Abstract

Objective: The current research was conducted to study the effectiveness of Goal Management Training (GMT) in the improvement of sustained attention, prospective memory, and response inhibition in methamphetamine abusers. Method: In a quasi-experimental study, 40 methamphetamine abusers who were in their early recovery period were selected through a random cluster sampling method. They were then randomly assigned into two groups, goal management training plus pharmacotherapy and pharmacotherapy. In order to assess sustained attention, prospective memory, and response inhibition, the researchers used Continuous Performance Test, Prospective and Retrospective Memory Questionnaire, and Stroop Color and Word Test. The data was analyzed by multivariate analysis of variance. Results: The results of the data analysis revealed that there was a significant difference between the two groups in terms of all components of sustained attention and prospective memory ($P<0.05$). Conclusion: The present study showed that goal management training significantly improves sustained attention, response inhibition, and prospective memory in former methamphetamine abusers. These findings suggest the effectiveness of neuropsychological rehabilitations on addiction treatment among methamphetamine users.

Keywords: methamphetamine, goal management training, sustained attention, prospective memory, response inhibition

Effectiveness of Goal Management Training in Sustained Attention, Prospective Memory, and Response Inhibition among Chronic Methamphetamine Users in the Early Abstinence Period

Rezaee, M.; Bigdeli, I.; Makvand Hosseini, S.

Rezaee, M.
Ph.D. Student of Psychology, Semnan University, Semnan, Iran, E-mail: rezaee.maryam63@gmail.com

Bigdeli, I.
Professor of Psychology, Mashhad University, Mashhad, Iran

Makvand Hosseini, S.
Associate Professor of Psychology, Semnan University, Semnan, Iran

Research on Addiction Quarterly Journal of Drug Abuse

Presidency of the I. R. of Iran
Drug Control Headquarters
Department for Research and Education

Vol. 11, No. 41, Spring 2017
http://www.etiadpajohi.ir

Introduction

The existence of cognitive deficiencies, especially the impairment of the executive functioning in methamphetamine users, has been widely investigated in research (Chen et al., 2015; King, Alicata, Cloak & Chang, 2010; London, Kohno, Morales & Ballard, 2015; Henry, Minassian & Perry, 2010). Evidence obtained from clinical and para-clinical studies suggests that the chronic consumption of this narcotic substance leads to a reduction in the volume of the limbic system structures (Simon, Dean, Cordova & Monterosso, 2010; Schwartz et al., 2010). Hippocampal deformation (Kim et al. 2010) and prefrontal lobe dysfunction (Salo, Ursu, Buonocore, Leamon & Carter, 2009) have a devastating effect on executive functions (Scott et al., 2007), which can continue operating even later after the abstinence of methamphetamine use (Johansson et al., 2006). Among the executive functions, some functions, such as sustained attention, prospective memory, and response inhibition undergo more damage than other functions and, accordingly, these functions have been studied more (Shariati et al., 2014; Perna et al. 2014; Nordahl, Salo, & Leamon, 2014).

Sustained attention refers to the ability to maintain a coherent behavioral response while doing repeated and ongoing activities that consists of two components of consciousness and subjective control (Bartolomeo, 2014). In this regard, prospective memory refers to a person's ability to successfully accomplish a delayed intent and involves complex cognitive processes (Kliegel & McDaniel, 2008; Stuss & Levine, 2002). Response inhibition also refers the ability to control thinking, inappropriate feelings or actions (Chambers, Garavan & Bellgrove, 2009) which is largely similar to the underlying mechanisms of suppressing the drug-seeking behaviors and relapse prevention (Smith, Mattick, Jamadar & Iredale, 2014). According to research findings, many methamphetamine users suffer weaknesses in these functions (Wang, Zhou & Chang, 2015; Dean, Groman & Morales, 2013; Weinborn, Woods, Nulsen & Park, 2011; Iudicello, Weber & Grant, 2011; Elm Mehrgerdi, Nowrozzi, Bar, & Akbari, 2012).

Despite the importance of executive functions in individuals' social and cognitive behavior and their decisive role in the continuity of drug abuse, a relatively limited number of valid interventions have addressed the rehabilitation of these functions (Boelen, Allain, Spikman & Fasotti, 2011; Cicerone et al. 2011; Rohling, Faust, Beverly & Demakis, 2009). One of these promising interventions is Goal Management Training (GMT) that has been designed based the theories of goal processing and sustained attention (Robertson & Garavan, 2000) and teaches some strategies to improve attention and conduct training assignments (Stuss & Alexander, 2007). In fact, GMT is a metacognitive intervention in which sustained attention and alerting techniques are used to enhance executive functions (Chen et al., 2011). This intervention will help patients increase their consciousness of their mistakes and be equipped with

some techniques to tackle these mistakes (Bertens, Fasotti, Boelen & Kessels, 2013; Grant, Ponsford & Bennett, 2012).

The positive impacts of this approach on prospective memory, sustained attention, and response inhibition in various clinical populations, including people with brain lesion (Novakovic et al., 2011), local cerebellar damage (Schweizer et al., 2008), encephalitis (Levin Et al., 2000), brain tumors (Metzler-Baddeley & Jones, 2010), and schizophrenia (Levaux et al., 2012) have been well supported. Due to the known defects of sustained attention, response inhibition, prospective memory in methamphetamine users, and also the proven effects of goal management training on the mentioned functions, the implementation of this approach is expected to improve the mentioned defects in these individuals. However, the review of the related literature shows that this approach has not been specifically examined on this group of people, and the initial experiments that had been designed to assess the effectiveness of this approach suffered fundamental procedural pitfalls (Fahmi, 2013). Therefore, in this study, the effect of this method on sustained attention, prospective memory, and response inhibition was examined in the form of a pilot study in the methamphetamine users who were in the early stages of their recovery.

Method

Population, sample, and sampling method

A quasi-experimental along with pre-test/post-test/control group was employed for the conduct of this study. The statistical population of the present study included all the individuals who underwent pharmacotherapeutic treatment in addiction centers or the psychiatric hospital of Tabriz because of methamphetamine abuse disorder. These individuals were in their recovery period at the time of the research. From among this population, 40 methamphetamine abusers were selected through random cluster sampling method. For this purpose, three addiction treatment centers and one psychiatric hospital were randomly selected. After providing general explanation and obtaining the consent of individuals for participation in the research, Continuous Performance Test, Prospective and Retrospective Memory Questionnaire, and Stroop Color and Word Test were administered to all individuals. After scoring these tests and considering the entry and exit criteria, two 20-person groups with the minimum required scores in the aforementioned tests.

The entry criteria of the study were: 1. Satisfaction of the methamphetamine abuse criteria based on diagnostic interview extracted from the fifth version of the Practical and Statistical Manual of Psychological Disorders; 2. Abstinence of methamphetamine use for at least one month and at most three months; 3. Abstinence of methamphetamine use during the research time (through urine test on a weekly basis); 4. Placement in the 18-to-45-year-old age range; 5. Literacy; 6. Consumption of methamphetamine for at least four years with three consecutive relapses. The exit criteria were: 1. IQ less than 80 (based on clinical

interview and psychiatrist's opinion); 2 Use of any psychoactive drug during the research except for the allowed psychiatric drugs used during treatment; 3. Suffering color blindness and attention-deficit hyperactivity disorder; 4. Acquisition of a score greater than 11 in Beck Depression Inventory (second edition); 5. Receipt of other psychiatric treatments at the same time; 6. Suffering psychotic disorders or severe psychiatric disorders based on clinical interview and psychiatrist's diagnosis; 7. Suffering AIDS.

After the selection of 40 participants, they were randomly assigned to two groups, i.e. pharmacotherapy (SD = 3.3, M = 34.9), and GMT plus pharmacotherapy (SD = 3.7, M = 31.9), and relevant interventions were performed on them.

Instrument

1-Persian version of the Continuous Performance Test (CPT): The Persian version of CPT is a software test that consists of two sets of stimuli (Persian numerals, or images), some of which are target stimuli and of the participant is expected to respond by observing them (pressing the key) (Mashhadi, Rasoulzadeh, Tabatabai, Azad-Fallah & Soltani-Far, 2010). The variables obtained from the administration of this test are error of omission (no response to the target stimuli), error of commission (response to non-target stimuli), and reaction time (in milliseconds), which are calculated and stored by computer. The administration of a complete round of this test lasts approximately four minutes. In order to assess the attentional span for a long time, the test was administered four rounds non-stop, which lasted a total of 16 minutes. Hadianfar, Najarian, Shokrkon & Mehrabianzadeh reported the reliability coefficients within the range of 0.59 to 0.93 through re-test method within a 20-day interval. The criterion validity of this test was assessed and the comparison of normal and clinical groups showed a significant difference (Hadianfar, Najarian, Shokrkon, Mehrabizadeh, & Honarmand, 1999).

2. Prospective Memory Questionnaire (PMQ): This questionnaire was designed by Smith, Del Sala, Logie, & Maylor (2000) to assess prospective memory. In this questionnaire, some indexes have been presented in conjunction with environmental or internal clues that provide valuable information about participants' prospective memory. This instrument consists of 16 items and includes 8 subscales pertaining to prospective and retrospective memory. Respondents should rate their difficulties in recalling events or the goals focused on the future and the past on a 5-point scale. The items numbered 1, 3, 5, 7, 10, 12, 14, and 16 belong to prospective memory and the items numbered 2, 4, 6, 8, 9, 11, 13, and 15 measure retrospective memory. Each item receives a score between 1 and 5 and, thereby, the total score is between 16 and 80. Low scores reflect fewer difficulties and higher scores indicate more problems. The reliability of the questionnaire has been reported to be acceptable by using internal consistency, and the Cronbach alpha coefficients of the questionnaire

have also been reported equal to 0.80 and 0.84 for prospective and retrospective memory, respectively (Crawford, Smith, Maylor, Della Sala, & Logie, 2003).

3. Stroop Color and Word Test: Stroop Test, introduced by John Ridley Stroop (1935), is a classic psychological test that measures response inhibition. In this study, the computer version of this test, which included two experimental attempts, was used. The variables obtained from the administration of this test include the number of wrong responses, reaction time, and interference score. The wrong responses and reaction time are calculated separately for congruent and incongruent words. The interference score was also obtained from the subtraction of the reaction time of incongruent words from the reaction time of congruent words. The studies carried out on this test confirm its appropriate reliability and validity in the inhibition measure in different age groups. The reliability of this test has been reported through re-test in the range of 0.8 to 0.9 (Ghara'eapour, Atef-Vahid, Naser Esfahani, Asgharnejad, & Asghari, 2006).

4. Beck Depression Inventory-II: This 21-item questionnaire measures the current severity of depression symptoms (Beck, Steer, & Brown, 1996). Respondents should rate their discomfort from symptoms of depression on a 4-point scale; each item receives a score between 0 and 3 and, thereby, the total score of the scale may range from0 to 63. In this study, the individuals who obtained a score above 11 on this scale (mild depression) were excluded from the research project. The studies conducted to examine the validity of Beck Depression Inventory-II show that this questionnaire enjoys acceptable reliability (VanVoorhis, & Blumentritt, 2007; Carmody, 2005). The internal consistency coefficients of this questionnaire on clinical and non-clinical samples were reported to be equal to 89% and 90%, respectively, and the re-test reliability coefficient of this scale on a non-clinical sample was obtained equal to 0.94 (Kapci et al., 2008).

5. Ishihara Color Plate Test: This tool is a prestigious global test that has been recognized by many ophthalmologists as one of the best screening tests for the detection of blinding (Van Everdingen, Went, Keunen & Osterhuis, 1992) and has an acceptable reliability (Holmes, 2011). Pages in the pertinent book are displayed to individuals in natural light. If a pause for more than 3 seconds to read numbers is repeated more than four times, it indicates a mild blindness color. These pages are included in a booklet whose first page is a witness and can easily be detected in people with and without color blindness. The second to fifth pages are read by normal people as 8, 6, and 29, respectively, while the same numbers are read as 3, 5, and 70, respectively by people with green and red color blindness. Regarding the employment of Stroop Color and Word Test in the current study, the color blindness was considered to be an exit criterion, and people with mild to severe color blindness were excluded from the study.

Procedure

For the implementation of the research plan, two 20-member groups of former methamphetamine users were formed. Both the experimental and control groups completed Stroop test, CPT, prospective memory, color blindness test, and depression test in the pre-test and were interviewed clinically before the assignment of them to each of the groups. The treatment program of the experimental group (objective management training plus pharmacotherapy) included the receipt of methamphetamine abstinence drugs, weekly visits with a psychiatrist, receipt of 10 GMT sessions at a clinic or hospital, and, finally, the post-test administration. The treatment sessions were held twice a week and each session lasted an average of one hour. The control group (pharmacotherapy) was visited once a week by the psychiatrist. These individuals were under methamphetamine treatment by using methadone syrup or pill and, if needed, buprenorphine pill. In order to control the Hawthorne effect, 10 one-hour sessions of psychological health training were considered for this group by the same trainer. Abstinence of methamphetamine use in both groups was investigated by a urine test. Finally, after the completion of the 10 sessions of psychological health training, the post-test was administered to these individuals and multivariate covariance analysis was run for data analysis.

The treatment program of the experimental group (objective management training plus pharmacotherapy) included the receipt of methamphetamine abstinence drugs, weekly visits with a psychiatrist, receipt of 10 GMT sessions at a clinic or hospital, and, finally, the post-test administration. The treatment sessions were held twice a week and each session lasted an average of one hour. The structure of the sessions was as follows.

Table 1: The content of GMT sessions

Sessions	*Content*
First	Introduction and familiarity with the format of the sessions, creation of a therapeutic unity, an introduction to goal management training, administration of Minnesota test
Second	Description of the effects of methamphetamine on cognitive abilities with an emphasis on executive functions, an introduction to the laboratory of the mind, introduction of the concept of slip, discussion around the presence/ absence of mind
Third	Description of automatic behavior, the relationship between automatic acts and slips, the influence of distraction on other abilities, the conditions and consequences of distraction, the employment of goal management training approach to reduce slips and errors
Fourth	Introducing the concept of stopping, teaching how to stop automatic behaviors, mentioning the benefits of stopping daily activities and examining the barriers to practice it, examining the factors affecting sustained attention and preserved concentration
Fifth	Definition of the mind map, mention of how to stop the current behavior and examine the mind map, stay in the current moment and practice of breathing, an introduction to memory types with an emphasis on prospective memory

Table 1: The content of GMT sessions

Sessions	*Content*
Sixth	Definition of goals, teaching how to set goals, introduction of a stop-suspension cycle to examine the component of the performed tasks and the steps taken component by component, focus on breathing with the aim of mindfulness
Seventh	Preparation of a list of tasks in progress, the definition of conflicting goals, the prioritization of conflicting goals, the understanding and perception of emotional reactions to dilemmas, engagement with goals, practice of the stop-suspension cycle to reduce stress and doubts
Eighth	Definition of complicated and challenging goals, teaching how to divide goals to sub-goals, practice of stop-suspension-division cycle
Ninth	Identification of possible errors in the stop-suspension-division cycle, monitoring, an introduction to the concept of habitual responses and response inhibition and their role in the establishment of a stop-suspension cycle, review of the use of stop to monitor the daily assignments, review of the strategies for the increase of mindfulness
Tenth	Review of the key concepts of stop, suspension, division, discussion and wrap-up of the sessions, confrontation with relapse

Results

In this study, three components of errors of omission, error of commission, and reaction time were used to measure sustained attention. To this end, Box's test was first run to examine the assumption of the equality of variance-covariance matrices. The results showed that this assumption has not been fulfilled ($P < 0.05$). Due to the equality of the sample sizes of the two groups, it seems that the test is robust to the violation of this assumption. In addition, Levene's test was run to investigate the equality of error variances. The results of Levene's test indicated that this assumption has been met in all variables ($P > 0.05$). Therefore, multivariate analysis of covariance was run and the results indicated the existence of a significant difference between the two groups in the linear combination of the components (Eta-squared = 0.841; $F = 8.24$; $P < 0.01$; Wilks's Lambda = 0.658). To examine the patterns of difference, univariate analysis of covariance was run using Bonferroni adjusted alpha ($\alpha = 0.044$) and its results are presented in table 1.

Table 1: Comparison of sustained attention components between the experimental and control groups

Variable	*Group*	*Pre-test*	*Post-test*	*F*	*Sig.*	*Eta squared*
Error of omission	Experimental Control	0.27±0.12 0.31±0.14	0.08±0.02 0.24±0.11	20.18	0.0005	0.54
Error of commission	Experimental Control	7.16±5.4 6.9±5.1	2.3±1.8 6.2±9.4	18.17	0.0005	0.48
Reaction time	Experimental Control	716±110 692±104	545±92 778±118	6.7	0.008	0.33

In order to compare the prospective memory components between the experimental and control groups, multivariate covariance analysis should be used. To this end, Box's test was run to examine the assumption of the equality of variance-covariance matrices. The results showed that this assumption has been fulfilled (P> 0.05). In addition, Levene's test was run to investigate the equality of error variances. The results of Levene's test indicated that this assumption has been met (P> 0.05). Therefore, multivariate analysis of covariance was run and the results indicated the existence of a significant difference between the two groups in the linear combination of the components (Eta-squared = 0.761; F = 24.73; P < 0.01; Wilks's Lambda = 0.239). To examine the patterns of difference, univariate analysis of covariance was run using Bonferroni adjusted alpha (α = 0.002) and its results are presented in table 2.

Table 2: Comparison of prospective memory components between the experimental and control groups

Variable	*Group*	*Pre-test*	*Post-test*	*F*	*Sig.*	*Eta squared*
Short-term memory of self	Experimental	5.8±1.9	2.3±0.6	6.5	0.001	0.674
	Control	5.5±1.7	5.5±1.7			
Short-term memory of environment	Experimental	5.1±1.5	2.1±0.5	5.9	0.001	0.697
	Control	4.9±1.3	4.7±1.2			
Long-term memory of self	Experimental	5.4±1.7	1.9±0.5	5.3	0.001	0.655
	Control	5.3±1.5	5.1±1.3			
Long-term memory of environment	Experimental	5.7±1.8	½±0.7	6.1	0.001	0.744
	Control	5.7±1.9	5.5±1.7			

In order to evaluate the effectiveness of goal management training in the improvement of response inhibition, multivariate covariance analysis should be used. To this end, Box's test was run to examine the assumption of the equality of variance-covariance matrices. The results showed that this assumption has been fulfilled (P> 0.05). In addition. Levene's test was run to investigate the equality of error variances. The results of Levene's test indicated that this assumption has been met (P> 0.05). Therefore, multivariate analysis of covariance was run and the results indicated the existence of a significant difference between the two groups in the linear combination of the components (Eta-squared = 0.75; F = 17.41; P < 0.01; Wilks's Lambda = 0.250). To examine the patterns of difference, univariate analysis of covariance was run and its results are presented in table 3.

Table 3: Comparison of Stroop Test between the experimental and control groups

Variable	*Group*	*Pre-test*	*Post-test*	*F*	*Sig.*	*Eta squared*
Number of errors in congruent stimuli	Experimental	0.55±0.60	0.25±0.44	17.87	0.0005	0.351
	Control	0.40±0.50	0.35±0.48			
Number of errors in incongruent stimuli	Experimental	5.90±2.57	2.90±1.20	39.633	0.0005	0.697
	Control	5.75±2.51	5.45±2.41			
Reaction time in congruent stimuli	Experimental	975±102	1221±123	1.975	0.169	0.655
	Control	1084±116	1081±119			
Reaction time in incongruent stimuli	Experimental	1265±126	1343±102	2.21	0.147	0.744
	Control	1318±118	1320±117			
Interference score	Experimental	289±57.27	269±53.13	0.071	0.791	0.002
	Control	265±52.45	258±50.19			

As it has been shown in Table 3, there are significant differences between the two groups in terms of the number of errors in congruent and incongruent stimuli. The number of errors in congruent and incongruent stimuli in the experimental group was significantly lower than that in the control group ($P < 0.001$).

Discussion and Conclusion

The aim of this study was to investigate the effectiveness of Goal Management Training (GMT) in the improvement of sustained attention, prospective memory, and response inhibition in methamphetamine abusers. According to the obtained findings, this therapeutic approach improved all three of these functions. This finding is in line with the results of studies conducted by Mahomed (2015), Krasny-Pacini et al (2014), and Fahmi (2013). Alfonso, Caracuel, Delgado-Pastor & Verdejo-García (2011) found that the participation in GMT significantly improved response inhibition and reduced the difficulties of working memory and decision-making compared with the standard treatment of addiction. Levin et al. (2011) also found that the employment of GMT approach would lead to the significant enhancement of sustained attention. This approach also improves the visual-spatial capability and, in total, supports the effectiveness of goal management training in the promotion of executive functions. In sum, the related studies at our disposal all confirmed the positive effects of goal management training on impaired executive functions, and no inconsistent results were found.

To interpret these findings, it can be argued that since neuro-cognitive exercises increase the levels of dopamine and D1 receptor binding in the cerebral and parietal cortex (McNab et al., 2009), these exercises also tackle the dopaminergic system disorders in methamphetamine users and improve their executive functions (Carroll, 2001). The long-term abuse of methamphetamine has a deleterious effect on the dopaminergic system, and this deficiency is the

root of the majority of the cognitive disorders observed in methamphetamine users and is also the biggest barrier to treatment (Ares-Santos et al., 2014; Parsegian, & See, 2014; Ares-Santos, Granado, & Moratalla, 2013).

Imaging data have also shown that cognitive rehabilitation normalizes prefrontal cortex activity and improves the brain function system and brings about structural changes in the white and gray cortex (Wexler, Anderson, Fulbright, & Gore, 2000). In addition, cognitive tasks prescribe the conduct of behaviors similar to the damaged ones and this leads to the activation of neuroanatomical regions that are similar to the damaged areas; thus, it compensates for the disturbed functions (Kleim, & Jones, 2008). Based on research evidence, learning, experience, and practice bring about changes in the sensory cortex and motor representations. Here, the underlying mechanisms of such changes are the foundation of the behavioral effects of rehabilitation therapies (Kolb, 2013; Duffau, 2006). Goal management training also organizes the representation of related and unrelated information that is encoded in the forehead cortex in addition to impacting the brain processes associated with goal management (Chen et al., 2011). Such a mechanism results in an increase in the rate of nerve-related shootings associated with the goal and also leads to a reduction in the frequency of unrelated nerve shots (Laatsch et al., 2004).

In addition to the plastic changes of the brain, the improved performance monitoring and compatibility with the task (which are in line with the specific objectives of goal management training) lead to the reduction of the omission error and commission error in the continuous performance test, and this results in the improvement of sustained attention (Dutilh et al., 2012). Additionally, the cessation of the current behavior and de-automatization of the behavior (which are the main strategies of goal management training) prevent the issuance of impulsive and habitual responses, reduce impulsivity, and improve response inhibition (Diemen, Szobot, Kessler & Pechansky, 2007; Malloy-Diniz et al., 2008). This finding is consistent with the theoretical assumption that goal management training addresses the underlying aspects of attention control (Levine et al., 2000). In this protocol, some exercises have been designed to facilitate the suspension of current behavior, the improvement of the maintenance of relevant information, and, then, management of the sequence of required steps to achieve and complete the goals. These exercises, in addition to promoting attention, suppress habitual and automatic behaviors and simultaneously reinforce response inhibition and sustained attention, which hold common infrastructure mechanisms (Fassbender et al., 2004).

The other finding of this research was the effectiveness of goal management training in the improvement of methamphetamine users' prospective memory. To explain this finding, one can argue that the concept of mind map and the method of stopping-thinking in this approach have taught participants to review their intentions periodically. This leads to the more effective switching of attention between internal and external cognition and, as a result, it improves the

prospective memory of the self and the environment. On the other hand, the word "stop" can be considered as a kind of clue and sign, which facilitates the recall and preservation of prospective intentions in addition to suppressing automatic responses (Levine, & Downey-Lamb, 2002; Manly, Hawkins, Evans, Woldt, & Robertson, 2002).

The present study, conducted in the form of a pilot study, indicated that goal management training leads to the improvement of sustained attention, prospective memory, and response inhibition among amphetamine users. These findings indicate the effect of this approach on addicted people's cognitive aspects, the reversibility of prefrontal cortex deficiencies, and impairment in patients' executive function. Of course, the approach should be used with caution. Since executive functions are associated with such valid bio-indexes as blood flow in the frontal lobe and brain waves, it is suggested that future studies include brain imaging techniques and examine these indexes.

One of the most important limitations of the present study pertains to the generalizability of the results that has emerged due to the lack of control over the dose of the drug use, the duration of the abuse, and the history of consuming alcohol or other drugs by the patients. Therefore, it is recommended that these factors be controlled by appropriate measures in future research.

Reference

Alfonso, J. P., Caracuel, A., Delgado-Pastor, L. C., & Verdejo-García, A. (2011). Combined goal management training and mindfulness meditation improve executive functions and decision-making performance in abstinent poly-substance abusers. *Drug and alcohol dependence*, *117*(1), 78-81.

Ares-Santos, S., Granado, N., & Moratalla, R. (2013). The role of dopamine receptors in the neurotoxicity of methamphetamine. *Journal of internal medicine*, *273*(5), 437-453.

Ares-Santos, S., Granado, N., Espadas, I., Martinez-Murillo, R., & Moratalla, R. (2014). Methamphetamine causes degeneration of dopamine cell bodies and terminals of the nigrostriatal pathway evidenced by silver staining. *Neuropsychopharmacology*, *39*(5), 1066-1080.

Bartolomeo, P. (2014). The attention systems of the human brain. In *Attention Disorders after Right Brain Damage* (pp. 1-19). Springer London.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). Beck depression inventory-II. *San Antonio, TX*, 78204-2498.

Bertens, D., Fasotti, L., Boelen, D. H., & Kessels, R. P. (2013). A randomized controlled trial on errorless learning in goal management training: study rationale and protocol. *BMC neurology*, *13*(1), 64.

Boelen, D. H., Allain, P., Spikman, J. M., & Fasotti, L. (2011). Script generation and the dysexecutive syndrome in patients with brain injury. *Brain injury*, *25*(11), 1091-1100.

Carmody, D. P. (2005). Psychometric characteristics of the Beck Depression Inventory-II with college students of diverse ethnicity. *International Journal of Psychiatry in Clinical Practice*, 9 (1), 22-/28.

Carroll, K. M. (2001). Combined treatments for substance dependence.

Chambers, C. D., Garavan, H., & Bellgrove, M. A. (2009). Insights into the neural basis of response inhibition from cognitive and clinical neuroscience.*Neuroscience & biobehavioral reviews*, *33*(5), 631-646.

Chen, A. J. W., Novakovic-Agopian, T., Nycum, T. J., Song, S., Turner, G. R., Hills, N. K., ... & D'Esposito, M. (2011). Training of goal-directed attention regulation enhances control over neural processing for individuals with brain injury. *Brain*, *134*(5), 1541-1554.

Chen, C. K., Lin, S. K., Chen, Y. C., Huang, M. C., Chen, T. T., Ree, S. C., & Wang, L. J. (2015). Persistence of psychotic symptoms as an indicator of cognitive impairment in methamphetamine users. *Drug and alcohol dependence*, *148*, 158-164.

Cicerone, K. D., Langenbahn, D. M., Braden, C., Malec, J. F., Kalmar, K., Fraas, M., ... & Ashman, T. (2011). Evidence-based cognitive rehabilitation: updated review of the literature from 2003 through 2008. *Archives of physical medicine and rehabilitation*, *92*(4), 519-530.

Crawford, J., Smith, G., Maylor, E., Della Sala, S., & Logie, R. (2003). The Prospective and Retrospective Memory Questionnaire (PRMQ): Normative data and latent structure in a large non-clinical sample. *Memory*, *11*(3), 261-275.

Dean, A. C., Groman, S. M., Morales, A. M., & London, E. D. (2013). An evaluation of the evidence that methamphetamine abuse causes cognitive decline in humans. *Neuropsychopharmacology*, *38*(2), 259-274.

Diemen, L. V., Szobot, C. M., Kessler, F., & Pechansky, F. (2007). Adaptation and construct validation of the Barratt Impulsiveness Scale (BIS 11) to Brazilian Portuguese for use in adolescents. *Revista Brasileira de Psiquiatria*,*29*(2), 153-156.

Duffau, H. (2006). Brain plasticity: from pathophysiological mechanisms to therapeutic applications. *Journal of clinical neuroscience*, *13*(9), 885-897.

Dutilh, G., Vandekerckhove, J., Forstmann, B. U., Keuleers, E., Brysbaert, M., & Wagenmakers, E. J. (2012). Testing theories of post-error slowing.*Attention, Perception, & Psychophysics*, *74*(2), 454-465.

Fahmi, H. (2013). *Goal Management Training: A Web-Based Approach* (Doctoral dissertation), University of Toronto.

Fassbender, C., Murphy, K., Foxe, J. J., Wylie, G. R., Javitt, D. C., Robertson, I. H., & Garavan, H. (2004). A topography of executive functions and their interactions revealed by functional magnetic resonance imaging. *Cognitive Brain Research*, *20*(2), 132-143.

Ghara'eapour, M., Atef-Vahid, M., Naser Esfahani, M., Asgharnejad, F., & Asghari, A. (2006). Neuropsychological functions in suicide attempters with major depressive disorder, *Iranian Journal of Psychiatry and Clinical Psychology (Thought & Behavior)*, 12 (4), 346-352.

Grant, M., Ponsford, J., & Bennett, P. C. (2012). The application of Goal Management Training to aspects of financial management in individuals with traumatic brain injury. *Neuropsychological rehabilitation*, *22*(6), 852-873.

Groman, S. M., Morales, A. M., Lee, B., London, E. D., & Jentsch, J. D. (2013). Methamphetamine-induced increases in putamen gray matter associate with inhibitory control. *Psychopharmacology*, *229*(3), 527-538.

Hadianfar, H., Najarian, B., Shokrkon, H., & Mehrabizadeh Honarmand, M. (1999). Preparation and Construction of Persian Form of Continuous Performance Test, *Journal of Psychology*, 4 (4), 388-404.

Henry, B. L., Minassian, A., & Perry, W. (2010). Effect of methamphetamine dependence on everyday functional ability. *Addictive behaviors*, *35*(6), 593-598.

Holmes, W. (2011). Colour vision testing: what can be achieved in everyday practice? *Optima Practice*, *12*, 167-178.

Iudicello J. E., Weber E., Grant I., Weinborn M., Woods S. P. (2011). The HIV Neurobehavioral Research Center (HNRC) Group. Misremembering future intention in methamphetamine dependent individuals. *The Clinical Neuropsychologist*. 25, 269–286.

Johanson, C. E., Frey, K. A., Lundahl, L. H., Keenan, P., Lockhart, N., Roll, J., ... & Schuster, C. R. (2006). Cognitive function and nigrostriatal markers in abstinent methamphetamine abusers. *Psychopharmacology*, *185*(3), 327-338**.**

Kapci, E. G., Uslu, R., Turkcapar, H., & Karaoglan, A. (2008). Beck Depression Inventory II: Evaluation of the psychometric properties and cut-off points in a Turkish adult population, *Depression and Anxiety*, 25, 104–110.

Kim YT, Lee JJ, Song HJ, Kim JH, Kwon DH, Kim MN *et al* (2010). Alterations in cortical activity of male methamphetamine abusers performing an empathy task: fMRI study. *Hum Psychopharmacol* 25, 63–70.

King, G., Alicata, D., Cloak, C., & Chang, L. (2010). Neuropsychological deficits in adolescent methamphetamine abusers. *Psychopharmacology*, *212*(2), 243-249.

Kleim, J. A., & Jones, T. A. (2008). Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. *Journal of speech, language, and hearing research*, *51*(1), S225-S239.

Kliegel, M., & McDaniel, M. A. (2008). Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives. *Taylor & Francis*.

Kolb, B. (2013). *Brain plasticity and behavior*. Psychology Press.

Krasny-Pacini, A., Limond, J., Evans, J., Hiebel, J., Bendjelida, K., & Chevignard, M. (2014). Context-sensitive goal management training for everyday executive dysfunction in children after severe traumatic brain injury.*The Journal of head trauma rehabilitation*, *29*(5), E49-E64.

Laatsch, L. K., Thulborn, K. R., Krisky, C. M., Shobat, D. M., & Sweeney, J. A. (2004). Investigating the neurobiological basis of cognitive rehabilitation therapy with fMRI. *Brain injury*, *18*(10), 957-974.

Levaux, F., Larøi, M., Malmedier, I., Meyer, J., Danion, M., & M. Van der Linden, M. (2012). Rehabilitation of Executive Functions in a Real-Life Setting: Goal Management Training Applied to a Person with Schizophrenia, *Case Reports in Psychiatry*, 15, 30-45.

Levin, B., Schewizer, T.A., O'Connor, C., Turner, G., Gillingham, S., Manly, T., & Robertson, I.A. (2011). Rehabilitation of executive functioning in patients with frontal lobe brain damage with goal management training. *Frontiers in Human Neuroscience*, 5(9), 36-44.

Levine, B., & Downey-Lamb, M. (2002). Design and evaluation of intervention experiments. *Neuropsychological interventions: Emerging treatment and management models for neuropsychological impairments*, 80-104.

Levine, B., Robertson, I. H., Clare, L., Carter, G., Hong, J., Wilson, B. A., ... & Stuss, D. T. (2000). Rehabilitation of executive functioning: An experimental–clinical validation of goal management training. *Journal of the International Neuropsychological Society*, *6*(03), 299-312.

London, E. D., Kohno, M., Morales, A. M., & Ballard, M. E. (2015). Chronic methamphetamine abuse and cortico-striatal deficits revealed by neuroimaging. *Brain research*, *1628*, 174-185.

Mahomed, A. (2015). *Rehabilitation of executive functioning following pediatric traumatic brain injury: evaluating a goal management training intervention* (Doctoral dissertation, University of Cape Town).

Malloy-Diniz, L. F., Leite, W. B., Moraes, P. H. P. D., Correa, H., Bechara, A., & Fuentes, D. (2008). Brazilian Portuguese version of the Iowa Gambling Task: transcultural adaptation and discriminant validity. *Revista Brasileira de Psiquiatria*, *30*(2), 144-148.

Manly, T., Hawkins, K., Evans, J., Woldt, K., & Robertson, I. H. (2002). Rehabilitation of executive function: facilitation of effective goal management on complex tasks using periodic auditory alerts. *Neuropsychologia*, *40*(3), 271-281.

Mashhadi, A., Rasoulzadeh Tabatabai, K., Azad-Fallah, P., & Soltani-Far, A. (2010). Comparison of response inhibition and interference control between children with attention deficit hyperactivity disorder and normal children, *Journal of Clinical Psychology*, 11 (1), 151-170.

McNab, F., Varrone, A., Farde, L., Jucaite, A., Bystritsky, P., Forssberg, H., & Klingberg, T. (2009). Changes in cortical dopamine D1 receptor binding associated with cognitive training. *Science*, *323*(5915), 800-802.

Mehrjerdi, Z., Noroozi, A., Barr, A.M., Ekhtiari, H. (2012). Attention deficits in chronic methamphetamine users as potential target for enhancing treatment efficacy. *Basic Clincal Neuroscience*; 3:5–14.

Metzler-Baddeley, C., & Jones, R. W. (2010). Brief communication: cognitive rehabilitation of executive functioning in a case of craniopharyngioma. *Applied neuropsychology*, *17*(4), 299-304.

Nordahl, T. E., Salo, R., & Leamon, M. (2003). Neuropsychological effects of chronic methamphetamine use on neurotransmitters and cognition: a review. *The Journal of neuropsychiatry and clinical neurosciences*, *15*(3), 317-325.

Novakovic-Agopian, T., Chen, A. J. W., Rome, S., Abrams, G., Castelli, H., Rossi, A., ... & D'Esposito, M. (2011). Rehabilitation of executive functioning with training in attention regulation applied to individually defined goals: a pilot study bridging theory, assessment, and treatment. *The Journal of head trauma rehabilitation*, *26*(5), 325-338.

Parsegian, A., & See, R. E. (2014). Dysregulation of dopamine and glutamate release in the prefrontal cortex and nucleus accumbens following methamphetamine self-administration and during reinstatement in rats. *Neuropsychopharmacology*, *39*(4), 811-822.

Perna, E. D. S. F., Theunissen, E. L., Kuypers, K. P. C., Heckman, P., de la Torre, R., Farre, M., & Ramaekers, J. G. (2014). Memory and mood during MDMA intoxication, with and without memantine pretreatment. *Neuropharmacology*, *87*, 198-205.

Robertson, I. H., and Garavan, H. (2000). "Vigilant attention," in *The New Cognitive Neurosciences*, ed. M. Gazzaniga (Cambridge, MA: MIT Press), 563–578.

Rohling, M. L., Faust, M. E., Beverly, B., & Demakis, G. (2009). Effectiveness of cognitive rehabilitation following acquired brain injury: a meta-analytic re-examination of Cicerone et al.'s (2000, 2005) systematic reviews. *Neuropsychology*, *23*(1), 20

Salo, R., Ursu, S., Buonocore, M. H., Leamon, M. H., & Carter, C. (2009). Impaired prefrontal cortical function and disrupted adaptive cognitive control in methamphetamine abusers: a functional magnetic resonance imaging study. *Biological psychiatry*, *65*(8), 706-709.

Schwartz DL, Mitchell AD, Lahna DL, Luber HS, Huckans MS, Mitchell SH *et al* (2010). Global and local morphometric differences in recently abstinent methamphetamine-dependent individuals. *Neuroimage* 50: 1392–1401.

Schweizer, T. A., Levine, B., Rewilak, D., O'Connor, C., Turner, G., Alexander, M. P., ... & Stuss, D. T. (2008). Rehabilitation of executive functioning after focal damage to the cerebellum. *Neurorehabilitation and Neural Repair*, *22*(1), 72-77.

Scott, J. C., Woods, S. P., Matt, G. E., Meyer, R. A., Heaton, R. K., Atkinson, J. H., & Grant, I. (2007). Neurocognitive effects of methamphetamine: a critical review and meta-analysis. *Neuropsychology review*, *17*(3), 275-297.

Shariati, M. B. H., Sohrabi, M., Shahidi, S., Nikkhah, A., Mirzaei, F., Medizadeh, M., & Asl, S. S. (2014). Acute effects of ecstasy on memory are more extensive than chronic effects. *Basic and clinical neuroscience*, *5*(3), 225.

Simon, S. L., Dean, A. C., Cordova, X., Monterosso, J. R., & London, E. D. (2010). Methamphetamine Dependence and Neuropsychological Functioning: Evaluating Change During Early Abstinence*. *Journal of studies on alcohol and drugs*, *71*(3), 335-344.

Smith, G., Del Sala, S., Logie, R. H., & Maylor, E. A. (2000). Prospective and retrospective memory in normal ageing and dementia: A questionnaire study. *Memory*, *8*(5), 311-321.

Smith, J. L., Mattick, R. P., Jamadar, S. D., & Iredale, J. M. (2014). Deficits in behavioral inhibition in substance abuse and addiction: a meta-analysis. *Drug and alcohol dependence*, *145*, 1-33.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of experimental psychology*, *18*(6), 643.

Stuss, D. T., & Alexander, M. P. (2007). Is there a dis executive syndrome? *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *362*(1481), 901-915.

Stuss, D. T., & Levine, B. (2002). Adult clinical neuropsychology: lessons from studies of the frontal lobes. *Annual review of psychology*, *53*(1), 401-433.

van Everdingen, J. A., Went, L. N., Keunen, J. E., & Osterhuis, J. A. (1992). X linked progressive cone dystrophy with specific attention to carrier detection. *Journal of medical genetics*, *29*(5), 291-294.

VanVoorhis, C. R. W., & Blumentritt, T. L. (2007). Psychometric properties of the Beck Depression Inventory-II in a clinically-identified sample of Mexican American adolescents. *Journal of Child and Family Studies*, *16*(6), 789-798.

Wang, D., Zhou, C., & Chang, Y. K. (2015). Acute exercise ameliorates craving and inhibitory deficits in methamphetamine: An ERP study. *Physiology & behavior*, *147*, 38-46.

Weinborn, M., Paul Woods, S., Nulsen, C., & Park, K. (2011). Prospective memory deficits in Ecstasy users: Effects of longer ongoing task delay interval. *Journal of clinical and experimental neuropsychology*, *33*(10), 1119-1128.

Wexler, B. E., Anderson, M., Fulbright, R. K., & Gore, J. C. (2000). Preliminary evidence of improved verbal working memory performance and normalization of task-

related frontal lobe activation in schizophrenia following cognitive exercises. *American Journal of Psychiatry, 157*(10), 1694-1697.