Investigating an Executive Function Intervention Using Goal Management Training in HIV+ Adolescents in South Africa

Angela Harwood

HRWANG002

A minor dissertation submitted in *partial fulfillment* of the requirements for the award of the Degree of Master of Arts in Neuropsychology

Faculty of the Humanities

University of Cape Town

2021

COMPULSORY DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signature: Signed by candidate Date: 14 March 2021

Acknowledgements

This research project would not have been possible without the support, understanding and thoughtfulness of my supervisors. Firstly, I would like to express sincere thanks to A/Prof Leigh Schrieff for her guidance, patience and encouragement as my research supervisor. It has certainly been a challenging undertaking, but a rewarding one nonetheless. I am also immensely grateful to my co-supervisor, A/Prof Kevin Thomas. Firstly, for his mentorship and support throughout my postgraduate research journey, and secondly, for his extensive and meticulous feedback on my thesis.

I would like to acknowledge Vakele Gama, Dr Millicent Atujuna and the amazing team at the Desmond Tutu HIV Foundation for providing the access and assistance needed to execute this project. Further, thanks to Minah and Thozama for their help with isiXhosa translations, as well their enthusiasm and commitment to this project.

My sincere thanks to the family, friends and colleagues who helped in innumerable ways. Special thanks to Carrie Allen for her constant reassurance and meticulous proof reading through every step of this project. Thanks to my postgraduate colleagues for their help with data collection and scoring, as well as to Alexa Leach for her timely assistance with various practical elements of the thesis write-up. I'm also grateful to Rosalind Adams for her optimism, humour and warmth throughout my studies. Sincere thanks to my partner, Roy, for his patience, tolerance and kindness in the final phases of this project. Most importantly, I appreciate the unwavering support, encouragement and generosity of my mother, without whom I would not have had the courage or means to begin, continue or complete my studies.

This research was undertaken with the generous support of the Harry Crossly Research Foundation, as well as the National Research Foundation. Thank you for recognising the value and importance of my research.

Abstract

Advances in pharmacological treatment and medical management of HIV have resulted in decreases in HIV-associated mortality and morbidity for people living with HIV worldwide. However, many HIV+ individuals continue to experience some degree of neurocognitive impairment, particularly in the domain of executive functioning. HIV-related executive deficits are particularly pertinent in the adolescent population as individuals transition into adulthood and assume greater responsibility for their daily functioning. Despite the high prevalence of HIV in South African adolescents, neuropsychological rehabilitation interventions are largely absent. Currently, metacognitive approaches such as Goal Management Training (GMT) demonstrate the best evidence base for improving executive functions. The main aim of this study was to evaluate the effectiveness of a pGMT intervention for HIV+ adolescents in South Africa. A secondary objective was to provide commentary on the feasibility of conducting cognitive rehabilitation interventions in low-resourced settings such as those commonly found in South Africa.

This quantitative study used a pre-test post-test quasi experimental research design to investigate the effectiveness of a 7-week pGMT intervention in HIV+ adolescents in South Africa. Participants included 18 HIV+ adolescent (aged 14-17) first language Xhosa speakers from low socio-economic backgrounds. Participants formed two groups: a pGMT-intervention (n = *1*0), and a Control (n = *8*) group. A neuropsychological test battery was administered pre- and post- intervention to assess executive functions.

Neuropsychological test scores were sorted into four executive function composite domains. To assess the efficacy of the pGMT intervention, these executive function domains were analysed using a mixed-design ANOVA and Mann-Whitney U analysis of difference scores. No significant effects were detected, suggesting that the pGMT intervention demonstrated limited efficacy in the study sample. However, the successful implementation of the intervention supports the use of the GMT protocol in low-resourced settings such as those commonly found in LMICs like South Africa. Findings of the current study contribute valuable insights into the limitations and opportunities relevant not only to research in this field, but also more broadly to the implementation of cognitive rehabilitation interventions in LMICs such as South Africa.

Keywords: HIV, executive function, adolescents, GMT, cognitive rehabilitation

Table of Contents

List of Tables

List of Figures

Introduction

Human immunodeficiency virus (HIV) is a highly neurotrophic lentivirus that enters the central nervous system (CNS) shortly after seroconversion, and thereafter often leads to impaired cognitive performance (Kabuba et al., 2017; Kanmogne et al., 2018; Watson et al., 2019). Worldwide, an estimated 38 million people were living with HIV in 2019 (UNAIDS, 2020); WHO, 2020). Of these, 7.5 million are resident in South Africa, making this country the site of the largest HIV epidemic in the world.

Approximately 340 000 of these South African people with HIV are children under the age of 14 years. Most of those children acquired HIV perinatally via vertical transmission – i.e., from mother to child (UNAIDS, 2020; WHO, 2020). Over the past 10 years, the South African government has made significant progress in its response to HIV, with 5.2 million people living with HIV (PLHIV) accessing treatment (UNAIDS, 2020). In 2013, the United Nation's programme on HIV/AIDS established the 90-90-90 treatment target aimed at ending the AIDS epidemic through the principle of worldwide testing and treatment. Accordingly, the 90-90-90 target was that, by 2020, 90% of all PLHIV would know their HIV status, 90% of people diagnosed with HIV would be accessing antiretroviral treatment, and 90% of people receiving treatment would have suppressed viral loads (UNAIDS, 2020). South Africa met the first of these targets in 2018, whereby 90% of South African PLHIV knew their HIV status. Of those, 62% of PLHIV were accessing treatment and 54% were virally suppressed (UNAIDS, 2020).

Worldwide, advances in pharmacological treatment and medical management of HIV have resulted in decreases in HIV-associated mortality and morbidity for PLHIV (Cysique & Brew, 2009; D'Antoni et al., 2018; Walker & Brown, 2018). However, many PLHIV continue to experience some degree of cognitive impairment (D'Antoni et al., 2018; du Plessis et al., 2014; Heaton et al., 2011; Walker & Brown, 2018; Watson et al., 2019). One cognitive domain commonly affected, and an area of particular importance in adolescents, is executive functioning (i.e., top-down processes involved in the control and regulation of thoughts, emotions and behaviours; Hoare et al., 2016; Koekkoek et al., 2008; Laughton et al., 2013; Pearlstein et al., 2014; Phillips et al., 2016; Sirois et al., 2016; Smith & Wilkins, 2015).

Given that HIV-associated cognitive deficits (particularly in the domains of executive functioning) could translate into a variety of adverse everyday functional outcomes, effective interventions to improve these cognitive deficits are necessary. As such, researchers have begun exploring cognitive and behavioural approaches to treatment intervention (Weber et al., 2013; Wilson et al., 2017). Though the evidence base is currently limited, the few studies that have investigated the use of cognitive rehabilitation for HIV-associated cognitive deficits demonstrate positive gains and establish proof of concept (Casaletto et al., 2016; Weber et al., 2013).

Presently, research suggests that metacognitive approaches (thinking about thinking) have the strongest evidence base for addressing executive dysfunction in a variety of patient populations (Krasny-Pacini et al., 2014a; Stamenova & Levine, 2018). Goal Management Training (GMT; Robertson et al., 2005) is one of the most extensively studied and widely adopted metacognitive rehabilitation programmes. GMT has been evaluated for the remediation of executive functions (EF) in numerous clinical populations (e.g., acquired brain injury, schizophrenia, spina bifida), and was recently applied in a cohort of HIV+ individuals with substance use disorder (Casaletto et al., 2016; Cicerone et al., 2019; Krasny-Pacini et al., 2014a; Stamenova & Levine, 2018; Weber et al., 2013). A more detailed review of the neurocognitive sequelae of HIV and related treatment follows next.

Literature Review

Pathophysiology of HIV

HIV crosses the blood-brain-barrier (BBB) and enters the brain via infected monocytes and lymphocytes. Once in the CNS, HIV disrupts neural systems via direct infection of microglia, macrophages, and astrocytes, as well as through indirect neurotoxic inflammatory processes (Kanmogne et al., 2018; Ortega et al., 2015; Sillman et al., 2018). Persistent neuroinflammation is linked to endothelial and synaptodendric injury, as well as to focal or diffuse damage to white matter and microvasculature (Phillips et al., 2016; Spudich & González-Scarano, 2012; Woods et al., 2009).

Pathological and neuroimaging studies consistently show that HIV has a strong predilection for frontostriatal regions of the brain, most prominently the basal ganglia, frontal neocortex, and the white matter structures connecting these (du Plessis et al., 2014; Israel et al., 2019; Smith & Wilkins, 2015; Woods et al., 2009). Neuroimaging studies of symptomatic perinatally-exposed HIV+ children and adolescents have found cortical and subcortical atrophy in both grey and white matter structures (seen as sulcal widening and ventricular enlargement), as well as calcification of the basal ganglia and prefrontal white matter (Phillips et al., 2016; Smith & Wilkins, 2015). The structural and functional changes that result from HIV infection of the CNS contribute to neurocognitive impairment in PLHIV (Casaletto, 2015; Phillips et al., 2016).

Neurocognitive Sequelae of HIV Infection

The cognitive, behavioural, and motor impairments directly attributable to HIV are collectively referred to as HIV-associated neurocognitive disorder (HAND; Antinori et al., 2007; Reger et al., 2002). According to the Frascati criteria, there are three stages of HAND based on a neuropsychological assessment of an individual's cognitive impairment and related functional limitation (Wei et al., 2020). These impairments vary considerably, with the most severe patterns of manifestation seen in HIV-associated dementia (HAD), and milder presentations in asymptomatic neurocognitive impairment (ANI) and mild neurocognitive disorder (MND; Antinori et al., 2007; du Plessis et al., 2014; Kabuba et al., 2017; Smith & Wilkins, 2015). Though the advent of combination antiretroviral therapy (cART), the primary treatment for HIV, has greatly extended the lives of HIV+ individuals and reduced the incidence of HIV-encephalopathy (HIVE) and HAD, the milder forms of HAND persist (du Plessis et al., 2014; Heaton et al., 2011; Sillman et al., 2018; Wei et al., 2020). The global prevalence of HAND is an estimated 42.6% of the HIV+ adult population, with ANI, MND and HAD contributing 23.5%, 13.3% and 5.0% respectively (Wang et al., 2020).

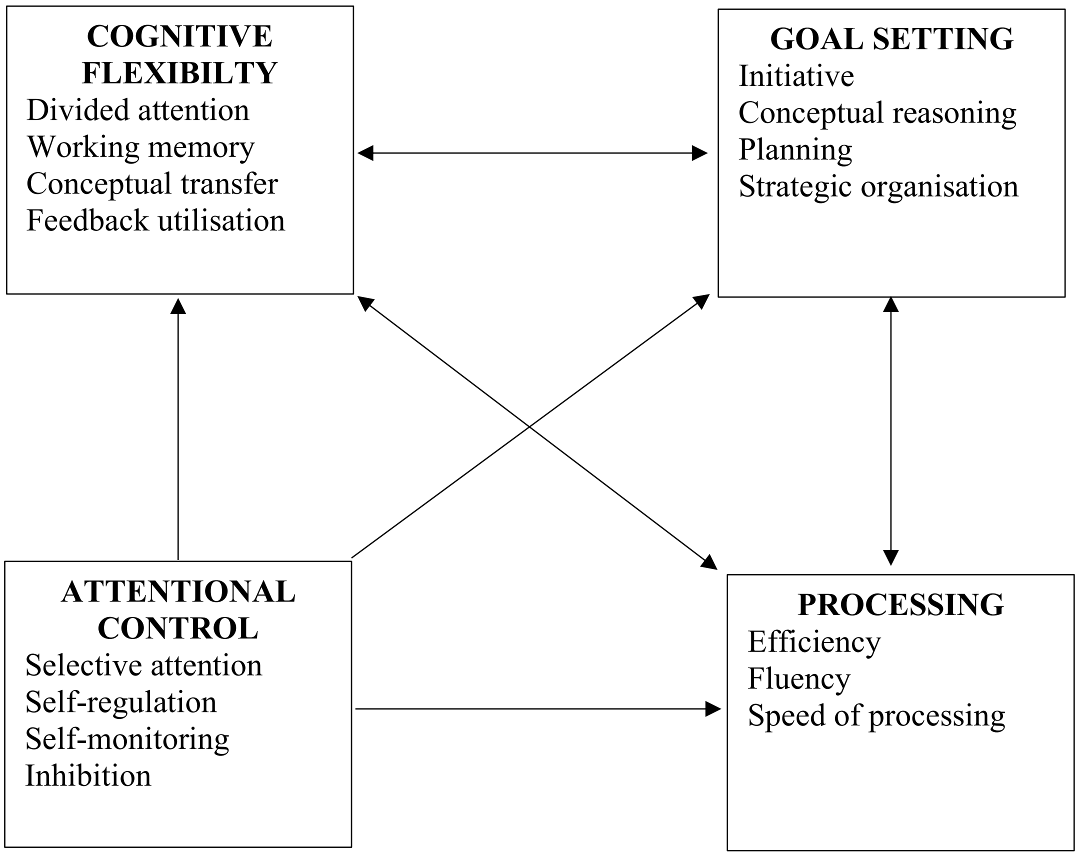
Commensurate with the virus's predilection for the fronto-striato-thalamo-cortical circuits of the brain, HAND is most frequently characterized by deficits in the domains of executive function, learning, and memory (Casaletto, 2015; du Plessis et al., 2014; Heaton et al., 2011; Ortega et al., 2015; Walker & Brown, 2018; Wilson et al., 2017; Woods et al., 2009). However, executive functions emerge as one of the most severely and consistently impaired cognitive domains (Cysique et al., 2006; Kanmogne et al., 2018; Koekkoek et al., 2008; McIntosh & Lobo, 2019; Phillips et al., 2016; Reger et al., 2002; Walker & Brown, 2018). Interestingly, in the pre-cART era, HIV was considered a subcortical dementia with primary impairments in psychomotor skills and coordination (Heaton et al., 2011; Weber et al., 2013). In the cART era, additional cortical cognitive deficits have been observed, resulting in a primarily dysexecutive cognitive profile (Heaton et al., 2011; Ortega et al., 2015; Weber et al., 2013).

Briefly, executive functions include top-down cognitive processes involved in goal-directed and purposeful behaviour. These cognitive abilities (e.g., attention, working memory, inhibition, processing speed, sequencing, organisation and planning) are required to effectively initiate, monitor and regulate thoughts and actions, which have associated real-world functional outcomes (Anderson et al., 2010; Cicerone et al., 2019; Kanmogne et al., 2018; Smith & Wilkins, 2015; Tornås et al., 2019; Walker & Brown, 2018). Several researchers have developed theoretical models that help to define and understand EFs (see Anderson et al., 2010; Karr et al., 2018 for overviews). A model proposed by Miyake et al. (2000) that is frequently cited in HIV literature espouses the existence of three executive function domains: updating and working memory, set-shifting, and inhibition. However, other conceptualisation posit that equally important components of EFs might include a broader set of cognitive functions such as planning, organisation, decision making, and conceptual reasoning (Walker & Brown, 2018). An EF model commonly referred to in developmental studies, and thus applicable to the adolescent population in this study, is Peter Anderson's (2002) model of the Executive Control System (ECS).

P. Anderson's (2002) ECS model of EF was derived from factor analytic and developmental neuropsychology studies. The ECS model conceptualises EF as incorporating four separable but interdependent domains that interact in a functional manner to enable overall executive control. These four domains are attentional control, cognitive flexibility, goal setting, and information processing; each has specific subcomponents (see Figure 1). Attentional control forms the basis of the model and mediates the functions of the other three domains. Cognitive flexibility, goal setting and information processing function in an interdependent manner, as indicated by the bi-directional arrows depicted in Figure 1.

Figure 1

P. Anderson's (2002) Model of the Executive Control System



Impact of HIV on Executive Functions in Adolescents

Adolescence is a developmental stage often characterized by instability as individuals transition into adulthood and undergo behavioural experimentation and identity formation (Kim et al., 2014; Laughton et al., 2013; Smith & Wilkins, 2015). It is also a period wherein individuals are often expected to assume greater independence from caregivers in their daily life activities (Garvie et al., 2014; Harris et al., 2018; Pearlstein et al., 2014).

During adolescence, key cognitive capacities such as executive control and self-regulation are developed and refined (Laughton et al., 2013; Watanabe, 2017). These changes coincide with increases in white matter with myelination, as well as re-organisation with synaptogenesis and pruning, predominantly in the frontal and prefrontal cortex (Anderson et al., 2001; Laughton et al., 2013; Luna et al., 2010; Watanabe, 2017). As noted earlier, HIV-associated neuropathology primarily affects these brain regions, along with the basal ganglia. This confers additional risk of disruptions in the neurodevelopment of adolescent brains, with consequent deficits in executive functions facilitated by these frontal-striatal regions (du Plessis et al., 2014; Ortega et al., 2015; Smith & Wilkins, 2015; Walker & Brown, 2018).

EF deficits have been identified as one of the most common domains of impairment in HIV+ children and adolescents (Hoare et al., 2016; Phillips et al., 2016). This is particularly pertinent given the emerging and important role of executive functions in academic and/or vocational success, medication and financial management, as well as decision-making processes regarding risky behaviours, such as substance use and sexual activity (Ettenhofer et al., 2009; Heaton et al., 2004; Sirois et al., 2016; Smith & Wilkins, 2015; Weber et al., 2013). Furthermore, these HIV-related executive function impairments, and their associated deficits in daily functioning, are clinically meaningful for PLHIV (Heaton et al., 2004; Pearlstein et al., 2014; Smith & Wilkins, 2015). Difficulties with EFs such as planning, organising and monitoring behaviour confer increased risk of poor adherence to ART, which may undermine the beneficial health gains associated with optimal treatment (Ettenhofer et al., 2009; Fogarty et al., 2002; Hinkin et al., 2004; Walker & Brown, 2018).

Treatment and Intervention

Antiretroviral Therapy (ART)

Combination ART (cART) and highly active ART (HAART) both involve a combination of antiretrovirals (ARVs) used as the primary treatment in both adults and children (Joska et al., 2010; Mothobi & Brew, 2012; Smith & Wilkins, 2015). cART reduces viral load and restores immune functioning, thus extending and improving the lives of PLHIV (D'Antoni et al., 2018; Ortega et al., 2015). The introduction of cART in the 1990s greatly reduced the prevalence and incidence of HIV-associated morbidities (e.g., opportunistic infections) and mortalities (Fogarty et al., 2002; Ortega et al., 2015; Smith & Wilkins, 2015; Weber et al., 2013). Effective medical management (e.g., early initiation of treatment and optimal treatment compliance) and the above-described advancements in treatment have resulted in improved neurological functioning and neurodevelopment, particularly in the paediatric population (Harris et al., 2018; Laughton et al., 2013; Smith & Wilkins, 2015).

Despite the positive impact of cART on more severe cases, an estimated 30-50% of persons with chronic HIV continue to show clinical symptoms of HAND on suppressive ART (Cysique et al., 2006; D'Antoni et al., 2018; du Plessis et al., 2014; Heaton et al., 2011; Joska et al., 2010; Mothobi & Brew, 2012; Weber et al., 2013). Furthermore, differential treatment guidelines and inconsistent access to ART in South Africa over the past two decades has led to a high degree of variability in disease severity and treatment exposure among HIV+ youth (Hoare et al., 2016). Given that there are a range of negative functional outcomes associated with HIV-related neurocognitive deficits (especially ART non-adherence), and that ART alone cannot reverse the neurodevelopmental consequences of HIV infection, supplementary interventions are necessary (Laughton et al., 2013; Weber et al., 2013).

Cognitive Rehabilitation of HIV-Associated Cognitive Deficits

The aim of cognitive rehabilitation is to improve an individual's ability to function independently and effectively in daily life (Lewis et al., 2011; Wilson et al., 2017). Briefly, restorative approaches to neurorehabilitation rely on principles of neuroplasticity and adopt the principle of 'drill-and-practice' to retrain and/or restore cognitive functions (Mishra & Gazzaley, 2014; Wykes & Spaulding, 2011). By contrast, compensatory approaches do not necessarily attempt to directly correct underlying cognitive deficits, but rather aim to improve cognitive functioning by training both internal (e.g., chunking procedures) or external (e.g., cueing reminders) strategies to support damaged cognitive processes (Cicerone et al., 2019; Twamley et al., 2003).

To date, very few studies have been published on cognitive rehabilitation for HIV-associated cognitive deficits (for a review see, Weber et al., 2013). The three published studies reviewed by Weber et al. (2013) used computerised restorative interventions focusing on domains such as attention, memory, visual motor functioning, and logic (Boivin et al., 2016); memory, attention, gnosis, and executive functions (Becker et al., 2012); and speed of information processing (Vance et al., 2012). All three studies demonstrated at least some positive gains, with reported effect sizes in the medium range. Beneficial gains were most notable for visual learning, information processing speed, and everyday functional ability (Boivin et al., 2016; Vance et al., 2012).

A growing body of research on rehabilitation of executive dysfunction in other clinical populations with a variety of etiologies (e.g., traumatic brain injury, stroke, polysubstance abuse) demonstrates the efficacy of cognitive interventions (Krasny-Pacini et al., 2014a; Langenbahn, et al., 2013; Stamenova & Levine, 2018; Weber et al., 2013; Wilson et al., 2015). Similar rehabilitation approaches may thus prove beneficial for the remediation of EF deficits in PLHIV. Currently, metacognitive approaches demonstrate the best evidence base for improving EF (Stamenova & Levine, 2018). GMT is one of the most extensively studied metacognitive interventions, the aim of which is to achieve successful execution of goal-directed behaviour (Levine & Stamenova, 2017; Robertson et al., 2005).

One recent study investigated the effectiveness of a brief Metacognitive Training module compared to GMT (alone or with Metacognitive Training) for HIV+ substance users (HIV/SUD) with executive dysfunction (Casaletto, 2015). The between-subjects, randomised design comprised three study groups: 1) Active Control; 2) GMT only; 3) Metacognitive Training plus GMT. Groups were compared post intervention on a measure (Everyday Multitasking Test) of instrumental activities of daily living (iADL). Accordingly, HIV/SUD individuals who completed GMT training (with or without Metacognitive Training) showed significant medium effect-size benefits for everyday multitasking abilities when compared to the Control condition. As such, the study findings support the use of GMT as a brief compensatory rehabilitation approach to improve everyday multitasking and metacognition among HIV+ adults with substance use disorders (Casaletto, 2015; Casaletto et al., 2016).

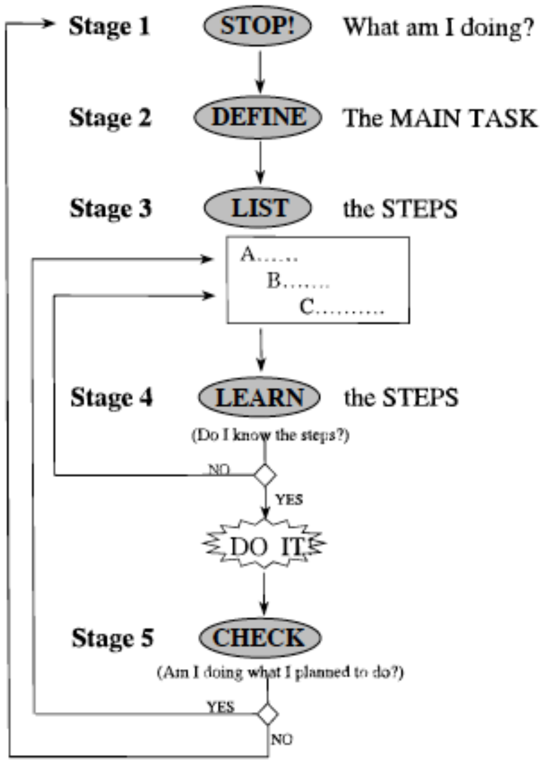
Goal Management Training (GMT)

GMT is a theoretically derived programme that relies on metacognitive strategies to reinstate cognitive control in the self-regulation of behaviour (Robertson et al., 2005). It is one of a few empirically validated, standardized, commercially available interventions for executive dysfunction (Casaletto et al., 2016; Krasny-Pacini et al., 2014a; Levine et al., 2011; Tornås et al., 2019). The theoretical foundation of GMT is based on Duncan's (1986) theory of 'goal neglect. This theory holds that disorganised behaviour and a failure to execute intentions results in everyday dysfunction, especially in patients with damage to their frontal systems. GMT addresses the subset of executive functions involved in top-down control of attention and problem solving in order to improve self-regulation of behaviour in the service of goal-directed functioning (Krasny-Pacini et al., 2014a; Stamenova & Levine, 2018; Tornås et al., 2019). The programme incorporates mindfulness practice and trains participants to evaluate all aspects of goal-directed behaviour. The manualized protocol uses goal lists to direct behaviour through a series of steps (see Figure 2 below), including: 1) stop and orient to the relevant goals before beginning a new task; 2) define and select the task goal; 3) list the steps and form sub-goals needed to complete the task; 4) learn and retain goals needed to complete the steps; and 5) monitor the outcome of action compared to the intended goal-state (Casaletto, 2015; Levine et al., 2000).

GMT was originally developed for adult populations with executive dysfunction, and is most frequently applied in adult patients with acquired brain injury (ABI; Levine & Stamenova, 2017). A recent review by Stamenova and Levine (2018) assessed the efficacy of GMT for patients with executive deficits across a wide range of clinical conditions (e.g., ABI, cerebrovascular disease, unhealthy aging, SUD). GMT was associated with improved performance on objective and subjective measures of EF, as well as laboratory-based tasks used to assess everyday functionality and iADLs (Stamenova & Levine, 2018). The authors conclude that overall, GMT has a beneficial effect in patients with executive deficits, and that these cognitive gains were maintained at follow-up.

Figure 2

The Five Stages of Goal Management Training



Note. Flowchart reproduced from Levine et al. (2000).

Goal Management Training for Paediatric Populations

The adult version of the GMT protocol has been revised for use with paediatric populations (pGMT; see Krasny-Pacini et al., 2014b). The most recent revision by Mahomed (2015) was further adapted for paediatric populations in the South African context. At present, there is a paucity of research on the utility of the GMT protocol with children and adolescents, and none involving HIV+ children and adolescents. One published study investigated the use of a context-sensitive GMT in a paediatric population (children aged 8 to14 years) with severe traumatic brain injury (TBI; Krasny-Pacini et al., 2014b). The study results were inconclusive as only partial improvements in EF were noted and participation in the study was poor. Similarly, two unpublished master's dissertations investigating the efficacy of GMT in paediatric patients with TBI reported inconclusive results due to varying levels of success within their samples (Corbett, 2008; Mahomed, 2015). However, both authors support the feasibility of implementing pGMT as a cognitive rehabilitation tool within the South African context.

Availability of Cognitive Rehabilitation in South Africa

In most high-income countries (HICs), the importance of neurocognitive rehabilitation is recognised and the provision of such services is well established (Wilson et al., 2017). This is not the case in low- to middle-income countries (LMICs), such as South Africa, where access to and availability of neuropsychological services is still largely absent. Schrieff-Elson and Thomas (2017) submit two possible reasons for the dearth of cognitive rehabilitation services in South Africa: 1) a paucity of research to support the implementation of cognitive rehabilitation interventions in local conditions; and 2) limited financial and human resources to support these services. Consequently, there exists a treatment gap in South Africa: Cognitive rehabilitation is not part of standard practice, and hence individuals with HIV-related neurocognitive deficits do not receive any such intervention.

Rationale, Aims and Hypotheses

Improving executive function capabilities in the HIV+ adolescent population is particularly important as they transition into adulthood and assume greater responsibility for their healthcare and independence in everyday life. The pGMT protocol specifically addresses executive function deficits, and as such, establishing the efficacy and feasibility of the program may prove helpful to this population, as well as populations with other developmental or acquired aetiologies which result in similar impairments. Additionally, reporting on insights gained throughout the intervention process will contribute towards a better understanding of the opportunities and limitations of implementing cognitive rehabilitation interventions in LMICs such as South Africa.

Given the prior success of GMT in remediating cognitive dysfunction across a variety of adult clinical populations, the overall aim of this study was to evaluate the effectiveness of a pGMT intervention for HIV+ adolescents in South Africa. Specifically, I set out to determine whether a seven-session pGMT protocol resulted in improved executive functioning in that sample of adolescents.

Accordingly, the main study hypothesis was that HIV+ adolescents who received the pGMT intervention would (a) show improved performance on standard neuropsychological measures of executive functioning from baseline to post-intervention, and (b) show greater baseline to follow-up improvement on those measures than HIV+ adolescents who did not participate in the intervention. As a consequence of this study design, I will submit additional qualitative comments pertaining the feasibility of conducting cognitive rehabilitation interventions using the GMT protocol in low-resourced settings such as those commonly found in South Africa.

Method

Research Design and Setting

This quantitative study used a within- and between-subjects quasi experimental research design to investigate the effectiveness of a GMT intervention in HIV+ South African adolescents. The study involved only HIV+ adolescents who were assigned to either the intervention group (pGMT group), or the control group. The current study was a follow-up to Gama's (2020) study investigating EF and patterns of adherence to ART in South African adolescents living with HIV. The first aim of that study, which bears relevance here, was to compare EF profiles (using P. Anderson's model of EF) between HIV+ adolescents and a Healthy Control Group. The current study and Gama's (2020) study were part of the larger HlangananiPlus Health Care Transition (HCT) research project, run by the Desmond Tutu HIV Foundation (2017).

The HlangananiPlus HCT is a psychoeducation programme intended to support HIV+ adolescents as they transition into the adult healthcare system. The programme is administered over several weeks and ordinarily comprises four group-based modules: (1) health education; (2) health care transitioning; (3) life skills and resilience; and (4) body, mind and spirit. Our pGMT intervention was appended as a fifth module of the HlangananiPlus HCT programme.

All participants in the current study took part in the HlangananiPlus HCT project. Upon conclusion of the four HlangananiPlus HCT modules, participants were invited to enrol in the fifth module. Those participants who elected to enrol were assigned to the intervention group (pGMT group); those who did not were assigned to the Control group. Participants in the intervention group received pGMT training for 7 weeks. Participants in the Control group only continued to receive standard medical care (treatment as usual) at Crossroads Community Health Clinic, which is located approximately 20km from Cape Town city centre.

Regarding the within-group component of the study, all participants were tested at baseline prior to commencement of the four HlangananiPlus HCT modules, and again following the experimental manipulation (i.e., post-pGMT training - for the Intervention Group, or following treatment as usual - for the Control Group).

All test and intervention sessions were held in the hall at the Hannan Crusaid Treatment Centre, which is a community health centre and research site for the Desmond Tutu HIV Foundation. The Hannan Crusaid Treatment Centre is based in Gugulethu, a township located approximately 15km from the Cape Town city centre. The current study ran for a year, starting with baseline testing in September 2018, and concluding once post-manipulation testing was complete in September 2019.

Participants

Recruitment

All participants recruited into this study were involved in the HlangananiPlus HCT research project. Twenty-two HIV+ adolescents (aged 14-17 years) were invited to participate in the current study. Each group (pGMT Group and Control Group) comprised 11 participants. Ten of the 11 Intervention-Group participants completed the pGMT training and post-intervention testing. Eight of the 11 Control Group participants completed post-manipulation testing. Hence, the final sample size was $N = 18$.

Inclusion Criteria

English- and Xhosa-speaking adolescents (aged 14-17 years) were eligible for inclusion. All participants had to be (1) HIV positive, and (2) of low or middle socioeconomic status (SES). HIV status was determined by a health practitioner as part of the HlangananiPlus HCT project.

Exclusion Criteria

Individuals who used secondary co-morbid medication (e.g., to treat tuberculosis or meningitis) were excluded from participation as ingestion of these medications may compromise ART adherence. Also excluded were individuals with prenatal exposure to potentially teratogenic substances because consequent diagnoses or conditions (e.g., Fetal Alcohol Spectrum Disorder) may confound existing HIV-related impairment, including executive function deficits (Mattson et al., 2011).

Measures and Apparatus

Sample Demographic and Clinical Characteristics

Demographic information (age, sex and SES) was obtained directly from participants. With ethical approval granted as part of the HlangananiPlus HCT, clinical information relevant to this study (CD4 count and viral load) was extracted from participants' medical records at the Hannan Crusaid Treatment Centre.

Socioeconomic Status

School quintile and school fee-paying status were used as a proxy measures of SES in order to determine that the stipulated criterion in that regard was met. In South Africa, school quintile is based on the surrounding community in which the school is located, and serves as an indicator of poverty and capacity of community-dwelling families to afford the cost of schooling. Classifications range from 1 to 5, where 1 is the poorest and 5 is the wealthiest. Accordingly, schools classified in low quintiles are frequently subsidized schools in poor communities (Department of Basic Education, 2018). School subsidization is also stipulated in the Department of Basic Education's (2018) listing according to fee-paying status of the school, whereby fully subsidized schools are listed as "No-Fee" schools. Participants provided the name of the school they attend. The school quintile and fee-paying status of each participant's school was determined via the Department of Basic Education's (2018) listing. Most participants in this study were from No-Fee schools and schools classified as quintile 3.

Baseline and Post-Manipulation Test Measures

The neuropsychological test battery administered at baseline and post-manipulation included measures selected for their capacity to assess specific processes supported by executive functions. A more comprehensive neuropsychological test battery (including IQ testing) was administered at baseline (see, Gama, 2020 for details on the full battery). I will only describe those tests relevant to the current study.

Wechsler Abbreviated Scale of Intelligence (WASI). The brief test battery (Wechsler, 1999) is used to assess general intellectual functioning and is suitable for individuals aged between 6 and 89 years. Reliability scores for the four subtests that comprise the battery (*Vocabulary, Block Design, Similarities,* and *Matrix Reasoning*) range between .81 and .93. The full battery was administered at baseline, whereas only the *Similarities* and *Matrix Reasoning* subtests were administered at post-manipulation. The *Matrix Reasoning* subtest was used to assess participants' conceptual reasoning in the visual modality, whereas the *Similarities* subtest was used to assess conceptual reasoning in the verbal modality. The WASI has been used in several published studies of South African child and adolescent clinical samples (see, e.g., Hoare et al., 2012; Hoogenhout & Malcolm-Smith, 2014; Phillips et al., 2018).

Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV). The WISC-IV is used to assess general intelligence and has been both normed and standardized for children aged between 6 and 16 years. This test battery has internal reliability scores ranging between .79 and .90 across its 10 subtests, two of which were administered in this study (Kezer & Arik, 2012). The WISC_IV has been used in published studies of South African child and adolescent HIV+ clinical samples (see, e.g., Hoare et al., 2012; Phillips et al., 2018; Webster, 2011). Here, the *Coding* and *Symbol Search* subtests were used as measures of information processing speed.

Children's Memory Scale (CMS). This test battery (Cohen, 1997) has been standardised and normed for North American populations and is appropriate for children and adolescents aged between 5 and 16 years. In this study, the *Numbers Backwards* subtest was used to assess working memory as a measure of cognitive flexibility. For this subtest, the examiner reads out digit sequences of increasing length and participants but are required to then repeat them in the reverse order. Reliability coefficients for the *Numbers Backwards* subtest range from .66 to .82, respectively. The CMS has been used in South Africa in both research and clinical contexts (Ferrett, 2011; Ferrett et al., 2010; Malgas, 2010; Van der Merwe, 2011).

Delis-Kaplan Executive Function System (DKEFS). This test battery, which was originally standardised and normed for North American populations, is appropriate for use in individuals aged 8-89 years. The DKEFS test battery has test-retest coefficients in the moderate range, with considerable variability among the subtests. In addition, internal consistency, test-retest reliability and validity have been established for each of the subtests (Delis et al., 2001). The DKEFS has been used in published studies of adolescent HIV+ samples in the USA (Willen et al., 2017), as well in South African HIV+ child samples (Webster, 2011). In this study, only the *Tower Test* and *Verbal Fluency* subtests were used.

The *Tower Test* was used as a measure of goal setting ability. Participants are shown a model (initially) or picture depicting the desired arrangement and position of the tower. Using the discs provided, participants are then required to reproduce the tower in the fewest number of moves. They begin from a specified start point (one of three pegs) and must adhere to a set of predefined rules. As the task progresses, items increase in difficulty, thus making demands on the individual's visuo-spatial planning and problem solving abilities.

The *Verbal Fluency* subtest comprises three testing conditions each with a 1-minute time limit in which the examinee is required to say as many words as they can. In the standard administration of the letter fluency task, participants are asked to generate words as quickly as possible starting with the letters F, A, and S. For this study, the letters M, A, and T were used when the task was administered in isiXhosa as research has established these as equivalent alternatives when testing isiXhosa speaking individuals (Ferrett, 2011). For the category fluency task, participants are required to generate as many words as possible within a specified semantic category. Lastly, for the category switching task, participants are required to switch between generating words belonging to different categories, such as fruit and furniture. Conditions 1 and 2 were used to assess verbal fluency as a measure of information processing speed. Condition 3 was used to assess switching ability as a measure of cognitive flexibility.

NEPSY-II. This test battery, which was originally, standardised and normed for North American populations, is appropriate for use in children and adolescents aged between 5 and 16 years. It has good psychometric properties, with stability coefficients between .62 and .89 across time and age groups. In addition, both content and construct validity have been evidenced by studies using clinical samples (Korkman et al., 2007).

In this study, the *Inhibition* subtest assessed participants' ability to inhibit automatic responses and shift between response types. The subtest consists of three trials (Naming, Inhibition, and Switching) across two conditions (i.e., Shapes and Arrows). In this study, the Inhibition trial was used to assess inhibitory control and self-monitoring, while the Switching trial was used to assess switching ability as a measure of cognitive flexibility. Both trials have a time limit of 240 seconds each. The NEPSY-II has been widely used in South African clinical paediatric research (see, e.g., Hoare et al., 2012; Hoogenhout & Malcolm-Smith, 2014; Phillips et al., 2018).

Children's Color Trails Test (CCTT). This test, which was originally standardised and normed for North American populations, is suitable for use in children and adolescents aged between 8 and 16 years. The CCTT was normed using samples of healthy children (aged 8 to 16 years), as well children from various clinical groups (Llorente et al., 2009). Accordingly, the two trials of the CCTT demonstrated good convergent validity, as well as alternate form reliability of .85 and .90 for CCTT-1 and CCTT-2 respectively. The CCTT has been used in several studies with HIV+ child and adolescent populations, both in the USA (Nichols et al., 2015) and South Africa (Corbett, 2008; Hoare et al., 2016; Phillips et al., 2018).

Both trials of the CCTT were administered in the current study, but only trial two was used in the study analysis as a measure of switching ability in the cognitive flexibility domain. On Trial 2, participants are presented with two sequences of numbers, each scattered around the same page but written in a different colour. They are required to connect the numbers in sequence but alternate colours (i.e., pink-1 to yellow-2, yellow-2 to pink-3, and so forth).

The Intervention

The version of the pGMT used here was based on a series of adaptations (see Appendix A). These adaptations were aimed at making the GMT more suitable for paediatric populations and ensuring that the materials were relevant and age-appropriate for the South African population.

The 7 modules of the pGMT were presented as MS PowerPoint slideshows. Each session in which a module was presented was designed to be centred around interactive discussions that incorporated stories and real-life examples solicited from participants in order to convey the principles contained in each module. In each module, a new concept was introduced and presented. From Session 2 onwards, each week's lesson built on that of the previous week in a cumulative fashion. A brief summary of the concepts presented in each session follows.

Session 1. The two parts of this module together set out to introduce and define the concept of goal setting. In the first part, 'Mr. STOP and THINK' was introduced to interrupt the process of 'automatic pilot' (i.e., inappropriate expressions of habit). In addition to various exercises, a story about forgetting your goals was introduced. The second part of the module used this story to introduce the principle of forgetting and 'OOPS mistakes'. Where possible, examples of everyday experiences were incorporated to aid and strengthen learning.

Session 2. In part one of this module, the concept of working memory and on-line maintenance of goals was introduced as the 'BRAIN NOTEPAD'. Prospective memory tasks were used to emphasize the concepts of planning and remembering. In the second part of this module, the concept of 'AUTOMATIC PILOT' was introduced to illustrate the tendency to rely on habitual processing when during routine and familiar tasks.

Session 3. This module introduced two concepts. The first, 'PLANNING TO ACHIEVE A GOAL', emphasized stating a goal in order to activate goal representation after stopping to identify and remember goals at the present time. The second, 'WRITING DOWN THE STEPS', focused on using 'to-do-lists' to aid decision making in the context of competing goals and indecision.

Session 4. As a follow on from the previous session's 'WRITING DOWN THE STEPS', participants were introduced to the concept of 'CHECKING THE STEPS'. This module taught participants to split tasks into sub-goals as a strategy for effective problem solving, and to verify their goals.

Sessions 5-8. These sessions served to repeat and revise the concepts taught in the first four sessions. Specifically, participants were encouraged to continue to (1) use 'Mr STOP and THINK' and make fewer 'OOPS' mistakes; (2) plan and remember using the 'BRAIN NOTEPAD' and interrupt 'AUTOMATIC PILOT'; (3) use the skills associated with 'PLANNING TO ACHIEVE A GOAL' and 'WRITING DOWN THE STEPS' to activate goals in the present time and to aid in the decision making process in the context of competing goals or indecision; and (4) split tasks into sub-goals and by 'CHECKING THE STEPS'.

Repetition was incorporated throughout the 4 core modules and specifically emphasised in the final 3 revision sessions.

Procedure

The pGMT intervention was appended as the fifth module of the HlangananiPlus HCT programme. Each intervention session was conducted in a group setting, with all modules delivered to the entire pGMT group as a whole. All test administration and scoring, as well as intervention procedures were overseen by my main supervisor (LS). Bilingual English-Xhosa translators assisted with communication at all sessions as most participants were first-language Xhosa speakers, with varying levels of English proficiency. Prior to commencement of the baseline test session, written consent from parents/caregivers (Appendix B) and written assent from participants (Appendix C) was obtained. The consent/assent documents are outlined the study purpose and procedure. These documents had been translated into Xhosa.

Baseline Testing

Neuropsychological test batteries were individually administered to all participants by postgraduate neuropsychology students, with assistance from the translators. Each test session took approximately 2.5 hours to complete. At the conclusion of each test session, participants received ZAR30 for transportation and a snack pack or food voucher as compensation for their time.

Manipulation

All intervention sessions were held in the hall at the Hannan Crusaid Treatment Centre in Gugulethu. The pGMT programme was administered to the entire Intervention Group by a postgraduate neuropsychology student and a fluent Xhosa-speaking facilitator. Sessions were held once a week and lasted approximately 1.5 hours each. Participants received ZAR30 for transportation and lunch was provided at the centre after every session.

Participants in the Control Group did not attend any of the pGMT intervention sessions. Upon conclusion of the four HlangananiPlus HCT modules, control participants continued to receive treatment as usual (i.e., receiving general medical care and HIV medication) at the Crossroads Community Health Clinic.

Post-Manipulation Testing

Participants from both groups were individually administered a neuropsychological test battery upon completion of the intervention or control conditions. The majority of participants (56%) were tested within one month of completing the intervention or control condition. However, due to the limited availability of participants, some participants were tested three months (11%), and four months (33%) after completing the intervention or control condition. Tests were administered in much the same fashion as they had been at baseline. Each test session lasted approximately 2.5 hours. Participants again received ZAR30 for transportation and a snack pack or food voucher as compensation for their time.

Data Management and Statistical Analysis

All instruments were scored following the procedures outlined in the relevant scoring manuals (Cohen, 1997; Delis et al., 2001; Korkman et al., 2007; Llorente et al., 2003; Wechsler, 1999, 2003). Then, each participant's raw score for each neuropsychological test outcome variable was converted into an age-adjusted scaled score (again, following the procedures outlined in the relevant scoring manuals; note that the normative data used here were those contained in those manuals) to facilitate appropriate comparisons of test scores. I used SPSS (version 26.0) to complete all data preparation and statistical analytic procedures, with the threshold for statistical significance for all analyses (α) set at .05. Effect size estimates were calculated using Cohen's *d,* or $\eta^{2,}$ when analysing between-group differences for continuous variables, or Cramer's *V* for categorical variables. Effect size estimates were calculated using η^2_p for analysis of variance. The magnitude of effects was interpreted as small, medium or large with d = 0.2, 0.5, and 0.8; η^2 = 0.02, 0.13, and 0.26; V = 0.1; 0.3, and 0.5; and η^2_p = 0.01, 0.09, and 0.25 respectively. For all variables, I examined all assumptions underlying inferential analyses (e.g., normality of distribution, homogeneity of variance, sphericity). Where assumptions were violated, I used appropriate non-parametric statistical modelling.

Sample Demographic and Clinical Characteristics

Descriptive statistics were computed for all sample demographic and clinical characteristics. Between-group differences were analysed using *t*-tests (or Mann-Whitney *U* tests where assumptions of normality were violated) for continuous variables, and chi-square tests of contingency (or Fisher's exact test where expected cell counts were < 5) for categorical variables.

Deriving Composite Scores

Due to the small sample size and the absence of specifically-recruited healthy control participants, the EF composites used in the current study are based on those described by Gama (2020). That research used a hybrid method of deriving composite scores (Ferrett et al., 2010; Medina et al., 2007; Phillips et al., 2018) to reduce the number of dependent variables that were examined. Specifically, each outcome from the set of neuropsychological tests was assigned to an EF domain (either attention control, cognitive flexibility, goal setting, or information processing) that fit within the taxonomy described by Anderson's (2002) model (see Table 1). Once grouped, scaled scores were converted into *z*-scores using the study control sample data (means and standard deviations). Next, individual z-scores were averaged to derive composite scores for each executive function domain. The internal consistency of the scores within each domain was calculated using Cronbach's alpha. Those values were: .84 for attentional control, .75 for cognitive flexibility, .69 for goal setting, and .83 for information processing (Gama, 2020). An overall EF total composite score was calculated by taking the average performance across all 17 outcome variables. Cronbach's alpha for the overall EF composite was .71. Taken together, the internal consistency values indicate that (a) the test scores included in each domain share sufficient variance to suggest they measure the same or a similar construct, and (b) the overall EF composite can be considered an overarching factor.

Table 1

Sub-test Groupings per Domain of P. Anderson's (2002) Executive Function Model

Domain	Sub-tests	Cognitive construct
Attentional Control:	Inhibition (NEPSY-II)	Inhibitory control
	Inhibition errors (NEPSY-II)	Self-monitoring/Inhibitory control
Cognitive Flexibility:	Numbers backwards (CMS)	Working memory
	Switching (NEPSY-II)	Switching ability
	Verbal fluency condition 3 (DKEFS)	Switching ability
	Verbal fluency switching accuracy (DKEFS)	Switching ability
	Children's color trails test 2 (CCTT)	Switching ability
Goal Setting:	Towers (DKEFS)	Planning & problem solving
	Similarities (WASI)	Conceptual reasoning (Verbal)
	Matrix reasoning (WASI)	Conceptual reasoning (Visual)
Information Processing:	Coding (WISC)	Processing speed
	Symbol search (WISC)	Processing speed
	Verbal Fluency condition 1&2 (DKEFS)	Verbal fluency

Note. Table reproduced from Gama (2020)

Pre- and Post-Manipulation Within- and Between-Group Comparisons

Analyses of variance. Five separate mixed-design ANOVAs (in terms of dependent variables, one for each of the four sub-domain composite scores and one for the overall EF total composite) examined the efficacy of the pGMT intervention in improving executive function. In each model, the independent variables were Measurement Point (baseline, post-manipulation) and Group (pGMT, Control). Although these ANOVAs were most interested in the Measurement Point x Group interaction effect, I also report on the main effects of each independent variable.

Between-group comparison of change from baseline to post-manipulation. I calculated a difference score for each of the five outcome variables by subtracting the post-manipulation composite score from the baseline composite score for each participant. For each of the resulting outcome variables, I investigated normality of distribution and homogeneity of variance. Because data were not normally distributed for each of the variables, Mann-Whitney *U* tests assessed between-group differences.

Ethical Considerations

All study procedures were approved by the Human Research Ethics Committees of the University of Cape Town's Department of Psychology and Faculty of Health Sciences (see Appendix C and Appendix D).

Consent, Voluntary Participation and Confidentiality

Written consent and assent were obtained from parents/caregivers and participants, respectively, prior to commencement of study procedures. Parents/caregivers and participants were informed about the confidential nature of the study, as well as their voluntary participation in the study. They were also told that they had the option to withdraw from the study at any stage without facing any penalty. The isiXhosa translators used in this study have extensive experience in pediatric neuropsychology settings and thus aware of and adhere to ethical standards of confidentiality at all times. All participant information remained confidential throughout the study, and will continue to be stored in a locked file cabinet and on password-protected computers. Participant data were anonymised and are reported without identifying details. Access to study data is restricted to the researcher, her supervisors and co-investigators from the HlangananiPlus HCT project.

Risks and Benefits

There were no known physical or emotional risks for participants throughout the invention and assessment. However, due to the lengthy and cognitively intense sessions, participants may have experienced fatigue. Hence, refreshments were provided and participants were offered the opportunity to take breaks when needed. Participants also received a snack pack or food voucher as well as compensation (ZAR30; the equivalent of approximately US$2 at the time of the study) for their travelling costs. Given that this study was nested within the larger HlangananiPlus HCT project, counsellors and psychologists on board for that project were available to participants throughout this study should they have required such services.

Results

Sample Demographic and Clinical Characteristics

As Table 2 shows, analyses detected no significant between-group differences with regard to sex distribution and school characteristics (no-fee status and quintile). There was, however, a significant between-group difference with regard to participant age. On average, participants in the Control Group (*M* = 15.82, *SD* = 0.63) were significantly older than those in the pGMT Group (*M* = 14.86, *SD* = 0.69), *t*(16) = -3.08, *p* = .007 Cohen's *d* = 1.45. However, all participants in both groups were aged between 14 and 17 years and hence fell within the adolescent age range.

Regarding clinical characteristics, all participants were prenatally infected with HIV. CD4 counts and viral load measures were obtained from clinical data made available through the HlangananiPlus HCT study. Although CD4 count was taken on different dates, all measures were within four years of enrolment into this study. A Mann-Whitney *U* test detected no significant between-group difference in CD4 count, pGMT group *Mdn* = 545.00, *IQR* = 292.00 - 869.00), Control group *Mdn* = 625.00, *IQR* = 532.25 - 819.00, *U* = 44.50, *p* = .423, η^2 = .039. All viral load measures were taken within one year of enrolment into this study, with most taken in 2019. As Table 2 shows, analyses detected no significant between-group difference with regard to viral load.

Table 2

Sample Demographic and Clinical Characteristics (N = 18)

	pGMT Group		Control Group		Test statistics	
Variable	*n*	Frequency[a]	*n*	Frequency[a]	*p*	ESE[b]
Sex	10		8		.321	0.316
Female		8 (80%)		4 (50%)		
Male		2 (20%)		4 (50%)		
No-Fee School	10		7[c]		.338	0.278
Yes		6 (60%)		6 (75.0%)		
No		4 (40%)		1 (12.5%)		
School Quintile[d]	10		7[c]		.287	0.465
Quintile 1		0 (0%)		0 (0%)		
Quintile 2		1 (10%)		1 (12.5%)		
Quintile 3		5 (50%)		6 (75.0%)		
Quintile 4		3 (30%)		0 (0%)		
Quintile 5		1 (10%)		0 (0%)		
Viral Load[e]	10		8		.618	0.060
< 1000 copies/mL		8 (80%)		6 (75%)		
≥ 1000 copies/mL		2 (20%)		2 (25%)		

Note. Fisher's Exact Test was performed because > 20% of expected cell counts were < 5. [a]Frequencies are presented as observed cell counts with percentage frequencies in parenthesis. [b]ESE - Cramer's *V* for chi-square tests of contingency. [c]The school name for one Control participant was not listed by the DBE; therefore, the sample size was reduced to *n* = 7. [d]Quintile – South African public-school ranking system based on the wealth of the surrounding community (1 being the poorest and 5 being the wealthiest) to determine learner subsidisation. Data was retrieved from the Department of Basic Education (DBE, 2018). [e]Viral load was classified in accordance with Clinical Info (2019) virological definition of treatment failure and coded as; (1) < 1000 copies/mL; or (2) ≥ 1000 copies/mL.

Executive Functioning Outcomes: Pre- and post-manipulation within- and between-group comparisons

Descriptive Statistics

The descriptive statistics for the individual subtests that comprise these domains (attentional control, cognitive flexibility, goal setting, and information processing) can be found in Appendix F. Table 3 presents descriptive statistics for group performance, at both the baseline and post-manipulation measurement points, on each of the four composite EF variables as well as on the overall EF composite variable.

Table 3

Descriptive Statistics for Outcome Variables (N = 18)

	pGMT Group				Control Group			
	Baseline		Post - Manipulation		Baseline		Post- Manipulation	
Variable	*n*	*M (SD)*	*n*	*M (SD)*	*n*	*M (SD)*	*n*	*M (SD)*
Attentional Control	10	0.73 (1.35)	10	0.52 (0.60)	8	-0.08 (0.98)	8	-0.07 (0.98)
Cognitive Flexibility[a]	10	0.71 (0.77)	10	0.69 (0.86)	7	-0.01 (0.78)	7	0.08 (0.84)
Goal Setting	10	0.27 (0.37)	10	0.65 (0.61)	8	-0.00 (0.43)	8	0.00 (0.48)
Information Processing[b]	10	0.49 (0.83)	10	0.28 (0.77)	7	0.06 (0.82)	7	0.07 (0.81)
EF Total[c]	10	0.50 (0.57)	10	0.56 (0.66)	7	0.03 (0.54)	7	0.07 (0.61)

Note. Variable scores are presented as *z*-scores. Higher scores denote better performance. Means are presented with standard deviations in parentheses. [a]Cognitive Flexibility: 1 Participant in the Control group did not complete the Switching task included in the composite score for cognitive flexibility. [b]Information Processing: One participant in the Control group did not complete the verbal fluency task included in the composite score for information processing. [c]EF Total: The EF composite score could not be calculated for one Control group participant due to non-completion on two sub-tests.

Analyses of Variance

Exploration of the assumptions underlying these analyses indicated that homogeneity of variance was upheld for all dependent variables, but the assumption of normality of distribution was violated for most variables. Given the robustness of the *F*-test with respect to violations of distributional assumptions, I proceeded with the analyses, but note that these findings may not generalise to other populations (Field, 2009; Tredoux & Durrheim, 2002). Moreover, box-and-whisper plots identified three outliers (see Appendix G). Hence, the statistical analysis was run first with outliers retained, and then re-run with outliers removed (see Appendix H). Because these two sets of analyses delivered similar results, findings from the analysis using the complete dataset (i.e., the one with outliers retained) are reported below.

Attentional Control. The analysis detected no significant main effect of Measurement Point, $F(1, 16) = 0.27$, $p = .613$, $\eta_p^2 = .016$, of Group, $F(1, 16) = 2.49$, $p = .134$, $\eta_p^2 = .135$, or of the Measurement Point x Group interaction, $F(1, 16) = 0.36$, $p = .559$, $\eta_p^2 = .022$.

Cognitive Flexibility. The analysis detected no significant main effect of Measurement Point, $F(1, 15) = 0.04$, $p = .846$, $\eta_p^2 = .003$, of Group, $F(1, 15) = 3.32$, $p = .089$, $\eta_p^2 = .181$, or of the Measurement Point x Group interaction, $F(1, 15) = 0.10$, $p = .754$, $\eta_p^2 = .007$.

Goal Setting. The analysis detected no significant main effect of Measurement Point, $F(1, 16) = 2.87$, $p = .110$, $\eta_p^2 = .152$, or of the Measurement Point x Group interaction, $F(1, 16) = 2.82$, $p = .112$, , $\eta_p^2 = .150$. However, it did detect a significant main effect of Group, $F(1, 16) = 5.31$, $p = .035$, $\eta_p^2 = .249$.

Information Processing. The analysis detected no significant main effect of Measurement Point, $F(1, 15) = 1.57$, $p = .230$, $\eta_p^2 = .095$, of Group, $F(1, 15) = 0.69$, $p = .419$, $\eta_p^2 = .044$, or of the Measurement Point x Group interaction, $F(1, 15) = 1.69$, $p = .213$, $\eta_p^2 = .101$.

EF Total. Consistent with the results for the four domains comprising the overall EF composite, the analysis detected no significant main effect of Measurement Point, $F(1, 15) = 2.80$, $p = .604$, $\eta_p^2 = .018$, of Group, $F(1, 15) = 2.90$, $p = .109$, $\eta_p^2 = .162$, or of the Measurement Point x Group interaction, $F(1, 15) = 0.02$, $p = .889$, $\eta_p^2 = .001$.

Between-Group Comparison of Change from Baseline to Post-Manipulation

Exploration of the assumptions underlying these analyses indicated that homogeneity of variance was upheld for all dependent variables, but the assumption of normality of distribution was violated for most variables. As such, independent-samples Mann-Whitney U tests were used. Table 4 presents the relevant descriptive statistics (median and inter-quartile range) and test statistics for the five outcome measures (i.e., the five difference scores). Analyses detected no significant between-group differences (all *p*s >.05) with small to medium effect sizes ($\eta^2 < .2$), thus supporting the findings of the mixed-design ANOVAs presented above.

Table 4

Between-group Differences and Descriptive Statistics for Outcome Variables (N = 18)

	pGMT group		Control group		Test statistics		
Variable	*n*	*Mdn (IQR)*	*n*	*Mdn (IQR)*	*U*	*p*	η^2
Attentional Control	10	-0.22 (-0.63 - 0.56)	8	0.18 (-0.11 - 0.46)	34.00	.594	.016
Cognitive Flexibility[a]	10	0.09 (-0.62 - 0.40)	7	-0.11 (-0.28 - 0.46)	31.00	.696	.009
Goal Setting	10	0.26 (<0.01 - 0.82)	8	-0.03 (-0.33 - 0.44)	23.00	.131	.127
Information Processing[b]	10	-0.21 (-0.51 - 0.05)	7	0.04 (-0.20 - 0.18)	20.00	.143	.126
EF Total[c]	10	-0.01 (-0.22 - 0.26)	7	0.08 (-0.16 - 0.27)	33.00	.161	.002

Note. Medians are presented with Inter-quartile range in parenthesis. ESE - Effect size estimate is η^2 for Mann-Whitney U. [a]Cognitive Flexibility: 1 Participant in the Control group did not complete the Switching task included in the composite score for cognitive flexibility. [b]Information Processing: I participant in the Control group did not complete the verbal fluency task included in the composite score for information processing. [c]EF Total: The EF composite score could not be calculated for 1 Control group participant due to non-completion on 2 sub-tests.

Qualitative Observations and Descriptions of the Intervention

Our pGMT intervention was administered to the entire intervention group (*n* = 10) in a large hall at the Hannan Crusaid Clinic in Gugulethu. This was the same centre that participants attended for their regular treatment follow-ups, and as such, the space and location was familiar to them. Participants sat in a circle arranged in such a way that both the facilitators and slide projections were visible to all participants. Minimal equipment was required as MS PowerPoint slideshows were projected directly onto a clean wall using a laptop and projector.

In addition to the researchers, a bi-lingual (English and Xhosa) facilitator, who also has extensive experience as a translator in clinical (particularly paediatric) neuropsychology settings, was present for the duration of the intervention. The facilitator played an important role in creating a fun and supportive atmosphere, and provided Xhosa translations where needed. The stories, activities and examples used in the modules were both age-appropriate and contextually relevant (see Table 5 for details). Participants were encouraged to think of personally relevant examples and ways in which the pGMT steps could be applied to real-life situations. They were given the opportunity to share their ideas and stories with the group. Some participants were shy to start, but warmed up and got more involved as the sessions progressed. Interaction was encouraged, but never forced. At the end of each session, participants were given a small lunch, which they ate together. This provided further opportunity for interaction and the development of group cohesion.

Evidence of Engagement

Attrition over the course of the intervention was low, with a consistently high percentage of participants in attendance at each session (see Table 5). Overall, participants appeared eager to cooperate and take part in the pGMT intervention and the activities/tasks included in the modules. After covering all the content modules (weeks 1 to 4), the group, with the guidance of the facilitator, developed a short rap song with corresponding dance moves, which outlined the pGMT steps (namely; “Stop and think”, “Say your goal”, “Write your plan”, “Do it”, “Check”). They performed this routine at each subsequent session, which served as an engaging way of encoding and recalling the steps. Participants were also given the opportunity to create and submit posters depicting the pGMT steps. Some participants took up this task, which was optional. These posters demonstrate the ability of participants to transfer the knowledge gained from the pGMT intervention and apply it to everyday situations. For example, as shown in Figure 3, one participant described how they used the pGMT steps to help study for and write their school exam. Figures 4 and 5 below show two additional examples.

Table 5

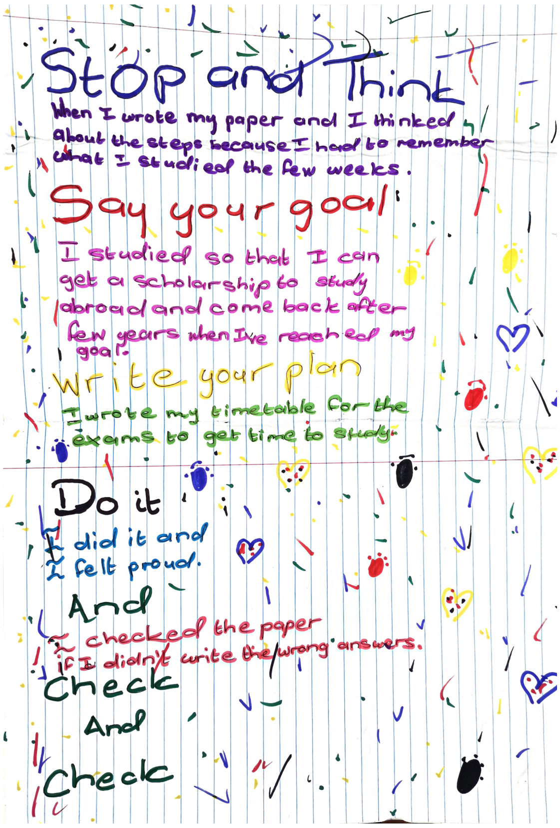
Participant Attendance and Qualitative Observations of pGMT Administration

Session	Attendance	Module concept	Content notes
Week 1	90%	*Part 1* Mr. STOP and THINK (35 slides)	Participants were introduced to the concept of goals and were asked to attempt five tasks within a 4-minute period. These were: Put the cards in order, Join the points, Find out the words, Find out the differences, and Circle by category. A story about Alex losing his soccer ball, getting distracted, and then forgetting his friends was used to show the importance of stopping to remember one's goals.
		Part 2 OOPS mistakes (11 slides)	A story about Paul forgetting his karate competition was introduced, along with examples of what makes 'OOPS mistakes' more likely.
Week 2	90%	*Part 1* BRAIN NOTEPAD (36 slides)	A story about Cathy using and losing multiple notes was used to show the importance of using one paper notepad as an additional prospective memory aid given the limited capacity and duration of working memory.
		Part 2 AUTOMATIC PILOT (21 slides)	A story about Lisa forgetting to collect her sister Emily from school, while listening to a story about Nelson Mandela was shared. This was used to illustrate that the 'Brain Notepad' has limited capacity and that 'Automatic pilot' takes over while doing routine or familiar tasks (i.e., walking home from school).
Week 3	70%	*Part 1* PLANNING TO ACHIEVE A GOAL (30 slides)	A story about Paul having too many things to do was used to show how feeling 'stressed out' can lead to more 'OOPS mistakes', and that using the previously learned steps can help minimise mistakes by being organised. A story about Alex needing to choose between two goal conflicts was used to illustrate the effect that procrastination, indecision and negative feelings can have on decision making.
		Part 2 WRITING DOWN THE STEPS (12 slides)	An example of making a sandwich was used to illustrate the usefulness of 'WRITING DOWN THE STEPS' on a notepad. Additional everyday examples were elicited from participants.

Session	Attendance	Module concept	Content notes
Week 4	80%	*Part 1* Continuation of WRITING DOWN THE STEPS (13 slides)	An additional example of planning a birthday party was used to further illustrate the importance of writing down the steps by developing sub-goals required to achieve the main goal.
		Part 2 CHECKING THE STEPS (31 slides)	The previous stories involving Alex, Paul and Lisa were re-introduced to illustrate the concept of ‘CHECKING THE STEPS’ and verifying goals.
Week 5	90%	Repetition and revision (15 slides)	All five pGMT steps taught in previous weeks were presented diagrammatically on a single PowerPoint slide. The rap song and dance were enacted and recited. Participants were given four tasks to do within a 3-minute period, with the goal of completing a little bit of each task.
Week 6	80%	Repetition and revision (14 slides)	All five pGMT steps taught in previous weeks were presented diagrammatically on a single PowerPoint slide. The rap song and dance were enacted and recited. Participants were reminded of the two stories involving Lisa and Cathy to illustrate ‘OOPS mistakes’ and ‘AUTOMATIC PILOT’. Participants were given a task and reminded to use the pGMT steps to sort and order cards pertaining to various morning activities.
Week 7	80%	Repetition and revision (12 slides)	All five pGMT steps taught in previous weeks were presented diagrammatically on a single PowerPoint slide. The rap song and dance were enacted and recited. Participants were given another task to use the steps and order the cards, this time to help Paul feel more organised and less stressed. Participants were also assigned two tasks to use the pGMT steps to help Alex choose between competing tasks, and to make a sandwich.

Figure 3

Participant Poster - Example 1



Note. The poster describes how the participant applied the pGMT steps to studying for and writing a school exam.

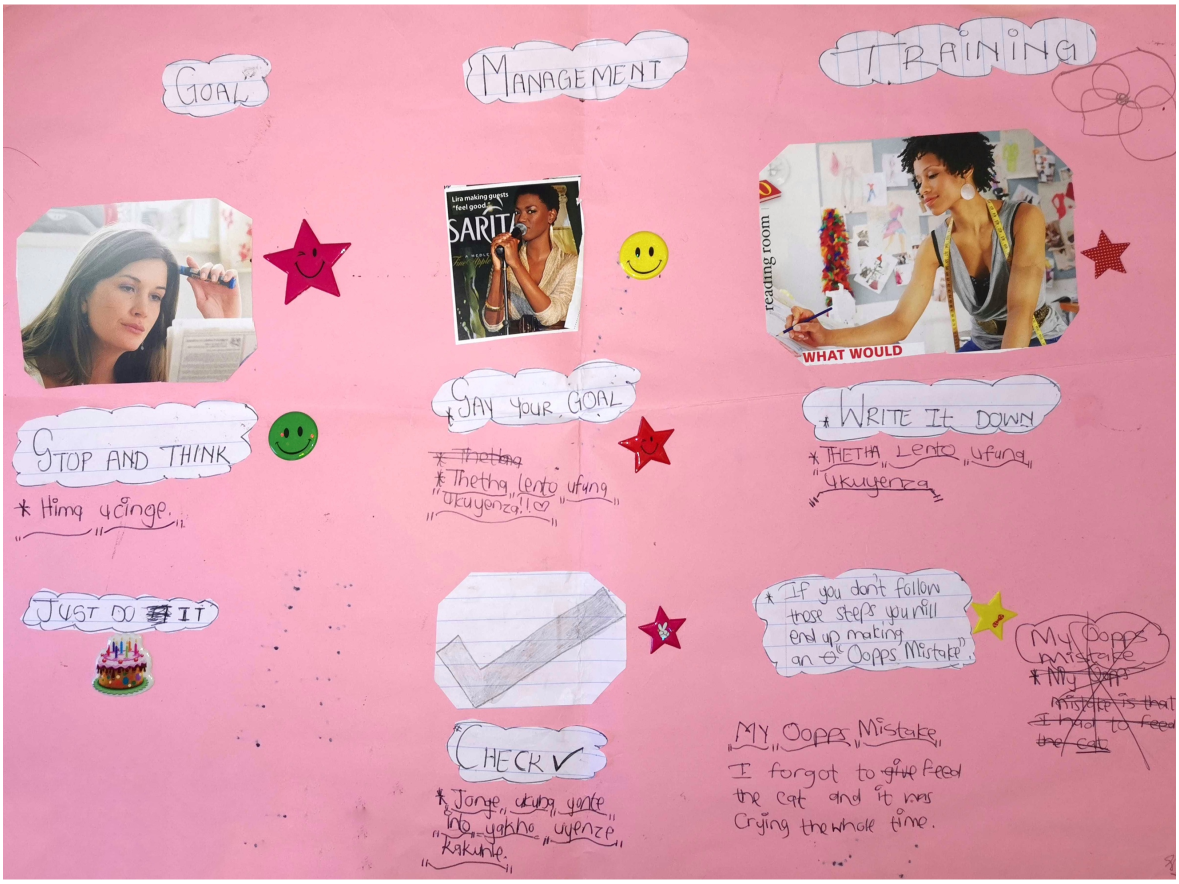
Figure 4

Participant Poster - Example 2

Note. The poster lists the GMT steps written in Xhosa with pictures corresponding to each step. The poster heading translates to: The five steps you need to take. The steps listed are: 1. Stop and think; 2. Say your goal; 3. Write your plan; 4. Do it; 5. Check yourself.

Figure 5

Participant Poster - Example 3



Note. pGMT steps are written in English with Xhosa translations below. The pictures depict the behaviour described in the corresponding pGMT step.

Discussion

Executive functioning (EF) deficits commonly associated with HIV infection are particularly pertinent in the adolescent population as individuals transition into adulthood and assume greater responsibility for their daily functioning. Despite the high prevalence of HIV in South African adolescents, and despite HIV-associated neuropsychological sequelae being well documented in the literature, neuropsychological rehabilitation interventions are largely absent.

Goal Management Training (GMT; Robertson et al., 2005) is a well-established neuropsychological rehabilitation protocol used to address EF deficits, most commonly in adult patients with acquired brain injury (Levine & Stamenova, 2017). The main aim of this study was to evaluate the effectiveness of a pGMT intervention on executive function for HIV+ adolescents in South Africa. This study employed a pre- and post-manipulation within- and between-subjects experimental design, and comprised two groups - an Intervention Group (n = 10) and a Control Group (n = 8). The Intervention Group received 7 sessions of pGMT training, whereas the Control Group received no intervention but continued with their treatment as usual at Crossroads Community Health Clinic. Participants in both groups were assessed on neuropsychological measures of EF at baseline and again post-manipulation. The study also sought to explore the feasibility of conducting cognitive rehabilitation interventions using the GMT in low-resourced settings such as those commonly found in South Africa. Below, I will discuss the findings of this study and evaluate the results in comparison to those previously reported in relevant literature. First, I will discuss the quantitative results pertaining to the study's main aim and related hypothesis. Next, I will discuss my qualitative observations regarding the implementation of the pGMT intervention. Finally, I will address the limitations of this study along with recommendations for future research.

Effectiveness of the pGMT Intervention in Improving Executive Functioning

Initial analyses of sample demographic (e.g., SES) and clinical (e.g., viral load) characteristics sought to ensure that the intervention and control groups were comparable in those regards. Factors such as SES, especially, affect performance on neuropsychological tests, and therefore ensuring the groups were matched on these variables was important (Ferrett et al., 2014; Hackman et al., 2015; Hoare et al., 2016). The statistical analysis detected no significant between-group differences except for participant age: the mean age of the non-GMT group was significantly higher than that of the GMT group. However, because all participants in both groups fell within the adolescent (14-17) age range, these groups are comparable in terms of the EF outcomes (Luna et al., 2010; Theodoraki et al., 2020).

Main Aim: To Determine Whether the pGMT Intervention Resulted in Improved Executive Functions in HIV+ Adolescents in South Africa

Following the study's main aim, the primary hypothesis was that HIV+ adolescents who participated in the pGMT intervention would show both within- and between-group improvements on neuropsychological measures of executive functioning (as compared to HIV+ adolescents who did not participate in the pGMT intervention). Of interest was the analysis of possible group (pGMT, Control) by time (baseline and post-manipulation) interaction effects, as this allowed me to isolate and assess any improvements in EF as a result of participation in the 7-session pGMT intervention. Analyses detected no significant interaction effects. These results were further supported by the non-significant between-group comparison of change in EF performance from baseline to post-manipulation. Together, these results suggest that exposure to the pGMT intervention did not lead to detectable improvement in EF in this study sample.

The findings of this study are inconsistent with those from several other studies investigating the efficacy of GMT in various patient samples. A recent quantitative systematic review of the research literature on GMT identified 21 studies comprising 19 treatment groups (300 patients) that met the study inclusion criteria (Stamenova & Levine, 2018). The review concluded that, overall, there is a beneficial effect of GMT for patients with executive deficits, with improved performance seen on all primary outcome measures within EF sub-domains. However, the reviewed studies included only adult samples, and although the authors noted that GMT has been applied in various patient groups, most studies involved patient samples with acquired brain injury (ABI). None of them included HIV+ samples. Therefore, the findings of the current study are not directly comparable to the studies included in that review. In fact, as noted in a qualitative review by Weber et al. (2013), very few published cognitive neurorehabilitation studies have featured patients with HIV-associated neurocognitive disorders (HAND). They identified only three such studies. All three used a restorative neurorehabilitation approach, and all showed promising results in support of neurocognitive rehabilitation of HAND (Weber et al., 2013). However, the studies reviewed were not limited to those assessing EF deficits, and none employed compensatory neurorehabilitation approaches such as GMT.

Currently, the literature contains only one published study investigating the use of GMT in an HIV+ sample. That study sought to determine the effectiveness of metacognitive training compared to GMT among HIV+ substance users with executive dysfunction (Casaletto, 2015). Consistent with the findings reported in the review studies noted above, Casaletto (2015) found beneficial effects of GMT on both everyday multitasking abilities and metacognitive task appraisals in their sample. However, the GMT training component of their study was a brief (10 minute) single-session intervention, and the effectiveness thereof was measured using a performance-based Everyday Multitasking Test to assess instrumental activities of daily living. As such, though the Casaletto (2015) study is comparable to the current study on the basis of their application of GMT with an HIV+ sample, their study methodology provides proof-of-principle for the use of GMT, but is limited with regards to evaluating GMT as a rehabilitation protocol.

The present study findings are, however, consistent with the conclusions of an earlier systematic review aimed at evaluating the effectiveness of GMT interventions for the rehabilitation of EF in patients with ABI (Krasny-Pacini et al., 2014a). In addition to four proof-of-principle studies, that review assessed eight rehabilitation studies using GMT alone or using comprehensive EF interventions drawing heavily on the principles of GMT. The review concluded that there was insufficient evidence to support the use of GMT alone as an intervention for patients with ABI. The authors posited that those studies reporting the effectiveness of GMT as a stand-alone intervention were either low-quality case studies or proof-of-principle studies assessing the immediate application of a cognitive strategy.

In summary, the findings related to the main aim of the current study are inconsistent with most of the recent literature on the efficacy of GMT for the rehabilitation of EFs. However, as noted above, none of the studies published to date match the specific conditions of the current study, either in terms of the sample characteristics (i.e., participant age and/or pathology) or in terms of the type and/or duration of the intervention employed or outcome measures used. Further possible explanations will be discussed next.

Non-Significant Change in Test Scores.

Cognitive Profile of the Study Sample. Participants in the current study were recruited via the HlangananiPlus HCT project, a Cape Town based initiative run by the Desmond Tutu HIV Foundation. The same participants formed part of the HIV+ group in a study investigating executive functioning and patterns of adherence to antiretroviral therapy (ART) among adolescents living with HIV in South Africa (Gama, 2020). As part of that previous study, HIV+ participants were compared to healthy controls on measures of EF, with sub-domains defined following Peter Anderson's (2002) model. In contrast to the findings of several other studies (e.g., Nichols et al., 2015), Gama's analyses detected no significant between-group differences in most EF outcomes; the lone exception was Processing Speed. Gama also noted that, on average, participants in both her groups scored at least 2 *SD* below the mean (with norms derived from the relevant scoring manuals) on the administered EF tests. To account for the overall low EF scores across both groups, Gama suggested that confounding factors such as low SES and poor quality of education may have impacted cognition more generally.

These findings and interpretations are relevant to the current study because (a) the results suggest that the HIV+ group (i.e., the same participants comprising both groups in the current study) are functioning at a cognitive level typical of low-SES adolescents in the local context, and (b) the poor performance on EF tests may be associated with factors separable from the pathological mechanisms of HIV. As such, the pGMT intervention may have lacked the potential to effect meaningful change in this study sample.

Regarding the effects of SES on cognition, there is a well-established link between low SES and poor cognitive performance (Duncan & Magnuson, 2012; Ferrett et al., 2014; Hoare et al., 2016; Last et al., 2018; Lawson et al., 2018; Lipina, 2017; Shuttleworth-Edwards et al., 2004; Ursache & Noble, 2016). Low SES is commonly associated with factors such as poverty, limited and poor quality of education, less cognitive stimulation, malnutrition, poor medical access, and exposure to stress (Duncan & Magnuson, 2012; Hackman et al., 2015; Schrieff-Elson et al., 2017). Recent research has found that EF is one of the cognitive systems most vulnerable to the effects of low SES (Hackman & Farah, 2009; Hackman et al., 2010; Last et al., 2018; Lawson et al., 2018). Although a large body of research exists demonstrating a relationship between HIV infection and EF impairment, some studies suggest that demographic and clinical factors moderate the effects of HIV infection on specific forms of EF (Walker & Brown, 2018). For example, Nichols et al. (2015) investigated EF in a large cohort of perinatally HIV-exposed children and adolescents (7-16 years). The study comprised two groups, one with perinatally acquired HIV (PHIV) and the other perinatally HIV exposed but uninfected (PHEU). Results suggested no significant between-group (i.e., HIV status) differences on the outcome measures, leading the authors to conclude that EF impairments were likely associated with factors other than HIV.

Although the current study did not investigate the presence or absence of specific factors related to low SES, information regarding school quintile and school fee-paying status was obtained and the former was used as a proxy measure of SES. This contextual measure uses the wealth of the neighbourhood in which the school is located as an indicator of poverty and quality of education (Department of Basic Education [DBE], 2018; Oakes & Rossi, 2003; Ogbonnaya & Awuah, 2019). Most participants in both groups were from low-quintile schools (i.e., quintile 3 or below, indicating that most participants are from low SES backgrounds as these are frequently subsidized schools located in poor communities). Given that no significant differences in EF were detected between these HIV+ participants and the healthy control group in Gama's (2020) study, the possibility exists that factors beyond the pathological mechanisms of HIV, such as low SES and associated poor quality of education, may have unduly hindered the performance of the study participants, and limited their potential to benefit from the pGMT intervention. An alternative explanation is that the participants in the current study may be functioning at a cognitive level typical of low-SES adolescents and that, as such, their poor performance on the neuropsychological tests of executive function may not be indicative of pathological cognitive impairment related to HIV. In other words, our study sample may not have needed cognitive rehabilitation, thus diminishing the study's potential to detect meaningful change. As noted in a review by Weber et al. (2013), this differential effect has even been documented in pharmacological studies of HIV, with treatment-associated cognitive gains were only detectable in individuals with confirmed HAND (Heseltine et al., 1998).

Another factor that may have contributed to the limited efficacy of the pGMT intervention is the study sample's limited degree of insight and problem awareness (or awareness of their deficits). GMT is a metacognitive intervention that aims to reinstate cognitive control in the self-regulation of behaviour and attainment of higher-order goals (Robertson et al., 2005; Stamenova & Levine, 2018). Hence, the success of GMT interventions is thought to be contingent on patients' awareness of their impairments (Krasny-Pacini et al., 2014a). The first few modules train individuals to recognize attentional slips and to reorient to the task at hand, while the final step emphasizes the need to monitor and check their performance (Levine & Stamenova, 2017). Integral to this process is an individual's awareness of their own cognitive strengths and weaknesses, as well as an understanding of the task demands that indicate the need to implement compensatory strategies (Stamenova & Levine, 2018; Weber et al., 2013).

It is estimated, however, that up to 50% of HIV+ individuals exhibit poor insight into their cognitive deficits (Weber et al., 2013). Therefore, although insight and problem awareness were not measured in the current study, there is a strong possibility that some participants lacked awareness of their cognitive weaknesses or failed to recognize the applicability of the GMT steps during neuropsychological testing. Consequently, some participants in the pGMT intervention may have failed to implement the strategies learned, thus nullifying the anticipated gains in compensatory behaviour.

The factors discussed above suggest that the observed pGMT null effects may be attributable to characteristics of the study sample. Next, I will discuss methodological considerations as they relate to the suitability of neuropsychological tests as measures of neurocognitive rehabilitation interventions more broadly.

Methodological Considerations. Several decades of research have made it clear that the application of neuropsychological tests developed and normed in non-local contexts is problematic (Casaletto & Heaton, 2017; Fernandez, 2019; Fernández & Abe, 2018; Ferraro, 2015; Pedraza, 2019; Shuttleworth-Edwards et al., 2004). One of the major critiques in this regard is that non-local tests frequently fail to discriminate between the performance of neurologically impaired versus unimpaired individuals (Ferrett et al., 2014; Lezak et al., 2004). This failure is generally attributed to the use of non-appropriate normative data as well as the influence of confounding sociodemographic factors on test performance (Casaletto & Heaton, 2017; Fernández & Abe, 2018). The inclusion of a control group in the current study allowed for comparison of test performance between groups rather than in reference to historical controls or non-local normative data. However, a number of sociodemographic factors (e.g., SES, quality of education, home language and language of schooling, degree of urbanisation, and experience with test-taking) may have influenced participants' test performance (Cave & Grieve, 2009; Ferrett et al., 2014; Lawson et al., 2018; Pedraza, 2019). As such, tests that are not adapted for the South African context, or that are culturally biased, may fail to detect meaningful differences in test performance between groups or between testing occasions (Casaletto & Heaton, 2017; Fernandez, 2019; Fernández & Abe, 2018; Ferraro, 2015; Ferrett et al., 2014). In the current study, despite the presence of an Xhosa translator throughout testing, the use of non-local tests may have impacted negatively on participants' test performance, and therefore contributed to the failure to detect meaningful change in EF as a result of the pGMT intervention.

The suitability of standardized neuropsychological tests for the evaluation of rehabilitation interventions has also been questioned. The aim of cognitive rehabilitation is to improve an individual's ability to function in everyday life (Cicerone et al., 2019; Krasny-Pacini et al., 2014a; Lewis et al., 2011; Wilson et al., 2017). This is especially true of EF interventions, as deficits in this domain are consistently shown to impact negatively on everyday functional capacity (Heaton et al., 2004; Smith & Wilkins, 2015; Walker & Brown, 2018). Additionally, current recommendations for cognitive rehabilitation emphasize the importance of tailoring interventions to be relevant to the strengths, weaknesses, and environmental context and requirements of the individual patient (Cicerone et al., 2019; De Luca et al., 2018; Langenbahn et al., 2013). These factors contribute to the ecological validity of cognitive rehabilitation interventions and to the generalizability of the trained skills (Mishra & Gazzaley, 2014; Oliveira et al., 2018; Wilson et al., 2017). GMT was designed to promote generalization through the inclusion of personally relevant examples of task failures and successes, as well as through an emphasis on patients' real-life issues (Levine et al., 2011). Ecological validity is also an important criterion to consider when selecting assessment measures to evaluate the effectiveness of a rehabilitation intervention – these measures should predict everyday functioning (Lewis et al., 2011).

The ecological validity of neuropsychological tests of EF tends to be fairly low (Oliveira et al., 2018; Parsons et al., 2017). This may in part be due to the prioritisation of veridicality over verisimilitude, given the extensive use of these standardized measures in experimental cognitive psychology studies (Lewis et al., 2011). Additionally, the application of formal measures of EF in clinical practice is primarily for diagnostic purposes, with a focus on the identification of cognitive *in*ability and impairment (Gioia et al., 2008; Ledochowski et al., 2019; Miyake & Friedman, 2012; Pereira et al., 2018; Wilson, 1996). As such, neuropsychological tests of EF may underestimate cognitive strengths - such as the type of compensatory strategies trained in GMT - and are limited in their capacity to directly assess real-life functional capacity (Krasny-Pacini et al., 2014a). For this reason, it is argued that the use of test scores is an ineffectual means of evaluating rehabilitation interventions (Cicerone et al., 2019; De Luca et al., 2018; Parsons et al., 2017; Wilson, 2008).

In summary, the use of neuropsychological tests as the primary outcome measure in this study may have underestimated improvements in executive functioning, and/or may have failed to detect improvements relevant to everyday functioning. This inability to detect change may be attributed to the use of non-local tests that lack sufficient discriminability, or the inefficacy of neuropsychological tests as outcome measures for rehabilitation interventions.

Qualitative Observations Regarding the Feasibility of Implementing the pGMT

As discussed previously in this paper, the availability of and access to neuropsychological rehabilitation in LMICs such as South Africa is largely absent. This is purportedly due to a dearth of research supporting the application of cognitive rehabilitation interventions in local conditions, as well as the limited infrastructure required to support these services (Schrieff-Elson & Thomas, 2017). Qualitative observations regarding the feasibility of using the pGMT protocol in low-resourced settings such as those commonly found in South Africa are described below.

The current study supports the feasibility of implementing the pGMT intervention in the local context. Important factors that enabled the successful implementation of the intervention relate to the design, mobility and setting of the programme. Firstly, regarding the pGMT design, the inclusion of contextually relevant stories and examples meant that participants were able to relate to the pGMT steps in personally meaningful ways. The manualised protocol was easy to administer, and thus facilitated a high degree of engagement with participants. Additionally, the presentation of the programme via MS PowerPoint slides projected onto a large wall, made it easy to administer the intervention in a group setting. The repetition of the pGMT steps in the last three sessions allowed participants to explore the concepts further and become familiar with them through the exploration of concrete examples and activities. As previously described, participants developed a rap song in collaboration with the intervention facilitator. In addition to reinforcing and consolidating the pGMT steps, this activity generated a lot of energy and enthusiasm within the group.

Secondly, regarding mobility, the programme did not involve any heavy equipment or materials. As such, it was easy to transport and move around, supporting the use of this intervention in a variety of settings at fairly low cost.

Thirdly, with regards to setting, the pGMT intervention was administered in a community hall at the same clinic that participants attended for regular medical follow-ups. As such, participants were familiar with the facilities and location of the centre. This may be one factor contributing to the consistently high attendance rates observed throughout the intervention.

Another important factor that contributed to the successful implementation of the intervention, was the involvement of a highly skilled facilitator. Our facilitator had extensive experience working with children and adolescents from diverse backgrounds. She infused the sessions with energy and managed group dynamics with sensitivity and confidence. She also fulfilled a crucial role as a translator, as she is fluent in both English and isiXhosa. Using a first language isiXhosa intervention facilitator also contributed significantly to being able to build rapport with the participants and in making the intervention even more accessible.

Participants in our pGMT intervention demonstrated engagement in the programme in various ways. In addition to the rap song noted above, three participants made posters depicting or describing examples of how the pGMT steps could be applied in everyday life. Participants were invited to make these posters but this activity was not compulsory. There was also a high degree of participation in sessions, whereby individuals willingly partook in activities and shared personally relevant anecdotes.

The observations detailed above support the pragmatic feasibility of implementing GMT interventions in low resourced settings such as those commonly found in South Africa. Additionally, these observations provide evidence of participant engagement in the intervention. Thus, although quantitatively there were no significant changes to neuropsychological outcome scores from pre- to post-intervention, qualitatively the implementation of the intervention was successful and feasible in the resource limited local context.

Limitations and Recommendations for Future Research

Several methodological limitations must be noted when interpreting and attempting to generalize the results of the current study.

First, the study's small sample size may have implications for the generalizability of the findings. Especially because the observed effect sizes were quite small, it is likely that the study was statistically underpowered to accomplish its aims and was at high risk of committing Type II errors. Future neurorehabilitation intervention studies of this nature would, therefore, benefit from larger sample sizes. This study's sample size was limited primarily because participants were recruited from an existing pool of HIV+ individuals enrolled in the HlanganiPlus HCT project. Recruiting our participants from this pool had the benefit of ensuring that participants in the intervention and control groups were comparable in terms of demographic and clinical characteristics, thus reducing the effect of possible confounding variables (e.g., age, SES, language, and quality of education).

Second, although the research team had hoped to implement randomised assignment of participants to each study condition, this was not feasible at the time data collection commenced because not all participants wished to continue with research involvement upon conclusion of the four HlanganiPLus HCT modules. Hence, those participants who were willing to continue formed the intervention group and received pGMT training. We acknowledge that this practice may have introduced bias into the study, and therefore recommend that future studies employ more rigorous randomised group assignment.

Third, participant's CD4 count and VL measures were not obtained directly in this study. Archival data on plasma VL and CD4 counts were garnered retrospectively from patient medical files at Hannan Crusaid Clinic. All participants' VL measures were taken within two years of the current study, whereas CD4 counts were measured within a broader time frame of five years prior to the start of this study. While routine virological monitoring in combination with immunological and clinic assessments for HIV is infrequently implemented in resource-limited settings, these measures are predictive of immunological failure and disease progression and severity (Oliveira et al., 2010). Furthermore, data regarding nadir CD4 count, peak VL and history of encephalopathy were not available for use in this study. Given that indicators of past disease severity or significant immunocompromise confer increased risk of poor neurocognitive outcomes, I acknowledge this limitation in my study and recommend that future studies should include more recent and more detailed clinical information for HIV+ samples (Nichols et al., 2015; Walker & Brown, 2018; Weber et al., 2013).

Fourth, the study did not include behavioural measures of EF. Formal neuropsychological tests of EF, such as those employed in this study, have been used widely in EF intervention studies (for reviews see, Krasny-Pacini et al., 2014a; Stamenova & Levine, 2018). However, as discussed previously, these measures may not reflect real-life everyday functioning (Lewis et al., 2011). In addition to a pre-intervention measure of EF capability, future studies would benefit from the inclusion of more ecologically valid measures of EF, such as behavioural tasks and caregiver reports. The inclusion of these additional measures would also aid in assessing the generalizability of GMT-trained skills to everyday activities, which is a critical factor when evaluating the effectiveness of neurorehabilitation tools (Cicerone et al., 2019; Lewis et al., 2011; Wilson et al., 2017).

Fifth, some post-manipulation testing was delayed due to limited availability of participants. Although the research team made every effort to test all participants within the month immediately following the conclusion of the intervention period, two participants were only available for testing 3 months post-manipulation while six others were only available a further month after that. Consequently, the immediate gains resulting from the pGMT training may not have been detectable because they might have diminished over time. Although few GMT evaluation studies include follow-up assessments, the review by Stamenova and Levine (2018) indicates that the effects of GMT on cognitive test performance was maintained at follow-up, which was usually 6 months post-training. Ideally, future studies should include post-intervention assessments both shortly after the completion of training (e.g., within 1 month) and again 6 months later.

Finally, the same neuropsychological tests were used pre- and post-intervention. Although this is common practice in intervention studies, it may not be the most suitable methodological solution when assessing EF interventions, as task novelty is often necessary to make the requisite demands on EF (Duncan, 1986; Krasny-Pacini et al., 2014a; Lewis et al., 2011). A possible alternative method would be to measure EF between groups only after the intervention. However, although this method ensures task novelty, the exclusion of baseline testing precludes the possibility of within-group pre- and post-intervention comparisons. Another consideration would be to source tests with parallel versions that demonstrate strong test-retest reliability and draw on the same EF processes, but differ sufficiently in format and content to ensure task novelty (Krasny-Pacini et al., 2014a).

Summary and Conclusion

The results of this intervention study suggest that Goal Management Training (GMT) did not affect significant improvement on tests of executive function in the study sample. However, the study design may have been limited in its potential to detect meaningful change as a result of factors pertaining to characteristics of the study sample, and/or methodological shortcomings related to the use of neuropsychological tests alone as outcome measures. Despite these non-significant findings, the successful implementation of the intervention supports the use of the GMT protocol in low-resourced settings such as those commonly found in LMICs like South Africa.

Currently, there appears to be a paucity of research on neurorehabilitation for HIV-associated executive impairments, and an even greater dearth of research investigating the efficacy of GMT in this population. At the same time, very few cognitive rehabilitation studies are conducted in LMICs, and this contributes to the lack of availability and access to cognitive rehabilitation services in South Africa. Given that executive functions play a critical role in everyday functioning, further research into the efficacy and feasibility of interventions such as the GMT, particularly in low-resourced settings and with vulnerable populations such as HIV+ adolescents, is urgently needed. Findings of the current study contribute valuable insights into the limitations and opportunities relevant not only to research in this field, but also more broadly to the implementation of cognitive rehabilitation interventions in LMICs.

References

Anderson, P. (2002). Assessment and Development of Executive Function (EF) During Childhood. *Child Neuropsychology*, *8*(2), 71–82. https://doi.org/10.1076/chin.8.2.71.8724

Anderson, V. A., Anderson, P., Northam, E., Jacobs, R., & Catroppa, C. (2001). Development of executive functions through late childhood and adolescence in an Australian sample. *Developmental Neuropsychology*, *20*(1), 385–406. https://doi.org/10.1207/S15326942DN2001_5

Anderson, V. A., Jacobs, R., & Anderson, P. J. (2010). *Executive Functions and the Frontal Lobes: A Lifespan Perspective*. Psychology Press.

Antinori, A., Arendt, G., Becker, J. T., Brew, B. J., Byrd, D. A., Cherner, M., Clifford, D. B., Cinque, P., Epstein, L. G., Goodkin, K., Gisslen, M., Grant, I., Heaton, R. K., Joseph, J., Marder, K., Marra, C. M., McArthur, J. C., Nunn, M., Price, R. W., … Wojna, V. E. (2007). Updated research nosology for HIV-associated neurocognitive disorders. *Neurology*, *69*(18), 1789–1799. https://doi.org/10.1212/01.WNL.0000287431.88658.8b

Becker, J. T., Dew, M. A., Aizenstein, H. J., Lopez, O. L., Morrow, L., Saxton, J., & Tarraga, L. (2012). A Pilot Study of the Effects of Internet-Based Cognitive Stimulation on Neuropsychological Function in HIV Disease. *Disability and Rehabilitation*, *34*(21), 1848–1852. https://doi.org/10.3109/09638288.2012.667188

Boivin, M. J., Nakasujja, N., Sikorskii, A., Opoka, R. O., & Giordani, B. (2016). A Randomized Controlled Trial to Evaluate if Computerized Cognitive Rehabilitation Improves Neurocognition in Ugandan Children with HIV. *AIDS Research and Human Retroviruses*, *32*(8), 743–755. https://doi.org/10.1089/aid.2016.0026

Casaletto, K. B. (2015). *A Metacognition-Based Approach to Improve HIV-associated Neurocognitive Disorders among Substance Users* [UC San Diego]. https://escholarship.org/uc/item/7js8m00h

Casaletto, K. B., & Heaton, R. K. (2017). Neuropsychological Assessment: Past and Future. *Journal of the International Neuropsychological Society : JINS*, *23*(9–10), 778–790. https://doi.org/10.1017/S1355617717001060

Casaletto, K. B., Moore, D. J., Woods, S. P., Umlauf, A., Scott, J. C., & Heaton, R. K. (2016). Abbreviated Goal Management Training Shows Preliminary Evidence as a Neurorehabilitation Tool for HIV-associated Neurocognitive Disorders among Substance Users. *Clinical Neuropsychologist*, *30*(1), 107–130. https://doi.org/10.1080/13854046.2015.1129437

Cave, J., & Grieve, K. (2009). Quality of education and neuropsychological test performance. *New Voices in Psychology*, *5*(1), 29–48.

Cicerone, K. D., Goldin, Y., Ganci, K., Rosenbaum, A., Wethe, J. V., Langenbahn, D. M., Malec, J. F., Bergquist, T. F., Kingsley, K., Nagele, D., Trexler, L., Fraas, M., Bogdanova, Y., & Harley, J. P. (2019). Evidence-Based Cognitive Rehabilitation: Systematic Review of the Literature From 2009 Through 2014. *Archives of Physical Medicine and Rehabilitation*, *100*(8), 1515–1533. https://doi.org/10.1016/j.apmr.2019.02.011

Clinical Info. (2019, December 18). *Guidelines for the use of antiretroviral agents in adults and adolescents living with HIV: Virologic failure.* https://clinicalinfo.hiv.gov/en/guidelines/adult-and-adolescent-arv/virologic-failure

Cohen, M. J. (1997). Children's memory scale. Administration manual. San Antonio, Texas: The Psychological Corporation.

Corbett, C. (2008). *Rehabilitation of executive functioning following paediatric traumatic brain injury: A Goal Management Training intervention* [Unpublished master's thesis]. University of Cape Town, South Africa.

Cysique, L. A., & Brew, B. J. (2009). Neuropsychological Functioning and Antiretroviral Treatment in HIV/AIDS: A Review. *Neuropsychology Review*, *19*(2), 169–185. https://doi.org/10.1007/s11065-009-9092-3

Cysique, L. A. J., Maruff, P., & Brew, B. J. (2006). The neuropsychological profile of symptomatic AIDS and ADC patients in the pre-HAART era: A meta-analysis. *Journal of the International Neuropsychological Society*, *12*(3), 368–382. https://doi.org/10.1017/S1355617706060401

D'Antoni, M. L., Paul, R. H., Mitchell, B. I., Kohorn, L., Fischer, L., Lefebvre, E., Seyedkazemi, S., Nakamoto, B. K., Walker, M., Kallianpur, K. J., Ogata-Arakaki, D., Ndhlovu, L. C., & Shikuma, C. (2018). Improved Cognitive Performance and Reduced Monocyte Activation in Virally Suppressed Chronic HIV After Dual CCR2 and CCR5 Antagonism. *JAIDS Journal of Acquired Immune Deficiency Syndromes*, *79*(1), 108. https://doi.org/10.1097/QAI.0000000000001752

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis Kaplan Executive Function System: Technical manual.* San Antonio, TX: Psychological Corporation.

Department of Basic Education. (2018). School Masterlist Data. Retrieved from https://www.education.gov.za/EMIS/EMISDownloads/tabid/466/Default.aspx

De Luca, R., Calabrò, R. S., & Bramanti, P. (2018). Cognitive rehabilitation after severe acquired brain injury: Current evidence and future directions. *Neuropsychological Rehabilitation*, *28*(6), 879–898. https://doi.org/10.1080/09602011.2016.1211937

Desmond Tutu HIV Foundation. (2017). Retaining HIV-positive youth in care: A model for transitioning adolescents receiving ART from pediatric to adult care. [Unpublished project protocol]. Cape Town, South Africa.

Duncan, G. J., & Magnuson, K. (2012). Socioeconomic status and cognitive functioning: Moving from correlation to causation. *WIREs Cognitive Science*, *3*(3), 377–386. https://doi.org/10.1002/wcs.1176

Duncan, J. (1986). Disorganisation of behaviour after frontal lobe damage. *Cognitive Neuropsychology*, *3*(3), 271–290. https://doi.org/10.1080/02643298608253360

du Plessis, S., Vink, M., Joska, J. A., Koutsilieri, E., Stein, D. J., & Emsley, R. (2014). HIV infection and the fronto–striatal system: A systematic review and meta-analysis of fMRI studies. *AIDS*, *28*(6), 803. https://doi.org/10.1097/QAD.0000000000000151

Ettenhofer, M. L., Hinkin, C. H., Castellon, S. A., Durvasula, R., Ullman, J., Lam, M., Myers, H., Wright, M. J., & Foley, J. (2009). Aging, Neurocognition, and Medication Adherence in HIV Infection. *The American Journal of Geriatric Psychiatry : Official Journal of the American Association for Geriatric Psychiatry*, *17*(4), 281–290. https://doi.org/10.1097/JGP.0b013e31819431bd

Fernandez, A. L. (2019). Modern neuropsychological tests for a diversity of cultural contexts. *The Clinical Neuropsychologist*, *33*(2), 438–445. https://doi.org/10.1080/13854046.2018.1560501

Fernández, A. L., & Abe, J. (2018). Bias in cross-cultural neuropsychological testing: Problems and possible solutions. *Culture and Brain*, *6*(1), 1–35. https://doi.org/10.1007/s40167-017-0050-2

Ferraro, F. R. (2015). *Minority and Cross-Cultural Aspects of Neuropsychological Assessment: Enduring and Emerging Trends*. Psychology Press.

Ferrett, H. L. (2011). *The adaptation and norming of selected psychometric tests for 12- to 15-year-old urbanized Western Cape adolescents* [Thesis, Stellenbosch : Stellenbosch University]. https://scholar.sun.ac.za:443/handle/10019.1/17799

Ferrett, H. L., Carey, P. D., Thomas, K. G. F., Tapert, S. F., & Fein, G. (2010). Neuropsychological performance of South African treatment-naïve adolescents with alcohol dependence. *Drug and Alcohol Dependence*, *110*(1), 8–14. https://doi.org/10.1016/j.drugalcdep.2010.01.019

Ferrett, H. L., Thomas, K. G. F., Tapert, S. F., Carey, P. D., Conradie, S., Cuzen, N. L., Stein, D. J., & Fein, G. (2014). The cross-cultural utility of foreign- and locally-derived normative data for three WHO-endorsed neuropsychological tests for South African adolescents. *Metabolic Brain Disease*, *29*(2), 395–408. https://doi.org/10.1007/s11011-014-9495-6

Field, A. (2009). Exploring assumptions. In *Discovering Statistics Using SPSS*. https://doi.org/10.1111/insr.12011_21

Fogarty, L., Roter, D., Larson, S., Burke, J., Gillespie, J., & Levy, R. (2002). Patient adherence to HIV medication regimens: A review of published and abstract reports. *Patient Education and Counseling*, *46*(2), 93–108. https://doi.org/10.1016/S0738-3991(01)00219-1

Gama, V. L. (2020). *Investigating executive functioning and patterns of adherence to antiretroviral therapy among adolescents living with HIV in South Africa* [Unpublished master's thesis]. University of Cape Town.

Garvie, P. A., Zeldow, B., Malee, K., Nichols, S. L., Smith, R. A., Wilkins, M. L., & Williams, P. L. (2014). Discordance of Cognitive and Academic Achievement Outcomes in Youth with Perinatal HIV Exposure. *The Pediatric Infectious Disease Journal*, *33*(9), e232–e238. https://doi.org/10.1097/INF.0000000000000314

Gioia, G. A., Isquith, P. K., & Kenealy, L. E. (2008). Assessment of behavioral aspects of executive function. In *Executive functions and the frontal lobes: A lifespan perspective* (pp. 179–202). Taylor & Francis.

Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*(2), 65–73. https://doi.org/10.1016/j.tics.2008.11.003

Hackman, D. A., Farah, M. J., & Meaney, M. J. (2010). Socioeconomic status and the brain: Mechanistic insights from human and animal research. *Nature Reviews Neuroscience*, *11*(9), 651–659. https://doi.org/10.1038/nrn2897

Hackman, D. A., Gallop, R., Evans, G. W., & Farah, M. J. (2015). Socioeconomic status and executive function: Developmental trajectories and mediation. *Developmental Science*, *18*(5), 686–702. https://doi.org/10.1111/desc.12246

Harris, L. L., Chernoff, M. C., Nichols, S. L., Williams, P. L., Garvie, P. A., Yildirim, C., McCauley, S. R., & Woods, S. P. (2018). Prospective memory in youth with perinatally-acquired HIV infection. *Child Neuropsychology*, *24*(7), 938–958. https://doi.org/10.1080/09297049.2017.1360854

Heaton, R. K., Franklin, D. R., Ellis, R. J., McCutchan, J. A., Letendre, S. L., LeBlanc, S., Corkran, S. H., Duarte, N. A., Clifford, D. B., Woods, S. P., Collier, A. C., Marra, C. M., Morgello, S., Mindt, M. R., Taylor, M. J., Marcotte, T. D., Atkinson, J. H., Wolfson, T., Gelman, B. B., … for the CHARTER and HNRC Groups. (2011). HIV-associated neurocognitive disorders before and during the era of combination antiretroviral therapy: Differences in rates, nature, and predictors. *Journal of NeuroVirology*, *17*(1), 3–16. https://doi.org/10.1007/s13365-010-0006-1

Heaton, R. K., Marcotte, T. D., Mindt, M. R., Sadek, J., Moore, D. J., Bentley, H., Mccutchan, J. A., Reicks, C., Grant, I., & Group, T. H. (2004). The impact of HIV-associated neuropsychological impairment on everyday functioning. *Journal of the International Neuropsychological Society*, *10*(3), 317–331. https://doi.org/10.1017/S1355617704102130

Heseltine, P. N. R., Goodkin, K., Atkinson, J. H., Vitiello, B., Rochon, J., Heaton, R. K., Eaton, E. M., Wilkie, F. L., Sobel, E., Brown, S. J., Feaster, D., Schneider, L., Goldschmidts, W. L., & Stover, E. S. (1998). Randomized Double-blind Placebo-Controlled Trial of Peptide T for HIV-Associated Cognitive Impairment. *Archives of Neurology*, *55*(1), 41–51. https://doi.org/10.1001/archneur.55.1.41

Hinkin, C. H., Hardy, D. J., Mason, K. I., Castellon, S. A., Durvasula, R. S., Lam, M. N., & Stefaniak, M. (2004). Medication adherence in HIV-infected adults: Effect of patient age, cognitive status, and substance abuse. *AIDS (London, England)*, *18 Suppl 1*, S19-25. https://doi.org/10.1097/00002030-200418001-00004

Hoare, J., Fouche, J.-P., Spottiswoode, B., Donald, K., Philipps, N., Bezuidenhout, H., Mulligan, C., Webster, V., Oduro, C., Schrieff, L., Paul, R., Zar, H., Thomas, K., & Stein, D. (2012). A diffusion tensor imaging and neurocognitive study of HIV-positive children who are HAART-naïve “slow progressors”. *Journal of NeuroVirology*, *18*(3), 205–212. https://doi.org/10.1007/s13365-012-0099-9

Hoare, J., Phillips, N., Joska, J. A., Paul, R., Donald, K. A., Stein, D. J., & Thomas, K. G. F. (2016). Applying the HIV-associated neurocognitive disorder diagnostic criteria to HIV-infected youth. *Neurology*, *87*(1), 86–93. https://doi.org/10.1212/WNL.0000000000002669

Hoogenhout, M., & Malcolm-Smith, S. (2014). Theory of mind in autism spectrum disorder: Does DSM classification predict development? *Research in Autism Spectrum Disorders*, *8*(6), 597–607. https://doi.org/10.1016/j.rasd.2014.02.005

Israel, S. M., Hassanzadeh-Behbahani, S., Turkeltaub, P. E., Moore, D. J., Ellis, R. J., & Jiang, X. (2019). Different roles of frontal versus striatal atrophy in HIV-associated neurocognitive disorders. *Human Brain Mapping*, *40*(10), 3010–3026. https://doi.org/10.1002/hbm.24577

Joska, J. A., Gouse, H., Paul, R. H., Stein, D. J., & Flisher, A. J. (2010). Does highly active antiretroviral therapy improve neurocognitive function? A systematic review. *Journal of Neurovirology*, *16*(2), 101–114. https://doi.org/10.3109/13550281003682513

Kabuba, N., Anitha Menon, J., Franklin, D. R., Heaton, R. K., & Hestad, K. A. (2017). Use of Western Neuropsychological Test Battery in Detecting HIV-Associated Neurocognitive Disorders (HAND) in Zambia. *AIDS and Behavior*, *21*(6), 1717–1727. https://doi.org/10.1007/s10461-016-1443-5

Kanmogne, G. D., Fonsah, J. Y., Tang, B., Doh, R. F., Kengne, A. M., Umlauf, A., Tagny, C. T., Nchindap, E., Kenmogne, L., Franklin, D., Njamnshi, D. M., Mbanya, D., Njamnshi, A. K., & Heaton, R. K. (2018). Effects of HIV on executive function and verbal fluency in Cameroon. *Scientific Reports*, *8*(1). https://doi.org/10.1038/s41598-018-36193-7

Karr, J. E., Areshenkoff, C. N., Rast, P., Hofer, S. M., Iverson, G. L., & Garcia-Barrera, M. A. (2018). The unity and diversity of executive functions: A systematic review and re-analysis of latent variable studies. *Psychological Bulletin*, *144*(11), 1147–1185. https://doi.org/10.1037/bul0000160

Kezer, F., & Arik, R. S. (2012). An Examination and Comparison of the Revisions of the Wechsler Intelligence Scale for Children. *Procedia - Social and Behavioral Sciences*, *46*, 2104–2110. https://doi.org/10.1016/j.sbspro.2012.05.436

Kim, S.-H., Gerver, S. M., Fidler, S., & Ward, H. (2014). Adherence to antiretroviral therapy in adolescents living with HIV: Systematic review and meta-analysis. *AIDS (London, England)*, *28*(13), 1945–1956. https://doi.org/10.1097/QAD.0000000000000316

Koekkoek, S., de Sonneville, L. M. J., Wolfs, T. F. W., Licht, R., & Geelen, S. P. M. (2008). Neurocognitive function profile in HIV-infected school-age children. *European Journal of Paediatric Neurology*, *12*(4), 290–297. https://doi.org/10.1016/j.ejpn.2007.09.002

Korkman, M., Kurk, U., & Kemp, S. L. (2007). *NEPSY-II clinical and interpretive manual.* San Antonio, TX: Harcourt Brand.

Krasny-Pacini, A., Chevignard, M., & Evans, J. (2014a). *Goal Management Training for rehabilitation of executive functions: A systematic review of effectivness in patients with acquired brain injury*. https://hal.sorbonne-universite.fr/hal-01513577

Krasny-Pacini, A., Limond, J., Evans, J., Hiebel, J., Bendjelida, K., & Chevignard, M. (2014b). Context-sensitive goal management training for everyday executive dysfunction in children after severe traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *29*(5), E49-64. https://doi.org/10.1097/HTR.0000000000000015

Langenbahn, D. M., Ashman, T., Cantor, J., & Trott, C. (2013). An Evidence-Based Review of Cognitive Rehabilitation in Medical Conditions Affecting Cognitive Function. *Archives of Physical Medicine and Rehabilitation*, *94*(2), 271–286. https://doi.org/10.1016/j.apmr.2012.09.011

Last, B. S., Lawson, G. M., Breiner, K., Steinberg, L., & Farah, M. J. (2018). Childhood socioeconomic status and executive function in childhood and beyond. *PLOS ONE*, *13*(8), e0202964. https://doi.org/10.1371/journal.pone.0202964

Laughton, B., Cornell, M., Boivin, M., & Van Rie, A. (2013). Neurodevelopment in perinatally HIV-infected children: A concern for adolescence. *Journal of the International AIDS Society*, *16*(1). https://doi.org/10.7448/IAS.16.1.18603

Lawson, G. M., Hook, C. J., & Farah, M. J. (2018). A meta-analysis of the relationship between socioeconomic status and executive function performance among children. *Developmental Science*, *21*(2), e12529. https://doi.org/10.1111/desc.12529

Ledochowski, J., Andrade, B. F., & Toplak, M. E. (2019). A novel unstructured performance-based task of executive function in children with attention-deficit/hyperactivity disorder. *Journal of Clinical and Experimental Neuropsychology*, *41*(5), 445–459. https://doi.org/10.1080/13803395.2019.1567694

Levine, B., Robertson, I. H., Clare, L., Carter, G., Hong, J., Wilson, B. A., Duncan, J., & Stuss, D. T. (2000). Rehabilitation of executive functioning: An experimental–clinical validation of Goal Management Training. *Journal of the International Neuropsychological Society*, *6*(3), 299–312. https://doi.org/10.1017/S1355617700633052

Levine, B., Schweizer, T. A., O'Connor, C., Turner, G., Gillingham, S., Stuss, D. T., Manly, T., & Robertson, I. H. (2011). Rehabilitation of Executive Functioning in Patients with Frontal Lobe Brain Damage with Goal Management Training. *Frontiers in Human Neuroscience*, *5*. https://doi.org/10.3389/fnhum.2011.00009

Levine, B., & Stamenova, V. (2017). Goal Management Training. In J. Kreutzer, J. DeLuca, & B. Caplan (Eds.), *Encyclopedia of Clinical Neuropsychology* (pp. 1–5). Springer International Publishing. https://doi.org/10.1007/978-3-319-56782-2_9048-1

Lewis, M. W., Babbage, D. R., & Leathem, J. M. (2011). Assessing executive performance during cognitive rehabilitation. *Neuropsychological Rehabilitation*, *21*(2), 145–163. https://doi.org/10.1080/09602011.2010.543867

Lezak, M. D., Howieson, D. B., Loring, D. W., Hannay, H. J., & Fischer, J. S. (2004). *Neuropsychological assessment, 4th ed* (pp. xiv, 1016). Oxford University Press.

Lipina, S. J. (2017). Critical considerations about the use of poverty measures in the study of cognitive development. *International Journal of Psychology*, *52*(3), 241–250. https://doi.org/10.1002/ijop.12282

Llorente, A. M., Voigt, R. G., Williams, J., Frailey, J. K., Satz, P., & D'Elia, L. F. (2009). Children's Color Trails Test 1 & 2: Test–Retest Reliability and Factorial Validity. *The Clinical Neuropsychologist*, *23*(4), 645–660. https://doi.org/10.1080/13854040802427795

Llorente, A. M., Williams, J., Satz, P., & D'Elia, L. (2003). Children's Color Trails Test 1 & 2 manual. Lutz, FL: Psychological Assessment Resources.

Luna, B., Padmanabhan, A., & O'Hearn, K. (2010). What has fMRI told us about the Development of Cognitive Control through Adolescence? *Brain and Cognition*, *72*(1), 101. https://doi.org/10.1016/j.bandc.2009.08.005

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

Malgas, N. (2010). *A cognitive profile of South African children with traumatic brain injury*. [Unpublished master's thesis]. University of Cape Town.

Mattson, S. N., Crocker, N., & Nguyen, T. T. (2011). Fetal alcohol spectrum disorders: Neuropsychological and behavioral features. *Neuropsychology Review*, *21*(2), 81–101. https://doi.org/10.1007/s11065-011-9167-9

McIntosh, R. C., & Lobo, J. D. (2019). Correlates of Executive Dysfunction in HIV. In A. Ardila, S. Fatima, & M. Rosselli (Eds.), *Dysexecutive Syndromes: Clinical and Experimental Perspectives* (pp. 261–284). Springer International Publishing. https://doi.org/10.1007/978-3-030-25077-5_13

Medina, K. L., Hanson, K. L., Schweinsburg, A. D., Cohen-Zion, M., Nagel, B. J., & Tapert, S. F. (2007). Neuropsychological functioning in adolescent marijuana users: Subtle deficits detectable after a month of abstinence. *Journal of the International Neuropsychological Society: JINS*, *13*(5), 807–820. https://doi.org/10.1017/S1355617707071032

Mishra, J., & Gazzaley, A. (2014). Harnessing the neuroplastic potential of the human brain & the future of cognitive rehabilitation. *Frontiers in Human Neuroscience*, *8*. https://doi.org/10.3389/fnhum.2014.00218

Miyake, A., & Friedman, N. P. (2012). The Nature and Organization of Individual Differences in Executive Functions: Four General Conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Mothobi, N., & Brew, B. (2012). Neurocognitive dysfunction in the highly active antiretroviral therapy era. *Current Opinion in Infectious Diseases*, *25*(1), 4–9. https://doi.org/10.1097/QCO.0b013e32834ef586

Nichols, S. L., Brummel, S. S., Smith, R. A., Garvie, P. A., Hunter, S. J., Malee, K. M., Kammerer, B. L., Wilkins, M. L., Rutstein, R., Tassiopoulos, K., Chernoff, M. C., & Mellins, C. A. (2015). Executive Functioning in Children and Adolescents With Perinatal HIV Infection: *The Pediatric Infectious Disease Journal*, *34*(9), 969–975. https://doi.org/10.1097/INF.0000000000000809

Oakes, J. M., & Rossi, P. H. (2003). The measurement of SES in health research: Current practice and steps toward a new approach. *Social Science & Medicine*, *56*(4), 769–784. https://doi.org/10.1016/S0277-9536(02)00073-4

Ogbonnaya, U. I., & Awuah, F. K. (2019). *Quintile ranking of schools in South Africa and learners' achievement in probability*. https://repository.up.ac.za/handle/2263/72837

Oliveira, J., Gamito, P., Alghazzawi, D. M., Fardoun, H. M., Rosa, P. J., Sousa, T., Picareli, L. F., Morais, D., & Lopes, P. (2018). Performance on naturalistic virtual reality tasks depends on global cognitive functioning as assessed via traditional neurocognitive tests. *Applied Neuropsychology: Adult*, *25*(6), 555–561. https://doi.org/10.1080/23279095.2017.1349661

Ortega, M., Brier, M. R., & Ances, B. M. (2015). Effects of HIV and Combination Antiretroviral Therapy (cART) on Cortico-Striatal Functional Connectivity. *AIDS (London, England)*, *29*(6), 703–712. https://doi.org/10.1097/QAD.0000000000000611

Parsons, T. D., Carlew, A. R., Magtoto, J., & Stonecipher, K. (2017). The potential of function-led virtual environments for ecologically valid measures of executive function in experimental and clinical neuropsychology. *Neuropsychological Rehabilitation*, *27*(5), 777–807. https://doi.org/10.1080/09602011.2015.1109524

Pearlstein, S. L., Mellins, C. A., Dolezal, C., Elkington, K. S., Santamaria, E. K., Leu, C.-S., Cruz, J. E., & Abrams, E. J. (2014). Youth in Transition: Life Skills Among Perinatally HIV-Infected and HIV-Exposed Adolescents. *Journal of Pediatric Psychology*, *39*(3), 294–305. https://doi.org/10.1093/jpepsy/jst077

Pedraza, O. (2019). *Clinical Cultural Neuroscience: An Integrative Approach to Cross-Cultural Neuropsychology*. Oxford University Press.

Pereira, A., Lopes, S., Magalhães, P., Sampaio, A., Chaleta, E., & Rosário, P. (2018). How Executive Functions Are Evaluated in Children and Adolescents with Cerebral Palsy? A Systematic Review. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.00021

Phillips, N., Amos, T., Kuo, C., Hoare, J., Ipser, J., Thomas, K. G. F., & Stein, D. J. (2016). HIV-Associated Cognitive Impairment in Perinatally Infected Children: A Meta-analysis. *Pediatrics*, *138*(5), e20160893. https://doi.org/10.1542/peds.2016-0893

Phillips, N. J., Hoare, J., Stein, D. J., Myer, L., Zar, H. J., & Thomas, K. G. F. (2018). HIV-associated cognitive disorders in perinatally infected children and adolescents: A novel composite cognitive domains score. *AIDS Care*, *30*(sup1), 8–16. https://doi.org/10.1080/09540121.2018.1466982

Reger, M., Welsh, R., Razani, J., Martin, D. J., & Boone, K. B. (2002). A meta-analysis of the neuropsychological sequelae of HIV infection. *Journal of the International Neuropsychological Society: JINS*, *8*(3), 410–424.

Robertson, I. H., Levine, B., & Manly, T. (2005). *Goal Management Training manual and materials*. Toronto, Canada: Rotman Institute, University of Toronto.

Schrieff-Elson, L. E., Ockhuizen, J.-R. H., During, G., & Thomas, K. G. F. (2017). Attention-training with children from socioeconomically disadvantaged backgrounds in Cape Town. *Journal of Child & Adolescent Mental Health*, *29*(2), 147–167.

Schrieff-Elson, L. E., & Thomas, K. G. F. (2017). In Wilson, B. A., Winegardner, J., Heugten, C. M. van, & Ownsworth, T. (Ed.). *Neuropsychological Rehabilitation: The International Handbook* (pp. 526-529). Psychology Press. https://doi.org/10.2989/17280583.2017.1372285

Shuttleworth-Edwards, A. B., Kemp, R. D., Rust, A. L., Muirhead, J. G. L., Hartman, N. P., & Radloff, S. E. (2004). Cross-cultural Effects on IQ Test Performance: A Review and Preliminary Normative Indications on WAIS-III Test Performance. *Journal of Clinical and Experimental Neuropsychology*, *26*(7), 903–920. https://doi.org/10.1080/13803390490510824

Sillman, B., Woldstad, C., Mcmillan, J., & Gendelman, H. E. (2018). Chapter 3—Neuropathogenesis of human immunodeficiency virus infection. In B. J. Brew (Ed.), *Handbook of Clinical Neurology* (Vol. 152, pp. 21–40). Elsevier. https://doi.org/10.1016/B978-0-444-63849-6.00003-7

Sirois, P. A., Chernoff, M. C., Malee, K. M., Garvie, P. A., Harris, L. L., Williams, P. L., Woods, S. P., Nozyce, M. L., Kammerer, B. L., Yildirim, C., & Nichols, S. L. (2016). Associations of Memory and Executive Functioning With Academic and Adaptive Functioning Among Youth With Perinatal HIV Exposure and/or Infection. *Journal of the Pediatric Infectious Diseases Society*, *5*(suppl 1), S24–S32. https://doi.org/10.1093/jpids/piw046

Smith, R., & Wilkins, M. (2015). Perinatally acquired HIV infection: Long-term neuropsychological consequences and challenges ahead. *Child Neuropsychology*, *21*(2), 234–268. https://doi.org/10.1080/09297049.2014.898744

Spudich, S., & González-Scarano, F. (2012). HIV-1-Related Central Nervous System Disease: Current Issues in Pathogenesis, Diagnosis, and Treatment. *Cold Spring Harbor Perspectives in Medicine*, *2*(6). https://doi.org/10.1101/cshperspect.a007120

Stamenova, V., & Levine, B. (2018). Effectiveness of goal management training® in improving executive functions: A meta-analysis. *Neuropsychological Rehabilitation*, 1–31. https://doi.org/10.1080/09602011.2018.1438294

Theodoraki, T. E., McGeown, S. P., Rhodes, S. M., & MacPherson, S. E. (2020). Developmental changes in executive functions during adolescence: A study of inhibition, shifting, and working memory. *British Journal of Developmental Psychology*, *38*(1), 74–89. https://doi.org/10.1111/bjdp.12307

Tornås, S., Løvstad, M., Solbakk, A.-K., Schanke, A.-K., & Stubberud, J. (2019). Use It or Lose It? A 5-Year Follow-up Study of Goal Management Training in Patients with Acquired Brain Injury. *Journal of the International Neuropsychological Society*, 1–6. https://doi.org/10.1017/S1355617719000626

Tredoux, C., & Durrheim, K. (Eds.). (2002). *Numbers, hypotheses and conclusions: A course for the social sciences.* UCT Press.

Twamley, E. W., Jeste, D. V., & Bellack, A. S. (2003). A Review of Cognitive Training in Schizophrenia. *Schizophrenia Bulletin*, *29*(2), 359–382. https://doi.org/10.1093/oxfordjournals.schbul.a007011

UNAIDS. (2020). *Global HIV & AIDS statistics — 2020 fact sheet.* https://www.unaids.org/en/resources/fact-sheet

Ursache, A., & Noble, K. G. (2016). Neurocognitive development in socioeconomic context: Multiple mechanisms and implications for measuring socioeconomic status. *Psychophysiology*, *53*(1), 71–82. https://doi.org/10.1111/psyp.12547

Vance, D. E., Fazeli, P. L., Ross, L. A., Wadley, V., & Ball, K. (2012). Speed of Processing Training with Middle-Age and Older Adults with HIV: A Pilot Study. *The Journal of the Association of Nurses in AIDS Care : JANAC*, *23*(6), 500–510. https://doi.org/10.1016/j.jana.2012.01.005

Van der Merwe, H. M. (2011). *The construct validity and reliability of the child memory scale, the search and memory task, and the Toulouse-Pieron Test for a sample of South African primary school learners.* [University of the Witwatersrand]. http://hdl.handle.net/10539/9400

Walker, K. A., & Brown, G. G. (2018). HIV-associated executive dysfunction in the era of modern antiretroviral therapy: A systematic review and meta-analysis. *Journal of Clinical and Experimental Neuropsychology*, *40*(4), 357–376. https://doi.org/10.1080/13803395.2017.1349879

Wang, Y., Liu, M., Lu, Q., Farrell, M., Lappin, J. M., Shi, J., Lu, L., & Bao, Y. (2020). Global prevalence and burden of HIV-associated neurocognitive disorder: A meta-analysis. *Neurology*, *95*(19), e2610–e2621. https://doi.org/10.1212/WNL.0000000000010752

Watanabe, M. (2017). The teenage brain issue. *Birth Defects Research*, *109*(20), 1611–1612. https://doi.org/10.1002/bdr2.1181

Watson, C. W.-M., Sundermann, E. E., Hussain, M. A., Umlauf, A., Thames, A. D., Moore, R. C., Letendre, S. L., Jeste, D. V., Morgan, E. E., & Moore, D. J. (2019). Effects of trauma, economic hardship, and stress on neurocognition and everyday function in HIV. *Health Psychology*, *38*(1), 33–42. https://doi.org/10.1037/hea0000688

Weber, E., Blackstone, K., & Woods, S. P. (2013). Cognitive Neurorehabilitation of HIV-associated Neurocognitive Disorders: A Qualitative Review and Call to Action. *Neuropsychology Review*, *23*(1), 81–98. https://doi.org/10.1007/s11065-013-9225-6

Webster, V. (2011). *The neuropsychological and behavioural profiles of HIV-infected asymptomatic HAART-naïve children : a cross sectional and follow-up study*. (Thesis). University of Cape Town ,Faculty of Humanities ,Department of Psychology. Retrieved from http://hdl.handle.net/11427/11208

Wechsler, D. (1999). *Wechsler abbreviated scale of intelligence*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2003). *Wechsler intelligence scale for children – Fourth edition (WISC-IV) administration and scoring manual*. San Antonio, TX: The Psychological Corporation.

Wei, J., Hou, J., Su, B., Jiang, T., Guo, C., Wang, W., Zhang, Y., Chang, B., Wu, H., & Zhang, T. (2020). The Prevalence of Frascati-Criteria-Based HIV-Associated Neurocognitive Disorder

(HAND) in HIV-Infected Adults: A Systematic Review and Meta-Analysis. *Frontiers in Neurology*, *11*, 581346. https://doi.org/10.3389/fneur.2020.581346

Willen, E. J., Cuadra, A., Arheart, K. L., Post, M. J. D., & Govind, V. (2017). Young adults perinatally infected with HIV perform more poorly on measures of executive functioning and motor speed than ethnically matched healthy controls. *AIDS Care*, *29*(3), 387–393. https://doi.org/10.1080/09540121.2016.1234677

Wilson, B. A. (1996). The ecological validity of neuropsychological assessment after severe brain injury. *Ecological Validity of Neuropsychological Testing*, 414–428.

Wilson, B. A. (2008). Neuropsychological Rehabilitation. *Annual Review of Clinical Psychology*, *4*(1), 141–162. https://doi.org/10.1146/annurev.clinpsy.4.022007.141212

Wilson, B. A., Wills, P., Pretorius, C., & Swartz, L. (2015). Cognitive rehabilitation groups: A thematic analysis of feasibility and perceived benefits for clients with moderate to severe traumatic brain injury living in the Western Cape. *African Journal of Disability*, *4*(1). https://doi.org/10.4102/ajod.v4i1.175

Wilson, B. A., Winegardner, J., van Heugten, C. M., & Ownsworth, T. (2017). *Neuropsychological Rehabilitation: The International Handbook*. Psychology Press.

Woods, S. P., Moore, D. J., Weber, E., & Grant, I. (2009). Cognitive Neuropsychology of HIV-Associated Neurocognitive Disorders. *Neuropsychology Review*, *19*(2), 152–168. https://doi.org/10.1007/s11065-009-9102-5

World Health Organization. (2020, November 30). *HIV/AIDS: Key facts*. https://www.who.int/news-room/fact-sheets/detail/hiv-aids

Wykes, T., & Spaulding, W. D. (2011). Thinking About the Future Cognitive Remediation Therapy—What Works and Could We Do Better? *Schizophrenia Bulletin*, *37*(Suppl 2), S80–S90. https://doi.org/10.1093/schbul/sbr064

APPENDIX A

Adaptations to the GMT

The first adaptation was described in an unpublished honours project by Corbett (2008). The project aimed to adapt the original adult GMT (see Robertson, Levine & Manly, 2005) for paediatric populations, with a focus on low SES children in South Africa. Content changes were made to the language, examples and exercises included in the original program to ensure they were applicable and relatable to children. A pilot study by Corbett (2008) evaluated this adapted version on three children, 10 to 13 years of age, with executive function impairment due to TBI of varying severity. The study yielded varied results and noted that family involvement is important. It was also recommended 7 modules should be implemented as per the original version, rather than the shortened 5-module version.

A second attempt to adapt the GMT for paediatric populations was undertaken by Krasny-Pacini et al (2014). Components of both the original adult GMT (Robertson et al., 2005) and Corbett's (2008) adapted version were used to produce a new 8-module version that was simpler, age-appropriate, and more colourful and engaging. Krasny-Pacini et al (2014) tested this version on five French children, aged 8 to 14, with severe executive difficulties due to TBI, and found the adapted GMT was enjoyable for children and feasible to implement.

Further adaptations were made by Mahomed (2015) in consultation with a group of professionals in the field of psychology. These included a pediatric neuropsychologist, an educational psychologist, a clinical psychologist and two developmental psychology specialists (Mahomed, 2015). Changes were made firstly by translating the French version of the paediatric GMT by Krasny-Pacini et al (2014b) into English, and then by adapting the content of materials used (e.g. language and illustrations) to ensure that they were age-appropriate and suitable for the South African paediatric population. Content changes were made in instances where the stories and examples used to illustrate the pGMT concepts may have been unfamiliar in the South African context. For example, the story of Elbert Einsten was removed, and a story of Nelson Mandela was used to replace the Trojan horse. Further changes were made by condensing the 8 modules from the Krasny-Pacini et al. (2014)b version into 4 core modules, which were repeated over an additional 5 revision modules. The session periods were also reduced from 2 hours to approximately 45-60 minutes per session. The current study made use of this version, hereon referred to as the pGMT-SA, but reduced the number of revision sessions, such that the full GMT intervention was administered over 7 weekly sessions as outlined below.

References

Corbett, C. (2008). *Rehabilitation of executive functioning following paediatric traumatic brain injury: A Goal Management Training intervention.* (Unpublished thesis). University of Cape Town, South Africa.

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

Robertson, I. H., Levine, B., & Manly, T. (2005). *Goal Management Training manual and materials.* Toronto, Canada: Rotman Institute, University of Toronto.

APPENDIX B

Parent/Guardian's Informed Consent Document

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

Informed Consent to Allow Participation in Research and Authorization for Collection, Use, and Disclosure of Cognitive Performance and Other Personal Data

You are being asked to allow your child to take part in a research study. This form provides you with information about the study and seeks your authorization (permission) for the collection, use and sharing of your child's cognitive performance data, as well as other information necessary for the study. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also describe this study to you and answer all of your questions. Your participation is entirely voluntary. Before you decide whether or not to take part, read the information below and ask questions about anything you do not understand. By refusing participation in this study you or your child will not be penalized or lose any benefits to which you would otherwise be entitled.

My research will be conducted in a manner that adheres to the ethical guidelines and principles of the International Declaration of Helsinki.

1. **Title of Research Study**

Investigating an Executive Function Intervention Using Goal Management Training in HIV+ Adolescents in South Africa

2. **What is the purpose of this research study?**

The purpose of this study is to investigate the efficacy of a paediatric Goal Management Tool (pGMT) intervention program in a group of HIV positive adolescents in South Africa. The study also aims to contribute to studies on the feasibility of using the pGMT protocol in a low- and middle-income country (LAMIC) setting like South Africa.

3. **How many people are expected to participate in the research?**

We have invited 22 adolescents to participate in the study. Some participants may choose to exit the study so the total number of participants may decrease over the course of the study.

4. **Principle Investigator(s) and Telephone Number(s)**

Angela Harwood: 082 474 0326

5. **What will be done if you provide consent for your child to part in this research study?**

During this study, you will be asked to complete some questionnaires to obtain information about who you are and information regarding your child's behaviour and emotional state. In addition, we will also test your child's thinking (their attention, memory and how fast they think) and problem solving. This will take place at the Hannan Crusaid Clinic in Gugulethu.

6. **If you choose to allow your child to participate in the study, how long will they be involved in the research?**

Participation in the administration of the pGMT will take 7 weeks. In addition, there will be 3 sessions of neuropsychological testing each taking an estimated 2.5 hours

7. **What are the possible discomforts and risks to your child?**

The pGMT intervention will take 7 weeks, in addition there will be 3 sessions of neuropsychological testing each taking an estimated 2.5 hours. Due to the lengthy process of the testing and the intervention administration, participants may feel fatigued or irritable. Therefore, regular breaks will be provided.

8. **What are the possible benefits of this study?**

This research aims to help us understand some of the factors that may improve optimal executive functioning in adolescents.

9. **If you choose to allow your child to take part in this research study, will it cost you anything?**

There will be no costs associated with participating in the study.

10. **Can you or your child withdraw from this research study and if you withdraw, can information about you still be used and/or collected?**

You or your child may withdraw your consent or assent and stop participation in this study at any time without any penalty. Information already collected may still be used.

If you have a complaint or questions about your rights and welfare as research participants, please contact the Human Research Ethics Committee.

Tel: 021 406 6492

E-mail: sumaya.ariefdien@uct.ac.za

11. **Once information is collected, how will it be kept confidential in order to protect your privacy and what protected health information about you may be collected, used and shared with others?**

The information gathered from you and your child will be demographic information (info about who you are), records of his/her performance on neuropsychological (thinking and problem solving) tests and questionnaires on their emotional and behavioural state. Information collected will be stored in locked filing cabinets and on computers with security passwords. Only certain people - the researchers for this study and certain University of Cape Town officials - have the right to review these research records. Your research records will not be released without your permission unless required by law or a court order.

12. What should you tell your child?

You may wish to discuss the study with your child to find out whether he/she feels comfortable taking part. The assessment takes the form of games, puzzles and presentations. Your child should know that he/she can choose not to participate in the study. Your child should also know that if he/she does choose to participate, he/she can withdraw at any time during the study with no negative consequences.

13. How will the researcher(s) benefit from your child being in the study?

In general, presenting research results helps the career of a scientist. Therefore, the Principal Investigator and others attached to this research project may benefit if the results of this study are presented at scientific meetings or in scientific journals.

14. Signatures

As a representative of this study, I have explained to the participant the purpose, the procedures, the possible benefits, and the risks of this research study; the alternatives to being in the study; and how the participant's protected health information will be collected, used, and shared with others:

____ ______________________

Signature of Person Obtaining Consent Date

You have been informed about this study's purpose, procedures, possible benefits, and risks; and how your child's performance and other data will be collected, used and shared with others. You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily consent to allow your child to participate in this study. You hereby authorize the collection, use and sharing of your child's performance and other data. By signing this form, you are not waiving any of your legal rights.

____ ______________________

Signature of Person Consenting Date

Name of Participant (your child)

____

APPENDIX C

Assent Form for Participants

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

I am doing a study with adolescents attending the Hannan Crusaid Adherence Clinic in Gugulethu, Cape Town who speak English, Afrikaans and isiXhosa. I want to see if there will be any improvement in their adherence patterns if they undergo Goal Management training.

You are going to be asked to play some games and do some puzzles; and participate in a presentation. The person who is going to ask you the questions has told you that you can stop if you are feeling tired and need to take a break, and that nobody else will be told your answers to the questions.

Signing this paper means that you want to be in the study. If you don't want to be in the study, you don't have to sign the paper. No one will be angry if you don't sign this paper, and no one will be angry if you change your mind later and want to stop.

You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me on (072 038 0652) or ask me next time.

Signature of Child — Date

Signature of Researcher — Date

Name of Participant (your name)

APPENDIX D

UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone (021) 650 3417
Fax No. (021) 650 4104

09 December 2019

Angela Harwood
Department of Psychology
University of Cape Town
Rondebosch 7701

Dear Angela

I am pleased to inform you that ethical clearance has been given by an Ethics Review Committee of the Faculty of Humanities for your study, *An executive function intervention using GMT in HIV+ Adolescents in South Africa.* The reference number is PSY2019-064.

I wish you all the best for your study.

Yours sincerely

University of Cape Town
PSYCHOLOGY DEPARTMENT
Upper Campus
Rondebosch

Signature Removed

Lauren Wild (PhD)
Associate Professor
Chair: Ethics Review Committee

APPENDIX E

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

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

18 October 2017

HREC REF: 283/2017

Dr Millicent Atujuna
Desmond Tutu, HIV Foundation
IIDMM
Medical School

Dear Dr Atujuna

PROJECT TITLE: RETAINING HIV-POSITIVE YOUTH IN CARE: A MODEL FOR TRANSITIONING ADOLESCENTS RECEIVING ART FROM PAEDIATRIC TO ADULT CARE. (HCT)

Thank you for submitting your response to the Faculty of Health Sciences Human Research Ethics Committee dated 13 October 2017.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 October 2018.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

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

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

Signature Removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

Form FHS007: Amendment – study staff

HREC office use only (FWA00001637; IRB00001938)			
☐ Approved			
This serves as notification that all changes to the study staff and documentation described below are approved.			
Chairperson of the HREC signature	Signature Removed	Date	1/6/22

Principal Investigator to complete the following:

1. Protocol Information

Date (when submitting this form)	18 March 2020
HREC REF Number	283/2017
Protocol title	Retaining HIV-positive youth in care: A model for transitioning adolescents receiving ART from pediatric to adult care (HCT)
Protocol number (if applicable)	
Principal Investigator	Dr Millicent Atujuna
Department / Office Internal Mail Address	Level 1, Wernher Beit North Building, Desmond Tutu HIV Foundation, Faculty of Health Sciences, University of Cape Town
1.1 Does this protocol receive US Federal funding?	☐ Yes	x No

2.1 Staff changes (tick ✓)

Are new personnel being added to this research?	x Yes	☐ No
Are current personnel being removed from this research?	☐ Yes	x No
Is the principal investigator for this research being changed? If yes, please attach revised conflict of interest and PI declaration statements. (Refer: sections 7 and 8.3 in the New Protocol Application Form - FHS013)	☐ Yes	x No
Do the consent and assent forms need modification to reflect these staff changes? If yes, please attach copies of the revised forms, with all changes highlighted or tracked and listed in the documents for approval.	☐ Yes	x No

HUMAN RESEARCH ETHICS COMMITTEE
17 APR 2020
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

2.2 Amended study staff details

Title, first name, surname	Department/Division	E-mail	Role of new staff member
Miss Angela Harwood	Psychology	hrwang002@myuct.ac.za	MA student assisting with a component of the study (previously approved as part of the overall study)

3. List of documentation for approval

Please list below all staff documentation such as CVs, declarations, GCP certificates and revised consent forms which need approval. This information must correspond to all 'yes' answers in 2.1 above. This form will be signed and returned to the PI as notification of approval. Please add extra pages if necessary.

Miss Harwood's CV is attached. There are no other documents requiring approval.

4. Signature

My signature certifies that I will maintain the anonymity and/ or confidentiality of information collected in this research. If at any time I want to share or re-use the information for purposes other than those disclosed in the original approval, I will seek further approval from the HREC.

Signature of PI	Signature Removed	Date	27 March 2020

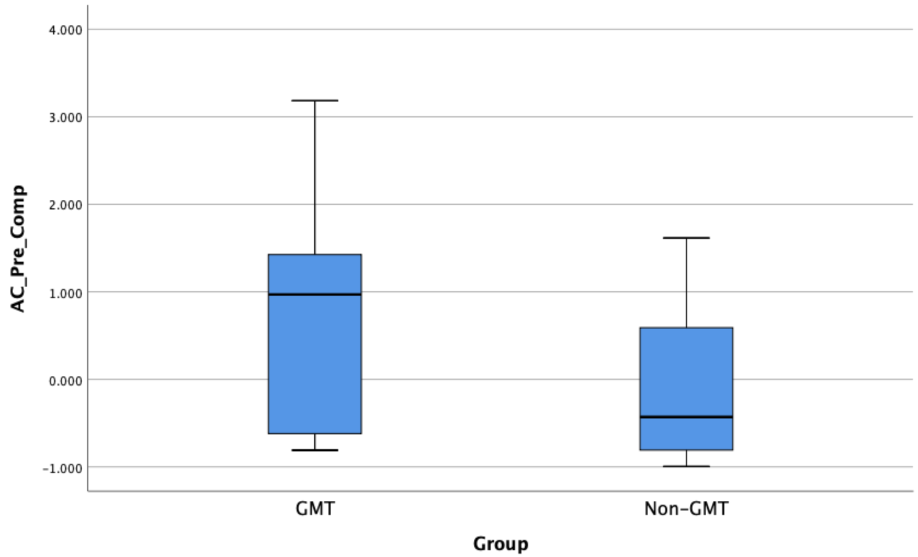
APPENDIX F

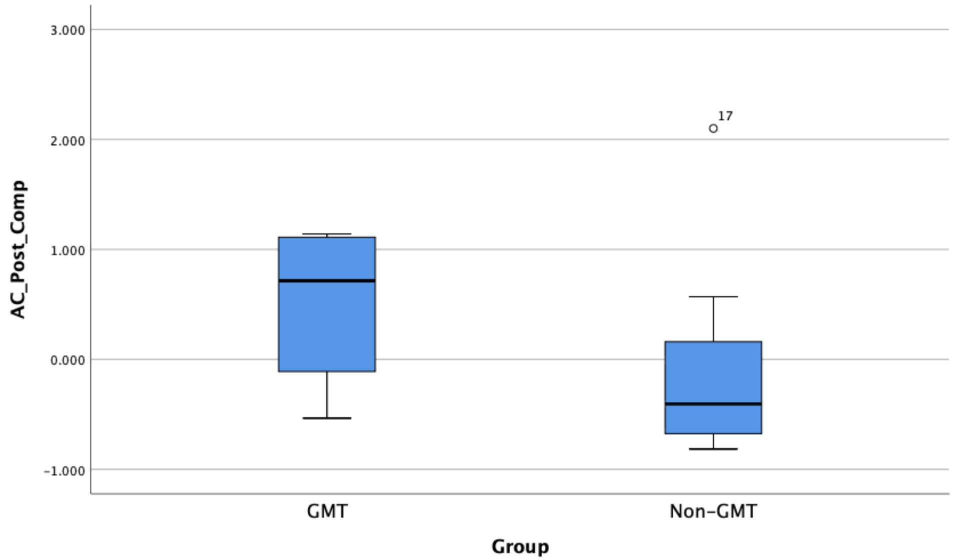
Table 6

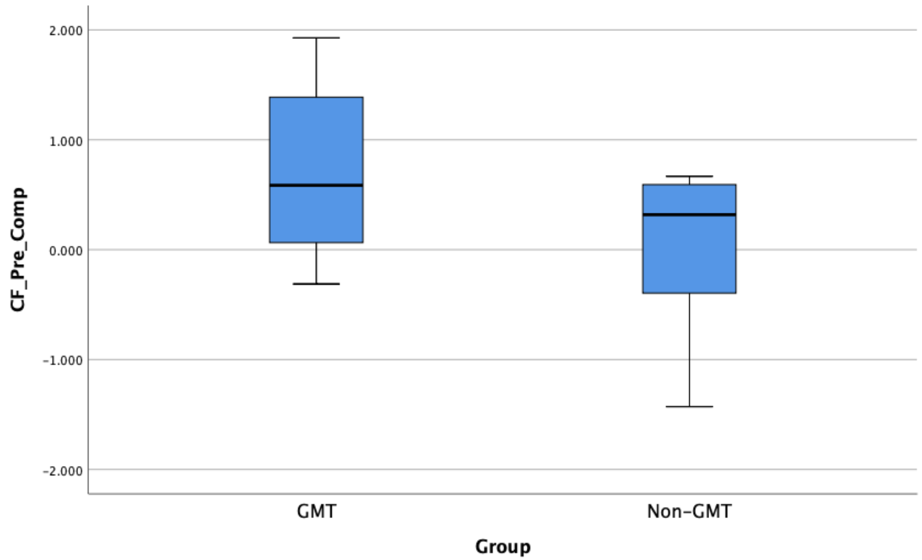
Descriptive Statistics for Composite sub-tests (N = 18)

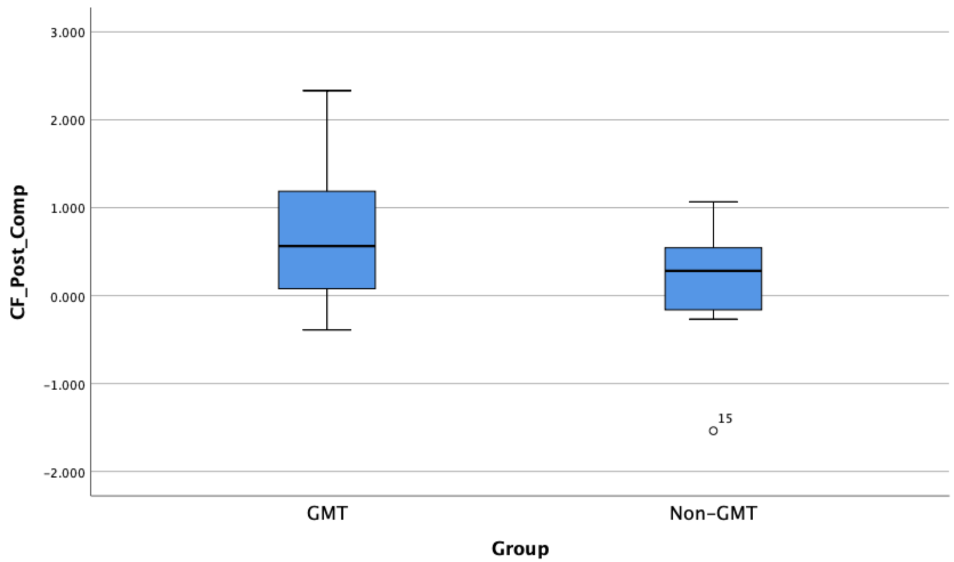
	GMT Group						Non-GMT Group					
	Pre-Test			Post-Test			Pre-Test			Post-Test		
Variable (z scores)	*n*	*M (SD)*	*Range*	*n*	*M (SD)*	*Range*	*n*	*M (SD)*	*Range*	*n*	*M (SD)*	*Range*
Attentional Control	10	0.73 (1.35)	3.10	10	0.52 (0.60)	1.68	8	-0.08 (0.98)	2.61	8	-0.07 (0.98)	2.92
Inhibition Combined	10	0.73 (1.66)	4.56	10	0.63 (0.59)	1.99	8	-0.17 (1.04	2.65	8	-0.14 (1.00)	3.11
Inhibition Total Errors	10	0.73 (1.23)	3.43	10	0.41 (0.69)	1.59	8	<0.01 (1.0)	2.57	8	<-0.01 (1.0)	2.72
Cognitive Flexibility	10	0.71 (0.77)	2.24	10	0.69 (0.86)	2.72	7	-0.01 (0.78)	2.10	7	0.08 (0.84)	2.60
Numbers Backwards	10	0.75 (1.25)	4.40	10	0.71 (1.15)	3.20	8	<0.01 (1.00)	3.20	8	<0.01 (1.00)	2.40
Switching Combined	10	-0.03 (1.13)	3.42	10	0.22 (0.67	1.80	7	<-0.01 (1.00)	2.28	8	<0.01 (1.00)	3.10
Verbal Fluency: Cond. 3	10	1.28 (1.28)	3.12	10	1.24 (1.29)	4.33	8	<0.01 (1.00)	2.74	8	<-0.01 (1.00)	3.61
Verbal Fluency: Switch	10	1.22 (1.03)	2.84	10	0.83 (1.57)	5.76	8	<-0.01 (1.00)	2.84	8	<0.01 (1.00)	3.08
Children's Colour Trail 2	10	0.32 (0.28)	0.85	10	0.45 (0.25)	0.74	8	<0.01 (1.00)	3.04	8	<0.01 (1.00)	3.01
Goal Setting	10	0.27 (0.37)	1.12	10	0.65 (0.61)	1.72	8	<-0.01 (0.43)	1.32	8	<0.01 (0.48)	1.42
Similarities	10	0.59 (1.22)	3.19	10	1.63 (1.43)	4.56	8	<-0.01 (1.00)	2.83	8	<0.01 (1.00)	2.85
Matrix Reasoning	10	-0.28 (0.71)	1.89	10	0.58 (1.21)	2.88	8	<-0.01 (1.00)	2.70	8	<0.01 (1.00)	2.88
Tower: Achievement	10	0.07 (0.68)	2.16	10	0.65 (0.69)	2.40	8	<0.01 (1.00)	3.24	8	<-0.01 (1.00)	3.00
Tower: Time Move Ratio	10	0.74 (1.66)	5.83	10	0.05 (1.01)	2.75	8	<-0.01 (1.00)	3.10	8	<-0.01 (1.00)	3.43
Tower: RVPIR	10	-0.05 (0.76)	2.26	10	0.41 (0.10	0.32	8	<-0.01 (1.00)	2.82	8	<0.01 (1.00)	2.85
Tower: Move Accuracy	10	0.53 (0.95)	3.14	10	0.60 (0.90)	3.06	8	<0.01 (1.00)	3.14	8	<0.01 (1.00)	2.68
Information Processing	10	0.49 (0.83)	2.55	10	0.28 (0.77)	2.08	7	0.06 (0.82)	2.52	8	0.07 (0.81)	2.28
Coding	10	0.54 (0.93)	2.93	10	0.19 (0.96)	3.44	8	<0.01 (1.00)	3.34	8	<0.01 (1.00)	3.06
Symbol Search	10	0.28 (0.77)	2.49	10	0.18 (0.58)	2.03	8	<0.01 (1.00)	3.31	8	<-0.01 (1.00)	3.39
Verbal Fluency Cond. 1	10	0.56 (1.43)	4.45	10	-0.08 (0.83)	2.23	8	<0.01 (1.00)	2.66	8	<0.01 (1.00)	2.73
Verbal Fluency Cond. 2	10	0.57 (1.06)	3.16	10	0.85 (1.24)	3.56	7	<0.01 (1.00)	3.16	8	<0.01 (1.00)	2.58

APPENDIX G
Box and Whisker Plots showing outliers

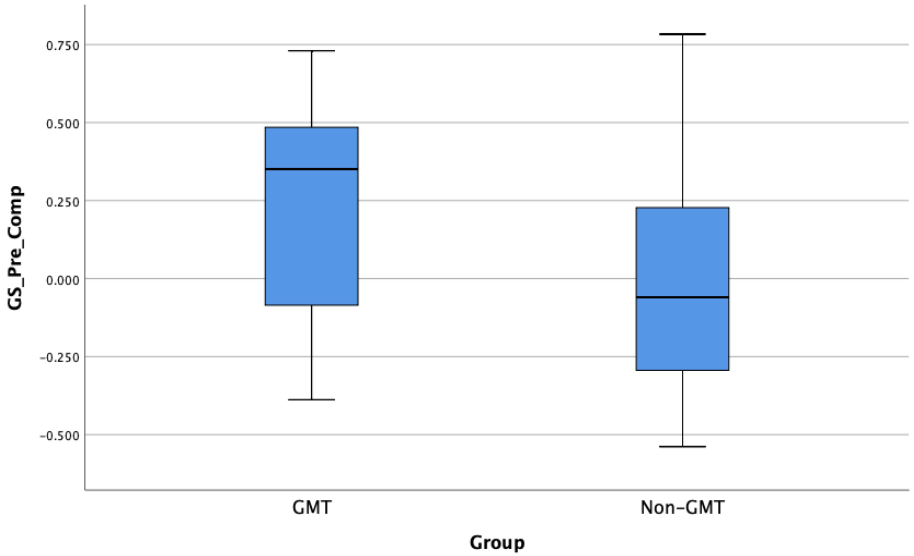


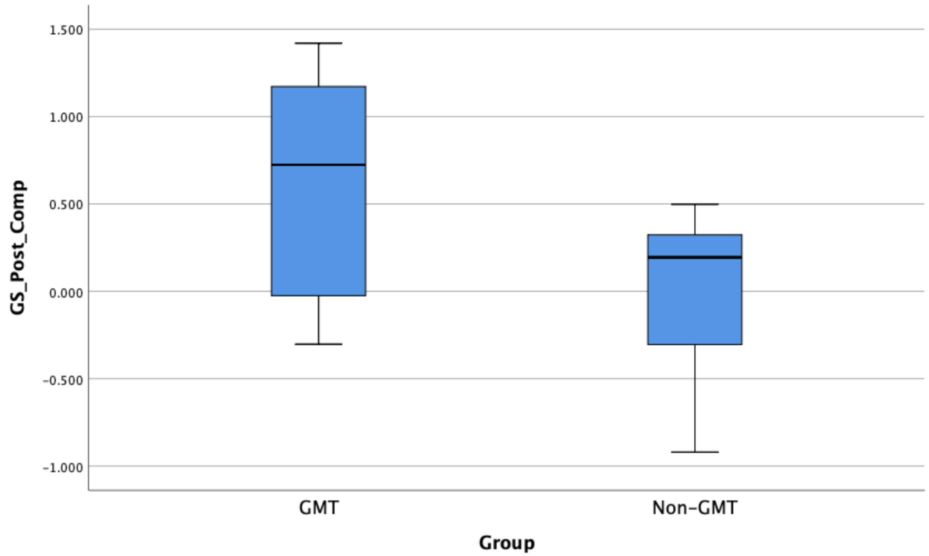


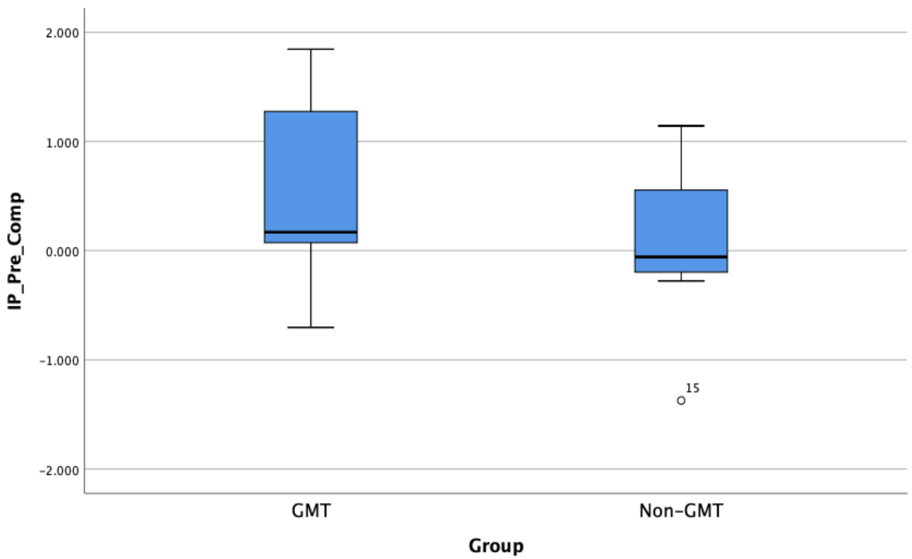


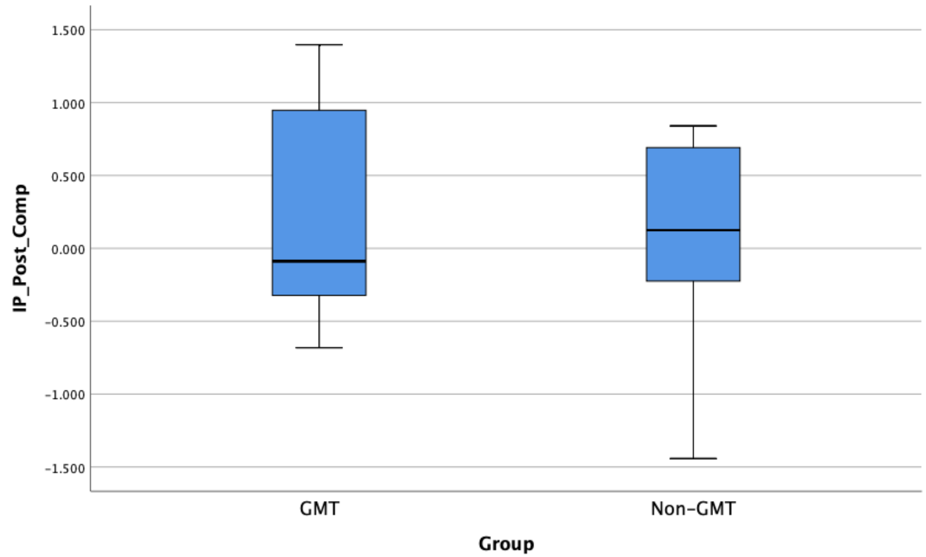


Box and Whisker Plots showing outliers









APPENDIX H

Analysis of Outcome Variables with Outliers Removed

Examination of the Box and Whisker plots (Appendix G) revealed 3 outliers. Two of these were from the same participant and fell minimally within two standard deviations of the mean. The third outlier deviated more than two standard deviations from the mean. All three data points were removed and replaced with the group mean for that variable. The mixed-design ANOVA was re-run on this data.

Attentional control. No significant main effect was observed for time, $F(1, 16) = 1.28$, $p = .274$, $\eta_p^2 = .074$ but there was a significant main effect for group, $F(1, 16) = 4.57$, $p = .048$, $\eta_p^2 = .222$. However, the small effect size suggests a low practical significance (Cohen, 1998). There was also no significant interaction effect for time and group, $F(1, 16) = 0.02$, $p = .904$, , $\eta_p^2 = .001$.

Cognitive flexibility. No significant main effect was observed for time, $F(1, 15) = 0.62$, $p = .443$, $\eta_p^2 = .040$, nor for group, $F(1, 15) = 2.95$, $p = .107$, $\eta_p^2 = .164$. There was also no significant interaction effect for time and group, $F(1, 15) = 0.81$, $p = .383$, $\eta_p^2 = .051$.

Goal setting. No significant main effect was observed for time, $F(1, 16) = 2.87$, $p = .110$, $\eta_p^2 = .152$, but there was a significant main effect for group, $F(1, 16) = 5.31$, $p = .035$, $\eta_p^2 = .249$. However, the small effect size suggests a low practical significance (Cohen, 1998). There was also no significant interaction effect for time and group, $F(1, 16) = 2.82$, $p = .112$, , $\eta_p^2 = .150$.

Information processing. No significant main effect was observed for time, $F(1, 15) = 2.85$, $p = .112$, $\eta_p^2 = .160$, nor for group, $F(1, 15) = 2.45$, $p = .138$, $\eta_p^2 = .140$. There was also no significant interaction effect for time and group, $F(1, 15) = 1.00$, $p = .991$, $\eta_p^2 = .000$.

EF Total. Consistent with the results for the four domains comprising the overall EF composite, there was not a significant main effect observed for time, $F(1, 15) = 2.80$, $p = .604$, $\eta_p^2 = .018$, nor for group, $F(1, 15) = 2.90$, $p = .109$, $\eta_p^2 = .162$. There was also no significant interaction effect for time and group, $F(1, 15) = 0.02$, $p = .889$, $\eta_p^2 = .001$