV diagnostic criteria for substance abuse and/or substance dependence at some point during their lifetime. Participants could meet diagnostic criteria for more than one substance, as such the drug categories are not mutually exclusive.

[4] Information regarding DSM-IV diagnostic criteria for cannabis abuse or dependence was not collected for the first participant.

[5] Scores on the HIV Risk-Taking Behavior Scale may range from 0 to 55, with higher scores indicating greater frequency of risk behavior. Scores ranged from 0 to 17 with 6 being the most common score.

Table 2

Distribution of Scores for Computerized Prospective Memory Training Program Tasks

	Event-based tasks		Time-based tasks	
Proportion correct	**Score Frequency**	**% of sample**	**Score Frequency**	**% of sample**
0.00	1	4.8	3	14.3
0.33	2	9.5	4	19.0
0.67	3	14.3	4	19.0
1.00	15	71.4	10	47.6

Note. Frequencies of proportion correct score on event- and time-based prospective memory tasks for the 21 participants who completed the computerized prospective memory training program. The proportions are based on three event-based and three time-based tasks during the session.

Table 3

Mean Proportion of Responses in Each Response Category across Task Type in the Virtual Week

		Regular	Irregular	Event	Time
Mean Proportion (SD)	Correct	0.62 (0.45)	0.52 (0.33)	0.60 (0.38)	0.54 (0.34)
	Miss	0.30 (0.42)	0.34 (0.31)	0.27 (0.31)	0.36 (0.34)
	Late	0.06 (0.14)	0.05 (0.08)	0.06 (0.16)	0.05 (0.08)
	Early	0.00 (0.00)	0.05 (0.08)	0.05 (0.08)	0.01 (0.03)
	Little Late	0.02 (0.04)	0.03 (0.06)	0.01 (0.03)	0.04 (0.06)
	Little Early	0.01 (0.03)	0.01 (0.03)	0.01 (0.03)	0.01 (0.03)

Note. Above are the proportions of responses in the Virtual Week program that fell into each response category (correct, miss, late, early, little late, little early) for each prospective memory task type (regular, irregular, event, time). Each prospective memory task was regular or irregular and event or time-based, so task type categories are not mutually exclusive. Summed proportions for regular and time-based tasks exceed 100 due to rounding error.