Supplementary Material for the Article

A Randomized Controlled Trial of the Effects of Working Memory Training in Methadone Maintenance Patients

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2.3 Cognitive Outcomes

2.3.1 Working Memory.

Working memory was assessed using verbal and nonverbal measures. (a) *Digit Span* (Wechsler, 1981): participants listened to a series of digits of increasing length and were asked to repeat the digits in the same (forward task), or reverse order (backward task). The dependent measure was span length. (b) *Operation Span* (Turner and Engle, 1989; Engle, Cantor, and Carullo, 1992): participants read aloud a two-operation arithmetic problem (e.g., (7x1)-2=5) and determined whether the presented solution was correct. Then, participants read aloud a monosyllabic, 4-letter word. Participants were asked to recall all the presented words following each set of 2 to 5 arithmetic problem/word presentations. Each set size (2, 3, 4, and 5) occurred three times. The dependent measure was the proportion of correctly recalled words. (c) *N-back Task* (Jonides et al., 1997; Mintzer and Griffiths, 2007): participants clicked "yes" or "no" to indicate whether the presented letter matched a target letter 'n' letters earlier for 60 trials in two memory load conditions, 0-back and 2-back. To prevent simple perceptual matching, upper and lower case letters were randomly intermixed. The 0-back is a control condition involving minimal memory and provides a measure of focused attention only; participants were told to click 'yes' whenever the letter on the screen matched a predetermined target letter (e.g., m) and to click 'no' if not. Dependent measures were proportion of yes responses made to target letters (hit rate), proportion of yes responses made to non-target letters (false alarm rate), and signal detection measures of sensitivity in distinguishing between target and non-target letters (d') and response bias (C) (Snodgrass and Corwin, 1988). (d) *Visuo-spatial Working Memory Task* (Rapport et. al., 2008): participants viewed a screen with nine squares arranged in an offset 3x3 grid pattern where 3, 5, or 7 dots were serially presented. All but one red dot within each trial

was black; the red dot was counterbalanced to appear in each of the 9 squares, but never presented as the first or last stimulus in the sequence to minimize potential primacy or recency effects. Participants were asked to replicate the sequence of dots, but enter the position of the red dot last. Each condition (3, 5, 7 dots) had 24 trials. The dependent measure was proportion of correctly replicated sequences.

2.3.2. Episodic memory and metamemory.

Episodic memory was assessed using *word recall* and *recognition*. Participants studied 70 words, presented serially. After 75 minutes, they were given 5 minutes to recall the words. The dependent measure was number of words correctly recalled. The subsequent recognition memory assessment consisted of a serial presentation of 140 words, half of which had been presented earlier. Participants made confidence judgments on a 6-point scale about the degree to which they recognized (old) or did not recognize (new) the words from the study phase. Dependent variables were the proportion of old responses made to old words (hit rate), proportion of old responses made to new words (false alarm rate), sensitivity in distinguishing between old and new words (d'), and response bias (C) (Snodgrass and Corwin, 1988). *Metamemory* was evaluated by calculating the Goodman-Kruskal gamma correlation between confidence ratings and recognition memory accuracy, collapsed across old and new words for sufficient power (Goodman and Kruskal, 1954).

2.3.3 Psychomotor Speed and Attention

(a) *Trail Making Test A and B* (Halstead, 1947; Reitan, 1955) measured psychomotor speed and conceptual flexibility. Participants connected numbers in numerical sequence (Part A) or alternated between sequential numbers and letters (Part B). Dependent measures were completion time (in seconds), number of errors, and the difference in time to complete B and A.

(b) A computerized *Digit Symbol Substitution Task* (DSST) (McLeod et al., 1982; based on Wechsler, 1981) measured focused attention. Dependent measures were the number of trials attempted and the proportion of correct trials.

2.3.4 *Reasoning*

Reasoning ability was assessed using *Raven's Standard Progressive Matrices* (Raven, 1939). Participants selected the appropriate images to complete patterns. The dependent measure was the proportion of correct trials.

2.3.5 Response Inhibition and Self-Control

A *Continuous Performance Task* (Epstein et al., 1998) measured response inhibition. Participants were shown 360 letters, sequentially, and pressed the spacebar for any letter except "X." Dependent measures were proportion of correct non-X trials (hit rate), proportion of incorrect X-trials (false alarm), sensitivity in distinguishing between non-X letters and X (d'), and response bias (C).

Two variations of *Delay Discounting Tasks* measured self control. (a) *Hypothetical Delay Discounting Task* (Baker et al., 2003; Johnson and Bickel, 2002; Johnson et. al., 2007, Johnson et. al., 2010): participants were presented with a series of choices between smaller immediate rewards and larger delayed rewards. The larger delayed reward was fixed ($1000). The smaller immediate reward was adjusted based on participants' choices until either the immediate or delayed reward was chosen consistently (indifference point; rewards were valued approximately equivalently). Delay ranged from one day to 25 years and was increased throughout the task until an indifference point was reached at each delay length. (b) The *Quick Discounting Operant Task* (QDOT; Johnson, 2012) was used to assess self-control with actual contingencies in terms of reward delivery and the requirement to wait to receive rewards during the task. Participants

chose between immediate (e.g., 5 cents now) and delayed rewards (e.g., 80 cents in 5 seconds). Choices resulted in coin rewards of up to $16 over 12 trials. The amount of the smaller immediate reward and the delay length were adjusted until an indifference point was reached. A waiting period at the end of the task ensured that total task time was not dependent on participants' choices. The dependent measure for both tasks was discounting rate.

A modified computerized version (Mintzer and Stitzer, 2002) of the *Iowa Gambling Task (Bechara et al., 1994)* measured risk-taking and self-control. Participants were instructed to optimize earnings by selecting cards from four card decks (A, B, C, and D) presented on a computer screen over 100 trials. Decks varied on the proportion of reward vs. penalty cards and gain/loss amount. Over time, continued selection from either Deck C or D resulted in a net gain (advantageous decks), whereas continued selection from either Deck A or B resulted in a net loss (disadvantageous decks). The dependent measure was difference in number of cards selected from the advantageous versus disadvantageous decks, calculated separately for the decks associated with high frequency (i.e. C minus A) and low frequency (i.e. D minus B) of penalties, and collapsed across frequency of penalties [i.e. (C plus D) minus (A plus B)].

2.4 Substance use and functional outcomes.

Self-reported drug use history and severity were assessed at baseline via a *Drug History Questionnaire*. *Timeline Follow Back* assessed recent use of cocaine, opiates, benzodiazepines, cannabis, and alcohol at pre and post assessment. Functional outcomes (i.e., composite measures for medical, employment, alcohol and other drug use, legal, family, and psychiatric status) were assessed via the *Addiction Severity Index* (ASI; Sobell and Sobell, 1996; McLellan et al., 1992) at pre and post assessment. Drug use during the study was assessed via urine specimens tested

for cocaine, opioids, benzodiazepines, and cannabis and via breathalyzer for alcohol on training and assessment session days.