# THE EFFECT OF COGNITIVE TRAINING ON IMPULSE CONTROL AMONG METHAMPHETAMINE ADDICTS IN THE WESTERN CAPE

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## ABSTRACT

Substance use addiction is a debilitating and destructive human disorder that affects millions of people worldwide. Of all the provinces in South Africa, the Western Cape has the highest rate of MA use. This highly addictive stimulant, locally known as 'tik', has multiple physiological, psychological, and social effects on the user. The effects are associated with neurocognitive deficits that include deficiencies in working memory and high rates of delay discounting. Current neuropsychopharmacology literature seems to suggest that changes in neurotransmitter functioning and particular brain areas occur that contribute to some of the addictive behaviours associated with chronic MA use. New evidence is emerging that working memory training can help to improve rates of impulsivity in those addicted to MA by strengthening cognitive control**.** The aim of this project was to establish whether differences in impulse control existed in a sample of 33 male patients at a Western Cape drug rehabilitation centre who received either working memory training with standard drug rehabilitation and or standard drug rehabilitation only. Data was collected with a self-report impulsivity scale (BIS – 11) and analysed using inferential statistics. The results suggest that working memory training, when paired with a standard rehabilitation program, has superior effects in decreasing self-reported rates of impulsivity when compared to standard rehabilitation only. These findings suggest that working memory training may serve as a useful addition to improving impulsivity rates in MA rehabilitation treatment. Further research on a larger scale is required to investigate the findings of this project.

**DECLARATION**

I hereby declare that *The Effect of Cognitive Training on Impulse Control among Methamphetamine Addicts in the Western Cape* is my own work in its entirety, that I have not submitted it before for any degree or examination in any other university, and that I have indicated and acknowledged all sources used or quoted as complete references.

Gert J. E. Coetzee

Signed: _____

Date: 17 October 2016

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Substance use addiction is a debilitating and destructive human disorder that affects millions of people worldwide (United Nations Office of Drug and Crime, UNODC, 2015). It is as a relentless state in which there is a decreased ability to control compulsive drug seeking and consumption irrespective incorrigible of the danger of damaging consequences (Bellamoli et al. 2014). Within the spectrum of possible drugs of abuse, methamphetamine (MA) is the second most commonly abused illicit drug in the world; second only to cannabis (Tolliver et al. 2012). Globally, between 14.3 million and 52.5 million adults use MA and other amphetamine-type stimulants for non-medical reasons (United Nations Office of Drug and Crime, UNODC, 2012). This highly addictive drug had a marked increase in global seizures between the year 2008 and 2010 and users consumed it at higher levels than heroin and cocaine combined (Hart, Marvin, Silver & Smith, 2012). These estimates are a cause of great concern since MA abuse has disastrous personal, social, economic, health, and educational consequences.

In South Africa, MA use has been on an incline during the last decade with slight decreases seen since 2010 (United Nations Office of Drug and Crime, UNODC, 2015). For example, between 2004 and 2006 increases in treatment admissions for methamphetamine-related complications in Cape Town reflect the most rapid surge in admissions for a specific drug ever recorded in South Africa (Plüddemann, Plüddemann, Myers & Parry, 2008). Of all the provinces in South Africa, the Western Cape has the highest rate of MA use (Watt et al. 2013). This highly addictive stimulant, locally known as “tik”, has multiple physiological,

psychological, and social effects on the user, and is associated with increased risk of mental health problems, global neuropsychological impairment, and cognitive defects (May, et al. 2013). These impairments and defects relate to memory, executive functioning, attention, and more specifically, neurocognitive deficits that include deficiencies in working memory and high rates of delay discounting (Tolliver et al. 2012).

Current research understands MA and other psychoactive drug addictions as a brain disorder. This is due to the altered brain functions associated with the long-term use of the psychoactive drugs (United Nations Office of Drug and Crime, UNODC, 2004). These alterations affect perceptions, emotional, and motivational processes and, when drug abuse takes over the individual's ability to apply self-control, can become seriously dysfunctional (Volkow, 2010). Therefore, an understanding of the effects of drugs on the brain advances our understanding on how it affects human behaviour. Initially, individuals may use MA for a variety of social, cultural, and psychological reasons but, once users expose their brain and body to MA, fundamental physiological and psychological changes begin to occur (Rawson, Gonzales & Brethen, 2002). Since behaviour and thoughts are produced by the working of the brain, a dysfunction brought on by MA results in complex behavioural symptoms linked to judgement, decision making, learning and memory, and behaviour control (Volkow, 2010). The changes that alter the functioning of the brain may explain the compulsive and destructive behaviours of addiction.

One of the biggest threats to the treatment efficacy of MA use disorders is relapse. Relapse is a persistent process of returning to addictive behaviours after a period of abstinence or restraint (Witkiewitz, Lustyk & Bowen, 2013). In a traditional sense relapse is understood as a discrete event or end of state, although some argue that this view liken brief 'slips' with complete relapse, blocking out important differences in process and outcomes (Brandon, Vidrine, & Litvin, 2007). A 'slip' or complete relapse is because of over-learned habits with

biological, psychological, and social determinants. These behaviours are characterised by the provision of immediate rewards that increase pleasure and/or decrease pain, thereby maintaining their excessive frequency, intensity, and duration, despite the delayed negative consequences that can be long lasting and severe (Brandon et al. 2007). This study identifies relapse as going back to drugs, even once (Marlatt, Parks & Witkiewitz, 2002).

Current neuropsychopharmacology literature seems to suggest that changes in neurotransmitter functioning and particular brain areas occur that contribute to some of the addictive behaviours associated with chronic MA use (Hart et al. 2012 & Recinto et al. 2012). These structural and neurochemical alterations, specifically in the frontostriatal brain circuitry, may contribute to consistently observed impairments in several cognitive domains (Tolliver et al. 2012). Certain neuropsychological profiles reflect the impairments that play a key function in the process of relapse, i.e. impulsivity, cognitive inhibition, and poor working memory. This seems to indicate that the brain regions associated with the impairments requires strengthening in order to regain cognitive control, thereby increasing the ability to delay gratification.



Multiple treatment methods exist for MA use disorder but within each treatment context, relapse continues to threaten the recovery process from addiction (Brandon et al. 2007). This could be due to deficits in memory, perceptual motor speed, inhibition, problem solving, mentalisation, abstract thinking, and mental flexibility that continue during abstinence (Simon, Dacey, Glynn, Rawson & Ling, 2004). Several treatments like self-help relapse prevention, cognitive behaviour therapy, motivational interviewing, contingency management, cue exposure therapy, and the Gorski's Centre of Applied Sciences model have been developed but the first three seem most effective (Sofuoglu, De Vito, Waters & Carroll, 2013). One of the reasons might be due to the inability of those who seek treatment from MA addiction to retain the treatment content because of cognitive deficits brought about by chronic MA use (Vocci,

2008). In fact, Vocci (2008) postulates cognitive impairment in MA addicts is at its highest during the initial stages of treatment, which makes cognitive processing and retention difficult.

Garavan, Brennan, Hester, and Whelan (2013) suggests that the recovery process is twofold: the first is the active process of abstaining from drug use, and the second is the restoration of function that arises from the brain's ability to repair itself once the neurotoxic influences of drugs of abuse desist. However, during this time of reparation treatment might have low success due to cognitive deficits (Fals-Stewart & Lam, 2010). Certain studies have shown that cognitive enhancement, rehabilitation, or training strategies can stimulate the brain in ways that increase chances of preventing relapse by promoting treatment content retention and recall (Fals-Stewart & Lam, 2010; Vocci, 2008). Research on the efficacy of behavioural therapies (Sofuoglu et al. 2013; Zgierska et al. 2009) has highlighted the importance of cognitive control network integrity and specifically, working memory skills, to maintaining abstinence. The studies stresses that cognitive training interventions are methods of stimulating certain brain networks implicated in impulse control, a key cognitive process for preventing relapse. This project will examine cognitive training and its effect impulsivity in those with a history of MA dependence. It forms part of a larger research study conducted by researchers from the University of Cape Town (UCT).



**1.2 Rationale**

New evidence is emerging that working memory training can help to improve rates of impulsivity in those addicted to MA by strengthening cognitive control (Bickel, Yi, Landers, Hill, & Baxter, 2011). Currently, a brain imaging research study is underway to identify the areas of the brain implicated in working memory performance specifically with a population with a history of MA use. The study incorporated cognitive training, using a working memory task over 20 sessions, to establish whether it strengthened cognitive inhibition systems in the

brain, including impulsivity. This embedded project examines whether exposure to 20-session of cognitive training in addition to standard drug rehabilitation improved impulsivity rates in 28 MA addicts six weeks after admission and 2-years after their discharge from an inpatient drug treatment facility in Cape Town, South Africa. A well-researched and established impulsivity measurement tool is utilised in the examination of the changes in impulsivity rates of the MA addicts over the course of two years.

### 1.3 Aims and objectives

#### 1.3.1 Aims of the study:

The primary aim of this study was to establish whether differences in impulse control existed between those who received cognitive training with standard drug rehabilitation (cognitive training group or CTG) and those who received standard drug rehabilitation only (rehab group or RG). The secondary aim was to identify whether the effects of the drug rehabilitation and cognitive training showed durability after a 2-year follow-up.



#### 1.3.2 Objectives of the study:

The objectives of the study were to determine:

a) whether four weeks of standard drug rehabilitation with cognitive training can decrease impulsivity at a greater rate compared to four weeks of standard drug rehabilitation only.
b) whether six weeks of standard drug rehabilitation with four weeks of cognitive training have lasting significant effects (durability) on impulsivity compared to six weeks of standard drug rehabilitation only.
c) whether four weeks of standard drug rehabilitation can significantly decrease impulsivity after four weeks.

d) whether six weeks of standard drug rehabilitation has lasting effects (durability) on impulsivity two years after discharge from drug rehab.
e) whether four weeks of standard drug rehabilitation with four weeks of cognitive training can significantly decrease impulsivity after four weeks.
f) whether six weeks of standard drug rehabilitation with four weeks cognitive training has lasting effects (durability) on impulsivity two years after discharge from drug rehab.

**1.4 Definition of concepts**

Several concepts central to this study require some definition and elaboration in order to ensure enhanced clarity and understanding.

Cognitive training: For the purpose of this project, cognitive training will refer to an experimental treatment method that provides training of target cognitive abilities, specifically working memory. The training began two weeks after admission to the drug treatment facility, and lasted for four consecutive weeks.



Impulsivity rate: This term refers to the impulsivity scale's unit of measurement. For example, decreases in impulsivity rates suggest that there are increases or improvements in impulse control and vice versa.

Standard drug rehabilitation: In this project, standard drug rehabilitation will refer to the rehab program that the drug treatment facility offered at the where the participants for this project was recruited and tested.

Drug addiction: For the purpose of this project, the terms drug addiction, substance dependence, and substance use disorder (used interchangeably throughout this report) all refer to the state

of being addicted to drugs, i.e. being physically and/or psychologically dependent on an addictive substance such as methamphetamine or heroin.

Impulsivity: In this project, impulsivity is defined as "a predisposition towards rapid, unplanned reactions to internal and external stimuli without regard for the negative consequences of these reactions to themselves or others" (Koob, 2009). For the purposes of this report, the terms impulsivity and impulsive behaviour are used interchangeably.

Embedded research study: This project forms part of a larger research study that primarily focusses on neuroimaging, as described later. In an attempt to promote clarity, the larger study to which this project is connected will be referred to as the primary research study while this project will be referred to as "project" or "research project".


**1.5 Thesis report format**

This report follows a logical order in an attempt to guide the reader through the complete research project. Chapter 2 presents a literature review and discusses literature relevant to this study by looking specifically at drug addiction, MA and the brain, impulsivity and compulsivity, delay discounting and working memory, and brain training to decrease delay discounting. Additionally, the chapter also presents the theoretical frameworks underlying the study. Chapter 3 describes the methodology of the project by presenting the hypotheses, research design, procedure, participants, data collection instruments, data analysis methods, and ethical considerations. Chapter 4 presents the quantitative data analysis and results relevant to this project while chapter 5 presents the discussion of the results in relation to the project hypotheses. Chapter 5 includes a section on the implications of the results on clinical practice and theory, a section on the limitations of this project, and presents several recommendations for future research.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

The aim of this literature review is to provide a review of the relevant literature to the field of substance addiction and treatment. This section will review studies in the arena of addiction, and more specifically, MA addiction, and will cover concepts such as neurobiology of addiction, delay discounting, working memory, cognitive control, and cognitive training. It will investigate the links between these topics and will highlight the importance of establishing a connection between cognitive training and its effect on impulsivity as a treatment option in MA dependence.



## 2.2 Drug Addiction

During the 1930's, drug addiction was believed to be due to a flawed morality and a lack of will power. Due to advancements in science, scientific research understands drug addiction more clearly as a brain disease (Bellamoli et al. 2014). Research describes it as a brain disease as drugs change the structure and function of the brain to the extent that it may result in damaging behaviours (Volkow, 2010). It is true that not all drugs have the same effects on the brain, but certain types of drugs, more specifically, psychoactive drugs, can severely disrupt the brain in several ways, resulting in addictive behaviour, a well-known feature of drug addiction (Brick & Erickson, 2013; United Nations Office of Drug and Crime, UNODC, 2015).

The transition towards addiction occurs when the chemical properties of psychoactive drugs disrupt the brain's neural systems, structures, and chemical compositions responsible for activating the capacity to choose according to long-term as opposed to short-term outcomes

(Noël, Brevers & Bechara, 2013; Rawson, Rachel & Brethen, 2002). When individuals habitually expose their bodies to the pharmacological effects of psychoactive substances, they become biologically dependent and conditioned; attaching value and importance to the experiences associated with the drugs (Volkow, Fowler & Wang, 2004). As a result, their experiences and sensations reinforce their drug use, which leads to brain disruption. Neuroimaging techniques together with human and animal models of addiction confirms the reinforcement phenomenon by illuminating the psychoactive drugs' ability to take over the brain's neural reward system by rewiring the neural circuitry with chronic use (Taylor, Lewis & Olive, 2013).

Because of the long-term disruption of the brain through chronic drug use, optimum brain functioning becomes impaired. Several studies illustrate this process of impairment by associating chronic psychoactive drug use with deficits in cognitive functioning, including decision making, response inhibition, planning, working memory, and attention (Durazzo et al. 2010; Fernandez-Serrano et al. 2012; Jovanovski et al. 2005; Nordahl et al. 2003). Additionally, habitual drug use may eventually become compulsive drug use where drug users lose control over their drug consumption (Taylor et al. 2013).



**2.3 MA and the brain**

Apart from cannabis, MA is the most widely abused illicit drug in the world (Tollivier et al. 2012). MA, a psychoactive drug often referred to as meth, speed, or crystal (and locally 'tik') is a synthetic central nervous system stimulant, which can be smoked, injected, snorted, or ingested orally, and similar to other drugs eventually leads to dependence when used over extended periods. MA (a subgroup of amphetamines) was first introduced as a medical treatment for certain cardiovascular conditions in 1932 and was later used for treating several other conditions including mild depression, chronic alcoholism, and narcolepsy (Watanabe-

Galloway et al. 2009). During the 1960's amphetamines were only available by prescription and in 1970 became classified as a Schedule–II drug (a class of drug that has abuse potential together with medical uses) when its dangers were more fully understood. Currently, varieties of amphetamine types such as methylphenidate, mixed amphetamine salts, and lisdexamfetamine dimesylate are recommended pharmacotherapy treatments for individuals with attention deficit and hyperactivity disorder (Kollins, 2008).

Current research provides a comprehensive view of the acute long-term effects of the pharmacological properties of MA on the human body (Sulzer et al. 2005; Fleckenstein et al. 2007). For example, Watanabe-Galloway (2009) notes that MA stimulates the synaptic sites of the brain, producing a variety of physiological and psychological experiences. Physiological changes occur in heart rate, blood pressure, and body temperature and can trigger heightened libido, increase in energy, and enhanced well-being (Lineberry & Bostwick, 2006). Psychological consequences on the other hand include experiences of euphoria, elevated mood, feelings of well-being, enhanced alertness and concentration, increased talkativeness, and decreased fatigue with improved physical performance (Lee et al. 2007). However, the acute and long-term impact of MA on the body may have profound negative consequences, such as vasospasms, cerebrovascular haemorrhage, seizures, cardiomyopathy, weight loss, and several distinct clinical effects such as memory loss, depression, psychotic symptoms, and confusion may occur (Watanabe-Galloway et al. 2009). After immediate cessation of MA after prolonged use individuals may experience withdrawal symptoms from a few days to several weeks, and even after long periods of abstinence the effects of MA on the brain may still be present (Chang, Alicata, Ernst & Volkow, 2007).

Many researchers have studied the long-term consequences of MA use on the brain comprehensively to determine its effect on the brain's neuronal mechanisms, and several

studies demonstrate the profound brain changes that occur because of chronic MA use (Volkow & Li, 2004; Tollivier et al. 2012; Taylor et al. 2013). For example, in one study Tollivier and colleagues (2012) report that chronic MA use is specifically associated with structural and neurochemical changes in the frontostriatal brain circuitry. Another study that focussed on the effects of psychostimulant addiction on the neurocircuitry highlights that long-term MA use systematically alters the brain so that lasting neuroadaptations emerge (Taylor et al. 2013). What is particularly alarming is that these brain changes are long lasting, and even after cessation of MA use, addictive behaviour might still be highly prevalent (Volkow & Li, 2004).

In addition to understanding the changes of the brain due to chronic MA use, research in MA addiction attempts to make connections between these changes and the behavioural manifestations of those who become addicted to MA (Bickel et al. 2007; Volkow, 2010). Taylor and colleagues (2013) identify several behaviour manifestations such as continual relapsing, difficulty limiting the drug, high motivation to continue drug use, negative emotional and physiological experiences when users stop using the drug, and continued use despite negative consequences. Another study reports that MA addiction wears away at the social-cognitive functioning of addicted individuals and as a result impairs social behaviour (Homer et al. 2008). The studies not only demonstrate that addictive behaviour is a consequence of the profound brain changes that occur as a result of chronic MA use but also illustrate that impulsive behaviour emerges as one of the core features of addictive behaviour in MA addiction (Volkow, Fowler & Wang, 2004; Taylor et al. 2013).



**2.4 Impulsivity in MA addiction**

Impulsive behaviour is defined as the inclination to act prematurely on automatically triggered desires and impulses without precaution for future consequences (Madden, Bickel & Critchfield, 2009; Dalley, Everitt & Robbins, 2011). Although impulsivity is conceptualised

in psychiatric theories as an already present personality trait, chronic MA use and its effect on the brain may bring about behavioural manifestations typical of impulsivity, such as poor planning, overly risky behaviours, or involvement in inappropriate activities (Dalley, Everitt & Robbins, 2011). In fact, addiction research identifies impulsivity as a core deficit in MA addiction (Koob, 2009).

Impulsivity is a well-researched construct of addiction and is conceptualised as consisting of different domains. For example, Koob (2009) reports two domains, namely the decision of a smaller instant reward over a greater delayed reward, and the inability to subdue behaviour by altering the course of action or to halt a response once introduced. Similarly, Madden and colleagues (2009) identifies these two domains within impulsivity but includes attention as a third domain. Reportedly, these three domains have received considerable focus in the study of impulsive behaviour (Madden et al. 2009). These and other studies seem to agree that the first mentioned domain, termed delayed discounting, is of particular interest to the understanding of impulsivity in substance dependence, particularly MA addiction, as it is hypothesised to be a predictor of success in drug rehabilitation (Yoon et al. 2007). Additionally, research findings demonstrate that MA addiction correlates positively with high rates of delay discounting (Kirby & Finch, 2010).



**2.5 Delay Discounting and working memory**

Delayed discounting is defined as a cognitive activity that equips an individual with the ability to make a mental comparison between an immediate and delayed rewards, where higher rates of discounting describes the tendency to prefer smaller more immediate rewards as opposed to larger delayed rewards (Matta, Gonçalves & Bizzarro, 2012). Drug addicts reduce the value of a future reward because they deem the immediate gratification via an immediate reward as more valuable. For example, MA addicts consume the drug due to the incentive salience

associated with MA related cues (immediate reward) while discounting abstinence, healthy relationships, employment etc. (greater delayed rewards) (Tolliver et al. 2011).

Due to the correlation between delay discounting and addictive behaviour, researchers have attempted to conduct further studies. This in part has resulted in studies that demonstrate significant correlations between measures of delayed discounting and working memory (Bobova, Finn, Rickert & Lucas, 2009; Shamosh et al. 2008). Bickel and colleagues (2011) reports that the inability to think about the future and the past relates to deficits in working memory function. As research shows that working memory significantly correlates with delay discounting and the inability to delay an immediate reward for a future one, ruminating on a future reward is likely a function of working memory. This suggests that, if individuals are largely impulsive, they cannot rely on their working memory to think about future events and consequences. Therefore, it might be possible to decrease a person's discounting of future events by training their working memory functions thereby increasing their ability to remember the past and ruminate about future events (Bickel et al. 2011).



In order to establish neurocognitive evidence for the correlation between delayed discounting and working memory, research efforts have attempted to gain more understanding into the neurocognitive processes involved in delay discounting and working memory. Several studies have demonstrated that certain brain areas have a functional overlap between delayed discounting and working memory (Bickel & Marsch, 2001; MacKillop et al. 2011; Dalley et al. 2011). For example, Wesley and Bickel (2013) have isolated brain activity during tasks of delay discounting and working memory, which revealed that delay discounting and working memory share a large cluster of activity lateralized in the left prefrontal cortex. Their research findings suggest that this section of the left prefrontal cortex is distinctively qualified, through its executive functioning effort, to provide functions common to delay discounting and working

memory that may account for a behavioural relationship. This is consistent with the neurobehavioral decision system hypothesis of addiction whereby the impulsive decision system of the limbic and paralimbic brain regions together with the executive system of the prefrontal cortex are implicated in delayed discounting. This hypothesis suggests that high rates of delayed discounting are due to the interaction between a hyperactive impulsive system and a hypoactive executive system (Bickel et al. 2011). Their research results demonstrate that activation of the executive system through working memory training decreases rates of discounting.

**2.6 Training the working memory to decrease delay discounting**

Efforts to enhance efficacy of treatment to address high treatment dropout rates, and the multiple physiological and psychological pathologies associated with MA addiction, is greatly significant for the public health system (Vocci, 2008; Ling Murtaugh, Davis, Reback & Shoptaw, 2013). One particular avenue explored for several years in addition to the varieties of drug rehabilitation programmes, is computer-based interventions for drug use disorders. A review of computerized cognitive rehabilitation demonstrated that cognitive remediation improved treatment retention in both cognitively impaired and unimpaired patients who voluntarily entered into a residential treatment program (Vocci, 2008). Another study published in 2010 demonstrated that computer-assisted cognitive rehabilitation was effective in addressing deficits in multiple executive functions that resulted in increased patient engagement and commitment to treatment together with better long-term outcomes (Fals-Stewart & Lam; 2010). These studies implicated several cognitive abilities, especially those in the domain of executive functioning, that showed improvement with cognitive rehabilitation.

Several studies indicated that working memory training improved clinical outcomes among individuals with attention-deficit/hyperactivity disorder, problematic drinking

behaviour, and schizophrenia (Wesley & Bickel, 2013). In an attempt to explore the functionality of delayed discounting and working memory, Bickel and colleagues (2011) examined whether working memory training resulted in decreased rates of discounting among stimulant addicts who abused cocaine, MA, or both. Their findings suggest working memory-training results in a decrease in delayed discounting. Their findings were consistent with previous studies that reported a relationship between delay discounting and working memory (Bobova, Finn, Rickert & Lucas, 2009; Shamosh et al. 2008). However, the durability (far-reaching effects) of the decreases in delay discounting due to the working memory remains uncertain. Since these studies established a behavioural relationship between delayed discounting and specifically working memory, a new target is formulated for treatment strategies, namely that of enhancing the ability to increase working memory processes as treatment for high rates of delayed discounting (Wesley & Bickel, 2013).

**2.7 Theoretical Framework**



This project subscribes to the assumption that addiction is a biological psychopathology whereby medical research implicates organic causes as its operating mechanism. This view, known as the medical model, offers an understanding of abnormal behaviour that consists of an embodiment of basic assumptions about medicine that are driven by investigation and scientific enquiry of physical or psychological difficulties based on causation and remediation (Shah & Mountain, 2007). Diagnosing a patient with a particular syndrome, based on presentation of certain symptoms, and then treating the patient with practices based on scientific research is an example of an approach that follows the medical model.

This project follows the biological approach to psychopathology in several ways. Firstly, it investigates addiction as a behavioural product of the structural and functional changes that psychoactive drugs bring about in several areas of the brain. Therefore, this

project subscribes to the understanding that the construct of impulsivity and its different domains belong to the symptom spectrum of addiction and other syndromes as categorically allocated in classification manuals. The Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5, American Psychological Association, 2013), or the International Classification of Diseases and Related Health Problems, tenth edition (ICD-10, World Health Organisation, 2004) are two such manuals. For example, one of the disorders within the substance use spectrum in the DSM-5 termed Stimulant Use Disorder specifically list symptoms associated with substances that share behavioural manifestations understood to be due to the impact of the pharmacological make-up of the substance on human physiology.

Secondly, the methodology and results sections of this project investigated an experimental procedure within the context of a cause and effect process that understands and measure impulsivity as a quantifiable phenomenon. Stimulating certain brain structures with specific cognitive training methods to influence the rate at which MA addicts experience impulsivity subjectively, and making objective inferences based on how impulsivity rates are influenced, is inherently a medical model approach. The concepts of delay discounting and working memory, and how these are understood as neurobiological functions that perpetuate MA addiction when the neurobiological constructs responsible for these functions are under the influence of MA, illustrates the medical model approach further. For example, one study of MA addiction suggests that it can be conceptualised as a brain disorder that is due to neurotransmitter imbalances brought about by the neurotoxicity of the abused substance (Rawson, Gonzales, & Brethen, 2002). Another study suggests that when a drug addict abuses psychoactive substances, progressive dysregulations and pathophysiological changes in multiple structures and systems of the brain occur due to its stimulating function of the reward pathways in the brain (Le Moal & Koob, 2007). A third view, one that focuses on the rehabilitation aspect of addiction, explains intervention in terms of an effort for continued

abstinence. To achieve this goal, individuals must regain control of certain cognitive functions that were lost while they became addicted to their drugs of choice and at the same time address several cognitive deficits as a product of their addiction (Vocci, 2008). These studies illustrate the medical model of addiction to which this project subscribes.

**2.8 Conclusion**

The above literature review aimed to evaluate addiction research in order to problematize the current rates of drug abuse and investigate how MA addiction and its neurophysiological mechanisms are understood. The literature review highlights impulsivity as a central phenomenon in MA addiction and the findings that describe how specific domains of impulsivity overlap with certain cognitive constructs that, when targeted with certain treatments, may reverse or decrease impulsivity rates. The review highlighted several research efforts that targeted cognition through enhancement of different kinds in order to target impulsivity, and specifically identifies working memory as a target for training to reduce delayed discounting as a domain of impulsivity. This project aims to add to the literature by investigating whether cognitive training has an effect on impulsivity in MA addicts.

# CHAPTER 3

# METHOD

## 3.1 Introduction

This chapter will introduce the method utilised in this project. First, it will include a brief discussion of the primary study and embedded project followed by the outline of the research hypotheses. Next, the research design, participants, and procedure are identified and described and this is followed by an outline of the data collection instrument. The chapter ends with a description of the project's ethical considerations.

## 3.2 Primary study



The current project was an embedded quantitative research study and formed part of a primary study (figure 1) that aimed to investigate the effects of cognitive training on specific brain structures of the human brain.

The primary study incorporated state of the art neuroimaging and neuropsychological testing with the aim of identifying neural mechanisms associated with the cognitive control of addiction. The study utilised an experimental design within a drug treatment setting by introducing working memory training (cognitive training) to one of two treatment groups for the purposes of investigating a) its effect on particular brain structures implicated in impulsivity, and b) its effect on impulsive behaviour in individuals with methamphetamine (MA) addiction.

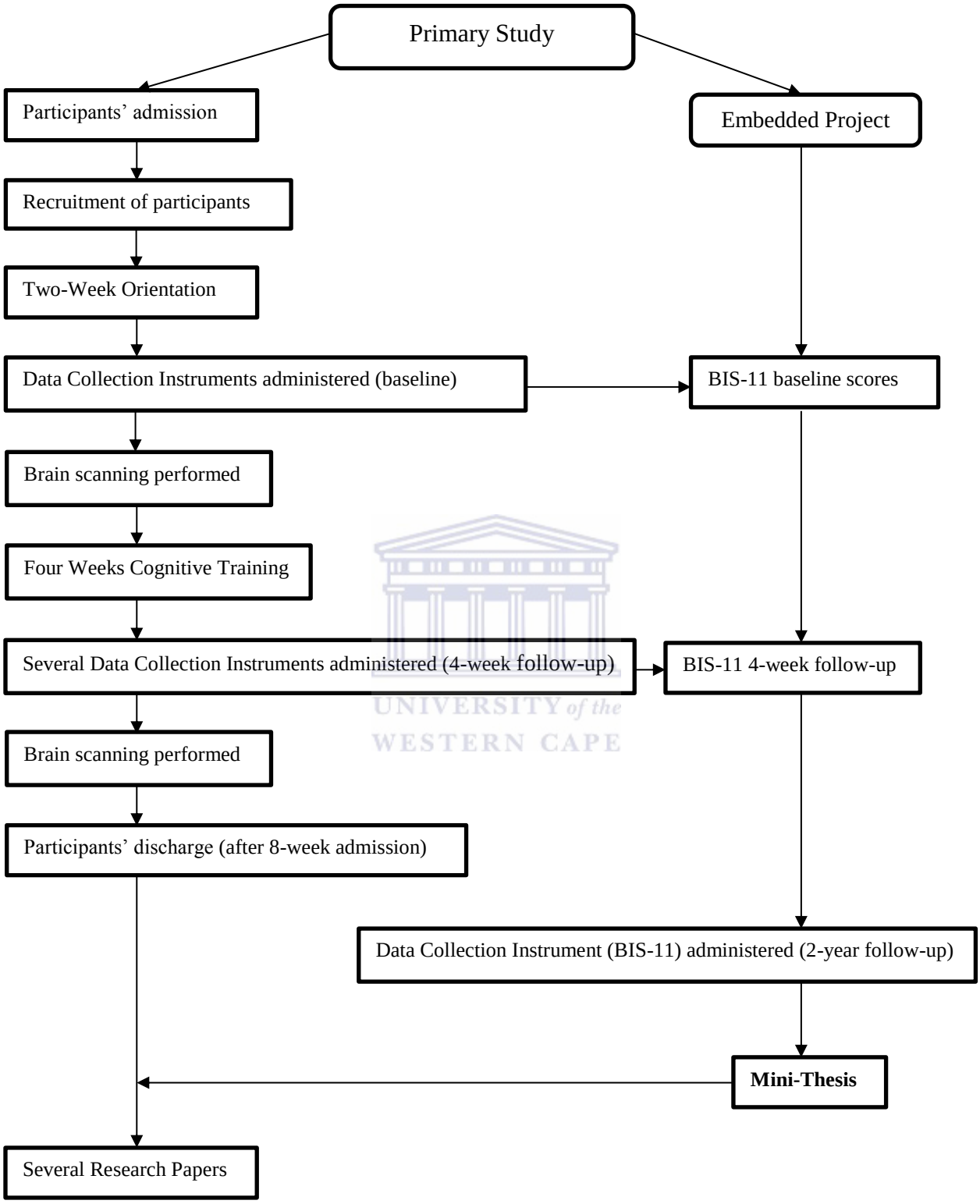


*FIGURE 1: Research Study Flow Diagram*

Essentially, the researcher from the primary study introduced cognitive training to a group of patients in a voluntary drug treatment centre as an experimental intervention. The treatment centre personnel trained the patients with a simple computer-based working memory task (the N-Back task) on a standard laptop at the drug treatment centre. The initial training session lasted no more than one hour per day for four weeks and consisted of a repetition of training schedules, as advised by a recent review (Vinogradov et al. 2012). This task had increasing levels of difficulty (e.g. 1-back, 2-back, 3-back etc.), known to exponentially recruit pre-frontal cortex (PFC) resources. The patients had to press a mouse button when the 'current' letter on the screen was the same as '1 before (1-back)', '2 before (2-back)', '3 before (3-back)' and so on. They were trained on the lowest level first until the error rate was extinguished (e.g. false positives, false negatives), and then moved on to the next level and repeated the procedure. Participants were required to successfully complete at least 3-back, and the highest level they achieved (e.g. highest level with only 5 percent error) became the level at which they completed the task for the subsequent week at the clinic. A laptop was utilised at the rehab centre and the researcher trained that personnel to administer the simple and short task to the CTG participants for four weeks (1 hour per day). Responses (number of errors, response times) were automatically recorded in a text file by the programme and used in subsequent neuroimaging analyses (e.g. as regressors of interest).

The researchers administered several data collection instruments via repeat administration at two periods to provide baseline and 4-week follow-up data. They performed neuroimaging scans at both periods as well. The results of the instruments together with the neuroimages provided the data required for the primary study. The primary study followed a paradigm previously piloted experimentally in females with anorexia nervosa, who appear to have better working memory performance than healthy controls (Brooks et. al., 2012). Additionally, another research project is utilizing the in an fMRI experiment in Sweden.

### 3.3 Embedded Project

This embedded project was designed to focus on one of the primary study's two areas for investigation, namely the effect of cognitive training on impulsive behaviour. In order to do this the project made use of baseline and 4-week follow-up data obtained by the researchers from the primary study, and collected a third set of data at a 2-year follow-up period. Due to the limited scope of this project, data was selected from only one impulsivity instrument, namely the Barratt Impulsivity Scale, eleventh edition (BIS-11). The results of this project may serve as additional data to support the primary study's research findings.

### 3.4 Hypotheses

The hypotheses for the current project were formulated as follows:

1. The **rate of decrease** in impulsivity for the CTG from baseline to the 4-week follow-up will be significantly greater than the rate of decrease in impulsivity for the RG from baseline to four weeks.
2. The **rate of decrease** in impulsivity for the CTG from 4-week follow-up to 2-year follow-up will be significantly greater than the rate of decrease in impulsivity for the RG from 4-week follow-up to two years.
3. There will be a significant **decrease in impulsivity** for the RG at 4-week follow-up compared to baseline.
4. There will be a significant **decrease in impulsivity** for the RG at 2-year follow-up compared to 4-week follow-up.
5. There will be a significant **decrease in impulsivity** for the CTG at 4-week follow-up compared to baseline.

6. There will be a significant **decrease in impulsivity** for the CTG at 2-year follow-up compared to 4-week follow-up.

### 3.5 Research design

A research design is a scientific strategy or blueprint for the collection, measurement, and analysis of data (Burns & Grove, 2003). It is a calculated, purposeful approach to the study of a topic and it offers a method for engagement and sense making in a meaningful way. A pre-test, post-test experimental design was selected for the purpose of this project. Three main reasons supported this decision. Firstly, the nature of the design, that is, to study participants before and after an experimental manipulation, fulfils the requirements necessary to aid in attempting to answer our research questions. The process of this design is as follows: Firstly, researchers from the primary study collected baseline data (pre-test) by measuring specific characteristics (dependent variable) of the study participants. The intervention (independent variable) follows the baseline testing and the post-test follows the intervention. This provides data that measures the effect of the independent variable or intervention (post-test). In other words, the design offers a method to compare participant groups and measure the degree of change occurring from an intervention or treatment. Secondly, pre-test post-test designs are especially useful when there is a concern for the risk of confounding factors affecting the study findings. Akobeng (2005) argues that the pre-test post-test design provide the necessary rigour in terms of generating evidence on the effectiveness of interventions. Thirdly, when researchers employ randomisation within this design, it significantly reduces potential threats to the internal validity of a study (Chan, 2003). Lastly, the design will be employed in this project as it offers a scientifically sound approach to determine the effect of the cognitive training (independent variable) on impulse control (dependent variable) among the study participants.

### 3.6 Participants

The researchers for the primary study initially recruited 43 male patients between the ages of 18 and 50 years (*M*= 28.88; *SD*= 6.224) at a drug rehabilitation centre in the Western Cape. All the patients fulfilled the inclusion criteria required, therefore that (a) a psychiatrist or psychologist at the treatment centre diagnosed them with MA addiction, (b) the treatment centre admitted them as new patients for the rehab program, and (c) that they sought treatment for MA addiction voluntarily. Group assignment occurred two weeks after the drug treatment centre admitted the patients. The principal researcher assigned them randomly into two treatment groups. Only 77% of the initial group were included for this project due to dropout or missing psychometric scores. At baseline testing there were 28 patients in the CTQ and 17 in the RG. After four weeks, only 19 patients in the CTG and 14 in the RG completed the follow-up testing. Several participants dropped out of the study due to premature discharge from the centre or the researcher disqualified them from the study due to incomplete base-line scores. At the two-year follow-up, only eight patients from the CTG and seven patients from the RG completed the impulsivity scale as several patients were either unreachable, in rehab, imprisoned, or declined participation for the project.



### 3.7 Procedure

During the first two weeks, all patients participated in the drug centre's rehab programme. After random group assignment, the one group started their four weeks of working memory training (1 hour per day) in addition to the rehab program. After four weeks, both groups completed the follow-up administration of data collection instruments (4-week follow-up testing). All the participants from both groups completed the rest of the rehab program and the

treatment centre discharged them from the centre two weeks later. After two years, the two research groups were followed up telephonically and the BIS-11 was completed for the third time (2-year follow-up testing).

### 3.8 Data Collection Instruments

The primary researchers administered the following instruments to the research participants as part of the data collection process:

#### 3.7.1 General demographics questionnaire (Appendix A)

This single page information sheet requested the following information from the respondent: name; place of birth; handedness; claustrophobic; gender; ethnicity; education level; marital status; living arrangement; dependents; smoking history; drug history; methamphetamine history; quantity/frequency of methamphetamine; abstinence period; current medications; medical conditions; medical history; dietary style; current drug use (over the counter, prescription, illicit, or other).



#### 3.7.2 The Barratt Impulsivity Scale (BIS-11) (Appendix B)

The BIS-11 is a tool designed to quantify the personality trait of impulsivity as it transpires in natural human settings by asking individuals to give account on their tendency to act impulsively (Barratt, 1994). It is a self-report questionnaire with a 30-item, 4-point Likert scale (Rarely/Never, Occasionally, Often, Almost Always) without any relation to time. When completed and scored, the scale provides a full-scale score (30–120) indexing impulsiveness. It provides scores for three second-order subscales (Non-planning Impulsivity, Motor Impulsivity, and Attentional Impulsivity) and six first-order subscales (Attention, Motor, Self-Control, Cognitive Complexity, Perseverance, and Cognitive Instability). Stanford and

colleagues (2009) suggests that researchers should regard total scores between 52 and 71 on the BIS-11 as within normal parameters for impulsiveness.

Researchers have used the BIS-11 extensively in both clinical and research settings and practitioners have applied it in assessing general levels of impulsiveness (Tziortzis, Mahoney, Kalechstein, Newton & De La Garza, 2011). It is one of the most extensively employed self-report measures of impulsivity in psychiatric research and evidence shows that scores on this scale correlate with clinical symptoms and risky behaviour (Stanford et al. 2009). A recent review on the widely used BIS-II supports the strong validity of the scale – assessed by correlations with similar self-report measures, as well as with clinical populations (e.g., substance-use disordered, suicide attempters), and assessments of cognitive and neurocognitive function. The internal consistency of the scale is good (Cronbach's $\alpha > .80$) (Stanford et al. 2009). In addition, results from a systematic review by Vasconcelos and colleagues (2012) of the BIS-11 indicate reliability and validity in both developed and developing countries. The BIS-11 has been validated in psycho-stimulant abuse and dependency populations, prison inmates, general psychiatric patients, undergraduates, while several studies have validated a relationship between impulsivity and drug use (Coffey et al. 2003), withdrawal, treatment dropout (Moeller et al. 2001b), and age of first drug use (Moeller et al. 2004).



**3.8 Ethical considerations**

Ethics in research supplies researchers with rules and requirements in order to ensure that they maintain and respect the humanity of the individuals participating in the research. University of Cape Town granted permission to conduct the primary study and the researchers obtained ethical clearance (See Appendix D). Participants of the primary study who volunteered while at the treatment centre gave their consent for the participation in the study and were informed that they could withdraw from the study at any time without experiencing any negative

consequences for doing so. The researchers informed them that the research study will follow precautions to ensure their anonymity through confidentiality and that this research, both the brain scan and the training period, may help to improve their treatment outcomes. All participants were fully debriefed, compensated for their time (in line with UCT procedures), and offered any published work arising from this study if they would like it.

For the current project, the principal researcher of the primary study gave additional permission for use of the data collected during the intake and the follow-up of the participants (See Appendix C). Since the current project is for Master's Degree purposes at the University of the Western Cape and was not part of the original design of the primary study, additional ethical clearance was required, and obtained, in addition to the clearance obtained from UCT for the primary study. The effort for ethical clearance aimed at protecting the participants from any harm or distress while ensuring confidentiality and anonymity.

# CHAPTER 4

# RESULTS

## 4.1 Introduction

This chapter presents the results from the statistical analyses of the research data outlined in the previous chapter. It contains several sections and covers the essential areas of focus intrinsic to the study. The first section reports the descriptive information of the sample, while the second validates the randomisation of the research sample. The sections to follow compares the impulsivity scores of the two research groups from baseline to the 4-week follow-up, and from 4-week to the 2-year follow-up.

An across-subjects design is employed first, followed by a within-subjects design. Additionally, the within-subjects design includes a section that investigates the stability of the impulsivity scores of both treatment groups from baseline to the 4-week follow-up as well as from the 4-week follow-up to the 2-year follow-up. This set of analyses attempts to establish some level of confidence in the stability of any statistically significant impulsivity scores over time for both research groups.



The main aim of the analyses is to determine the efficacy and durability (Bickel et al. 2011) of the rehab only and rehab with cognitive training on impulsivity levels over time. In other words, we want to establish whether standard rehabilitation only and rehabilitation with cognitive training had any effect on impulsivity levels and whether these effects were durable over time. In these instances, the term *effect* refers to changes in impulsivity levels from baseline assessment to a 4-week follow-up while *durability* refers to the consistency of the changes from 4-week follow-up to 2-year follow-up. It is important to note that in all the results, decreases in impulsivity scores suggest behaviour that is less impulsive whereas increases in scores signify behaviour that is more impulsive.

## 4.2 Data Analysis

Descriptive and inferential statistics were utilised for analysis of the data. Descriptive statistics are methods used to provide a concise description of a collection of quantitative information, such as frequencies of the variables in terms of age, gender, and employment (Kaplan & Saccuzzo, 2009). Inferential statistics are procedures employed to make inferences from observations of a sample to the population. For this project, the data was analyzed using independent sample t-tests, paired sample *t*-tests, and correlation analysis (Kaplan & Saccuzzo, 2009). The independent sample t-tests were used to analyse the differential change in the impulsivity scores between the two research groups. The paired sample t-tests measured group differences relative to themselves. Differential change analysis was utilized to determine the efficacy and durability of the rehab and cognitive training on impulsivity rates.

Correlation analysis served as the method of investigating whether some level of stability was present in the impulsivity scores of the two groups in the project. Due to the quantitative nature of the study the Windows based Statistical Package for the Social Sciences (IBM SPSS - 2015) was used to analyse the data.



## 4.3 Descriptive Statistics

The research sample consisted of 33 male participants, mostly coloured (one black participant), and almost two thirds have no matric. The average age is almost 29 years (median age at 28, suggesting a normal distribution) and on average used drugs for 10 years (median of 10 years, suggesting a normal distribution). The sample of 33 males was randomly assigned into two groups. The CTG consisted of 19 participants while the RG was made up of 14 participants (Table 2). The majority of patients have been taking drugs between 3 and 10 years while almost

40 percent have been taking drugs between 11 and 22 years (Table 4). Of the total sample, 57.6 percent were in the CTG and 42.4 percent in the RG.

**Table 1: Demographic Characteristics of Sample**

| | | Group | Education Level | Ethnicity | Age | Male/ Female | Duration of drug taking |
|---|---|---|---|---|---|---|---|
| N | Valid | 33 | 33 | 33 | 33 | 33 | 33 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 2.5758 | 1.39 | 1.97 | 28.88 | 1.00 | 10.03 |
| Median | | 3.0000 | 1.00 | 2.00 | 28.00 | 1.00 | 10.00 |

**Table 2: Intervention Group Distribution**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Rehab Only | 14 | 42.4 | 42.4 | 42.4 |
| | Rehab plus Training | 19 | 57.6 | 57.6 | 100.0 |
| | Total | 33 | 100.0 | 100.0 | |



**Table 3: Sample Educational Attainment**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | No matric | 20 | 60.6 | 60.6 | 60.6 |
| | Matric | 13 | 39.4 | 39.4 | 100.0 |
| | Total | 33 | 100.0 | 100.0 | |

**Table 4: Duration of Drug Use**

| Years of Drug Use | Participant Frequency per year | Participant Frequency per year (%) | Participant Cumulative (%) |
|---|---|---|---|
| 3 | 2 | 6.1 | 6.1 |
| 6 | 2 | 6.1 | 12.1 |
| 8 | 7 | 21.2 | 33.3 |
| 9 | 3 | 9.1 | 42.4 |
| 10 | 9 | 27.3 | 69.7 |
| 11 | 4 | 12.1 | 81.8 |
| 12 | 1 | 3.0 | 84.8 |
| 13 | 2 | 6.1 | 90.9 |
| 16 | 1 | 3.0 | 93.9 |
| 20 | 1 | 3.0 | 97.0 |
| 22 | 1 | 3.0 | 100.0 |
| Total | 33 | 100.0 | |



### 4.4 Validation of Randomization of CTG and RG Groups

For the purposes of establishing the validity of the randomization between the CTG and RG, we performed t-tests on three key demographic variables and the ten BIS composite impulsivity scores (Table 5). The results show that age, educational level, and duration of drug taking have no significant differences in the mean values between the two groups. Regarding the composite impulsivity scores, which include the total, first order, and second order scores, the results reflect no significant differences between the two groups. These results provide confidence in the analysis going forward as the observed differences in scores may not be attributable to significant differences at baseline testing between the CTG and RG.

**Table 5: Validation of Randomization at Baseline**

| | | t-test for Equality of Means | | | |
|---|---|---|---|---|---|
| | | t | df | Mean Diff. | Sig. (2-tailed) |
| Education Level | Equal variances assumed | .339 | 31 | .060 | .737 |
| Age | Equal variances assumed | -.017 | 31 | -.038 | .987 |
| Duration of drug taking | Equal variances assumed | 1.263 | 31 | 1.684 | .216 |
| Full-scale | Equal variances assumed | .470 | 31 | 1.996 | .641 |
| 1st Order Attention | Equal variances assumed | -.357 | 31 | -.331 | .723 |
| 1st Order Motor | Equal variances assumed | -.106 | 31 | -.173 | .916 |
| 1st Order Self-Control | Equal variances assumed | 1.243 | 31 | 1.421 | .223 |
| 1st Order Cognitive Complexity | Equal variances assumed | -.092 | `31 | -.094 | .927 |
| 1st Order Perseverance | Equal variances assumed | .389 | 31 | .331 | .700 |
| 1st Order Cognitive Instability | Equal variances assumed | 1.399 | 31 | .842 | .172 |
| 2nd Order Attentional | Equal variances assumed | .413 | 31 | .511 | .682 |
| 2nd Order Motor | Equal variances assumed | .071 | 31 | .158 | .944 |
| 2nd Non Planning | Equal variances assumed | .697 | 31 | 1.327 | .491 |



### 4.5 Test of Efficacy and Durability of Rehab and Cognitive Training by means of differential change analysis using an across subjects design

This section presents an across subjects design to investigate the differential changes in impulsivity scores between the CTG and RG at 4 weeks and at two years. The analyses examines for differences across the two groups at each time point by use of independent sample t-tests. All analyses included the impulsivity scores for the full scale and nine subscales. The differential change in impulsivity scores from baseline to 4-week follow-up demonstrates the efficacy of the rehabilitation and cognitive training while the differential change in impulsivity scores from 4-week to 2-year follow-up demonstrates the durability of the rehabilitation and cognitive training. To conduct this analysis, differential scores were developed as the difference between scores at baseline and four weeks, and the difference between scores at 4

weeks and two years. The t-tests then examined how these difference scores varied across the two groups.

### 4.5.1 Analysis of Efficacy of Rehab and Cognitive training on the CTG and RG from baseline to 4-week follow-up

This analysis examined for variation in the differential scores across the CTG and RG from baseline to 4-week follow-up. Table 6 presents the group statistics of the CTG and RG and reflects the differential changes in mean impulsivity scores from baseline to 4-week follow-up for the full-scale and all sub-scales.

The change in the BIS full-scale and sub-scale scores from baseline to 4 weeks revealed increases and decreases in mean impulsivity scores for both the CTG and RG. In terms of mean full-scale impulsivity scores, both groups showed a decrease in scores, but the decrease was marginally greater for the CTG (*M* = -5.53; *SD* = 8.25) as compared to the RG (*M* = -3.93; *SD* = 11.39). Similar score patterns emerged on the attention (CTG: *M* = -1.26, *SD* = 3.25; RG: *M* = -0.21, *SD* = 3.77), motor (CTG: *M* = -1.58, *SD* = 3.37; RG: *M* = -0.57, *SD* = 5.47) second order motor subscales (CTG: *M* = -2.11, SD = 4.42; RG: *M* = -1.21, *SD* = 6.58). On the second order attentional subscales the CTG (*M* = -1.63, *SD* = 4.47) has a slight decrease in impulsivity score while the RG (*M* = 0.07, *SD* = 4.12) had a minor increase.

This was also observed on the cognitive instability subscale (CTG: *M* = -0.37, *SD* = 2.09; RG: *M* = 0.29, *SD* = 2.67). On the cognitive complexity subscale, the RG (*M* = -0.43, *SD* = 2.95) had a decreased rate of change mean score while the CTG had a slight score increase (*M* = 0.05, *SD* = 2.48). The rate of change in mean impulsivity on the self-control subscale in the RG (*M* = -2.36, *SD* = 3.39) showed marginally greater decreases in score than that observed in the CTG (*M* = -1.84, *SD* = 2.5). This was similar for the perseverance (RG: *M* = -0.64, *SD*

= 3.30; CTG: *M* = -0.53, *SD* = 2.76) and second order non-planning subscales (RG: *M* = -2.79, *SD* = 4.64; CTG: *M* = -1.79, *SD* = 3.57).

**Table 6: Group Differences at 4-week follow-up**

| | Group | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Full-scale | Rehab Only | 14 | -3.9286 | 11.39139 | 3.04448 |
| | Cognitive Training | 19 | -5.5263 | 8.24869 | 1.89238 |
| 1st Order Attention | Rehab Only | 14 | -.2143 | 3.76581 | 1.00645 |
| | Cognitive Training | 19 | -1.2632 | 3.24623 | .74474 |
| 1st Order Motor | Rehab Only | 14 | -.5714 | 5.47321 | 1.46278 |
| | Cognitive Training | 19 | -1.5789 | 3.37171 | .77352 |
| 1st Order Cognitive Complexity | Rehab Only | 14 | -.4286 | 2.95386 | .78945 |
| | Cognitive Training | 19 | .0526 | 2.48269 | .56957 |
| 1st Order Self-Control | Rehab Only | 14 | -2.3571 | 3.38792 | .90546 |
| | Cognitive Training | 19 | -1.8421 | 2.50029 | .57361 |
| 1st Order Perseverance | Rehab Only | 14 | -.6429 | 3.29585 | .88085 |
| | Cognitive Training | 19 | -.5263 | 2.75617 | .63231 |
| 1st Order Cognitive Instability | Rehab Only | 14 | .2857 | 2.67261 | .71429 |
| | Cognitive Training | 19 | -.3684 | 2.08728 | .47885 |
| 2nd Order Attentional | Rehab Only | 14 | .0714 | 4.12244 | 1.10177 |
| | Cognitive Training | 19 | -1.6316 | 4.47475 | 1.02658 |
| 2nd Order Motor | Rehab Only | 14 | -1.2143 | 6.57710 | 1.75780 |
| | Cognitive Training | 19 | -2.1053 | 4.42084 | 1.01421 |
| 2nd Order Non-Planning | Rehab Only | 14 | -2.7857 | 4.64391 | 1.24114 |
| | Cognitive Training | 19 | -1.7895 | 3.56805 | .81857 |

To determine whether the differential changes in impulsivity scale scores between the RG and CTG from baseline to 4-week follow-up were significantly different, we performed independent sample t-tests (Table 7). We conducted the t-tests for conditions of both *equal variances* and *unequal variances*. In terms of the full-scale scores, the results indicate that there were no significant differences between the CTG and the RG (t (31) = 0.47, p = 0.64), under both conditions of assumption of equal variances or unequal variance. Similarly, there

were no statistically differences observed in the differential changes for any of the sub-scales across the CTG and RG (see Table 7).

The results in Table 6 indicate that the CTG participants experienced a greater decrease in impulsivity scores for the full-scale and the majority of sub-scales. Although these results are consistent with the hypothesis that cognitive training has a greater impact on impulsivity than rehab alone, the effect is not consistent as some of the observed changes were actually in favour of the rehab group. More importantly, these differences were not statistically significant (Table 7). Accordingly, although the majority change is in the right direction, we have no reason to conclude that the rate at which the impulsivity scores changed from baseline to 4-week follow-up was significantly different between the groups. In other words, we have no reason to conclude that the CT produced a substantively greater reduction in impulsivity as compared to rehab alone. The lack of statistical significance also means that we cannot conclude anything about those instances where the change for sub-scales was greater in the RG as compared to the CTG.



**Table 7: Independent Samples Test Baseline to 4 week follow-up**

| | | t-test for Equality of Means | | |
|---|---|---|---|---|
| | | t | df | Sig. (2-tailed) |
| Full-scale | Equal variances assumed | .468 | 31 | .643 |
| 1st Order Attention | Equal variances assumed | .857 | 31 | .398 |
| 1st Order Motor | Equal variances assumed | .653 | 31 | .518 |
| 1st Order Cognitive Complexity | Equal variances assumed | -.508 | 31 | .615 |
| 1st Order Self-Control | Equal variances assumed | -.503 | 31 | .618 |
| 1st Order Perseverance | Equal variances assumed | -.110 | 31 | .913 |
| 1st Order Cognitive Instability | Equal variances assumed | .790 | 31 | .435 |
| 2nd Order Attentional | Equal variances assumed | 1.117 | 31 | .273 |
| 2nd Order Motor | Equal variances assumed | .466 | 31 | .645 |
| 2nd Order Non-Planning | Equal variances assumed | -.698 | 31 | .491 |

### 4.5.2 Analysis of Durability of Rehab and Cognitive training on the CTG and RG from 4-week to 2-year follow-up

This analysis examined for variation in the differential scores across the CTG and RG from 4-week to 2-year follow-up. Table 8 presents the group statistics of the CTG and RG and reflects the differential changes in mean impulsivity scores from 4-week follow-up to 2-year follow-up for the full-scale and all sub-scales.

**Table 8:**
**Differential Change 4-week Follow-up to 2-year Follow-up**

| | Group | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Full-scale | Rehab Only | 7 | .8571 | 7.98809 | 3.01921 |
| | Cognitive Training | 8 | 6.0000 | 12.72792 | 4.50000 |
| 1st Order Attention | Rehab Only | 7 | 1.1429 | 4.63424 | 1.75158 |
| | Cognitive Training | 8 | .8750 | 2.79987 | .98990 |
| 1st Order Motor | Rehab Only | 7 | -.7143 | 3.54562 | 1.34012 |
| | Cognitive Training | 8 | -.2500 | 3.37004 | 1.19149 |
| 1st Order Self-Control | Rehab Only | 7 | 1.1429 | 2.03540 | .76931 |
| | Cognitive Training | 8 | 3.8750 | 2.64237 | .93422 |
| 1st Order Cognitive Complexity | Rehab Only | 7 | 1.1429 | 3.62531 | 1.37024 |
| | Cognitive Training | 8 | 1.1250 | 5.11126 | 1.80710 |
| 1st Order Perseverance | Rehab Only | 7 | -1.5714 | 2.82000 | 1.06586 |
| | Cognitive Training | 8 | -.8750 | 2.74838 | .97170 |
| 1st Order Cognitive Instability | Rehab Only | 7 | -.2857 | 2.05866 | .77810 |
| | Cognitive Training | 8 | 1.2500 | 1.90863 | .67480 |
| 2nd Order Attentional | Rehab Only | 7 | .8571 | 5.75698 | 2.17594 |
| | Cognitive Training | 8 | 2.1250 | 4.35685 | 1.54038 |
| 2nd Order Motor | Rehab Only | 7 | -2.2857 | 2.56348 | .96890 |
| | Cognitive Training | 8 | -1.1250 | 4.70372 | 1.66302 |
| 2nd Order Non-Planning | Rehab Only | 7 | 2.2857 | 4.23140 | 1.59932 |
| | Cognitive Training | 8 | 5.0000 | 6.78233 | 2.39792 |

The change in the BIS full-scale and sub-scale scores from 4-week follow-up to 2-year follow-up revealed both increases and decreases in mean impulsivity scores for the CTG and RG. In terms of mean full-scale impulsivity scores, both groups showed an increase in scores, but the increase was greater for the CTG ($M$ = 6.0; $SD$ = 12.73) as compared to the RG ($M$ = 0.86; $SD$ = 8.0). Similar score patterns emerged on the self-control (CTG: $M$ = 3.88, $SD$ = 2.64; RG: $M$ = 1.14, $SD$ = 2.04), second order attentional (CTG: $M$ = 2.13, $SD$ = 4.36; RG: $M$ = 0.86, $SD$ = 5.76) and second order non-planning (CTG: $M$ = 5.0, $SD$ = 6.78; RG: $M$ = 2.29, $SD$ = 4.23).

On the attention subscales a larger increase in impulsivity score was observed in the RG ($M$ = 1.14, $SD$ = 4.63) while a marginally smaller increase in score was observed in the CTG ($M$ = 0.88, $SD$ = 2.8). This pattern was also observed on the cognitive complexity subscale (RG: $M$ = 1.14, $SD$ = 3.63; CTG: $M$ = 1.13, $SD$ = 5.11). On the perseverance subscale, the RG ($M$ = -1.57, $SD$ = 2.82) had a decreased rate of change mean score which was marginally greater than the decrease in score observed in the CTG ($M$ = -0.88, $SD$ = 2.75). This pattern was similar to the scores observed on the motor (RG: $M$ = -0.71, $SD$ = 3.55; CTG: $M$ = -0.25, $SD$ = 3.37) and second order motor subscales (RG: $M$ = -2.11, SD = 4.42; CTG: $M$ = -1.21, $SD$ = 6.58). The rate of change in mean impulsivity on the cognitive instability subscale in the RG ($M$ = -0.29, $SD$ = 2.06) showed a marginal decreases in score while a slight increase in mean impulsivity score was observed in the CTG ($M$ = 1.25, $SD$ = 1.91).

To establish if the differential changes in impulsivity scale scores between the RG and CTG from 4-week follow-up to 2-year follow-up were significantly different, we performed independent sample t-tests (Table 9). We conducted the t-tests for conditions of both *equal variances* and *unequal variances*. In terms of the full-scale scores, the results indicate that there were no significant differences between the CTG and the RG (t (13) = -0.92, p = 0.37), under both conditions of assumption of equal variances or unequal variance. In terms of the

subscales, only self-control indicated a statistically significant difference in the differential change between the CTG and RG, under both conditions of unequal variance (t (13) = -2.25, p = 0.042) and equal variance (t (13) = -2.22, p = 0.045). None of the other tests returned significant results, indicating that there is no reason to conclude that observed differences from 4 weeks to two years are substantive in nature.

**Table 9:**
**Independent Samples Test 4 week follow-up to 2 year follow-up**

| | | t-test for Equality of Means | | |
|---|---|---|---|---|
| | | t | df | Sig. (2-tailed) |
| Full-scale | Equal variances assumed | -.920 | 13 | .374 |
| 1st Order Attention | Equal variances assumed | .138 | 13 | .893 |
| 1st Order Motor | Equal variances assumed | -.260 | 13 | .799 |
| 1st Order Self-Control | Equal variances assumed | -2.217 | 13 | .045 |
| 1st Order Cognitive Complexity | Equal variances assumed | .008 | 13 | .994 |
| 1st Order Perseverance | Equal variances assumed | -.484 | 13 | .637 |
| 1st Order Cognitive Instability | Equal variances assumed | -1.499 | 13 | .158 |
| 2nd Order Attentional | Equal variances assumed | -.485 | 13 | .636 |
| 2nd Order Motor | Equal variances assumed | -.580 | 13 | .572 |
| 2nd Order Non-Planning | Equal variances assumed | -.912 | 13 | .378 |

The results in Table 8 indicate a combination of both increases and decreases in rate of change in impulsivity scores over all the scales. These results are not in support of the hypothesis that cognitive training has a greater impact on impulsivity than rehab alone, but the effect is not consistent as some of the observed changes varied in directionality for both the CTG and RG. Except for the self-control subscale, the differences in the differential change of impulsivity were not statistically significant (Table 9). Accordingly, although the rate of

change is in both directions, we have no reason to conclude that the rate at which the impulsivity scores changed from 4-week follow-up to 2-year follow-up was significantly different between the groups. In other words, we have no reason to conclude that the CT produced a substantively greater reduction in impulsivity as compared to rehab alone. The lack of statistical significant also means that we cannot conclude anything about those instances where the change for sub-scales was greater in the RG as compared to the CTG.

### 4.5.3 Conclusion on the CTG and RG across Subjects Analysis

The previous section reported the results for the independent samples t-tests using the across groups design. However, one limitation of these results is the reliance on the across-group design for the analysis. While the randomisation of the groups was believed to have been successful, as is evident from the lack of statistically significant differences in the baseline scores for the CTG as compared to the RG, there were nonetheless some differences observed. The presence of these differences may be argued to be amplified in the study because of the very small sample. Consequently, despite the lack of statistical significance in difference at baseline, it is difficult to rule out any potential impact the small, observed non-statistical differences might have had at subsequent assessments.



## 4.6 Test for Stability, Efficacy, and Durability of Cognitive Training by means of within Subjects Design

To compensate for the possible impact of the small, observed non-statistical differences observed in the results of the previous section, a further set of analyses was conducted using the within-groups design. This design is arguably more robust than the within-group design as it accounts for the repeated measures component of the study. In such a design, the comparisons are not conducted across groups at specified times, but rather within group across

times. In this way, we are able to examine if the change within a group is statistically significant when comparing one assessment period to another. To achieve this, the analysis examined within-group differences from baseline to four weeks and four weeks to two years for the CTG and then the RG. All analyses were conducted using the paired sample t-test.

However, prior to conducting the paired group t-tests, it was important to consider the stability of the scores across times. The score stability essentially relates to the relative positioning of individual scores within the group distribution. For example, scores that are low on the distribution at one time period will remain low on the distribution at another time, even though there has been change from the first to second times. That is, despite observed changes due to the intervention, the relative ranking of individuals remain constant, or mostly so. This is important as it indicates that the effect of the intervention is largely consistent across individuals: improvements observed for the group may vary across individuals but are all in the same general direction. Anomalies or deviations from this would prevail in the instance where individuals who are low on the distribution of BIS scale scores at baseline end up being high on the distribution at 4 weeks.



### 4.6.1 Assessing Score Stability of the CTG and RG

One way of assessing the stability of the intervention is by way of correlational analysis. If the scores were stable, we would observe significant correlations, and vice versa. The purpose of this test is not to provide substantive analysis, but rather to demonstrate some measure of stability. If no stability is observed, the results of the paired sample analysis might be compromised. However, if stability is observed, full or partial, it does not guarantee significant paired-sample t-test results, merely that the results of t-tests can be interpreted with greater confidence. That is, differences observed in the paired sample t-tests are more robust when the correlations are significant than when they are not.

#### 4.6.1.1 RG Score Stability from Baseline to 4-week follow-up

Table 10 presents the full scale and all subscale paired sample correlation results from baseline to 4-week follow-up for the RG.

**Table 10:**
**Paired Samples Correlations RG Baseline to 4-week follow-up**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Full-scale | 14 | .368 | .195 |
| Pair 2 | Attention | 14 | .125 | .669 |
| Pair 3 | Motor | 14 | .299 | .299 |
| Pair 4 | Self-Control | 14 | .309 | .283 |
| Pair 5 | Cognitive Complexity | 14 | .554 | .040 |
| Pair 6 | Perseverance | 14 | .208 | .476 |
| Pair 7 | Cognitive Instability | 14 | .098 | .739 |
| Pair 8 | 2nd Order Attentional | 14 | .396 | .161 |
| Pair 9 | 2nd Order Motor | 14 | .410 | .146 |
| Pair 10 | 2nd Order Non-Planning | 14 | .618 | .019 |



As the table reveals, in only two cases the correlations are statistically significant, indicating that these scores are relatively stable across the two periods.

#### 4.6.1.2 RG Score Stability from 4-week to 2-year follow-up

Table 11 presents the full-scale and all subscale paired sample correlation results from 4-week follow-up to 2-year follow-up for the CTG.

As the table reveals, in a few of the cases the correlations are statistically significant, indicating that these scores are relatively stable across the two periods.

**Table 11:**
**Paired Samples Correlations RG 4-week follow-up to 2-year follow-up**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Total | 7 | .773 | .041 |
| Pair 2 | Attention | 7 | -.066 | .889 |
| Pair 3 | Motor | 7 | .754 | .050 |
| Pair 4 | Self-Control | 7 | .891 | .007 |
| Pair 5 | Cognitive Complexity | 7 | .312 | .495 |
| Pair 6 | Perseverance | 7 | .625 | .134 |
| Pair 7 | Cognitive Instability | 7 | .549 | .202 |
| Pair 8 | 2nd Order Attentional | 7 | .165 | .724 |
| Pair 9 | 2nd Order Motor | 7 | .920 | .003 |
| Pair 10 | 2nd Order Non-Planning | 7 | .700 | .080 |

#### 4.6.1.3 CTG Score Stability Baseline to 4-week follow-up

Table 12 presents the full scale and all subscale paired sample correlation results from baseline to 4-week follow-up for the CTG.



**Table 12:**
**Paired Samples Correlations CTG Baseline to 4-week follow-up**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Full-scale | 19 | .778 | .000 |
| Pair 2 | Attention | 19 | .196 | .422 |
| Pair 3 | Motor | 19 | .636 | .003 |
| Pair 4 | Self-Control | 19 | .727 | .000 |
| Pair 5 | Cognitive Complexity | 19 | .581 | .009 |
| Pair 6 | Perseverance | 19 | .450 | .053 |
| Pair 7 | Cognitive Instability | 19 | .065 | .793 |
| Pair 8 | 2nd Order Attentional | 19 | .163 | .506 |
| Pair 9 | 2nd Order Motor | 19 | .671 | .002 |
| Pair 10 | 2nd Order Non-Planning | 19 | .788 | .000 |

As the table reveals, in the majority of the cases the correlations are statistically significant, indicating that these scores are relatively stable across the two periods.

#### 4.6.1.4 CTG Score Stability 4-week to 2-year follow-up

Table 13 presents the full scale and all subscale paired sample correlation results from 4-week follow-up to 2-year follow-up for the CTG.

**Table 13:**
**Paired Samples Correlations CTG 4-week follow-up to 2-year follow-up**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Total | 8 | .334 | .418 |
| Pair 2 | 1st Order Attention | 8 | .659 | .076 |
| Pair 3 | 1st Order Motor | 8 | .164 | .697 |
| Pair 4 | 1st Order Self-Control | 8 | .556 | .152 |
| Pair 5 | 1st Order Cognitive Complexity | 8 | -.409 | .315 |
| Pair 6 | 1st Order Perseverance | 8 | .097 | .820 |
| Pair 7 | 1st Order Cognitive Instability | 8 | .556 | .153 |
| Pair 8 | 2nd Order Attentional | 8 | .473 | .237 |
| Pair 9 | 2nd Order Motor | 8 | .176 | .677 |
| Pair 10 | 2nd Order Non-Planning | 8 | .185 | .662 |



As the table reveals, none of the cases yielded statistically significant values, indicating that these scores are not stable across the two periods.

#### 4.6.1.5 Conclusion on Score Stability

Overall, the stability of the impulsivity scale scores varied for both the CTG and RG over both periods. From baseline to four weeks, there is greater stability in scores for the CTG as compared to the RG while the RG yields greater score stability from four weeks to two years than those of the CTG.

### 4.6.2 Test of Efficacy and Durability of Cognitive Training by means of Within-Subjects Design

The previous section reported for correlation analysis to consider the stability of the impulsivity scaled scores across two time periods and found greater score stability for the CTG from baseline to four weeks, and for RG from four weeks to two years. These analyses demonstrated some measure of stability and offers greater confidence in the interpretation of analyses of some of the scores going forward. Now that some stability in scores was demonstrated, we can continue with the paired sample t-tests by means of within subjects design.

#### 4.6.2.1 Analysis of RG from baseline to 4 week follow-up

This analysis examined for within-group differences is scores from baseline to 4-week follow-up for the RG. Table 14 presents the group statistics of the RG from baseline to 4-week follow-up and reflects the differential changes in mean impulsivity scores for the full-scale and all sub-scales.



The change in the BIS full-scale and sub-scale scores revealed that most of mean impulsivity scores for RG decreased from baseline to 4-week follow-up. In terms of mean full-scale impulsivity scores, a decrease in score was observed at 4-week follow-up ($M$ = 64.86; $SD$ = 9.502) compared to the baseline score ($M$ = 68.79; $SD$ = 10.69). Similar score patterns emerged for the first order attention (4-weeks: $M$ = 9.93, $SD$ = 2.97; baseline: $M$ = 10.14, $SD$ = 2.71), motor (4-weeks: $M$ = 16.57, $SD$ = 4.15; baseline: $M$ = 17.14, $SD$ = 5.02), self-control (4-weeks: $M$ = 11.64, $SD$ = 2.71; baseline: $M$ = 14, $SD$ = 3.04), cognitive complexity (4-weeks: $M$ = 11.21, $SD$ = 3.36; baseline: $M$ = 11.64, $SD$ = 2.82), and perseverance (4-weeks: $M$ = 8.21, $SD$ = 2.72; baseline: $M$ = 8.86, $SD$ = 2.51) subscales. On the cognitive complexity scale a slight increase in impulsivity mean score was observed at 4-week follow-up ($M$ = 64.86; $SD$ =

9.502) compared to the baseline score (*M* = 64.86; *SD* = 9.502). This was also seen on the second order attentional scale (4-weeks: *M* = 17.21, *SD* = 3.95; baseline: *M* = 17.21, *SD* = 3.53). The last two second order scales followed the pattern of the full-scale scores as both second order motor (4-weeks: *M* = 24.79, *SD* = 5.06; baseline: *M* = 26, *SD* = 6.76) and non-planning (4-weeks: *M* = 22.86, *SD* = 5.56; baseline: *M* = 25.64, *SD* = 5.002) had decreased scores at 4-week follow-up compared to baseline.

**Table 14:**
**Paired Samples Statistics RG Baseline to 4-weeks**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Full-scale Baseline | 68.79 | 14 | 10.693 | 2.858 |
| | Full-scale 4 weeks | 64.86 | 14 | 9.502 | 2.539 |
| Pair 2 | 1st Order Attention Baseline | 10.14 | 14 | 2.713 | .725 |
| | 1st Order Attention 4 weeks | 9.93 | 14 | 2.973 | .795 |
| Pair 3 | 1st Order Motor Baseline | 17.14 | 14 | 5.021 | 1.342 |
| | 1st Order Motor 4 weeks | 16.57 | 14 | 4.146 | 1.108 |
| Pair 4 | 1st Order Self-Control Baseline | 14.00 | 14 | 3.038 | .812 |
| | 1st Order Self-Control 4 weeks | 11.64 | 14 | 2.706 | .723 |
| Pair 5 | 1st Order Cognitive Complexity Baseline | 11.64 | 14 | 2.818 | .753 |
| | 1st Order Cognitive Complexity 4 weeks | 11.21 | 14 | 3.355 | .897 |
| Pair 6 | 1st Order Perseverance Baseline | 8.86 | 14 | 2.507 | .670 |
| | 1st Order Perseverance 4 weeks | 8.21 | 14 | 2.723 | .728 |
| Pair 7 | 1st Order Cognitive Instability Baseline | 7.00 | 14 | 2.112 | .565 |
| | 1st Order Cognitive Instability 4 weeks | 7.29 | 14 | 1.858 | .496 |
| Pair 8 | 2nd Order Attentional Baseline | 17.14 | 14 | 3.527 | .943 |
| | 2nd Order Attentional 4 weeks | 17.21 | 14 | 3.945 | 1.054 |
| Pair 9 | 2nd Order Motor Baseline | 26.00 | 14 | 6.760 | 1.807 |
| | 2nd Order Motor 4 weeks | 24.79 | 14 | 5.056 | 1.351 |
| Pair 10 | 2nd Non Planning Baseline | 25.64 | 14 | 5.002 | 1.337 |
| | 2nd Order Non Planning 4 weeks | 22.86 | 14 | 5.559 | 1.486 |

The change in the BIS full-scale and sub-scale scores revealed that most of mean impulsivity scores for RG decreased from baseline to 4-week follow-up. In terms of mean full-

scale impulsivity scores, a decrease in score was observed at 4-week follow-up (*M* = 64.86; *SD* = 9.502) compared to the baseline score (*M* = 68.79; *SD* = 10.69). Similar score patterns emerged for the first order attention (4-weeks: *M* = 9.93, *SD* = 2.97; baseline: *M* = 10.14, *SD* = 2.71), motor (4-weeks: *M* = 16.57, *SD* = 4.15; baseline: *M* = 17.14, *SD* = 5.02), self-control (4-weeks: *M* = 11.64, *SD* = 2.71; baseline: *M* = 14, *SD* = 3.04), cognitive complexity (4-weeks: *M* = 11.21, *SD* = 3.36; baseline: *M* = 11.64, *SD* = 2.82), and perseverance (4-weeks: *M* = 8.21, *SD* = 2.72; baseline: *M* = 8.86, *SD* = 2.51) subscales. On the cognitive complexity scale a slight increase in impulsivity mean score was observed at 4-week follow-up (*M* = 64.86; *SD* = 9.502) compared to the baseline score (*M* = 64.86; *SD* = 9.502). This was also seen on the second order attentional scale (4-weeks: *M* = 17.21, *SD* = 3.95; baseline: *M* = 17.21, *SD* = 3.53). The last two second order scales followed the pattern of the full-scale scores as both second order motor (4-weeks: *M* = 24.79, *SD* = 5.06; baseline: *M* = 26, *SD* = 6.76) and non-planning (4-weeks: *M* = 22.86, *SD* = 5.56; baseline: *M* = 25.64, *SD* = 5.002) had decreased scores at 4-week follow-up compared to baseline.



To examine if the means presented in Table 14 are significantly different, paired sample t-tests were conducted for each set of means. The results are presented in Table 15. As can be seen in Table 15, there are statistically significant differences in the means for self-control ($t= -2.60$, $p < 0.05$) and second order non-planning ($t= -2.24$, $p < 0.05$) sub-scales from baseline to 4-week follow-up. In both instances, there is a statistically significant reduction in impulsivity scores at 4 weeks when compared to the baseline. None of the other tests returned significant results, indicating that there is no reason to conclude that any observed differences in impulsivity scores are substantive in nature. Stated differently, the impulsivity scores at baseline and at four weeks for these impulsivity scales are equivalent, implying no change or effect because of rehab alone.

**Table 15:**
**Paired Samples Test RG Baseline to 4-week follow-up**

| | | Paired Differences | | | | |
|---|---|---|---|---|---|---|
| | | Mean | Std. Error Mean | t | df | Sig. (1-tailed) |
| Pair 1 | Full-scale | -3.929 | 3.044 | -1.290 | 13 | .110 |
| Pair 2 | 1st Order Attention | -.214 | 1.006 | -.213 | 13 | .418 |
| Pair 3 | 1st Order Motor | -.571 | 1.463 | -.391 | 13 | .351 |
| Pair 4 | 1st Order Self-Control | -2.357 | .905 | -2.603 | 13 | .011 |
| Pair 5 | 1st Order Cognitive Complexity | -.429 | .789 | -.543 | 13 | .298 |
| Pair 6 | 1st Order Perseverance | -.643 | .881 | -.730 | 13 | .239 |
| Pair 7 | 1st Order Cognitive Instability | .286 | .714 | .400 | 13 | .348 |
| Pair 8 | 2nd Order Attentional | .071 | 1.102 | .065 | 13 | .475 |
| Pair 9 | 2nd Order Motor | -1.214 | 1.758 | -.691 | 13 | .251 |
| Pair 10 | 2nd Non Planning | -2.786 | 1.241 | -2.244 | 13 | .022 |



#### 4.6.2.2 Analysis of RG from 4-week follow-up to 2-year follow-up

This analysis examined for within-group differences is scores from 4-week to 2-year follow-up for the RG. Table 16 presents the group statistics of the RG from 4-week to 2-year follow-up and reflects the differential changes in mean impulsivity scores for the full-scale and all sub-scales.

The change in the BIS full-scale and sub-scale scores revealed increases and decreases in the mean impulsivity scores for RG from 4-week to 2-year follow-up. In terms of mean full-scale impulsivity scores, an increase in score was observed at 2-year follow-up ($M$ = 66.43; $SD$ = 12.21) compared to the 4-week follow-up score ($M$ = 65.57; $SD$ = 11.41). Similar score patterns emerged for the attention (2-years: $M$ = 11.43, $SD$ = 2.76; 4-weeks: $M$ = 10.29, $SD$ = 3.55), self-control (2-years: $M$ = 13.29, $SD$ = 3.73; 4-weeks: $M$ = 12.14, $SD$ = 2.19), cognitive complexity (2-years: $M$ = 12.14, $SD$ = 2.19; 4-weeks: $M$ = 11, $SD$ = 3.65), second order

attentional (2-years: *M* = 18.43, *SD* = 3.05; 4-weeks: *M* = 17.57, *SD* = 5.41) and the second order non-planning (2-years: *M* = 25.43, *SD* = 5.59; 4-weeks: *M* = 23.14, *SD* = 5.31) sub-scales.

**Table 16:**
**Paired Samples Statistics RG 4-week follow-up to 2-year follow-up**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Full-Scale 4 weeks | 65.57 | 7 | 11.414 | 4.314 |
| | Full-Scale 2 Years | 66.43 | 7 | 12.205 | 4.613 |
| Pair 2 | 1st Order Attention 4 weeks | 10.29 | 7 | 3.546 | 1.340 |
| | 1st Order Attention 2 Years | 11.43 | 7 | 2.760 | 1.043 |
| Pair 3 | 1st Order Motor 4 weeks | 16.14 | 7 | 5.367 | 2.029 |
| | 1st Order Motor 2 Years | 15.43 | 7 | 3.690 | 1.395 |
| Pair 4 | 1st Order Self-Control 4 weeks | 12.14 | 7 | 2.193 | .829 |
| | 1st Order Self-Control 2 Years | 13.29 | 7 | 3.729 | 1.409 |
| Pair 5 | 1st Order Cognitive Complexity 4 weeks | 11.00 | 7 | 3.651 | 1.380 |
| | 1st Order Cognitive Complexity 2 Years | 12.14 | 7 | 2.193 | .829 |
| Pair 6 | 1st Order Perseverance 4 weeks | 8.71 | 7 | 3.592 | 1.358 |
| | 1st Order Perseverance 2 Years | 7.14 | 7 | 1.952 | .738 |
| Pair 7 | 1st Order Cognitive Instability 4 weeks | 7.29 | 7 | 2.430 | .918 |
| | 1st Order Cognitive Instability 2 Years | 7.00 | 7 | 1.000 | .378 |
| Pair 8 | 2nd Order Attentional 4 weeks | 17.57 | 7 | 5.412 | 2.045 |
| | 2nd Order Attentional 2 Years | 18.43 | 7 | 3.047 | 1.152 |
| Pair 9 | 2nd Order Motor 4 weeks | 24.86 | 7 | 6.256 | 2.365 |
| | 2nd Order Motor 2 Years | 22.57 | 7 | 5.028 | 1.901 |
| Pair 10 | 2nd Order Non Planning 4 weeks | 23.14 | 7 | 5.305 | 2.005 |
| | 2nd Order Non Planning 2 Years | 25.43 | 7 | 5.593 | 2.114 |

On the motor subscale, decreases in mean impulsivity score was observed after 2 years (*M* = 15.43; *SD* = 3.69) compared to 4 weeks (*M* = 16.14; *SD* = 5.37). This was pattern was observed with the perseverance (2-years: *M* = 7.14, *SD* = 1.95; 4-weeks: *M* = 8.71, *SD* = 3.59), cognitive instability (2-years: *M* = 7.0, *SD* = 1.0; 4-weeks: *M* = 7.29, *SD* = 2.43), and second order motor (2-years: *M* = 25.43, *SD* = 5.59; 4-weeks: *M* = 23.14, *SD* = 5.31) subscales.

To examine if the means presented in Table 16 are significantly different, paired sample t-tests were conducted for each set of means. The results are presented in Table 17.

**Table 17:**
**Paired Samples Test RG 4-week follow-up to 2-year-follow-up**

| | | Paired Differences | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | t | df | Sig. (1-tailed) |
| Pair 1 | Full-scale | -.857 | 7.988 | 3.019 | -.284 | 6 | .393 |
| Pair 2 | 1st Order Attention | -1.143 | 4.634 | 1.752 | -.652 | 6 | .269 |
| Pair 3 | 1st Order Motor | .714 | 3.546 | 1.340 | .533 | 6 | .307 |
| Pair 4 | 1st Order Self-Control | -1.143 | 2.035 | .769 | -1.486 | 6 | .094 |
| Pair 5 | 1st Order Cognitive Complexity | -1.143 | 3.625 | 1.370 | -.834 | 6 | .218 |
| Pair 6 | 1st Order Perseverance | 1.571 | 2.820 | 1.066 | 1.474 | 6 | .096 |
| Pair 7 | 1st Order Cognitive Instability | .286 | 2.059 | .778 | .367 | 6 | .363 |
| Pair 8 | 2nd Order Attentional | -.857 | 5.757 | 2.176 | -.394 | 6 | .354 |
| Pair 9 | 2nd Order Motor | 2.286 | 2.563 | .969 | 2.359 | 6 | .028 |
| Pair 10 | 2nd Non Planning | -2.286 | 4.231 | 1.599 | -1.429 | 6 | .102 |



As can be seen in Table 17, although there are differences observed in both upward and downward directions, only second order motor ($t$ (6)= 2.359, $p$<0.05) yielded a statistically significant difference of the RG from 4-week to 2-year follow-up. None of the other scales returned significant results, indicating that there is no reason to conclude that their observed differences in impulsivity scores are substantive in nature. Stated differently, the impulsivity scores at 4-week and at 2-year follow-up for these impulsivity scales are equivalent, implying no change or effect because of rehab alone.

#### 4.6.2.3 Analysis of CTG from baseline to 4-week follow-up

This analysis examined for within-group differences is scores from baseline to 4-week follow-up for the CTG. Table 18 presents the group statistics of the CTG from baseline to 4-week follow-up and reflects the differential changes in mean impulsivity scores for the full-scale and all sub-scales.

**Table 18:**
**Paired Samples Statistics CTG Baseline to 4-week follow-up**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Full-scale Baseline | 66.79 | 19 | 12.947 | 2.970 |
| | Full-scale 4 weeks | 61.26 | 19 | 11.440 | 2.624 |
| Pair 2 | 1st Order Attention Baseline | 10.47 | 19 | 2.568 | .589 |
| | 1st Order Attention 4 weeks | 9.21 | 19 | 2.551 | .585 |
| Pair 3 | 1st Order Motor Baseline | 17.32 | 19 | 4.308 | .988 |
| | 1st Order Motor 4 weeks | 15.74 | 19 | 2.182 | .501 |
| Pair 4 | 1st Order Self-Control Baseline | 12.58 | 19 | 3.388 | .777 |
| | 1st Order Self-Control 4 weeks | 10.74 | 19 | 3.380 | .776 |
| Pair 5 | 1st Order Cognitive Complexity Baseline | 11.74 | 19 | 2.941 | .675 |
| | 1st Order Cognitive Complexity 4 weeks | 11.79 | 19 | 2.371 | .544 |
| Pair 6 | 1st Order Perseverance Baseline | 8.53 | 19 | 2.342 | .537 |
| | 1st Order Perseverance 4 weeks | 8.00 | 19 | 2.848 | .653 |
| Pair 7 | 1st Order Cognitive Instability Baseline | 6.16 | 19 | 1.344 | .308 |
| | 1st Order Cognitive Instability 4 weeks | 5.79 | 19 | 1.686 | .387 |
| Pair 8 | 2nd Order Attentional Baseline | 16.63 | 19 | 3.499 | .803 |
| | 2nd Order Attentional 4 weeks | 15.00 | 19 | 3.416 | .784 |
| Pair 9 | 2nd Order Motor Baseline | 25.84 | 19 | 5.919 | 1.358 |
| | 2nd Order Motor 4 weeks | 23.74 | 19 | 4.507 | 1.034 |
| Pair 10 | 2nd Non Planning Baseline | 24.32 | 19 | 5.677 | 1.302 |
| | 2nd Order Non Planning 4 weeks | 22.53 | 19 | 5.211 | 1.195 |

The change in the BIS full-scale and sub-scale scores revealed that almost all of the mean impulsivity scores for CTG decreased from baseline to 4-week follow-up. In terms of

mean full-scale impulsivity scores, a decrease in score was observed at 4-week follow-up (*M* = 61.26; *SD* = 11.44) compared to the baseline score (*M* = 66.79; *SD* = 12.95). Similar score patterns emerged for the first order attention (4-weeks: *M* = 9.21, *SD* = 2.55; baseline: *M* = 10.47, *SD* = 2.57), motor (4-weeks: *M* = 15.74, *SD* = 2.18; baseline: *M* = 17.32, *SD* = 4.31), self-control (4-weeks: *M* = 10.74, *SD* = 3.38; baseline: *M* = 12.58, *SD* = 3.39), perseverance (4-weeks: *M* = 8.0, *SD* = 2.85; baseline: *M* = 8.53, *SD* = 2.34), and cognitive instability (4-weeks: *M* = 5.79, *SD* = 1.69; baseline: *M* = 6.16, *SD* = 1.34) subscales. All three second order sub-scales followed the pattern of the full-scale scores as seen on second order attentional (4-weeks: *M* = 15.0, *SD* = 3.42; baseline: *M* = 16.63, *SD* = 3.5), second order motor (4-weeks: *M* = 23.74, *SD* = 4.51; baseline: *M* = 25.84, *SD* = 5.92) and non-planning (4-weeks: *M* = 22.53, *SD* = 5.21; baseline: *M* = 24.32, *SD* = 5.68) had decreased scores at 4-week follow-up compared to baseline. On the cognitive complexity scale a minute increase in impulsivity mean score was observed at 4-week follow-up (*M* = 11.79; *SD* = 2.37) compared to the baseline score (*M* = 11.74; *SD* = 2.94).



To examine if the means presented in Table 18 are significantly different, paired sample t-tests were conducted for each set of means. The results are presented in Table 19.

As can be seen in Table 19, there are statistically significant differences in the means for the full-scale ($t = -2.92$, $p<0.05$), motor ($t = -2.041$, $p<0.05$), self-control ($t = -3.21$, $p<0.05$), second order motor ($t = -2.076$, $p<0.05$), and second order non-planning ($t = -2.186$, $p<0.05$) sub-scales from baseline to 4-week follow-up. In these instances, there is a statistically significant reduction in impulsivity scores at 4 weeks when compared to the baseline. In other words, on five (full-scale, motor, self-control, second order motor, second order non-planning) of the ten BIS-11 scales a significant difference in impulsivity score from baseline to 4-week follow-up is observed. In addition, the directionality of the five scales shows a significant decrease in impulsivity scores from baseline to 4-week follow-up. Stated differently, the impulsivity

scores for these scales from baseline to 4-week follow-up are not equivalent and imply a significant change or effect because of the addition of the cognitive training to the standard rehab program. However, none of the other tests returned significant results indicating that there is no reason to conclude that any observed differences in impulsivity scores on these scales are substantive in nature. In other words, the impulsivity scores at baseline and at four weeks for these impulsivity scales are equivalent, implying no change or effect because of cognitive training.

**Table 19:**
**Paired Samples Test CTG Baseline to 4-week follow-up**

| | | Paired Differences | | | | |
|---|---|---|---|---|---|---|
| | | Mean | Std. Error Mean | t | df | Sig. (1-tailed) |
| Pair 1 | Full-scale | -5.526 | 1.892 | -2.920 | 18 | .005 |
| Pair 2 | 1st Order Attention | -1.263 | .745 | -1.696 | 18 | .054 |
| Pair 3 | 1st Order Motor | -1.579 | .774 | -2.041 | 18 | .028 |
| Pair 4 | 1st Order Self-Control | -1.842 | .574 | -3.211 | 18 | .003 |
| Pair 5 | 1st Order Cognitive Complexity | .053 | .570 | .092 | 18 | .464 |
| Pair 6 | 1st Order Perseverance | -.526 | .632 | -.832 | 18 | .208 |
| Pair 7 | 1st Order Cognitive Instability | -.368 | .479 | -.769 | 18 | .226 |
| Pair 8 | 2nd Order Attentional | -1.632 | 1.027 | -1.589 | 18 | .065 |
| Pair 9 | 2nd Order Motor | -2.105 | 1.014 | -2.076 | 18 | .027 |
| Pair 10 | 2nd Non Planning | -1.789 | .819 | -2.186 | 18 | .021 |



#### 4.6.2.4 Analysis of CTG from 4-week follow-up to 2-year follow-up

This analysis examined for within-group differences is scores from 4-week to 2-year follow-up for the CTG. Table 20 presents the group statistics of the CTG from 4-week to 2-year follow-up and reflects the differential changes in mean impulsivity scores for the full-scale and all sub-scales. The change in the BIS full-scale and sub-scale scores revealed that most of the mean impulsivity scores for CTG increased from 4-week to 2-year follow-up. In terms of mean full-

scale impulsivity scores, an increase in score was observed at 2-year follow-up (*M* = 66.75; *SD* = 10.58) compared to the 4-week follow-up score (*M* = 60.75; *SD* = 11.45). Similar score patterns emerged for the attention (2-years: *M* = 10.0, *SD* = 3.7; 4-weeks: *M* = 9.13, *SD* = 2.17), self-control (2-years: *M* = 14.50, *SD* = 2.88; 4-weeks: *M* = 10.63, *SD* = 2.72), cognitive complexity (2-years: *M* = 13.13, *SD* = 3.4; 4-weeks: *M* = 12, *SD* = 2.67), and cognitive instability (2-years: *M* = 7.13, *SD* = 1.25; 4-weeks: *M* = 5.88, *SD* = 2.3) subscales. On the motor subscale, a minute decrease in impulsivity mean score was observed at 2-year follow-up (*M* = 15.13; *SD* = 2.85) compared to the 4-week follow-up score (*M* = 15.38; *SD* = 2.33). Similar patterns were observed on the perseverance (2-years: *M* = 6.88, *SD* = 1.81; 4-weeks: *M* = 7.75, *SD* = 2.25) and second order motor (2-years: *M* = 22.0, *SD* = 3.25; 4-weeks: *M* = 23.13, *SD* = 4.05) subscales.

**Table 20:**

**Paired Samples Statistics CTG 4-week follow-up to 2-year-follow-up**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Full-Scale 4 weeks | 60.75 | 8 | 11.449 | 4.048 |
| | Full-Scale 2 Years | 66.75 | 8 | 10.580 | 3.740 |
| Pair 2 | 1st Order Attention 4 weeks | 9.13 | 8 | 2.167 | .766 |
| | 1st Order Attention 2 Years | 10.00 | 8 | 3.703 | 1.309 |
| Pair 3 | 1st Order Motor 4 weeks | 15.38 | 8 | 2.326 | .822 |
| | 1st Order Motor 2 Years | 15.13 | 8 | 2.850 | 1.008 |
| Pair 4 | 1st Order Self-Control 4 weeks | 10.63 | 8 | 2.722 | .962 |
| | 1st Order Self-Control 2 Years | 14.50 | 8 | 2.878 | 1.018 |
| Pair 5 | 1st Order Cognitive Complexity 4 weeks | 12.00 | 8 | 2.673 | .945 |
| | 1st Order Cognitive Complexity 2 Years | 13.13 | 8 | 3.399 | 1.202 |
| Pair 6 | 1st Order Perseverance 4 weeks | 7.75 | 8 | 2.252 | .796 |
| | 1st Order Perseverance 2 Years | 6.88 | 8 | 1.808 | .639 |
| Pair 7 | 1st Order Cognitive Instability 4 weeks | 5.88 | 8 | 2.295 | .811 |
| | 1st Order Cognitive Instability 2 Years | 7.13 | 8 | 1.246 | .441 |
| Pair 8 | 2nd Order Attentional 4 weeks | 15.00 | 8 | 3.854 | 1.363 |
| | 2nd Order Attentional 2 Years | 17.13 | 8 | 4.549 | 1.608 |
| Pair 9 | 2nd Order Motor 4 weeks | 23.13 | 8 | 4.051 | 1.432 |
| | 2nd Order Motor 2 Years | 22.00 | 8 | 3.207 | 1.134 |
| Pair 10 | 2nd Order Non Planning 4 weeks | 22.63 | 8 | 4.868 | 1.721 |
| | 2nd Order Non Planning 2 Years | 27.63 | 8 | 5.706 | 2.017 |

To examine if the means presented in Table 20 are significantly different, paired sample t-tests were conducted for each set of means. The results are presented in Table 21.

**Table 21:**
**Paired Samples Test CTG 4-week follow-up to 2-year-follow-up**

| | | Paired Differences | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | t | df | Sig. (1-tailed) |
| Pair 1 | Full-Scale | -6.000 | 12.728 | 4.500 | -1.333 | 7 | .112 |
| Pair 2 | 1st Order Attention | -.875 | 2.800 | .990 | -.884 | 7 | .203 |
| Pair 3 | 1st Order Motor | .250 | 3.370 | 1.191 | .210 | 7 | .420 |
| Pair 4 | 1st Order Self-Control | -3.875 | 2.642 | .934 | -4.148 | 7 | .002 |
| Pair 5 | 1st Order Cognitive Complexity | -1.125 | 5.111 | 1.807 | -.623 | 7 | .277 |
| Pair 6 | 1st Order Perseverance | .875 | 2.748 | .972 | .900 | 7 | .199 |
| Pair 7 | 1st Order Cognitive Instability | -1.250 | 1.909 | .675 | -1.852 | 7 | .053 |
| Pair 8 | 2nd Order Attentional | -2.125 | 4.357 | 1.540 | -1.380 | 7 | .105 |
| Pair 9 | 2nd Order Motor | 1.125 | 4.704 | 1.663 | .676 | 7 | .260 |
| Pair 10 | 2nd Non Planning | -5.000 | 6.782 | 2.398 | -2.085 | 7 | .038 |

As can be seen in Table 21, there is a statistically significant difference in the means for the self-control ($t$ = -4.15, $p$<0.05), cognitive instability ($t$ = -1.85, $p$<0.05) and second order non-planning ($t$ = -2.09, $p$<0.05) subscales only. In this instance, there is a statistically significant increase in impulsivity scores at two years when compared to four weeks. None of the other tests returned significant results, indicating that there is no reason to conclude that any observed differences in impulsivity scores are substantive in nature. In other words, the impulsivity scores at 4 weeks and at 2 years for these impulsivity scales are equivalent, implying no change or effect because of rehab alone.

#### 4.6.2.5 Conclusion on the RG and CTG within Subjects Analyses

Overall, from the results of the within subjects design for the RG, minimal change was observed in impulsivity scores from baseline to 4-week follow-up and no significant change was observed from 4-week follow-up to 2-year follow-up. The results for the CTG was significantly different as more of the impulsivity scales yielded statistically significant scores from baseline to 4-week follow-up compared to the RG.

# CHAPTER 5

# DISCUSSION

## 5.1 Introduction

The aim of this research project was to identify the effect of cognitive training on impulsivity in MA addicts in the Western Cape. This chapter presents a discussion of the results reflected in chapter 4 in light of the research objectives of this project as outlined in chapter 1. Each research objective is discussed in relation to the results to show how the findings support or contradicts the research hypotheses. The results are then discussed in relation to other research findings.

## 5.2 Discussion

### 5.2.1 Comparing the changes in impulsivity of the Rehabilitation group with the Cognitive training group



The first objective of this project aimed at investigating the rate of change in impulsivity, from baseline to four weeks, between the participants of the RG and the participants of the CTG. The second objective aimed at investigating the differential change in impulsivity, from four weeks to two years, of the RG and the CTG. For this investigation, an across-group design was performed for the purpose of these comparisons. In all instances the differences in the rate of change in impulsivity for the CTG, while different from that of the RG, was not statistically significant. In other words, these results did not support the project's first two hypotheses, i.e. that the rate of decrease in impulsivity for the CTG will be significantly greater than the rate of decrease in impulsivity for the RG over the periods that they were compared. This would seem to suggest that the cognitive training when paired with standard rehab did not have a stronger effect in decreasing impulsivity compared to the effect of standard rehab only.

However, an important limitation in comparing the CTG with the RG using the across-subjects design is that the sample size is so small that even minute differences in the original baseline scores can have a significant impact on what the differentials are. Although we observed that there are no statistically significant differences in the impulsivity scores between the CTG and RG at baseline, there still are differences. Therefore, the above comparison fails to account for originating or prior differences in the two groups. Had the sample been larger, this limitation would have not been an issue. Compensating for the above limitation, a comparison was performed to establish how impulsivity rates changed in the research participants relative to themselves using a within-subjects design. In order to make these comparisons useful we investigated the impulsivity rates for RG and CTG at baseline and four weeks, and at four weeks and two years, and the impulsivity rates for CTG at baseline and four weeks, and at four weeks and two years. The assumption here was that, because the project is tracking the same individuals over the two periods, the approach diminishes the amount of error variance. Therefore, all the factors that in some way confounded the across group analysis above are reduced as we are in fact comparing individuals to themselves. These comparisons aimed at addressing research objectives three through to six.



### 5.2.2 The Effect of Standard Rehabilitation on Impulsivity

The third research objective aimed at investigating the change in impulsivity for the RG from baseline to four weeks, to determine whether standard rehab only had significant effect on impulsivity after four weeks. The results found that from baseline to 4-week follow-up there were two instances, namely self-control and second order non-planning, which showed significant reductions in impulsivity rates due to the standard rehabilitation that the research participants were receiving. The findings support the third research hypotheses i.e. that there will be a significant decrease in impulsivity for the RG when baseline impulsivity rates are

compared to 4-week follow-up rates. This would seem to suggest that standard rehab has the effect of significantly decreasing some aspects of impulsivity. As the self-control and second-order-non planning scales of the CTG also reflect statistically significant reductions in impulsivity from baseline to 4-week follow-up, it is possible that the standard rehabilitation that was offered at the treatment facility stimulated working memory functioning to some extent. However, considering that the full-scale score rendered non-significant results, it is likely that that the reductions in impulsivity reflected here are minimal. This is in line with the literature as previous studies reflect that MA addicts show persistent cognitive deficits after abstinence and recovery. For example, research findings by Simon and colleagues (2010) suggests that MA addicts do not show substantial gains in cognitive abilities one month after abstinence, while and earlier study by Volkow and colleagues (2001) demonstrated that neuropsychological functioning in MA addicts did not recover after prolonged abstinence of at least 9 months.



Of more importance in the attempt to assess the effectiveness of the standard rehabilitation in reducing impulsivity, is whether the changes had lasting effect, or rather, demonstrated durability. The fourth research objective of this project aimed at investigating this effect by determining whether standard rehabilitation alone had significant durability effect by decreasing impulsivity rates of the RG two years after their integration back into society. The results indicated that only one scale, second order motor, had a statistically significant reduction in the rate of impulsivity. This supports the fourth research hypotheses i.e. that there will be a significant decrease in impulsivity for the RG when 4-week follow-up impulsivity rates are compared to the rates at 2-year follow-up. However, the impulsivity sub-scales that demonstrated significant reductions from baseline to four-week follow-up, i.e. self-control and second order non-planning, did not render significant reductions at 2-year follow-up. This would seem to suggest that the standard rehabilitation did not have lasting effect on the

reductions in impulsivity at 4-week follow-up. The standard rehabilitation does however have a significant effect on second order motor impulsivity.

### 5.3 The Effect of Cognitive Training with Standard Rehabilitation on Impulsivity

The fifth objective of the project aimed at investigating the change in impulsivity for the CTG from baseline to 4-week follow-up to determine whether four weeks of cognitive training with standard rehabilitation had significant effect on impulsivity. The results found that, from baseline to 4-week follow-up, five instances, namely full scale, motor, self-control, second order motor, and second order non-planning, showed statistically significant decreases in impulsivity rates. This finding supports the fifth hypotheses that cognitive training when paired with standard rehabilitation has the effect of significantly decreasing impulsivity rates. The results indicate that the CTG had reductions in more components of impulsivity than the RG suggesting that this variation of cognitive training that targets and trains working memory as a cognitive function shows promise in its ability to decrease subjective impulsivity when paired with a standard drug rehabilitation program. However, it could be theorized that the significant reductions in self-control and second order non-planning demonstrated in both RG and CTG is because of the standard rehabilitation while the reductions in full-scale, motor, and second order motor impulsivity that is evident in the CTG but not in the RG are because of the added cognitive training. Nevertheless, due to the small sample and the lack of significant differences demonstrated in the across-group design, these theories can only be stated tentatively.



The findings of significant reductions in impulsivity after cognitive training are in line with other studies that demonstrate correlations between working memory training and lower levels of impulsivity. For example, two studies demonstrate that working memory training improved the clinical outcomes of individuals diagnosed with conditions know to have a problematic impulsivity component. Klingberg and colleagues (2002) utilized a four-subtest

working memory battery with increasing difficulty to a small child sample (n=7 per group) with a diagnosis of ADHD. Pre- and post-training evaluations consisted of five cognitive tasks. The results suggest that working memory training had a significant effect in decreasing motor impulsivity. Houben and colleagues (2011) on the other hand, investigated whether working memory training restored control over problematic drinking behaviour in an adult sample (n=48) of hazardous drinkers. The participants performed three working memory tasks during 25 sessions over at least 25 days. The results suggest that working memory may be a useful strategy to decrease alcohol consumption by increasing control over automatic impulses implicated in uncontrolled alcohol consumption. Bickel and colleagues (2011) incorporated four different computerised memory programs into a working memory training trail for 27 male participants with a stimulant-abuse/dependent diagnosis and the results demonstrated that working memory training was able to significantly reduce delay discounting as a domain of impulsivity. Fals-Steward and Lam (2010) demonstrated that patients with a substance use disorder who had standard drug treatment with computerised cognitive remediation, designed to improve cognitive abilities such as problem solving attention, and memory, were more engaged and committed in treatment, and reported better long-term outcomes.



One of the recommendations that Bickel and colleagues (2011) stated was that future studies are needed to determine the durability of the working memory training on the decreases in delay discounting. This project does not specifically demonstrate whether the cognitive training addresses delay discounting directly given that the BIS-11 does not specifically measure delayed discounting. However, since the training targets working memory functioning and the literature supports the notion that working memory and delayed discounting are positively correlated (Bickel et al. 2011), it could be hypothesised that the subscales of the BIS-11 that showed statistically significant results in the CTG represents reductions in impulsivity characteristic of lower rates of delayed discounting. The sixth

objective of the project aimed at investigating this recommendation by analysing the change in impulsivity for the CTG from four weeks to two years to determine whether four weeks of cognitive training with standard rehabilitation had significant durability in decreasing impulsivity rates. From 4-week to 2-year follow-up three instances, namely self-control, cognitive instability, and second order-non-planning, showed statistically significant increases in impulsivity. This finding does not support the sixth hypotheses that cognitive training, when paired with standard rehabilitation, has significant durability effect by significantly reducing impulsivity rates two years after the participants left the treatment facility. The increases in impulsivity of the CTG after two years may suggest that the changes in impulsivity due to the working memory training did not persist over two years. Interestingly, the self-control and non-planning impulsivity scales that failed to show significant durability in the RG demonstrates significant increases after two years with the CTG. This seems to suggest that the cognitive training when offered with standard rehabilitation has no durability over a two-year period. From the significant results here, it seems that the cognitive training did not offer the participants durable effects in maintaining significantly reductions in self-reported impulsivity after 2-year follow-up. On the contrary, it seems that the working memory training resulted in significant increases in self-reported rates of impulsivity in the three scales identified above. One possible explanation is that the acquired gains in working memory functioning after the cognitive training, which had a decreasing effect on subjective impulsivity, deteriorated over time due to a lack of maintenance or follow-up practice sessions (Shaffer, 2016). Once an awareness of cognitive control was established to some degree after cognitive training, a systematic loss of cognitive control over time may magnify the subjective experience of the consequences related to this loss, in this case increases in areas of self-reported impulsivity.

# CHAPTER 6

# CONCLUSION

## 6.1 Introduction

This chapter presents the implications of the results for clinical practice and theory, and highlights the research project's limitations. The chapter concludes with future research suggestions.

## 6.2 Implications of results in terms of clinical practice and theory

The results of this project may have several implications in terms of theory of MA addiction and clinical practice.



### 6.2.1 Implications for theory of MA addiction

Firstly, the results serves as additional support in addiction research that positively correlate working memory training with decreases in impulsive behaviour of individuals with MA addiction. More specifically, the results support the neurobehavioural decision system hypothesis of addiction as demonstrated by Bickel and colleagues (2011). The results verifies that working memory training, which targets working memory functioning within the domain of the executive system, has the potential to decrease rates of impulsivity. Therefore, working memory training appears activate the hypoactive executive system implicated with high rates of impulsive behaviour. Secondly, the results support the theoretical assumptions of this project as outlined by Shah and Mountain (2007) as it demonstrates the causation and remediation relationship between brain functioning and impulsive behaviour. The relationship is illustrated by the decreased rates of impulsivity in the CTG after the experimental treatment (working memory training) that specifically targeted one aspect (working memory) of the

executive functioning system of the brain. Thirdly, the results may lead to further research on a larger scale to investigate the effects of working memory training on impulsivity. This is the first know project that demonstrates findings related to the far reaching effects (durability) of working memory training on rates of impulsivity in a Western Cape population with MA addiction and addressed in part some of the research considerations suggested by other similar studies (Bickel et al. 2011). In addition, the findings have the potential to lead to investigations of the effect of cognitive training on impulsivity in other clinical populations with impulsive disorders. However, this study requires investigation on a larger scale to determine the method by which the far-reaching effects of working memory training can be improved.

### 6.2.2 Implications for clinical practice

The findings of this project confirm that the type of working memory training used in this project has the potential to decrease rates of impulsivity. The findings support the notion that neurocognitive rehabilitation may be a useful addition to drug rehabilitation programmes, specifically for MA addiction. This is in line with findings by Bickel and colleagues (2011) who demonstrated that working memory training has the ability to decrease rates of delay discounting. The possibility exists that treatment of MA addiction, and possibly other impulsivity disorders, may have greater success if a validated working memory programme is introduced. Clinical use of this type of working memory training greatly depends on treatment replication and validation.



## 6.3 Limitations of the study

This research project had a few limitations that require consideration. Firstly, due to small sample sizes, specifically within the 2-year follow-up groups, there are some boundaries regarding the reliability of the results and firm conclusions cannot be made. Additionally, as

previously mentioned, due to the small sample the results of the validation of randomization analysis cannot account for the differences that may be present in the two groups, which placed limitations on the extent to which inferences could be made when comparing the changes in impulsivity rates of the CTG with those of the RG. However, the analysis controlled for this limitation by performing the within-group design. Thirdly, due to the limited scope of this project only one well-established self-report impulsivity scale was selected as the measurement tool. However, a self-report measure on its own does not provide high interpretive power without supporting measurement strategies and tools. The measure does not specifically target the domain of delay discounting but rather impulsivity as a whole, and inferences about the effect of the cognitive training on delay discounting specifically can therefore only be made tentatively in relation to the connection that addiction literature has established between working memory functioning and delayed discounting.

### 6.4 Future research suggestions



This research initiative was an embedded project that formed part of a larger study. Due to the results reflected here, further research on a larger scale may offer substantive (and significant) evidence to support the notion that cognitive training, specifically working memory training, may be a useful treatment tool in addiction rehabilitation. These findings therefore not only contribute to the knowledge base of methamphetamine addiction but also have implications for the application of treatment modalities.

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## APPENDIX A: General demographics questionnaire

| | |
|---|---|
| **Name:** | |
| **Date of Birth:** | |
| **Place of Birth:** | |
| **Handedness:** | |
| **Claustrophobic?** | |
| **Gender:** | |
| **Ethnicity:** | |
| **Education Level:** | |
| **Marital Status:** | |
| **Living Arrangement:** | |
| **Dependents:** | |
| **Smoking History:** | |
| **Drug History:** | |
| **How long taking Methamphetamine:** | |
| **What was the quanity/frequency?** | |
| **How long stopped taking meth?** | |
| **Current Medications:** | |
| **Medical Conditions:** | |
| **Medical History:** | |
| **Dietary Style:** | |
| **Current drug use:** | |
| **over the counter?** | |
| **perscription?** | |
| **illicit?** | |
| **other?** | |

## APPENDIX B: Barratt Impulsivity Scale – Eleventh Edition (BIS– 11)

DIRECTIONS: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and put an X on the appropriate circle on the right side of this page. Do not spend too much time on any statement. Answer quickly and honestly.

① Rarely/Never ② Occasionally ③ Often ④ Almost Always/Always

| | | | | | |
|---|---|---|---|---|---|
| 1 | I plan tasks carefully. | ① | ② | ③ | ④ |
| 2 | I do things without thinking. | ① | ② | ③ | ④ |
| 3 | I make-up my mind quickly. | ① | ② | ③ | ④ |
| 4 | I am happy-go-lucky. | ① | ② | ③ | ④ |
| 5 | I don't "pay attention." | ① | ② | ③ | ④ |
| 6 | I have "racing" thoughts. | ① | ② | ③ | ④ |
| 7 | I plan trips well ahead of time. | ① | ② | ③ | ④ |
| 8 | I am self controlled. | ① | ② | ③ | ④ |
| 9 | I concentrate easily. | ① | ② | ③ | ④ |
| 10 | I save regularly. | ① | ② | ③ | ④ |
| 11 | I "squirm" at plays or lectures. | ① | ② | ③ | ④ |
| 12 | I am a careful thinker. | ① | ② | ③ | ④ |
| 13 | I plan for job security. | ① | ② | ③ | ④ |
| 14 | I say things without thinking. | ① | ② | ③ | ④ |
| 15 | I like to think about complex problems. | ① | ② | ③ | ④ |
| 16 | I change jobs. | ① | ② | ③ | ④ |
| 17 | I act "on impulse." | ① | ② | ③ | ④ |
| 18 | I get easily bored when solving thought problems. | ① | ② | ③ | ④ |
| 19 | I act on the spur of the moment. | ① | ② | ③ | ④ |
| 20 | I am a steady thinker. | ① | ② | ③ | ④ |
| 21 | I change residences. | ① | ② | ③ | ④ |
| 22 | I buy things on impulse. | ① | ② | ③ | ④ |
| 23 | I can only think about one thing at a time. | ① | ② | ③ | ④ |
| 24 | I change hobbies. | ① | ② | ③ | ④ |
| 25 | I spend or charge more than I earn. | ① | ② | ③ | ④ |
| 26 | I often have extraneous thoughts when thinking. | ① | ② | ③ | ④ |
| 27 | I am more interested in the present than the future. | ① | ② | ③ | ④ |
| 28 | I am restless at the theater or lectures. | ① | ② | ③ | ④ |
| 29 | I like puzzles. | ① | ② | ③ | ④ |
| 30 | I am future oriented. | ① | ② | ③ | ④ |

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## APPENDIX C: Permission to access data from primary research study

**UNIVERSITY OF CAPE TOWN**
**Faculty of Health Sciences**
**Human Research Ethics Committee**

**Room E52-24 Old Main Building**
**Groote Schuur Hospital**
**Observatory 7925**
**Telephone** [021] 406 6338 • **Facsimile** [021] 406 6411
**Email:** shuretta.thomas@uct.ac.za
**Website**: www.health.uct.ac.za/research/humanethics/forms

14 March 2014

**HREC REF: 113/2014**

**Dr S Brooks**
Psychiatry & Mental Health
J2, GSH

Dear Dr Brooks

**PROJECT TITLE: COGNITIVE TRAINING IN OBSESSIVE DISORDER (OCD) PATIENTS (Degree - Vaneshren Naidoo)**

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.



Before formal approval can be given, the investigator must address the issue/s raised by the Committee:

1. Please provide a citation for the statement that 3% of the global population suffers from OCD (page 1 of section b).
2. Please clarify whether a study involving 10 participants will have sufficient statistical power to show a significant difference on the outcome of interest. Please clarify the power calculation process and the assumptions used.
3. In relation to the question of statistical power, the investigators need to provide clear indication of the likely change in scores on the primary outcomes (clearly identifying which instruments/measures will be used to assess the primary outcomes working memory and OCD).
4. Study design: the study is described as a case-control study, yet information is only provided on the recruitment of 10 OCD patients, and elsewhere reference is made to a "follow-up within patient group, baseline-controlled pilot study". Please clarify what is the main study design.
5. If the design is a case-control study, more information needs to be provided on the characteristics, enrolment and assessment of the "control" group.
6. Please provide justification for the use of many instruments that do not have a bearing on the main research question, or duplicate other measures (e.g. Childhood Trauma questionnaire, SDS, HADS, 2 impulsivity scales etc). it is important to balance the needs of the study with the burden/fatigue of the participants. For the additional questionnaires the HREC suggest a justification is provided for how these shed light on the main research questions, or what new research questions they are intended to answer.
7. In point c, on the informed consent form (page 2) a very brief explanation of the task is provided, but this doesn't give a clear sense of what is required – mention is made of participants seeing letters on a screen and needing to concentrate hard, but the actual working memory task is not adequately described. Please provide more detail, so that participants

understand what will be required. More detail is provided on the separate information sheet, but the HREC suggest that a summary is also provided on the informed consent form.

8. The informed consent form currently focuses mainly on the intervention, but doesn't provide information on the nature and length of the assessment, e.g. the time that will be required to complete the many instruments listed in the protocol. A general summary of the assessment interview and how long it will take to complete should also be provided.
9. If the study is in fact a case-control study, then a modified informed consent form will need to be created for the (presumably non-OCD) control participants.
10. There needs to be some description of the piloting of the instruments, e.g. if the assessment interview takes 3 hours to complete, it might be better to know this before the full study recruitment commences.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

**Please quote the HREC REF in all your correspondence.**

Yours sincerely

**PROFESSOR MARC BLOCKMAN**
**CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE**



HREC 113/2014

## APPENDIX D: Ethical clearance – University of Cape Town (UCT)

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

### FHS016: Annual Progress Report / Renewal

| HREC office use only (FWA00001637; IRB00001938) This serves as notification of annual approval, including any documentation described below. | | | |
|---|---|---|---|
| ☑ Approved | Annual progress report | Approved until/next renewal date | 30/11/2014 |
| ☐ Not approved | See attached comments | | |
| Signature Chairperson of the HREC | | Date Signed | 15/10/2013 |

| Comments to PI from the HREC | HUMAN RESEARCH ETHICS COMMITTEE 15 OCT 2013 HEALTH SCIENCES FACULTY UNIVERSITY OF CAPE TOWN |
|---|---|

**Principal Investigator to complete the following:**

**1. Protocol information**

| | | | |
|---|---|---|---|
| Date form submitted | 02.10.2013 | | |
| HREC REF Number | 554/2012 | Current Ethics Approval was granted until | 30.11.2013 |
| Protocol title | Neural connectivity and cognitive function in methamphetamine addiction using structural and functional brain imaging in South Africa | | |
| Protocol number (if applicable) | N/A/ | | |
| Are there any sub-studies linked to this study? | ☐ Yes X No | | |
| If yes, could you please provide the HREC Ref's for all sub-studies? **Note:** A separate FHS016 must be submitted for each sub-study. | | | |
| Principal Investigator | Dr. Samantha Brooks | | |
| Department / Office Internal Mail Address | Department of Psychiatry and Mental Health, J2 Building, Old Groote Schuur Hospital, Anzio Road, Observatory, Cape Town. 7995 | | |

| | | |
|---|---|---|
| 1.1 Does this protocol receive US Federal funding? | ☐ Yes | X No |
| 1.2 If the study receives US Federal Funding, does the annual report require full committee approval? | ☐ Yes | X No |



(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

## APPENDIX E: Permission from primary researcher to conduct embedded study



**Department of Psychiatry and Mental Health**

UCT Dept of Psychiatry and Mental Health, Groote Schuur Hospital (J-2), Anzio Rd,
Observatory 7925, Cape Town, South Africa
Phone: +27 21 4042137 Fax: +27 21 4488158
URL: http://www.health.uct.ac.za/departments/psychiatry/about/

27th March, 2014

To whom it may concern,

Re. Gert Coetzee's research project for MPsych 2014

I am writing to permit Mr Coetzee to use the Barratt Impulsivity as well as general demographics (e.g. age, ethnicity, socio-economic status, drug use history), to conduct his project with our research group who have given consent to participate in this research project. The project examines the effects of cognitive training on craving status in methamphetamine abusers.

Specifically, Mr Coetzee is examining the hypothesis that 4 weeks of cognitive training using a working memory task will lower relapse rates in ex-inpatients of Kensington Treatment Centre (KTC) following their release back in to their home environments. Mr Coetzee will also examine whether cognitive training that was given at KTC as an adjunct to treatment as usual over a four-week (20 sessions) period will alter impulsivity and self-regulation scores.

While I am not Mr Coetzee's formal supervisor, as I am based at UCT, I am willing to offer him support when I can, so that his project progresses smoothly.

Please do not hesitate to contact me at: drsamanthabrooks@gmail.com should you have any further queries relating to this project.

With best regards,

Samantha Brooks, PhD, CMBPS