

Assessing the impact of working memory training on ADHD teenagers in a secondary school

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Abstract

This practitioner sought to assess the impact of a working memory training intervention on students presenting or diagnosed with ADHD symptoms. This intervention took place in a small group and 1:1 setting. The aims were to:

1. Identify common deficits in academic attainment owing to the impairments of ADHD symptoms.
2. Assess the efficacy of a working memory training intervention on addressing these impairments.
3. Observe the extent to which far-transfer effects from this training was noticeable in the classroom.
4. Explore the possibility of a school-wide working memory training intervention programme being implemented long term by staff.

The selection criteria for students involved in this pilot intervention was limited to students who acutely presented or were already diagnosed with ADHD symptoms. The selection criteria was narrow to select students whose academic attainment was observed to be affected by ADHD symptomatology. Questionnaires were completed before and after by teachers to identify possible candidates in the former and to assess impact in the latter. Comprehension tests and examination data of participating students was collected prior to and following the intervention. Through partnerships with colleagues and parents the implemented intervention was an 11-week self-devised Working Memory Training (WMT) program that challenged attentional and memory function. Each pupil received 2 hours 15 minutes of working memory training per week split between a 1hr 1:1 once a week, and five 15-minute sessions per school day. The WMT

training program devised combined sustained reading as a group in the 15-minute daily sessions and WMT training games played individually in a 1 hour 1:1.

Contents Page

Abstract	2
Table of Contents	4
Introduction	5
Literature Review	
Attention Deficit Hyperactivity Disorder	8
Working Memory	16
Working Memory Training	20
Working Memory Training for ADHD Students	24
Limitations in the Literature	25
Methodology	29
Ethics	31
Pre and Post-Tests	32
The Intervention: Working Memory Training	34
Findings and Analysis	41
Discussion	60
Opportunities for Further Research	65
Professional Development	68
Collaboration	70
Conclusion	72
References	73

Assessing the Impact of Working Memory Training on ADHD Students

Inattentiveness and attention deficit hyperactivity disorders are one of the most diagnosed neuropsychiatric disorders among school-aged children (Athanasios Koutsoklenis et al. 2020). The link between attention deficit hyperactivity disorder (ADHD) and working memory has gained substantial interest in the field of education (Martinussen et al, 2005; Gathercoe et al. 2008) owing to the important role attention and working memory play in the academic development of students. Studies have emphasised the role of attention control in memory as a crucial predictor of exam success (Cowen, 1999). Furthermore, working memory is considered definitive in predicting academic achievement (Alloway & Alloway, 2010). Both can be adversely impacted by the presence of inattentiveness and hyperactivity (Brown, 2009) and therefore presents a cause for concern for practitioners in the field of education.

The prevalence of ADHD in school aged children in the United Kingdom is thought to be between 2% to 5%. In my school ADHD diagnosed students account for 23.25% of the SEN student register and 5% of the school cohort. Concern for the school's ADHD students is prevalent across my academic institution. Both my colleagues and our parents frequently reference evidence of poor academic progress in these student's learning. Academic institutions like mine are ranked on their ability to equip students with sufficient information to attain highly at examination. One function of a school monitored by teachers and parents is to attain Key Stage goals based on the demonstration of appropriate content knowledge. Attention and working memory are key enablers of that process.

Studies suggest efficient attention and working memory are indicative of optimal exam performance (Koutsoklenis, 2020). This is explained in research conducted by Mishna, Bavelier and Gazzaley (2012) who identify a student must select goal-relevant information and reject task-irrelevant information, this is the function of attention. Then, a student must hold goal-relevant content in their memory for later use, this is the function of working memory. They build upon a growing number of studies that claim, attention and working memory capacity can be improved by training. In light of these studies, it was agreed I would lead an intervention for 8 students diagnosed with ADHD. The agreed intervention targeted the attentional control and working memory of students to a task using sustained reading and a variety of non-computerised working memory training games. The purpose of this pilot intervention was to assess the efficacy and feasibility of using WMT to improve cognitive performance across transdiagnostic areas of concern. Through partnerships with colleagues and parents I implemented an 11-week self-devised Working Memory Training (WMT) program that challenged attentional and memory function. Each pupil received 2 hours 15 minutes of working memory training per week split between a 1hr 1:1 once a week, and five 15-minute sessions per school day. The WMT training program I devised combined sustained reading as a group in the 15-minute daily sessions and WMT training games played individually in a 1 hour 1:1. The purpose of creating a high-volume contact time program was to give substantial visibility to the program, aiding an increased buy-in from the participants and stimulating feedback from teaching staff of any changes noticeable in the classroom.

Retention rate of the training was 100% with many students reporting an increased enjoyment of reading and subject specific knowledge of the book. Assessing the impact of working memory training on ADHD students did not lead to a singular conclusion of increased academic attainment. Monitoring the progress of participants produced a range of progress areas. I have collected these into three categories; increased organisation, improved attention and increased self-efficacy.

An increase in self-efficacy was an unpredicted outcome reported. Students demonstrated engagement that extended beyond the formal training sessions, moreover, intervention students began to teach their peers a series of the card games learnt in the 1:1 session. Interestingly, this intervention was significant in its qualitative increase of student self-efficacy and motivation. Through teacher and parent reports it is possible to conclude that this type of intervention has the potential to improve quality of school experience for ADHD students and impact positively on student confidence and self-belief. However, a significant main effect between WMT and increased attentional and memory function for classroom progress was not found. The limitation of the intervention was in observing the transfer of attentional and memory function from the trained task to diverse demands in the classroom. Where improvements in trained processes were measurable, far-transfer of improved cognitive processes to differential tasks were not. However, methodological issues such as insufficient measurements of ability and differentials of assessed skill have been argued to complicate the interpretation of transfer effects (Donk et al, 2016). It is this researcher's opinion that the inconsistencies in measuring far-transfer effect does not negate the benefits of WMT on cognitive processes that support classroom progress

(Shipstead, Redick, & Engle, 2012). The following study seeks to fully assess the impact of working memory training on students with ADHD.

Literature Review

Attention Deficit Hyperactivity Disorder

The diagnosis of ADHD is an increasingly controversial debate with many misconceptions surrounding the disorder (American Psychological Association, APA, 2017). On one side, ADHD is recognised as a serious psychiatric condition accounted for by genetic differences (Faraone & Larsson, 2018) and on the other, ADHD is argued to be provoked by chaotic environmental factors (Nigg, 2017). Moreover, further uncertainty between researchers is evident, for example, Sami Timimi goes as far as saying 'ADHD is *not* a diagnosis...it is a description of certain behaviours that occur together' (Timimi & Leo, 2009). When attempting to define ADHD, professionals will employ the *Diagnostic and Statistical Manual of Mental Disorders*, referred to henceforth as DSM-V. With reference to the DSM-V, ADHD is recognised as "a neurodevelopmental disorder that interferes with executive functioning or cognitive development" (DSM-V, 2017). Current estimates place the global number of those diagnosed with ADHD between 8% to 11% with school aged children accounting for 2% to 5%. The interference with executive functioning and cognitive development, as outlined in the DSM-V definition, is of concern for those tracking the progress of school aged children. Meeting the DSM-V definition for ADHD stipulates that reasonable adjustments are made in the United Kingdom under the Equality Act 2010. Under this Act, ADHD is classified as a disability and not only are schools required to provide accordingly to accommodate this individual difference, but the SEND

code of practice also stipulates 'local authorities must work to integrate educational provision with health and social care provision' (Section 3.13). Recent estimates suggest ADHD represent 13% of all youth receiving school-based services to support deficits in the areas of executive functioning or cognitive development. The criteria to meet the DSM-V defined ADHD diagnosis is fit to three main symptoms; inattentiveness, hyperactivity and impulsivity. The first of these, inattentiveness, can be recognised as the inability to remain focused on a task, the struggle to persist through difficulty to complete a task and a difficulty to be organised. The second described symptom is hyperactivity which is observed through behaviours that involve fidgeting, restlessness and calling out. Finally, impulsivity is recognised as a prevalent symptom of ADHD and described as 'making decisions without appropriate consideration of the physical, emotional or financial consequences prior to acting' (DSM-V, 2017). Despite this criterion being available, the *Updated European Consensus Statement on diagnosis and treatment of adult ADHD* suggests ADHD is currently "underdiagnosed and undertreated in many European countries, leading to chronicity of symptoms and impairment" (Kooij, et. Al. 2018). As stated previously, the definitions for diagnosis are wide ranging and conflicting, with a stigmatised language basis defining the condition as 'deficit' and 'disorder'. In historic literature, psychoanalytic explanations of ADHD were met with dissatisfaction and disillusionment (Weatherwax and Benoit, 1962) because the lack of effective treatment. This led to interpretations of the condition being viewed as a biological defect (Still, 1902) resulting from pre- or postnatal brain damage. Early pioneers in stimulant treatment for ADHD fuelled this belief of ADHD sitting firmly within a study of biological treatment and linked brain damage with hyperactivity in children. This

early literature identifies these behavioural patterns and educational failings as the 'nature of the brain-injured child's deficit' (Strauss and Werner, 1943). This brought a stigma to the diagnosis and limited it to the category of 'childhood disorder' linked to brain damage, rather than understanding it as a developmental challenge that spans across adult life (Schmidt & Petermann, 2019). However, notes of change in the literature with reference to both concept and terminology of ADHD are evident by 1960. Studies began to emerge citing motor excess, with a greater emphasis on hyperkinesias or hyperactivity (Chess, 1960). The nuances of ADHD in a new collection of literature began to approach ADHD as a grouping of behavioural difficulties, for example Douglas (1983) contributed to the revision of the DSM-III on account of his work identifying specific symptoms of the disorder. Nigg (2017) argues that the change to symptomology was the catalyst to a reconceptualization in diagnostic labelling of ADHD. The semantic development made at this time was to redress the terms as ADD and ADHD, the former 'Attention Deficit Disorder' is considered to present without hyperactivity and the latter 'Attention Deficit Hyperactivity Disorder' is considered to present with hyperactivity. The semantic shift brought about a greater heterogeneity in the diagnostic criteria of ADHD labelling and increased accessibility to sufferers of the symptoms. Arguably this had a positive impact on the cultural acceptance and explanation of symptoms. However, Hoff (2002) argues it weakened the legitimacy of ADHD labelling, reducing it to a catch-all diagnosis (Hoff et al., 2002). There is a pervasive acceptance within the field of research on ADHD that assessment and treatment delineations vary widely. By early 2000, explanatory concepts of ADHD were well defined, but a neurobiological formulation of ADHD was not precisely agreed upon. For example, advances in neuropsychology using

laboratory findings from clinical groups observed mechanisms of over or under arousal of the central nervous system leading to labels of 'state regulation deficit' (Sergeant and Van der Meere, 1990). In other words, Van de Meere makes the case that factors such as presentation of stimulus, reward and external control are more indicative of children's attentional control than their ability. He suggests that whether a child can sustain their attention or not is dependent on whether a task is deemed interesting by the child (Kronenberger & Meyer, 2001). If a task can 'tap the state' of a student it is unlikely that symptoms of a hyperactive disorder will emerge. In contrast to the conflation in neuropsychology between genetic and environmental variance, opponents from molecular genetics suggest little evidence for the impact of shared environmental factors and instead emphasise the aetiology of 'highly heritable' ADHD symptoms. These genetic studies look for associations between a genomic region and disordered behaviour (Waldman et al, 1998). Such studies are focused on the casual effect of the gene in isolation rather than findings extracted from population stratification artefacts (Faraone et al., 2001). Therefore, the developments in the literature are siloed into reductionist channels that whilst extending explanation cannot reach agreement on a universally applicable formulation of ADHD.

I am interested in recent developments in the literature that point out the limitations of these reductionist definitions. For example, Nigg (2017) cites a "next-generation" scientific approach to the understanding of ADHD (Nigg, 2017). Nigg argues that ADHD is more than inattentiveness or hyperactivity, he argues for a redirection of the literature toward 'self-regulation' where we are to understand that active or inactive expressions of the genome are modified by the environment (Howard, 2018). In other words, ADHD is more than a genetic

predisposition or a fixed environmental state and instead, genes that contribute to ADHD tendencies can be switched off or on by environmental factors. This field of study is called epigenetics and has further impacted the definitions of ADHD from its first iteration as an attention problem. Nigg argues, readdressing how science communicates about ADHD is important because the impairments related to ADHD go beyond the narrow definitions given to teachers and parents. Rather, ADHD involves a complex interplay of biology, genetics, epigenetic effects, and environmental influences (Nigg, 2017). There is heterogeneity of symptoms, concepts, and language because the interplay of ADHD features is widely agreed to render distinct observations in behaviour, for example some children can be hyperactive and others underactive. However, a feature shared in the literature between researchers is that inattention, hyperactivity and impulsivity reflect one or multiple deficits in the domains of executive functioning (Alloway et al., 2009). Self-regulation offers an avenue towards appropriate intervention. Self-regulation refers to the skill to enact certain brain activity patterns that combat the perceived behavioural problems associated with the core symptoms of inattentiveness, hyperactivity and impulsivity. Unskilled self-regulation may compromise the provision of resources for attention processes and management of excitability thresholds (Nigg et al., 2005). However, Nigg does not give sufficient credit to where self-regulation has already appeared in the remit of literature on executive function. The work of Barkley (1997) attempted to explain the relationship between ADHD and executive function "towards a final verdict that ADHD is a development disorder of self-regulation" (Barkley, 1997). His argument proposed that the ability to inhibit is the principal discipline which supports all other executive functions. Because learning requires students to

select relevant information and discard irrelevant information, shift between suitable processes to problem-solve and sustain concentration on a task, appropriate development of inhibition is crucial to satisfactory performance in these executive functions. Diamond and Lee (2011) identified a positive correlation between executive function skills and school successes; secure executive function skills predicted reading and math aptitude. There is a consensus that children with ADHD have difficulty detecting, filtering and accumulating information for effective use (Sergeant, 2000). Self-regulation and executive functioning can support these processes with reference to the impact on a student's learning (Overman & Robbin, 2014) because they highlight the cognitive functions within the executive function domain that need improvement. Barkley's model provided a foundation, through the explanation of self-regulation, to conceptualise a relationship between ADHD and executive function. Subsequent researchers have utilised this model to relate successful completion of executive functioning tasks to both school specific expectations and daily demands (Brown, 2006). There are various models for grouping executive functioning skills. Brown (2005) outlines six clusters of cognitive function: activation, focus, effort, memory, emotion and action (Brown, 2005).

Of these clusters that recognises the neurological deficits underlying ADHD, the role of working memory has received particular attention (Willcutt et al., 2005; Martinussen & Tannock, 2006). The research is confident that executive function is substantially impaired by ADHD (Minear & Shah, 2006; Alloway et al., 2009) and further to this, impairment impacts more complex cognitive functions and 'core behavioural symptomatology characteristics' (Chacko, 2013). For

example, frequent failures are observed in organisation, prioritisation and commencement of work (Brown, 2006). Cognition and other complex executive functions play a crucial role in academic attainment (Gathercole et al., 2004). Jaeggi suggests executive function deficits act as the *primary* source of cognitive impairment (Jaeggi & Buschkuhl, 2013). This cognitive impairment leads to poor academic attainment because students with ADHD experience consistent hinderance to their executive functioning. For most students diagnosed with ADHD there are only a few academic areas that are not adversely affected by impaired executive functioning. Nigg outlines that activation is disrupted when staying on task. Focus is distracted when initiating or sustaining concentration. Working memory encounters issues with both short-term retrieval and long-term storage of information. Self-regulation is overwhelmed with stress, anxiety and mismanaged soothing strategies (Sroufe, 2020). Finally, action is compromised with marked impairments in inhibitory behaviour (Nigg, 2001). These negative associations are often recognised by teachers through problematic behaviour such as becoming distracted, forgetting teacher instructions and insufficient work (Alloway et al., 2009). Consequently, problematic behaviours arising from ADHD and limitations to executive function typically become the defining feature of diagnosed students while in the classroom. Dawson and Guare (2009) describe students with executive function deficits as 'smart but scattered' and this leads to various inappropriate social and school behaviours. The term 'smart but scattered' implies a co-occurring deficit; the internal processes of thinking and listening ('smart) and the external presentation of behaviours ('scattered'). The Child Mind Institute suggests that students with ADHD are recognisable in both the internal and external signs of ADHD (2015). Owing to the impact of ADHD on

a student, individuals have difficulty adjusting appropriate attention, emotion, thought processing and behaviour to match school specific expectations, or their own goals. Nigg explains this as "sluggish cognitive tempo" (Nigg, 2017) rather than problematic behaviour. Literature like this is important to challenge the views held by teachers who can view ADHD students as "socially intrusive" (National Institute of Mental Health, 2020) and deliberately choosing of interruption in the classroom. The motivation of those investigating self-regulation is to positively reframe the language of ADHD diagnosis and treatment (Strehl et al., 2006). This language basis empowers the student to effectively learn to regulate their brain activity for increased success enacting executive functioning demands (Gevensleben et al., 2014). The commonly held perception of ADHD students as 'socially intrusive' may in part explain why students with ADHD have shown significant association with school failure, poor academic outcome and lower socioeconomic status (Kirby, et. al. 2005). A 2018 study to investigate the cognitive and functional outcomes that a childhood ADHD diagnosis predicts in adulthood reported that diagnosis of ADHD in childhood predicted a greater variety of worse outcomes (Taylor, et. al. 2018). This longitudinal study reported that diagnosed childhood ADHD correlates to young adult negative outcomes including executive dysfunction (Biederman et al., 2007) and lower levels of functional independence (Barkley, Fischer, Smallish, & Fletcher, 2006). According to Biederman, students with ADHD are three times more likely to have to repeat an academic year and still underperform in contrast to their non-ADHD peers (Biederman et al., 2004). Given that ADHD predicts several poor outcomes for students, a range of interventions have been explored, for example, behavioural therapies, pharmacological medication (most commonly stimulants),

working memory training (Swanson & Jerman, 2007) and other cognitive training programs (Gray et al., 2012). Of these, working memory training is an intervention being actively disseminated for clinical use in routine practice and has recorded moderate improvements (Gathercoe, 2008; Holmes et al., 2010; Dahlin, 2011; Overman & Robbins, 2014; Donk et al., 2016).

Working Memory

Working memory is believed to be a central component of executive function and is understood by Baddeley (2010) to be a "limited-capacity, multicomponent cognitive system". This 'limited-capacity' system only temporarily allows the brain to hold on to and manipulate information for response or use in the imminent context. The model conceptualised by Baddeley and Hitch (1974) and later extended by Baddeley (2000) proposes that Working Memory has three distinct components. There are two systems named the phonological loop and the visuo-spatial sketchpad that act as storage and another component named the central executive that acts as a control system. Each of these is considered to perform a unique function; the phonological loop is part of the working memory responsible for retaining verbal information in mind, and the visuo-spatial sketchpad acts a system responsible for retaining visual and spatial (non-verbal) information in mind. The central executive was devised by Baddeley to explain how this information is regulated and is responsible for the flow of information, coordinating the execution of two or more tasks and links information to the long-term memory (Baddeley, 2000). Unlike long-term memory, working memory only allows temporary storage of information, if the information is not used or 'rehearsed' it leads to decay of that information (Feifer, 2016). Working memory therefore is a

key controller to complete various cognitive demands, for example remembering instructions for successful completion of tasks and retaining academic information relevant to learning processes in a lesson (Nigg, 2006). For students who have been diagnosed with ADHD, impairments across all three components of Baddeley's model have been found (Rapport et al., 2008), leading to lower working memory capacity (Minear & Shah, 2006). Working memory is a predictor of academic outcome and educational success; Alloway argues it is more definitive than measures of intelligence when predicting scholastic achievement (Alloway & Alloway, 2010). Working memory is defined by Holmes et al. (2010) as "the cognitive system responsible for the temporary storage and manipulation of information, [and] is crucial for maintaining focused behaviour in practical situations". It is believed students differ in the scale of this temporary storage and manipulation (Ball et al., 2021). Moreover, owing to working memory comprising multiple cognitive processes, aspects of working memory such as control of attention are related to accurate storage and manipulation of information. Individual difference in working memory have been linked to individual differences in attentional control (Gathercole & Baddeley, 1993). It is argued, if poor attention control is found, resulting problems occur in the regulation of the contents of working memory which impedes academic success. A 2008 study found that those with ADHD encountered significantly more difficulty compared to a control group when required to overcome interference to hold onto information in the working memory (Englehardt et al., 2008). Other studies similarly report working memory deficits in ADHD adolescents, particularly when compared to a control group, for example a study compared ADHD and non-ADHD verbal and visuo-spatial working memory performance with the findings concluding a significant

impairment visible for ADHD adolescents (Martinussen et al., 2005). These impairments to working memory are associated with ADHD symptoms and impose limits on students' ability to remember instructions, organise themselves and sustain attention. However, although Baddeley deems working memory to have a limited capacity, researchers believe working memory capacity is not fixed, as previously thought. Klingberg (2002) has reported that the plasticity of the brain and the capacity of working memory can be improved through intensive training. Finding treatments to alleviate the effect of ADHD symptoms is a focal point of many clinical studies. Currently, pharmacological usage outweighs other interventions owing to the empirically measurable effect it produces. However, once stimulants are withdrawn their benefits also disappear. The development of other treatments to ameliorate the symptoms of ADHD and build upon the findings of Klingberg are promising for the uptake of brain training. In addition, Nigg has identified the negative impact of cognitive load in decreasing working memory capacity. Therefore, cognitive training, including central executive training, working memory training and attention control training, have been a proposed route of nonpharmacological treatments. These types of training tend to take the form of regular, adaptive training exercises on generic neuropsychological tasks e.g. reading (Christopher et al., 2012), sequencing (Pimpterton & Nation, 2010) and memorising (Nigg, 2000). Researchers suggest this type of training can ameliorate the effect of ADHD symptoms by training the brain to accommodate a greater cognitive load and exercise the systems found in Baddeley's working memory model; the phonological loop, visuo-spatial sketchpad and central executive to work at a higher efficacy.

This collection of 'next generation' cognitive training protocols are proposed to overcome the deficits experienced from ADHD because of improved targeting (Kasper, Alderson, & Hudec, 2012). Central executive training, behavioural parent training and new working memory training are deemed 'next generation' because they seek to enable treatment group improvements rather than decrements of symptoms (Redick, 2015). Recent literature has critiqued training protocols as insufficient because they have targeted a working memory system unrelated to the disorder's phenotypic expression (Rapport et al., 2013). This misspecification in the training target was argued by Rapport (2013) to focus too exclusively on simple storage of short-term memory rather than the 'working' behind working memory. Working memory is a multi-componential process constructed of dual-processing, continuous updating, and serial reordering of information (Wager & Smith, 2003). The cognitive characteristics at work to enable working memory are argued by Chacko (2014) as differential to short term memory, which he considers the simple maintenance of stored memory. Instead working memory is the processing and maintenance of stored memory. Thus far, working memory training protocols have not received recommendation as an educational tool (Sala & Gobet, 2017) because they do not train working memory (Roberts et al., 2016). However, Kofler argues that ADHD literature has not placed sufficient demand on the specific processes impaired by ADHD and the next generation training protocols will overcome this. He identifies three primary processes to target; dual-processing, continuous updating and series reordering (Kofler, 2018). These collectively are expounded by Baddeley (2007) as the central executive, in essence the 'working' components of working memory. In neuropsychological literature the central executive is a network of synaptic brain activity originating

from the midlateral prefrontal cortex (Nee et al., 2013). Wager and Smith (2013) give deeper insight to these interrelated processes. Dual-processing acknowledges that information is concurrently being acted upon and stored, continuous updating relates to the process of adding or deleting information from the working memory, and serial reordering refers to the sorting and sequencing of information for coherency. This research compels any practitioner wishing to take on a working memory training intervention to target improving the central executive processes behind working memory rather than the practice of remembering as a singular target. Central executive training remains in a developmental stage with nuanced differences from other cognitive training interventions. It is therefore appropriate to explore secure literature in the field of working memory training to support a self-devised cognitive training plan by this practitioner.

Working Memory Training

Working Memory Training seeks to improve working memory function. The development of working memory training (WMT) was based on the association between working memory capacity and effects on other areas of cognition (Melby-Lervag et al., 2016). A study by Pugin et al. (2015) detected synaptic plasticity on an electroencephalographic following three weeks of working memory training. The changes WMT produced were positively correlated to improved working memory, leading Pugin to conclude that working memory is trainable (Pugin et al. 2015). Other studies concur with these findings, reporting that working memory is malleable and if improved can enhance future learning potential (Bergmann et al., 2017) and that increased activity has been detected following WMT in regions of

the brain responsible for executive function (Stevens et al., 2016). The field of research on WMT primarily targets working memory processes through repetitive training. The aim of this training, however, is to produce generalised results that impact a learner beyond the trained domain, in effect to 'transfer' the skills obtained in training to other areas of cognition. It is debated to what extent such a transfer from a trained to untrained context has been demonstrated (Owen et al., 2010). Considering this, researchers have divided transfer effects into near or far (Willis, 2001). Near transfer refers to the trained task having a positive effect on non-trained but closely related cognitive tasks and far transfer means the trained task has a positive effect on a non-trained distinctive cognitive task (Zelinski, 2009). Jaeggi, argues there is ample evidence for the presence of near transfer effects in WMT but limited literature to conclude WMT has far-transfer effects on cognition. Many WMT studies have begun to point towards far transfer effects, even if like Karbach, positive far transfer was limited to one specific cognitive function in reading and did not improve maths (Karbach et al., 2015). Far transfer effect was reported in improved decoding mathematical word problems by Cornoldi (Cornoldi et al., 2015) and by Spencer-Smith & Klingberg for increased attentiveness (Spencer-Smith & Klingber, 2015). Orsolini studied the impact of WMT on generalised problem solving and reported effective transfer of mastery to problem-solving distinct from the original WMT task (Orsolini et al., 2019). Finally, Malby-Lervag (2016) demonstrated improvements for both phonological and visuo-spatial working memory following WMT (Malby-Lervag & Hulme, 2016).

A meta-analysis of a range of WMT literature highlighted a consensus between researchers that its effect is debatable. However, certain interventions measured more impact than others. For example, interventions that either led to or were based on reading comprehension improvements had a higher success rate in group difference from pre to post test (Henry et al., 2014). Based on the research, neuropsychology evidences an established relationship between reading comprehension and working memory abilities (Henry et al., 2014). Another study that sought to improve recall and processing also demonstrated some success for children with reading difficulties (Cain et al., 2004). Additional findings suggest that working memory training, specific to reading comprehension, benefits the capacity of a learner to choose and retain relevant information whilst inhibiting irrelevant information (Melby-Lervag & Hulme, 2012). Chein & Morrison (2010) generated results from their working memory training that evidenced a correlation between verbal working memory increases and reading comprehension improvements. Studies like this are encouraging to hypothesise the transfer effect from working memory training to other cognitive functions integral in the learning process, which justifies it as a beneficial use of teacher time to support student ADHD students. This justification is further expounded by Chein & Morrison who put forward a compelling case for the transfer benefits to multiple 'domain-general mechanisms' in their working memory training (Chein & Morrison, 2016). Other studies have shown that WMT benefits do extend to other working memory processes, for example, Dahlin when using reasoning tasks (2008) inferred an impact on the feature of the central executive that support working memory updating and Klingberg when using reading comprehension tasks (2005) measured an impact on the efficacy of cognitive control (inhibitory control). A large

portion of literature is dedicated to Cogmed working memory training. Cogmed is a commercial cognitive-training program (Pearson, 2016) consisting of computerised programs designed to enhance working memory capacity and by extension increase overall cognitive function and academic achievement. Its claim is far-reaching, proposing its software increases performance across a range of settings by improving attention, reading, maths, cognitive control and functioning. Three significant evaluations of these claims via meta-analysis have been conducted (Spencer-Smith and Klinberg, 2015; Nutley and Ralph, 2012; Aksayli, Sala and Gobet, 2019) and they differ in their focus and scope of studies included. Nevertheless, they seek to interpret the mixed findings and draw a conclusion. However, this conclusion sits between claims of the optimistic (Shinaver et al., 2014) and the insufficient (Simons et al., 2016). A consensus in the examination of Cogmed working memory training is that it does not enhance working memory capacity (Aksayli et al., 2019) however, it may slightly enhance student's ability to perform in a specific class of tasks. Shipstead concedes the training might enhance efficiency to perform similar tasks in other settings therefore alleviating cognitive load and supporting learning outcomes (Shipstead et al., 2016). Furthermore, a positive discovery for this study is that research suggests WMT, including Cogmed, is most effective in populations who require most improvement and therefore WMT could be recognised as a beneficial intervention for ADHD diagnosed students (Farcas & Szamoskozi, 2016; Kofler et al., 2019).

Working Memory Training for ADHD Students

WMT has yielded inconsistent results and inconclusive effects on near and far transfer skills, apart from in the domain of ADHD (Passarotti et al., 2019). A sufficiently sized range of literature exists to investigate and implement WMT for ADHD students. One such implementation observed an improvement of reading fluency in students between 10 and 16 years after a computerized WMT game (Passarotti et al., 2019). This result is supported by studies showing positive 'far transfer effect to reading' following similar WMT (Dahlin, 2011; Holmes & Gathercole, 2014). Recent studies with a focus on younger school aged pupils conducted in America account for a significant increase in working memory and numeracy skills (Capodjeki et al., 2018) whilst a similar study of Reception age students demonstrated improved fluency with non-trained tasks on completion of the WMT (Zhang et al., 2019). However, the limitations of these programs of training are also documented. Questions have been raised concerning the usefulness of WMT if the far transfer effects remain minimal or absent (Kassai et al., 2019; Aksayli et al., 2019). This recent study reflects the assertions made by Jaeggi that WMT leads to near transfer effects but lacks effectiveness in enhancing far transfer effect. Kassai states that WMT does not generalise to untrained tasks (Kassai et al., 2019). Although these results have remained inconclusive, the adaptive multi-functional computerised system of Cogmed has produced a trend that was promising in the efficacy of improved executive function, soecific to ADHD sufferers (Kazemia & Mohammadi, 2019). Unlike Kassai's findings, studies using Cogmed WMT over a consistent period for a sustained timeframe is believed to target ADHD deficit areas. Positively impacted areas range from reducing the symptoms of hyperactivity through to improved

executive functioning. In addition, observations were documented by Chacko (2018) and Egeland (2013) to show improvements in the areas of working memory processing and phonological fluency respectively. In addition to *cognitive* far transfer there is a range of Cogmed literature to suggest WMT, by alleviating cognitive load, improves behaviour related ADHD, for example a greater sustained attention span, adaptability to change and a reduction in impulsivity (Bigorra et al., 2016). Finally, a very compelling study concluded Cogmed has acted as an equaliser between ADHD and non-ADHD in executive function. This study measured performance from both groups and determined achievement to be the same (Ackermann et al., 2018). Equalising the academic outcome potential of ADHD and non-ADHD students is a priority of educational practice in our current climate.

Limitations in the Literature

It is important to note that a limitation in the wealth of research on WMT is that few interventions have been carried out in a school setting (Wiest et al., 2022). Wiest acknowledges that these interventions lack any examination of children receiving this training in school. In other words, the examined training effects occur outside the school setting, and this limits the accuracy of information available in the research to inform any ongoing benefit to academic achievement and outcome. It also may inform recommendations of evidenced-based education towards a direction that is not specific to the protocols or processes of school-based learning. Wiest states that research of cognitive training protocols within school settings are desperately needed. I could find only 1 study using a working memory training intervention within a school setting (Bennet, Holmes & Buckley,

2013). This training was administered to Down Syndrome children by Teaching Assistants to assess if it could reduce the memory difficulties associated with Down Syndrome. In 2013 this was the first and only study to assess WMT for Down Syndrome, the results were positive for parent-rated behaviour following treatment (with a reduction in problem behaviours associated with executive function visible) and for boosting performance on visuo-spatial short term memory tasks. Future research suggested by Bennet, Holmes and Buckley identifies the preliminary observation of improved attention shifting that could be trained to enable improved processing of multi-component task instructions or accommodation behaviours for upcoming change.

The school setting is very important when assessing improvements and developments in social, academic, or behavioural outcomes. Distinct from a clinical setting, teachers have the potential and longevity to observe, to know and impact a pupil from a variety of skilled bases; academic, sporting, creative, social, and familial. Missing from the literature of working memory training is the role of the school as a distinctive social institution in which extrinsic questions are implemented in a temporal, spatial and social pedagogical order (Brinkmann, 2021). The lived time and space of a school, inclusive of the role of a teacher are argued by Brinkmann to be productive in and of themselves. He uses a pedagogical phenomenological model to expound the belief that schools "enter into active and productive communication with other social spheres and practices ... to play a decisive role in society" (Brinkmann, 2021). Arguably many of the symptoms of ADHD have a social impact; organisation, attention, inhibiting. Moreover, ADHD can be promulgated by environmental variance and factors,

meaning it is important to consider the student's learning time and space as two significant effects on outcome. Brinkmann's reference to time is significant because the diagnostic criterion identifies ADHD sufferers as 'getting lost in time' or having poor time management. Langeveld argues that schools demand expectations that are essentially 'un-childlike' based on the belief that 'time' as a concept is determined differently by adults as it is children. This means that a child can lose track of time, or get lost in its winding maze, yet in contrast the time of a school is linear and measurable. The politics of time are arguably alien to a child and can prove difficult to be learnt. Brinkmann's second reference, to space, explores the compulsory pre-existing structures that act as an embodied-spatial dimension for the student (Brinkmann, 2021). Pupils are expected to sit for long periods of time, to complete tasks and to collaborate with others they have not chosen to work with. Phenomenologically, the school is both a communicative space of teaching and learning and a space of social interaction. Both will affect the student's interpretation of the world and their questioning of it. It is relevant then, as schools are store houses of questions, to note that within the school space there have been shifts in meaning making and models of truth; Fink argues the modern human being exists in a world of increasing pluralisation and retreating traditional, cultural and religious norms (Fink, 1970). This state of play he argues dresses educational aims in the robes of production, absent of meaning, therefore schools are not determined by related traditions but are a distinct political institution of production (Fink, 1960). In order to perceive meaning in the conditions of pluralisation and relativism there is a need for counsel, or goal-setting. Fink articulates that 'humans draft their human-goals as the conscious production of sense and meaning' (Fink, 1970). Goal-setting here is seen as the

development of action in response to deficit, it cannot be viewed as empirically-based such as pharmacological interventions but instead students are shaped by the counsel of the community they are situated in. This is relevant to adolescent ADHD intervention in a secondary school context because cognitive development at this stage is characterised by identity formation and an increasing need for meaning-making factors to decide upon identity (Dawson, 2009). As the practitioner lead on this intervention my belief is that any positive outcomes are inextricably linked to the relational influence and investment of the student's school community. Diamond (2014) whilst investigating the interventions most successful in affecting executive functions references the impact of relationship. He says that interventions should increase joy and feelings of social inclusion if they are to successfully mitigate the negative consequences of ADHD symptoms or symptom related stress (Diamond, 2014). Support is key to the flourishing of a student (Diamond, 2014). Other research reiterates this, suggesting that the role of an advocate or the presence of good counsel in a student's life can both increase student engagement (Kubina, 2000) and improve their functional outcomes (Smith, 2005). The link between the social (akin in the phenomenological literature to the religious or traditional) and the psychological is under explored and presents a gap in the literature for further investigation.

Methodology

The purpose of this mixed methods practitioner intervention study was to assess the impact of working memory training on ADHD students. Eight students aged 13 to 15 consisting of 5 boys and 3 girls with a primary diagnosis of ADHD or teacher reported ADHD behaviours were included in this study. The selection

criteria were not rigorous but informed by frequency of teacher concern in relation to SEND status and underachievement. The ethnic diversity included five White, one Pakistani and two Asian participants. A co-morbidity of diagnosis was prevalent with six of the eight diagnosed with a secondary educational need and, further to this, three of the eight held a tertiary SEND. The students were identified following sustained tracking and monitoring concerns with teacher reported underachievement and poor academic attainment in testing windows. Parents were contacted inviting participation; twelve students were invited to participate in the study and eight agreed to attend the 11-week intervention. The letter parents received briefed them on the working memory training proposed and the predicted areas of improvement to be achieved. The vocabulary of the letter did not communicate negative concerns for the student in question or their progress, rather it proposed this as an initiative for personalised improvement.

This practitioner sought to assess the impact of a working memory training intervention on students presenting or diagnosed with ADHD symptoms. This intervention took place in a small group and 1:1 setting. The aims were to:

1. Identify common deficits in academic attainment owing to the impairments of ADHD symptoms.
2. Assess the efficacy of a working memory training intervention on addressing these impairments.
3. Observe the extent to which far-transfer effects from this training were noticeable in the classroom.

4. Explore the possibility of a school-wide working memory training intervention programme being implemented long term by staff.

The selection criteria for students involved in this pilot intervention was limited to students who acutely presented or were already diagnosed with ADHD symptoms. Questionnaires were completed before and after by teachers to identify possible candidates in the former and to assess impact in the latter. Psychometric tests and examination data of participating students was collected prior to the intervention, and examination data was collecting following the intervention. Through partnerships with colleagues and parents the implemented intervention was an 11-week self-devised Working Memory Training (WMT) program that challenged attentional and memory function. Each pupil received 2 hours 15 minutes of working memory training per week split between a 1hr 1:1 once a week, and five 15-minute sessions per school day. The WMT training program devised combined sustained reading as a group in the 15-minute daily sessions and WMT training games played individually in a 1 hour 1:1. The purpose of creating a high-volume contact time program was to give substantial visibility to the program, aiding an increased buy-in from the participants and stimulating feedback from teaching staff of any changes noticeable in the classroom.

This project followed a participatory research approach in which I as a practitioner, in collaboration with colleague teaching staff, implemented an intervention that sought to bring about change, development and improvement. The participatory nature of this intervention sought to move towards change through empowerment,

giving participants and researchers a sense of equal control and ownership (Cohen, Manion & Morrison, 2011). Owing to research that notes student voice impacts and informs teacher practice, prior to the intervention, students were asked to set themselves goals to acquire during the intervention. In parallel with this feedback the methodological design was discussed with the SENCO and SpLD teacher. During this discussion, pupil progress and areas of weaknesses were highlighted. These areas of weakness were primarily related to executive function skill and academic performance; the SENCO and SpLD teacher were able to help specify which ADHD related cognitive deficits were most prevalent and most in need of development during the intervention. Finally, the Maths and English teachers of each participant were consulted to understand engagement in lessons and academic attainment evident in work. This verbal consultation acted as an addition to the questionnaires completed via Microsoft forms. A notice of the intervention and participating students was circulated amongst the teaching staff inclusive of a summary outline of aims, expected outcomes and timeframe.

Ethics

BERA provides seven ethical principles by which research should adhere. These are outlined with reference to the specific context of this intervention:

Consent. Written consent was obtained from the head of school and all teachers were informed of the nature of the intervention. Parents of the students were approached, informed and provided written consent for their child to be included in the intervention.

Transparency. Prior to the intervention, and also outlined on the consent letter, students were properly informed of the nature of the project including the time expectations and how their feedback on the intervention would be used.

Right to withdraw. All students were informed they could withdraw at anytime from the intervention and did not have to give a reason to do so.

Incentives. There were no incentives offered as part of this study. Encouragement was given to enable motivation and ongoing participation, this was enacted verbally.

Harm arising from participation in research. Minimising harm was a key consideration; group intervention was conducted outside of school hours to not impact academic progress or social integration. All students were empowered to voice any concerns or stress they might experience immediately.

Privacy and data storage. All data was stored securely with password enabled access only. Participants did not remain anonymous during the intervention however, they were aware of how positively this impacted their classroom experience.

Disclosure. Participants were aware that all or any safeguarding or prevent disclosures must be passed on.

Ethical consent was obtained by CUREC prior to the carrying out of this intervention

Pre and Post Tests

Pre- and post tests were carried out, the first to measure ADHD symptomatology present at home and in the classroom, the second a comprehension test conducted by the SpLD teacher and myself to track reading and decoding fluency

progression. In the first of these tests, parents and teachers were requested to complete a questionnaire to assess the executive function behaviours of the student. This questionnaire was taken from The Behaviour Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000) and completed via Microsoft Forms. The BRIEF is a tool to measure executive function behaviours and specifically employed for students whose age range is 5 to 18 years old. This was disseminated to parents and teachers who responded to a series of questions that measure common ADHD deficit; organisation, working memory, inhibiting and emotional control. On the BRIEF, if the student scores 65 and above it is considered to have clinical significance. The second test was a comprehension exercise conducted in partnership with the SpLD teacher. It consisted of a comprehension, spelling and free writing exercise to gauge reading fluency and command of grammatical techniques. The observations of the SpLD teacher also helped inform the extent of engagement and effortfulness presented. In addition to the questionnaire and comprehension, I observed students in their classroom setting to assess how they presented and engaged over the duration of an hour lesson. This was done by assessing the student's academic engagement time to determine if a student was on task in an active or passive manner, and, alternatively if a student was off task. If they were off task I assessed if their behaviour was characterised as excessive motor behaviour, inappropriate talk or inattentive passivity.

The Intervention: Working Memory Training

I wished to address three research questions:

1. Can WMT alleviate hyperactivity and/or inattentiveness in a classroom setting?
2. Can WMT improve executive function? Specifically Working Memory?
3. Can WMT improve academic attainment?

The terminology surrounding working memory training and the purposes for it risk exposing students to negative reasoning for its introduction and explanation. The ADHD foundation (2022) have emphasised the need for a move away from language that suggests dysfunction or deficit. In addition to language possessing negative connotations, the concepts of executive function and working memory training have an adult basis of comprehension and frequently cannot be 'seen' by teenagers and children. It was important therefore to frame the intervention both simplistically and positively to enable student understanding and preserve student confidence. The design of the intervention had to appeal to the student's attention spans and sense they were participating in something fun and destigmatised. The intervention design had to be innovative to target ADHD students who are historically under-reached in mainstream education and have a higher incidence of school failure and underachievement. The intervention had to use inexpensive and widely available games without reliance on computerised systems in order to increase accessibility and reduce disqualifying barriers e.g. insecure computer use. The design of the intervention had come without complicated methodologies or precluding language so it could appeal to the student and contain the possibility of being shared with others. The intervention

also had to demonstrate a social interaction as this was identified as improving cognition (Carlson et al., 2008). Therefore, I decided upon 5 short group sessions a week, totally 15 minutes each in duration, and a 1-hour 1:1 session with each individual participant. The 1:1 was possible owing to these eight participants following a reduced timetable (consisting of one less subject and therefore allowing for 2-hours of free time per week) to support their special educational needs. It was agreed I would redirect one of their study sessions for WMT. I kept a weekly diary to note significant observations and track the activity completed in each session.

During the training phase, each student received 1.15-hrs of interventionist time. I determined that the 15-minute reading task happened prior to the school day each morning but had to follow the constrictions in the timetable to meet with each pupil during their free lesson. Therefore, there may be variables in pupil engagement and outcome if comparable intervention was received at 9:00am or 3:30pm.

An orientation of the program was provided for each student prior to the first session. They all met outside of a task context to receive instructions and introduce themselves if they had not previously met. It was significant for longevity of participation that students believed they belonged to something, and they were presented with 'quiz books' to signify their agreement to being involved. During the introductory session a cartoon video about working memory capacity and trainability was watched. This helped propel discussion of aims in the upcoming weeks and prompted questions which were answered at that time. In addition, the

book to be read in the morning sessions was introduced and students discussed their experience of it. The book is a widely available and popular children's fiction book. The book's reading age difficulty is considered between 9-12 years old; this falls under the chronological age of the students however, was selected owing to its dynamic characters and memorable visual imagery. For the SEND cohort participating in the intervention, the pitch of the book facilitated a broad accessibility owing to the low reading age of the group and was deemed appropriate as a title. As referenced previously, Fink argues that 'humans draft their human-goals as the conscious production of sense and meaning' (Fink, 1970). Identifying and setting specific goals was crucial for the student's sense of purpose and belonging to the intervention. Using Fink's language that goal-setting is the development of action in response to deficit; actioning goals prior to commencing the intervention was done. Laminated cards with statements were placed on a table and students could either select 2 to 3 goals from the ready-made options or use them as guidance for devising their own. The statements ranged in their focus from "have fun" and "make new friends outside my year group" through to "complete reading tasks in less time" and "feel more confident in lessons".

The intervention took place over the course of 11-weeks and a weekly reflection diary was kept.

Week 1

ADHD learners require information to be presented in short and repetitive modalities to ensure maximum attentional control and retention of information. A visual timetable for the sessions was created to map the activities correlated to the time spent on them. The sessions were constructed of 4 segments with

specific time allocations (Welcome, Retrieve, Read, Reflect), a clock image to accompany each section was used to reinforce the concept of time determined boundaries in each segment. Owing to this intervention being the first of its kind and the non-clinical setting of the intervention, the culture and structure of the sessions was impacted. Adaptations and accommodations were necessary to facilitate the pupil's sense of safety and belonging to the sessions. Week 1 revealed a series of adaptations that were required, first, a 'settling in' time distinct from connotations of 'work'. This adaptation meant on the second morning I introduced a bean-bag throwing game to relax and engage the participants; a bean bag was thrown with a word association game working in parallel. This created mental space to open the book and read in turns. The second adaptation required was the provision of reading rulers to visually track the progression of the text. The most significant observations from the week were orientated around a perception that protocols had to be tightly planned and provided for, owing to inattentiveness continually seeking the next stimulus, and yet conflictingly a requirement for flexibility. Fundamentally, the intervention was alien to its participants and week 1 proved cumbersome a fit to the student's sense of normative school routine. The third adaptation introduced was the transition from a paper quiz to a digital quiz platform. At the end of each week, participants are quizzed on questions relating to the aspects of the book read throughout the week. The second and fourth segments of each daily session 'retrieve' and 'reflect' act as mini plenaries to embed knowledge throughout the week however, it was deemed appropriate to quiz regularly, gamifying the process and establishing a mini-finish line each week to motivate. Following week 1 I transitioned from a quiz

sheet and books to a digital website quiz creator as buy-in for the pen and paper quiz was low.

Week 2 – 10

Weeks 2 to 10 ran in a repetitive routine following the 4-stage program originally introduced. However, additionally introduced were the 1:1 sessions employing a series of non-computerised memory games. Coinciding with the morning group sessions, I conducted 1-hour 1:1s with each student participant. These 1:1s emulated gamified cognitive training interventions that challenge attentional and memory function. The card games used adapted working memory tasks into fun and competitive games that required skills of dual-processing, continuous updating and series reordering.

Between three to five card games were introduced to participating students. The initial game taught is named 'Spit' and requires the player to sequence cards in competition with an opposing player as quickly as possible whilst turning over the remaining cards in front of them to ensure they use their entire hand. This game tests the working memory and executive function of the student in a context of hyperfocus. Moreover, once a card game had been taught, students were not permitted to play the game again unless they could remember the card set up and rules of the game. By employing the student as teacher of the game as quickly as possible their knowledge of it was consolidated and working memory activated to retrieve and store information for use. A second game introduced is named 'Crazy Eights', this helped train fluid intelligence as well as working memory by requiring student to select appropriate cards for successful outcomes in the game. In this game, cards have values that must be identified and matched to other cards held

in the player's hand. This selecting of relevant information and discarding of irrelevant information is a key cognitive training skill for success across many executive function domains. The third game introduced to all participants is named Durak, it is considered a highly skilled game requiring strategic and lateral thinking. The game consists of attacks and defences being made through the presentation of thoughtfully selected cards in a clockwise direction. This multi-componential and highly complex game tested the working memory, attentional control and dual-processing of each of the participants. Card games were introduced one at a time when sufficient mastery of the former had been attained. This meant the cognitive training had an adaptive nature, providing progress for those who had effectively remembered rules of play and elongating consolidation time for those who had not. Five of the eight participants were introduced to all five card games; the remaining two were 'Bridge' and the boardgame Risk. These two games complimented the former games, which had emphasised speed of processing, by introducing problem solving strategy skills that required memory of previous player moves. The winners of the game were recorded following each intervention session to incentivise and affirm participant effort. By gamifying the intervention tools of learning and enabling wide-reach access, students found the games fun to play and worth sharing with non-intervention peers – this further consolidated their working memory of the game set-up and play. Self-initiation was a trend throughout the course of the intervention. Progress through the book was significant and regular quizzing using a digital platform was satisfactory. There were several evolutionary changes throughout the course of the morning session delineation. A significant change was the sense of confidence and leadership the students acquired. Week 3 observed a transition from a solely

teacher-led intervention to a co-production; the students asked to lead the introductory games for the first segment 'welcome'. Additionally, an emergence of self-realisation and awareness was noted by colleagues. One pupil began to initiate with teachers; during week 6 of the intervention, I was told by colleagues that one pupil had sought them out to ask follow up questions from the lesson and about homework set. A final observation during the running of the intervention to mention here was the social bonding between students that occurred; they increased the time spent together in non-intervention times of the day.

Week 11

Week 11 consisted only of the group reading intervention and 1:1s were dedicated to hearing student participant feedback and reflections on the duration of the intervention. In addition to feedback, students were coached on how to continue their independent progress by first, finishing the book – as we did not accomplish this during the session window – and second, continuing investment in learning and teaching new games based on strategy. Each morning in the final week of the group reading intervention the 4-stage model was implemented with consistency however, the quiz session on Friday drew upon a range of knowledge that should have been acquired from the book across the full duration of the intervention, rather than specific to the reading material acquired that week. All participants were given a certificate on completion of the 11-weeks and a positive postcard home to parents.

Following the 11-week intervention, tests were carried out and questionnaires distributed to investigate the perceived impact of the training.

To address research questions one "Can WMT alleviate hyperactivity and/or inattentiveness in a classroom setting?" behavioural points were collected and pastoral briefing minutes were analysed.

To address research questions two "Can WMT improve executive function? Specifically Working Memory?" A parent and teacher rated Behaviour Rating Inventory of Executive Function questionnaire was completed pre and post intervention.

To address research question three "Can WMT improve academic attainment?" A comprehension test was sat and resat, and formal academic test data analysed from before the intervention window (November) and following the intervention window (June).

Findings and Analysis

The purpose of this mixed methods practitioner intervention study was to assess the impact of Working Memory Training on ADHD students.

To address research questions one "Can WMT alleviate hyperactivity and/or inattentiveness in a classroom setting?" behavioural points were collected and pastoral briefing minutes were analysed.

To answer research question one, I began with a broad analysis, which was primarily descriptive, to identify trends in behavioural and pastoral feedback collated in each student's digital records. Prior to the intervention I collected data

on behaviour. Our school sub-divides behaviour into 5 distinctive categories. These are aggressive behaviour towards pupil (including verbal, physical and cyber aggression); aggressive behaviour towards staff; defiance; disruptive behaviour, and, no homework. Behaviour points are accrued based on the points allocated to the incident category.

Behaviour Code	Behaviour Description	Points	Include in Register?	Is this a Bullying Type?
AGP	Aggressive Behaviour towards pupil	1	Y	Y
AGS	Aggressive Behaviour towards staff	5	N	N
DEF	Defiance	2	Y	N
DIS	Disruptive Behaviour	2	Y	N
HME	No Homework	1	Y	N

Table 1

Initial analysis of behavioural data from the student participants highlighted all sub-categorised behaviours to be present over a period of 4 months, with significant prevalence of 'disruptive behaviour' and 'no homework'. This behaviour is indicative of prior trends observed in ADHD symptomology and supports a profile of ADHD in the lack of inhibitory control and lack of executive function (organisation/time management) commonly found in ADHD students. Historically, hyperactivity or inattentiveness have commonly been identified by teaching staff as disruptive behaviour in my institution. One staff member remarked:

“I think behaviour is disruptive when it is not helping the class to get what they need out of the learning. When things get silly or there’s distraction and chaos, it’s a problem in the classroom”

The descriptive language of this teacher points towards a presentation of behaviour sourced from hyperactivity or inattentiveness. The observation of ‘distraction’ interlinked with ‘chaos’ infers an inattentiveness, or the disorganised mind frequently linked with executive function deficits.

In my institution, disruptive behaviour is distinct from aggressive behaviour in the sense that the target of the behaviour is generic (e.g. flicking a pen across the room) however it is no less intrusive to a classroom.

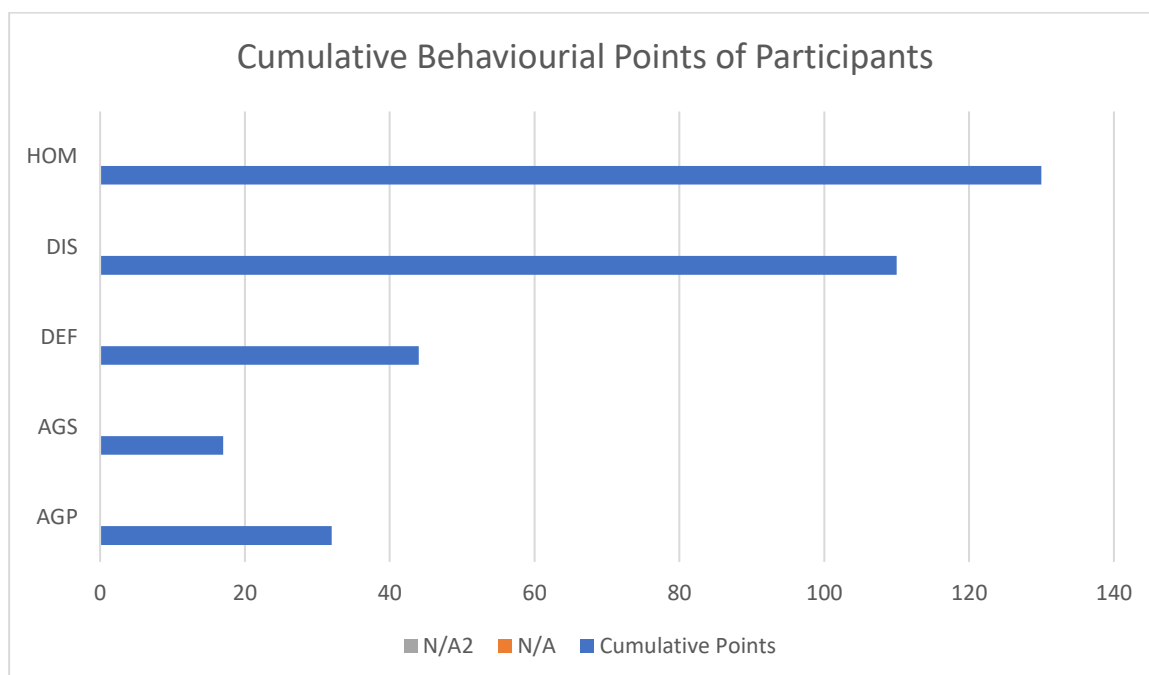


Figure 1

The distinctive trend notable in the behaviour data is the prevalence of ‘no homework’ with 130 points accrued and ‘disruptive behaviour’ with 110 points. The next highest scoring behavioural category is defiance with 44 points. This

means there is a 150% gap between defiance and the next highest scoring behaviour. With reference to these prevalent trends in behavioural data I interviewed the Head of KS3 pastoral and Head of KS4 pastoral. My school in addition to monitoring and tracking employ a 'Tier' system to highlight students of concern. Six out of Eight participating in this study are categorised as 'Tier 3', the highest Tier of concern and subsequently are discussed on a weekly basis. Discussions concerning these students are very cyclical, many of the same concerns arise again and again without resolution. The Head of KS3 pastoral is noted to have said "we've haven't cracked that case yet, all our efforts have little sticking power". This notion was supported by the SENCO of the school who articulated of these student profiles "we're very good at holding these students and getting them to the end, but I'm not sure how good we are at helping them". It may be possible to conclude, following data collection of behaviour, and interviews with teaching colleagues that first, hyperactive and inattentive behaviours are commonly labelled as 'disruptive behaviour' in my institution. Secondly, there is a clear deficit presented by these learners that cause a barrier to resist distraction and organise themselves sufficiently enough to complete homework. Third, these two forerunner deficits are likely to be significant in my comparative data analysis.

Following the intervention, I interviewed the Head of KS3, Head of KS4 and the SENCO. I collected behavioural points for the timeframe following the intervention however, only had 2 months of the academic year remaining and therefore the results are not a like for like. I was interested to see if disruptive behaviour and homework remained the most prevalent behaviours and if so, by what margin. I have presented the cumulative pointed accrued over the remaining 2 months of

the academic year and have also selected a specific, not exhausted overview of students to discuss.

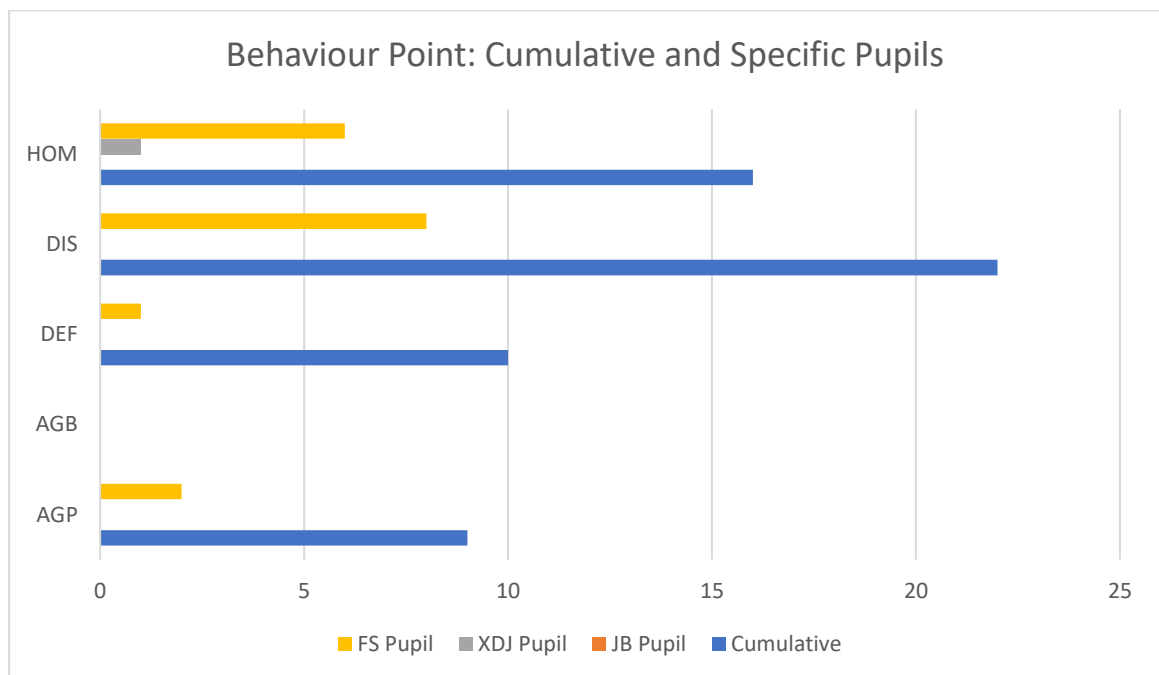


Figure 2

The data suggests that 'no homework' and 'disruptive behaviour' remain the most prevalent however, the highest scoring behaviour is disruptive, rather than no homework. Disruptive behaviour accounted for 22 points and no homework for 16 points. Defiant behaviour accrued 10 points. This means there is only a 60% increase from defiant behaviour to the next highest score accounting for a margin that has decrease by 60%. There were no records of aggressive behaviour towards staff during this period. This is promising to support an argument that WMT can impact executive function positively towards an increase of organisational competency. It may also suggest that WMT can develop a student's ability to inhibit more frequently, in other words to resist distraction.

The behavioural data is significant to discuss the impact of WMT for the individuals in this cohort. JB Pupil did not accrue any behavioural points following

the intervention. In addition to this the Head of KS4, in response to the question “Do you feel the WMT intervention has impacted students” notes:

“Yes. J’s ability to initiate and take ownership of her work. She has grown in confidence and language basis to communicate her needs for support. J can now anticipate where she might struggle and although she needs to vocalise this earlier she has the foresight to understand the expectations and timeframes of the GCSE course. J’s social interaction and confidence has supported her collaborative work with others in the class and she has made significant improvements academically”

Not only in the lack of behavioural points but also in the positive changes marked out by the Head of KS4 and JB’s other teachers, it is possible to suggest that parts of the WMT intervention have made a positive impact. With reference to ADHD deficits noted previously, this intervention for JB Pupil has skilled her in a range of executive functions previously underdeveloped. Observations from the Head of KS4 such as ‘initiate’ and ‘anticipate’ point towards high-order executive function skills of organisation and time-management. In addition, the observation evident here is that JB acquired additional language useful to her in communicating her need for support, not only is this a successful outcome of the intervention but it also contributes towards a growth in agency and independence critical for success at KS4 and beyond. Finally, the increased sense of confidence articulated here by the Head of KS4 is also evident in a staff survey following the 1:1 provision. 27 respondents selected one way the intervention (called Study Sessions here to destigmatise language) impacted students and 30% opted for

an increase in student self-esteem. Interestingly the data in figure 3 supports the behavioural points analysis of decreased ‘no homework’ incidents by highlighting teacher perception that student organisation (homework punctuality or quality has increased) is the most significant improvement following intervention.

1. Which of the following do you feel Study Sessions best improve

[More Details](#)

● Student self-esteem	8
● Student academic attainment (r...	4
● Student academic potential (en...	4
● Student organisation (homewor...	10
● Other	1



Figure 3

A second significant student profile was XDJ Pupil. XDJ Pupil demonstrated significant improvements following the intervention with behavioural data showing he only missed 1 homework and did not demonstrate any other behaviours from the end of the intervention to the close of the academic year. One of XDJ Pupil’s teachers noted that he was able to ‘keep up’ better in lessons following the intervention. He says:

“The study sessions have definitely helped XDJ reinforce learning from lessons. XDJ has been able to 'keep up' with others, also develop a better understanding of the topics.”

	Cumulative	JB Pupil	XDJ Pupil	FS Pupil
AGP	9	0	0	2
AGB	0	0	0	0
DEF	10	0	0	1
DIS	22	0	0	8
HOM	16	0	1	6

Table 2

It may be possible to infer that the WMT training did indeed increase the capacity of XDJ's working memory, enabling him to hold onto and, store more efficiently, information required for performance in lessons. It may also be possible to infer that aspects of attentional control were also improved, hence XDJ's ability to be seen to 'keep up' i.e. remain on task for more successful completion. Most significantly for XDJ pupil was the lack of missed homework. This reflects the perception by most respondents to the question "which of the following do you feel study sessions best improved" that organisation (homework punctuality or quality has increased) was the most improved; 37% of respondents opted for this as the most impacted outcome.

A less successful student profile following the intervention was FS pupil. FS pupil is diagnosed co-morbid ADHD, Autism and PTSD. He accounted for the highest number of disruptive behaviour points however, less behavioural points were recorded overall following the intervention comparative to a previous 2 month period. This may owe itself to either a greater visibility of his needs and therefore increased sympathy for these behaviours from teachers, or indeed a decreased frequency of mismanaged behavioural response in lessons. FS pupil enabled the greatest scope of collaboration with other teachers and profited a supportive and integrated approach of care owing to his high profile. One teachers notes:

“I have very much valued being able to ask you to support students with specific areas of difficulty. I feel we have communicated well and been able to support students better as a result of having a shared understanding of the situation.”

For students like FS pupil the priority of impact shifts to place a greater emphasis on support of them as a human being and articulating the value they contribute as their own person to the fabric of the school. It is evident this intervention increased the profile of ‘students with specific areas of difficulty’ and provided an opportunity to give a name to a behaviour that is more than ‘disruptive’. It is in this context of analysis where the literature from Diamond (2014), Kubina (2000) and Fink (1970) is palpable. Interventions must increase joy if they are to successfully mitigate the negative consequences of ADHD (Diamond, 2014). In order to do this, there must be a deeply embedded sense of support and advocacy for the student (Kubina, 2000). This advocacy and counsel is the key to the flourishing of the pupil; flourishing that for the wellbeing of the student (their engagement and motivation) and the production of their functional outcomes (academic attainment) (Fink, 1970). Behavioural points and pastoral notes suggest a significant decrease in all behavioural categories, with a most noticeable change in the prevalence of disruptive behaviours and no homework. On account of these shifts observable in the data it may be possible to argue that WMT may be linked to an alleviation in symptoms of hyperactivity and/or inattentiveness following intervention.

To address research questions two "Can WMT improve executive function? Specifically Working Memory?" A parent and teacher Behaviour Rating Inventory of Executive Function questionnaire was completed pre and post intervention.

The BRIEF (Gioia et al., 2000) is a diagnostic tool used in clinical settings to predict the likelihood of ADHD in children aged 5-18. Behaviours are reported by parents and teacher using a number of clinical scales and organised around three regulation indexes. These indexes are 'Behaviour Regulation Index', 'Emotion Regulation Index' and 'Cognitive Regulation Index'. The latter index includes a working memory scale which measures online representational memory, in other words, the function to hold information in mind for the purpose of completing a task. It also seeks to assess how successful sequential steps of a task are recalled and finally how information is encoded. These are all key skills of proficient working memory. It was the CRI measure that the research was primarily interested in extracting. CRI reflects a student's ability to control, manage and problem solve using cognitive processes. It is made up of five scales; Initiate, Working Memory, Plan/Organise, Task-Monitor and Organisation. Each of these cognitive processes are executive functions, they are considered vital for completing daily tasks effectively (e.g. organisation measures orderliness of spaces such as desk, rucksack and bedroom) and developing academically (e.g. Task-Monitor measures on task behaviours and work-checking habits). On this scale of measurement T scores of 65 and above are considered clinically significant and put the student in the 'at-risk' category. It was predicted that most students would attain a score greater than 65 owing to an existing diagnosis of ADHD which made them eligible for this intervention. Therefore, the dependent

variable for research question two was the change on the BRI, EMI and CRI on the BRIEF, with particular attention to CRI.

Statistically significant pre-post changes were evaluated through calculations of BRIEF score difference between January 2022 and June 2022. BRIEF forms were completed by parents and teachers of participating students first in January 2022 and following the cessation of the intervention in June 2022. Table 1 shows Parent rated scores pre and post-test. Table 2 shows Teacher rated scores pre and post-test.

Parent Rating on BRIEF		Student T-Scores							
		JB	XDJ	FS	ME	MM	MH	FB	EP
BRI	Pretest	63	59	88	86	80	61	78	73
	Posttest	56	51	87	80	66	60	70	67
	Difference	-7	-8	-1	-6	-14	-1	-8	-6
ERI	Pretest	50	52	68	70	78	64	50	51
	Posttest	49	52	59	62	78	60	50	51
	Difference	-1	0	-9	-8	0	-4	0	0
CRI	Pretest	68	65	71	70	66	69	76	76
	Posttest	50	61	70	70	53	62	71	70
	Difference	-18	-4	-1	0	-13	-7	-5	-6

Table 3

Teacher Rating on BRIEF		Student T-Scores							
Measure		JB	XDJ	FS	ME	MM	MH	FB	EP
BRI	Pretest	70	65	72	82	66	70	72	70
	Posttest	63	61	73	80	60	69	70	70
	Difference	-7	-4	1	-2	-6	-1	-2	0
ERI	Pretest	68	67	74	73	72	70	66	65
	Posttest	60	63	73	73	70	65	61	61
	Difference	-8	-4	-1	0	-2	-5	-5	-4
CRI	Pretest	67	65	70	72	65	68	70	69
	Posttest	52	62	70	72	60	61	61	65
	Difference	-15	-3	0	0	-5	-7	-9	-4

Table 4

Changes to BRI, ERI and CRI scores on BRIEF were wide-ranging and significant. Parent rated scores demonstrate a statistical significance for the impact of WMT training across all areas of ADHD symptomology. 80% of posttest scores measure a reduction in traits considered to put students in a category of risk and clinical concern. The most affected indexes in parent rated scores are BRI and CRI. ERI remained more stable. 100% of parents record a change in BRI which can be considered a beneficial impact of the intervention. 87.5% of parents (7 out of 8) perceived a measurable change in CRI behaviour which can be considered a beneficial impact following the intervention. In the CRI recorded score, the most significant changes were recorded by JB Pupil and MM Pupil whose functioning during pre-test predicted clinical significance (<65) in contrast

to post-test scores which fell under the level of clinical significance. The parents of MM Pupil evidence a significant change in her BRI and CRI scores however, these stand in contrast to the ERI difference pre and post-test which measures no change. There is a parallel in the data, although not as pronounced, between the BRI, CRI and ERI scores given by teachers for MM Pupil; teachers rate BRI and CRI to be changed by a difference of 6 and 5 respectively, ERI is only changed by a difference of 2. In parent rated scores, XDJ Pupil and MH Pupil also scored below the level considered to be of clinical significance following intervention. Conversely, a significant change was not found in FS Pupil and ME Pupil within CRI. These results are consistent with teacher reported BRIEF rating where neither FS Pupil nor ME Pupil changed whatsoever from their original score. Moreover, these two students were not significantly impacted across the range of BRIEF measurements, although ME Pupil is perceived to have improved his behaviour in the home setting with Parent rated BRI scores significantly changed pre to post-test.

Teacher rated scores for all participants are promising in that they identify a majority change following intervention. Comparative to parent rated score, teachers record 80% success rate with at-risk traits declining in all but 5 instances. Contrastingly, teachers record an increase for FS in BRI. The index to record most significant change in teacher rated scores is CRI. This category of indices measurement is specific to the research outcomes and the best impacted category in the BRIEF suggesting that WMT can improve executive function skills in ADHD students. The post-test Teacher rated BRIEF for CRI identifies that 75% of students (6 out of 8) were significantly impacted by the intervention with visible impact to their cognitive processes that support executive function inclusive of

working memory. Moreover, the post-test Parent rated BRIEF for CRI measures impact at 87.5% with 7 out of 8 students recording significant change to measurable cognitive processes following intervention. The success of JB is comparable between both parent rated and teacher rated scores with significant change recorded. MH pupil scored the same change for CRI across both parent and teacher rated scores. The comparable changes of both success (JB, MM, MH) and discrepancy (FS, ME) is promising to suggest an agreement between parents and teaching staff that change is notable. Based upon parent and teacher rating on the BRIEF results there is a suggestion that WMT provides some level of positive improvement to executive function (CRI) and secondly to behaviour (BRI), however, it is difficult to extract the specific impact of WMT to the isolated cognitive function of working memory.

To address research question three "Can WMT improve academic attainment?" A comprehension test was sat and resat, and formal academic test data analysed from before the intervention window (November) and following the intervention window (June).

In collaboration with the school SENCO and SpLD teacher I conducted diagnostic psychometric tests to assess fluency of literacy skills pre and post-test. The test used is called YARC (York Assessment of Reading for Comprehension). The YARC is a helpful tool to pinpoint difficulties in the mechanisms of reading for comprehension because it measures; recognition of words, reading speed and comprehension of words read. It was deemed appropriate as a measure to support analysis of executive function improvement for academic attainment.

YARC	JB	XDJ	FS	ME	MM	MH	FB	EP
SWRT								
Pretest	103	89	100	99	101	98	89	112
Posttest	109	103	101	102	112	107	107	118
Reading Rate								
Pretest	98	70	83	82	99	88 <70		103
Posttest	102	74	90	90	110	100	98	109
Comprehension								
Pretest	109	91	92	97	112	125	115	121
Posttest	112	97	94	97	123	121	122	125

Table 5

The data collected is promising to highlight the benefit of a reading based WMT intervention owing to all participants increasing their performance across all assessed areas of the YARC. This is notable in the short amount of time between assessments; YARC is typically used at the beginning and end of the academic year. In addition to the scores, the analysis of the SpLD teaching whilst assisting with the running of these tests offered additional insight for example, she notes of XDJ pupil:

“Reassessed on YARC - Some improvement: SWRT SS 103 (up from 89); Reading Rate 74 (up from less than 70) ; Comprehension SS 97 (up from 91)
He made much better attempts at decoding unknown words. In the comprehension he had difficulty with questions involving elaborative inference but had less difficulty retrieving information than before.”

The strengthening sense of self-efficacy noted by classroom teachers (figure 3) is equally as evident here in the acknowledgement that more ‘attempts’ had been made in contrast to the previous YARC. In addition, the observation that XDJ pupil struggled *less* to *retrieve* information infers that his working memory has been positively impacted, if, working memory is consider the ability to hold information in mind to successfully complete a task. Similarly, it was noted of FB pupil:

“Retested YARC - The raw score mas marginally better and reflected in Standard score. He decoded more fluently and less laboriously. His word recognition was up from 89 to 107. Reading rate has improved to achieve a

standard score. He is very keen to stop support now and I think it would be demoralising for him to continue.”

The observation enabled by undergoing the YARC highlights the improvement in decoding of words and a decreased effortfulness in reading. Improving executive function skills is suggested to enable a greater fluency to process and organise information; decreased effortfulness is a promising sign that this may have been achieved in part. In addition to the cognitive impact the intervention has made, the reference here to FB’s wish to cease intervention points towards a developed sense of self who is empowered to continue developing more autonomously. Teachers remarked of FB a growing frequency of initiation and instances where FB had engaged his intrinsic motivation to complete a task rather than await a prompt from teachers:

“As FB’s teacher I would have to say that [intervention sessions] can be very impactful. I think students have been guided effectively and FB has been given a clear purpose, with enriching input from skilled staff. I have seen a marked change in his proactivity and independence.”

The trends visible in the pre and post-intervention YARC data suggest significant and positive changings both in student resilience, for example “made much better attempts” and “I have seen a marked change in his proactivity” and also towards greater academic fluency and progression. For ME the increase in his reading rate accelerated his chronological reading age (as assessed by YARC) by almost 2 years, raising his scored age from 12yrs 10months to 14yrs 9months. GCSE examination papers require a minimum reading age of 15yrs 9months and it therefore appropriate to link increased reading rate with improved academic attainment.

My school provides bi-annual testing windows to formally monitor academic attainment. I located the Autumn (November) and Summer (June) test scores and extracted the students who participated in the intervention. Figure 4 depicts the numerical data shown in table 6. As this data was not specific to the intervention itself but co-occurring as part of a typical academic year it may not reliably inform on impact of an 11-week WMT intervention. However, part of this data corroborates previous findings. For example, MM was absent for her Autumn maths exam owing to a period of emotional dysregulation which turned into temporary school refusing. MM's BRIEF scores for ERI were both of clinical significance (parent rated= 78; teacher rated= 72) and minimally impacted (parent rated= 0; teacher rated= -2). Such scores predict the likelihood of emotional dysregulation towards risk taking behaviours such as school refusing however, MM's BRIEF BRI and CRI was significantly and positively impacted and arguably was able to offset some emotional instability to result in MM turning up for and completing *all* her summer exams. In addition, JB's end of year academic performance consolidates the upward trend of progress visible in intervention specific data. JB was excluded from school in October 2021 and was not anticipated to attain her age-related stage in English and Maths. However, test data, intervention data and teacher feedback suggest that support work for JB has been effective to improve her academic outcomes and future potential. Another significant academic outcome was attained by MH pupil. MH pupil was expected to sit only foundation papers for English and Maths however, it was agreed MH would sit the higher English paper on account of the progress observed by teachers. This arguably supported MH's progress to attain 69% in the end of year English test. Discussion of an improvement that seemed unlikely

to his originally starting point and therefore of importance to note is FB pupil. FB pupil is noted by a range of teachers to have responded particularly well to intervention content and involvement. One teacher recalls the commencement of the academic year with FB and said of him:

“FB didn't attempt to work out harder words and didn't have strategies to do so. Spelling and capitals are better but still inconsistent.”

His attainment in English rose from 23% to 56%, this not only shows he has progressed academically but also that he has developed a greater resilience to attempt harder questions and resist giving up on exam answers. Finally, the overall data suggests that academic attainment in English has been more successful than maths over the academic year. English test scores improved by 56% and maths test scores improved by 24%. Moreover, FS and ME's performance in the end of year maths exam dropped below their previous performance. This might suggest that far-transfer of Working Memory Trained functions has not occurred, owing to the most significant improvement being situated in the domain of literacy rather than numeracy. However, it might suggest that a reading based WMT intervention can positively impact literacy-based academic attainment. Although it is not possible to conclude that an 11-week reading based WMT intervention is the reason for this variation, it may have contributed to student performance by way of increasing a confidence to problem-solve literacy-based questions and by developing the executive function skills required in formal testing. The combination of improved YARC scores and bias of progress in English attainment does have grounding to suggest that a reading based WMT intervention can profit academic attainment, even if this is limited to the domain of training offered by the intervention.

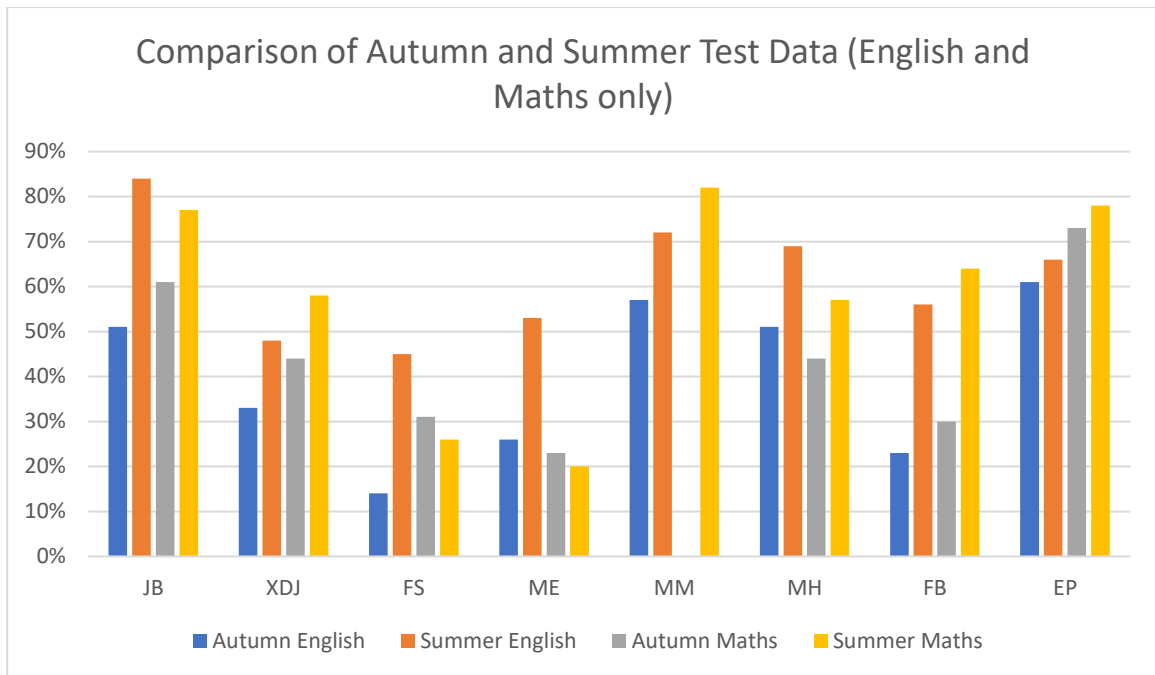


Figure 5

	Autumn English	Summer English	Autumn Maths	Summer Maths
JB	51%	84%	61%	77%
XDJ	33%	48%	44%	58%
FS	14%	45%	31%	26%
ME	26%	53%	23%	20%
MM	57%	72%	n/a	82%
MH	51%	69%	44%	57%
FB	23%	56%	30%	64%
EP	61%	66%	73%	78%

Table 6

Discussion

This study sought to assess the impact of Working Memory Training by analysing the relation between a reading based WMT intervention on the alleviation of ADHD symptoms i.e. inattentiveness, hyperactivity and impulsivity. The training utilised in this intervention was divided between five 15-minute group reading session per week and one 1hr 1:1 cognitive card game session per week. First, a notable success of the intervention can be seen in the 100% retention rate

meaning all participants received fifty-five 15-minute group sessions and nine 1hr 1:1s. The cumulative time each student spent in intervention was 23hours and 15minutes. Over the course of this time various levels of positive change were observed and reported for all students participating. The purpose of research question one was to establish whether a WMT intervention could alleviate ADHD symptoms problematic to school progress, i.e. inattentiveness, hyperactivity and impulsivity. Research question one provided significant results for the dilution of problematic behaviours recorded by teachers against participants. Symptoms of ADHD can be inferred to have decreased using the behaviour data to evidence an 80% reduction in disruptive behaviour recorded and 88% reduction in missed homework. Moreover, aggressive behaviour towards teachers scored zero in the 2 months following intervention showing a 100% decrease in these instances. The purpose of research question two was to determine whether WMT could enhance executive function, specifically working memory. Research studies have found an association between working memory capacity and effects on other areas of cognition that support executive function (Melby-Lervag et al., 2016). Studies suggest working memory is malleable and if improved can enhance future learning potential (Bergmann et al., 2017). Evidence collected from the BRIEF substantiate these claims because both executive function (CRI) and learning potential (BRI) were significantly impacted following WMT. The majority of parent and teacher ratings on BRIEF measured new scores to all categorised indexes which were for the benefit of student self-regulation. Significant benefit previously discussed was in JB and MM's scores posttest however, most participants can be said to have been beneficially impacted by the WMT with reference to the clinical scales employed by BRIEF. BRIEF as an outcome measure to determine

the association between WMT and improved executive function appears to show a positive correlation. The purpose of research question three was to ascertain whether WMT can improve academic attainment. Data was gathered using YARC for comparative analysis pre and post-test. Data using examination results from the beginning and end of the academic year was also gathered to support analysis. The YARC data indicated improvement in each assessed area of the YARC for all participants, except for one score that decreased (MH; Comprehension). FB's improvement enabled him to attain a standard score that was numerically measurable, rather than falling below standard score digits; he increased his reading rate from <70 to 98. For all participants, SWRT and Reading Rate was improved, and Comprehension improved for 6 out of 8 participants. In contrast to other data, FS and ME students performed better on the pre to post-test YARC difference than on other behavioural rating, BRIEF scales or examination data. FS demonstrated marginal improvements across all categories tested in the YARC. ME demonstrated significant improvement in reading rate (82 to 90), marginal improvement in SWRT (99 to 102) and no improvement to comprehension (97 and 97). However, these scores are the most significant, contrast to other data collected for FS and ME to suggest improvement. Examination data from November and June is in addition to the dependent variable of WMT but not as reliable a measure owing to other influences on progress, however it is worth reiterating that improvements in English were more significant than maths. This may be considered significant related to a reading based WMT intervention and therefore contain validity to suggest WMT can improve academic attainment.

In addition to the three research questions, an unforeseen impact of the WMT was the increase in student self-efficacy and ownership of their learning. Teachers noted that the intervention enabled students to become more integrated in lessons and feel more at ease next to their higher performing peers.

2. Do you think study sessions aid inclusion of SEND students?

[More Details](#)



Figure 6

Teacher responses to this question of inclusion identify that 92% believed the intervention fully enabled students to increase their sense of belonging in the classroom. 7% believed it might increase inclusion. One teacher noted:

“EP really made the most of these sessions and I am so grateful to everyone involved in them! EP is coming out of his shell a lot more; he seems more willing to have a go at an answer”

There is a suggestion in the feedback here that, for the classroom teachers of intervention students, no skills specific impact of WMT is tangible, or at least can be attributed to a singular intervention. The language used emphasises EP’s manner and rapport e.g. ‘more willing’ and ‘made the most of’, rather than being able to define specific executive function improvements. WMT in a school setting is not widely represented in the literature, arguably because as a dependent variable its results are difficult to disentangle from the lived time and space of a

school which is productive in and of itself, and impacts change in students (Brinkmann, 2021). Rather, teacher feedback frequently commented on the person rather than the performance of the student during and following intervention. For example, one comment collected said;

“She is more optimistic about learning, it doesn’t seem to get her down like it was doing”

Another comment outlines:

“He’s doing better, definitely better, look at the length of his answers, he is keen to have a go now”

These comments, highlighting ‘optimism’ and ‘keenness’ are indicative of a changed feeling in student approach to learning and student belief that teachers are on their side. This is quantifiable in the absence of negative points for behaviour category ‘aggressive behaviour towards staff’. This unforeseen outcome of the intervention in student self-efficacy, or optimism as one teacher comments, coexists with an increase of teacher support and advocacy for these students. There may be an argument to be made that if the school polity is enabling of a culture where students and staff choose to work for and with one another, it benefits student self-efficacy and increases their optimism. This culture becomes a tool to impact positive change across many of the skills learnt through the intervention. Conversely, teachers communicated disappointment when their support of students did not impact positive change. One teacher commented:

“I would say that certain students received a lot of structured 1:1 support which they did not engage with. This is such a precious opportunity and a privilege, so without sounding too harsh, I feel there should be a consequence/follow up to students who do not engage/a serious talk with someone from SLT so they

understand how important it is that they engage with these sessions. Thank
you!”

This comment communicates a sense of frustration for when support and advocacy for students is rejected. The teacher’s perspective that intervention is a “privilege” suggests it is an offer out of good will. In other words, it is offered for the good of the student’s flourishing in partnership with the school community, not because the student as an individual has a right to such provision. The community of our school can be seen by teachers to be disrupted by ADHD behaviours when students cannot inhibit or are unable to “understand how important it is that they engage”. This unforeseen impact in outcome for how intervention affected both student self-efficacy in the positive and a sense of lacking gratitude in the negative highlights a gap in the literature.

Opportunities for Further Research

As previously mentioned, schools are distinctive social institutions in which extrinsic questions are implemented in a temporal, spatial and social pedagogical order (Brinkmann, 2021). The lived time and space of a school are arguably productive in and of themselves. Schools play a decisive role in society, not least that they influence the next citizens of the world. Calls for further research have been made, for example by Kleinman (2001) to keep a connection between psychiatry and cultural anthropology as close as possible. However, a gap in the literature remains and the opportunity for further research evident here is a bridge between the psychological analysis in clinics and the cultural norms in schools. In this intervention, as the deficits in psychological function were seen to be supported, so an improvement in student citizenship was noted. This looked like

a greater cooperation with learning outcomes, a better attitude towards teachers and increased self-regulation (organisation and perseverance). Patrick Deneen (2018) makes a perceptive observation that constraining impulsivity, in preference for the cultivation of virtue and self-rule, is the key to good citizenship and the corrective of tyranny. If we are to understand tyranny as “absolute rule by one” it is very similar to how teachers in my institution describe the effects of ADHD behaviour and stands in opposition to good citizenship in the classroom. Therefore, it is interesting to note that current ADHD coaching and executive function training puts emphasis on growing skills akin to the sorts of virtue education contained in Ancient Greek and Roman society. For example, the virtues of temperance, wisdom and moderation might arguably have been redressed as improving a student’s capacity to inhibit (temperance), improving memory retrieval and organisation of mind (wisdom) and self-regulation (moderation). The language of new ADHD coaching contains striking parallels to the virtues expected of citizens in early Greek formulations of liberty, as Deneen explains “liberty had long been believed to be the condition of self-rule that forestalled tyranny, within both the polity and the individual soul. Liberty was thus thought to involve discipline and training in self-limitation of desires and ...corresponding virtues that fostered the arts of self-government”. In other words, the existence of liberty which benefits the polity (i.e. classroom) is established only through the cultivation of behaviours that are dependent on good self-governance (i.e. self-regulation). The reference to ‘discipline and training’ of the ancient world has remarkable similarities to the ADHD executive function training of ‘next generation’ intervention in the modern world. Next generation executive function training seeks to equip students with core skills to manage and follow the

protocols of institutional governance, for example students should arrive on time with the right equipment and submit homework in a timely manner. Deneen's compelling case maps out the reimagining of liberty from an Aristotelian standard of self-limitation towards a Machiavellian emphasis on pride, selfishness and a quest for glory. He argues this overturned preceding religious and social norms. By overturning these norms, personal relationships become conditional to how they serve self-interest. Ergo, evaluating the value of institutions, societies and people is dominated by calculations of how it best serves the one rather than the community. The paradigm shift that took place moved from imparting wisdom and experience of the past, cultivating virtues of self-restraint and civility, to one of immediate gratification, synonymous with distraction and detachment (Deneen, 2018). I am not saying that ADHD is synonymous to tyranny however, the literature misses how significant new social norms (e.g. liberalism understood as free action unconstrained by obligations to the community) may be in informing the development of our school citizens. Vice versa, if the value of institutions, societies and people *is* dominated by calculations of how it best serves the one rather than the community, then in turn, institutions are guilty of modelling this. It was Fink who argued the modern human being exists in a world of retreating cultural and religious norms, meaning educational aims emphasise production not meaning. Production as an emphasis confines a student to the demands of the institution. Deneen argues ultimately that is it a question of ontology with two competing sides: the liberated individual and the controlling state (Deneen, 2018). As behaviour in my institution is perceived to get worse so the control of the institution on students increases. However, the rise of protoliberal thinking cannot withdraw autonomy meaning we are left in a state of spiralling confinement of our

students which perpetuates ADHD symptomology because they are not experiencing true freedom. This school of thought draws parallels with research conducted by Rosenberg (2006) and Singh (2006) who suggest the symptomatic remission seen among adult ADHD is explained by changes in occupational and educational setting, the most notable change being greater freedom. Friedman (2014) suggests ADHD is context-dependent and when adults have more freedom to choose the environment in which they live and work they find a better match for their cognitive style. More needs to be done to explore how the psychological and socio-cultural coalesce to affect ADHD behaviour in a school setting.

Professional Development

Presenting the findings of this research to support ongoing professional development and respond to the fourth aim of this study (explore the possibility of implementing a school wide WMT intervention by staff) was organised into three streams. The first stream presented the viability of offering Working Memory Training in future academic years, exploring the successes and barriers for the intervention. The second stream described the unforeseen impact of WMT on student self-efficacy. The third stream considered how teachers could develop their inclusion and support of ADHD students. With reference to the fourth aim of this study, to explore the possibility of a school wide WMT intervention being implemented by staff, the first stream presented the behaviour and YARC data to suggest moderate success for the intervention. The viability of allotting appropriate time to such intervention was discussed as unfeasible in the current allocation of teaching hours. The hours allocated to the intervention were

discussed and agreed to be a barrier in up-scaling the intervention however, during the presentation 'retrieval practice' was discussed as a more appropriate tool for supporting working memory. The second stream described the increase in self-efficacy reported by both teachers and students following the intervention. This inspired conversations amongst staff who attended, and an explanatory consensus arose highlighting how increased visibility of these students and joined up communications about these students had increased staff involvement in their progress, meaning productive communication and collaborative participation may have accounted for a significant change in the area of student self-efficacy. This collaborative element of the intervention is discussed further below. The third stream considered how teachers could develop their support of ADHD students. I created 2 'TeachMeet' style pamphlets with recommendations. One was entitled 'Teaching ADHD Students; strategies and ideas' and the second 'Caring for ADHD Students; compassion and advocacy'. The former contained a range of examples and models of task design and strategies that fit with ADHD profiling e.g. chunking long sections of text, providing a visual timetable with breakout sections and embedding regular prompts to reengage students. The latter outlined teacher feedback, referencing the increase in student self-efficacy and also presented student reflections, referencing an increased academic confidence. I printed 200 pamphlets; 100 of each subject heading. Teachers were invited to take any information they might find helpful. 37 of the 'Teaching ADHD Students; strategies and ideas' and 29 of the 'Caring for ADHD Students; compassion and advocacy' were taken. This might infer that teachers in my institution perceive ADHD to be a disorder that can be fixed with the right teaching tools; however, I believe continued professional development must move closer

to a holistic and inter-professional advocacy of ADHD students. This may look like increasing the impact of the tutor in communicating positive praise to students. It may look like teachers slowing down to truly look, listen, and consider the input or needs of ADHD students. It may look like a cultural shift away from efficiency or 'production' (Fink, 1960) and towards compassionate human relationships.

Collaboration

ADHD is considered a disability under the 2010 Equality Act and moreover, is specifically referenced in the DfE SEND Code of Practice (Section 6.32) as associated with Social, Emotional, Mental Health Disorders. This in turn means that collaboration to deliver support for ADHD students is a statutory requirement. The tension here is how to reconcile the medical interventions peer-reviewed and set in experimentally controlled conditions for delineated samples with an educational setting affected by personal and contextual factors for non-delineated samples. Although there is some recognition that a developmental context sees an interplay of personal and environmental factors, collaborative emphasis must attempt to retrieve a synthesis between the social and medical models (Hollenwager, 2011). Hollenwager's integrated model between the individual's personal factors and their environmental context argues that any intervention must be specific to the interplay of these factors in a student's life. This bio-psycho-social model is specifically cited within the ADHD literature as having relevance to the deficits in a diagnosed student's social, emotional and mental health areas (Daniels et al., 2007). Because schools have a significant environmental influence on the functioning of a student, an integration of medical and social models is required in response. Therefore, collaboration in my

institution requires an inter-professional approach that is sympathetic to the psychological impacts that institution has by way of its educational activities, social conditions and organisational systems. One way forward for this complex interplay of actors is called 'knotworking' (Engestrom, 1999). Knotworking extends the initial utility of networking to conceive of a concept that is rapidly adapting with no sole agent bearing responsibility or taking control. Knotworking is dialogue with real-time feedback enabling teachers involved in the support of a student to continually tie and untie separate threads to individualise provision based on a certain student's holistic needs. This fully integrated system can offer an ongoing relationship to the student that is continually customised to their needs and appropriate to the SEMH deficits common in ADHD students. This highly demanding level of participation and dialogue required for successful knotworking does present a challenge in the context of oversubscribed, under-resourced schools however, the bio-psycho-social model of collaboration to involve inter-professional investment should be seriously considered by my institution as a substitute for the 'unviable' upscaling of Working Memory Training as a route to support students with ADHD.

Conclusion

This study assessed the impact of Working Memory Training on ADHD Students in a secondary school setting. This study did not lead to a singular conclusion of increased academic attainment, rather, the progress of participants produced a range of impacted areas that are best termed; increased organisation, improved attention and increased self-efficacy. An increase in self-efficacy was an unpredicted outcome reported and accounts for the most significant effect on this

practitioner's interpretations and discussion. Qualitative reports of student change with reference to self-efficacy, engagement and optimism significantly increased socio-cultural interpretations of this psychologically based WMT intervention, leading to an extended consideration of environmental factors and social norms specific to the school setting. A significant main effect between WMT and increased attentional and memory function for classroom progress was not found. However, a positive correlation between WMT and good student citizenship was reported by teachers. The limitation of the intervention was in observing the transfer of attentional and memory function from the trained task to diverse demands in the classroom. However, improvements have been reported in the increased instances of students 'having a go' and developing discrete executive functioning skills of organisation and attention. Further research is needed to expand this study and determine if environmental effects among those with ADHD affect Working Memory Training outcomes.

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