What predicts response to Mega Team executive function training in ADHD and autistic children?

by

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Abstract

Neurodevelopmental disorders like Attention Deficit/Hyperactivity Disorder (ADHD) and autism are associated with a range of real-world difficulties, some of which stem from executive function (EF) impairments. To date, computerized EF training shows improvement in specific skills trained (near transfer) but limited benefits to real-world outcomes (far-transfer) in ADHD and autism. Given that ADHD and autism are highly heterogeneous disorders, exploration of participant level variation in response is warranted to better understand response to treatment. ADHD (n = 186) and autistic (n = 67) participants aged 6 to 12 years old were randomized to receive Mega Team EF training for five weeks or to the treatment as usual (TAU) control group. Participants completed assessments of EF task performance and caregivers rated their behaviours at three times points: baseline, immediately after 5 weeks post treatment, and at 6 month follow-up. In this study, age, gender, baseline EF abilities, baseline clinical characteristics, and time on task were explored using multiple linear regression models with response inhibition, working memory, EF impairment, ADHD symptoms, planning, and academic fluency as outcomes. Results show that baseline EF abilities and time on task are key moderators of response to training for near transfer outcomes in ADHD participants. No factors explored were associated with far transfer outcomes in the ADHD group or with any outcomes in the autism group. Identification of individual factors associated with treatment response has the potential to address heterogeneity in treatment response for children and youth with EF deficits.

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List of Acronyms

ADHD Attention-Deficit/Hyperactivity Disorder
ADOS-2 Autism Diagnostic Observation Schedule, second edition
BRIEF-2 Behaviour Rating Inventory of Executive Function, second edition
D-KEFS Delis-Kaplan Executive Function System
DMQ Demographic Medical Questionnaire
EF Executive Functions
FSIQ Full-Scale Intelligence Quotient
GEC Global Executive Composite
IQ Intelligence Quotient
OCD Obsessive Compulstive Disorder
ODD Oppositional Defiant Disorder
PICS Parent Interview for Child Symptoms
RCT Randomized Controlled Trial
SCQ Social Communication Questionnaire
SNAP-IV Swanson, Nolan and Pelham Questionnaire, fourth edition
SSRT Stop Signal Reaction Time
TAS Total Achievement Score
TAU Treatment as Usual
WASI-II Wechsler Abbreviated Scale of Intelligence second edition
WJ-III Woodcock Johnson, third edition

Chapter 1

Introduction

1.1 Background

Neurodevelopmental disorders are persistent and impairing lifelong conditions resulting from combined genetic and environmental influences (Faraone et al., 2021). Attention-Deficit/Hyperactivity Disorder (ADHD) is a highly heritable (Pettersson et al., 2019) neurodevelopmental disorder diagnosed in approximately 8% of children and youth worldwide (Ayano et al., 2023) and is characterized by persistent inattention and/or hyperactivity symptoms causing impairment in multiple settings (American Psychiatric Association, 2022). Likewise, autism is a highly heritable neurodevelopmental disorder diagnosed in 1% of children worldwide (Zeidan et al., 2022) identified by atypical social communication, sensory differences, and stereotyped patterns of interests and behaviours (American Psychiatric Association, 2022). Though distinct, these two disorders are highly co–occurring at roughly 40% with overlapping features and impairment (Rong et al., 2021). Both ADHD and autism are associated with a range of challenges including difficulties with academic achievement, peer relationships, and behaviour regulation (French et al., 2024; Posar & Visconti, 2019). Interventions for ADHD include use of stimulant or non-stimulant medications, behavioural parent training, and environmental accommodations (Faraone et al., 2021). Although each of these may result in improvements at the group level, benefits are generally time limited and impairment remains in many individuals (Faraone et al., 2021). For autism, similar interventions are used (e.g. medications, behavioural therapies, and skills training) but there is no standard treatment approach due to the heterogeneity of presentations and variation in treatment goals (Lord et al., 2020).

In response to the demand for novel intervention for neurodevelopmental disorders, there has been an interest in executive function (EF) training-based interventions. Many of the real-world challenges associated with ADHD and autism rely on EF skills (Barkley, 1997; Diamond, 2013; Yang et al., 2022) which are cognitive processes that are essential for managing behaviours to achieve goals and are often impaired in these neurodevelopmental disorders (Sadozai et al., 2024; Townes et al., 2023). Response inhibition, working memory, and shifting are three core interrelated but distinct EF skills (Friedman & Miyake, 2017) which are impaired in ADHD and autistic individuals (Townes et al., 2023). Computerized EF training interventions aim to train specific EFs (e.g., working memory)

using repetition and adaptive increases in difficulty to strengthen the underlying neural networks by leveraging brain plasticity (Cortese et al., 2015). In general, EF training programs are designed to improve the specific EF(s) being trained (e.g., training in response inhibition leading to improvement on response inhibition tasks) - referred to as near transfer of training, and ultimately onto untrained downstream skills (e.g., training in response inhibition leading to decreased ADHD symptoms) - referred to as far transfer of training (Cortese et al., 2015). Far transfer targets range from lab-based measures not directly trained (e.g. planning, academic fluency) to parent ratings of manifestations of real-life behaviour (e.g. daily EF related impairment). Existing evidence suggests that the use of EF training programs has resulted in near transfer of skill development, whereas their use is less consistently associated with far transfer (see reviews by Cortese et al., 2015; Westwood et al., 2023).

Computerized EF training has been studied for more than two decades. Over this time, interest in computerized EF training has exploded with more than 15 unique EF training programs for children and more than 36 randomized controlled trials (RCTs) evaluating these programs in ADHD participants and four in autistic participants (see reviews by Pasqualotto et al., 2021; Robledo-Castro et al., 2023; Westwood et al., 2023). Despite limited evidence for overall efficacy of existing computerized EF training programs, several EF training games are used commercially. For example, CogMed Working Memory Training is a popular EF training program which specifically targets working memory skills (Klingberg et al., 2002). This program, however, has been criticized for its lack of far transfer beyond the specific skills trained, the high amount of training time required (45 minutes per day), and cost ($1500 per child) (Roberts et al., 2016). More recently, EndeavorRx is the first Food and Drug Administration approved video game-based EF training program for ADHD but the near-transfer of effects from the original study evaluating this program (Kollins et al., 2020) have yet to be replicated.

A recent review by Robledo-Castro et al. (2023) that looked at the components of EF training programs suggests that features such as dosage of the interventions, degree of adaptiveness of training, types of devices used, and EFs being trained vary widely across existing programs. Adaptive training (decreasing or increasing difficulty based on performance) is commonly used in EF training programs and is suggested to be an essential component of effective EF training (Cortese et al., 2015). Broadly, the most frequently trained EF in these programs is working memory, while other EFs including attention, response inhibition, or multiple EFs at once have also been the focus (Pasqualotto et al., 2021; Robledo-Castro et al., 2023; Westwood et al., 2023). There is some evidence suggesting that multi-EF training may be superior to single-EF training (Alabdulakareem & Jamjoom, 2020; Cortese et al., 2015), whereas a more recent review did not see a greater benefit to multi-EF training than single-EF training (Westwood et al., 2023). Optimization of EF training program features is an area of ongoing work to understand the intervention elements associated with treatment effects.

Some research has investigated participant-level variability in evaluations of EF training programs. For example, ADHD and autism are each heterogeneous disorders with broad clinical presentations (Luo et al., 2019; Masi et al., 2017) which may result in variation in response to treatment that is masked by treating each diagnosis homogeneously. In addition to the clinical heterogeneity of these disorders, there is individual variation in other pre-treatment features such as the EF skills themselves. For example, executive dysfunction is not a diagnostic criterion in either of these disorders but is a common deficit resulting in a range of impairments, even though EF abilities vary

widely within ADHD (Lambek et al., 2018) and autistic individuals (Hill, 2004). This variability may be associated with a differential response to EF training, potentially explaining the range of group-level results in these disorders. Given the large number of trials for computerized EF training programs with mixed outcomes in ADHD and increasing number in autism, there is a need to better understand the impact of individual pre-treatment characteristics on heterogeneity in EF training intervention results.

1.2 Mega Team

Mega Team is a computerized EF training program co-developed with youth partners. Mega Team is designed to adaptively train working memory and response inhibition using engaging minigames which are played on a laptop and tablet. The Mega Team training algorithm adapts to the individual's performance and increases or decreases in difficulty based on the user's performance in order to remain challenging. In the RCT evaluation of Mega Team were randomized to either receive Mega Team training or waitlisted in a treatment as usual (TAU) control group (Cheung et al., in prep). Mega Team training was administered on average for 25 days over five weeks for 15 minutes per day. At three time points (baseline, immediately post five weeks of treatment, and at follow-up six months after beginning training) participants' EF task performance and academic fluency were assessed and caregivers provided ratings of EF impairment and ADHD or autism traits. Results showed significant overall near transfer of treatment effects with improved EF performance, far transfer of effects with improved ADHD symptoms and caregiver-rated EF impairment, and no treatment effects on planning or academic fluency in the ADHD participants. Most treatment effects were present at five weeks post-treatment and were maintained until six month follow-up, except for working memory which was not significantly improved immediately after treatment but was significantly improved at six month follow-up. There were no overall treatment effects in the autism participant group. The current study seeks to explore the influence of individual and training level factors on the treatment-effects of Mega Team EF training within this initial RCT evaluation of the program.

1.3 Factors Influencing EF Training Outcomes

1.3.1 Demographic Characteristics

EF skills develop and strengthen through childhood and adolescence with more rapid development at earlier ages (Best & Miller, 2010), suggesting that younger children may respond better to EF-focused interventions compared to older children. A meta-analysis of computerized EF training identified that most studies to date have been on children and effect sizes amongst these studies have not been related to the participants' age (Westwood et al., 2023). However, another meta-analysis looking across game-based and traditional computerized EF training interventions found that younger children benefited more from computer-based EF training than older children (Cao et al., 2020). The Westwood et al. (2023) meta-analysis focused on ADHD participants of all ages whereas the Cao et al. (2020) review looked at multiple neurodevelopmental diagnoses together in children, which may have contributed to the inconsistencies in findings across these meta-analytic

reviews.

Gender is an understudied participant characteristic in computerized EF training research. Existing work often refers to sex (biological) and gender (social) interchangeably and consists of largely male samples (e.g., Chacko et al., 2014; Dovis et al., 2015; Medina et al., 2021), with roughly double the number of male to female participants as reported by a recent review (Robledo-Castro et al., 2023). Diagnostic rates and presentations vary across sexes in ADHD (e.g., Hasson & Fine, 2012) and autism (Zeidan et al., 2022). For example, in ADHD, "sex differences" may be due to differences in referral and diagnostic rates rather than differential presentation of ADHD, potentially reflecting variation in gender expectations rather than biological sex differences (Assari, 2021). EF performance, however, does not systematically differ by gender (Grissom & Reyes, 2019). Interestingly, analysis of sex-based differences in response to EndeavorRx attention training showed greater improvement in attention scores in female participants compared to male participants and acknowledged the lack of available gender information (Flannery et al., 2024). Given the lack of existing work examining the contribution of gender in treatment effects, more research is needed in this area.

1.3.2 Baseline Clinical Characteristics

Some studies sought to identify baseline (pre-treatment) clinical characteristics of participants who benefit from computerized EF training. For example, previous work has shown that stimulant medication use and EF training together resulted in improvement in working memory more than just medication or training alone (Holmes et al., 2010). Additionally, more recent work has found that children on stimulant medication benefited most from training in their visual spatial working memory and this effect was maintained at six-month follow-up (van der Donk et al., 2020).

With respect to severity of symptoms, one study found that a high ADHD symptom severity subgroup of participants showed a greater response to treatment on attention and working memory compared to lower ADHD symptom severity participants (Davis et al., 2018), however another found no effect of ADHD symptom severity (Jones et al., 2018). In another study, predominantly Inattentive type ADHD participants improved more than Combined type on parent and teacher rated EF impairment (in behavioural regulation) at post-treatment and improved more on word reading accuracy at follow-up (van der Donk et al., 2020). Similarly, there are mixed results on the impact of autism traits on the outcomes of computerized EF training. For example, de Vries et al. (2018) found that less severe autism traits predicted better training outcomes in autistic participants whereas Kirk et al. (2021) did not find evidence of autism traits predicting attention outcomes in participants with intellectual and developmental disorders. Altogether, research findings in this area are mixed and warrant further exploration of the influence of clinical characteristics on EF training outcomes.

1.3.3 Baseline EF Abilities

Existing literature in ADHD participants has shown that baseline working memory predicted and moderated near transfer of working memory skills such that below average and average working memory participants improved on attention and visual spatial working memory tasks whereas performance decreased in above average baseline working memory participants (van der Donk et al.,

2020). A similar pattern was seen in another study with poorer response inhibition predicting greater improvement in response inhibition following treatment (Dovis et al., 2019). These results align with the idea that individuals with weaker EFs at baseline may leave more capacity for improvement when trained compared to those with stronger EF (Diamond & Lee, 2011). However, these results were not corrected for multiple comparisons (van der Donk et al., 2020) or did not remain after correction (Dovis et al., 2019). Conversely, Minder et al. (2019) found that the group with low parent-rated EF impairment at baseline improved more than the high impairment group after EF training on parent-rated EF impairment, which aligns more with the theory of a magnification effect whereby individuals with stronger skills are able to gain more from training (e.g., Von Bastian & Oberauer, 2014). In an autistic sample of children and youth it was found that better baseline EF (flexibility) predicted improvement in a quality of life measure following working memory and shifting training (de Vries et al., 2015).

1.3.4 Engagement with Intervention

Possible dosage effects of computerized EF training have also been examined. For example, Liu et al. (2024) found increasing benefits of computerized EF training for every five additional minutes of training per day up to an optimal dose at 25 minutes per day for 6 days a week in adults. Alloway et al. (2013) showed that a higher dose of working memory training was more beneficial than a lower dose and Jaeggi et al. (2014) identified that greater engagement with intervention was related to greater improvement.

1.4 Aim

Computerized EF training programs have shown consistent growth in development and investigation, with several commercial options currently available. The existing research on efficacy of these programs is variable and largely shows a lack of far transfer to untrained skills. Most videogame-based EF training programs in neurodevelopmental disorders have focused on ADHD, with more recent work exploring applications in autism. However, both disorders are characterized by high heterogeneity in clinical and EF characteristics pointing to potential key factors that may be associated with variability in response to EF training. There has been limited investigation on factors associated with heterogeneity in responses to treatment, which is essential to understand what intervention works best for whom. To address gaps in the research on currently available EF training programs, our team co-created Mega Team with youth co-designers with a focus on accessibility, affordability, and multi-skill training. Overall results of the main RCT show near and far transfer in ADHD participants but not in autistic participants (Cheung et al., in prep). This project will explore a broad range of baseline predictors to better understand patterns in individual factors of response to computerized EF training in a sample of ADHD and/or autism children.

Research Question: Do demographic (age and gender), clinical (use of stimulant medication, ADHD symptoms, autism traits), EF (response inhibition, working memory baseline performance, and EF-related impairment), and training (time on task) factors predict magnitude of response to treatment in near and far transfer (near: response inhibition and working memory; far: ADHD symptoms, daily EF impairment, planning, and fluency) outcome measures immediately after Mega

Team training and at six month follow-up in ADHD children and autistic children?

Chapter 2

Methods

2.1 Participants

Children aged 6-12 years old with a diagnosis of ADHD (n = 186) or autism (n = 67) were randomized in the study (see Table 2.1). Children on medication were included if they were on a stable dose for the preceding month before training and not concurrently participating in a medication trial. Participants had a diagnosis of ADHD or autism with or without co-occurring ADHD. All other comorbidities were included in both participant groups. Overall inclusion criteria were: (a) 6 to 12 years old; (b) Full Scale Intelligence Quotient (FSIQ) > 70 on a standardized norm-referenced IQ measure; (c) reliable access to the internet; (d) either diagnosed with ADHD based on Diagnostic Statistical Manual fifth edition (American Psychiatric Association, 2022) criteria confirmed by responses on the Parent Interview for Child Symptoms (PICS) (Ickowicz et al., 2006) or diagnosed with ASD based on the DSM-5 criteria confirmed by ratings on the Autism Diagnostic Observation Schedule – Second Edition (ADOS-2) (Lord et al., 2012).

2.2 Measures

Demographic Medical Questionnaire (DMQ): On the DMQ caregivers reported on general characteristics of their children, including age, gender, and some medical history and comorbidities. From this measure, **age**, **gender,** and **medication status** were used as predictors in the current study. See Appendix A for complete measure.

Social Communication Questionnaire - Lifetime (SCQ): The SCQ (Rutter et al., 2003) is a brief screener for autism traits consisting of 40 yes/no statements that caregivers reported on regarding the child's entire developmental history. The SCQ can discriminate autism from typical development and has good sensitivity and specificity in school-aged children (Chandler et al., 2007). In this study, the **SCQ Total** score was used.

Wechsler Abbreviated Scale of Intelligence second edition (WASI-II): Two subtests (Vocabulary and Matrix Reasoning) of the WASI-II (Wechsler, 2011) were administered to determine if participants met the inclusion criteria of an estimated minimum 70 Full-Scale Intelligence Quotient

Table 2.1: Demographics

Characteristic	ADHD		Autism	
	Mega Team N = 94	**TAU** N = 92	**Mega Team** N = 33	**TAU** N = 32
Age	9.33 (1.62)	9.27 (1.63)	9.06 (1.85)	8.38 (1.74)
Gender				
Cisgender Boy	72 (77%)	70 (76%)	23 (72%)	25 (78%)
Cisgender Girl	22 (23%)	21 (23%)	9 (28%)	6 (19%)
Gender Diverse	0 (0%)	1 (1.1%)	0 (0%)	1 (3.1%)
Takes Stimulant Medication	56 (60%)	54 (59%)	8 (24%)	7 (22%)
ADHD	94 (100%)	92 (100%)	16 (48%)	17 (53%)
Autism	0 (0%)	1 (1.1%)	33 (100%)	32 (100%)
ODD	13 (14%)	8 (8.7%)	1 (3.0%)	1 (3.1%)
Tics	8 (8.5%)	7 (7.6%)	2 (6.1%)	2 (6.3%)
OCD	1 (1.1%)	2 (2.2%)	0 (0%)	0 (0%)
Anxiety*	10 (11%)	21 (23%)	4 (12%)	1 (3.1%)
Other	18 (19%)	26 (28%)	5 (15%)	4 (13%)
IQ	104 (15)	102 (14)	100 (15)	103 (15)
Baseline ADHD Symptoms	34 (9)	35 (9)	29 (12)	32 (13)
Baseline Autism Traits	5.9 (4.7)	6.5 (5.8)	16.4 (5.1)	16.8 (7.5)

Note: M (SD); n (%); TAU: Treatment as Usual; ODD: Oppositional Defiant Disorder; OCD: Obsessive Compulstive Disorder; IQ: Intelligence Quotient. ADHD symptoms: SNAP Total score; Autism Traits: SCQ Total score. *p < 0.05 comparing Mega Team versus TAU within the diagnosis group.

(FSIQ). This measure was only administered if there was no recently administered measure (within the last two years) providing an FSIQ or equivalent metric available for the participant. WASI-II is considered a reliable and valid estimate of cognitive ability that converges with scores provided by other more comprehensive measures (e.g., Wechsler Intelligence Scale for Children, fourth edition) (Irby & Floyd, 2013).

Parent Interview for Child Symptoms (PICS): The PICS is a semi structured interview (Ickowicz et al., 2006) which was used to confirm the pre-existing ADHD diagnosis in all ADHD participants based on DSM-5 criteria within prior six months. The interview was administered by a clinician or clinician-trained research staff. The PICS has good reliability and validity (Ickowicz et al., 2006).

Autism Diagnostic Observation Schedule - Second Edition (ADOS-2): The ADOS-2 (Lord et al., 2012) is a semi-structured observational assessment. It was administered by an ADOS-trained clinician to confirm the autism diagnosis in participants who did not have a previous ADOS-2 assessment completed. A systematic review and meta-analysis of the clinical utility of the ADOS-2 showed high specificity and sensitivity in research and clinical settings for ASD evaluation (Lebersfeld et al., 2021).

Stop Signal Task: The Stop Signal Task measures response inhibition (Logan et al., 1997). This computerized task is composed of one practice block and four assessment blocks which contain 24 trials each. Participants were instructed to make a speeded response to either the X or O stimulus

on the screen and withhold their response if the stimulus was preceded by a beep. The Stop Signal Task is made up of go trials and stop trials. Go trials are trials when the participant is expected to make a speeded response. Stop trials are trials when a stop signal (e.g. auditory tone) is presented, and participants are expected to withhold their speeded response. The percentage of stop trials a participant successfully inhibits their response on is referred to as the percent stop inhibition (PSI) and is used in determining validity of administration. **Stop signal reaction time (SSRT)** was calculated as an estimate of the participants' response inhibition in milliseconds – a faster SSRT indicates better response inhibition. This task was administered at all three assessment visits.

N-back Task: The N-back Task measures working memory (Owen et al., 2005). The computerized version of this task used for the current study was a verbal stimulus identification N-back task using letters and 3 levels (0-back, 1-back, and 2-back) were administered. Each level of the task is composed of one practice block and three assessment blocks which contain 40 trials each. Each block is made up of target trials and non-target trials. Target trials are ones in which the stimulus on the screen corresponds with the stimulus seen N trials previously. Non-target trials are ones in which the stimulus on the screen does not match the one seen N trials previously. In a given trial, participants use a key press to indicate if the current stimulus on the screen matched the one presented N trials before (e.g., one trial ago for 1-back). The 0-back task does not measure working memory and participants are required to press one key when a specific stimulus appears on screen and another key for all other stimuli, this task functions as comparison for the more demanding 1-back and 2-back tasks. **Target accuracy** was used as the outcome measure for each level of the N-back to reflect the percentage of target trials correctly responded to. The N-back tasks were administered at all three assessment visits.

Behaviour Rating Inventory of Executive Function, second edition (BRIEF-2): The BRIEF-2 (Gioia et al., 2000) measures daily impairments associated with EF deficits. Caregivers rated their child's behaviour on a 3-point Likert scale from "never" to "often" on 63 statements describing day-to-day use of EF skills. Within the BRIEF, the **Global Executive Composite (GEC)** is the total score computed and was used as a measure of daily EF impairment for the current study. The BRIEF-2 has been used in clinical and research settings and is able to differentiate between typically developing and clinical populations. Additionally, it shows strong internal consistency and moderate to strong internal validity and concurrent validity (Hendrickson & McCrimmon, 2019). In this study, the BRIEF-2 was administered at all three study timepoints (baseline, 5 weeks post-treatment, and 6 month follow-up).

Swanson, Nolan and Pelham Questionnaire, fourth edition (SNAP-IV): The SNAP-IV; (Swanson et al., 1981) measures ADHD symptoms. Caregivers rated their child's behaviours on a 4-point Likert scale from "not at all" to "very much" on 26 statements describing inattention (9 items), hyperactivity/impulsivity (9 items), and oppositional (8 items) behaviours. The **SNAP total sum** reflects the number and severity of symptoms, with higher scores reflecting greater ADHD symptoms. The SNAP-IV shows acceptable internal consistency and demonstrates parent scores predictive of an ADHD diagnosis for scores above 1.8 on inattention and above 2.4 for hyperactivity/impulsivity (Bussing et al., 2008). The SNAP-IV was administered at baseline, 5 weeks post treatment, and at 6 month follow-up.

Delis-Kaplan Executive Function System (D-KEFS) Tower Test: The D-KEFS Tower Task measures planning/organizing ability (Delis et al., 2001). Participants complete up to nine items of increasing difficulty in which they use three to five disks to recreate an image while following specific rules (e.g. without placing a larger disk on a smaller disk, without moving multiple pieces at once). The raw **total achievement score (TAS)** reflects the speed, efficiency, and accuracy of completion and was used as a measure of planning ability for the current study. This task has moderate to high internal consistency and test-retest reliability is moderate for children and youth (Delis et al., 2001). The tower task was administered at all three study visits.

Woodcock-Johnson III - Fluency Tasks: The Woodcock-Johnson III Reading Fluency, Math Fluency, and Writing Fluency tasks assess unique aspects of academic fluency (McGrew et al., 2007). In the reading fluency task participants quickly read true or false sentences (aloud or silently) for three minutes and receive a point for each correctly read sentence. In the math fluency task participants quickly solve addition, subtraction, and multiplication problems for three minutes and receive a point for each correctly completed problem. In the writing fluency task participants quickly wrote sentences using three target words and received a point for each correctly written complete sentence. A **fluency composite score** was created by combining the standard scores of the three fluency tasks as a measure of overall academic fluency for the current study. The fluency tasks show good to excellent test-retest reliability (McGrew et al., 2007) and load into a unique fluency factor in factor analysis (Dombrowski, 2015).

Time on Task: Time on task was logged automatically through Mega Team gameplay. When this was unavailable due to technological issues, caregiver report of time on task was collected. Total time on task in minutes was used for the current study.

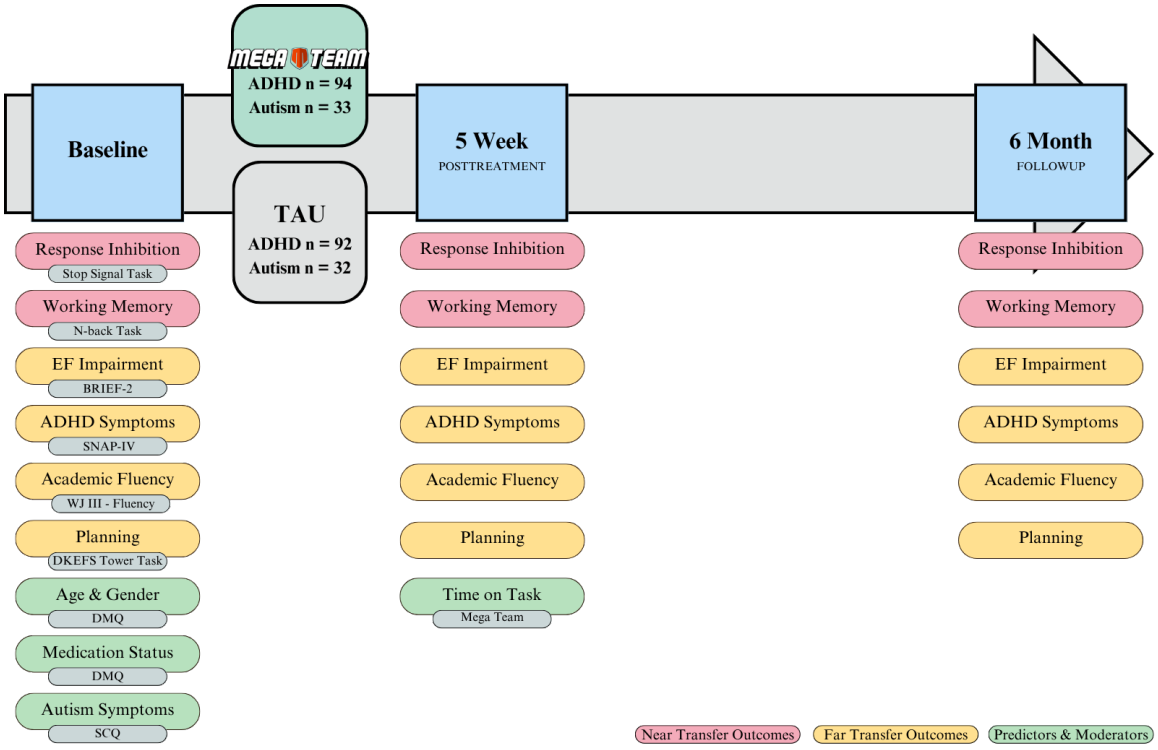
2.3 Procedure

The current analysis was part of an RCT examining the efficacy of Mega Team training in ADHD children and youth and in ASD children and youth. For a comprehensive description of the procedure and measures, please see the main efficacy paper (Cheung et al., in prep). Participants were recruited from a community sample via flyers distributed in online parent groups and advocacy organizations (e.g. CHILD-BRIGHT Network). Informed consent was obtained from the caregivers, and assent was obtained from the children at the beginning of the study. Ethics approval was obtained through the SickKids Research Ethics Board. The trial was registered at ClinicalTrials.gov, trial number NCT03502239.

Each study visit was preceded by a 24-hour stimulant medication washout period for participants using stimulant medication (roughly 60% of the ADHD group and 25% of autism group). Demographic information and ratings on the autism screener were collected only during the baseline visit. At all three assessment visits participants completed measures of response inhibition, working memory, planning, and academic fluency and caregivers reported on ADHD symptoms and impairment associated with EF (see Figure 2.1). Participants were randomized into either the treatment group (to play Mega Team for 15 min per day, 5 days per week, for 5 weeks) or the Treatment-As-Usual (TAU) control group (did not play Mega Team). Diagnosis and stimulant medication status were included in the randomization. Participants in the treatment group were trained in how to play the

game at the end of the baseline visit, and training was completed at home for five subsequent weeks. Each week, a call was conducted with all participants to collect qualitative information about game play and to provide technical support when needed. The treatment group was asked about Mega Team, and the TAU control group was asked about their typical game play during these calls. After five weeks all participants returned for the post-treatment assessment visit (also known as the 5 week visit) where the treatment group was instructed to discontinue playing. All participants returned for their follow-up assessment visit six months after their baseline visit. At the end of this visit the Mega Team game and training schedule was provided to all participants to use if/as they wished. All cognitive and academic measures were administered by a member of the research team who was blinded to the participant's randomization.

Figure 2.1: Schedule of Measures



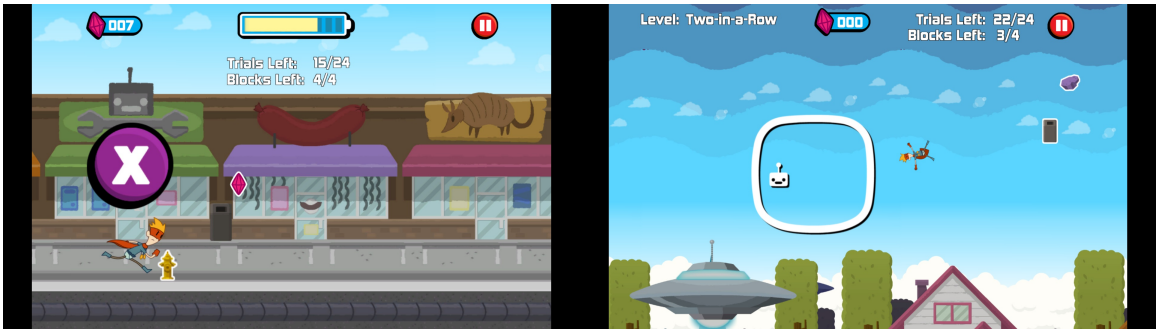
2.4 Intervention

The Mega Team intervention trains response inhibition and working memory. There are four minigames in Mega Team. Two minigames are played on a laptop and two are played on a tablet. On each device, one game trains response inhibition and the other trains working memory. Ideally the games are collectively played for a total of 15 minutes per day, five days per week, for five weeks, alternating between laptop and tablet minigames with equal time spent on each minigame. The minigames are adaptive so that the difficulty level is adjusted automatically and dynamically to match the participant's ability while they play to remain appropriately challenging. In the laptop minigames participants play as various superhero characters dodging obstacles and collecting gems to save other members of their superhero team (see Figure 2.2). In the tablet minigames partici-

pants play the role of a ninja battling different types of robots to beat each level. In the response inhibition minigames participants are asked to intermittently withhold their speeded response when a stop signal is randomly presented and in the working memory minigames participants progress in the game by indicating whether the picture on the screen matches one presented previously. There is one minigame for each skill on the laptop and on the tablet. Participants in the treatment group are instructed to play all four minigames equally during the training period. After the baseline assessment tasks were completed, participants who were randomized to the treatment group were trained on how to play the games. Parents were additionally provided with picture-based instructions for reference and contact information of an unblinded research assistant who could assist them with game-related questions. Participants were incentivized to play daily using a training tracker on which they used stickers to mark the days they played to earn a gift card at their post-treatment visit.

Figure 2.2: Mega Team games

(a) Response inhibition training task (b) Working memory training task



2.5 Analysis

Data were screened for validity to check that certain thresholds were met to indicate the task was completed accurately with a minimum proportion of responses. An invalid Stop Signal Task administration contained any of the following: fewer than 36 go trials, fewer than 12 stop trials, PSI less than 0.15 or greater than 0.85, greater than nine non-responses, greater than two pre-pushes on stop trials, SSRT less than 50 milliseconds (see supplemental materials in Schachar et al., 2023). An invalid N-back task contained any of the following: target accuracy greater than non-target accuracy plus twenty-eight, or fewer than five target trials (e.g. Plas et al., 2016). Invalid administration of tasks were excluded. Rates of invalid administrations collapsed across all time points were not significantly different between the treatment and TAU groups. Where multiple valid administrations were collected at one study visit (due to technological issues), the first administration was used to minimize the impact of fatigue on outcomes. Raw scores for measures were used where possible as the current study examined intra-individual change, and normed scores would limit the ability to detect smaller changes.

Analyses were conducted in R [R version 4.4.1; R Core Team (2024)] on a machine using a Windows 11 64-bit operating system. Analyses were run separately on the ADHD and autism diagnosis groups and used an intention to treat principle. To examine the individual factors that predict

Table 2.2: ADHD Outcome Measures

Characteristic	Baseline		5 Week Visit		6 Month Visit	
	Mega Team N = 94	**TAU** N = 92	**Mega Team** N = 91	**TAU** N = 84	**Mega Team** N = 85	**TAU** N = 84
SSRT	375 (153)	360 (137)	306 (100)	352 (188)	294 (79)	317 (157)
1-back Target Accuracy	64 (20)	60 (20)	60 (24)	62 (21)	69 (21)	66 (21)
2-back Target Accuracy	43 (20)	39 (16)	37 (21)	40 (22)	47 (22)	47 (21)
BRIEF2-GEC	135 (19)	139 (18)	129 (19)	137 (17)	128 (21)	138 (18)
SNAP Total	34 (9)	35 (9)	29 (10)	32 (9)	29 (10)	34 (10)
Fluency Composite	85 (14)	84 (14)	86 (15)	86 (16)	87 (15)	86 (14)
Total Achievement Score	13.8 (3.6)	13.5 (3.6)	16.5 (3.2)	16.2 (3.6)	17.11 (2.95)	17.46 (3.07)

Note: M (SD); TAU: Treatment as Usual; SSRT: Stop Signal Reaction Time, BRIEF2-GEC: BRIEF2 Global Executive Composite

outcomes after Mega Team training, multiple linear regression analyses were used. The fixed factor was treatment group (either Mega Team or TAU). The outcomes were change scores after 5 weeks and after 6 months on Stop Signal Task SSRT, 1-back target accuracy, 2-back target accuracy, BRIEF-2 GEC, SNAP total sum, Tower Task total achievement score, and an academic fluency composite created from the Woodcock Johnson's reading, math, and writing fluency standard scores. Means and standard deviations of outcomes are presented in Table 2.2 for the ADHD group and Table 2.3 for the autistic group. For the ADHD group, the predictors and moderators tested were age, gender, stimulant medication use, baseline ADHD symptoms, baseline autism traits, baseline response inhibition, baseline working memory, baseline daily EF impairment, and time on task over the course of treatment. In the autism group predictors and moderators tested were baseline ADHD symptoms, baseline autism traits, baseline response inhibition, baseline working memory, and time on task over the course of treatment. The models included interactions by randomization group on the predictors which allowed confirmation that the results specifically reflect significance in response to treatment (Mattes & Roheger, 2020). The default lm function listwise deletion was applied to missing data for complete case analysis which is the most common approach (Bell et al., 2014). All predictors were entered into each linear regression model together for a given outcome to determine significance in the overall model and examine the significance of individual predictors.

Predictor variables were checked for multicollinearity prior to inclusion in the regression models. All baseline variable pairs returned $R2 < 0.8$ resulting in a variance inflation factor of less than 5 (Kim et al., 2019) confirming no impact of multicollinearity on results. Regression model diagnostics showed all assumptions necessary for linear regression models were met. Diagnostic plots showed linearity of data, normality of residuals, homogeneity of residual variance, and independence of residual error terms in all models.

Significant predictors that displayed a pattern of results that could not be distinguished from a potential regression to the mean were not interpreted as meaningful significant predictors. Given the multiple comparisons, Bonferroni correction was applied to adjust significance threshold to reduce potential for false positives (i.e., Type I error). The corrected significance value for the 14 models for the ADHD group was $p < 0.0035$ (0.05/14) and the 6 for the autism group was 0.008 (0.05/6).

Table 2.3: Autism Outcome Measures

Characteristic	Baseline		5 Week Visit		6 Month Visit	
	Mega Team N = 33	**TAU** N = 32	**Mega Team** N = 29	**TAU** N = 28	**Mega Team** N = 26	**TAU** N = 30
SSRT	322 (171)	436 (228)	310 (112)	392 (203)	276 (84)	289 (117)
1-back Target Accuracy	61 (22)	56 (20)	61 (24)	56 (20)	67 (22)	62 (22)
BRIEF2-GEC	129 (26)	141 (22)	124 (24)	135 (26)	129 (25)	138 (18)

Note: M (SD); TAU: Treatment as Usual; SSRT: Stop Signal Reaction Time

Chapter 3

Results

3.1 ADHD Group

3.1.1 Baseline Factors Related to Change in Response Inhibition

A multiple linear regression model for change in response inhibition after 5 weeks of intervention with all the predictors (age, gender, baseline response inhibition, working memory, EF impairment, ADHD symptoms, autism traits, stimulant medication use, and time on task) entered revealed a significant model fit indicating that the baseline characteristics entered predicted response to treatment, accounting for 45% of the variance ($F = 4.7$, $p < 0.001$, $R^2 = 0.45$). Baseline response inhibition (β = -0.30, $p = 0.02$) and baseline working memory (β = -0.40, $p = 0.0014$) predicted improvement in response inhibition after 5 weeks regardless of treatment group such that lower (i.e., worse) baseline response inhibition and higher (i.e., better) baseline working memory (on the N-Back 1-back condition) predicted greater improvement after 5 weeks. Additionally, the model showed a significant interaction effect of baseline response inhibition by randomization group moderating change in response inhibition at 5 weeks post-treatment (β = -0.65, $p = 0.01$), ruling out the potential for regression to the mean explaining the result.

This result showed that lower (i.e., worse) baseline response inhibition was associated with a larger improvement in the Mega Team treatment group than in the TAU control group in response inhibition after 5 weeks of treatment. No other factors were significant predictors or moderators of change in response inhibition after 5 weeks of treatment (see Table 3.1).

A multiple linear regression model for change in response inhibition at 6 month follow-up with all predictors entered showed a significant model fit indicating that the baseline characteristics entered predicted response to treatment, accounting for 55% of the variance ($F = 6.7$, $p < 0.001$, $R^2 = 0.55$). Gender predicted improvement in response inhibition regardless of treatment group such that girls improved more after 6 months compared to boys ($\beta = 0.20$, $p = 0.01$). Baseline response inhibition (β = -0.60, $p < 0.001$) and baseline working memory (N-back 1-back condition only) (β = -0.40, $p = 0.0011$) predicted improvement in response inhibition at 6 month follow-up regardless of treatment group, such that lower (i.e., worse) baseline response inhibition and higher (i.e., better) baseline

working memory (1-back) predicted greater improvement at 6 month follow-up. Additionally, there was a significant interaction effect of baseline working memory (1-back) by randomization group moderating change in response inhibition ($\beta = 0.91$, p = 0.013), such that in the TAU control group greater (i.e., better) baseline working memory was associated with more improvement in response inhibition compared to those in the Mega Team treatment group. No other baseline factors were significant predictors or moderators of change in response inhibition at 6 month follow-up.

3.1.2 Baseline Factors in Change in Working Memory

A multiple linear regression model for change in working memory (1-back condition of the N-back) after treatment with all baseline predictors entered revealed a significant model fit indicating baseline characteristics entered predicted change in working memory accounting for 32% of the variance (F = 2.9, $p < 0.001$, $R^2 = 0.32$). Lower (i.e., weaker) baseline working memory (1-back) predicted greater improvement in working memory (1-back) after 5 weeks regardless of treatment group (β = -0.60, $p < 0.001$). Additionally, time on task was a significant predictor of change in working memory after 5 weeks of treatment ($\beta = 0.46$, p = 0.037), such that greater time on task during treatment was associated with greater improvement in working memory after 5 weeks of treatment. No other individual baseline factors were significant predictors or moderators of change in working memory after 5 weeks of treatment.

The overall multiple linear regression model for change in 1-back working memory at 6 month follow-up with all baseline predictors entered significantly predicted change in working memory accounting for 25% of the variance (F = 2, p = 0.014, $R^2 = 0.25$); however this finding did not maintain significance after Bonferroni correction ($p < 0.0035$).

The overall multiple linear regression model for change in 2-back working memory after 5 weeks of treatment with all baseline predictors entered revealed a significant model fit which predicted 35% of the variance (F = 3.2,$p < 0.001$, $R^2 = 0.35$). Lower (i.e., weaker) baseline 2-back working memory predicted more improvement on 2-back regardless of treatment group at 5 weeks post-treatment (β = -0.40, p = 0.003). No other variables predicted improvement, and none were significant moderators of change in working memory (2-back task) at post-treatment.

At 6 month follow-up the multiple linear regression model for change in 2-back working memory revealed a significant model fit such that it predicted 38% of the variance (F = 3.5, $p < 0.001$, R^2 = 0.38). Similar to post-treatment, lower (i.e., weaker) baseline 2-back working memory predicted more improvement at 6 month follow-up regardless of treatment group (β = -0.60, $p < 0.001$). Additionally, there was a significant interaction effect of baseline 1-back working memory by randomization group which moderated change in 2-back working memory at 6 month follow-up ($\beta = 1.3$, p = 0.0024), such that higher (i.e., better) baseline 1-back accuracy was associated with more improvement in the treatment group but not in the TAU group. No other factors were significant predictors or moderators of 2-back working memory change at 6 month follow-up.

3.1.3 Baseline Factors in Change in ADHD Symptoms

A multiple linear regression model predicting change in ADHD symptoms after 5 weeks of training was significant overall and predicted 30% of the variance (F = 2.7, $p < 0.001$, $R^2 = 0.3$) and after 6

month follow-up predicting 35% of the variance ($F = 3.1$, $p < 0.001$, $R^2 = 0.35$). At both time points, lower baseline ADHD symptoms predicted greater improvement regardless of treatment group: $\beta =$ -0.70, $p < 0.001$, 6 months: $\beta =$ -0.50, $p < 0.001$). Additionally, at both time points lower baseline EF impairment predicted greater improvement in ADHD symptoms regardless of treatment group ($\beta =$ -0.50, $p < 0.001$, 6 months: $\beta =$ -0.40, $p = 0.005$). No variables moderated the relationship by treatment. See Table 3.2 for results.

3.1.4 Non-Significant Results

A multiple linear regression with all predictors entered did not significantly predict change in planning at 5 weeks post-treatment ($F = 0.97$, $p = 0.5$, $R^2 = 0.14$) or at 6 month follow-up ($F = 0.81$, $p = 0.69$, $R^2 = 0.12$) or predict academic fluency at 5 weeks post-treatment ($F = 0.96$, $p = 0.51$, $R^2 = 0.16$) or at 6 month follow-up. See Table 3.3 for results.

A multiple linear regression with all predictors entered did not significantly predict change in EF impairment after 5 weeks of training ($F = 1.1$, $p = 0.33$, $R^2 = 0.15$) or at 6 month follow-up ($F = 1.9$, $p = 0.02$, $R^2 = 0.24$). See Table 3.2 for results.

Table 3.1: Multiple Linear Regression Model Results Predicting Response Inhibition and Working Memory in ADHD group

Predictors	Outcomes											
	Δ SSRT 5 Week F = 4.7* R^2 = 0.45		**Δ SSRT 6 Month** F = 6.7* R^2 = 0.55		**Δ 1-back 5 Week** F = 2.9* R^2 = 0.32		**Δ 1-back 6 Month** F = 2 R^2 = 0.25		**Δ 2-back 5 Week** F = 3.2* R^2 = 0.35		**Δ 2-back 6 Month** F = 3.5* R^2 = 0.38	
	β	p	β	p	β	p	β	p	β	p	β	p
Stimulants	0.14	0.5	-0.18	0.4	0.23	0.3	-0.04	0.9	-0.29	0.2	0.18	0.4
Treatment Group	0.15	0.3	-0.15	0.9	-1.0	0.066	-0.12	0.4	-0.93	0.4	-0.25	0.4
SNAP Total	0.16	0.2	0.19	0.11	-0.03	0.8	0.11	0.5	0.03	0.8	0.10	0.5
SCQ Score	0.13	0.2	0.10	0.3	-0.03	0.8	-0.02	>0.9	-0.12	0.3	-0.21	0.071
SSRT	-0.30	**0.022**	-0.65	**<0.001**	-0.12	0.4	-0.17	0.3	-0.17	0.2	-0.20	0.12
Target Accuracy (1-back)	-0.40	**0.001**	-0.38	**0.001**	-0.56	**<0.001**	-0.59	**<0.001**	0.15	0.2	0.05	0.7
Target Accuracy (2-back)	0.06	0.6	-0.02	0.9	0.15	0.3	0.02	0.9	-0.43	**0.003**	-0.55	**<0.001**
BRIEF-2 GEC	-0.11	0.5	-0.12	0.4	0.01	>0.9	-0.23	0.2	-0.08	0.6	-0.10	0.5
Age	0.21	0.066	-0.04	0.7	-0.08	0.5	0.29	**0.034**	0.22	0.063	0.19	0.12
Gender	0.02	>0.9	0.59	**0.011**	0.31	0.2	-0.14	0.6	-0.09	0.7	0.10	0.7
Time on task	-0.15	0.5	-0.05	0.8	0.46	**0.037**	0.02	>0.9	0.17	0.5	0.07	0.7
Stimulants * Treatment Group	-0.16	0.6	0.43	0.11	-0.10	0.7	0.17	0.6	0.45	0.2	-0.04	>0.9
Treatment Group * SNAP Total	0.05	0.8	0.01	>0.9	-0.20	0.4	0.01	>0.9	0.09	0.7	0.25	0.3
Treatment Group * SCQ Score	-0.24	0.14	-0.13	0.4	-0.11	0.5	-0.12	0.5	-0.02	>0.9	0.01	>0.9
Treatment Group * SSRT	-0.43	**0.010**	-0.19	0.2	0.10	0.6	0.09	0.7	0.24	0.2	0.00	>0.9
Treatment Group * Target Accuracy (1-back)	0.22	0.2	0.43	**0.013**	0.10	0.6	0.23	0.3	0.27	0.2	0.61	**0.002**
Treatment Group * Target Accuracy (2-back)	-0.06	0.7	-0.14	0.4	-0.06	0.8	-0.10	0.6	-0.27	0.15	-0.19	0.3
Treatment Group * BRIEF-2 GEC	-0.06	0.8	-0.06	0.8	0.10	0.7	0.26	0.3	-0.15	0.5	-0.13	0.6
Treatment Group * Age	-0.11	0.5	-0.03	0.9	0.33	0.076	-0.19	0.3	0.05	0.8	-0.07	0.7
Treatment Group * Gender	0.04	0.9	-0.53	0.11	-0.54	0.13	0.00	>0.9	-0.03	>0.9	-0.21	0.6

Note: SSRT - Stop Signal Reaction Time. *p-value < 0.0035 (Bonferroni corrected); Bold p-value < 0.05.

Table 3.2: Multiple Linear Regression Model Results Predicting EF Impairment and ADHD Symptoms in ADHD group

Predictors	Outcomes							
	Δ BRIEF2-GEC 5 Week F = 1.1 R^2 = 0.15		**Δ BRIEF2-GEC 6 Month** F = 1.9 R^2 = 0.24		**Δ SNAP-IV Total 5 Week** F = 2.7* R^2 = 0.3		**Δ SNAP-IV Total 6 Month** F = 3.1* R^2 = 0.35	
	β	p	β	p	β	p	β	p
Stimulants	-0.01	>0.9	-0.21	0.4	-0.04	0.9	-0.19	0.4
Treatment Group	0.33	0.8	-0.20	0.3	0.13	0.4	-0.66	0.7
SNAP Total	-0.04	0.8	0.01	>0.9	-0.75	**<0.001**	-0.49	**<0.001**
SCQ Score	-0.05	0.7	-0.02	0.9	-0.03	0.8	0.03	0.8
SSRT	0.18	0.2	0.12	0.4	-0.05	0.7	0.11	0.4
Target Accuracy (1-back)	-0.04	0.8	0.08	0.6	-0.03	0.8	0.04	0.8
Target Accuracy (2-back)	-0.16	0.3	-0.10	0.5	-0.01	>0.9	0.00	>0.9
BRIEF-2 GEC	-0.22	0.2	-0.16	0.3	0.54	**<0.001**	0.45	**0.005**
Age	0.04	0.8	-0.23	0.084	-0.05	0.7	-0.21	0.10
Gender	0.10	0.7	-0.04	0.9	-0.44	0.085	0.21	0.4
Time on task	-0.14	0.6	-0.21	0.4	-0.18	0.4	0.19	0.4
Stimulants * Treatment Group	-0.45	0.2	0.21	0.5	0.05	0.9	0.10	0.8
Treatment Group * SNAP Total	0.01	>0.9	-0.13	0.6	0.09	0.7	-0.21	0.4
Treatment Group * SCQ Score	0.08	0.7	-0.03	0.9	0.15	0.4	-0.27	0.13
Treatment Group * SSRT	-0.28	0.2	-0.26	0.2	0.01	>0.9	-0.13	0.4
Treatment Group * Target Accuracy (1-back)	0.12	0.6	-0.32	0.14	0.02	>0.9	-0.17	0.4
Treatment Group * Target Accuracy (2-back)	0.03	>0.9	0.15	0.5	0.08	0.7	0.14	0.5
Treatment Group * BRIEF-2 GEC	0.00	>0.9	-0.05	0.8	-0.21	0.4	0.24	0.3
Treatment Group * Age	0.14	0.5	0.01	>0.9	-0.10	0.6	-0.21	0.3
Treatment Group * Gender	-0.26	0.5	0.07	0.9	0.23	0.5	-0.30	0.4

Note: SSRT - Stop Signal Reaction Time. *p-value < 0.0035 (Bonferroni corrected); Bold p-value < 0.05

Table 3.3: Multiple Linear Regression Model Results Predicting Planning and Fluency in ADHD group

Predictors	Outcomes							
	Δ TAS 5 Week F = 0.97 R^2 = 0.14		**Δ TAS 6 Month** F = 0.81 R^2 = 0.12		**Δ Fluency 5 Week** F = 0.96 R^2 = 0.16		**Δ Fluency 6 Month** F = 0.45 R^2 = 0.086	
	β	p	β	p	β	p	β	p
Stimulants	0.02	>0.9	-0.10	0.7	-0.38	0.2	-0.09	0.8
Treatment Group	-0.98	0.3	-0.32	0.9	-0.50	0.068	0.17	0.6
SNAP Total	-0.37	**0.018**	-0.37	**0.025**	-0.12	0.5	0.05	0.8
SCQ Score	0.12	0.3	-0.02	0.9	-0.04	0.8	-0.07	0.6
SSRT	0.26	0.10	0.20	0.2	0.18	0.3	-0.11	0.5
Target Accuracy (1-back)	-0.08	0.6	0.01	>0.9	0.23	0.2	0.14	0.4
Target Accuracy (2-back)	0.14	0.4	-0.04	0.8	0.26	0.2	-0.26	0.2
BRIEF-2 GEC	0.33	0.070	0.33	0.072	0.13	0.6	0.15	0.5
Age	-0.06	0.7	-0.08	0.6	0.14	0.4	0.12	0.5
Gender	-0.03	>0.9	-0.10	0.7	-0.09	0.8	0.16	0.6
Time on task	0.45	0.072	-0.03	>0.9	0.11	0.7	-0.07	0.8
Stimulants * Treatment Group	0.10	0.8	0.06	0.9	0.35	0.4	0.03	>0.9
Treatment Group * SNAP Total	0.58	**0.022**	0.23	0.4	-0.11	0.7	-0.02	>0.9
Treatment Group * SCQ Score	-0.13	0.5	0.11	0.6	-0.04	0.9	0.12	0.6
Treatment Group * SSRT	-0.26	0.2	-0.10	0.6	-0.17	0.5	0.06	0.8
Treatment Group * Target Accuracy (1-back)	0.21	0.4	-0.14	0.5	-0.47	0.059	-0.15	0.6
Treatment Group * Target Accuracy (2-back)	-0.08	0.7	0.25	0.3	-0.27	0.3	0.25	0.3
Treatment Group * BRIEF-2 GEC	-0.55	**0.031**	-0.23	0.4	-0.19	0.5	-0.30	0.4
Treatment Group * Age	-0.12	0.6	0.15	0.5	-0.07	0.8	0.12	0.6
Treatment Group * Gender	0.19	0.6	0.38	0.4	0.06	>0.9	-0.48	0.3

Note: SSRT: Stop Signal Reaction Time; TAS: Total Achievement Score (Tower Task). *p-value < 0.0035 (Bonferroni corrected); Bold p-value < 0.05

3.2 Autism Group

A multiple linear regression model with all predictors entered (baseline response inhibition, working memory, ADHD symptoms, autism symptoms, and time on task) significantly predicted improvement in response inhibition at post-treatment ($F = 2.4$, $p = 0.027$, $R^2 = 0.38$) and at 6 month follow-up ($F = 10$, $p < 0.001$, $R^2 = 0.74$). Baseline response inhibition was a significant predictor of improvement in response inhibition across both groups at post-treatment (= -0.6, $p = 0.0024$) and at 6 month follow-up (= -0.6, $p < 0.001$). No other individual factors were significant predictors or moderators of response inhibition at 5 weeks or 6 months. See Table 3.4 for results.

Multiple linear regression models with all the predictors did not predict improvement in working memory (1-back) after 5 weeks post-treatment ($F = 1.4$, $p = 0.2$, $R^2 = 0.26$) or at 6 months follow-up ($F = 1.3$, $p = 0.25$, $R^2 = 0.26$).

Finally, a multiple linear regression model with all predictors entered predicting EF impairment was not significant at post-treatment ($F = 0.86$, $p = 0.59$, $R^2 = 0.2$). However, at 6 months follow-up the multiple linear regression model significantly predicted improvement in daily EF impairment ($F = 2.1$, $p = 0.044$, $R^2 = 0.4$); however, no individual variables significantly predicted or moderated response.

However, after applying Bonferroni correction to adjust for multiple comparisons (threshold $p < 0.008$) only the model predicting response inhibition at 6 month follow-up remained significant.

Table 3.4: Multiple Linear Regression Model Results Predicting Response Inhibition, Working Memory, and EF Impairment in Autistic group

Predictors	Outcomes											
	Δ SSRT 5 Week F = 2.4 R^2 = 0.38		**Δ SSRT 6 Month** F = 10 R^2 = 0.74		**Δ 1-back 5 Week** F = 1.4 R^2 = 0.26		**Δ 1-back 6 Month** F = 1.3 R^2 = 0.26		**Δ BRIEF-2 5 Week** F = 0.86 R^2 = 0.2		**Δ BRIEF-2 6 Month** F = 2.1 R^2 = 0.4	
	β	p	β	p	β	p	β	p	β	p	β	p
SCQ Score	-0.10	0.6	0.03	0.8	-0.12	0.5	-0.05	0.8	-0.22	0.3	-0.06	0.7
Treatment Group	-0.21	>0.9	-0.97	0.3	-1.3	0.14	0.64	0.8	1.3	0.5	1.4	0.8
SNAP Total	-0.40	**0.033**	-0.22	0.092	-0.02	>0.9	-0.18	0.4	0.20	0.7	0.38	0.3
SSRT	-0.60	**0.002**	-0.80	**<0.001**	0.02	>0.9	-0.11	0.6	-0.16	0.5	0.12	0.6
Target Accuracy (1-back)	0.22	0.3	0.10	0.4	-0.34	0.2	-0.37	0.12	0.12	0.6	-0.01	>0.9
Time on task	-0.05	>0.9	0.51	0.3	0.86	0.10	-0.26	0.7	-0.83	0.13	-0.84	0.15
SCQ Score * Treatment Group	-0.09	0.8	0.21	0.4	0.57	0.14	0.64	0.13	0.50	0.2	0.49	0.2
Treatment Group * SNAP Total	0.45	0.14	0.13	0.5	-0.34	0.3	-0.33	0.3	-0.54	0.3	-0.44	0.4
Treatment Group * SSRT	-0.04	>0.9	0.02	>0.9	0.36	0.4	0.04	>0.9	-0.22	0.6	-0.26	0.6
Treatment Group * Target Accuracy (1-back)	-0.30	0.3	-0.06	0.8	0.17	0.6	0.12	0.7	-0.15	0.7	-0.25	0.4
BRIEF-2 GEC									-0.23	0.7	-0.87	0.10
Treatment Group * BRIEF-2 GEC									0.04	>0.9	0.32	0.6

Note: SSRT: Stop Signal Reaction Time; TAU - Treatment as Usual; *p-value < 0.008 (Bonferroni corrected); Bold p-value < 0.05

Chapter 4

Discussion

4.1 Main Findings

This project aimed to explore the impact of individual factors on response to EF training given the heterogeneity of previous study results examining efficacy of EF training in ADHD and autistic children. In particular, the current study explored whether participants' baseline demographic, EF and clinical characteristics, as well as their engagement during EF training (as indexed by time spent training) were predictors and moderators of response to EF training. Age, gender, response inhibition, working memory, EF impairment, ADHD symptoms, autism traits, stimulant medication use, and time on task were used as predictors and moderators of response. The overall goal of the study was to explore how these individual factors were associated with response to Mega Team immediately after training (5 weeks) and at 6 month follow-up on measures of near transfer of training (response inhibition and working memory) and far transfer of training (EF impairment, ADHD symptoms, planning, and fluency) in a sample of 186 ADHD and 67 autistic children. Existing work on computerized EF training interventions have shown that EF training is moderated by age (Cao et al., 2020), sex (Flannery et al., 2024), ADHD symptom severity (Davis et al., 2018), ADHD subtype (van der Donk et al., 2020), autism traits (de Vries et al., 2018), baseline working memory (van der Donk et al., 2020), baseline response inhibition (Dovis et al., 2019), and medication use (Holmes et al., 2010; van der Donk et al., 2020). However, these previous results were often not replicated or were not corrected for multiple comparisons.

Results of the current study revealed several significant predictors and moderators of response to EF training in the ADHD participants but not in the autistic participants. In the ADHD participants, baseline working memory and gender were significant predictors of improvement in response inhibition and baseline EF impairment was a significant predictor of improvement in ADHD symptoms over time regardless of treatment group. In addition, baseline response inhibition and baseline working memory were significantly moderated by treatment group on indices of change in response inhibition and working memory. Finally, time on task was a significant predictor of improvement in working memory across both groups.

4.1.1 ADHD Group

Age & Gender

In the current study, age was not a significant predictor or moderator of EF training related improvement at either time point for any outcome. This is contrary to findings from a review looking across diagnosis groups (typically developing, ADHD, fragile X, and learning disabilities) including participants with an age range of 3-12 years old that showed an age effect whereby younger children benefited more from computerized EF training than older children (Cao et al., 2020). Findings from the Westwood et al. (2023) review, however, did not show a similar relationship in studies of 8-14 year old ADHD children only. Given the rapid development of EFs in preschool ages (Reilly et al., 2022), our sample of school aged children may not have a wide enough age range to observe age-related influences in EF training related outcomes that may exist earlier in development.

A review of the literature describes minimal group level differences in EF performance by gender across ages, but identifies some differences in development of EFs in children by gender, for example typically developing girls outperforming boys in an attention task at 8-10 years old whereas no gender differences are observed in adolescence (Grissom & Reyes, 2019). In the current analysis, gender predicted improvement in response inhibition at 6 month follow-up irrespective of treatment group such that girls improved more than boys. The results are in line with a recent analysis showing female participants improved more than male participants in attention scores following attention training (Flannery et al., 2024), which did not distinguish the presence of a treatment specific effect over and above an effect of time. Altogether, the current results suggest that there are differences in development of EFs in childhood by gender, but no reported differences in response to training.

EF Characteristics

Results from the current study support previous findings showing a relationship between baseline response inhibition and improvement in response inhibition (near transfer) as a function of EF training (Dovis et al., 2019). Specifically, we found that that receiving EF training resulted in significantly greater improvement for participants with relatively worse baseline response inhibition than ones who did not receive EF training. This aligns with the theory that weaker baseline EF leaves a greater capacity for improvement as described by Diamond & Lee (2011) otherwise known as a compensation effect. This pattern has been observed in studies of working memory training (van der Donk et al., 2020) and attention training (Davis et al., 2018), specifically when the EF being measured at baseline (e.g. low working memory) matched the type of EF training (e.g. working memory). However, this same pattern was not observed when using a composite of multiple EF skills as a predictor and moderator (Minder et al., 2019), suggesting that a broad metric of multiple EF skills may not be sensitive enough to pick up this relationship. Results from the current study are consistent with previous research showing that worse baseline ability on a specific skill predicted greater improvement on that same skill when the training content matched that deficit pre treatment.

On the other hand, we observed an interaction by treatment group effect such that higher (better) baseline 1-back working memory performance was associated with greater improvement in 2-back working memory in the Mega Team treatment group but not in the TAU control group at 6 month follow up which is contrary to the findings of van der Donk et al. (2020). This finding is notable given

that results from the Mega Team RCT did not show significant group-level (i.e., Mega Team vs TAU) differences in 2-back working memory within the same time frame (Cheung et al., in prep), indicating the presence of a unique treatment response in a subset of the group. A potential explanation for this discrepancy may be the differences in the type of training between the studies. Whereas van der Donk et al. (2020) administered only working memory training (CogMed) for a longer total session length in their computerized EF training condition, Mega Team training was composed of both response inhibition and working memory training and for a shorter total session length. This resulted in an average of 1125 minutes of total working memory training per participant in the van der Donk et al. (2020) study and an average of 187.5 minutes of total working memory training per participant in our study over a 5 week training period in both. In general, working memory training doses vary within the literature (see review Robledo-Castro et al., 2023) with some evidence that higher doses of working memory training could be more effective than lower doses (Alloway et al., 2013; Liu et al., 2024). Our results may indicate that in the context of a lower dose of training, individuals with relatively stronger baseline working memory may improve more with training and perhaps that a higher dose of working memory training than what was completed in our study may be required to benefit participants with lower working memory at pre-treatment. This dose-related pattern of improvement has been shown in a sample of typically developing older adults (Matysiak et al., 2019).

Our results also show significant cross-EF (i.e. working memory to response inhibition) prediction of response to training at both outcome time points, and significant moderation by treatment group at 6 month follow-up. Higher (better) baseline 1-back working memory predicted greater improvement in response inhibition at 5 weeks post-treatment and at 6 month follow-up overall across treatment groups. More specifically at 6 month follow-up the participants in the Mega Team group with stronger baseline working memory no longer had an advantage over weaker baseline working memory participants as seen in the control group. To date, other studies have not observed this cross-EF moderation effect (Dovis et al., 2019; Minder et al., 2019; van der Donk et al., 2020). This finding may be explained by the relationship between working memory and response inhibition. First, stronger working memory may predict subsequent improvement in response inhibition because both skills rely on overlapping brain regions necessary across EFs such as the fronto-parietal and cingulo-opercular networks (Friedman & Robbins, 2022) and may be the result of better developed shared brain regions at baseline across participants (both Mega Team and TAU groups) which result in more improvement as a function of time. However, this explanation would be best supported with results showing a stronger baseline in *either* working memory or response inhibition predicts improvement in the other skill, which is not seen in our study. An alternative explanation may be based in theoretical models of EFs which propose the various ways working memory, response inhibition, and other EF skills may be interrelated and rely on one another in ADHD individuals. For example, some models propose underlying skill deficits that may explain impairments associated with ADHD such as response inhibition (Barkley, 1997) or working memory (Rapport et al., 2008). Our results align with theoretical models proposing working memory as the key underlying deficit explaining other difficulties in ADHD as we found that improvement in response inhibition at 5 weeks post treatment and at 6 month follow-up was associated with better developed working memory at baseline across Mega Team and TAU groups. It may be that response inhibition development over time in ADHD children may be reliant on earlier working memory ability. Then in response to Mega Team training,

this relationship is negated at 6 month follow-up, so baseline working memory no longer explained improvements in response inhibition, indicating all levels of baseline working memory could benefit from Mega Team Training.

Parent rating of EF impairment via the BRIEF-2 rating scale at baseline predicted greater improvement in ADHD symptoms over time across both Mega Team and TAU control groups at 5 weeks post-treatment and at 6 month follow-up. Findings from the literature suggest that EF impairment as rated on the BRIEF-2 is correlated with ratings of ADHD severity (Jacobson et al., 2020). Results align with expectations of the developmental relationship between EF impairment and ADHD symptoms across participants (Mega Team and TAU) over time. However, this relationship was not moderated by treatment group (Mega Team or TAU) at any time point and baseline daily EF impairment scores did not predict or moderate any other outcome. Minder et al. (2019) showed that lower parent rated daily EF impairment at baseline was associated with greater improvement in EF impairment after 12 weeks of EF training than in a higher parent rated impairment subgroup, however they did not compare these outcomes with those of a control group's making it difficult to distinguish the presence of a treatment-specific change in EF impairment. There is no other existing literature that we know of exploring EF impairment as a moderator of response to EF training in ADHD children. Despite non-significant relationships with training outcomes, ratings of daily EF related impairments warrant further investigation as a factor in EF training response. Baseline EF impairment may relate to adherence to treatment protocol especially in interventions with high EF demands in engaging with intervention or minimal rewards or external motivators. Future work should consider the relationship of baseline EF functioning to other training-related factors beyond training outcomes.

Clinical Characteristics

Clinical characteristics (e.g. ADHD symptoms, autism traits, stimulant medication use) were not significant predictors or moderators of improvement at either time point for any outcome in the current study. Existing literature has demonstrated a significant effect for ADHD severity (Davis et al., 2018), subtype (van der Donk et al., 2020), autism traits (de Vries et al., 2018), and stimulant medication status (Holmes et al., 2010; van der Donk et al., 2020) on response to EF training, however, these findings are inconsistent (e.g., no effect of ADHD severity or stimulant medication (Jones et al., 2018), no effect of autism traits (Kirk et al., 2021)). It is possible that measurement or sample differences explain inconsistent results across studies. In the present study, parent rated clinical characteristics were used as predictors and moderators, whereas studies with significant ADHD severity and subtype used outcomes from diagnostic interviews and psychological report reviews. In the existing literature, autism traits were significant only in an autistic sample, not in another condition (i.e. intellectual and developmental disorders) (Kirk et al., 2021), which may explain why they were not a significant predictor of treatment response in our ADHD participants.

Time on Task

In the present study, greater time on task during EF training predicted greater improvement on working memory at 5 weeks post-treatment. These findings reflect the importance of engagement with training as individuals who played more practiced their EFs more and therefore improved more at 5 weeks post-treatment. This result is notable within the context of the overall efficacy results

showing no significant differences in group-level (Mega Team vs TAU) performance (Cheung et al., in prep). Previous research has shown evidence of greater efficacy of working memory training because of intervention dosage. This has been observed when dosage was randomly assigned (Alloway et al., 2013) and when dosage of training varied due to participants' motivation to train (Jaeggi et al., 2014). Despite the initially straightforward nature of this relationship, the components underlying a metric like time on task are complex. In the present study, all participants were instructed to play the minigames for the same amount of time so the variation in time played is reflective of individual differences like motivation to play or the influence of caregivers' EFs on facilitating training (e.g., scheduling). Existing literature indicates there are differences in reward processing and motivation in individuals with neurodevelopmental disorders versus typically developing children suggesting overall deficits in reward processing with variation within and between groups (Dichter et al., 2012; Kohls et al., 2014). In line with the literature, Mega Team games were designed based on children and youth's interests (e.g. variety of games) and efforts were made to support motivation to play with weekly tracker and salience of associated rewards. However, motivation to play and interest in the games were not directly analyzed so future work should investigate whether games and rewards used during Mega Team training were perceived as motivating and rewarding. Existing literature also suggests that the relationship between parent and child EF skills fits within a complex multifaceted framework composed of genetic and socialization factors (Bridgett et al., 2015). Based on this, efforts were made to minimize demands on caregiver EFs to engage with intervention and incorporate the games into their existing lifestyles as much as possible (e.g., focusing on portability of training with minimal reliance on WiFi, providing weekly phone reminders and check ins). Caregivers' EF ability and level of involvement in facilitating the training were not captured in this study and future research exploring their impact on time on task may be beneficial in understanding these relationships. Notably, many of the design elements described above were a result of engagement with youth and parents, supporting the use of patient-oriented research approaches in digital intervention design (described further in Cheung et al., in prep). Given the significance of time on task in the present study, future research should aim to better understand barriers and facilitators to engaging with videogame-based EF training, which could impact time spent training by children and thereby impact treatment outcomes.

4.1.2 Autism Group

The small sample size (N = 67) of autistic children in our sample may have influenced the non-significant findings in the autistic group. Additionally, despite randomization to treatment condition, the Mega Team and TAU groups had some significantly different baseline scores (e.g., baseline response inhibition) potentially restricting the range of scores in each group and interfering with the ability to detect relationships. None of the factors explored were significant in influencing training outcomes for the autism group, conflicting with findings reported by de Vries et al. (2018) showing autism traits were a significant predictor. This may reflect that the predictors and moderators selected were not specific enough to the autism phenotype as de Vries et al. (2018) found that baseline flexibility was a significant predictor in training outcomes. Individual factors predicting response to treatment in the autistic participants may need to be approached differently to be more specific to the presentation - for example capturing additional EF skills such as including shifting or examining the severity and variation associated with restricted, repetitive, behaviours and interests

in addition to social communication.

4.1.3 Summary

Overall results highlight the importance of baseline EF profiles and time on task in near transfer of EF training. There were significant factors in the context of both significant overall group-level Mega Team versus TAU differences (e.g. response inhibition) and in the context of no overall differences in response (e.g. 1-back working memory at 5 weeks). This avenue of work has the potential to clarify the key ingredients influencing transfer of training. None of the factors explored were significant moderators of far transfer of training (as indexed by parent rated daily EF impairment, ADHD symptoms, planning, and fluency). Different factors were significant at 5 weeks post treatment (response inhibition and time on task) and at 6 month follow-up (response inhibition and working memory). Baseline response inhibition and time on task during training were significant factors associated with response at 5 weeks post-treatment in improvement in response inhibition and working memory, whereas baseline working memory was a significant factor associated with ongoing benefit or maintenance of gains at 6 month follow-up in improvements in working memory and response inhibition. Age, gender, and clinical characteristics were not meaningful moderators of response.

4.2 Strengths & Limitations

A major strength of this project is the patient-oriented approach. Mega Team minigames and study protocols were designed together with families and youth with lived and living experiences. Iterative feedback was incorporated during pilot phases to optimize child interest and enjoyment in games and convenience and practicality for caregivers. Given the significance of time on task as a predictor of improvement on working memory, future studies should prioritize family and youth perspectives in intervention designs to increase engagement. Efforts to increase enjoyment and convenience are likely to increase accessibility by for example, minimizing demands on parent EFs to facilitate training. Another strength of the current study was the multi-EF training design as there are relatively fewer studies exploring multi-EF training compared to single-EF training (Westwood et al., 2023). Existing work on predictors and moderators of response in multi-skill training is very limited. In addition, the inclusion of a 6 month follow-up to observe predictors and moderators of longer-term benefits or maintenance of effects was another positive of the current study. Several significant relationships appeared at 6 month follow-up that were not present immediately at 5-weeks post-treatment. Evidence from a meta-analysis suggests that within the limited trials looking at overall efficacy at follow-up, there were a range of significant improvements maintained and some small effects emerged only at follow-up (Westwood et al., 2023). Inclusion of a follow-up in understanding predictors and moderators of response clarifies factors associated with not only immediate response but also later consolidation and maintenance of gains. Finally, though not significant, the inclusion of autistic participants is an important step in developing a better understanding of the effects of computerized EF training across overlapping diagnostic categories like ADHD and autism.

Results also need to be considered in the context of study limitations. First, when interpreting the parent questionnaire results, it should be noted that parents were aware of their child's treatment

group. This knowledge may have biased results on parent-reported outcomes (daily EF impairment and ADHD symptoms) due to expectation of improvement and masked the presence of moderators of response. Future studies should seek to incorporate an active sham condition (e.g., games with no EF load) so that parents and children are blinded to minimize inflation of results. Second, data collection for the current study spanned the COVID-19 pandemic which impacted this research like many others during this period. Data was collected from 2018 to 2023 with a subset of participants experiencing delayed follow-up assessments due to lockdowns with 14 participants having post-treatment visits more than 8 weeks after baseline and 10 participants having follow-up visits more than 9 months after baseline. Participant retention was prioritized over strict adherence to post-treatment and follow-up visit schedule given the unprecedented circumstances. Future studies may benefit from incorporating a sensitivity analysis to better understand COVID-19 related impacts on results. Finally, the autism participant group was ultimately quite small and reflected a fairly narrow slice of the population. These participants had average IQ and were primarily verbal. Despite a lack of variation in these characteristics, autism is known to be quite heterogeneous in other aspects as well and so the small sample size may not have captured enough of a range of characteristics to identify potential predictors and moderators. Despite randomization, autistic participants in the Mega Team group had significantly stronger response inhibition performance at baseline than the TAU control group. Given these limitations, results may not accurately capture predictors or moderators of response in autistic individuals. As computerized EF training in autism is currently a fairly small area of study, it would be beneficial for future research efforts to incorporate predictors and moderators of response while exploring overall efficacy.

4.3 Implications & Future Directions

Theoretical implications of this work are relevant to EF models of impairment in ADHD and compensation versus magnification effects in EF skills. Different models have been proposed to explain the roles of various EF skills within ADHD related impairment (for example summary table within Kofler et al., 2024) and these findings support the idea that working memory may be a core deficit (Rapport et al., 2008) explaining some of the other difficulties observed in ADHD. A better understanding of the relationship between the EF deficits observed in neurodevelopmental disorders is key for improving intervention design. The second theoretical implication addresses hypotheses of how individual differences in EF skills change in response to intervention. Literature is mixed with competing hypotheses suggesting either a compensation effect (i.e., lower baseline EF have greater capacity for improvement) (e.g. Diamond & Lee, 2011) or a magnification effect (i.e., higher baseline EFs are able to benefit more from intervention) (e.g., Von Bastian & Oberauer, 2014). We saw evidence for both types of effects in different baseline EF skills and so it remains unknown if the variation could be the result of different skills responding differently to intervention, baseline ability interacting with training intensity, or some other difference in the components of intervention. Further work is needed to identify potential patterns in how baseline EF abilities respond to intervention.

Methodological implications of these results support the inclusion of follow-up appointments in assessments of EF training. In the limited work following up after treatment there is some evidence of improvements emerging only at mid to long term follow-up (Westwood et al., 2023). Our results

support the presence of baseline characteristics that may be relevant factors in continued development of skills or retention of training gains at follow-up.

A clinical implication of these findings is the lack of explanation for what factors influence far transfer of computerized EF training as there were no significant moderators of far transfer. The unexplained heterogeneity in far transfer results supports the caution around computerized EF training as a clinically meaningful intervention option at this time (Westwood et al., 2023). Heterogeneity in far transfer results in computerized EF training warrants further work with blinded trial designs to understand predictors and moderators of response.

Another clinical implication is that lower baseline EF impairment (better EF) predicted improvement in ADHD symptoms regardless of group. This relationship adds to our understanding of how real-world EF impairment relates to changes in ADHD symptoms over time. In line with the established gap between EF task performance and EF related impairment (Toplak et al., 2013), performance-based EF tasks do not predict later ADHD symptoms (Coghill et al., 2014) but parent ratings of EF impairment do (Hawkey et al., 2018). Understanding the mechanisms that translate EF skills to application in real-world settings is essential to identifying factors associated with far transfer of training.

In conclusion, the current study showed that near transfer of response to EF training (as indexed by response inhibition and working memory tasks) was associated with baseline EF characteristics and time spent training but not with baseline clinical or demographic characteristics in ADHD children. Personalizing EF training based on baseline EF characteristics and developing interventions that are engaging may enhance treatment results. EF training may be equally beneficial across a range of clinical presentations as none of the clinical characteristics measured in the current study (e.g., ADHD symptoms or autism traits) were associated with near or far transfer of outcomes. Relevant participant characteristics that are associated with far transfer of training remain unknown. In addition, more work is needed to identify potential characteristics associated with computerized EF training responses in autistic children.

References

Alabdulakareem, E., & Jamjoom, M. (2020). Computer-assisted learning for improving ADHD individuals' executive functions through gamified interventions: A review. *Entertainment Computing*, *33*, 100341. https://doi.org/10.1016/j.entcom.2020.100341

Alloway, T. P., Bibile, V., & Lau, G. (2013). Computerized working memory training: Can it lead to gains in cognitive skills in students? *Computers in Human Behavior*, *29*(3), 632–638. https://doi.org/10.1016/j.chb.2012.10.023

American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders : DSM-5-TR* (5th edition, text revision.). American Psychiatric Association Publishing. https://doi/book/10.1176/appi.books.9780890425787

Assari, S. (2021). Emotional, behavioral, and cognitive correlates of attention deficit and hyperactive disorder (ADHD) screening and diagnosis history: Sex/gender differences. *Journal of Neurology & Neuromedicine*, *6*(1). https://doi.org/10.29245/2572.942X/2021/1.1278

Ayano, G., Demelash, S., Gizachew, Y., Tsegay, L., & Alati, R. (2023). The global prevalence of attention deficit hyperactivity disorder in children and adolescents: An umbrella review of meta-analyses. *Journal of Affective Disorders*, *339*, 860–866. https://doi.org/10.1016/j.jad.2023.07.071

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Bell, M. L., Fiero, M., Horton, N. J., & Hsu, C.-H. (2014). Handling missing data in RCTs; a review of the top medical journals. *BMC Medical Research Methodology*, *14*(1), 118. https://doi.org/10.1186/1471-2288-14-118

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development*, *81*(6), 1641–1660. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Bridgett, D. J., Burt, N. M., Edwards, E. S., & Deater-Deckard, K. (2015). Intergenerational transmission of self-regulation: A multidisciplinary review and integrative conceptual framework. *Psychological Bulletin*, *141*(3), 602–654. https://doi.org/10.1037/a0038662

Bussing, R., Fernandez, M., Harwood, M., Hou, W., Garvan, C. W., Swanson, J. M., & Eyberg, S. M. (2008). Parent and teacher SNAP-IV ratings of attention deficit/hyperactivity disorder symptoms: Psychometric properties and normative ratings from a school district sample. *Assessment*, *15*(3), 317–328. https://doi.org/10.1177/1073191107313888

Cao, Y., Huang, T., Huang, J., Xie, X., & Wang, Y. (2020). Effects and moderators of computer-based training on children's executive functions: A systematic review and meta-analysis. *Fron-*

tiers in Psychology, *11*, 580329. https://doi.org/10.3389/fpsyg.2020.580329

Chacko, A., Bedard, A. c., Marks, D. j., Feirsen, N., Uderman, J. z., Chimiklis, A., Rajwan, E., Cornwell, M., Anderson, L., Zwilling, A., & Ramon, M. (2014). A randomized clinical trial of Cogmed Working Memory Training in school-age children with ADHD: A replication in a diverse sample using a control condition. *Journal of Child Psychology and Psychiatry*, *55*(3), 247–255. https://doi.org/10.1111/jcpp.12146

Chandler, S., Charman, T., Baird, G., Simonoff, E., Loucas, T., Meldrum, D., Scott, M., & Pickles, A. (2007). Validation of the social communication questionnaire in a population cohort of children with autism spectrum disorders. *Journal of the American Academy of Child & Adolescent Psychiatry*, *46*(10), 1324–1332. https://doi.org/10.1097/chi.0b013e31812f7d8d

Cheung, T. C. K., Ram, N., Anagnostou, E., Ameis, S. H., Sananes, R., Bedard, A.-C., & Crosbie, J. (in prep). *Cognitive rehabilitation (Mega Team) and its effects on emotional and behavioural regulation in ADHD and ASD children*.

Coghill, D. R., Hayward, D., Rhodes, S. M., Grimmer, C., & Matthews, K. (2014). A longitudinal examination of neuropsychological and clinical functioning in boys with attention deficit hyperactivity disorder (ADHD): Improvements in executive functioning do not explain clinical improvement. *Psychological Medicine*, *44*(5), 1087–1099. https://doi.org/10.1017/S0033291713001761

Cortese, S., Ferrin, M., Brandeis, D., Buitelaar, J., Daley, D., Dittmann, R. W., Holtmann, M., Santosh, P., Stevenson, J., Stringaris, A., Zuddas, A., & Sonuga-Barke, E. J. S. (2015). Cognitive training for attention-deficit/hyperactivity disorder: Meta-analysis of clinical and neuropsychological outcomes from randomized controlled trials. *Journal of the American Academy of Child & Adolescent Psychiatry*, *54*(3), 164–174. https://doi.org/10.1016/j.jaac.2014.12.010

Davis, N. O., Bower, J., & Kollins, S. H. (2018). Proof-of-concept study of an at-home, engaging, digital intervention for pediatric ADHD. *PloS One*, *13*(1), e0189749. https://doi.org/10.1371/journal.pone.0189749

de Vries, M., Prins, P. J. M., Schmand, B. A., & Geurts, H. M. (2015). Working memory and cognitive flexibility-training for children with an autism spectrum disorder: A randomized controlled trial. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *56*(5), 566–576. https://doi.org/10.1111/jcpp.12324

de Vries, M., Verdam, M. G., Prins, P. J., Schmand, B. A., & Geurts, H. M. (2018). Exploring possible predictors and moderators of an executive function training for children with an autism spectrum disorder. *Autism : The International Journal of Research and Practice*, *22*(4), 440–449. https://doi.org/10.1177/1362361316682622

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System*. https://doi.apa.org/doi/10.1037/t15082-000

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4–12 years old. *Science (New York, N.Y.)*, *333*(6045), 959–964. https://doi.org/10.1126/science.1204529

Dichter, G. S., Damiano, C. A., & Allen, J. A. (2012). Reward circuitry dysfunction in psychiatric and neurodevelopmental disorders and genetic syndromes: Animal models and clinical findings. *Journal of Neurodevelopmental Disorders*, *4*(1), 19. https://doi.org/10.1186/1866-1955-4-19

Dombrowski, S. C. (2015). Exploratory bifactor analysis of the WJ-III achievement at school age via the schmid-leiman orthogonalization procedure. *Canadian Journal of School Psychology*, *30*(1), 34–50. https://doi.org/10.1177/0829573514560529

Dovis, S., Maric, M., Prins, P. J. M., & Van der Oord, S. (2019). Does executive function capacity moderate the outcome of executive function training in children with ADHD? *ADHD Attention Deficit and Hyperactivity Disorders*, *11*(4), 445–460. https://doi.org/10.1007/s12402-019-00308-5

Dovis, S., Oord, S. V. der, Wiers, R. W., & Prins, P. J. M. (2015). Improving executive functioning in children with ADHD: Training multiple executive functions within the context of a computer game. A randomized double-blind placebo controlled trial. *PLOS ONE*, *10*(4), e0121651. https://doi.org/10.1371/journal.pone.0121651

Faraone, S. V., Banaschewski, T., Coghill, D., Zheng, Y., Biederman, J., Bellgrove, M. A., Newcorn, J. H., Gignac, M., Al Saud, N. M., Manor, I., Rohde, L. A., Yang, L., Cortese, S., Almagor, D., Stein, M. A., Albatti, T. H., Aljoudi, H. F., Alqahtani, M. M. J., Asherson, P., … Wang, Y. (2021). The world federation of ADHD international consensus statement: 208 evidence-based conclusions about the disorder. *Neuroscience & Biobehavioral Reviews*, *128*, 789–818. https://doi.org/10.1016/j.neubiorev.2021.01.022

Flannery, J. E., Hinshaw, S. P., Kollins, S. H., & Stamatis, C. A. (2024). Secondary analyses of sex differences in attention improvements across three clinical trials of a digital therapeutic in children, adolescents, and adults with ADHD. *BMC Public Health*, *24*, 1195. https://doi.org/10.1186/s12889-024-18597-5

French, B., Nalbant, G., Wright, H., Sayal, K., Daley, D., Groom, M. J., Cassidy, S., & Hall, C. L. (2024). The impacts associated with having ADHD: An umbrella review. *Frontiers in Psychiatry*, *15*. https://doi.org/10.3389/fpsyt.2024.1343314

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *86*, 186–204. https://doi.org/10.1016/j.cortex.2016.04.023

Friedman, N. P., & Robbins, T. W. (2022). The role of prefrontal cortex in cognitive control and executive function. *Neuropsychopharmacology : Official Publication of the American College of Neuropsychopharmacology*, *47*(1), 72–89. https://doi.org/10.1038/s41386-021-01132-0

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). Behavior rating inventory of executive function. *Child Neuropsychology*, *6*, 235–238. https://doi.org/http://dx.doi.org/10.1076/chin.6.3.235.3152

Grissom, N. M., & Reyes, T. M. (2019). Let's call the whole thing off: Evaluating gender and sex differences in executive function. *Neuropsychopharmacology : Official Publication of the American College of Neuropsychopharmacology*, *44*(1), 86–96. https://doi.org/10.1038/s41386-018-0179-5

Hasson, R., & Fine, J. G. (2012). Gender differences among children with ADHD on continuous performance tests: A meta-analytic review. *Journal of Attention Disorders*, *16*(3), 190–198. https://doi.org/10.1177/1087054711427398

Hawkey, E. J., Tillman, R., Luby, J. L., & Barch, D. M. (2018). Preschool executive function predicts childhood resting-state functional connectivity and attention-deficit/hyperactivity disorder and depression. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *3*(11), 927–936.

https://doi.org/10.1016/j.bpsc.2018.06.011

Hendrickson, N. K., & McCrimmon, A. W. (2019). Test review: Behavior rating inventory of executive function®, second edition (BRIEF®2) by gioia, G. A., isquith, P. K., guy, S. C., & kenworthy, L. *Canadian Journal of School Psychology*, *34*(1), 73–78. https://doi.org/10.1177/0829573518797762

Hill, E. L. (2004). Executive dysfunction in autism. *Trends in Cognitive Sciences*, *8*(1), 26–32. https://doi.org/10.1016/j.tics.2003.11.003

Holmes, J., Gathercole, S. E., Place, M., Dunning, D. L., Hilton, K. A., & Elliott, J. G. (2010). Working memory deficits can be overcome: Impacts of training and medication on working memory in children with ADHD. *Applied Cognitive Psychology*, *24*(6), 827–836. https://doi.org/10.1002/acp.1589

Ickowicz, A., Schachar, R. J., Sugarman, R., Chen, S. X., Millette, C., & Cook, L. (2006). The parent interview for child symptoms: A situation-specific clinical research interview for attention-deficit hyperactivity and related disorders. *Canadian Journal of Psychiatry.*, *51*(5), 325–328. https://doi.org/10.1177/070674370605100508

Irby, S. M., & Floyd, R. G. (2013). Test review: Wechsler abbreviated scale of intelligence, second edition. *Canadian Journal of School Psychology*, *28*(3), 295–299. https://doi.org/10.1177/0829573513493982

Jacobson, L. A., Pritchard, A. E., Koriakin, T. A., Jones, K. E., & Mahone, E. M. (2020). Initial examination of the BRIEF2 in clinically referred children with and without ADHD symptoms. *Journal of Attention Disorders*, *24*(12), 1775–1784. https://doi.org/10.1177/1087054716663632

Jaeggi, S. M., Buschkuehl, M., Shah, P., & Jonides, J. (2014). The role of individual differences in cognitive training and transfer. *Memory & Cognition*, *42*(3), 464–480. https://doi.org/10.3758/s13421-013-0364-z

Jones, M. R., Katz, B., Buschkueh, M., Jaeggi, S. M., & Shah, P. (2018). Exploring n-back cognitive training for children with ADHD. *Journal of Attention Disorders*, 1087054718779230. https://doi.org/10.1177/1087054718779230

Kim, J., Gabriel, U., & Gygax, P. (2019). Testing the effectiveness of the Internet-based instrument PsyToolkit: A comparison between web-based (PsyToolkit) and lab-based (E-Prime 3.0) measurements of response choice and response time in a complex psycholinguistic task. *PLOS ONE*, *14*(9), e0221802. https://doi.org/10.1371/journal.pone.0221802

Kirk, H. E., Raber, A., Richmond, S., & Cornish, K. M. (2021). Examining potential predictors of attention training outcomes in children with intellectual and developmental disorders. *Journal of Intellectual & Developmental Disability*, *46*(3), 197–203. https://doi.org/10.3109/13668250.2020.1821939

Klingberg, T., Forssberg, & and Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology*, *24*(6), 781–791. https://doi.org/10.1076/jcen.24.6.781.8395

Kofler, M. J., Soto, E. F., Singh, L. J., Harmon, S. L., Jaisle, E. M., Smith, J. N., Feeney, K. E., & Musser, E. D. (2024). Executive function deficits in attention-deficit/hyperactivity disorder and autism spectrum disorder. *Nature Reviews Psychology*, 1–19. https://doi.org/10.1038/s44159-024-00350-9

Kohls, G., Thönessen, H., Bartley, G. K., Grossheinrich, N., Fink, G. R., Herpertz-Dahlmann, B.,

& Konrad, K. (2014). Differentiating neural reward responsiveness in autism versus ADHD. *Developmental Cognitive Neuroscience*, *10*, 104–116. https://doi.org/10.1016/j.dcn.2014.08.003

Kollins, S. H., DeLoss, D. J., Cañadas, E., Lutz, J., Findling, R. L., Keefe, R. S. E., Epstein, J. N., Cutler, A. J., & Faraone, S. V. (2020). A novel digital intervention for actively reducing severity of paediatric ADHD (STARS-ADHD): A randomised controlled trial. *The Lancet Digital Health*, *2*(4), e168–e178. https://doi.org/10.1016/S2589-7500(20)30017-0

Lambek, R., Sonuga-Barke, E., Tannock, R., Sørensen, A. V., Damm, D., & Thomsen, P. H. (2018). Are there distinct cognitive and motivational sub-groups of children with ADHD? *Psychological Medicine*, *48*(10), 1722–1730. https://doi.org/10.1017/S0033291717003245

Lebersfeld, J. B., Swanson, M., Clesi, C. D., & O'Kelley, S. E. (2021). Systematic review and meta-analysis of the clinical utility of the ADOS-2 and the ADI-r in diagnosing autism spectrum disorders in children. *Journal of Autism and Developmental Disorders*, *51*(11), 4101–4114. https://doi.org/10.1007/s10803-020-04839-z

Liu, L., Wang, H., Xing, Y., Zhang, Z., Zhang, Q., Dong, M., Ma, Z., Cai, L., Wang, X., & Tang, Y. (2024). Dose–response relationship between computerized cognitive training and cognitive improvement. *Npj Digital Medicine*, *7*(1), 1–7. https://doi.org/10.1038/s41746-024-01210-9

Logan, G. D., Schachar, R. J., & Tannock, R. (1997). Impulsivity and inhibitory control. *Psychological Science*, *8*(1), 60–64. https://doi.org/10.1111/j.1467-9280.1997.tb00545.x

Lord, C., Brugha, T. S., Charman, T., Cusack, J., Dumas, G., Frazier, T., Jones, E. J. H., Jones, R. M., Pickles, A., State, M. W., Taylor, J. L., & Veenstra-VanderWeele, J. (2020). Autism spectrum disorder. *Nature Reviews. Disease Primers*, *6*(1), 5. https://doi.org/10.1038/s41572-019-0138-4

Lord, C., Rutter, M., DiLavore, P., Risi, S., Gotham, K., & Bishop, S. (2012). *Diagnostic observation schedule, second edition (ADOS-2) manual (part I): Modules 1-4*. Western Psychological Services.

Luo, Y., Weibman, D., Halperin, J. M., & Li, X. (2019). A review of heterogeneity in attention deficit/hyperactivity disorder (ADHD). *Frontiers in Human Neuroscience*, *13*, 42. https://doi.org/10.3389/fnhum.2019.00042

Masi, A., DeMayo, M. M., Glozier, N., & Guastella, A. J. (2017). An overview of autism spectrum disorder, heterogeneity and treatment options. *Neuroscience Bulletin*, *33*(2), 183–193. https://doi.org/10.1007/s12264-017-0100-y

Mattes, A., & Roheger, M. (2020). Nothing wrong about change: The adequate choice of the dependent variable and design in prediction of cognitive training success. *BMC Medical Research Methodology*, *20*(1), 296. https://doi.org/10.1186/s12874-020-01176-8

Matysiak, O., Kroemeke, A., & Brzezicka, A. (2019). Working memory capacity as a predictor of cognitive training efficacy in the elderly population. *Frontiers in Aging Neuroscience*, *11*, 126. https://doi.org/10.3389/fnagi.2019.00126

McGrew, K., Woodcock, R., & Schrank, K. (2007). *Technical manual. Woodcock-Johnson III normative update*. Riverside.

Medina, R., Bouhaben, J., de Ramón, I., Cuesta, P., Antón-Toro, L., Pacios, J., Quintero, J., Ramos-Quiroga, J. A., & Maestú, F. (2021). Electrophysiological brain changes associated with cognitive improvement in a pediatric attention deficit hyperactivity disorder digital artificial intelligence-driven intervention: Randomized controlled trial. *Journal of Medical Internet Research*, *23*(11), e25466. https://doi.org/10.2196/25466

Minder, F., Zuberer, A., Brandeis, D., & Drechsler, R. (2019). Specific effects of individualized

cognitive training in children with attention-deficit/hyperactivity disorder (ADHD): The role of pre-training cognitive impairment and individual training performance. *Developmental Neurorehabilitation*, *22*(6), 400–414. https://doi.org/10.1080/17518423.2019.1600064

Owen, A. M., McMillan, K. M., Laird, A. R., & Bullmore, E. (2005). N-back working memory paradigm: A meta-analysis of normative functional neuroimaging studies. *Human Brain Mapping*, *25*(1), 46–59. https://doi.org/10.1002/hbm.20131

Pasqualotto, A., Mazzoni, N., Bentenuto, A., Mulè, A., Benso, F., & Venuti, P. (2021). Effects of cognitive training programs on executive function in children and adolescents with autism spectrum disorder: A systematic review. *Brain Sciences*, *11*(10), 1280. https://doi.org/10.3390/brainsci11101280

Pettersson, E., Lichtenstein, P., Larsson, H., Song, J., Agrawal, A., Børglum, A. D., Bulik, C. M., Daly, M. J., Davis, L. K., Demontis, D., Edenberg, H. J., Grove, J., Gelernter, J., Neale, B. M., Pardiñas, A. F., Stahl, E., Walters, J. T. R., Walters, R., Sullivan, P. F., … Polderman, T. J. C. (2019). Genetic influences on eight psychiatric disorders based on family data of 4 408 646 full and half-siblings, and genetic data of 333 748 cases and controls. *Psychological Medicine*, *49*(7), 1166–1173. https://doi.org/10.1017/S0033291718002039

Plas, E. van der, Schachar, R. J., Hitzler, J., Crosbie, J., Guger, S. L., Spiegler, B. J., Ito, S., & Nieman, B. J. (2016). Brain structure, working memory and response inhibition in childhood leukemia survivors. *Brain and Behavior*, *7*(2), e00621. https://doi.org/10.1002/brb3.621

Posar, A., & Visconti, P. (2019). Long-term outcome of autism spectrum disorder. *Turkish Archives of Pediatrics/Türk Pediatri Arşivi*, *54*(4), 207–212. https://doi.org/10.14744/TurkPediatriArs.2019.16768

R Core Team. (2024). *R: A language and environment for statistical computing*. https://www.R-project.org/

Rapport, M. D., Alderson, R. M., Kofler, M. J., Sarver, D. E., Bolden, J., & Sims, V. (2008). Working memory deficits in boys with attention-deficit/hyperactivity disorder (ADHD): The contribution of central executive and subsystem processes. *Journal of Abnormal Child Psychology*, *36*(6), 825–837. https://doi.org/10.1007/s10802-008-9215-y

Reilly, S. E., Downer, J. T., & Grimm, K. J. (2022). Developmental trajectories of executive functions from preschool to kindergarten. *Developmental Science*, *25*(5), e13236. https://doi.org/10.1111/desc.13236

Roberts, G., Quach, J., Spencer-Smith, M., Anderson, P. J., Gathercole, S., Gold, L., Sia, K.-L., Mensah, F., Rickards, F., Ainley, J., & Wake, M. (2016). Academic outcomes 2 years after working memory training for children with low working memory: A randomized clinical trial. *JAMA Pediatrics*, *170*(5), e154568. https://doi.org/10.1001/jamapediatrics.2015.4568

Robledo-Castro, C., Lerma-Castaño, P. R., & Bonilla-Santos, G. (2023). Effect of cognitive training programs based on computer systems on executive functions in children with ADHD: A systematic review. *Journal of Attention Disorders*, *27*(13), 1467–1487. https://doi.org/10.1177/10870547231187164

Rong, Y., Yang, C.-J., Jin, Y., & Wang, Y. (2021). Prevalence of attention-deficit/hyperactivity disorder in individuals with autism spectrum disorder: A meta-analysis. *Research in Autism Spectrum Disorders*, *83*, 101759. https://doi.org/10.1016/j.rasd.2021.101759

Rutter, M., Bailey, A., & Lord, C. (2003). *The social communication questionnaire: Manual*. West-

ern Psychological Services.

Sadozai, A. K., Sun, C., Demetriou, E. A., Lampit, A., Munro, M., Perry, N., Boulton, K. A., & Guastella, A. J. (2024). Executive function in children with neurodevelopmental conditions: A systematic review and meta-analysis. *Nature Human Behaviour*, *8*(12), 2357–2366. https://doi.org/10.1038/s41562-024-02000-9

Schachar, R. J., Dupuis, A., Arnold, P. D., Anagnostou, E., Kelley, E., Georgiades, S., Nicolson, R., Townes, P., Burton, C. L., & Crosbie, J. (2023). Autism spectrum disorder and attention-deficit/hyperactivity disorder: Shared or unique neurocognitive profiles? *Research on Child and Adolescent Psychopathology*, *51*(1), 17–31. https://doi.org/10.1007/s10802-022-00958-6

Swanson, J. M., Nolan, W., & Pelham, W. (1981). *Paper presented at the meeting of the american psychological association*.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *54*(2), 131–143. https://doi.org/10.1111/jcpp.12001

Townes, P., Liu, C., Panesar, P., Devoe, D., Lee, S. Y., Taylor, G., Arnold, P. D., Crosbie, J., & Schachar, R. (2023). Do ASD and ADHD Have Distinct Executive Function Deficits? A Systematic Review and Meta-Analysis of Direct Comparison Studies. *Journal of Attention Disorders*, *27*(14), 1571–1582. https://doi.org/10.1177/10870547231190494

van der Donk, M. L. A., Hiemstra-Beernink, A.-C., Tjeenk-Kalff, A. C., van der Leij, A., & Lindauer, R. J. L. (2020). Predictors and moderators of treatment outcome in cognitive training for children with ADHD. *Journal of Attention Disorders*, *24*(13), 1914–1927. https://doi.org/10.1177/1087054716632876

Von Bastian, C. C., & Oberauer, K. (2014). Effects and mechanisms of working memory training: A review. *Psychological Research*, *78*(6), 803–820. https://doi.org/10.1007/s00426-013-0524-6

Wechsler, D. (2011). *Wechsler abbreviated scale of intelligence - second edition (WASI-II)*. NCS Pearson INC.

Westwood, S. J., Parlatini, V., Rubia, K., Cortese, S., Sonuga-Barke, E. J. S., & European ADHD Guidelines Group (EAGG). (2023). Computerized cognitive training in attention-deficit/hyperactivity disorder (ADHD): A meta-analysis of randomized controlled trials with blinded and objective outcomes. *Molecular Psychiatry*, *28*(4), 1402–1414. https://doi.org/10.1038/s41380-023-02000-7

Yang, Y., Shields, G. S., Zhang, Y., Wu, H., Chen, H., & Romer, A. L. (2022). Child executive function and future externalizing and internalizing problems: A meta-analysis of prospective longitudinal studies. *Clinical Psychology Review*, *97*, 102194. https://doi.org/10.1016/j.cpr.2022.102194

Zeidan, J., Fombonne, E., Scorah, J., Ibrahim, A., Durkin, M. S., Saxena, S., Yusuf, A., Shih, A., & Elsabbagh, M. (2022). Global prevalence of autism: A systematic review update. *Autism Research: Official Journal of the International Society for Autism Research*, *15*(5), 778–790. https://doi.org/10.1002/aur.2696

Appendix A

Demographic Medical Questionnaire

Confidential

Demographic/Medical Questionnaire

Participant ID:	_____
Date:	_____
1. My child is:	◯ Male ◯ Female ◯ Other
Please explain 'Other'	_____
2. What is your child's date of birth?	◯ January ◯ February ◯ March ◯ April ◯ May ◯ June ◯ July ◯ August ◯ September ◯ October ◯ November ◯ December (Month)
Date of Birth Year	_____ (Year)
Date of Birth	_____
3. Does your child have any siblings (brothers or sisters with the same mother and father as the child) taking part in this study?:	◯ No ◯ Yes
If yes, how many siblings?	_____
4. What is your relationship with the child?	◯ Biological Mother ◯ Biological Father ◯ Adoptive Mother ◯ Adoptive Father ◯ Grandparent ◯ Stepmother ◯ Stepfather ◯ Legal Guardian
If Legal Guardian was selected please specify (e.g., foster parent, etc.)	_____

Confidential

5. Please indicate whether your child has ever had a diagnosis of or treatment for:	☐ Head injury ☐ Hearing problems ☐ Premature birth ☐ ADHD, ADD ☐ ODD ☐ Stroke ☐ Cardiac arrhythmia ☐ Congenital Heart Defect (CHD) ☐ Schizophrenia, manic depression, bipolar disorder, anxiety disorder, depression ☐ Obsessive-Compulsive Disorder ☐ Tics ☐ Substance abuse (alcoholism, illicit drug use) ☐ Seizures, convulsions ☐ ASD (Autism, Aspergers, PDD) ☐ Other ☐ None
Other, please specify:	_____
Head Injury	
How old was your child at the time of the head injury?	_____
Units	◯ Years ◯ Months
Did your child lose consciousness for more than 30 minutes?	◯ No ◯ Yes
Did your child have any of the following problems immediately after his/her head injury? Vomiting, nausea, dizziness, double vision, confusion about where he/she was, confusion about who he/she was, confusion about what time it was, dazed, foggy, slow to respond, tired or weak, confusion, sleepiness, asked questions over and over ◯ No ◯ Yes	
Was your child admitted overnight to the hospital?	◯ No ◯ Yes
6. Does your child receive any special care in any of the following?	◯ No ◯ Yes
If yes, please specify:	☐ Gifted ☐ English as a second language ☐ Resource room ☐ Special education ☐ Private/independent school ☐ Home schooled ☐ After school homework club ☐ Learning disability ☐ Language impairment ☐ Behavioural problems or ADHD ☐ Individualized education program (IEP) ☐ Resource teacher ☐ Student support program ☐ Personal support worker

Confidential

7. Has your child ever had a diagnosis of or treatment for any learning problems? ◯ No ◯ Yes

8. Are you and/or your child currently participating in:

☐ Individual Therapy ☐ Family Therapy ☐ Parent Training ☐ None of these

9. Is your child currently taking any prescribed medication? ◯ No ◯ Yes

Stimulant ADHD Medication:

☐ Adderall (Amphetamine and Dextroamphetamine)
☐ Ritalin (Methylphenidate)
☐ Ritalin SR (Methylphenidate)
☐ Concerta (Methylphenidate)
☐ Biphentin (Methylphenidate)
☐ Dexedrine (Dextroamphetamine)
☐ Dexedrine Spansules (Dextroamphetamine)
☐ Vyvanse (Lisdexamfetamine dimesylate)

Non-stimulant ADHD medication:

☐ Strattera (Atomoxetine)
☐ Intuniv (Guanfacine)
☐ Clonidine

☐ Risperdal (Risperidone)
☐ Seroquel (Quetiapine)
☐ Zyprexa (Olanzapine)
☐ Zeldox (Ziprasidone)
☐ Invega (Paliperidone)
☐ Abilify (Aripiprazole)
☐ Clozaril (Clozapine)
☐ Prozac (fluoxetine)
☐ Paxil (Paroxetine)
☐ Luvox (Fluvoxamine)
☐ Celexa (Citalopram)
☐ Cipralex (Escitalopram)
☐ Zoloft (Sertraline)
☐ Anafranil (Clomipramine)
☐ Wellbutrin (Bupropion)
☐ Zyban (Bupropion)
☐ Lithium

☐ Other

Other - Please specify: _____

10. Has your child taken any stimulant medication(s) within the past 24 hours? ◯ No ◯ Yes

11. Does your child play videogames? ◯ No ◯ Yes

Confidential

If yes, how often does he/she play in a week?	◯ Never ◯ Once a week ◯ 2/3 times a week ◯ 4/5 times a week ◯ Every day
What category of games does he/she play the most?	☐ Puzzle based games ☐ Sports ☐ Educational ☐ Battle ☐ Strategy / Problem solving ☐ Action / Adventure ☐ Other
Other, please specify	_____
Please name the video games you play most often.	_____

** Please remember not to disclose your child's randomization status (the treatment group he/she is assigned) to your child's teacher, or anyone performing assessments during the study visits at SickKids. This is a blinded study which means that we would like certain individuals not knowing the study treatment your child is receiving in order to get unbiased study results.