Executive Function Characteristics of Younger Adolescents Identified with Special Educational Needs

Thesis

Executive Function Characteristics of Younger Adolescents Identified with Special Educational Needs

Jennifer A Kearvell-White

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Abstract

Executive functioning (EF) was investigated in 134 young adolescents with Special Educational Needs (SEN) in comparison to 141 students not requiring additional support (Non-SEN peers). These students (11-14 years) completed standardized assessments of vocabulary, decoding and non-verbal reasoning, and verbal and non-verbal EF assessments of inhibition, executive working memory, switching and fluency. Significant group differences were found in all these measures (verbal switching excepted), but no significant differences were found between three SEN subgroups (school action, school action plus, and those with statements) apart from non-verbal inhibition. Cluster analyses suggested that despite significant group differences, both SEN and Non-SEN students were often included in the same clusters. Confirmatory factor analysis suggested that the best model of EF performance for the SEN group involved an immature organisation.

Parents, teachers and students completed the BRIEF questionnaire for ‘inhibit’, ‘working memory’ and ‘shift’. All three groups provided significantly different ratings for the SEN and Non-SEN groups, although the ratings varied for each group. Teachers also completed the Strengths and Difficulties Questionnaire (SDQ) and analyses revealed significantly higher concerns for the SEN group.

Binary logistic regressions were conducted to identify predictors of SEN status. Significant predictors from just the EF variables included inhibition, switching/shift and fluency. In the final analysis which included the three standardized assessments the significant predictors were decoding and the BRIEF ‘shift’ construct.

The findings have increased the limited knowledge about the characteristics of young adolescent students with SEN. These students were identified as having significantly lower EF abilities than their Non-SEN peers; the structural organization of the EF abilities appears similar to younger individuals, and the most important predictors of

their SEN status were decoding and shift. Task management and inflexibility (‘shift’) were important issues for coping with the demands of early secondary school life.

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GLOSSARY OF TERMS

ADHD	Attention Deficit/Hyperactivity Disorder
ASD	Autism Spectrum Disorder
BD	Behavioural Disorders
BPVS	British Picture Vocabulary Scales
BRIEF	Behavioural Rating Inventory of Executive Function
CHARGE Syndrome	Coloboma, Heart defects, Atresia choanae, Growth retardation and Ear abnormalities
DBD	Disruptive Behaviour Disorders
DCD	Developmental Co-Ordination Disorder
EWM/ELWM	Executive Working Memory/Executive Loaded Working Memory
EF	Executive Function
EHC	Education and Health Care (Plan)
GLD	General Learning Difficulties in Literacy and Maths
ID	Intellectual Deficit
KS3	Educational Key Stage 3
MBID	Mild to Borderline Intellectual Disability
MLD	Mild/Moderate Learning Difficulties
NC	National Curriculum
NFER	National Foundation for Educational Research
Ofsted	Office for Standards in Education
OR	Odds Ratio for probability of group inclusion
PAT	Progress and Attainment Tracking
RPM	Ravens Progressive Matrices
RVR	**R**eading (TOWRE) **V**ocabulary (BPVS) **R**easoning (RPM)
SA, SA+	School Action, School Action Plus
SAS and CS	Supervisory Attentional System and Contention Scheduling
SDQ	Strengths and Difficulties Questionnaire
SEBD	Social, Emotional and Behavioural Difficulties
SEN(D)	Special Educational Needs (and Disability)
SENCO	Special Educational Needs Co-Ordinator
SI, AI	School Intervention, Additional Intervention
SLCN	Speech, Language and Communication Needs
SLD/Spld	Specific Learning Difficulties
SLI	Specific Language Impairment
SSAMs	Standardized Student Assessment Measures (RVRs)
SSARs	Standardized score ability ranges
TOWRE	Test of Word Reading Efficiency

EXECUTIVE FUNCTION CHARACTERISTICS OF YOUNGER ADOLESCENTS IDENTIFIED WITH SPECIAL EDUCATIONAL NEEDS

CHAPTER 1

1 Introduction

1.1 Background to the Study

This thesis is introduced with an anecdote from personal experience about a student with SEN. He had a statutory statement of special educational needs and qualified for the maximum amount of learning support. At age 13, following years of misdiagnoses, his sensory, motor, communication and cognitive difficulties were diagnosed as a rare genetic syndrome. In his first school term, aged 5, his teacher stated he was like a caged lion with no idea of what was expected of him. The subsequent Educational Psychologist's report recommended a different school, where he settled but was isolated from his peers. During his first year at secondary school, teacher feedback was ambivalent: '…. no problem with him being in the class…but...' Always polite with a formal communicative style, he was nonetheless distant and extremely difficult to engage. Despite having a vocabulary score in the adult range with equivalent reading fluency, he did not appear to learn *anything*. He rarely wrote enough that could be usefully marked. Two years later, at the end of Year 9, his new maths teacher commented that the boy *never ceased to amaze him*. He did not appear able to follow the steps of a worked example, but, left to his own thinking skills, he invariably reached the correct solution. He *could not*, however, explain his calculations, claiming the answer just 'came to him'. His teacher was genuinely perplexed: 'I have no idea whatsoever how he manages to arrive at the answer, never mind the correct one'. With appropriate support, the boy went on to achieve: 10 A-C grade GCSEs, A levels and BSc (Hons) Environmental Science and Climate Change. This thesis is an investigation of the cognitive characteristics of young people who require additional support in the learning environment.

As pupils progress through the secondary education system, greater emphasis is placed on independent learning, requiring practical self-organized study skills and motivation. The capacity to comprehend, interpret and apply abstract concepts and manipulate knowledge is essential for academic progress and examination success. Adolescents who experience difficulties engaging with the complex cognitive demands of the classroom environment are at risk of failing to meet their academic potential and to have compromised life opportunities.

Whilst teaching Key Stage 3 (11 to 14 years) English to lower attaining students in secondary mainstream education, I observed consistent barriers to learning, including pervasive difficulties in planning/organisational skills, retention/application of instructions and distractibility. The learning environment was small classes of up to 12 students (two classes per year group, totalling six separate classes). The students were all on the school's register of Special Educational Needs (SEN). Areas of additional need usually focused on learning related issues, including school-identified diagnoses, such as 'dyslexia' or 'literacy/numeracy difficulties' but clinical diagnoses were also represented, including attention deficit disorder (ADHD), autism spectrum disorder (ASD), specific language impairments (SLI) and 'mild/moderate learning disorder' (MLD). There were also several students in each class who were temporarily taken out of mainstream classes for at least a term as a consequence of ongoing disruptive behaviours.

A general observation across the classes was that the students appeared to have certain characteristics in common, irrespective of their individual difficulties, including: difficulties starting tasks, despite showing understanding of the requirements; a need for frequent memory and behaviour prompts and reminders to keep on task, despite having their attention repeatedly drawn to clear instructions and prominent classroom rules. None of the students had non-correctable visual or hearing impairments but *all found engaging with learning problematic*, despite the application of SEN procedures for inclusive teaching such as differentiated materials, structured task strategies and clear communication. These observations suggest that these students have difficulties with the cognitive skills involving mental control and self-regulation, otherwise known as Executive Function (EF) skills and provided the basis for the impetus and motivation to investigate the characteristics of executive functioning in students with SEN. As of 2019 (Gov UK, 2019), the percentage of pupils of all ages identified as having special educational needs in England was 14.6 percent, it is clear that further investigation of the precise nature of their underlying learning difficulties remains a priority.

This chapter comprises two parts. Part One is concerned with SEN(D) and provides an overview of the support system and changes made to that system in 2014. This is followed by an examination of the SEN identification process, a review of the SEN population and prevalence of specific areas of additional need. Part One concludes by outlining the key issues regarding the extent to which SEN(D) identification and classroom practice take underlying cognitive difficulties into account when assessing individual needs. These issues introduce Part Two which concerns why it is so important to take executive function (EF) into account in this respect.

In Part Two, EF is defined and findings concerning EF difficulties amongst those with developmental disorders and learning difficulties are examined. The nature of the relationship between EF and language is introduced as literacy issues are of fundamental concern for academic achievement. How EF difficulties manifest across four theoretical levels of explanation is briefly discussed prior to considering the nature of EF difficulties within the SEN population. EF is then examined from a theoretical perspective with reference to seminal theories of core aspects of EF as a system. As younger adolescence spans a critical phase of brain structural development which supports self-regulatory capacities (Blakemore and Choudhury, 2006b), these neural systems are briefly examined with reference to relevant theoretical models. The chapter concludes by identifying gaps in the literature from which research questions for each of the current experimental chapters are identified. These ultimately provide reasons to justify why studying EF in the SEN(D) population is advantageous for developmental and educational research.

Part One SEN(D)

1.1.1 The Special Educational Needs (SEN) and Disability (SEND) Support System

Before 2014 the support structure for pupils with learning difficulties in England was termed the Special Educational Needs (SEN) system and this term is used when referring to the studies within the current thesis and to studies of SEN conducted before 2014. The post-2014 term SEN(D) includes ‘disability’ in the context of accessing the learning *environment*, as opposed to learning difficulties. SEN(D) is used in reference to post-2014 policy and guidelines. Data for the current study was collected during the spring, summer and autumn terms of 2012 when the 2001-2014 SEN system comprised a three-tiered hierarchical support structure based on gradations of severity and complexity of support needs (Ofsted, 2001). Consequently, these SEN sub-groups are also a focus of investigation relating to finer-grained differentiation within the SEN population. Subsequently, in 2014 the identification, support and terminology for students with special needs was modified and the term Special Educational Needs and Disability (SEND) was introduced (GOV.UK, 2014). The two systems are similar in terms of the identification of the broad population of students with special needs, but the sub-groups are slightly different, as is the process of support. The post-2014 system is less rigid in structure, adopting a continuum approach towards the needs of all but the most challenged students, who qualify for statutory statements. The next paragraph outlines the main changes and differences to the SEN(D) system since the data collection period.

Prior to 2014, children with school-identified needs were classified in two hierarchical tiers according to the SEN Code of Practice (2001) (Ofsted, 2001) guidance. Thus, entry level School Action (SA) support was recommended if performance (amongst other indicators) was amongst that of the lowest attaining 10 -15% of a student's age group, equivalent to a standardized test score in the low 80s. Students at SA received school-initiated interventions or were being monitored consequent to a lapse in attainment, and placement at this level was generally for up to one academic year. If progress was good, SEN status was revoked and if cause for concern continued, a move to the next level of support, termed School Action Plus (SA+) would trigger further assessment and support from external teaching services (Special Educational Support Service). According to the SEN Criteria for Provision (Leics) statutory guidance for placement at SA+, indicated attainment as amongst that of the lowest attaining 5% of the age group (equivalent to a standardized school attainment test scores of 75) (Westerman, 2001). It is worth noting, however, that individual assessments within schools tend to record raw scores, not standardized scores, for monitoring or attainment tracking purposes. In 2014 these two levels of additional support needs were combined as 'SEN Support'. Within the 2001-2014 Code of Practice, children with more complex, long term needs involving multi-agency input were likely to have a statutory statement of special educational needs, and ability levels for statement criteria were recommended for the lowest attaining 2% of the age group (equivalent to a standardized test score of below 70). Statutory statements were subsequently replaced by Education, Health and Care (EHC) needs and assessment plans in the 2014 SEN(D) Code of Practice (GOV.UK, 2014).

The categories of SEN provision in the 2001 system (see Chapter 3) were similar to the current 2014 code, which includes four separate categories of additional needs: communicating and interacting; cognition and learning; social, emotional and mental health difficulties; sensory and/or physical needs. The 2001 category 'social, emotional and *behavioural* difficulties' was re-classified to include an emphasis on mental health difficulties. As the process of identification of SEN(D) has not changed significantly, this is described in relation to the current practice. The first stage of the SEN(D) support system process is an assessment of needs involving parents, teachers and experts, such as an educational psychologist or health professional. A plan is then agreed which outlines how a child will benefit from the proposed targeted support and the school implements the plan and tracks progress through the involvement of teachers, the school Special Educational Needs Co-Ordinator (SENCO), support staff or specialist teaching staff. Following the intervention period agreed in the plan, the impact of the support is reviewed, and changes are made, if required.

The revised Code of Practice aims to give schools more autonomy to innovate and transform SEN provision. If the term ‘special needs’ is considered synonymous with ‘poor abilities’ then expectations may be lower than for students without identified additional needs (Ellins and Porter, 2005). According to Lupton (Lupton et al., 2010), teachers’ understanding of SEN is shaped by their experience of additional needs, which includes prioritizing and resource allocation according to factors such as individual targets for Key Stage attainment tests, administrative procedures, local authority finance policy and broader socio-economic influences. These considerations suggest the importance of identifying areas of strength as well as those that are below average in the standardized abilities of students with SEN status.

Literacy and numeracy difficulties tend to be identified in the primary school years, but children may not receive SEN status if the nature of their difficulties is deemed transitory with the likelihood of improving with maturity. This means that the students with SEN status entering secondary school are likely to have longer-term issues which are recorded on the SEN Register. Otherwise, those with attainment below the expected level 4 in the English National Curriculum literacy and/or numeracy statutory assessments in Year 6 (age 10) at the end of Key Stage 2, prior to secondary school entry, are identified for school-initiated interventions aimed at boosting core skills. Continuing with the theme of identification, the following section examines the progress and attainment tracking process (PAT) which is a precursor to SEN(D) assessment. Importantly, neither of these processes investigate EF, which I will argue is a fundamental underpinning of learning ability and should be investigated as a matter of routine.

1.1.2 Progress and Attainment Tracking: Teachers' Observations

All students' literacy and numeracy skills are assessed on entry to secondary school at age 11, which is the beginning of Key Stage 3, as part of a screening process and to predict attainment levels three years later at the end of Key Stage 3 at age 14. The procedure is not, however, a rigorously controlled process and testing occurs in a variety of school-determined contexts. Further, the selection of standardized assessments can differ between schools and specific tools vary in how they are administered. For example, the same National Foundation for Educational Research (NFER) comprehension assessment might be administered to a year group but spelling and vocabulary assessments might only be presented to lower attaining students whose grades are at least two levels below the expected National Curriculum (NC) grade level for the peer group. Unless previously diagnosed in primary schools, these students are likely to be receiving entry level interventions for literacy and/or numeracy support.

An interview with the SENCO of one of the schools which participated in the research for this thesis, revealed how slippages in achievement, effort or behaviour were identified termly through teacher comments on the school's Tracker database. Where an individual's progress was rated cause for concern, standardized literacy/numeracy tests were re-administered but raw scores rather than standardized scores were commonly recorded as indicators of difficulty (SENCO interview School 2/personal experience). The reason to record raw scores was because the emphasis was on individual attainment, not for comparison purposes. The SENCO also stated that descriptors of support needs tended to be less prescriptive than the statutory categories and not all students could be neatly classified. A Department of Education report released in 2017 supported the

SENCO's anecdotal comments thus: '*some of the descriptors used do not indicate the types of support an individual needs*' (Carroll et al., 2017; p.9). These commonly used tracking processes give rise to three major concerns in relation to the identification of pupils' learning needs. These concerns are examined next.

The first concern is that progress tracking comments do not address issues relating to the processes that underpin learning, such as working memory, inhibition and cognitive flexibility (i.e., the three key components of EF) but concern expected attainment targets, the actual levels of attainment and behaviour/learning attitude. Research into EF difficulties in young people with developmental disorders on one hand, and the impact of learning difficulties on academic achievement, on the other, suggests that students with SEN are a particularly vulnerable population. Meta-analytic reviews of EF research (including longitudinal studies of working memory) and academic attainment have shown that EF has considerable overlap with the core cognitive skills that underpin academic success, such as attention, reasoning, and problem solving (Gathercole et al., 2003, Jarvis and Gathercole, 2003, Gathercole et al., 2004b, Jurado and Rosselli, 2007, Best et al., 2009, Banich, 2009, Carretti et al., 2009, Hughes, 2011, Best et al., 2011). The message is that, although attainment levels are tracked and causes for concern across the curriculum are identified, the fundamental components which support learning skills, namely EF, are not assessed.

The second concern is that the tracking and assessment process focuses on individual attainment and the use of raw test scores rather than standardized test scores (which are corrected for age) fails to locate the student's difficulties in relation to age-related norms. Furthermore, individual raw scores in isolation cannot offer insights into patterns of strengths and difficulties which would be indicative of how the collective body of SEN students are progressing in relation to each other and in relation to their typical learner peers. Finally, where an official assessment of additional needs has not been conducted, schools tend to use a range of descriptors for areas of difficulty which lack the precision of diagnosis. This means that, whether from an individual or group perspective, there is no guarantee that underlying causes, nature and extent of learning difficulties have been fully identified, thereby enabling appropriately targeted interventions to be enacted.

The paragraph above exemplifies the argument made by Norwich and Lewis (2007) regarding terminology. Thus, diagnostic labels which have clinically or empirically based definitions, such as ASD, ADHD and dyslexia, contribute valuable knowledge of factors underpinning a learner's development. In contrast, less specific descriptors found in relation to SEN status, such as 'low attainers', 'emotional/behavioural difficulties' or 'Moderate Learning Difficulties' can be too general to be helpful. Norwich and Lewis (2007) also point out that SEN categories of provision reflect administrative and resource allocation decision-making but not necessarily categories of learner characteristics that have pedagogic relevance. For example, in the current SEN sample, a student at the intermediate intervention tier (School Action Plus – SA+) had primary needs described as 'Young Carer'. Such lack of precision in defining the area of learning need for some students compounds an important issue regarding teacher knowledge of SEN, which was raised in a Department for Education report (Carroll et al., 2017).

According to the 2014 SEN(D) Code of Practice, all teachers are teachers of SEN, which begs the question: how is the concept understood and approached in practice? The Department for Education (2017) report states that: 'Typically, teachers, especially secondary school teachers, receive minimal information on SEND as part of their initial teacher training. This knowledge is often something that comes informally, piecemeal and from '*experience … and it is not normally useful to assume that 'all' those with a particular need will require the same type of support'* (Carroll et al., 2017; p. 14 - 15). Previous research has also, according to Norwich & Lewis (2007), focused on identifying differences between learners across the SEN categories and systematically linking these with learners' needs for differential teaching, separate from normal provision, on the basis of aptitude and intervention. This requires accurate matching of needs with specific interventions, but the identification process examined above raises concerns that some individuals may have difficulties which are not targeted by standardized assessments. The next paragraph examines issues relating to a key element of teacher practice: classroom management and the importance of teacher awareness that an underlying impairment may be the cause of observed behavioural barriers to learning.

Teachers are required to differentiate lesson content and objectives to make learning accessible for students diagnosed with a learning disorder. In the classroom environment, however, a student might also manifest challenging behaviours which are interpreted as unrelated to the specified interventions and therefore considered in classroom management terms as a disciplinary issue. In a busy, resource constrained learning situation therefore, the teacher might need to prioritise between focusing on the student's core academic difficulties or the behaviours that might be presenting more serious barriers to learning (Crane and Leonard, 2012). The post-2014 Code of Practice places greater emphasis on mental health in the learning context so if challenging behaviours are unspecified or unidentified aspects of a diagnosis then the longer term implications of 'persistent disruption' can be extremely damaging for a young person's experience of learning and future prospects (Belen et al., 2018).

Norwich and Lewis (2007) investigated the different ways students across the SEN spectrum are perceived and how their difficulties (or absence of difficulties) are defined (thereby influencing teaching strategy). They found the nature of common SEN groups, including 'attention difficulties', 'Moderate Learning Difficulties' (MLD) and 'low attainers' to be defined in terms of environmental and contextual influences external to the individual (Norwich and Lewis, 2007). Behaviour difficulties were therefore interpreted as matters of conduct and addressed by containment of the disruptive impact (Lupton et al., 2010). Implicit in this scenario is what Norwich identified as the dilemma of whether or not to recognise difference (Norwich, 2009) in an inclusive educational environment where the risk is either of potential stigma or failure to provide adequately for individual needs (Norwich and Kelly, 2005, Norwich, 2009, Norwich, 2010, Norwich and Lewis, 2007). Patterns of maladaptive EF behaviours that impede successful negotiation of everyday life have been identified not only in the most common of the developmental disorders such as ADHD and ASD (Gilotty et al., 2002, Epstein et al., 2008, Toplak et al., 2008, Alloway et al., 2009a, Christ et al., 2010) but also in less well researched disorders such as pre-term birth (Aarnoudse-Moens et al., 2013, Burnett et al., 2013, Vollmer et al., 2017), foetal alcohol spectrum disorder (Gross et al., 2014) and brain injury (Byerley and Donders, 2013). These less common diagnoses feature on schools' SEN Registers but as descriptors give no indication of associated cognitive and behavioural issues likely to affect the individual's learning capacities.

To summarise, this section has identified concerns of exactitude in the identification of learning issues, including varying assessment processes across schools and imprecise descriptors and gaps in the understanding of SEN(D). Schools do not routinely assess the underlying cognitive skills that support learning and adaptive classroom behaviours. Consequently, teachers can interpret maladaptive behaviours as lack of compliance and/or conduct issues which can lead to a trajectory of misapprehension and lost opportunities to identify their underlying causes. Previous studies of specific disorders identified in the SEN(D) categories of provision have found poorer EF to be a factor, suggesting that students with SEN status may be particularly vulnerable to processing difficulties. While the above section has examined issues relating to progress and attainment tracking, the following section takes a closer look at the SEN population.

1.1.3 The SEN Population in England: 2014 and 2018

In this section the prevalence of SEN during the time of data collection is described. The information is from a report released by the government in 2014 (Whitaker, 2014) and more recent statistics from a report dated 26 July 2018, entitled ‘Special educational needs in England: January 2018’ (Statistics, 2018).

Government statistics released in 2014, which relate to the data collection timescale and three-tiered support structure, reported the prevalence of SEN as 17.9% of the total pupil population in England, of which 2.8% had statements. The three tiers of support were: entry level interventions for school identified difficulties (School Action or SA); the middle tier represented those with difficulties which had not responded to school based initiatives and were receiving external specialist teaching (School Action Plus or SA+) and those with the most complex profiles involving multi-agency input who met the criteria for a statutory statement of additional needs. The most common primary need was Speech, Language and Communication Needs, recorded for 20.6% of School Action Plus and statemented pupils. Autism Spectrum Disorder was the most common primary need amongst pupils with statements and SEN was more prevalent in boys across all age groups and school types (Whitaker, 2014). Statistics for School Action were not recorded as entry level support tends to be of a short-term nature and the population more fluid. Consequently, little is known about the characteristics of students who were being monitored as a result of raised concerns or receiving school-initiated support. Statistics for mainstream state funded secondary schools, the type of school which participated in this study, showed the three most frequent types of primary need as: Behaviour, Emotional & Social Difficulties (26.7%); Moderate Learning Difficulty (MLD) (20.3%); and Specific Learning Difficulty (15.6%). The prevalence of pupils with statements was 25.7%, contrasting with 20.9% (a reduction of 5%) for those with statements or EHC plans reported in the January 2018 school census. The prevalence of students with school identified additional needs (SEN support) in 2018 was 33.9%. The prevalence of SEN for the total student population across all schools, (which include primary, special, independent schools and pupil referral units) in January 2018 was 14.6% in January 2018 with 2.9% having a statement or EHC plan.

The 2018 statistics therefore suggest a decline in the number of children with SEN in mainstream secondary education since data collection. This could be the result of better identification of those who have SEN and those who do not, but this hypothesis has not been investigated. Other factors, such as financial constraints, however, may be pertinent.

According to the most recent figures presented in July 2018 for the total student population, the most common type of need for students on SEN support was Moderate Learning Difficulty (MLD) with a prevalence of 24%, while 28.2% of students with a statement or EHC had a diagnosis Autism Spectrum Disorder (ASD) (as in 2014). This appears to support Norwich's (2009) concern regarding a 'catch all' label for those whose needs do not qualify for extensive statutory assessment, evidenced in the prevalence of the diagnostic category of ASD. Table 1.1 below shows the range and prevalence of SEN issues supported from ages 5 to 16 in England.

Looking at Table 1.1, it is apparent that the majority of students with SEND status have clinical diagnoses of a developmental nature, such as: learning difficulties, speech, language and communication needs (SLCN) and ASD, as opposed to physical issues. Varying patterns of EF deficits have been reported in the most commonly studied developmental disorders and are thereby indicative of areas of weakness that may affect students across the SEN spectrum. These include ADHD (Biederman et al., 2004, Sonuga-Barke, 2005, Willoughby, 2005, Pennington, 2006, Rogers et al., 2011), ASD (Bishop and Snowling, 2004, Bishop and Norbury, 2005a, Bishop and Norbury, 2005b, Verté et al., 2006, Happé et al., 2006, Robinson et al., 2009, Dichter et al., 2009, Christ et al., 2010, Christ et al., 2011, Akbar et al., 2013, Troyb et al., 2013, Caterino, 2014), speech, language and communication impairment (SLI) (Henry, 2001b, Bishop and Snowling, 2004, Conti-Ramsden et al., 2006, Whitehouse et al., 2007, Bishop et al., 2009, Henry et al., 2012, Bishop, 2012) and general learning difficulties /intellectual deficit (ID) (Henry, 2001b, Danielsson et al., 2010, Henry and Winfield, 2010, Danielsson et al., 2012, Van der Molen et al., 2013, Bexkens et al., 2013, Jansen et al., 2013). Social, emotional and behavioural difficulties (SEBD) form a category of provision addressing the impact of adverse environmental factors on learning. For example, previous research suggests that chaotic home environments contribute to attention issues which then impact the capacity to learn, as noted in relation to ADHD and dyslexia (Boada et al., 2012) and that maltreatment has a negative impact on EF development and the ability to cope in the classroom (Kirke-Smith et al., 2014).

As Table 1.1 shows, the SEN(D) population is a broad church of individuals defined by a range of cognitive, social and behavioural barriers to accessing learning and the learning environment at varying degrees of severity. The following section, however, suggests the prevalence of discrete primary diagnoses recorded in Table 1.1 may not represent the complexity of SEND difficulties, particularly where potential difficulties are less well known, as in rarer syndromes. Studies have also identified shared characteristics across the most common developmental disorders and the implications of co-morbidity (co-occurrence of disorders) are also considered.

Table 1.1 Percentage of Students with each primary type of need on SEN Support or with a statement/EHC plan

Primary Type of Need	SEN Support %	Primary Type of Need	Statement EHC Plan %
Moderate Learning Difficulty	24.0	Autism Spectrum Disorder	28.2
Speech, Language and Communication Needs	22.8	Speech, Language and Communication Needs	14.6
Social, Emotional and Mental Health	17.5	Social, Emotional and Mental Health	12.8
Specific Learning Difficulty	15.0	Severe Learning Difficulty	12.5
Autism Spectrum Disorder	5.7	Moderate Learning Difficulty	12.0
Other Difficulty/Disability	5.1	Physical Disability	5.4
Physical Disability	2.4	Profound and Multiple Learning Difficulty	4.3
Hearing Impairment	1.7	Specific Learning Difficulty	3.5
Visual Impairment	1.0	Other Difficulty/Disability	2.6
Severe Learning Difficulty	0.3	Hearing Impairment	2.5
Multi-Sensory Impairment	0.2	Visual Impairment	1.4
Profound & Multiple Learning Difficulty	0.1	Multi-Sensory Impairment	0.3

Source: *Schools census, January 2018*

1.1.4 Does a focus on primary difficulties address the nature of SEN(D) difficulties adequately?

An important issue for SEN(D) provision is whether secondary difficulties are addressed appropriately, if at all, particularly if an undiagnosed disorder or deficit is less well researched (Butterworth and Kovas, 2013). Because of genetic testing, the prevalence of newly identified syndromes and sub-types is increasing (Thomas et al., 2013). The challenge for provision is that, although some syndromes may have a range of common difficulties, each individual child with the same diagnosis will have distinct patterns of characteristics which can emerge at different times during the developmental journey. Syndromes are inherently complex and where there is little longitudinal evidence of developmental pathways in rarer diagnoses, such as CHARGE syndrome (Blake et al., 2005, Hartshorne et al., 2005, Hartshorne, 2011), the support plan can be limited to immediate safety and learning concerns arising from identified physical difficulties, such as sight, hearing or gross motor skills. Teachers are therefore unlikely to be prepared for or to understand the underlying reasons for changes in a student's capacities when different developmentally related cognitive and behavioural difficulties arise in response to increasing challenges. Taking CHARGE as an example, inability to *articulate* self-related information is a pervasive deficit and the child's manifest frustration may be misapprehended as general lack of ability, poor attitude or wilful disruptive behaviour (Hartshorne, 2011). Communication difficulties have, in fact, been found to be associated with executive function impairment in CHARGE (Nicholas, 2005). Securing external assessment and appropriate provision to meet what might be perceived as difficulties unrelated to the diagnosis may then be a lengthy and uncertain process during a critical phase of education (Blake et al., 2005).

The on-going nature of difficulties arising from long-term developmental disorders are illustrated in Butterworth and Kovas' (2013) model shown in Figure 1.1 (below). This shows the web of causal influences which contribute to additional needs specified in the SEN categories of provision. These causal underpinnings are likely to be produced by layers of inter-relating causal impairments, from genetics to brain systems to different levels of cognitive processes and these interact to produce behavioural outcomes. In this way, a matrix of influences result in individual differences and specific additional needs (Butterworth and Kovas, 2013). (Permission to use figure below granted by author).

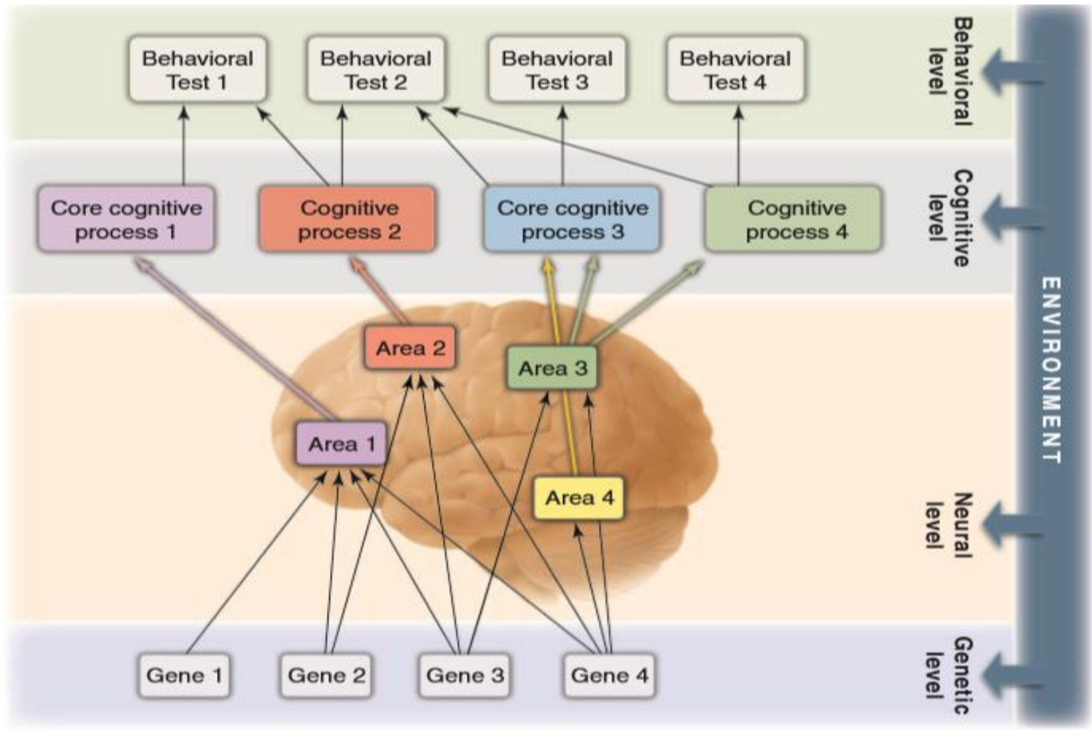


Fig. 1. Networks of interaction. Schematic model of the relationships among levels of explanation—genetic, neural, cognitive, and behavioral—following the causal modeling framework (*34*). There can be many-one, one-many, many-many, and one-one relationships between levels. A domain-general cognitive process and a domain-specific core cognitive process can have effects on more than one behavioral test, and performance on a behavioral test may be affected by more than one cognitive process. Moreover, one cognitive process may depend on another (e.g., memory on attention), and one behavior may causally affect another (e.g., poor reading may impair mathematical problem solving).

Figure 1.1 Butterworth & Kovas' (2013) Model of Networks of Interaction

The networks of causal interactions in Butterworth's model suggest the way cognitive processes ('domain general' is defined by Butterworth as an ability such as IQ, measured by standardized assessments, 'domain specific' includes separate EF modalities) interact as a web of influences which create the spectrum-like profiles of the SEN population. According to Butterworth, the important message from this type of multi-layered model is that what may be observed by teachers in the classroom as disruptive behaviours or poor learning skills is the complex outcome of a cascade of influences between inter-related and inter-dependent influences.

Sonuga-Barke's (2005) proposed paradigm shift for explaining ADHD exemplifies how this might manifest in a learning situation. Sonuga-Barke suggested a move from traditional models where causality is attributed to the role of common, simple core deficits, such as inhibitory control, to consider a model which focuses on the individual's developmental context and the goodness of fit between the individual and their environment and how well the person adapts to developmental constraint (Sonuga-Barke, 2005). By including the influence of motivation (explained at the level of reward systems in brain circuitry), this suggests that how the child experiences learning and perceives their own ability in response is an important factor for understanding maladaptive behaviours in developmental disorders.

Further, Butterworth also explains why a developmental deficit at the cognitive level, such as a diagnosis of numerosity impairment in the SEN categories of provision, is not necessarily confined to non-verbal processing capacities. Butterworth states that this is because maths skills appear to require good language abilities for the typical development of counting, calculation, and arithmetical principles (Butterworth and Kovas, 2013). In other words, the message is that an impairment in a specific domain such as non-verbal processing does not mean the corresponding verbal domain is intact, as found for non-verbal EF skills in students with SLI, as reported by Henry and colleagues (2012).

As Table 1.1 (above) shows in relation to the SEN sample, the primary area of need is the main focus of targeted interventions. Clinical diagnoses, such as ASD, are given when symptoms meet necessary and sufficient criteria for that specific disorder. Research studies in developmental disorders follow this clinical model by recruiting participants with the relevant diagnosis and ensure a 'pure' sample by excluding potential participants with other difficulties, or co-morbidities, which might influence the outcome. As mentioned earlier, research in learning difficulties has also tended to focus on individuals with similar issues for which specific interventions can be identified. The issue for SEN is that a focus on patterns of anomalies which are known to be common across individuals with a specific diagnosis may not sufficiently address the unique group of deficits for an individual (Pellicano, 2012). As Butterworth's model (Figure 1.1 above) suggests, changes in observable behaviours and capacities may be the outcome of the atypical developmental pathway of a specific syndrome, but the patterns and extent of emergent difficulties will vary across individuals.

The literature therefore contains a plethora of studies which report core deficits of a single disorder and sub-types which conform to the discrete categorical structure of the American Psychiatric Association's Diagnostic Manual (DSM-V). The cumulative impact of these studies is a complex web of inconsistent findings and limited explanatory frameworks which offer a fragmented understanding of the fundamental processes which support academic learning. In fact, studies which have examined, for example, the finer-grained details of ADHD sub-types and nuances in behaviour query the usefulness of a single label for intervention purposes (Chhabildas et al., 2001, Barkley, 2012). The following paragraphs examine a related complication for the identification of learning issues; the causal effects of multiple deficits across co-morbid disorders (Pennington, 2006).

The difference between co-morbidity and primary and secondary deficits originating from a single disorder is that shared characteristics across separate disorders imply spectrum-like multiple difficulties (Pennington, 2006) (see Hartshorne, above). Behaviourally defined developmental disorders such as dyslexia (reading disorder), ASD and attention deficit hyperactivity disorder (ADHD) are known to have overlapping characteristics with other disorders. For example, levels of co-morbidity for ADHD and dyslexia (Pennington et al., 1993, Boada et al., 2012) have been estimated at between 33% to 45%, and between ADHD and dyscalculia (numerosity impairment) (Willcutt et al., 2013) as 11% (Butterworth and Kovas, 2013). Furthermore, where ASD, an extremely complex disorder is concerned, the core criteria for diagnosis have traditionally focused on the social, communication and inflexibility impairment triad (e.g., Wing and Gould, 1979) but over 50% of individuals also have clinically significant impairment in structural language (SLI) (Bishop and Norbury, 2002, Williams et al., 2013). The prevalence of comorbidity strengthens concerns that students identified with a single diagnosis for intervention purposes may have further underlying issues. It also suggests that there may be common factors across these disorders which contribute to the learning difficulties of the SEN population.

Thus, the uneven syndrome-like patterns of deficit found in studies of co-morbid and/or multiple sub-category disorders, such as ADHD and ASD (Geurts et al., 2004, Verté et al., 2006, Barkley, 2012, Geurts et al., 2014) whereby capacities can vary for each cognitive skill within and across studies, is turned to advantage in this thesis. Embracing the diversity of the SEN spectrum recognises that there could be an important degree of homogeneity of the SEN population, which is related to the collective need for additional support in the learning environment. This approach offers the possibility that, by investigating EF processes and behaviours which have previously been the focus of studies of specific developmental disorders, or factors associated with academic attainment, a different and more educationally relevant understanding of the learning processes in this group of students could be achieved. This thesis can therefore add to previous research because a comparatively large sample of SEN students and their teachers affords: first, a different perspective on EF by investigating the difference in EF between SEN and non-SEN students and, second, an investigation of the relationship between EF and SEN status (i.e., whether or not a student is identified with SEN) as well as the influence of reading, vocabulary and non-verbal cognitive abilities on this predictive relationship.

1.1.5 Summary of Part One

Young people identified with SEN are a large body of students within the educational population, with diagnoses covering a range of developmental disorders and/or learning difficulties. Consequently, they comprise a unique population in offering scope for the investigation of both clinical and educational research questions. Issues relating to identification, focus of support and descriptors of additional need SEN criteria are unlikely to make explicit reference to EF as a risk factor, but studies of developmental disorders suggest that the SEN group may have less efficient EF skills than their peers with no identified learning difficulties. This is substantiated by research into developmental disorders which has highlighted the prevalence of co-morbidities across discrete disorders. Descriptors of additional need may lack precision and pedagogical relevance and are thereby likely to affect the identification and application of appropriate support interventions. Teacher understanding of SEN(D) is shaped by individual experience. In the absence of knowledge relating to the cognitive (EF) underpinnings of learning skills, maladaptive behaviours may be mis-interpreted as conduct matters and thus, opportunities to address underlying processing impairments are missed.

The overall message is that the extent of co-morbidities and broader behavioural difficulties indicate that within the SEN(D) population there are individuals whose needs do not fit neatly with clinical syndrome diagnoses. SEN(D) categories of provision cover a broad range of learning issues but, as with clinical diagnoses, priorities for intervention might focus on the primary area of need and unless specified, secondary issues may not be appropriately addressed. The prevalence of co-occurring disabilities also suggests that a different approach could be useful which focuses on commonalities across different disabilities rather than trying to identify the characteristics and needs of each specific disability. The advantages are two-fold. First, identifying common characteristics across the SEN(D) population in the cognitive processes which underpin fundamental verbal and non-verbal abilities would enable teachers to adopt a more inclusive approach by capitalizing on those skills identified as strengths across the body of SEN(D) students as well as addressing finer-grained issues of individuals. Second, examining SEN sub-groups offers the opportunity to identify nuances in skill patterns which may be related to the severity and complexity of additional needs, as indicated by level of support rather than diagnosis.

1.2 PART TWO EXECUTIVE FUNCTION

1.2.1 Introduction

The focus of Part Two is about executive function, beginning with definitions and an overview of theoretical perspectives about EF components and their operation as a system. According to Crone, adolescence is a period of significant cognitive development with improvement in the ability to control thoughts and actions to make them consistent with internal goals (Crone, 2009). This process coincides with the secondary school Key Stage 3 years, during which students aged 11 to 14 years prepare for the academic demands of the Key Stage 4 statutory GCSE examinations at age 16. Leaving the structured primary school environment, they need to adapt to expectations of increased independence and responsibility towards learning, as well as aspiring to academic targets indicative of prospective GCSE grades. For students with SEN(D) status, this transition is known to be particularly challenging as the additional pressures of adapting to the relatively unstructured secondary environment are significant (Evangelou et al., 2008, Rice et al., 2019). These include understanding and meeting the demands of daily timetables, adapting to different classroom environments for each subject, the introduction of new subjects and different teachers for each subject, all with varying expectations and concerns. If this large body of students is to meet their potential, these are likely to be critical years for improving and consolidating academic skills of literacy and numeracy.

Currently, there are gaps in the literature about the nature of EF across the SEN(D) population and this means there is an absence of knowledge about mechanisms and processes which could be helpful for interventions to address educational needs (but see Diamond and Ling, 2016). The next section begins with definitions of EF. This is followed by conceptualisations of the nature of EF as an executive system (Roberts and Pennington, 1996, Barkley, 1997, Baddeley, 1998, Miyake and Friedman, 2000, Miyake and Friedman, 2012), and the developmental process (D'Souza and Karmiloff-Smith, 2011, Thomas et al., 2009, Thomas et al., 2013). This prefaces a review of the ways that impaired EF processing and behaviour might affect the ability to thrive at secondary school, leading to further examination of reported links between EF and academic achievement. The chapter ends with reasons for studying the SEN population and EF, a summary of important gaps in the literature, and the research questions addressed in this thesis.

1.2.2 Definitions and Conceptualizations of EF

The subsections below begin with a selection of definitions which conceptualise the role of EF in daily life. This is followed by an introduction to a seminal model of EF, the Unity and Diversity Model (Miyake and Friedman, 2000, Miyake and Friedman, 2012). This model specifies the three core components which have been used extensively in studies investigating links between EF and academic achievement. It is also the model used in Chapter 5 to investigate EF structure and relations. In this section there is also an explanation of the approach adopted in the current study due to the under-representation of SEN(D) in the EF literature. The last topic in this section considers varying theoretical conceptualizations of EF as a system together with important insights from previous studies which suggest that impairment in one component is likely to affect the system as a whole.

1.2.2.1 Definitions of EF and their Relevance to SEN(D)

Research in EF has been informed by a range of theoretical and conceptual frameworks, including; neurological research on individuals with acquired brain damage, cognitive psychology, developmental psychology and neuropsychology. Thus, as Rabbitt noted, there is no unitary definition of EF (Rabbitt, 1996). A useful definition from cognitive psychology, however, is that executive processes are the part of cognition that logically must occur *after* perception but *before* action (Pennington and Ozonoff, 1996). Diamond and Ling (2016) defined EF recently as mechanisms of "inhibitory control, working memory, and cognitive flexibility [which] enable us to think before we act, resist temptations or impulsive reactions, stay focused, reason, problem-solve, flexibly adjust to changed demands or priorities, and see things from new and different perspectives". These skills are critical for success in all life's aspects and, according to Diamond, are sometimes more predictive than even IQ or socioeconomic status (Diamond and Ling, 2016; p. 34). Thoughts and actions governed by EF can be distinguished from habits, or forms of mental activity that are acquired gradually through repeated practice and that provide fixed automatic solutions to well-defined problems (Kamkar and Morton, 2017). EF therefore enables negotiation of complex and changing circumstances in the absence of automatic solutions (Diamond, 2013). Eslinger (Eslinger, 1996) asserted that:

"[the] development and elaboration of executive functions are *critically dependent on memory and attention* and […] can provide a basis for the continuing adaptation, adjustment and achievement throughout the life span" (Eslinger, 1996; p. 392).

In other words, EF is involved in all aspects of everyday life whenever flexible and adaptive responses are necessary for successful outcomes. These definitions suggest that as EF is a complex concept, the next paragraph focuses on the nature of its core elements. A seminal model of EF is the Unity and Diversity model (Miyake and Friedman, 2000) whereby three core components were identified from confirmatory factor analysis of performance on many individual EF tasks tapping somewhat different sub-skills in adults. These variables contributed differentially to performance on complex EF tasks and although evidence showed that the three components of EF were distinct, nevertheless they were still loosely related to each other, thus demonstrating the unity and diversity of EF (this model is elaborated in section 1.2.3.2 below and in Chapter 5). The first component, updating, represents the ability to update and store information concurrently. Updating is a very similar concept to executive working memory (EWM) and there is evidence that these types of measures are highly related (St Clair-Thompson, 2006). The second component, switching/shifting, is the ability to switch to a more adaptive strategy to achieve a goal after negative feedback. The third component, inhibition, is required to prevent irrelevant or distracting information from interfering with the achievement of goals (Miyake and Friedman, 2000, Henry et al., 2015a). These core EF components are considered to be the building blocks which support less central but nevertheless essential EF skills, such as fluency, planning and organization (Messer et al., 2018). Miyake's models are discussed further in the context of structural analyses of EF in SEN and Non-SEN groups in Chapter 5. Several of the studies in this thesis also include measures of verbal and non-verbal fluency. Verbal fluency tasks involve the person identifying as many words as possible that are related to a category (e.g., furniture or animals). Fluency can be considered a supplementary EF process which harnesses the core mechanisms to enable successful goal-oriented outcomes. Fluency has been assessed in previous investigations of EF and appears to discriminate between those with disabilities and typically developing comparison groups (Takács et al., 2013, Henry et al., 2015a).

Studies using latent variable modelling suggest that early adolescence is a period of flux in typical EF structural organisation (Klenberg et al., 2010, Xu et al., 2013, Lee et al., 2013) with greater co-dependencies between components than in mature EF structural organization (Miyake and Friedman, 2000, Miyake, 2009), which begs the question of how EF components inter-relate in SEN during adolescence. Where provision is concerned, this is important information as EF may also support academic related abilities of reading, vocabulary and reasoning (van der Sluis et al., 2007). This raises key issues which are outlined below.

A fundamental objective of SEN(D) provision is to improve students' literacy and numeracy where disparities in attainment have been identified in relation to normative expectations (GOV.UK, 2014). Reading, vocabulary and reasoning abilities are the basis of targeted interventions. No previous studies appear to have investigated whether differences exist between SEN(D) and Non-SEN(D) peers at Key Stage 3 in general learning abilities as assessed by EF, or if found, the extent of these differences. The question of whether there are differences in reading, vocabulary and reasoning abilities between SEN and Non-SEN peers is addressed in Chapter 3 by mapping the range of ability characteristics in each group as preliminary baseline information prior to investigating differences in EF according to SEN status (see Chapters 3, 4 and 8 respectively).

Several challenges arose from the lack of information in the literature concerning the nature of EF difficulties in younger adolescents identified with SEN. This absence was important as it meant a different approach was needed to identify the type of information which would be of greatest value to teachers and thus shape the research questions. As teachers are responsible for recognising learning difficulties in the classroom environment, the cognitive aspects of EF were an important consideration. An interview with the SEN Co-Ordinator of the third participating school identified difficulties with self-organisation skills and self-awareness as barriers to students' ability to progress as independent learners and to adapt to social aspects of learning. These skills include remembering appropriate equipment for specific lessons or homework deadlines and knowing when it is appropriate to talk in class, for example (see Part 1 section 1.1.2).

The behavioural aspects of EF were therefore a consideration that needed to be taken into account. As the study was aimed at the SEN population as a whole rather than students representing specific categories of provision, groupings were important. These were therefore identified by the tiered support system to be consistent with the levels at which teachers differentiate learning. This enabled baseline assessment of academically related abilities and EF to be investigated between two main groups: those students with and those without additional needs; and for finer grained nuances, between the three SEN levels of support. The issue of whether students with statutory statements differ in EF abilities to school identified SEN peers has relevance regarding the 2014 policy changes which combined the school identified levels of support, SA and SA+. If the systems for identifying additional needs in schools are adequate, then differences between these students and those with statements will reflect the greater complexities and severity of the challenges faced by the latter. From a pedagogical perspective, it was also important to select measures which would identify strengths and difficulties in the SEN group relevant to how teachers present information, e.g., verbally or visually. Thus, knowing if there are differences in patterns of performance between tasks presented in each of these modalities will enable teachers to maximise learning potential by teaching in ways which harness the stronger processing modality.

Findings from studies investigating aspects of EF in clinical groups (e.g., Developmental Language Disorder or DLD) tend to select tasks requiring either a verbal or non-verbal response to measure EF components (see Chapter 4 for details). Although these studies suggest that similar patterns of impairment might be expected in SEN students with a relevant diagnosis (e.g., all those with language disorders), this hypothesis needs to be tested more broadly across the SEN population to be of value from a teaching perspective. As no previous study, as far as I am aware, has investigated the verbal and non-verbal EF characteristics in younger adolescents with SEN in particular, so the investigations reported in this thesis could have findings relevant for targeted interventions.

This testing of verbal and non-verbal abilities is also needed because there can be different patterns of verbal and non-verbal EF performance in a clinical group. An interesting finding from research into developmental disorders is that uneven patterns of impairment can arise in the same EF component depending on whether tasks access verbal or non-verbal (visuospatial) skills. For example, Leonard and colleagues (2015) reported difficulties with non-verbal but not verbal EF in those with Developmental Co-Ordination Disorder (DCD) compared to typically developing peers (Leonard et al., 2015). Alloway and colleagues (Alloway and Temple, 2007) also reported specific patterns of difficulties in those with DCD on visuospatial as opposed to verbal EWM, when compared with typically developing controls, individuals with Attention Deficit Hyperactivity Disorder (ADHD) and those with SLI. Performance patterns across separate processing modalities do not appear to have been studied in SEN(D) and this was an additional reason for assessing EF using verbal and non-verbal tasks.

There is also the counterintuitive possibility that impairments in both verbal *and* non-verbal EF tasks occur in those with language disorders. Henry and colleagues (2012) compared EF in groups with SLI and typical development, after controlling for verbal and non-verbal ability. Poorer performance was still found in the SLI group compared with the typical group in verbal and non-verbal EWM, verbal fluency and non-verbal inhibition. In other words, poor EF performance indicated cross-modality processing difficulties in children with a core language deficit (Henry et al., 2012). As SEN(D) is under-researched, it is not known to what degree or extent impairment in these separate modalities may be an issue and so, for clarity and consistency, verbal and non-verbal measures of EF performance are presented for each of the EF components (see Chapter 3 for details).

The prevalence of co-occurring disorders and overlapping patterns of EF impairment identified from the clinical perspective (see Part One) also suggests the spectrum-like nature of developmental disorders whereby individual differences present a continuum of varying patterns and degrees of strengths and difficulties, as conceptualized in ASD. The concept of a spectrum embraces the diversity of SEN(D) and, because teachers work with students across the ability spectrum, the aim of this thesis is to map students' EF characteristics at the level that teachers work with, i.e., gradations of additional need, not diagnosis. In the absence of statutory statements, teachers rely on tracked performance, observations of classroom behaviour and attitude to identify learning issues and so there is a need to identify common impairment in SEN to help teachers. This study therefore turns the complexity of SEN status to advantage by investigating EF in a broader population to obtain findings which are relevant to teachers in identifying potential learning difficulties based on EF components. A question arising from a clinical approach is whether the diversity of the SEN sample might hide differences in EF profiles associated with specific conditions. From an educational perspective, however, identified differences between the educationally relevant populations, Non-SEN and SEN as a heterogeneous body, provide useful information which can be applied as adaptations within whole-class teaching (Norwich and Lewis, 2001, Norwich, 2010).

To summarise, EF in younger adolescents with SEN(D) is an under-researched topic and findings from narrowly defined clinical studies are not necessarily transferable to this broad and less rigorously defined educational population. This means that a more appropriate approach is to examine the EF characteristics of the SEN population according to students' classification within the graduated support hierarchy. As discussed above, the core EF components of inhibition, EWM and switching identified by Miyake and Friedman (2000) potentially influence the ability to negotiate both the cognitive and behavioural aspects of daily life. The prior identification of these components informed the choice of measures employed in the studies that are reported.

1.2.3 Different Perspectives about EF as a System

The theories and models examined in this sub-section focus on different conceptualizations of EF and the constituent components. Each offers useful insights of the implications of impairment where SEN(D) is concerned which helps to identify the measures of EF used in the thesis. The perspectives include: Baddeley's multi-component view of working memory as being controlled by a central executive system (Baddeley, 1998); Barkley's theory of the fundamental role of inhibition in ADHD (Barkley, 1997); Miyake and Friedman's revised Unity and Diversity model (Miyake and Friedman, 2012);

Anderson's four domain model of EF (Anderson, 2002) and finally, a brief examination of EF developmental trajectories from a neurocognitive perspective.

1.2.3.1 Attention and Working Memory as a System

The concept of EF as 'executive control' (Luria, 1973) involves regulatory aspects of cognitive processing and behaviour, capacities that become increasingly important for success in secondary school. The way EF has been conceptualized as part of a broader system can be seen in Baddeley's development of his model of working memory. (Baddeley, 1986, Baddeley, 1998). The original version of this model (Baddeley and Hitch, 1974) described three main components: a phonological loop to temporarily hold and manipulate verbal information; a visuo-spatial sketchpad to temporarily hold and manipulate visual and spatial information and an overall controller for the system, the central executive, to focus, divide and switch attention as necessary. The later version of this model (Baddeley, 2000) added a fourth component, the episodic buffer, which incorporates multimodal storage capacity and links to short-term knowledge that act to bind information from the whole system into a unitary representation. Baddeley initially conceptualized working memory as a temporary, limited resource storage system under attentional control that underpins the capacity for complex thought and, as suggested by Henry (2011), may be viewed as the bedrock for virtually every cognitive process that relies on temporary storage (Henry, 2011). The central executive manages limited resources involving memory and processing, and this is often referred to as Executive Working Memory (EWM). The revised model of working memory (Baddeley, 2000) shown below is reproduced from Henry (2011).

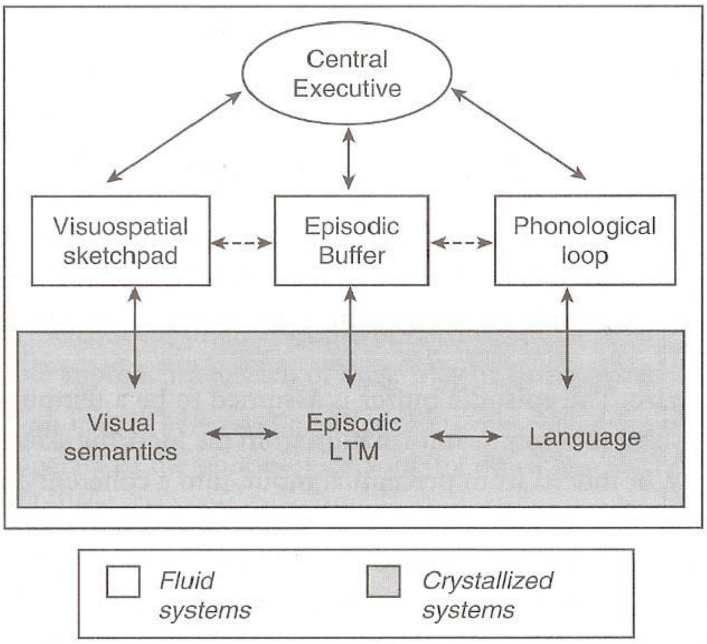


Figure 1.2 Baddeley's revised model of working memory (Henry, 2011)

One aspect of the revised model in Figure 1.2 is the distinction between fluid systems and crystallized systems which are related to two forms of intelligence; fluid intelligence (G*f*) and crystallized intelligence (G*c*). These systems are elaborated in Chapter 8 (Predicting SEN Status) in terms of the extent to which EF might influence academic related abilities. Fluid systems process procedural information, which is tacit and often rule-governed, usually having acquired automaticity from repeated practice, such as *knowing how to* write a report or work through a mathematical problem. Crystallized systems process acquired every-day and learned knowledge, as in schools' curricula subjects. Figure 1.2 shows the central executive and 'sub-systems' as fluid systems which interact with crystallized systems of visual representations, events stored in long-term memory and language.

Baddeley (1986) conceptualized the central executive using the 'supervisory attentional system' (SAS) model (Norman and Shallice, 1986). This model of attentional process comprises two separate modes for directing cognition and behaviour. The contention scheduling mode (CS) organises routine, habit-based, schema driven behaviours while the SAS (synonymous with Baddeley's central executive model of working memory) inhibits routine schemas and directs cognitive resources to solving novel problems and/or responding to the unexpected. The development and evolution of Baddeley's model is discussed in greater detail in Baddeley (2012). Roberts and Pennington (1996) elaborated Baddeley's initial interactive framework by proposing that optimal working memory reduces the effort required to inhibit an incorrect response, leading to improved performance. This perspective suggests that impaired working memory may compromise inhibitory processes (Roberts and Pennington, 1996). Poorer working memory has been identified in SEN (Pickering and Gathercole, 2004) and difficulties with reading have been attributed to a core deficit in the central executive (Wang and Gathercole, 2013). An alternative perspective is that inhibition may be the primary and essential influence supporting the other components in the EF system. This is considered next in relation to a model which suggests that response inhibition may be under-estimated as a causal factor in under-attainment.

1.2.3.2 The Role of Inhibition and Attentional Capacity in Relation to EF

This section contains an outline of three alternative conceptualizations of EF which have focus on the role of attentional capacity in relation to other abilities. Barkley's model of the role of inhibition in explaining ADHD (Barkley, 1997) conceptualized EF as an inter-related system of cognitive control, with a key assumption of his theory being that inhibition is in evolutionary terms the primal EF process. According to Barkley:

"The present theory holds that the satisfactory development of inhibition is essential for the normal performance of five other neuropsychological abilities: working memory, internalization of speech, self-regulation of affect-motivation—arousal, reconstitution, and motor control—fluency—syntax" (Barkley, 1997; p.86).

Figure 1.3 (below) represents Barkley's model which shows that behavioural inhibition affects motor control directly, and that four other EF components also affect motor control directly (Barkley, 1997). These components include working memory, self-regulation, internalisation of speech (which includes problem-solving and self-instruction), and reconstitution, which is similar to fluency. Barkley refers to working memory as a single undifferentiated component which is not as complex as Baddeley's concept, which considers working memory as part of the executive control function of the memory system, as shown in see Figure 1.2 (Henry, 2011). Consequently, according to Barkley, working memory is dependent on response inhibition and interference control to block irrelevant information or inappropriate habitual responses. Retention of information in working memory also depends on the inhibition of unnecessary information, which suggests that the role of inhibition is integral to the success of EWM. Barkley's model is represented below.

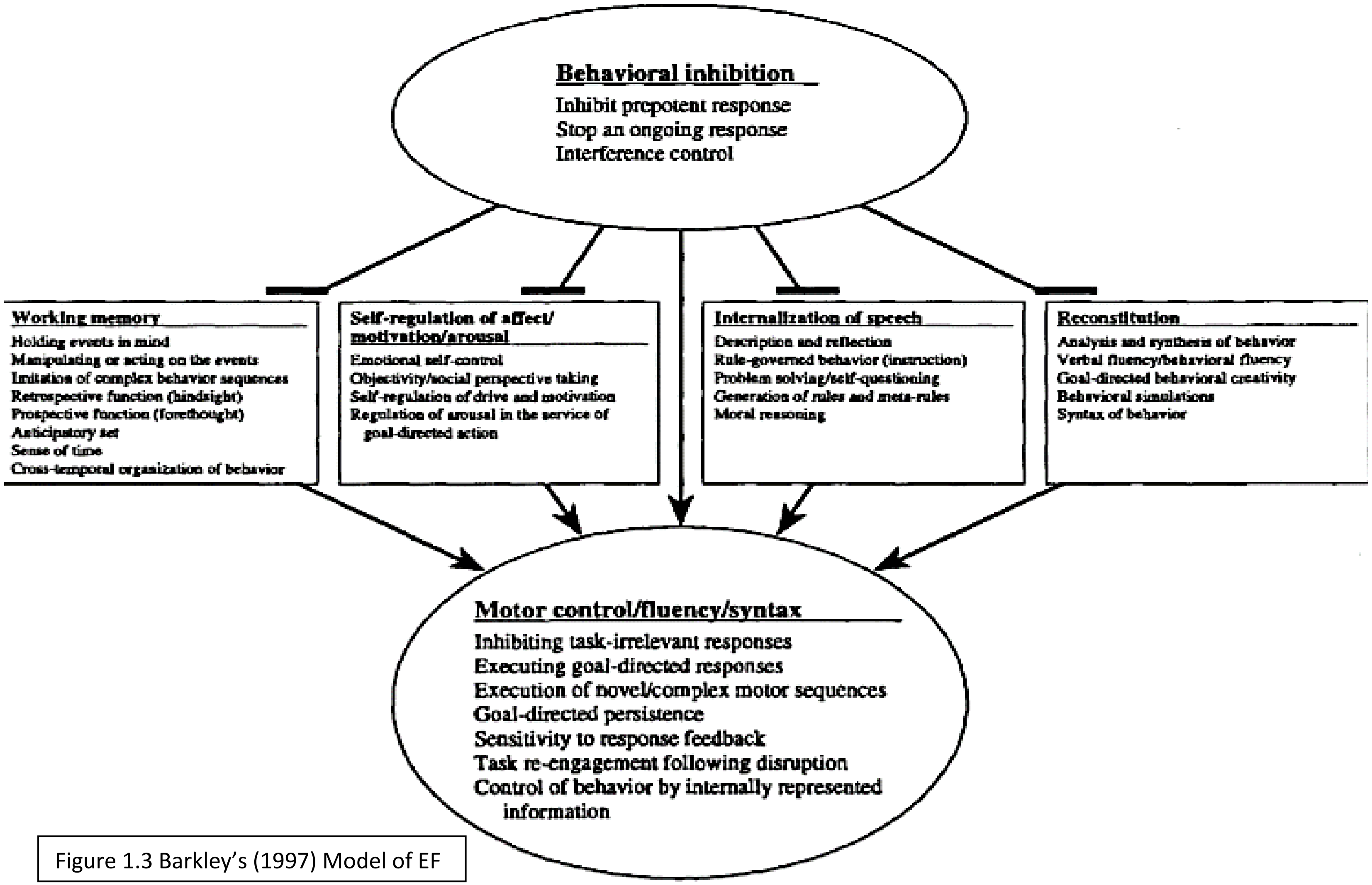


Figure 1.3 Barkley's (1997) Model of EF

Figure 1. A schematic configuration of a conceptual model that links behavioral inhibition with the performance of the four executive functions that bring motor control, fluency, and syntax under the control of internally represented information.

In contrast to Barkley's model which suggests primacy of inhibition, the Miyake et al. (2000) model of EF based on adult data (see Section 1.2.2.1) suggested three separate EF components (working memory/updating, switching, inhibition) that were nonetheless loosely related to each other. An updated model subsequently failed to identify an independent component attributable to inhibition (Miyake and Friedman, 2012). Instead, inhibition formed part of a component comprising inhibition, updating and shifting, defined as a general processing capacity or 'common EF'. Updating and shifting also contributed to the model as independent components, indicative of specialist processes. Thus, whereas Barkley considered inhibition separate to other components of EF, Miyake and Friedman interpreted common EF as an inter-dependent process of keeping task goals in mind while updating the ongoing processing demands with response inhibition suppressing irrelevant information.

Friedman and colleagues (Friedman et al., 2007, Friedman et al., 2011) studied links between attention problems in childhood and EF executive function in late adolescence, which are of relevance to the SEN(D) population. Friedman (2007) investigated relations between attention problems at different ages from 7 to 14, with latent variables indicative of the three core EF components again assessed at age 17. The 20-item Attention Problems scale was used for teacher ratings of children's responses to the demands of a structured classroom. Nine tasks, separately measuring performance on either updating, shifting or inhibition all loaded on one latent variable (showing these tasks to have variance in common). This enabled a common EF component to be identified (which is discussed next). Attention problems at all ages were predictive of later levels of response inhibition and updating, and to a lesser extent, shifting. The authors concluded that attention problems primarily reflect difficulties with response inhibition. The important message where the SEN(D) population is concerned, was that the relation of attention problems to later inhibition was stronger than relations to working memory and shifting. A common EF component has also been found to be predictive of individual differences in behavioural disinhibition (including attention deficits and conduct disorder) in adolescence (Young et al., 2009). A further study by Friedman et al., (2011) which used growth modelling to investigate EF developmental trajectories, is particularly relevant to SEN(D) as links were found between performance on a common EF factor (comprised of nine EF tasks and included all variance associated with inhibition) and self-regulation, with better childhood self-restraint associated with better general EF 14 years later. This suggests that if students have experienced long-term issues with impulsivity they are likely to have poorer EF in younger adolescence (Friedman et al., 2011).

A third model which also considers inhibition (and attentional control) as a primary process is that of Anderson's four domain model of EF (Anderson, 2002). Figure 1.4 below shows that any one or more of the four main domains may be impaired so there could be a variety of reasons for a young person to be experiencing difficulties adjusting to secondary school life or being classified as having SEN(D).

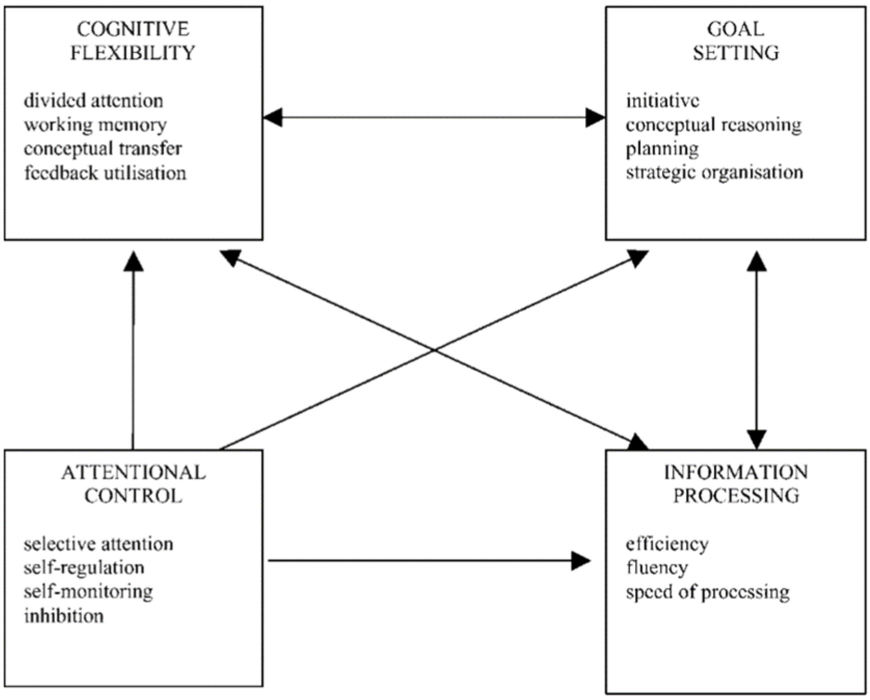


Figure 1.4 A four domain model of EF (Anderson, 2002)

The four domains in the model relate to, but do not exactly correspond to the EF components of inhibition, updating, switching and fluency described in Barkley's and Miyake's models. In Anderson's model the processes involved in Attentional Control (selective attention, self-regulation, self-monitoring and inhibition) have a one-way influence on the three other domains. This is consistent with first, Barkley's theory of ADHD because of the primacy afforded Attentional Control. Second, it is consistent with inhibition being regarded as part of a general ability within a common EF factor (Miyake and Friedman, 2012).

Adaptive functioning in the school environment requires self-organisation and self-regulation; skills at the behavioural level which begin to develop in younger adolescence (Rueda et al., 2010). Teachers rely upon observations of classroom behaviour as indicators of a student's attitude to learning. Anderson's model suggests that situational and contextual aspects of classroom life which contribute to teachers' assessments could be underpinned by processes which involve EF. It is concerning, therefore, that EF difficulties could manifest in ways which, Meltzer suggests, could be interpreted as poor application or conduct issues (Meltzer, 2007, Meltzer, 2010). As a self-regulatory system, inhibition underpins the ability to communicate fluently and function adaptively (Rueda et al., 2005, Rueda et al., 2010) and difficulties in these areas can potentially have an adverse impact on self-perception and mental well-being (Lawson et al., 2015).

Where SEN(D) is concerned, the difficulties associated with each of Anderson's domains can be applied to classroom learning skills and the capacity to utilize self-regulatory skills adaptively. Anderson shows that individuals who experience difficulties associated with *attention control* (which encapsulates self-regulatory skills) are likely to be impulsive, lack self-control, fail to complete tasks, commit procedural mistakes which they fail to correct, and respond inappropriately. The contribution of inhibition may therefore be considered a fundamental influence on goal-oriented processing and adaptive self-regulatory behavioural outcomes. In the classroom, such behaviours may be interpreted as 'laziness' or disruptive behaviours in conduct terms, synonymous with the hypo- and hyper- aspects of ADHD (Denckla, 1996, Morgan et al., 2000, Barkley, 2012). Poor communication skills in terms of self-regulating inappropriate responses is reported to have a detrimental effect on self-confidence and to contribute to disruptive behaviour in the learning environment (Hughes et al., 2009, Turkstra and Byom, 2010). Negative self-perception can also contribute to mental well-being issues (Lawson et al., 2015). This suggests that there might be relations between teacher ratings of student behaviour and their ratings of EF on questionnaire instruments such as the BRIEF (Gioia et al., 2000a). This question is addressed in Chapter 6.

The types of difficulties associated with each of the four domains in Anderson's model include frequently observed barriers to learning. For example, reduced output is a common concern, and according to Anderson's model is indicative of information processing impairment. Disruptive classroom behaviours, such as difficulties adapting to new demands or changes in activities or procedures are attributed to cognitive inflexibility. As these characteristics are frequently observed in relation to ASD (Akbar et al., 2013, Rosenthal et al., 2013) and also co-occur in ADHD (Happé et al., 2006, Grzadzinski et al., 2011, Lawson et al., 2015), they may be apparent in the SEN population. Anderson's model offers an explanation as to how the underlying EF impairments that appear to impede adaptive cognitive and behavioural functioning are likely to exacerbate the challenging behaviours identified in existing diagnoses of ASD and ADHD. The model also presents inhibition and self-regulation as primary influences which is concerning, and as these processes undergo changes in younger adolescence, are particularly relevant to this thesis. Furthermore, according to Barkley (Barkley, 1997; p.73), inhibitory control contributes to the internalization of speech, which contributes to even greater self-restraint and self-guidance, skills which are increasingly important for success at secondary level education. This underpins Morgan's contention that vulnerable students across the ability spectrum may experience difficulties in challenging or less structured learning contexts (Morgan et al., 2000).

A final consideration is the extent to which the theories and models about inhibition and EF translate to brain structure and function. Brain scan studies using functional imaging (Duncan and Owen, 2000, Duncan, 2010, Hampshire et al., 2010) have shown that when cognitive conflict was experienced which demanded an inhibitory response for resolution, a brain region responsible for impulse control and decision making was activated (the anterior cingulate cortex or ACC). In other words, the ACC detects the need for control when there is competition between two or more ways of behaving in a certain situation which requires input from separate (higher order processes) to resolve the conflict. The inhibitory signal from the ACC enables the separate but interconnected circuits within the dorsolateral pre-frontal cortex (DLPFC) to respond to the signal and thereby solve diverse cognitive problems with increased cognitive control. This information can be related to the theories and models of EF presented above as an inter-dependent and inter-related executive control system and supports the view of inhibitory processes as fundamental to complex processing.

Two of the three theories and models above (Barkley and Anderson) suggest that the role of inhibition is integral to the capacity of the EF system to process a successful task outcome. Friedman and Miyake's (2012) position differs in that inhibition is described as somewhat relegated to part of (subsumed within) a common EF factor. Where SEN(D) is concerned, EF impairment may be associated with a broad spectrum of cognitive and behavioural issues which present additional underlying barriers to students' ability to thrive in the learning environment. The next sub-section examines the development of EF since it is likely that some students identified with SEN(D) have neurocognitive impairments that are responsible for both EF and identification of SEN(D).

1.2.3.3 EF and Development

EF components are considered to go through a process of increasing separation from a single construct as skills become increasingly specialised, maturing in young adulthood (D'Souza and Karmiloff-Smith, 2011). EF skills are considered to improve in spurts, each taking different developmental trajectories (Karmiloff-Smith, 1998, Thomas et al., 2009). This process allows for greater cognitive control along with increasing automaticity and efficiency (Zelazo, 2013). The precise timescales within which these structural and organizational changes occur have not, however, been definitively clarified (Lehto et al., 2003, Brocki and Bohlin, 2004, Huizinga et al., 2006, St Clair-Thompson, 2006, van der Sluis et al., 2007, Wu et al., 2011 and see Chapter 5, Brydges et al., 2012, van der Ven et al., 2013, Xu et al., 2013, Messer et al., 2018). It is, therefore, important to understand the nature of these processes in younger adolescents for the following reasons.

First, because age-related changes in EF show improvements up to the age of 15 years (Brocki and Bohlin, 2004, Klenberg et al., 2010, Best et al., 2011, Xu et al., 2013) and beyond (Huizinga et al., 2006), this means that relations between EF components reported in younger children may not resemble those of younger adolescents. Where the likelihood of impairment is concerned, D'Souza and Karmiloff-Smith (2011) suggest that where developmental trajectories deviate from typical pathways due to neurological disturbance (Blakemore, 2012), increasing specialisation by separate components may not occur. Also, any processing improvements that occur in typical developmental are likely to take longer to manifest when EF trajectories are delayed (Bernstein and Waber, 2007). SEN(D) is often identified in primary school, but students may experience additional needs and EF issues at any point in their academic journey (Meltzer, 2007). According to Bernstein, any disruption which weakens or delays EF development *at any time in the developmental process* will impact performance in related skills (Bernstein and Waber, 2007) (exemplified in Part One Section 1.1.4). These points suggest that EF structure and relative influences between the components may differ in the SEN group to that of Non-SEN students. Studies of structural relations from overlapping age groups in fact suggest that SEN students may process information differently to their Non-SEN peers (Lehto et al., 2003, Wu et al., 2011, van Den Bergh et al., 2014).

As no previous study appears to have investigated either EF abilities or structure in the 11 to 14 years SEN(D) population, it is not known if performance measures will produce similar findings to the studies above or, indeed if structural configurations conform to theoretical expectations. A recent exploration of several types of EF tasks including inhibition, switching, EWM, fluency and non-verbal planning (Messer et al., 2018) (sample of 128 children; mean age 10:4) obtained a two-factor structure with verbal and non-verbal performance measures of inhibition forming a separate factor, and all other EF tasks loading on to a separate additional factor. As EF structure continues to mature into early adulthood, the reporting of just two EF factors in this age range was not an uncommon finding (see studies referenced above and further details in Chapter 5). The interesting finding from Messer et al., (2018), however, was that inhibition formed a separate factor, which is in line with Barkley's conceptualization of inhibition as separate to EF. Messer and colleagues' findings are also consistent with the process of ongoing maturation in adolescence of the neural mechanisms of inhibitory control, which support self-regulation (Vara et al., 2014). This could be important for SEN(D) as it suggests that vulnerable students may have poorer self-regulation which is likely to affect how well they adapt to the challenging expectations of the secondary school environment. Chapters 4 and 5 therefore investigate whether there are differences in EF task performance, structure and component relations (system) between SEN and Non-SEN groups.

The current part of this chapter has considered several theories, models and relevant findings about EF. Key messages are that EF is a system of inter-relating and inter-dependent components. Roberts (Roberts and Pennington, 1996) considered the interactive nature of working memory and inhibition as fundamental to successful goal-oriented processing. Three perspectives; that of Miyake's Unity and Diversity model of EF, Barkley's theory of ADHD and Anderson's four domain model of EF, suggest that inhibition, as a general ability which mediates access of information to working memory for subsequent processing, may be significant in contributing to EF difficulties. For SEN(D), this is very important as it suggests that poorer inhibition is likely to impact students' ability to engage appropriately in the classroom environment. As a system, however, the components interact to influence achievement. Although inhibition is important, other measures such as fluency have been used in studies of EF and language and hearing impairment (which has significant implications for language and learning) (Henry et al., 2015b, Messer et al., 2016b, Marshall et al., 2017). The following section outlines the measures of EF used in this thesis.

1.2.4 Measures of EF

Previous research has identified patterns of EF impairment in specific groups found across the SEN(D) categories of provision which suggests that this population may be vulnerable to poorer EF. In order to explore these important issues, in the investigations reported in the current thesis, two main groups, Non-SEN and SEN, completed verbal and non-verbal measures of the core EF components; inhibition, executive working memory (henceforth termed EWM in the thesis) and switching. Group differences in EF performance using verbal and non-verbal tasks are the focus of Chapter 4. Performance tasks were selected for empirical validity and reliability (Henry and Bettenay, 2010) as having been used in previous studies of different populations represented in SEN(D) of a similar age group and these measures are described in detail in Chapter 2 (Methods).

As well as the more usual assessments of EF, consideration was given to the possibility of including assessments of fluency. Barkley (1997) included fluency in his theory of EF and ADHD and he conceptualised fluency as a generative ability which transforms (reconstitutes) inner thought into external language with communicative intent. This skill is important from a teaching perspective as speaking and listening skills are assessed as part of the English curriculum, and essential for contributing effectively in collaborative group work (Turkstra and Byom, 2010). Studies of the three developmental disorders most frequently identified in the SEN(D) population (ADHD, ASD and language impairment) and broader populations such as disadvantaged adolescents (Kirke-Smith et al., 2014) and deaf children (Marshall et al., 2017) suggest that difficulties with communication skills and the generativity aspect of fluency may be expected (Bishop and Snowling, 2004, Bishop and Norbury, 2005a, Bernstein and Waber, 2007, Denckla, 2007, Whitehouse et al., 2007, Wetherell et al., 2007, Meltzer, 2010, Bishop et al., 2014). In terms of EF performance, measures of verbal fluency have been found to relate to inhibition (error monitoring within the phonemic fluency task) and not to EWM or switching (Henry et al., 2015a) but according to Messer and colleagues, uncertainties remain about how fluency relates to the core EF components (Messer et al., 2018).

Barkley's theory of ADHD suggests that the capacity to self-monitor internal language and manage its transformation to external communication (reconstitution or self-regulatory communication) is a fundamental aspect of the communicative role of fluency (see Figure 1.3 in section 1.2.3.2 above). The possible role of fluency in EF processing has been identified in cross-sectional studies of dimensional changes in EF structure which illustrate ongoing development. Thus, using measures of inhibition, working memory and verbal fluency, Brocki and Bohlin (2004) identified 3 dimensions which were interpreted as Disinhibition, Speed/Arousal, and Working memory/Fluency. The alignment of working memory and fluency is particularly important as fluency was not featured in Miyake's Unity and Diversity Model and suggests that fluency might be linked to more complex cognitive processes which involve language, rather than more fundamental processes involving inhibition or motivation. This is consistent with Barkley's model of

EF whereby verbal working memory and fluency 'reconstitute' information through processes of analysis and synthesis for adaptive behavioural outcomes. Brocki and Bohlin argue that, although Barkley's theory was clinically oriented, it is relevant to typical developmental processes as it assumed that there is no distinction between the processes underlying normal and abnormal executive functioning (Brocki and Bohlin, 2004; p. 573).

Where SEN is concerned, this raises two issues relating to fluency. The first is the role of language in contributing to verbal executive working memory and the generative aspect of fluency for reaching appropriate cognitive and behavioural goal-oriented outcomes. In the classroom context, this use of language is important for literacy skills of assimilating information and transforming it to meet task requirements, whether in written form (see section 1.2.5) or communicating ideas to peers in group work. The second issue is that, cross-sectional studies (Brocki and Bohlin, 2004, Klenberg et al., 2010) have shown that verbal fluency continues to develop with age into adolescence and this suggests that fluency skills as described above in the SEN group may be less mature than those of their peers. This all suggests that poorer fluency is likely to have a detrimental impact on the capacity to cope with learning tasks in the secondary environment, which can adversely affect a learner's self-perception, with potential behavioural implications. Consequently, a case can be made to include fluency as a process either related to or part of EF and because of this it was decided to include it with the other assessments of EF.

Performance measures of EF consist of decontextualized, strictly regulated tasks and consequently, they may lack ecological validity. To gain insights about EF abilities in everyday life, questionnaires about EF can be useful. Consequently, sections of the Behavioural Rating Inventory of Executive Function (BRIEF) (Gioia et al., 2000a) which corresponded to performance measures of inhibition, EWM and switching were completed by student groups, teachers and parents to assess group differences, and to assess the levels of agreement across these three respondent groups (see Chapters 6 and 7). The issue of how maladaptive EF behaviours are interpreted by teachers was also identified in Part One, raising the question of whether EF issues are associated with broader conduct issues (the term maladaptive has been used by researchers to refer to BRIEF ratings which are worse than is usually expected for the age group). According to McAuley (2010), it is unclear whether the BRIEF is more closely related to general measures of behavioural disruption and impairment or to specific measures of EF. This conclusion arose from their study of young people clinically referred with inattentive and hyperactive-impulsive symptoms which found that, although the BRIEF was related to parent and teacher ratings of behavioural disruption and impairment, neither was associated with scores on performance-based tasks of executive function (McAuley et al., 2010). The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997a) was also completed by teachers to address this question, also reported in Chapter 7.

Additionally, Toplak (2012) queried whether performance measures of EF and behavioural ratings of EF are measuring the same underlying construct. Consequently, the extent of agreement between EF performance and behaviours in the core components of EF (inhibition/BRIEF ‘inhibit’, switching/BRIEF ‘shift’ and EWM/BRIEF ‘working memory’) is considered in Chapter 7. This in turn, sets up the final investigative chapter, Chapter 8, which seeks to identify the predictors of SEN status. The following section develops this theme by examining evidence of links between EF, literacy skills and academic attainment.

1.2.5 Relationships between EF, Literacy and Academic Attainment

SEN(D) support addresses the difficulties defined as ‘learning disabilities’ which impact the ability to read, spell, calculate, reason and organize information (Hulme and Snowling, 2009), together with behavioural and mental health barriers to accessing the curriculum. Research investigating EF and academic attainment has shown consistently that children who have better skills in the core EF components of executive working memory (EWM), mental flexibility (switching) and self-control (inhibition) make more academic progress than their peers (Kamkar & Morton 2017). These and other links between EF and academic attainment in adolescence are well established (Gathercole et al., 2004a, Best et al., 2009, Alloway et al., 2010, Best and Miller, 2010, Best et al., 2011).

Attention problems have been shown to impact the ability to thrive academically with inhibitory processes cited in a range of studies as exerting both a direct and indirect influence on academic achievement. An example of the indirect influence by inattention on academic achievement is Rogers' (2011) investigation of the role of inattention and working memory in predicting academic achievement in older adolescents (13 to 18 years) referred for ADHD. The conclusion from a mediational path analysis model was that working memory was a risk factor for poorer academic outcomes in adolescents with attentional problems. Specifically, verbal working memory was associated with achievement in reading and mathematics, while non-verbal working memory was associated with achievement in mathematics (Rogers et al., 2011).

In other research, performance on tasks measuring inhibition and working memory have been consistently associated with maths and reading abilities (St Clair-Thompson, 2006, Blair and Razza, 2007, van der Sluis et al., 2007), although the influence of switching on achievement is less clear (St Clair-Thompson, 2006, but see van der Sluis et al., 2007). In a correlational sense, verbal fluency (with EWM and inhibition) has been found to predict word reading (Henry et al., 2015b, Messer et al., 2016a) and targeted *reading for writing*, while *reading for notetaking* has been predicted by inhibition (Altemeier et al., 2006). Bishop's (2009) study of reading skills and language impairment also identified an important difference in the relative influences of EF and acquired abilities such as language. Fluency was found to be related to the fundamental reading skill of decoding but where comprehension was concerned, language impairment was a better predictor (Bishop et al., 2009 but see Henry et al., 2014 for an EWM memory intervention with effects on reading comprehension). These studies therefore suggest fluency might have an important role in literacy skills.

In other research associations have been reported between EF in relation to language and literacy. Inhibitory control has been found to be a better predictor of grammatical ability (measured by accuracy in generating past tense forms of regular/frequent and irregular/infrequent words) than either vocabulary or age in Key Stage 1 young learners (Ibbotson and Kearvell-White, 2015). In early adolescence, Berninger and colleagues investigated relationships of attention and EF to speaking (along with reading and writing) and found that inhibition (related to focused attention) independently predicted oral language outcomes. Berninger's findings suggest that inhibition is a causal influence on the capacity to communicate effectively in the classroom environment (Berninger et al., 2016b).

The findings from the studies in this section show clear links between academic attainment in core subjects and EF. Furthermore, the fundamental components of academic success; literacy, communication and learning skills appear to be underpinned by EF. It is therefore expected that students with SEN will have poorer EF performance than their Non-SEN peers in the key EF components of inhibition, EWM, switching and fluency.

1.2.6 Summary of Part Two

In Part Two a range of theories and studies have been examined which have shown the extent to which EF contributes to the ability to thrive in the classroom learning environment. These include the skills which underpin successful processing of academic tasks and adaptive behavioural responses to daily demands of school life. From a theoretical perspective, there is evidence that inhibition may have a fundamental role in the EF system by suppressing irrelevant information, thereby affording EWM and switching greater cognitive control during task processing. In the classroom environment, inhibition has also been shown to influence self-regulation and support communication skills. EWM and inhibition have been found to be associated with attainment in core academic subjects while fluency is important for the generative aspect of language and literacy. The following section links the issues identified in this chapter to the three major research questions addressed in the research for this thesis.

1.2.7 Research Questions

The three main research questions concern differences between the two main groups, SEN and Non-SEN, in academically related abilities and levels of EF.

1.2.7.1 Research Question One: Differences between SEN and Non-SEN groups

As previously described, very little research has been conducted to date on younger adolescents (aged 11-14 years) with SEN. Consequently, little is known about the learning related abilities of this complex population. Because schools use different protocols and tools to identify learning difficulties, there is a need to map these abilities, as measured by standardized assessments of reading, vocabulary and non-verbal reasoning, and to evaluate how scores of those with SEN compare with those of their peers who have no identified learning issues (see Part 1 section 1.1.3). Similarly, where this age range is concerned, no previous study has investigated EF processes and behaviours by using performance and questionnaire assessments, or investigated the structural organization of EF in students with SEN. The evidence presented in the current chapter (particularly sections 1.1.2, 1.1.3 and 1.2.3.1, 2 and 3 and 1.2.5) overwhelmingly suggests that differences will be found between Non-SEN and SEN groups across these different levels of processing mentioned above. The lack of existing research is a gap in the understanding of SEN(D) at Key Stage 3, which is an important stage of developmental and educational transition. These are formative years during which the capacity for self-determined independence is developing concurrently with changes in the cognitive skills which underpin academic learning.

Research Question One

Are there differences between adolescents identified with SEN and not identified with SEN in the following;

a) Receptive vocabulary, decoding and non-verbal reasoning? (Chapter 3)

b) EF as assessed by EWM, inhibition, switching and fluency? (Chapter 4)

c) Structural organisation of EWM, inhibition switching? (Chapter 5)

d) EF as assessed by reports using the BRIEF? (Chapter 6)

The second set of research questions concern relations between the measures.

1.2.7.2 Research Question Two

What is the nature of relationships between performance on measures of EF, responses to the BRIEF and responses to the SDQ?

Concerns regarding the relationship between performance and behavioural measures of EF (BRIEF questionnaire) and between the BRIEF and indicators of disordered conduct (e.g., SDQ) have been raised in the literature (section 1.2.4 above). Although EF performance tasks are rigorous and objective, they are highly structured and conducted in controlled conditions. In contrast, questionnaires which tap behavioural adaptation in everyday situational contexts might be considered more ecologically valid but are subject to lack of standardization. Where SEN is concerned, knowing the extent to which performance measures of EF are related to questionnaires about adaptive EF behaviours is useful to better understand the best ways to assess EF abilities and target EF in interventions. The interpretations of behaviour by teachers has also been a theme in this introduction (section 1.1.3) so there is a need to clarify the relationship between maladaptive EF behaviours as measured by the BRIEF and conduct dysregulation as measured by the SDQ. This information is also a precursor to the final investigative chapter, Chapter 8 as it informs predictions of SEN status.

Research Question Two

a) What are the relations between EF as measured by performance and the BRIEF? (Chapter 7)

b) What are the relations between the BRIEF and the SDQ? (Chapter 7)

1.2.7.3 Research Question Three

The final research question concerns the prediction SEN status (i.e., whether or not a student has been identified as having SEN) from EF and other abilities. The lack of consistency in tools and protocols used by schools to identify learning difficulties was identified in Part One (section 1.1.3). If, as has been argued, EF affects school attainment (see sections 1.2.3.2 and 1.2.5), then EF measures should predict SEN status in logistic multiple regressions. The findings from this analysis could provide useful information about the best EF processes to target when developing interventions. Separate logistic regression analyses using student self-ratings and teacher ratings will be reported and these analyses will also include standardized measures of reading, vocabulary and non-verbal reasoning. By including these standardized measures as 'covariates', this will increase confidence about the usefulness of EF measures which remain as significant predictors.

Research Question Three

Which measures of EF and academic related abilities (reading, vocabulary and non-verbal reasoning) predict SEN status? (Chapter 8)

CHAPTER 2

Methods

2 Introduction

As outlined in the previous chapter, the research described in this thesis was designed to investigate the executive function characteristics of a sample of younger adolescents identified with Special Educational Needs. This chapter describes the protocols and procedures regarding access, participant recruitment and data collection, with ethical concerns.

2.1 Ethics

The study was conducted according to BERA and BPS ethical guidelines. As the research required access to vulnerable young people on a one-to-one basis, ethical considerations relating to participant wellbeing throughout the data collection process were of paramount concern. As a Higher-Level Teaching Assistant (HLTA), I previously taught younger adolescents with varying diagnoses and additional needs and I recognised the fundamental importance of establishing a relaxed, calm atmosphere whilst monitoring each individual for signs of 'coping fatigue'. My ability to draw on this experience was an important element in the successful application to the Open University Human Research Ethics Committee to conduct the research. Details of this application can be found in Appendix 1. Separate Enhanced CRB Clearances were required for each school in addition to the Open University Enhanced CRB clearance document which was essential for my initial acceptance by schools as a person requiring access to students for the purpose of carrying out academic research. I was granted access to the participating schools through my status as a researcher but a year prior to embarking on my Ph.D I had undergone training to gain Qualified Teacher Status (QTS) and my previous experience of working with vulnerable young people was discussed in detail before starting to collect data.

2.2 School and Participant Recruitment

Once ethical clearances had been granted, the process of recruiting schools began. I contacted the named Special Educational Needs Co-Ordinator (SENCO) in twenty-one secondary schools located within the southern, northern and eastern boundaries of Leicester City and Leicestershire County, informing them of the proposed study, its aims and objectives and followed up the initial contact with a telephone call to discuss their thoughts about participating and to answer any questions that they had.

Two schools out of the twenty-one that were contacted responded positively and I was invited to discuss the study with the SENCO, together with an interview with the Headteacher at one of the schools. One school agreed to be used on a pilot study basis for a limited time whereas the second school agreed to support a full-scale study. In all the schools that took part in the research, potential SEN participants were screened by the SENCO and researcher to exclude any students who were considered unsuitable to participate, such as heightened vulnerability or receiving support for English as an additional language (EAL). One SEN student from the pilot school and two SEN students from the second main study school were considered unsuitable for undisclosed reasons and six students in total were not considered as they were receiving support for EAL.

The pilot school required all contact with parents to be made via the school and participation to be on an opt-in basis. The school sent a covering letter and research information sheet with participant consent form to parents of selected SEN students and form group peers which conformed to the school's protocols for home-school communications. Precautions were taken to ensure informed consent was obtained by parents and students as follows. The consent letter invited parents to contact either the SENCO or myself at any time if they had any concerns or queries. It also asked them to discuss the study with their children and ensure they would be willing to participate prior to returning signed parental permission slips. No student was approached without signed parental permission. The letter to parents stressed that their child had the right to withdraw at any time during the process and that if they did, their data would be destroyed immediately. These letters explained that if they agreed to their child's participation parents and teachers would be asked to complete a questionnaire about their child. As detailed in Chapter 1, the parent questionnaire included the relevant sub-scales from the Behaviour Rating Inventory of Executive Functioning (BRIEF) (Gioia et al., 2000). The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997a) was completed by teachers. Paper data were kept in my house in a secure study and shredded after the information had been transferred to a password protected personal laptop and password protected external hard drive, which was kept in the house safe.

During data collection, students were reminded of the study purpose and written consent was obtained in the first session after they had been given information regarding the nature of the tasks and told they could stop participating at any time if they wished. They were told they could discuss any concerns with me, the SENCO or form tutor and post-participation contact information was given in the de-briefing and study feedback sheet (Appendix 6). To maintain confidentiality, participant performance was not discussed with staff or pupils.

Twenty consent forms were returned and 15 of these participants formed the pilot study, their data subsequently included with the main sample (the other five Non-SEN students exercised their right to opt out when the nature of tasks was explained). Once consent forms were obtained, the BRIEF parent questionnaire was sent in sealed envelopes home with the child and were to be returned to form tutors. This procedure was followed in the other schools. The SDQ was only included in the study after the pilot study was completed (see teacher consent form in Appendix 4).

Following the poor response from the pilot study school, the Open University Research Ethics Committee was approached to amend parental consent to active opt-out (see Appendix 2). This opt-out process was appropriate on the basis that the study used low risk procedures that students were familiar with as part of school activities (British Psychological Society Ethics Guidelines, 2011; current at the time). Additionally, the research took place in school in familiar surroundings under close collaboration with SENCOs and with permission of teachers, taking particular account of the sensitive nature of working with vulnerable young people. The second school sent a letter to parents requesting that each student on the SEN Register and their form group peers (Non-SEN participants) be given the opportunity to participate in a scientific research project and included the information sheet and consent form. The SENCO did not consider the clinical Strengths and Difficulties (SDQ) (Goodman, 1997a) appropriate for parents, however, as several items were considered too sensitive, e.g., 'Often lies or cheats'; 'Steals from home, school or elsewhere'. Form teachers agreed to complete the two study questionnaires for all SEN students and for Non-SEN on a goodwill basis. It was agreed that students would not be taken out of core subject lessons for testing if possible, in line with recommended teaching practice.

Following an introduction by the Open University's Partnership Schools Co-Ordinator a third school in East Lincolnshire was recruited (School 3), thereby broadening sample socioeconomic characteristics. This school was happy in principle for all SEN students to participate but discretionary screening only resulted in 35 potential participants. This was due to the sensitive nature of home-school relations reflecting the school catchment's low socioeconomic status and large cohort of SEN students with English as an additional language (EAL). The SENCO agreed to parents completing the BRIEF questionnaire but the SDQ was again considered inappropriate for the reason given above. The SENCO took responsibility for completing the BRIEF and SDQ questionnaires for SEN students while form tutors completed the Non-SEN participant questionnaires. Again, the school took responsibility for direct contact with parents/carers on an opt-out basis. The main letters to parents/carers in all three schools were compiled jointly with the SENCOs, signed by the SENCOs and distributed on school stationery as the schools' duty of care protocols did not allow communications to be sent to parents via a third party directly. Letters were sent to parents of all students in the form groups which contained the SEN students as an inclusive exercise. All SEN students who agreed to participate and for whom parental/carer consent was provided were included in the sample. Twelve parental refusals for their child's participation were received. Table 2.1 below details the participant contributions of each school.

Table 2.1 School sample numbers by participant group

School	Catchment	Type of School	Non-SEN	SEN	Total
School 1 Pilot	Suburban	Middle 11-14	3	12	**15**
School 2	City Outskirts	Middle 11-14	72	87	**159**
School 3	Semi-Rural	Secondary 11-18	88	36	**124**
Total			**163**	**135**	**298**

2.3 Participants

The participants formed a cohort which spanned the three academic years of a Key Stage 3 (11-14 years). This enabled a relatively large SEN sample and comparison group of Non-SEN peers to be recruited. In turn, this allowed the SEN students to be allocated to sub-groups to examine across the three SEN tiers of intervention. As the Non-SEN students were peers of the SEN students, this minimised group differences in terms of socio-economic status and education (St Clair-Thompson, 2011). With three participating schools including different education authorities, the sample was indicative of classroom populations encountered at Key Stage 3 in English state-funded mainstream schools.

Within the SEN population, some individuals' difficulties may be transient whereas others present with chronic problems across the 'more or less' continua of spectrum disorders or physical/medical diagnoses. Thus, the study included participants with difficulties across the following categories, as defined by the Special Education Support Service:

- Autism/Autism Spectrum Disorders
- Dyspraxia
- Emotional Disturbance and/or Behavioural Problems, including Attention Deficit Hyperactivity Disorder
- General Learning Disability
- Specific Speech and Language Disorders
- Physical Disabilities (cerebral palsy/accidental injury)
- Sensory Impairments (hearing/visual)
- Specific Learning Disabilities (dyslexia)

An interview with one school's Special Needs Co-Ordinator revealed, however, that not all students could be neatly classified within the parameters of distinct SEN categories, as specified in the SEN Code of Practice (Westerman, 2001). Thus, across the SEN sample thirty-one students had no specific difficulty attributed as they were either being monitored following raised cause for concern or awaiting specialist assessments. These students were at the entry level of support, School Action. As monitoring could be a short-term remedial intervention over several terms, this group was relatively fluid, in contrast to the longer-term needs of students at the higher tiers. As outlined in Chapter 1, School Action students who did not meet expected targets further to school initiated interventions were re-classified as School Action Plus and recommended for assessment and intervention by Specialist Teaching Services. The highest level of need comprised students with statutory statements.

The additional needs of the SEN sample are presented in Table 2.2 (below). The SEN sub-groups represent the three-tiered support structure which was in place at the time of data collection (pre-2014) which is described in greater detail in Chapter 1.

The main groups, Non-SEN and SEN formed a total sample of 275 participants who completed all the tasks, of which 141 (51.3%) were in the Non-SEN group and 134

(48.7%) in the SEN group. Twenty-two of the Non-SEN students in School 3 had full consent but were not tested due to term time constraints and priority being given to the SEN group.

The Non-SEN group had a mean age of 13 years 3 months with 80 girls and 61 boys. The SEN group had a mean age of 12 years 10 months with 39 girls and 95 boys. Within the SEN sub-groups, there were 76 students at School Action (SA) with 51 boys and 25 girls. This sub-group formed 27.6% of the whole sample. School Action Plus (SA+) contained 38 students, comprising 24 boys and 14 girls, totalling 13.8% of the whole sample and the Statement group had 20 students, all boys, totalling 7.3% of the whole sample.

Table 2.2 Individual Areas of Additional Need (as identified in the SEN Registers for the SEN Group)

School Action		School Action Plus		Statement	
Non-Specified	28	SPLD	8	Cerebral Palsy	3
SPLD (Specific Learning Difficulties)	18	MLD	6	ASD	3
MLD (Moderate Learning Difficulties)	13	SLCN (Speech Language Communication Needs)	6	SLCN	3
GLD (General Learning Difficulties)	2	ASD (Autism Spectrum Disorder)	3	Dyslexia, literacy	2
Behaviour	2	Non-Specified	3	Behaviour	1
Cerebral Palsy	1	Dyspraxia	2	SPLD	1
Dyspraxia, Speech and Language Difficulties	1	Dyslexia Literacy	2	Foetal Alcohol Syndrome	1
Literacy, behaviour	1	Sensory - partially sighted	1	Medical issues - premature birth	1
Literacy, numeracy	1	Non-verbal learning difficulties	1	Global Developmental Delay	1
Absence - Injury	1	Literacy, numeracy, epilepsy	1	ASD, Dyspraxia	1
Physical - partially sighted	1	Young carer, behaviour	1	ASD, Dyslexia	1

ADHD	1	Behaviour	1	Suppressed Immune Syndrome	1
Dyslexia	1	Attachment Disorder	1	Hirschsprung's Disease	1
SBD (Social, Behavioural difficulties)	1	GLD	1		
		Dyslexia	1		

As Table 2.2 shows, the majority of SEN students were in the intervention entry level School Action group, totalling 28% of the sample, with twice as many boys as girls. Non-specified issues formed the largest category (23%). Specific learning difficulties in a particular learning domain, such as literacy or numeracy, formed the next most frequent category (18%) then 13% with moderate learning difficulties (MLD). In the 14% of SEN students receiving or being assessed for specialist teaching support (School Action Plus), SEN categories of specific learning difficulties, moderate learning difficulties and speech, language and communication difficulties were the most frequently occurring issues. In contrast, within the smaller statement group, forming 7% of the SEN sample, there were three students identified with Autism Spectrum Disorder (ASD) and three with speech, language, communication difficulties, and two with dyslexia. For the remaining students in this group there were a range of difficulties, often with only one student having a particular need that often could be considered rare and often concerning syndromes with present complex difficulties requiring multi-agency input.

There were several issues that should be noted arising from the identification of educational issues in the SEN group. The terms used varied across schools, with some diagnoses, particularly in the SA group, adhering closely to SEN categories while others focused on capturing the individual nature of additional needs, such as 'literacy, numeracy' instead of Moderate/General Learning Difficulties. This suggests there is a notable proportion of SEN students at entry level whose additional needs may appear similar but may not necessarily conform to precise Code of Practice categories. This is why examining SEN characteristics as a group is likely to be a more valid approach than comparing individuals with 'similar' needs. Also, physical diagnoses, 'behaviour' or 'non-specified' issues give no indication of the extent, if any, of additional learning need as the level of support may reflect medical needs, the degree of difficulty accessing the learning environment or conduct supervision. The SEN sample is therefore heterogeneous and so does not allow the usual convention of excluding participants who do not meet strict diagnostic criteria of the population of interest.

2.4 Study variables

As outlined in Chapter 1, a focus of this research was to establish baseline information on the ability characteristics of the sample. Accordingly, the following measures were used to compare the performance of the SEN and Non-SEN groups. Standardized assessments with published norms were selected wherever possible, or alternatively, were directly relevant to the aims of the study with a history of validity and reliability in published developmental literature. Three sets of age-related normative standardized measures were included in the study. The first was the Test of Word Reading Efficiency (TOWRE) (Torgesen et al., 1999) which is a measure of decoding; the second was the British Picture Vocabulary Scales (BPVS) (Dunn et al., 1997) and finally, the Ravens Progressive Matrices (RPM) (Raven, 1983) measure of reasoning. Eight EF performance tasks were included which comprised of verbal and non-verbal measures of inhibition, executive working memory (EWM), switching and fluency. The final set included two behaviour rating questionnaires, the Behavioural Rating Inventory of Executive Function (BRIEF) (Gioia et al., 2000a) and the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997a). These sets are now described, with the standardized tests.

2.5 Standardized Student Assessment Measures

2.5.1 TOWRE: Test of Word Reading Efficiency (Torgesen et al., 1999)

The TOWRE was selected for assessing decoding as problems with letter-phoneme correspondence are noted by Torgesen et al. (1999) as the single most important defining feature of specific reading disabilities. Furthermore, the authors suggest that difficulty in rapid word recognition limits comprehension in older poor readers as cognitive resources for constructing meaning are constrained by the demands of identifying words (Torgesen et al., 1999). The TOWRE therefore measures both the ability to sound out words quickly and accurately and the ability to recognise familiar words as whole units or sight words. The test consists of lists of 104 real words tapping Sight Word Efficiency and 63 non-words measuring Phonetic Decoding Efficiency. The context-free presentation of the Phonetic Decoding Efficiency task requires skilled ability to fully analyse each word to produce the correct pronunciation. Three sets of standardized scores (means of 100 and standard deviation of 15) were derived from raw scores: sight reading efficiency, phonemic coding efficiency and total word reading efficiency. According to Waber and colleagues (2003), the validity of the TOWRE as a measure of reading efficiency is that it may be particularly sensitive to the demands that children face in actual reading situations (Waber et al., 2003). Since average coefficients range from .89 to .93 across the subtests and index scores, the TOWRE may be considered a reliable measure of sight word reading and phonetic decoding skills.

2.5.2 The British Picture Vocabulary Scale (BPVS), Second Edition (Dunn et al., 1997)

The BPVS involves the experimenter saying a word and the participant selects the appropriate picture from four possibilities and is an assessment of receptive vocabulary. Dunn et al., 1999 cite Dale and Reichert (1957) as suggesting vocabulary to be the best single index of school success and the BPVS is related to literacy abilities. As the BPVS is a measure of acquired learning it is considered analogous with crystallized intelligence

(G*c*). It is an appropriate assessment up to age 15 years with quick administration (less than 10 minutes), and items targeted over the student's critical range, thereby being neither too easy nor too hard. Items were presented until the participant scored eight or more errors in a set. Raw scores were converted to standardized scores with a mean of 100 and standard deviation of 15. Reliability is built into the confidence bands (confidence intervals 95%).

2.5.3 Ravens Standard Progressive Matrices (RPM), Raven et al. (2004; 2008)

The capacity for logical thinking and relational reasoning that is required for abstract thinking and puzzle solving has been frequently measured using the RPM. The 'classic' version (2004) was used with scoring using the updated age-related norms from Raven, Raven, and Court (2008). The RPM non-verbal reasoning task taps the general cognitive ability to form comparisons and reason by analogy. Also referred to as fluid intelligence (G*f*) in the literature (Engle et al., 1999), this ability has been closely associated with working memory (Salthouse and Davis, 2006, Friedman et al., 2006) as well as mechanisms of the procedural memory system that mediate access to information in long term memory (Was et al., 2012).

The measure consists of a series of diagrams or designs with a part missing and participants are required to select the correct part to complete each design from a number of options printed beneath. Raven (2000) claimed the task to be extremely robust and reliable across cultural and socioeconomic boundaries. More recently, psychometric properties are reported as; reliability above .80 and validity above .74 (Jansen, De Lange et al., 2013 citing Raven, 2008). The test has previously been used for research purposes with similar age groups (Jansen, De Lange et al., 2013, Van der Molen et al., 2007). Raw scores were converted to standardized scores with a mean of 100 and standard deviation of 15.

Although the RPM is not routinely measured in schools it offers a comparative benchmark of the groups' non-verbal abilities and as a control for tasks measuring visuo-spatial abilities. Also, not being strongly influenced by cultural and educational background, the RPM was an indicator of potential that may not be fully expressed in performance on school-related tasks (GL Assessment 2008).

2.6 Executive Function Performance Tasks

The EF performance tasks were selected to assess both verbal and non-verbal domains of functioning of the core constructs of: ‘inhibition’, ‘executive working memory’ and ‘switching’ (Henry et al., 2012) as well as verbal and non-verbal fluency. These are described below.

2.6.1 Inhibition

Verbal Inhibition: Day/Night, Sun/Moon (Henry, 2001)

This task measures the capacity to inhibit a pre-potent response built up over a set of twenty trials. First, the experimenter says one of two words (e.g., ‘day’ or ‘night’) and the participant’s task is to repeat the same word. After 20 repetitions, the instructions change, and the participant is required to respond with the alternative word for 20 repetitions. The process is repeated, totalling 80 repetitions. The task was then repeated with the words ‘sun’ and ‘moon’ to increase the robustness of the inhibit condition. The purely verbal nature of presentation and response constrains processing to the auditory-verbal domain.

The number of ‘errors’ in the second of the two sets of 20-word trials when the participant had to give the alternative response was recorded. An error was considered to occur if the participant’s immediate response was anything other than the required alternative word. ‘Errors’ were deemed more reliable as a measure of ‘inhibit’ than response time as it was not possible to adjust for individual differences in response speed. Also, the objective was to measure the ability to inhibit rather than processing speed per se, a separable construct (van der Ven et al., 2013). Words were presented immediately after the participant's response to maintain momentum and prevent errors arising from loss of focus.

Participants were asked to respond as quickly and as accurately as they could to each word. The emphasis on accuracy was the result of feedback during a pre-pilot practise session where one of the participants had been delaying responses to ensure accuracy, assuming this was the objective of the task. However, in a re-run, this same participant also made several anticipatory errors by guessing the next word to maximise speed. This was addressed in the pilot and main study by stressing the need to wait until the stimulus word had been fully said before responding.

Non-Verbal Inhibition: 'Walk Don't Walk'

The Test of Everyday Attention for Children (TEA-Ch, Manly et al., 1999)

The 'Walk, Don't Walk' motor inhibition task is described as a measure of sustained attention and response inhibition to action. Participants were given a marker pen and an A4 response sheet containing 20 items or 'paths', each item containing 14 squares. They were told their task was to 'walk' along one path at a time, taking steps by dotting a square each time they heard a tone (played on a CD through a laptop) called a 'go' tone. They were told that somewhere along each of the paths the tone unexpectedly ends differently ('no go' tone) which is a signal to stop and not dot the step. The procedure continued with four practice items which ensured that participants understood the process and instructions. It also allowed the possible detection of an unrecognized sensory deficit as participants were asked if they could hear the tone clearly (Baron, 2001).

The 'go' tone intervals in the task are presented at regular intervals but are reduced with each new item. The signal to not make a move forward ('no go') is an identical tone to start with but has a different ending which means that the participant must listen to the full tone to decide whether to go forward or not. As the 'no go' tone occurs unpredictably between the 2nd and 12th steps on each item, the task challenges inhibitory capacity.

The test manual states that the total number of correct trials should be used as a measure of inhibition and these are defined as the number of times the participant does not cross off the next square following a ‘stop’ tone. In the pilot study two students had difficulty keeping up with the tones and failed to reach the ‘stop’ square. Consequently, to retain the focus on inhibition, the dependent variable was ‘errors’ with errors recorded if the participant simply marked the next square when the ‘stop’ tone was heard, a scoring practice previously used by Mulder (Mulder et al., 2011). The assessment involved 20 trials (paths). Test-retest reliability is good (.73) (Henry and Bettenay, 2010).

2.6.2 Executive Working Memory (EWM)

Verbal Executive Working Memory (EWM): Listening Recall

A core functioning requirement of EWM is the capacity to simultaneously process, monitor, update and store information (Henry et al., 2012). The listening recall task was based on the listening span procedure originally developed by Daneman and Carpenter (1980) and further developed by Gathercole and Pickering (2001) within the Working Memory Test Battery for Children (WMTB-C).

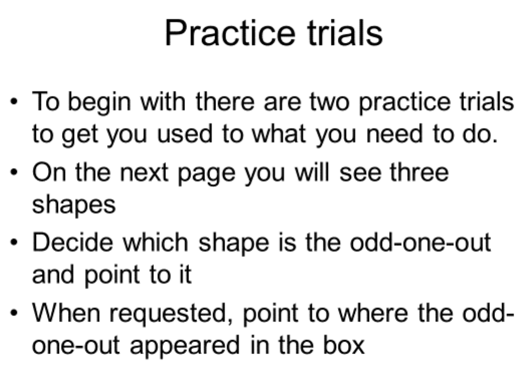
The task consisted of sets of sentences reflecting span length which began with a span of 1 and increased to a span of 5. Each span set consisted of trials of 4 sentences. The participant was asked to listen to a sentence and say if it was true or false and to recall the last word of each sentence in the set in the order they had been presented. Practice trials are presented below from the score sheet:

	Practice List	**True/False (T/F)**	**Recall**	**Trial Score (1 or 0)**
P1	People can WALK	T	WALK	
P2	Dogs fly in the SKY	F	SKY	
P3	Cars have SEATS I drink with a FORK	T F	SEATS FORK	
P4	Tables eat PIES Tigers have STRIPES	F T	PIES STRIPES	

The number of sentences before recall was increased until the participant responded *incorrectly* on at least four out of six repetitions on a particular span length. The processing element of the task was the true/false judgement and recall of the final word of each of the sentences in sequence formed the storage element (Henry, 2001a). The number of correctly recalled trials was used as a measure of verbal EWM with a minimum score of 0 and a maximum score of 36. Henry (2012), citing Ferguson, Bowey & Tilley (2002), considered total accuracy as more reliable than 'span'. This task utilizes the auditory (hearing) modality for input and verbal (speech) modality for output, tapping two of the four processing components of EWM. The test has been used previously, including studies of SLI (Henry et al., 2012), working memory (Alloway, 2009) and adolescents with a history of maltreatment (Kirke-Smith et al., 2014). Test-retest reliability has been reported as .88 (Alloway et al., 2009b).

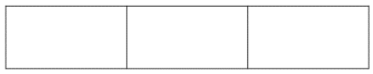
Non-Verbal Executive Working Memory (EWM): Odd One Out (Henry, 2001b)

This task complements the Listening Recall Task with the requirement for concurrent processing and storage of spatial information presented visually and to respond by pointing (motor modality) (Henry, 2001a). As with the listening recall task, the number of items to be recalled increases incrementally in span length from one to six. The task was presented as a power-point slide show. The first three slides, which were presented to participants as the first of two practice trials, are replicated below to illustrate the nature of the task and instructions:



- Which shape is the odd-one-out?

- Now point to where the odd-one-out shape appeared on the grid below



The number of stimulus rows presented increased until the participant responded *incorrectly* on at least two out of three repetitions of a particular span length. Number of totally correct trials was used as a measure of non-verbal EWM. In a pre-pilot procedure run, one participant used fingers from both hands to point out the sequence, thereby using kinaesthetic cues to aid recall. In the study participants were required to use the same finger throughout. This test was also used in the studies noted for the listening recall task. Test-re-test reliability of .88 has been reported for this task (Alloway et al., 2009b).

2.6.3 Fluency

Verbal Fluency
Delis–Kaplan Executive Function System (D-KEFS): Delis et al., (2001)

Measures of fluency/reconstitution require participants to generate items around a particular theme (e.g., verbal concepts, ideas or visuospatial criteria), to test the efficiency and flexibility of search processes (Henry and Bettenay, 2010). Participants completed tasks measuring two separate elements of fluency; phonemic and category (semantic). The phonemic task tapped lexical access and participants were asked to say as many different words as they could in 60 seconds starting with the same letter (three conditions, letters 'F', 'A', 'S'). Participants were given simple rules before starting the first letter task, including; using different words, no names of people or places or numbers or to give the same word with different endings, e.g., 'take' could not be followed by 'takes' or 'taking.' The semantic category task assessed 'fluency for overlearned concepts' with two conditions; 'Animals' and 'Boys Names'. The dependent variable was the average number of accurate words generated in each of the 60 second conditions with separate scores for the phonemic and category elements. Test–retest reliabilities by Delis et. al., (2001) are reported as: letter (.67), category (.70).

Non-Verbal Fluency
Delis–Kaplan Executive Function System (D-KEFS) Delis et al., 2001)

Nonverbal fluency (design fluency, D-KEFS) required the use of a response booklet containing patterns of dots in boxes. The participant was asked to draw as many different designs as possible in 1 minute, each in a different box, by connecting dots using four straight lines (with no line drawn in isolation). Condition 1 contained only filled dots; Condition 2 contained arrays of filled and empty dots and the participant connected only empty dots. Design fluency was the average raw score from these two conditions. Test–retest reliabilities are reported as: filled dots (.66) and empty dots (.43) (Delis et al., 2001).

2.6.4 Switching

Verbal Switching
Delis–Kaplan Executive Function System (D-KEFS) (Delis et al., 2001)

According to Davidson (2006), switching is fundamentally difficult and is an example of when executive control is required because generally it cannot be done 'on automatic.' Participants were told that they needed to switch back and forth between saying as many different kinds of fruits and as many different pieces of furniture as they could (i.e., a fruit, then a piece of furniture, then a fruit etc.) in 60 seconds. It did not matter which letter the words began with. As performance on category switching is predicted at least in part by performance on its simpler component task, semantic fluency (Wecker, Kramer, Hallam, & Delis, 2005), scoring took the form of a switching cost percentage; the average raw score from the category fluency task, minus the raw score from the switching task expressed as a cost percentage. Test-retest reliability is reported as 0.53-0.65 (Delis et al., 2001).

Non-Verbal Switching

Delis–Kaplan Executive Function System (D-KEFS)

Design switching was measured by using task 3 of the D-KEFS Design Fluency Test. Again the participant was presented with a page of response boxes that contained both filled and unfilled dots (5 of each), but this time the participant had to switch between filled and empty dots when producing drawings (a measure of both design fluency and cognitive flexibility), completing as many as possible in 60 seconds. Non-verbal switching 'cost' was the average raw score between Conditions 1 and 2 minus the raw score from Condition 3, converted to a percentage. Test–retest reliability is reported as .13 (Delis et al, 2001). This is low but as Henry (2010) noted, difference scores are not primary measures (as are accuracy totals, for example) but the result of abstract calculations *on* the primary measure, and therefore a step removed (Henry and Bettenay, 2010).

2.7 Behavioural Questionnaires

2.7.1 The Behavioural Rating Inventory of Executive Function (BRIEF, Gioia et al. 2000)

The BRIEF is a standardized measure of behaviours indicative of adaptive, self-regulation in everyday contexts. The BRIEF was selected for self-rating purposes as the statements are user-friendly with items presented in terms of 'skills', as opposed to explicit behavioural dysregulation as in the SDQ (see below) and it has been extensively used in previous research (see Chapter 1 and Chapter 6). This study utilized three complementary versions: the BRIEF self-report version, appropriate for young people aged 11-18 years together with teacher and parent versions. A shorter version of the questionnaire comprising three sub-scales 'inhibit', 'shift' and 'working memory' were used as these corresponded to the EF cognitive constructs. The shorter version also minimised imposition on teacher goodwill, to adhere to strict time constraints on access to students and maintain student focus. The following parametric information is provided by the authors: reliability - high internal consistency (*alphas* = .80-.98); test-retest reliability (*rs* = .82 for parents and .88 for teachers); and moderate correlations between teacher and parent ratings (*rs* = .32-.34). Convergent validity has been established with other measures of inattention, impulsivity, and learning skills and divergent validity demonstrated against measures of emotional and behavioural functioning; working memory and inhibit scales differentiate among ADHD subtypes (Gioia et al., 2000b).

2.7.2 The Strengths and Difficulties Questionnaire (Goodman, 1997a)

The SDQ is a 25-item questionnaire to provide measures of emotional symptoms, conduct problems, hyperactivity, peer problems and prosocial behaviour and is suitable to describe individuals of 3 to 16 years. The teacher version of the questionnaire was used in this research project. Goodman (1997) reported generally satisfactory reliability in the SDQ standardization study, with internal consistency (Cronbach .73), cross-informant correlation (mean: 0.34) and retest stability after 4 to 6 months (mean: 0.62).

2.8 Design

A cross-sectional design with two groups, Non-SEN (*n* = 141) and SEN (*n* = 134) was used and statistical techniques were selected as appropriate for addressing the specific research questions of each chapter. The study was designed to enable the use of statistical techniques which require large samples to meet parameter constraints, such as confirmatory factor analysis.

2.9 Procedure

The same procedure for task presentation was followed throughout data collection. The test battery was presented in two separate sessions of 50 minutes to one hour. The RPM and BRIEF questionnaire were completed by participating students in form groups of approximately 30 students which enabled them to meet the researcher with their peers prior to individual sessions for the remaining tasks. The decision to fix the order of EF task presentation, rather than Latin Square or randomised, was because individual participants were only allowed to miss a single lesson. Fixing the order meant that if a single lesson was insufficient then the Design Fluency tasks were the most appropriate to complete in short registration periods.

2.9.1 Session 1: RPM and BRIEF Questionnaire

During the first session the purpose of the study was briefly explained, and an information sheet distributed for written consent. The SENCO read the document aloud with assurances that the tasks were all straightforward and an opportunity to try something different. Following questions, the students signed their consent forms. The BRIEF instructions and items were read aloud and students were asked to identify any words they were unsure of. ‘Absent-minded’ and ‘impulsive’ were unfamiliar and a written definition was provided in the main study. At School 2 the RPM was presented as a power-point on individual PCs (up to 30 students per lesson) in an ICT Suite, but the pilot and third school used paper versions, presented in booklets with one slide per side of A4 landscape paper. To check the reliability of the RPM, Non-SEN students in the first main study school who performed below the 25^{th} Percentile on the first presentation (13 students) retook the test from booklets four months later. Test-retest was .74, indicating acceptably consistent performances.

2.9.2 Session 2: TOWRE, BPVS and EF Tasks

For the second session, students were collected personally at the end of a lesson and the walk to the test location established a relationship based on a relaxed but focused atmosphere. Participants were informed about the format of the session, stressing the nature of the tasks as games and reminded of their right to withdraw at any stage. They were told they would be working quite hard for the whole of the lesson but would get short breaks between tasks. They were then specifically asked if they were prepared to 'give it a go.' Following further verbal consent, the session began.

Task order was planned so that the verbal standardized assessments were at the end of the session to optimise performance. The TOWRE was presented first as a quick icebreaker then the BPVS. Executive function tasks followed a set order for all participants as verbal-nonverbal pairs with the more demanding executive loaded working memory tasks presented first. Short breaks were introduced between EF task pairs in order to establish clear breaks between the requirements of the previous task and reduce the possibility of confusion over instructions for the new task. This order of tasks was as follows: TOWRE, BPVS, Listening Recall, Odd-One-Out, Verbal Inhibition, Motor Inhibition, Verbal and Non-Verbal Fluency/Switch. After the tasks had been completed there was a short debriefing that included thanking the participant for their time and hard work, answering of any questions about the tasks and study. Participants were encouraged to seek out myself or their SENCO if they had any questions or reservations about participating. They were given an age appropriate explanation sheet detailing the rationale for each task, which they were encouraged to share with their parents (Appendix 6). Where time allowed, participants were also asked for their experiences of the EF tasks. Participants also received a certificate acknowledging their valuable contribution to scientific knowledge, presented either in school assemblies or by form tutors according to student preference (Appendix 7).

2.10 Adjustments for least able SEN students

The SEN students in School 2 who were in withdrawal groups for English and Maths completed the RPM and BRIEF in two separate lessons. The RPM was presented as a booklet as the SENCO felt that SEN students would make too many errors in the process of transferring their selected choice from the screen to the correct box on the answer sheet if using the power-point version. The SENCO read aloud each statement while students followed their paper copy and recorded their response. Students were monitored to ensure they were keeping up with the process and responding to each item.

The following chapter provides information about comparisons between students with no identified learning issues (Non-SEN group) and the SEN group using the standardized assessments of decoding, receptive vocabulary and non-verbal reasoning.

CHAPTER 3

Comparisons of Decoding, Receptive Vocabulary and Non-Verbal Reasoning in SEN and Non-SEN Younger Adolescents

3 Introduction

The aim of this chapter is to describe the standardized abilities of the SEN group in tests of decoding, vocabulary and non-verbal reasoning. These abilities underpin academic performance but do not appear to have been previously studied in the 11 to 14 age group. Consequently, little is known about the nature and extent of differences between students with no identified SEN issues (Non-SEN) and SEN groups. Similarly, there is little known about these standardized abilities in students with SEN issues across different levels of provision or whether group differences exist between these SEN sub-groups. As students with SEN status have either been identified with specific learning difficulties or are awaiting diagnosis, it is expected that this group will have poorer scores than their Non-SEN peers in the measures which were selected for having academic relevance. Similarly, it is expected that a trend of increasingly poorer scores will be found across the tiers of intervention. Thus, students with statutory statements are likely to have the poorest scores and those at the entry level of support, School Action (SA) performing better than the intermediate tier, School Action Plus (SA+). The findings will provide useful baseline information as not all students in the SEN group have a clinical or educational diagnosis. Also, if referrals have been made by medical or welfare agencies for in-school support, ‘learning difficulties’ may not be the primary area of concern (see Section 3.3). Consequently, in this chapter there is an exploration of the nature and scale of individual SEN issues and abilities, including diagnosis (clinical and/or educational, if present), placement within the (pre-2014) SEN structure and ability indicated by standardized score ability ranges (SSARs):

- Atypical: *extremely low* < 69 (2SD *below* the mean)
- Atypical: *borderline*: 70-84 (1SD *below* the mean)
- Typical: 85-115
- High Typical: >116 (1SD *above* the mean)

Further aims are to identify aspects of ability which not only indicate difference from the Non-SEN group but also whether there are overlapping characteristics across the two main groups. In meeting criteria for additional support, however, it is expected that the SEN group will have lower scores in standardized assessments of decoding, vocabulary and non-verbal reasoning.

This introduction is primarily concerned with issues relating to how ‘learning difficulties’ are defined from medical and educational perspectives and how these inconsistencies relate to SEN structure and provision. These concerns highlight why understanding patterns of ability across the SEN hierarchy is necessary before undertaking further investigations of the processes which underpin these abilities: namely, executive functions. The first issue relates to changes in SEN structure and differences between the educational and medical meanings of learning disorders.

The original pre-2014 SEN classification of SEN and hierarchical support structure is retained for this chapter. The three groups (School Action (SA), School Action Plus (SA+) and Statement) were in use at the time of data collection, with the nature and scale of SEN characteristics identified at increasing levels of additional needs, namely; ‘mild’, ‘moderate’ to ‘severe’. The clinical definition of learning disorders from the 5^{th} edition of the American Psychiatric Association’s Diagnostic Manual of Mental Disorders (2013) has levels of severity using the same terms but the scale of these levels differs (see Table 3.1 below). Where a student has a clinical diagnosis, the level of ‘severity’ identified does not necessarily relate to the level of SEN provision as the latter is determined by the complexity of issues in accessing the curriculum and educational environment. However, to demonstrate how these levels might be notionally juxtaposed, the DSM-5 'learning disorder' levels of severity are presented below with the SEN tiers placed alongside.

Table 3.1 Clinical Gradations of Severity (DSM-5) and Educational Levels of Support

DSM-V Level of Severity	Educational Level of Need	SEN Tier of Support
Mild	Some difficulties with learning in one or two academic areas, but may be able to compensate	School Action
Moderate	Significant difficulties with learning, requiring some specialized teaching and some accommodations or supportive services	School Action Plus
Severe	Severe difficulties with learning, affecting several academic areas and requiring ongoing intensive specialized teaching.	Statutory Statement includes learners with more *complex* needs involving multi-agency interventions and it is important to note that their learning difficulties are *not necessarily* within the severe category

Thus, although the DSM-5 and SEN Code are not entirely consistent, it is possible to envisage how levels of severity for a clinical diagnosis might be interpreted within the SEN structure. It should be noted that the revised SEND Code of Practice (2014) replaced entry level 'School Action' and the middle tier of support 'School Action Plus' with a single school-based SEN category 'SEN support', The following sections are concerned with issues which influence the understanding of SEN.

3.1 Definitions and SEN Categories

The clinical classification of Specific Learning Disorders (SLD) in DSM-5 (*Diagnostic and Statistical Manual of Mental Disorders, (2013)* refers to difficulties in the ability to learn and use core academic skills. The specific disorders categorised are dyslexia, dysgraphia and dyscalculia. These include issues with: reading which is, for example, inaccurate, slow and only with much effort; comprehension; spelling; written expression (e.g., problems with grammar, punctuation or organization); understanding number concepts, number facts or calculation and mathematical reasoning (e.g., applying mathematical concepts or solving mathematical problems) (APA, 2013).

These DSM-5 specific learning disorder categories are the fundamental areas of concern for which SEN provision is made. According to Tannock (Tannock, 2013), however, the DSM-5 medical definition of 'SLD' is not consistent with the interpretation of learning disorders within the educational context of SEN classification. This is because clinically defined SLDs relate to a type of neurodevelopmental disorder associated with alterations in brain structure and function. So, not all individuals who have learning difficulties from the educational perspective would meet DSM-5 criteria for SLD in degree, frequency, intensity, and persistence of the symptoms, as well as in the resultant impairments (Tannock, 2013). These conceptual differences in the fundamental meaning of the term 'learning disorder' suggest that school identified learning issues are likely to be less severe than a clinical 'learning disorder' diagnosis, although the learner's difficulties may be similar in nature.

As the SEND Code states, *every teacher is a teacher of SEN.* This means that teachers are required to accommodate the impact of learners' issues on their ability to function, learn and succeed in the educational environment. Thus, teaching students with SEN requires a differentiated and personalised (GOV.UK, 2014, Section 1.24) approach, based on an understanding of particular strengths and needs. Additional support should seek to address *all* identified needs, using well-evidenced interventions targeted at areas of difficulty. Within daily teaching practice, therefore, teachers are expected to adapt lesson content and resources to meet complex patterns of additional needs, as described within the SEND categories below:

- Communication and interaction
- Cognition and learning
- Social, emotional and mental health difficulties

- Sensory and/or physical needs

Although the SEND Code is based upon four broad categories of need, these are not interchangeable with clinical diagnostic categories, which aim to specify a primary deficit. In contrast, the SEN system acknowledges a wide spectrum of inter-related needs. This means that the learning issues of an individual profile could include aspects of each of the four SEND categories at varying levels of severity. For example, speech, language and communication needs can be a feature of a number of other areas of SEND and individuals with an Autism Spectrum Disorder may have needs across all areas (GOV.UK, 2014, Section 5.33). This dimensional perspective is difficult to reconcile in terms of sub-groups representing gradations of need, hence the identification of SEND groups by level of provision. These categories, as a dimensional continuum capture an extensive range of issues and acknowledge an essential heterogeneity within SEND status in the overlapping nature of disorders and associated difficulties which impact how well students are able to cope with the learning environment. It is apparent, therefore, that the SEND classification system concerns different methods and traditions of identification to clinical diagnoses. The differences between the SEND and clinical approaches to educational additional needs and diagnosis make it especially useful to use standardized tests to identify the characteristics of students with SEN and those in Non-SEN groups.

In view of the difficulties with terms identified above, when referring to educational difficulties, the term additional needs will be used as opposed to ‘learning disabilities’ or ‘intellectual disabilities,’ which tend to be used in social services and clinical contexts to denote low intellectual capacities. When referring to specific studies and schools’ Register of SEN, the terms used by the authors/schools are retained.

3.1.1 Summary

As already discussed, it is expected that RVR scores in the SEN group will be lower than those in the Non-SEN group. This is because teachers and external professionals will have identified students as needing further support either because of observations of their work in the classroom or because in other cases, external professionals have identified a need. Although there have been numerous studies of specific syndromes which have identified poorer scores in these students, there do not appear to be any studies which have examined SEND and Non-SEN RVR abilities.

The results will be presented in the following order:

1. Differences between groups
2. Percentage of individuals in standardized score boundaries
3. Information about diagnosis, category of provision and RVR scores.

Research Question 1

Were there differences between Non-SEN and SEN groups in standardized scores of decoding, vocabulary and non-verbal reasoning?

3.2 Results

3.2.1 Group Differences in RVR Standardized Learning Ability Assessments

Students on schools' Register of Special Educational Needs (SEN) were predicted to perform less well on standardized assessments of learning abilities. This prediction was supported from the data, as shown in the descriptive statistics for mean standardized scores in Table 3.2 (below). The mean standardized scores of the Non-SEN group were at typical levels in all standardized assessments: the BPVS test of receptive vocabulary, the TOWRE decoding test and the RPM non-verbal reasoning test. In contrast, the SEN group had mean standardized scores within the low typical range (i.e., a score between 85-99) for receptive vocabulary and decoding. Mean standardized scores on the RPM were the poorest (82.23). For both groups, however, there were individuals with high and low standardized scores on each of the assessments (see ranges in Table 3.2 below).

Table 3.2 Group Means, Standard Deviations and Ranges for Standardized Assessments in the SEN and Non-SEN Groups

Main Groups	BPVS		RPM		TOWRE	
	Mean *Std Deviation*	**Range**	**Mean** *Std Deviation*	**Range**	**Mean** *Std Deviation*	**Range**
Non-SEN	**99.58**	**68**	**99.57**	**85**	**107.01**	**53**
n: 141	*13.22*	*74 – 140*	*15.71*	*60 – 145*	*12.10*	*81 – 134*
SEN	**87.69**	**76**	**82.23**	**85**	**86.58**	**70**
n: 134	*15.19*	*57 - 133*	*15.69*	*55 – 140*	*13.58*	*54 – 124*
SEN Subgroups						
School Action (SA)	**88.14**	**63**	**82.10**	**85**	**88.17**	**69**
n: 76	*14.57*	*59 - 122*	*15.21*	*55 - 140*	*14.28*	*55 - 124*
School Action Plus (SA+)	**90.21**	**76**	**83.94**	**65**	**85.87**	**58**
n: 38	*16.65*	*57 - 133*	*17.09*	*60 - 125*	*13.11*	*57 - 115*
Statement	**81.20**	**62**	**79.50**	**55**	**81.90**	**54**
n: 20	*13.41*	*61 - 123*	*15.12*	*55 - 110*	*10.82*	*54 - 108*

The pattern for the SEN group as a whole was also present in SEN sub-groups. Students at the entry tier of intervention, School Action (SA) and School Action Plus (SA+) had mean scores around the *typical/below average* borderline for the three assessments (i.e., between 85-100), while the group with the highest level of intervention (Statement) had mean scores *below* the *typical/below average* borderline (< 85) across the three assessments. Not all students had low scores, though (see Section 3.2.2 below). Analysis of variance of the Non-SEN group and the three SEN sub-groups confirmed the main effect of 'Group' as statistically significant as follows:

- BPVS: $F_{(3,271)} = 18.050$, $p < 0.001$, $\eta^2 = 0.167$
- RPM: $F_{(3,271)} = 28.154$, $p < 0.001$, $\eta^2 = 0.238$
- TOWRE: $F_{(3,271)} = 59.634$, $p < 0.001$, $\eta^2 = 0.398$

Post-hoc Bonferroni adjusted multiple group comparison tests showed that differences between SEN sub-groups were not statistically significant on any of the three assessments. Thus, according to the standardized scores, the three SEN sub-groups were not significantly different from each other, although the Statement group had the lowest mean standardized scores of the three groups. The section below and Table 3.3 presents the distribution of students across grades of ability from extremely low to high typical.

3.2.2 Proportions of students in each grade of ability

The range of scores (see Table 3.2 above) showed that there some high and low scoring individuals in most of the groups. Because of this, further analyses were conducted to identify the frequency and percentage of young people across the different sub-groups who had standardized scores in the extremely low atypical range (<69), atypical (70-84), typical (85-115) and high typical range (above 115). These four ranges in standardized scores are referred to as grades of ability. This information is given in Table 3.3 below. As might be expected, the majority of individuals in the Non-SEN group had standardized scores above 84 (90% BPVS, 91% RPM, and 98% TOWRE) although it also should be noted that there were up to 10% of this group who had standardized scores in the atypical range (below 85). In the SEN group, there was a far lower percentage of individuals with standardized scores above 84 (BPVS 55%; RPM 47% and TOWRE 57%). This indicates that just over half the individuals in the SEN group had vocabulary and reading standardized scores in the typical range, but the majority were below average for non-verbal reasoning. In addition, there was only a small percentage with standardized scores above 115 (BPVS 5%; RPM 3% and TOWRE 2% of total SEN group).

The bottom half of Table 3.4 provides data about the three SEN sub-groups. There was a trend for the statement group to have fewer individuals with high standardized scores and more individuals with low standardized scores than the other two groups. However, the differences in the percentages were not particularly large, and this supports the findings from the post-hoc tests that there were not significant differences in the standardized scores of the three SEN subgroups.

The TOWRE produced the highest proportion of high typical Non-SEN student scores with 28% having particularly strong decoding skills but only 2% of SEN students performed similarly. These number of students and percentages are presented below.

Table 3.3 The number of student percentages in four grades of standardized scores for BPVS, RPM and TOWRE

GROUP	BPVS				RPM				TOWRE			
	*≤69 (%)	**70-84 (%)	***85-115 (%)	****≥116 (%)	≤69 (%)	70-84 (%)	85 – 115 (%)	≥116 (%)	≤69 (%)	70 – 84 (%)	85 – 115 (%)	≥116 (%)
Non-SEN	0	14 (9.9)	109 (77.3)	18 (12.8)	3 (2.1)	10 (7.1)	111 (78.7)	17 (12.1)	0	3 (2.1)	99 (70.2)	39 (27.7)
SEN	13 (9.7)	48 (35.8)	66 (49.3)	7 (5.2)	19 (14.2)	52 (38.8)	59 (44.0)	4 (3.0)	13 (9.7)	45 (33.6)	73 (54.5)	3 (2.2)
SEN Sub-Groups												
SA	6 (7.9)	29 (38.2)	36 (47.4)	5 (6.6)	10 (13.2)	30 (39.5)	33 (43.4)	3 (3.9)	7 (9.2)	22 (28.9)	44 (57.9)	3 (3.9)
SA+	4 (10.5)	9 (23.7)	23 (60.5)	2 (5.3)	5 (13.2)	15 (39.5)	17 (44.7)	1 (2.6)	3 (7.9)	15 (39.5)	20 (52.6)	0
Statement	3 (4.7)	10 (50.0)	7 (35)	0	4 (20.0)	7 (35.0)	9 (45.0)	0	3 (15.0)	8 (40.0)	9 (45.0)	0

* Atypical: extremely low < 69 (2SD below the mean), ** Atypical borderline: 70-84 (1SD below the mean), *** Typical, ****High Typical

As the TOWRE includes separate sight and phonemic tests, further analyses were carried out to examine proficiencies in each of these skills. The data are provided in Table 3.4 below, which shows that, where the SEN group is concerned, sight reading was poorer than phonemic reading. Compared with the Non-SEN group's mean score of 100 for sight reading, the SEN mean of 84 was practically one standard deviation lower, with 35% of SEN students having scores below 85 (<1*SD* from the mean). In terms of higher abilities, no SEN students were in the high typical range for *sight reading* whereas six students from SEN subgroups SA and SA+ had high typical skills in *phonemic reading*.

Five (3.5%) Non-SEN students had weak sight-reading skills**.**

Table 3.4 Student Numbers (Proportions) by Graded Ability Levels in TOWRE Sub-Components

GROUP	**SIGHT READING**				**PHONEMIC READING**			
	*≤69 *(%)*	**70-84 *(%)*	***85-115 *(%)*	****≥116 *(%)*	≤69 *(%)*	70-84 *(%)*	85-115 *(%)*	≥116 *(%)*
Non-SEN	3 *(2.1)*	2 *(1.4)*	121 *(85.8)*	15 *(10.6)*	0	1 *(0.7)*	88 *(62.4)*	52 *(36.9)*
SEN	12 *(9.0)*	35 *(26.1)*	87 *(64.9)*	0	5 *(3.7)*	43 *(32.1)*	80 *(59.7)*	6 *(4.5)*
SEN Sub-Groups								
SA	5 *(6.6)*	17 *(22.4)*	54 *(71.0)*	0	2 *(2.6)*	24 *(31.6)*	45 *(59.2)*	5 *(6.6)*
SA+	5 *(13.2)*	12 *(31.6)*	21 *(55.2)*	0	1 *(2.6)*	12 *(31.6)*	24 *(63.1)*	1 *(2.6)*
Statement	2 *(10.0)*	6 *(30.0)*	12 *(60.0)*	0	2 *(10.0)*	7 *(35)*	11 *(55.0)*	0

* Atypical - extremely low < 69 (2SD below the mean), ** Atypical – borderline 70-84 (1SD below the mean), 85 -115*** Typical, 116+****High Typical

3.2.3 Summary of Group Differences in Standardized Ability Assessments

Significant differences were found between the Non-SEN and SEN groups in all assessments. Decoding, measured by the TOWRE, was the area of greatest disparity and all eta squared values were large (TOWRE 0.40; BPVS 0.17 and RPM 0.24). Furthermore, sight reading was poorer in the SEN group than phonemic reading. More detail about the SEN group, including extreme scores, group characteristics across the assessment ability bands and profiles relating to individual support categories are provided in Appendix 9.

3.3 Discussion

As no previous investigations appear to have been conducted on differences in academic related abilities between Non-SEN and SEN students in this age group, the following sections discuss the findings in detail. In addition to Non-SEN and SEN group differences, the three SEN sub-group findings are examined for useful information in relation to the current two-tier SEND (2014) structure. The final sections discuss what the findings contribute to the broader debate on what SEN issues mean in relation to typical learners.

3.3.1 Were there differences between the SEN and Non-SEN groups in terms of their performance on the standardized tests of ability?

Although between group results *were* statistically significant, there was overlap with a proportion of below average scoring (<85) in the Non-SEN group and high average scoring (>116) performances in the SEN Group. The SEN group mean scores were just within the *low average* (scores 85-100) boundary for vocabulary and decoding but below average (scores <85) for non-verbal reasoning ability. In contrast, the Non-SEN Group had normative mean scores of 100 for vocabulary and non-verbal reasoning and even better decoding performance (mean 107). The differences in ability were greatest for decoding as only three Non-SEN students had below average scores in this test. The discrepancy between groups was particularly noticeable at extreme ends of the continuum, as group proportions with higher and lower abilities showed.

For decoding, only 2% of SEN students, all at the *lowest* tier of intervention (SA) achieved *high typical* scores (>116) as opposed to 28% Non-SEN overall. At the other extreme, 10% of SEN students had *extremely low* atypical scores (<69) while no Non-SEN students were in this bracket. This pattern was repeated for vocabulary, although fewer Non-SEN students had high typical scores compared with their decoding skills. However, the discrepancy between numbers of Non-SEN and SEN students performing within typical ranges (>85) in the non-verbal reasoning test was extremely noticeable; 90% of Non-SEN versus 47% of SEN.

Performance differences between the SEN groups at the graduated tiers of SA, SA+ and Statement were *not* statistically significant, despite the range of individual scores. Patterns of scores across literacy related abilities (vocabulary and decoding) and non-verbal abilities were uneven, consistent with specific learning difficulties where ability in one domain may be intact but impaired in the other. In contrast to the lower tiers of support, no statemented individuals achieved high typical scores in any of the tests.

A small percentage of Non-SEN students failed to attain average performance levels in the standardized assessments (10% BPVS, 9% RPM and 2% TOWRE). This indicates not only an overlap in characteristics between SEN and Non-SEN groups but that poorer ability scores appear not to have affected Non-SEN students' capacity to meet expected levels of attainment or that the issues facing these students were not identified in the schools. In contrast, as a proportion of SEN students with identified learning difficulties across the support hierarchy and categories performed at typical and high typical levels implies there may be underlying factors that influence the capacity to learn effectively.

3.3.2 SEN Characteristics, Diagnoses and Categories of Need

The findings show that SEN status does not necessarily imply poorer vocabulary, decoding or non-verbal reasoning ability in *all* students who were classified in this way. In particular, the instances of high typical performances in the SEN group are counterintuitive to SEN status as synonymous with low ability. In fact, a proportion of SEN students across the support hierarchy presented typical abilities in the standardized assessments (albeit with uneven score patterns). In contrast, the School Action group had a number of students with no identified learning difficulty whose below average standardized assessment scores revealed a need for help across a range of ability dimensions. It is uncertain why concerns had been raised about these students, but it is feasible they may have been receiving monitoring or pastoral support.

The implications of ambiguity in ‘catch all’ definitions noted by Norwich (Norwich and Kelly, 2005), discussed in Chapter 1, were borne out by students who were diagnosed with Moderate Learning Difficulties (MLD). These students’ ability characteristics suggested that schools used the term as a general label. The definition of general learning difficulties from the developmental perspective involves impairments in most cognitive functions with IQ scores below 70. This does not, however, apply to one individual diagnosed with ‘MLD’ who scored ‘high typical’ in receptive vocabulary, a measure of learned knowledge. The same student also scored in the typical ability range for decoding and non-verbal reasoning. The difference between ability and educationally defined diagnosis of learning difficulty is, however, consistent with Norwich’s view of the administrative value of labels for accessing resources

(Norwich, 2010). The final section briefly puts the findings in context regarding the updated SEN code and structure.

3.3.3 Post-2014 Classification and Structure

The fact that there were no differences between the SEN sub-groups justifies the current support structure of SEND since 2014, but there are other issues to consider. These include the implications of replacing the hierarchically defined entry level and specialist intervention levels with a single ‘catch all’ group. The identification of appropriately targeted individual support needs for those without a statutory statement or specific diagnosis is an important topic in the broader discussion of what SEN(D) means.

An interesting finding was the proportion of SEN students who were *not* statemented (i.e., not having complex issues involving multi-agency input), but who had extremely low scores in at least one assessment. Within the current system, these students would be classified in the new category of social, emotional and mental health difficulties as presenting with attachment disorder and behaviour difficulties, which is the category most likely to have external welfare support. Regarding the dilemma of labels, the number of SEN students at the old SA+ level with no diagnosis of additional need suggests a ‘label’ is not necessary to secure longer-term, more intensive support. Indeed, in view of the stigma associated with clinical diagnostic terms relating to ‘specific learning disorder’, the term ‘learning difference’ may be more appropriate, especially when discussing issues with students themselves, as it does not label them as ‘disordered’ (APA, 2013).

Two messages are clear from the above. First, the complexity in the dimensional range and patterns of abilities found within each level of the support hierarchy suggest that individuals with lowest ability scores are not necessarily the students with the most complex needs   Second, decoding and non-verbal reasoning were relatively weak areas across the SEN spectrum. As domain-general skills, thereby applicable across the core academic subjects of English, maths and science, poorer ‘decoding’ and ‘reasoning by analogy’ may be common characteristics of the SEN group.

3.4 Conclusion

Differences between the Non-SEN and SEN groups in standardized measures of decoding, receptive vocabulary and non-verbal reasoning were identified, these were expected as the SEN group was defined by a range of identified difficulties in the learning context. Even so, there was a range of overlapping individual profiles. The complexity of the SEN group was evident in the uneven abilities across found at each level of the SEN hierarchy, which may explain the non-significant levels of variance between SEN sub-groups. The findings of below average abilities in a proportion of Non-SEN students raises issues regarding the identification of potential learning difficulties which could remain ‘under the radar’.   This overlap in abilities raises further questions regarding underlying factors which may facilitate better learning capacities in some students than others. Further investigation of the processing skills involving EF that underpin the learning abilities are thereby warranted.

Furthermore, although criticisms can be made of the SEN classification system because the classification is based on the practicalities of decision making in schools, it provides a useful basis to investigate the way that EF is related to important dimensions of the students’ abilities and the support they are provided. In addition, by using an education-based classification, rather than a clinical based classification, it is possible that important insights into the nature of the EF processing characteristics of SEN students can be gained.

CHAPTER 4

Executive Function and SEN

4 Introduction

In the previous chapter, SEN students' performances were found to be significantly weaker in receptive vocabulary, decoding and non-verbal reasoning in comparison with their Non-SEN peers. However, there was no neat mapping between these standardized abilities, area of need and level of intervention. Also, a small proportion of Non-SEN students presented below average performances while half the SEN students performed at average levels or better. This overlap suggests the link between these three abilities and SEN status is not clear cut. In this chapter the question of whether there are similar differences in EF abilities is considered, and whether there are significant differences between SEN sub-groups in EF performance. The focus of this chapter is on differences in EF between SEN and Non-SEN groups and between SEN sub-groups. The following section examines evidence which suggest that differences can be expected between SEN and Non-SEN groups.

4.1 Impaired EF in Developmental Disorders Relating to SEN

As discussed in Chapter 1, varying patterns of EF deficits have been reported in the most commonly studied developmental and learning disorders and are thereby indicative of areas of weakness that may affect students across the SEN spectrum. For example: EF profiles in ADHD include inhibitory deficits, cognitive inflexibility, poor motor control and verbal/spatial working memory (Torgesen et al., 1999, Willcutt et al., 2005, Sonuga-Barke, 2005, Willoughby, 2005, Pennington, 2006, Barkley, 2006, Rogers et al., 2011), while ASD is associated with cognitive inflexibility and poor generativity (fluency) as well as executive control functions of switching and working memory (Verguts and De Boeck, 2001, Bishop and Snowling, 2004, Bishop and Norbury, 2005a, Bishop and Norbury, 2005b, Happé et al., 2006, Verté et al., 2006, Robinson et al., 2009, Christ et al., 2010, Christ et al., 2011, Akbar et al., 2013, Troyb et al., 2013, Soriano-Ferrer et al., 2014). Research in learning difficulties affecting literacy such as dyslexia/reading disorder (RD), speech and language impairment (SLI) and other non-specific language disorders show that EF deficits are not limited to verbal processes and affect a range of areas, such as inhibition, fluency, verbal and non-verbal EWM, although the latter is not a consistent finding (see section 4.1.1 below) (Henry, 2001b, Bishop and Snowling, 2004, Conti-Ramsden et al., 2006, Whitehouse et al., 2007, Booth and Boyle, 2009, Bishop et al., 2009, Bishop, 2012, Henry et al., 2012, Booth et al., 2014, Henry et al., 2015b).

Two EF components appear particularly important in language and reading disorders; inhibition and letter (phonological) fluency. A meta-analytic review of studies (Lipszyc and Schachar, 2010) using the stop signal task identified a large inhibitory deficit in children with reading disorders as well as ADHD. After controlling for IQ, Marzocci (Marzocchi et al., 2008), found poorer letter fluency performance in the RD group to be the only significant discriminator. Language skills, such as the generativity required for verbal fluency, are a major factor in academic success and a study of SLI (Henry et al., 2015b) showed language ability to predict nearly every aspect of phonemic fluency performance and some aspects of semantic fluency performance. Poor generativity has also been cited as underpinning the communication deficits of ASD (Dichter et al., 2009) with implications for group work and assessed speaking tasks in the classroom (see Chapter 6 for links between poor communication skills and learner self-perception). Considering the relative contribution of EF and language ability to verbal fluency performance, Henry and colleagues (Henry et al., 2015b) identified the importance of inhibition for rule-based error monitoring, as required in generative tasks. Thus, inhibition and fluency could have an important role in mediating the effectiveness of language-based tasks.

Finer-grained and counter-intuitive distinctions between the relative influences of verbal and non-verbal EF have also been identified by Booth and colleagues in studies of reading ability in typical children (Booth and Boyle, 2009, Booth et al., 2014). Booth (Booth and Boyle, 2009) examined the role of inhibitory functioning in children's reading skills and found evidence that reading ability was predicted by performance in an inhibition task. In *motor* based difficulties, such as developmental coordination disorder (DCD), more specific patterns of *non-verbal* EF impairment have been reported, including difficulties in non-verbal EWM, inhibition and fluency (Leonard et al., 2015) (although see Alloway and Temple, 2007). Research also suggests that adverse socio-environmental experiences can impact EF development adversely (Kirke-Smith et al., 2014). It is therefore predicted that the SEN group will have significantly lower EF scores than the Non-SEN group.

To my knowledge, no study to date has investigated EF performance across a range of verbal and non-verbal EF measures in a group comprising of SEN students whose needs span the SEN spectrum (as opposed to selective sub-groups defined by SEN provision categories). Studies which have compared sub-groups of students with SEN have tended to focus on working memory and these studies have found either no differences between SEN sub-groups (Jeffries and Everatt, 2004; dyslexia group and mixed profile group) or different patterns for groups with different diagnoses (Pickering and Gathercole, 2004; grouped by tier of intervention and diagnosis). These studies were, however, limited by small SEN sample sizes (47 and 55 respectively). Although the previous chapter, which investigated standardized assessment profiles across the three SEN sub-groups to ensure an accurate and nuanced overview, the decision was made from this chapter forward to reduce the three SEN sub-groups (School Action, School Action Plus and Statemented) to two SEN sub-groups. Thus, the first SEN sub-group comprises the entry-level School Action group, whose issues are more likely to respond to shorter-term school initiatives. This group is identified as School Intervention (SI). The School Action Plus (SA+) and Statemented groups have been amalgamated to form a new group, Additional Intervention (AI) as these students have longer-term, more severe needs and require additional support from specialist external agencies. This reduction in group numbers also increases statistical power for identifying differences between the where the analyses focus on group differences in the EF abilities which might be expected to support school-based activities, and as such is relevant to practitioners.

4.1.1 EF Impairment across Verbal and Non-Verbal Capacities

In view of the varied standardized test scores for the SEN group, an important finding from studies of language impairment and non-verbal cognitive development (Henry and MacLean, 2003, Botting, 2005, Henry et al., 2012) is that scores in the normal range do not necessarily predict intact EF in the corresponding area of processing. For example, an investigation of language difficulties by Henry, Messer & Nash (Henry et al., 2012) included measures of verbal and non-verbal inhibition, EWM, fluency, switching (and planning) in a large sample comprising three groups of 8-12 year olds: typical and two language disordered groups; low language functioning (LLF) and SLI. After controlling for impaired verbal and non-verbal ability, poorer performance was still found in the SLI group compared with the typical group across both verbal and non-verbal EF (specifically*;* EWM, verbal fluency and non-verbal inhibition). The assumption therefore is that poorer verbal *and* non-verbal EF performance can be expected in the SEN sub-group with greater educational needs (AI).

4.1.2 The Extent of EF Impairments: Issues from Clinical and Developmental Research

An important issue discussed by Johnson (Johnson, 2012) in relation to inconsistent findings in the clinical/developmental literature is that, although specific EF deficits may be reliably associated at group level in commonly researched developmental disorders, such as ADHD or ASD, these patterns are not necessary found in *all* individuals with the same diagnosis. Co-morbidity can also account for conflicting research findings whereby similar patterns of impairment in specific EFs may be found in individuals with different diagnoses. In fact, comorbidity of ADHD in ASD populations has been cited as ranging from 37- 85% (Dajani et al., 2016) although ASD EF profiles suggest impairments are more widespread with poorer performance than ADHD profiles (Geurts et al., 2004). Issues of overlapping characteristics and varying degrees of EF impairment suggest that a valuable approach to investigating a multi-faceted population such as SEN is to calculate the proportion of individuals with below average performance on each EF assessment. This will address the issue discussed by Johnson about the extent of impairments in the SEN group.

4.1.3 The Distribution of SEN Students in Whole Sample Clusters

As well as considering the extent of EF impairments in the SEN group, it was decided to investigate whether a cluster analysis using all the participants, would identify separate clusters of Non-SEN and SEN groups, or whether the clusters would contain participants from both these categories. This issue was prompted by the findings in Chapter 3 of an overlapping and broad range of standardized scores of the Non-SEN and SEN groups. As cluster analysis does not appear to have been previously used to investigate EF performance profiles of typical learners and those on the SEN spectrum, an exploratory approach which was not shaped by theoretical assumptions was considered acceptable. Taking advantage of the large sample, the aim is to identify a range of data-driven clusters with the objective of contributing to our understanding of the extent of differences and similarities between these two groups from an applied rather than theoretical perspective.

4.1.4 Summary

This investigation of SEN offers a unique opportunity to examine EF performance across a range of variables. To examine the nature and extent of EF impairment in young people in Key Stage 3 of their education, the first research question concerns whether there are EF differences between SEN students as a single group and their Non-SEN peers. This question is then applied to differences between SEN sub-groups defined by two support levels; School Intervention (SI) and Additional Intervention (AI). As this study is original in investigating a range of verbal and non-verbal EF characteristics in young people aged 11-14 years with educational needs spanning the SEN spectrum, two further issues are examined. These include the extent of EF impairment in the SEN population and the SEN profile of EF characteristics within whole sample clustering.

4.1.5 Research Questions

1. **Are there differences in EF performance between Non-SEN and SEN groups?**
2. **Are there differences in EF performance between SEN sub-groups School Intervention (SI) and Additional Intervention (AI)?**
3. **What is the extent of EF impairment in the SEN group as described by the percentage of individuals who have below average scores?**

4. **Does cluster analysis on EF performance scores provide evidence that there are different profiles of scores for SEN students and Non-SEN peers?**

4.2 Method and Results

4.2.1 Design

The first two research questions indicate the analysis of multiple dependent variables (EF task scores). As the sample meets the recommended number of 20 participants per variable, a one-way multivariate analysis of variance (MANOVA) was considered the most appropriate statistical test (Field, 2009). The MANOVA gives an overall measure of group differences as a canonical variate, i.e., it tests linear combinations of the performance variables for patterns, identifying any significant effects at an acceptable level of significance (correcting for type 1 errors). It then compares the mean canonical variate values for each group to identify whether a significant group difference exists (Wilks' Lambda statistic). It is then possible to identify which variables contribute to difference through univariate ANOVAs (ref: Statistics Solutions' Statistical Analysis: A Manual on Dissertation and Thesis Statistics in SPSS: www.StatisticsSolutions.com).

The design specified was a 2 x 10 model with Group (Non-SEN and SEN) as the independent variable. The multivariate dependent variable was EF performance scores on verbal and non-verbal tasks of inhibition, switching cost, EWM and fluency. There were four separate fluency tasks in this chapter in order to identify nuanced differences between sub-components. As described in Chapter 3, the Delis-Kaplan Executive Function fluency assessments measure separate aspects of fluency; verbal fluency consists of first, generating words with the same letter (phonemic or letter fluency) and second, generation of words from target semantic categories (category fluency). Similarly, the non-verbal tasks have two separate aspects; fluency for drawing as many different shapes as possible on a template of the *same pattern of dots* (filled dots condition) and the second template consisting of *filled and empty dots* where only empty dots had to be connected (empty dots condition).

4.2.2 Data Preparation

The preliminary analysis of the Non-SEN and SEN groups identified four outliers at 4SD from the mean (2 SEN participants for verbal inhibition, 1 Non-SEN for verbal switching and 1 Non-SEN for verbal EWM). Separate MANOVAs were conducted without and with outliers excluded and there was no difference in the outcome. The outliers were therefore retained as these participants' scores were within normal group limits on all EF tasks other than the outlier.

4.3 Results

4.3.1 Results for Research Question 1

Are there differences in EF performance between Non-SEN and SEN groups?

Table 4.1 EF Performance in the Non-SEN and SEN groups

EF Performance Task	**Non-SEN *n* = 141**		**SEN *n* = 134**	
	Mean	***Std. Deviation***	***Mean***	***Std. Deviation***
*Verbal Inhibition	6.73	4.02	8.97	5.70
*Non-Verbal Inhibition	3.60	2.82	6.47	4.04
**Phonemic Verbal Fluency	10.65	2.69	8.10	2.43
**Semantic Verbal Fluency	19.20	3.77	15.85	3.99
**Design Fluency	11.73	3.13	9.49	3.36
**Category Design Fluency	12.22	3.13	9.40	3.78
*Verbal Switching Cost	30.49	14.49	33.59	18.17
*Non-Verbal Switching Cost	56.89	14.41	63.95	15.87
**Verbal EWM	11.29	2.19	9.48	2.24
**Non-Verbal EWM	14.14	3.61	10.97	3.50

* Higher score equates to lower performance
**Higher score equates to higher performance

The overall model of significance showed Group to have a significant influence on the dependent variables (Wilks *Lambda* = 0 .620, $F_{(10, 264)} = 16.175$, $p < 0.001$, $\eta^2 = 0.38$). Examination of the separate univariate ANOVAs showed that Group (Non-SEN versus SEN) had a significant influence on all EF variables. The directions of effect showed the Non-SEN group to score higher functioning on all tasks apart from verbal switching cost (see below).

- Verbal Inhibition: $F_{(1,273)} = 14.184$, $p < 0.001$, $\eta^2 = 0.049$
- Non-Verbal Inhibition: $F_{(1,273)} = 47.156$, $p < 0.001$, $\eta^2 = 0.147$
- Phonemic Verbal Fluency: $F_{(1,273)} = 67.708$, $p < 0.001$, $\eta^2 = 0.199$
- Semantic Verbal Fluency: $F_{(1,273)} = 51.015$, $p < 0.001$, $\eta^2 = 0.157$
- Design Fluency: $F_{(1,273)} = 32.885$, $p < 0.001$, $\eta^2 = 0.108$
- Category Design Fluency: $F_{(1,273)} = 45.562$, $p < 0.001$, $\eta^2 = 0.143$
- *(Verbal Switching Cost: $F_{(1,273)} = 2.449$, $p = 0.119$ ns)*
- Non-Verbal Switching Cost: $F_{(1,273)} = 14.927$, $p < 0.001$, $\eta^2 = 0.052$
- Verbal EWM: $F_{(1,273)} = 45.898$, $p < 0.001$, $\eta^2 = 0.144$
- Non-Verbal EWM: $F_{(1,273)} = 54.445$, $p < 0.001$, $\eta^2 = 0.166$

A closer examination of standard deviations for each task showed reasonably similar standard deviations for all the variables in both groups apart from the switch variables for which they were extremely high. The largest difference between groups was in non-verbal inhibition where the SEN group had almost double the error rate as the Non-SEN group. As significant differences were found in all but one of the tasks between Non-SEN and SEN groups, the SEN sub-groups were examined to see if EF performances in those students with greater support needs was poorer than in those receiving shorter-term, teacher-initiated interventions.

4.3.2 Research Question 2

Are there differences in EF performance between SEN sub-groups; School Intervention (SI) and Additional Intervention (AI)?

4.3.2.1 Data Analysis

Because of the smaller SEN sub-group samples (SI $n = 76$, AI $n = 58$), univariate ANOVAs were more appropriate than MANOVA. ‘Group’, that is, School Intervention (SI) and Additional Intervention (AI) was the independent variable with the EF measures as the dependent variables. The only measure to differ significantly between the SEN sub-groups was non-verbal inhibition ($F_{1,133)} = 5.467$, $p < 0.05$, $\eta^2 = 0.040$) although the magnitude of effect was small. Using Anova, magnitudes of effect are small at 0.01, medium at 0.06 and large at 0.14 (c.f., imaging.mrc-cbu.cam.ac.uk/statswiki/FAQ/effectSize.) See Table 4.2 below for descriptive statistics.

Table 4.2 SEN Sub-Group Descriptive Statistics

EF Performance Task	School Intervention (SI) *n* = 76		Additional Intervention (AI) *n* = 58	
	Mean	***Std. Deviation***	***Mean***	***Std. Deviation***
***Verbal Inhibition**	9.17	5.34	8.71	6.19
***Non-Verbal Inhibition**	5.78	4.34	7.39	4.34
****Phonemic Verbal Fluency**	8.22	2.26	7.95	2.65
****Semantic Verbal Fluency**	16.22	3.80	15.37	4.22
****Design Fluency**	9.96	3.19	8.87	3.50
****Category Design Fluency**	9.90	3.48	8.74	4.08
***Verbal Switching Cost**	33.98	18.21	33.07	18.27
***Non-Verbal Switching Cost**	64.05	15.97	63.82	15.88
****Verbal EWM**	9.5	2.38	9.46	2.05
****Non-Verbal EWM**	11.27	3.44	10.58	3.50

* Higher score equates to lower performance
**Higher score equates to higher performance

The finding from the analyses so far show that, while the Non-SEN and SEN groups were significantly different ($p < 0.001$) for all EF measures (verbal switching excepted), the differences between the two SEN sub-groups were non-significant (non-verbal inhibition excepted).

4.3.3 Research Question 3

What is the extent of EF impairment in the SEN sub-groups?

4.3.3.1 Data Preparation and Analysis

The analysis included the same EF variables as questions one and two. To calculate the percentage of SEN participants who had below average EF scores at cut off points of 1 *SD* and 2 *SD* from the mean the following procedure was carried out (unlike the RVR scores analysed in the previous chapter many of the EF scores were not from standardized tests). A reference group was created containing the Non-SEN group and a random sample of 21% of the SEN group (34 students). This percentage was chosen as it corresponded to the National Statistic record of students with SEN at Key Stage 3 in 2013. Consequently, the reference group could be used to estimate for each EF variable the 1 *SD* and 2 *SD* cut off points that might be expected from a representative sample of young people of this age. To do this, *z* scores were computed for each EF variable from the representative sample with a mean of .0, *standard deviation* 1.00. The *z*-score cut-off values for 1*SD* (that is, 85) and 2*SD* (that is, 70) below the mean were identified. These two *z*-scores were used to identify the two appropriate cut-off points in the raw scores which were 1*SD* and 2 *SD* below the mean which was achieved by visual inspection of the *z*-scores and raw scores. Once two cut-off points in the raw scores for an EF variable were identified, then the number and percentage of participants in the SEN group with raw scores below the two cut-off points was calculated.

Table 4.3 Proportions of SEN Students with Below Average EF Performance in Each Task

	Representative Group (Non-SEN + 34 Random SEN) *n* = 175			SEN Sample *n* = 134		
EF Task	**Mean** ***SD***	***Z* score cut-offs at 1*SD* 2*SD* from mean**	**Raw Scores 1 *SD* 2 *SD* (*z*-score value in column 3)**	***n* and % SEN below 1*SD* cut-off but above 2 *SD***	***n* and % SEN below 2*SD***	**Total %**
Verbal Inhibit	10 *7.28*	1.13 2.34	8 19	*n* = 16 **11.94%**	*n* =7 **5.22%**	**17.16%**
Non-Verbal Inhibit	5 *3.15*	1.02 2.04	7 10	*n* = 33 **24.62%**	*n* =11 **8.20%**	**32.82%**
Phonemic Verbal Fluency	8 *2.29*	-1.04 -2.00	6.33 4.67	*n* = 28 **20.89%**	*n* = 4 **2.98%**	**23.87%**
Semantic Verbal Fluency	17 *4.17*	-1.11 -2.00	17.50 11.00	*n* = 34 **25.37%**	*n* = 5 **3.73%**	**29.1%**
Design Fluency	10 *3.16*	-1.03 -2.27	7 4	*n* = 38 **28.35%**	*n* = 4 **2.98%**	**31.33%**
Category Design Fluency	10 *3.20*	-1.12 -2.03	9 5	*n* = 36 **26.86%**	*n* = 7 **5.22%**	**32.08%**
Verbal Switching Cost	35% *18.19*	1.00 2.23	50% 66%	*n* = 27 **20.14%**	*n* = 2 **1.49%**	**21.63%**
Non-Verbal Switching Cost	59% *13.76*	1.02 2.18	77% 89%	*n* = 30 **22.38%**	*n* = 2 **1.49%**	**23.87%**
Verbal EWM	9 *2.83*	-1.21 -2.04	8 6	*n* = 18 **13.43%**	*n* = 3 **2.23%**	**15.66%**
Non-Verbal EWM	10 *3.16*	-1.16 -2.21	9 5	*n* = 23 **17.16%**	*n* = 1 **0.74%**	**17.9%**

SEN group EF performance showed varying patterns and degrees of difficulty across the tasks. Non-verbal inhibition, semantic fluency and both design fluency tasks had the highest proportions of students in the below average bracket (29% to 33%). In the ≤2 *SD*, category design fluency and verbal inhibit were represented by over 5% of the sample. Around one in five students were below average in both switching tasks and phonemic fluency. The results showed slightly better performance in verbal EF overall.

As two thirds of SEN students were in the average range across the tasks, the final question is whether cluster analysis would identify groups largely composed of SEN or non-SEN participants.

4.3.4 Research Question 4

Does cluster analysis on EF performance scores identify provide evidence that there are different profiles of scores for SEN students and Non-SEN peers?

4.3.4.1 Design

A hierarchical cluster analysis was used to investigate the overlap and separation of Non-SEN and SEN groups based on their EF scores. Canonical clustering was selected to base the clusters on the Mahalanobis distance between the central points, thereby preventing excessive influence from multiple variables that may be strongly correlated with one another. For ease of interpretation and greater descriptive precision, an initial ten cluster solution was reduced to five clusters (Table 4.4 below). Clusters with fewer than three participants (the minimum required for the post-hoc analysis reported below in Table 4.4) were eliminated from further analysis. The Tukey post-hoc test was selected because the Bonferroni correction is excessively conservative when a large number of post-hoc contrast tests are conducted:

http://www.ucdenver.edu/academics/colleges/nursing/Documents/PDF/ClusterHowTo.pdf

Table 4.4 Whole Sample Post-Hoc Analysis for Final Five EF Clusters in order of Strongest (Cluster 4) to Poorest (Cluster 9) Performances

EF Task	Cluster 4 *n* = 37 Non-SEN 30 SEN 7	Cluster 2 *n* = 72 Non-SEN 42 SEN 30	Cluster 1 *n* = 91 Non-SEN 49 SEN 42	Cluster 3 *n* = 52 Non-SEN 14 SEN 38	Cluster 9 *n* = 12 Non-SEN 0 SEN 12	
	*Cluster Means					**Homogeneous Cluster Subsets
Verbal Inhibition	6.46 strongest	7.89 3rd	7.09 2nd	9.12 4th	10.83 poorest	4,1,2,3 2,3,9
Non-Verbal Inhibition	3.19 strongest	4.67 2nd	4.76 3rd	6.17 3rd	11.42 poorest	4,2,1 2,1,3 9
Phonemic Fluency	11.03 strongest	9.98 2nd	9.62 3rd	7.99 4th	5.64 poorest	9 3,1 1,2,4
Semantic Fluency	18.57 strongest	18.34 2nd	17.81 3rd	16.14 4th	11.96 poorest	9 3,1,2,4
Design Fluency	11.81 2nd	11.93 strongest	10.53 3rd	9.10 4th	6.75 poorest	9, 3,1 1,4,2
Category Design Fluency	12.19 2nd	12.26 strongest	11.18 3rd	8.42 4th	6.08 poorest	9 3 1,4,2
Verbal Switching Cost	27.60 strongest	32.00 3rd	31.64 2nd	34.92 4th	33.33 poorest	Unitary set
Non-Verbal Switching Cost	55.73 strongest	60.65 3rd	59.41 2nd	61.02 4th	80.00 poorest	4,1,2,3 9
Verbal EWM	11.97 2nd	12.29 strongest	9.45 3rd	8.80 4th	6.08 poorest	9 3,1 4,2
Non-Verbal EWM	18.38 strongest	11.57 3rd	13.90 2nd	8.58 4th	5.92 poorest	Separate subsets

* Uses Harmonic Mean Sample Size = 32.37
** All non-significant at $p < 0.05$

4.3.4.2 Characteristics of the Clusters

Table 4 shows the EF performance of the 5 clusters that were selected from the original 10. The cluster analysis showed that, except for Cluster 9, the smallest one (n = 12), all the clusters contained some SEN and some Non-SEN participants. Thus, the cluster analysis *did not* identify most SEN participants in a separate cluster from the Non-SEN participants. Instead, although the clusters appeared to identify differing levels of EF performance, SEN participants were present in all the clusters.

In terms of the characteristics of each cluster, Cluster 4 contained the best performing participants. Eighty-one percent of the students were Non-SEN while 19% of SEN students achieved scores similar to these higher performing Non-SEN students. This cluster contained students with high verbal fluency abilities and high performance across verbal and non-verbal measures of inhibition, switching and EWM. Marginally better scores in all non-verbal fluency skills were found in Cluster 2, the second highest performing cluster where 58% were Non-SEN and 42% SEN.

The smallest cluster, Cluster 9, consisted solely of 12 SEN participants who had the lowest EF scores apart from verbal switching cost. The whole sample formed a unitary sub-set for this task, suggesting that all clusters had similar performance on this task. Although Cluster 9 contained students with widespread EF impairments, this group constituted a mere 4.5% of the sample of the final five clusters.

The diversity in SEN EF performance was revealed by the cluster analysis and the homogeneous sub-sets, which consist of students in different clusters who performed similarly in a particular task. Cluster homogeneity therefore reveals the extent of overlap across Non-SEN and SEN groups.

4.3.4.3 Cluster Homogeneity

Clusters 4, 2 and 1 (121 Non-SEN, 79 SEN) involved students with better EF performance and formed a homogeneous sub-set in measures of non-verbal inhibition, all non-verbal fluency measures and phonemic fluency, indicating there was similar EF performance for these measures. Cluster 3, the penultimate weakest scoring cluster (27% Non-SEN, 73% SEN) was included in a slightly larger sub-set of clusters with similar EF scores for verbal inhibition, semantic fluency and non-verbal switching cost. This suggests a good proportion of SEN students performed at the higher end of the dimensional continuum in these EFs.

The overlap between Cluster 1 and Cluster 3, which formed a separate sub-set in measures of phonemic fluency, basic design fluency and design fluency, appeared to include individuals from Cluster 1 whose performances were better matched with the *lower performing* students in Cluster 3. Clusters 1 and 3 together contained a larger proportion of SEN students (56%) who might be classified as a lower achieving group than the stronger performers in Cluster 1. Overall, the analysis of homogeneity revealed that EF performances matched those of best performing Non-SEN students in a small minority of cases (Cluster 4) but the general pattern indicated by the homogeneous sub-sets was that of a sliding scale of EF.

The background data of the SEN students in Clusters 4 and 9, representing the best and poorest EF performances, were then explored to better understand individual profiles of students in these two important clusters.

4.3.4.4 SEN performance in strongest and poorest clusters of EF performance (Clusters 4 and 9)

The EF task scores and the RVR scores of the SEN students in Clusters 4 and 9, representing the strongest and poorest EF performances, were then explored to better understand individual profiles of students in these two important clusters. SEN classification, stage of provision (SI, AI or Statement), scores in the standardized tests and EF are presented in Table 4.5 below. Yellow highlights on an EF score indicate good EF performance as the score is higher than the Non-SEN mean score for this group. Grey-blue highlights on a score indicates reasonable EF performance as the score is below the Non-SEN mean, but better than the SEN mean. Light blue highlights indicate poor EF performance as the score is below the SEN mean score for the group.

Table 4.5 Profiles of SEN Students in Highest and Lowest Performing Clusters Classified in Relation to SEN and Non-SEN Group Means

Case	M /F	SEN Tier	SEN Diagnosis	Verbal Inhibit	Non-Verbal Inhibit	Phonemic Fluency	Semantic Fluency	Basic Design Fluency	Category Design Fluency	Verbal Switch Cost %	Non-Verbal Switch Cost %	Verbal EWM	Non-Verbal EWM	BPVS	TOWRE	RPM
4 High																
176	F	SI	Cerebral Palsy	3	3	14	17.5	15	12	14.29	52.38	14	22	123	102	85
181	M	SI	None	12	0	11	17	13	17	29.41	72.09	12	17	122	98	105
211	M	SI	None	6	2	12	16.5	14	13	45.45	56.10	11	16	92	112	75
215	M	SI	Dyslexia Literacy	14	3	9	13.5	10	11	18.52	61.29	12	16	98	90	75
221	M	AI	None	2	3	12	17	8	10	41.18	61.54	12	17	113	107	140
236	F	AI	Physical	10	2	4	17	5	6	27.27	75.00	11	17	66	67	70
239	M	AI	Speech Language	8	7	9	15	12	11	26.67	54.29	12	19	133	90	100
9 Low																
153	M	SI	None	6	11	4	10.5	3	3	42.86	77.78	7	4	78	78	70
174	M	SI	Dyslexia Literacy	8	3	5	11	10	8	18.18	71.43	6	7	69	54	65
187	F	SI	None	17	10	5	14.5	10	7	35.71	92.59	6	6	80	89	70
194	M	SI	None	8	12	9	14.5	8	6	31.03	63.64	6	6	86	78	80
195	M	SI	None	16	15	6	22.5	9	12	64.44	66.67	6	6	92	84	85
219	M	AI	Dyspraxia Speech Language	4	15	5	12.5	6	5	44.00	64.71	6	8	97	80	75
234	M	AI	Attachment Disorder	5	8	6	10.5	12	7	20.00	80.65	7	5	70	82	65
249	M	AI	Speech Language	6	16	3	7.5	3	7	73.33	84.62	6	6	74	57	70
265	M	St	Speech Language	7	13	7	10.5	8	8	42.86	91.67	7	6	77	67	110

266	M	St	Global Dev Delay	8	11	6	9	4	1	22.22	77.78	5	6	64	75	85
272	M	St	ASD Dyspraxia	31	11	7	11	4	6	5.26	85.71	6	5	86	92	65
273	M	St	Suppressed Immune Syndrome	14	12	5	9.5	4	3	0	100	5	6	101	85	75

Better than Non-SEN Task Mean
Poorer than Non-SEN Task Mean but Better than SEN Task Mean
Poorer than SEN Task Mean

Seven SEN students were included in the higher performing cluster 4 with SI and AI similarly represented but none from the highest support tier that were statemented. An important characteristic of 6 of the 7 students was average or above average vocabulary and reading standardized scores. Only two students had specific diagnoses which related to ‘literacy’ and ‘speech, language and communication’ provision categories. Despite the nature of the diagnoses, both students had average scores (above 85) in vocabulary and word reading efficiency (one in the superior range above 115 for vocabulary). The remaining students had learning issues of no obvious origin and physically oriented difficulties. An exception to the average and above average standardized scores were those of a student with ‘physical’ difficulties who had vocabulary and reading standardized scores below 85. Scores for non-verbal reasoning were below average for two students; one diagnosed with dyslexia and the other with no identified classification of need. Thus, the individual scores of the students with SEN were usually above average in their EF performance and RVR abilities.

The students with SEN in cluster 9 had generally lower ability scores although two students with statements (suppressed immune syndrome and ASD/dyspraxia) had verbal abilities within the average range. Students across the support hierarchy were represented in equal proportions. The majority of diagnoses had cognitive origins, including four with language/literacy difficulties, one with ASD and motor difficulties and one student with global learning difficulties. The other classifications included emotional and medical issues. Four students at the entry level of support had no formal classifications and the majority of their standardized scores were average with one below average exception. Thus, the students with SEN in cluster 9 showed lower EF and RVR scores.

4.4 Discussion

Having established the difference between Non-SEN and SEN groups using RVR scores in Chapter 3, this chapter explored differences in EF performances. Four issues were addressed: first; to identify any differences in EF performance between Non-SEN and SEN groups and second, between sub-groups of the SEN sample classified by two tiers of provision; School Intervention and Additional Intervention. The third objective was to determine the extent of EF impairment in the SEN group, and the fourth was to use cluster analysis to investigate whether or not the SEN and Non-SEN groups were clearly separated into different clusters of EF performance. The results for each research question are examined in turn.

4.4.1 Research Question 1: Differences between Non-SEN and SEN Groups in EF Performance

On all measures of EF tasks there were significant differences between the two populations with the exception of verbal switching. The results support previous research investigating EF differences between typically developing children and a range of specific disorders, including widespread EF impairment reported by Henry et al (2012) in language impaired groups and Kirke-Smith et al (2014) for behaviourally dysregulated adolescents. This suggests that *lower EF performance*, compared with typical samples, occurs in groups of individuals who are identified as having SEN. This was expected as the SEN group included individuals with a range of issues and diagnoses consistent with clinical research in EF of single and overlapping disorders, such as ADHD and ASD (Dajani et al., 2016), ADHD and RD (Pennington et al., 1993), as well as co-occurring learning difficulties such as reading and mathematics disorders (van der Sluis et al., 2004). Students with SEN of no obvious origin (as defined by Gathercole and Pickering, 2001) also had poorer EF performance. In the analyses effect sizes were small, nevertheless, indicating that the gaps between groups were of lesser magnitude than implied by the high statistical significance, which can be attributed to the comparatively large sample sizes ($p < 0.001$). As with the standardized tests, this suggests overlap with students with no identified learning difficulties.

EWM was identified in the introduction to this chapter as an important factor underpinning effective learning and is therefore of particular interest regarding SEN. The significantly lower SEN performance in verbal and non-verbal EWM tasks are consistent with both Gathercole & Pickering's (2001) findings in children with *undiagnosed* learning difficulties and those for mixed SEN profile groups (Jeffries and Everatt, 2004), supporting the theory that students who are not reaching attainment targets, with or without identified learning needs, may have working memory difficulties (Jarvis and Gathercole, 2003). The similar effect sizes for verbal and non-verbal EWM performance (verbal: $\eta^2 = 0.144$; non-verbal: $\eta^2 = 0.166$) suggest that the SEN students found complex working memory processing equally difficult across both language and visuo-spatial modalities. This finding has relevance for how tasks are presented in classroom learning (see Berninger et al., 2016a) and suggests that students with SEN are less able to harness effective independent thinking skills for successful learning outcomes in early secondary education (Meltzer, 2007, Meltzer, 2010).

The between group differences in verbal fluency performances follow a similar pattern to the group differences in the language based standardized tests. Thus, not only did the SEN group differ from the Non-SEN group in receptive vocabulary and reading efficiency, but also in *generating* language at both word level and meaning. As verbal fluency has been shown to discriminate between language impaired sub-groups (Henry et al., 2015b) and to predict word reading decoding skills (Messer et al., 2016b), limited fluency may be an indicator of underlying language problems in students failing to meet literacy targets. The between-group differences in non-verbal fluency (design and category design) also suggest that the SEN group may be characterised by difficulties *applying* procedural and categorical information. Interestingly, the between-group effect sizes for verbal and non-verbal fluency performances are similar to those of the EWM tasks, suggesting that gaps in generating and self-monitoring, may also affect the ability of SEN students to update information efficiently in EWM (Gathercole et al., 2008).

Similar effect sizes across verbal and non-verbal domains in all EF domains (apart from non-verbal inhibition) imply that the SEN group found tasks equally difficult, irrespective of the discrete verbal/non-verbal processing demands, compared with the Non-SEN group. This suggests that impaired EF may be independent of the processing domain (e.g., Henry et al., 2012 in the context of SLI). The markedly poorer SEN non-verbal inhibition performance is also worth comment as this form of EF is a known predictor of reading ability in dyslexia (Booth and Boyle, 2009, Booth et al., 2014). Although the only other mixed profile SEN group study identified in the literature (Jeffries and Everatt, 2004) found inhibitory skills to be unimpaired, this study's large sample had far greater discriminatory power (134 participants versus 26).

It is notable though that the extent of EF impairment in the SEN group was relatively low, with approximately two thirds of students in the average range. As with RVR abilities, EF performance in isolation does not appear to be a necessary or a sufficient indicator of SEN status. The pattern for EF performance repeats that of the standardized tests where, despite group differences, half the SEN students were in the average ability range with a few attaining superior scores.

The finding of relatively intact verbal switching in the SEN group in view of significantly poorer verbal fluency in general was surprising but is consistent with non-significant findings in previous studies (Henry et al., 2012, Leonard et al., 2015, Henry et al., 2015b, Messer et al., 2016b) and may relate to task measurement issues (see Henry et al., 2012), thereby suppressing a true indication of potential group differences.

4.4.1.1 Summary

There were significant differences in EF performance between Non-SEN and SEN students, but these were accompanied by small effect sizes, suggesting overlap in the scores of both groups as in the standardized tests (Chapter 3).

4.4.2 Research Question 2: Differences between SEN Sub-Groups; School Intervention and Additional Intervention

Although it was predicted that SEN group differences would be found in all EFs, non-verbal inhibition was the only EF variable that produced a significant group difference, albeit with a not particularly robust effect size ($p < 0.05$, $\eta^2 = 0.04$). It is not entirely clear why this variable was the only one separating the SEN groups.

The lack of difference between SEN sub-groups, particularly in EWM is surprising considering that previous research has found this EF to be a valid predictor of attainment and discriminates between typical learners and students with no identified SEN as well as different groupings of students with SEN (Gathercole and Pickering, 2001, Gathercole et al., 2003). As previous research has also reported that students with moderate learning disabilities have significantly poorer EWM than those with mild learning disabilities (Henry, 2001b), it was expected that the SEN sub-group with greater learning needs would have significantly poorer EF. As there are few previous studies investigating EF in SEN sub-groups defined by support tiers, it is difficult to account for this counterintuitive finding. It is, however, consistent with the only previous study identified which investigated EWM and inhibition in SEN students with known learning difficulties (Jeffries and Everatt, 2004) and implies that where EF is concerned, SEN students appear to be a relatively homogeneous population, despite the varying categories and levels of need represented. In other words, the SEN three tier system is not closely related to the EF abilities of students within the system, despite overall differences between SEN students and Non-SEN peers.

Consequently, the following section examines findings regarding the *extent* of impairment in the SEN group.

4.4.3 Research Question 3: The extent of EF impairment in the SEN group

The proportion of SEN students with clinically significant levels of EF impairment, as defined by scores 1 *SD* and 2 *SD* from the mean was surprisingly small, ranging from 33% for non-verbal inhibit to 16% for verbal EWM. Minimal proportions (fewer than 5%) of SEN students were severely impaired at below 2 *SD* in any of the EFs apart from non-verbal inhibit. These results suggest that, as a population, SEN students cannot be separated from typical learners and there is no neat mapping of degree of EF impairment and level of educational need. In fact, EWM and verbal inhibition appear to be relative strengths with only 16 -18% of the SEN group having below average scores. This is in sharp contrast to the body of literature where significant differences have been reported between clinical and typical samples, as well as the significant EF differences found between the Non-SEN versus SEN in this sample. The areas with the highest proportions of students with below average performances were a set of EF tasks including design fluency non-verbal inhibition and semantic (category) fluency but even so, only a third of SEN students had scores below the 1 *SD* cut-off. It appears that the SEN students are more similar to their Non-SEN peers than their SEN status indicates, and this explanation is consistent with the small task effect sizes. It is interesting that the pattern of overlapping EF characteristics in SEN sub-groups follows that of the standardized tests of Chapter 3 where a broad range of abilities were found in all groups.

4.4.4 Research Question 4: The variability of EF performance in SEN as revealed by cluster analysis

A five-cluster solution was found to best represent the whole sample EF characteristics, revealing a continuum from students whose EF performances were consistently the strongest across the majority of tasks (design fluency and verbal EWM excepted) to a cluster of SEN students whose performances were the poorest across all tasks apart from verbal switching cost. One fifth of the highest performing cluster included SEN students, representing 5% of the SEN sample, while 9.5% of the SEN sample represented the worst performing cluster. Interestingly, the majority of SEN students were spread across the three remaining middle range performing clusters alongside the majority of Non-SEN students, indicating extensive overlap in EF performances across the groups. Overall, the message appears to be that, apart from the highest and lowest performing clusters, the EF performance of SEN students, surprisingly, was more similar to that of their Non-SEN peers than the large group differences across all tasks (F=16 in the Manova analysis) implied. This may be partially due to the fact that the SEN group included a proportion of students flagged as 'causing concern' according to performance and attainment tracking (PAT), the criteria including 'attainment, effort, attitude and behaviour'. As these students were likely to have been receiving short-term monitoring, they may have had difficulties of a transitory nature unrelated to cognitive abilities. Consequently, their individual EF performances within the SEN group could have reduced the degree of EF impairment in group statistical analyses.

Taking the three tier support levels as reference, students receiving *school initiated* (SI/SA) interventions and those in the middle tier of provision (AI without statements or SA+) were represented almost equally in the 5% of highest performing SEN students in Cluster 4 (see Table 4.5) and surprisingly, two students with *language-based* learning difficulties were included in this superior cluster. A consistent feature of all the students was high EWM performance together with average and above standardized verbal abilities. These characteristics, together with the lack of support category identification for three of the students who also had superior EF skills and abilities suggests that SEN provision is a broad church and the SEN population cannot be defined solely in terms of poor EF performance in comparison with Non-SEN students. Furthermore, the lowest performing cluster was less cohesive, characterised by uneven patterns of skill in individual EF performances and disparate ability profiles. Most notably, poor EWM and non-verbal inhibition contrasted with the patterns in the highest performing cluster.

4.5 Chapter Summary

Despite highly significant group differences between the Non-SEN and SEN groups, there were no significant differences between the school-initiated support group (SI) and those receiving external specialist support or with statements (AI) (non-verbal inhibition excepted). This pattern echoes that of the standardized ability tests and suggests that levels of provision (SI and AI) do not relate to the severity of EF impairments. The extent of impairment in the SEN group was less than expected and varied across the EF tasks from 29% to 33% of SEN students for the poorest areas to below 18% of students for the strongest areas.

At the individual level, whole sample clustering revealed that a large proportion of SEN students were in the same clusters with Non-SEN peers, apart from the lowest achieving cluster that contained inly students with SEN. Literacy and language/communication disorders characterized the lowest performing cluster and notable features of the highest performing cluster included better EWM and non-verbal inhibition. The next chapter extends the focus on EF by examining the structure of EF in SEN and Non-SEN groups.

CHAPTER 5

The Organization of EF in Younger Adolescents

5 Introduction

In the previous chapter the analyses indicated that the SEN group performed significantly worse than their Non-SEN peers in verbal and non-verbal EF tasks that were tapping inhibition, executive working memory (EWM) and non-verbal switching. Verbal switching performance was similar to that of their peers. Fluency is not referenced as it not a core EF component as defined in Miyake and Friedman's theoretical model which is the focus of this chapter (Miyake and Friedman, 2000). Thus, to build on these findings the analyses in this chapter examine the structural relations between the core EF abilities of inhibition, EWM and switching. After identifying the structural relations in the Non-SEN group, analyses will be conducted to identify whether there is evidence of different structural relations between EF processes in the Non-SEN and SEN samples. Identification of these relationships can help us to understand the organization and structure of higher-level cognitive operations and this could, in turn, be of relevance to classroom practice designed to support students with SEN and help target interventions more effectively.

5.1 The Development of EF Organizational Structures

The organization of EF in children is a topic of debate in the literature as EF develops in a non-linear manner with growth spurts occurring across the processes at different times and subject to individual differences (Thomas et al., 2013). Throughout maturation there is an ongoing process of separation between EFs and the studies discussed below show that differentiation may be discernible by the early adolescent years. As with research investigating EF in developmental disorders (see Chapters 1 and 4), there is a lack of consensus regarding a definitive structural organisation of EF across childhood in the literature (see Section 5 below) and few studies have included the 11-14 age group. As with EF group differences (see previous chapter) none, to my knowledge, have examined the EF organisation of typical learners in comparison with students identified with SEN. Mapping the EF structure in younger adolescents is particularly important, both from typical learner and SEN perspectives, as significant changes in prefrontal cortex structure occur between the ages of 11 and 13 years, causing a state of flux in EF growth (Blakemore and Choudhury, 2006a). According to Anderson (Anderson et al., 2001, Anderson, 2002) there is a transitory increase in impulsivity around 11 years and cognitive flexibility remains below adult levels at 13 years, even with minimal working memory demands (Davidson et al., 2006). Anderson (Anderson et al., 2001, Anderson, 2002) also suggest that whereas verbal working memory is relatively mature by 12 years of age, spatial (non-verbal) working memory capacity shows ongoing improvements from 9 years to 18 years. This means that the EF organizational structure in younger adolescents with no identified EF impairments (Non-SEN group) is expected to differ from that of younger age groups *and* adults (Section 5.1.2 below). Furthermore, as diagnoses for individuals in the SEN group include a range of disorders which have different patterns of EF impairment (Powell and Voeller, 2004), it is expected that organisational structure in the SEN group will differ from that of the Non-SEN group (Section 5.1.2 below).

The following section discusses the latent variable approach of identifying EF structure, specifically Miyake's influential three factor structural model of adult EF (Miyake and Friedman, 2000, Miyake and Friedman, 2012). This is followed by a discussion of claims as to whether a one, two or three factor structure is applicable in younger adolescence and the appropriate groupings of the core abilities; inhibition, switching and EWM.

5.1.2 Identifying EF Organisation by Confirmatory Variable Analysis: The Unity and Diversity Model of Adult EF Organisation

The majority of studies of EF organisation have been influenced by the 'three correlated factors' model of adult EF by Miyake and colleagues concerning the relations between the cognitive control functions of the central executive (Miyake et al., 2000). Although Miyake's work has concerned adults, and the findings may not apply to young people, the models have been very influential and are therefore described here. This model is referred to as theoretical Model 3a in this thesis and contained three separate but associated components; updating (synonymous with EWM), shifting (synonymous with switching) and inhibition. Figure 5.1 (below) represents this model and the variables used in this study have been included in the model.

Miyake's first model was subsequently presented in a revised format following further research in the nature of individual differences in EF structure and is referred to as Model 3b (Figure 5.2 below) (Miyake and Friedman, 2012).

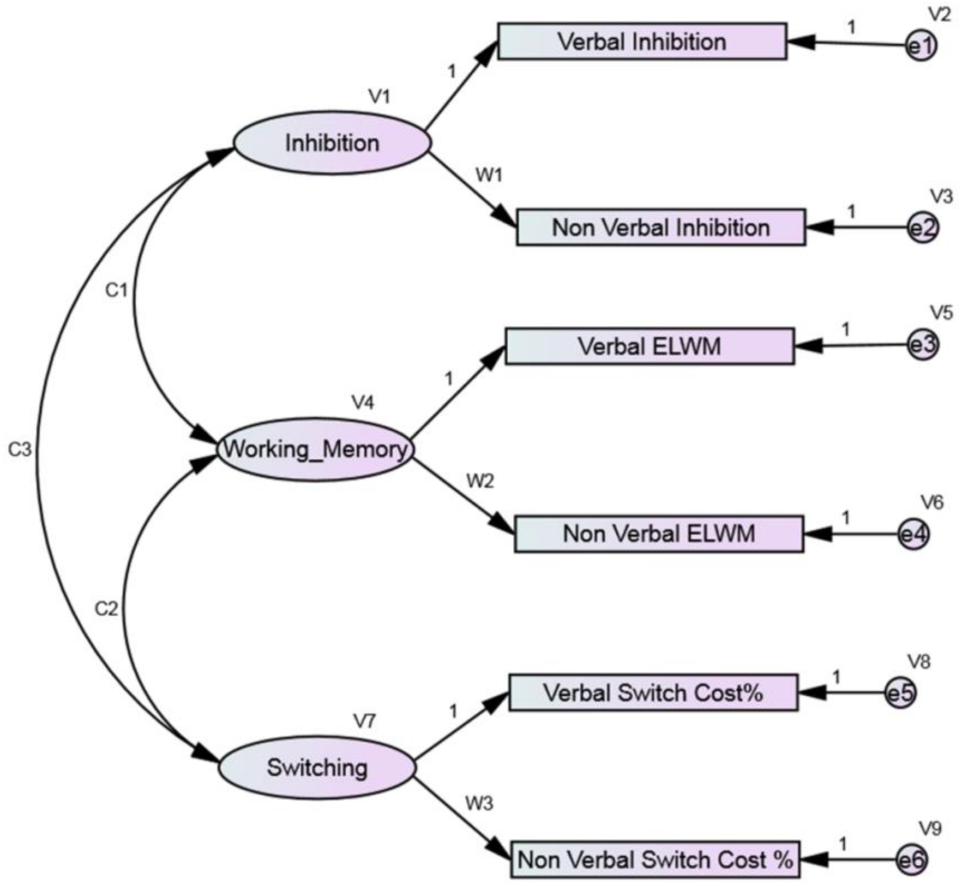


Figure 5.1 (above). The Three Correlating Factors Model of EF - Model 3a (Miyake and Friedman, 2000). The curved arrows indicate co-variances between latent variables; variance is indicated by 'Vn' and path relations between indicator variables (performance measures) and latent variables by 'Wn'

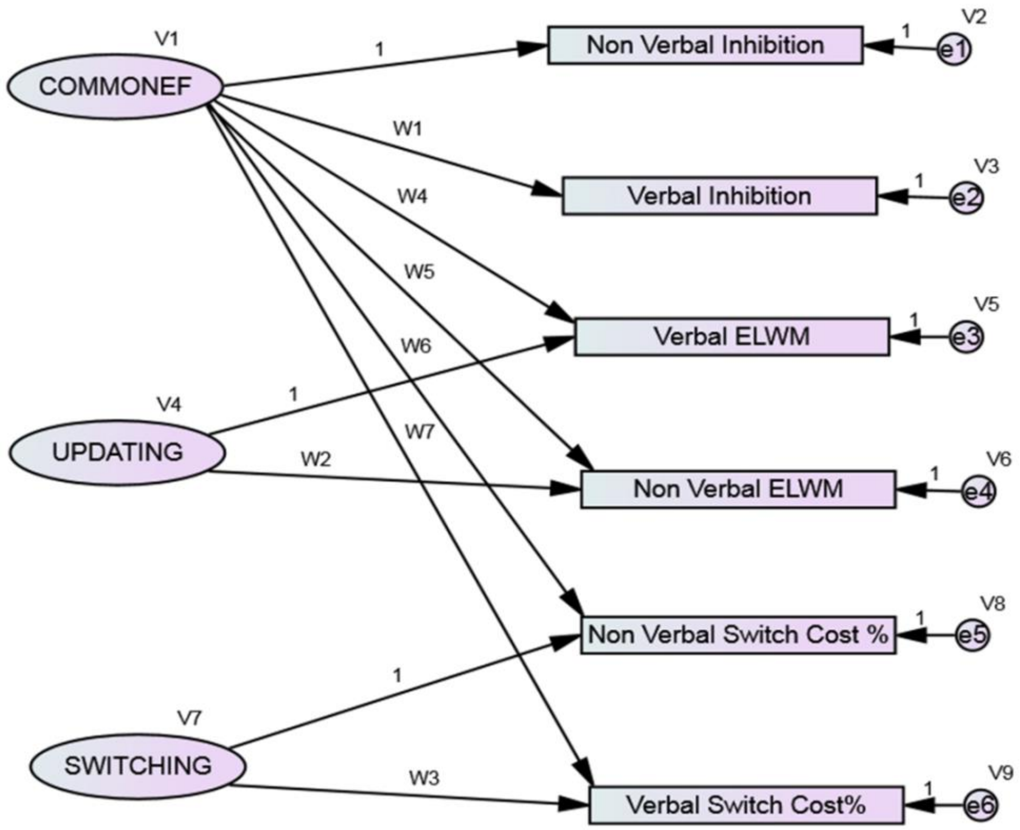


Figure 5.2 (above) Model 3b - The Unity/Diversity Model (Friedman et al., 2008, Friedman et al., 2011, Miyake and Friedman, 2012)

According to Miyake (2012), the ‘Common EF’ in Model 3b represents *what is shared across all EF tasks* and is suggested to be the ability to monitor and maintain goal and context information, (synonymous with the role of the frontal lobes). Model 3b does not include a separate factor for inhibition as this was not identified because the independent variance attributable to inhibition was ‘captured’ by Common EF. Measures of inhibition were therefore suggested to tap a common processing capacity. In contrast, separate ‘Updating’ and ‘Switching’ factors captured the variance that is unique to each of these processes, hence ‘diversity’. As ‘updating’ and ‘switching’ are not correlated with ‘Common EF’ or with each other, they appear to capture individual differences (Miyake and Friedman, 2012).

Miyake et al., (2000) used confirmatory factor analysis (CFA) to compare five structural models against a theoretical ‘three correlating factors’ model. Although the theoretical model (Model 3a) was predicted to provide an excellent fit to the data (Figure 5.1 above), possible alternatives needed to be considered by Miyake and colleagues to exclude the possibility of a more parsimonious fit. These included a one factor model where all functions tap the same underlying construct (Model 1 shown in Figure 5.3 below), two-factors tapping a common ability with the third constituting a separate factor (Figure 5.4 below) or three independent factors (Figure 5.5 below). The most appropriate model is the one which is closest to the theoretical model in terms of statistical fit and the simplest (most parsimonious) configuration for explaining the data accurately (Miyake and Friedman, 2000) (see Section 5.1.3 below for more detailed theoretical explanation).

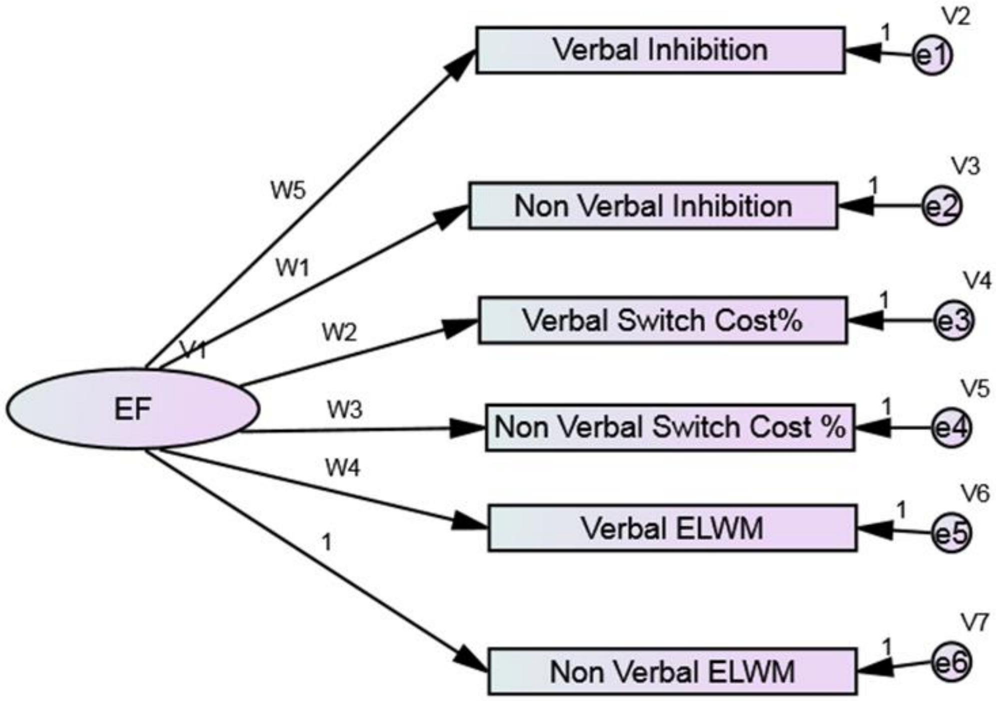


Figure 5.3 (above) Model 1 - A Single Factor EF Model

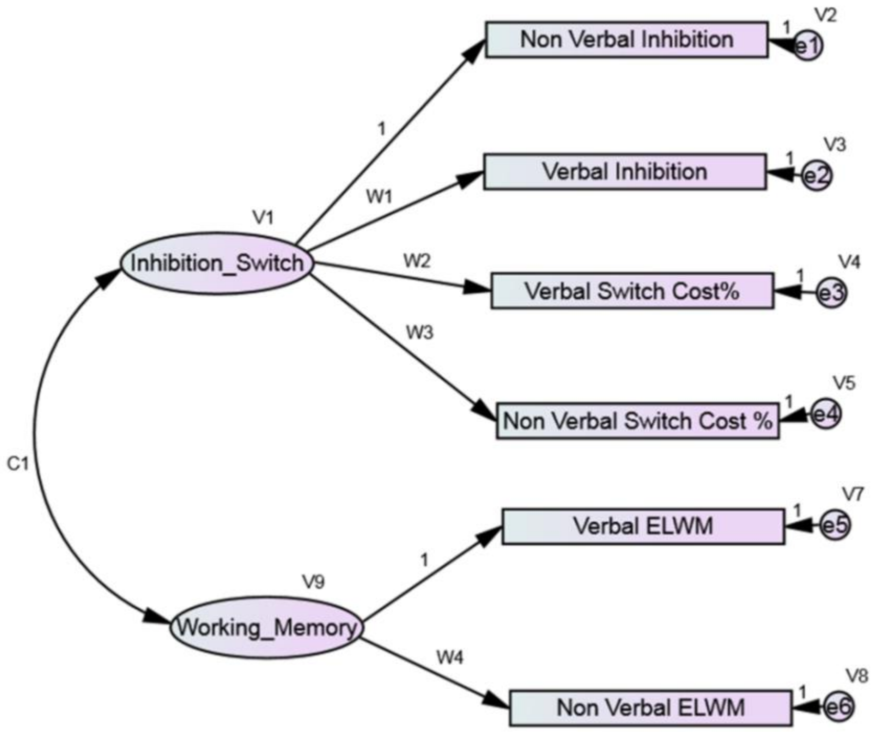


Figure 5.4 (above) An example of a Two-Factor Model (Model 2a) where ‘Inhibition’ and ‘Switching’ form a single factor with ‘Working Memory’ a separate dimension

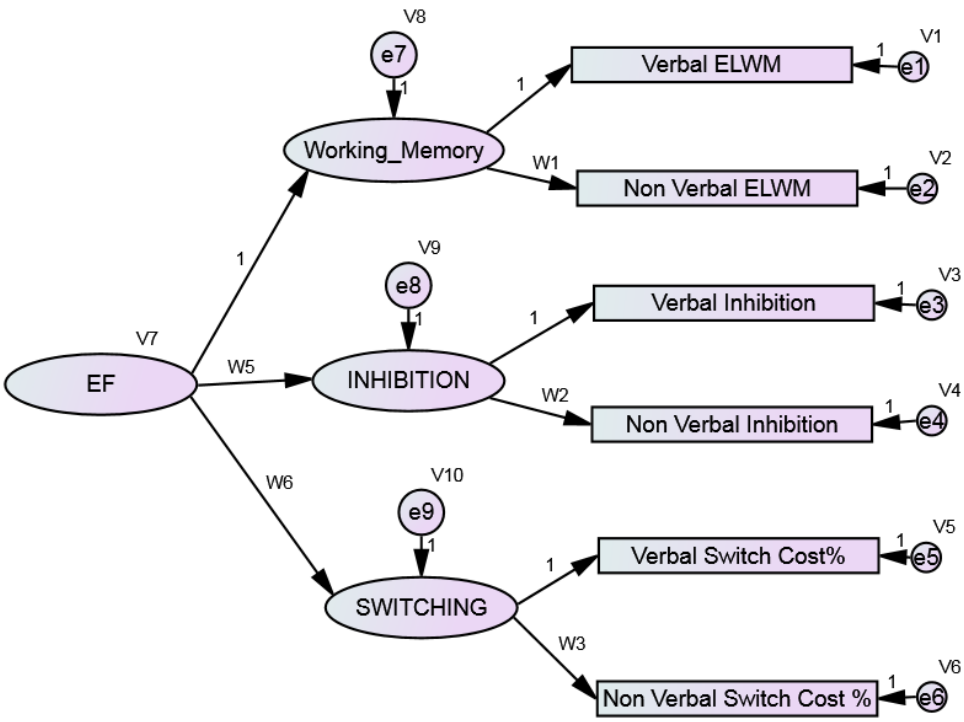


Figure 5.5 (above). Three Independent Factors Model with no correlations between factors and each contributing individually to EF processing (Model 3c)

The Miyake models did not include a fluency component as a core EF so these measures, which were reported in the previous chapter, have been excluded from the analyses. This simplifies the testing of models identified by previous investigators by focusing on common variables across different structures. However, different studies have used different tasks and modelling procedures with varied sample sizes as well as reporting selectively across differing model fit indices available in different modelling programs. To ensure the best fitting models are selected the following approach was used.

5.1.3 Thesis Model Evaluation and Measurement Indices

This study adopts a systematic evaluative approach by first identifying all models which are *acceptable* in absolute terms, i.e., a good fit between the data and model specification which is indicated by a small statistically *non-significant* Chi-square value relative to the number of degrees of freedom (van der Sluis et al., 2007). Next, the most *appropriate* model from a range of *alternative* models is considered in terms of parsimony. A parsimonious model gives a satisfactory description of the data that is theoretically sound and substantively meaningful with as few parameters as possible (Blunch, 2008; p. 98). So, if the differences between alternative models appear small on the basis of the fit indices, the Akaike information criterion (AIC) absolute fit index should be consulted because the difference in the chi-square values among the models cannot be interpreted as a test statistic (Schreiber et al., 2006; p. 326-331). However, it is arguable whether model selection on parsimony alone is enough due to the loss of information regarding the inter-relations between components provided by more complex models. So, a prudent approach to evaluating and reporting model outcomes will include assessment of absolute best fit, parsimony *and* information from alternative, statistically acceptable models.

Table 5.1 (below) presents the different configurations for EF structural organization used in this study which follow Miyake's approach and Table 5.2 presents findings relating to the different models from previous studies.

Table 5.1 Models of Possible EF Structural Organization

Possible Model Configurations	Model Description
One Factor	Single, undifferentiated factor
Two Factors	**Combinations Used in Study**
2a. Inhibition - Switching Working Memory	Inhibition and switching load onto one latent factor and correlate with a second factor, working memory
2b. Inhibition - Working Memory Switching	Inhibition and working memory load onto one latent factor and correlate with a second factor, switching
2c. Switching - Working Memory Inhibition	Switching and working memory load onto one latent factor and correlate with a second factor, inhibition
Three Factors	
3a. Three Correlated Factors (Theoretical Model)	Inhibition, switching and working memory are identified as correlated latent factors
3b. Unity/Diversity Model	All tasks load on one factor 'Common EF' with switching and working memory tasks also loading on separate ability-specific factors
3c. Independent Three Factors	Three EF components are identified as uncorrelated dimensions

5.1.4 EF Structure: Evidence from Previous Studies

In this section there is a description of research findings relating to the one-, two- and three-factor EF models. Table 5.2 below provides details about the models previously identified in research concerning EF, below this are brief details of the relevant research. This provides information about the breadth of studies which have previously investigated EF structure from a developmental perspective as well as the range of statistically acceptable models for age groups that include younger adolescence.

Table 5.2 EF Structural Organization Found in Children and Younger Adolescents

Previous Study		**Findings**
One Factor	Xu et al (2013) 10-12 years	Working memory, inhibition and switching load on a single factor
Two Factor	Messer et al (2018) 6-9 years	Inhibition separate from switching, EWM
	Van der Ven et al (2012) 7-8 years	Updating separate but combined inhibition and shifting
	Van der Sluis et al (2007) 9-12 years	EWM and shifting separate but not inhibition
	Huizinga (2006) 11 years	Updating and shifting separate factors but not inhibition
	Lee et al (2013) 11-14 years	Inhibition and switching load onto one latent factor and correlate with a second factor, working memory
Three Factors		
3a. Three Correlated Factors Theoretical Model	Xu et al (2013) 13 years upwards	Inhibition, switching and working memory are identified as correlated latent factors
	Rose et al (2011) 11 years	
	Wu et al (2011) 11 years	
	Lehto et al (2003) 8-13 years	

5.1.4.1 Evidence of a One-factor (Unitary) Structure of EF

Some of the evidence from research suggests that EF abilities mature at different rates and separation occurs due to increasing specialization. For example, Wiebe et al. (2008) report that up to the age of 6 years EF is undifferentiated and correlations between working memory and inhibition are strong, suggesting these processes function in a closely inter-related manner in young childhood (Wiebe et al., 2008). Evidence regarding the extent of separation in EF structural organisation in younger adolescents is, however, less clear. A cross-sectional study by Xu and colleagues (Xu et al., 2013) examined EF structure from 7-15 years across three groups including 10-12 years (n = 165) and 13-15 years (n = 152). Interestingly, one-factor *and three-factor* models were *both acceptable* in the youngest group of 7-9 years, but the 'unitary EF' single-factor model was a better statistical fit (smaller AIC value – see Section 5.1.2 above) and therefore this model was selected for ages 7-9 years on the principle of parsimony. For ages 10-12 years, multi-group confirmatory factor analysis (CFA) comparisons still supported a *single-factor EF model*, suggesting that measures of working memory, inhibition, and switching remain reciprocally supportive within a single-factor structure in the current study's younger participants aged 11-12 years. However, findings from studies of two-factor models, discussed in the next section, suggest a degree of separation cannot be excluded.

5.1.4.2 Evidence of a Two-factor Structure of EF

There have been a number of investigations of two-factor models of EF. However, there are a range of tasks employed in these investigations and different relations have been suggested between the three EF factors. All this makes interpretation of the findings difficult. The strong correlations between working memory and inhibition noted by Wiebe (Wiebe et al., 2008) appear to weaken in older children (Brydges et al., 2012) so it might be expected that two separate factors may be detected from the age of 11 years. Several investigations provide support for a two-factor model of EF abilities.

A cross-sectional study by Huizinga et al. (2006) found updating and shifting to be moderately correlated at age 11 (108 children at this age, total sample across four groups of 384), which they argued supported a two-factor structure. A third latent factor could not be identified due to low correlations between their three motor inhibitory measures but the large number of factors (6) and tasks (9) may have reduced the statistical reliability of relations between the parameters. Clear evidence of a two-factor structure consisting of Updating and Shifting abilities in children aged 9-12 years has also been reported using

CFA by van der Sluis et al., (2007). Like Huizinga, they controlled for processing speed and found inhibition and processing speed to be strongly related. They noted that while measures of inhibition were failing to tap a common and systematic source of individual differences in typical samples, these may be more evident in atypical samples.

In contrast, St. Clair-Thompson and Gathercole reported a different pattern which involved separate updating and inhibitory abilities in the principal component factor structure of a relatively small sample of 51 children aged 11 and 12 years. The authors suggested that mental flexibility might be a resource shared between updating/working memory and inhibition. A third factor was not identified because the two measures of switching (shifting), a 'plus–minus' task and 'local-global' task failed to load on a single factor (St. Clair-Thompson and Gathercole, 2006).

Lee at al. (2013) investigated two and three factor models across ages 11-14 years. Their three-factor model had good fit indices at age 11 years but with an extremely high estimated correlation (*r* = .86) between inhibition and switching. Consequently, their two-factor model, favouring separate updating and combined inhibition-switching constructs was considered the most parsimonious and therefore the best fitting model (Lee et al., 2013).

Thus, a range of studies have provided support for a two-factor structural model of EF abilities. There has been a lack of consistency about the composition of the two-factors and often the identification of two-factors was a result of poor loadings on a third dimension of EF (e.g., inhibition) and due to the inconsistent relationship between 'Inhibition' and 'Shifting' in the different studies. Consequently, it was decided to test different combinations of two abilities loading on one factor with a third ability as a separate dimension (e.g., Figure 5.4 above). For consistency, 'updating' will be referred to as 'working memory' in the models and 'shifting' as 'switching'. (Please note; in Model

Development Section 5.3.2 below these constructs are abbreviated to Inhib, Switch and WM).

The two-factor models, following Lee et al (2013), are therefore:

Model 2a. Inhibition-Switching and Working Memory
Model 2b. Inhibition-Working Memory and Switching
Model 2c. Switching-Working Memory and Inhibition

5.1.4.3 Evidence of a Three Factor and Undifferentiated Structure of EF

Evidence of a three-factor structure has recently been found. Investigating pre-term 11 year olds with no identified developmental difficulties, Rose and colleagues found performance deficits in all three EF abilities which were also distinguishable from each other and from processing speed (Rose et al., 2011). Rose's sample population is interesting as pre-term children were considered an 'at risk' group for SEN in younger adolescence by the authors. Furthermore, Wu and colleagues (2011) described the model they regarded as the best fit as 'three interrelated factors that are neither unitary, as represented by a one-factor model nor diversified, as represented by an uncorrelated three-factor model' (Wu et al., 2011; p.18). Using cross-sectional age-banded groups, their study was, however, limited by small numbers of participants in each group (49 at 11-12 years, 29 at 13-14 years) and, as critiqued by Lee et al (2013), the equally acceptable one-factor model was not discussed as a more parsimonious alternative, thereby weakening the claim about a three-factor model.

In contrast, Xu (Xu et al., 2013) obtained evidence of a clearly differentiated three-factor model in 13-15 year olds, correlations between constructs remained moderate (working memory – inhibition 0.61, inhibition – switching 0.62 and working memory to shifting 0.43). This suggests that some separability may be expected across the 11-13 years age group. Theoretically, this structure supported Miyake's interpretation of EF as separable but inter-related abilities in adults.

Issues with switching tasks and the overlapping nature of EF measures, however, are factors which need to be considered where assumptions of separability are concerned. For example, the switching paradigm in Xu's study was problematic as their method of simply subtracting condition response times did not control for the influence of processing speed. Suchy and colleagues (2010) suggested that switching may represent a construct that is separate from generative fluency and potentially more heavily reliant on attentional resources. For example, the design fluency tasks (Delis et al., 2001) are completed in a set order with the switching task comprising the final condition. Thus, in order to adhere to the 'switch' rule, the previous rule of ignoring distractor incongruent dots in the category design fluency task has to be suppressed to comply with the new 'alternate dot' rule. The interaction between executive working memory and inhibition is therefore evident in the process of 'switching' as the switch rule has to be kept in mind whilst generating novel designs (Suchy et al., 2010). Monsell (Monsell, 2003) demonstrated that responses are substantially slower and more error-prone immediately after a task switch. Also, St Clair-Thompson (2006) explained that switching costs may be confounded with mixing costs. Switching costs are associated with demands on cognitive flexibility when switching is required from one task to another within the same trial, whereas mixing costs occur where tasks are alternated as a trial sequence (St Clair-Thompson, 2006). Although Xu's study claimed a one-factor structure to be appropriate at 10-12 years and a three-factor structure at 13 years, the structure across the 11-14 age group remains unclear.

5.1.5 Summary

As a result of the review of previous research it was decided to evaluate the EF data in relation to 3 structural models (a single factor, 'unidimensional' model, two factor and three factor structures). Because of the range of structures found in previous studies, the combinations for two and three factor models presented in Table 5.2 will be included as follows: two factors - 2a Inhib-Switch and WM; 2b Inhib-WM and Switch; 2c. Switch-

WM and Inhib and three factors - 3a. Three Correlating factors; 3b. Unity/Diversity Model and 3c. Three Independent factors.

Thus, two studies provided support for three EF dimensions from age 10 upwards (Rose et al., 2011, Wu et al., 2011). A third study (Xu et al., 2013) found support for three separable EF dimensions but accepted a single factor structure in 10-12 year olds on grounds of parsimony, with three factors a better fit at 13 years. Statistical testing will therefore focus on one and three-factor structures with the aim of comparing a one-factor (Model 1) with the theoretical three-correlated factors model (Model 3a). The unity/diversity model (Model 3b) also will be tested as this does not require latent variables to be correlated. This will also enable the extent of switching-specific and working memory-specific abilities to be examined. Model 3c, the three fully independent factors model will also be compared with Models1, 3a and 3b to ensure all alternatives have been considered.

The studies discussed above highlight the core issue for identifying EF structural relations from a developmental perspective, namely; inconsistent findings across studies. As noted by Lee (Lee et al., 2013) these are attributable to design differences in task criteria, constructs and sample characteristics, resulting in disparate EF factor structures and parameter relations. Theory does, however, predict that structural organization in the Non-SEN group should differ from models derived from younger age groups and adults. A key issue to be addressed in the analyses was therefore:

5.2 Research Question 1: Does confirmatory factor analysis support a one, two or three factor EF structure in students aged 11-14 years with no identified learning difficulties?

The Non-SEN group will be the reference group for discussion relating to this research question.

5.2.1 EF Structural Relations in Students with SEN

Studies investigating Miyake's theoretical model from a developmental perspective focus on identifying age-related structural changes in typically developing children. This study takes a different perspective on the models by aiming to identify whether EF organization in the SEN group differs from that of the best-fitting model for the Non-SEN group. The nature of the SEN group, which includes students with developmental disorder diagnoses as well as those vulnerable to environmental 'at risk' factors (see previous Chapter) suggests that there are likely to be differences in factor structure and patterns of organization compared to the non-SEN group for two reasons. First, the literature (Burns, 2002, Eslinger et al., 2004, Sirois et al., 2008, Thomas et al., 2009) explains how congenital brain structural anomalies associated with a range of developmental syndromes may have impacted neural pattern development and consequent EF structural configuration. Second, relational patterns between components may reflect atypical EF developmental trajectories arising from acquired brain injury following trauma or infection or maturational delay, again associated with various developmental disorders (Thomas et al., 2009). As such, the relative importance of the relational constraints across components for the SEN group may differ from that found in the Non-SEN group (Bayliss et al., 2005). For example, the development of compensatory strategies which harness intact abilities to support weak skills has been evidenced in children with SLI (Ullman, 2004, Thomas, 2005). This is important as ways in which abilities cohere and share resources in the SEN group structural organization might indicate different ways of approaching cognitive tasks, with implications for learning support strategies (St. Clair-Thompson and Gathercole, 2006). The second research question is therefore:

5.2.2 Research Question 2: Does EF structure differ between Non-SEN and SEN students at ages 11 - 14 years?

5.3 Method

CFA was used to estimate goodness-of-fit indices across a set of differing models in terms of alternative possibilities across factor constructions (one to three) and configurations between two-factor and three factor models. The sample consisted of 138 Non-SEN and 132 SEN students. All models were tested for each group separately to identify the best fitting model for each group. If the same model offered the best fit for both groups, a group comparison analysis was conducted to test for measurement invariance (Blunch, 2008). As Blunch (Blunch, 2008) has explained, this means that an *unconstrained* model, where parameters are free to vary, is compared against a *constrained* model where all the weightings of the pathways are set to be equal between groups. A chi-square difference test then confirms that group-invariance is supported by the sample data. This implies that group similarities and differences may be explained by relative influences between the components rather than structural differences.

5.3.1 Data Preparation and Preliminary Correlations

Single measures of tasks tapping verbal and non-verbal processing domains of response inhibition, working memory (EWM) and switching (as described in the methods chapter) were used as indicator variables for factor loadings. Data screening had been conducted prior to multivariate ANOVA tests of the EF tasks, as described in the previous chapter. Inhibition measures were square root transformed to correct positive skewness. Untransformed EF task descriptives are presented in Table 5.3 (below).

Table 5.3 EF Task Descriptive Statistics

	NON-SEN *n* = 138				SEN *n* = 132			
EF Variable	**Mean**	***SD***	***Skew***	***Kurtosis***	**Mean**	***SD***	***Skew***	***Kurtosis***
Verbal Inhibition (Errors)	6.66	*3.76*	0.66	0.36	8.37	*5.18*	0.82	0.62
Non-Verbal Inhibition (Errors)	3.61	*2.84*	1.07	0.89	6.48	*4.03*	0.50	-0.63
Verbal Switching (Cost)	30.31	*14.55*	-0.17	0.05	33.79	*18.14*	-0.66	0.84
Non-Verbal Switching (Cost)	57.32	*13.40*	-0.28	0.31	63.66	*15.81*	-0.36	0.37
Verbal EWM (Accuracy)	11.25	*2.00*	0.66	0.98	9.56	*2.16*	0.27	0.08
Non-Verbal EWM (Accuracy)	14.10	*3.62*	0.17	-0.62	11.00	*3.49*	0.36	-0.20
Mardia's Multivariate Kurtosis	2.17				2.11			

After transformation, all variables showed normal distribution for both groups (absolute value of skewness <2 and kurtosis <7, as recommended by Xu et al, 2013 citing Curran et al, 1996) as well as meeting multivariate normality (value of Mardia's multivariate kurtosis < 3). The correlations for the EF tasks for each group are shown below in Tables 5.4 and 5.5.

Table 5.4 First-Order Correlations - Non-SEN

EF VARIABLE	VI	N-VI	VSW	N-VSW	VEWM	N-VEWM
Verbal Inhibition (VI)	1					
Non-Verbal Inhibition (N-VI)	**.180***	1				
Verbal Switch Cost (VSW)	.049	.065	1			
Non-Verbal Switch Cost (N-VSW	-.023	.103	-.002	1		
Verbal EWM (VEWM)	.001	**-.207****	.038	-.043	1	
Non-Verbal EWM (N-VEWM)	**-.150***	**-.281****	.003	-.120	**.318****	1

Significant correlations are in bold
* $p < 0.05$; ** $p < 0.01$

Table 5.5 First-Order Correlations – SEN

EF VARIABLE	1	2	3	4	5	6
Verbal Inhibition	1					
Non-Verbal Inhibition	.008	1				
Verbal Switch Cost	.154	.112	1			
Non-Verbal Switch Cost	.085	.054	.081	1		
Verbal EWM	-.019	**-.268****	-.102	**-.179***	1	
Non-Verbal EWM	-.063	**-.330****	-.098	-.153	**.340****	1

Significant correlations are in bold
* $p < 0.05$; ** $p < 0.01$

The patterns of correlations were different in the groups and across constructs. Similarities in the groups were found in significant correlations between non-verbal inhibition and both measures of EWM. Further analyses confirmed that the differences between the two correlation coefficients across groups, calculated using the Fisher $r - z$ transformation, were non-significant (non-verbal inhibition with verbal EWM: $z = 0.53$, $p = 0.30$ and with non-verbal EWM: $z = 0.44$, $p = 0.33$). EWM was the only EF variable to have a significant correlation across verbal and non-verbal domains in both groups but again, the difference in correlation coefficients was non-significant ($z = -0.2$, $p = 0.42$). Group differences were apparent for the correlations involving switching and inhibition. Verbal switching did not significantly correlate with any other measures in the Non-SEN group, but non-verbal switching significantly correlated with verbal EWM in the SEN group. A lack of association between verbal and non-verbal inhibition in the SEN group contrasted with significant association in the Non-SEN group.

5.3.2 Model Development

For each model, tasks were loaded on the *theoretically corresponding latent factor*. This is the main advantage of CFA over exploratory PCA (principal components analysis) as it enables statistically informed comparison of fit between models as well as other theoretically viable models, in contrast with atheoretical *data driven* PCA analyses (see Figure 5.1 above).

Confirmatory factor analyses were conducted using Amos 21. The estimation method was maximum likelihood to assess the overall fit of the models to the observed variance and covariance matrices. Where models returned unacceptable solutions, for example due to magnitude anomalies in covariance matrices, post hoc modifications were not conducted to improve fit as the aims and objectives were to test several competing models to *identify similarities and differences* between the groups. Three criteria were used to evaluate models; statistical acceptability, parsimonious best fit and absolute best fit, referencing the following indices:

1. The *chi-square* (χ^2) *index of absolute fit* to assess the degree to which the covariances predicted by the specified model differ from observed covariances.
2. *Bentler's Comparative Fit Index (CFI)* which takes account of the parsimony of a model and sample size.
3. *Akaike's Information Criterion (AIC)* as a supplement to the χ^2 statistic as it penalizes more complex models with fewer degrees of freedom.
4. The *Root Mean Square Error of Approximation (RMSEA)* of the covariance structures of the specified model to the observed covariance structures in the population (van der Sluis et al., 2007).

These offered a comprehensive package of fit indices that are insensitive to relatively small group sizes, i.e., < 150 (Miyake et al., 2000). The following section describes the modelling procedure and presents model results with graphic output for the best fitting models for each group and a brief overview of significant differences between Non-SEN and SEN groups.

Goodness of fit indices are presented below in Tables 5.6 (Non-SEN) and 5.7 (SEN). Parameter estimates for best fitting models are presented in Tables 5.8 (One Factor) and 5.9 (Two-factors).

5.4 Results

The model results for the Non-SEN group (Table 5.6) showed the best fits to the data was EF as a single unitary factor (Model 1) and two-factors with Working Memory separated from Inhibition and Switch which were functionally linked (Model 2a). The best fitting models for the SEN group (Table 5.7) were also unitary EF (Model 1) but a different configuration was more appropriate for two-factors where Switch was separated from functionally linked Working Memory and Inhibition (Model 2b).

Table 5.6 Goodness of Fit Indices for CFA Models in the Non-SEN Group

Models	[a]X^2	*df*	*p*	X^2/ *df*	[b]*RMSEA (90% CI)*	[c]*CFI*	[d]*AIC*	Comments
One Factor	**5.383**	**9**	**.80**	**.58**	**0(0/.06)**	**1.00**	**29.38**	**Most parsimonious so best fit overall**
Two Factors								
2a. *Inhib-Switch and WM	**3.560**	**8**	**.89**	**.44**	**0 (0/0.05)**	**1.00**	**29.56**	**Less parsimonious best fit**
2b. Inhib-WM and Switch	5.401	9	.79	.60	0 (0/0.06)	1.00	29.40	All 2-factor models returned acceptable solutions
2c. Switch-WM and Inhib	3.632	8	.88	.45	0 (0/0.47)	1.00	29.63	
Three Factors								
3a. Three Correlating factors	*3.413*	*6*	*.57*		*0 (0/0.06)*	*1.00*		***Solution not admissible*
3b. Unity/Diversity Model	*5.646*	*9*	*.77*	*.62*	*0 (0/0.06)*	*1.00*	*29.65*	****All factors adjusted*
3c. Three Independent factors	*3.436*	*7*	*.84*	*.49*	*0 (0/0.06)*	*1.00*	*31.43*	****Switch adjusted - Group differences significant*

Best fitting model in bold
[a]Chi-square values with $p > .05$ indicate acceptable model fit
[b] Values below .08 indicate a satisfactory fit
[c] Values higher than 0.95 indicate good fit
[d] Low values indicate best fit
*Less parsimonious best fitting model
** Residual covariance matrix not positive definite
***Adjustment required to error variance on latent variable(s) during model specification

Table 5.7 Goodness of Fit Indices for CFA Models in the SEN Group.

Models	$^{a}X^2$	*df*	*p*	X^2/ *df*	^{b}*RMSEA (90% CI)*	^{c}*CFI*	^{d}*AIC*	Comments
One Factor	**5.228**	**9**	**.81**	**.58**	**0 (0/0.06)**	**1.00**	**29.22**	**Most parsimonious so best fit overall**
Two Factors								
2a. Inhib-Switch and WM	*5.047*	*8*	*.75*	*.63*	*0 (0/0.07)*	*1.00*	*31.04*	*Solution not admissible*
2b. *Inhib-WM and Switch	5.059	8	.75	.63	0 (0/0.73)	1.00	31.05	**Less parsimonious best fit**
2c. Switch-WM and Inhib	*4.907*	*7*	*.76*	*.61*	*0 (0/0.07)*	*1.00*	*30.90*	*Solution not admissible*
Three Factors								
3a. Three Correlating factors	*4.661*	*6*	*.59*					*Solution not admissible*
3b. Unity/Diversity Model	*8.472*	*10*	*.58*	*.84*	*0 (0/0.08)*	*1.00*	*30.47*	*All factors required adjustment*
3c. Three Independent factors	*14.726*	*8*	*.06*	*1.84*	*0.08 (0/0.14)*	*0.79*	*40.72*	*WM and Inhib adjusted*

Although the one-factor model was statistically most acceptable for both groups, the group parameter estimates (Table 5.8 below) showed different variables influencing the EF latent variable for each group. Whereas EWM and Non-Verbal Inhibition were the most reliable indicators in the Non-SEN group, Verbal Inhibition and Switch were the most reliable indicators in the SEN group.

Table 5.8 Group Parameter Estimates: One Factor Model

Observed Variable	*β*		*B*		*SE*		*SMS*	
	Non-SEN	SEN	Non-SEN	SEN	Non-SEN	SEN	Non-SEN	SEN
Verbal EWM	0.443	0.546	1	1			**0.197**	0.06
Non-Verbal EWM	0.677	0.636	2.767**	1.882**	1.068	0.583	**0.458**	0.038
Verbal Inhibition	-0.207	-0.092	-0.185	-0.076	0.109	0.093	0.043	**0.243**
Non-Verbal Inhibition	-0.45	-0.493	-0.429**	-0.362**	0.15	0,111	**0.202**	0.008
Verbal Switching	-0.015	-0.195	-0.25	-3.002	1.832	1.821	0	**0.404**
Non-Verbal Switching	-0.163	-0.246	-2.464	-3.294*	1.7897	1.635	0.027	**0.298**

NB: SMS (Squared Multiple Correlations) give an indication of the reliability of the observed variables in relationship to the latent constructs (Schreiber et al., 2006).
*$p < .05$; **$p < .01$; ***$p < .0.001$

Table 5.9 Factor Loadings and Parameter Estimates for Best Fitting Two-factor Models.

Observed variable	Latent construct	*β*	*B*	*SE*	SMS
Non-SEN Two-factor Model (2a)					
Verbal Inhibition	INHIB-SWITCH	0.665	1		0.069
Non-Verbal Inhibition	INHIB-SWITCH	0.262	0.369	0.234	**0.442**
Verbal Switching	INHIB-SWITCH	0.07	1.809	3.108	0.005
Non-Verbal Switching	INHIB-SWITCH	0.161	3.837	3.243	0.026
Verbal EWM	WM	0.447	1		0.2
Non-Verbal EWM	WM	0.71	2.875*	1.279	**0.5**

Correlation between latent variables: -0.623

SEN Two-factor Model (2b)

Verbal Inhibition	INHIB-WM	-0.09	-0.074	0.093	0.008
Non-Verbal Inhibition	INHIB-WM	-0.494	-0.363*	0.111	**0.244**
Verbal Switching	SWITCH	0.252	1		0.063
Non-Verbal Switching	SWITCH	0.321	1.112	0.818	**0.103**
Verbal EWM	INHIB-WM	0.545	1		**0.297**
Non-Verbal EWM	INHIB-WM	0.639	1.893*	0.589	**0.408**
Correlation between latent variables: -0.749					

The following sections examine each model in turn.

5.4.1 Model 1: One Factor EF

This was identified as the best fitting model on grounds of *parsimony* for both groups: Non-SEN χ^2 = 5.383, χ^2/df = .58, p = .80; SEN χ^2 = 5.228, χ^2/df = .58, p = 0.81, returning the lowest AIC index (Non-SEN 29.38, SEN 29.22). A multi-group comparison confirmed group invariance and therefore *a lack of difference between groups in the organization of EF* (chi-square difference statistic; 4.571, df = 5, p = 0.47). As figures 5.6 and 5.7 show below, working memory and non-verbal inhibition were the best indicators of EF in both groups with factor loadings (standardized regression weights): verbal EWM; Non-SEN .45, SEN .55, non-verbal EWM; Non-SEN .66, SEN .63, non-verbal inhibition; Non-SEN -.45, SEN -.48). The model explained about 44% of the variance in non-verbal EWM and 20% for verbal EWM and non-verbal inhibition respectively in the Non-SEN group, this was less in the SEN group (non-verbal EWM 39%, verbal EWM 31% and non-verbal inhibition 23%).

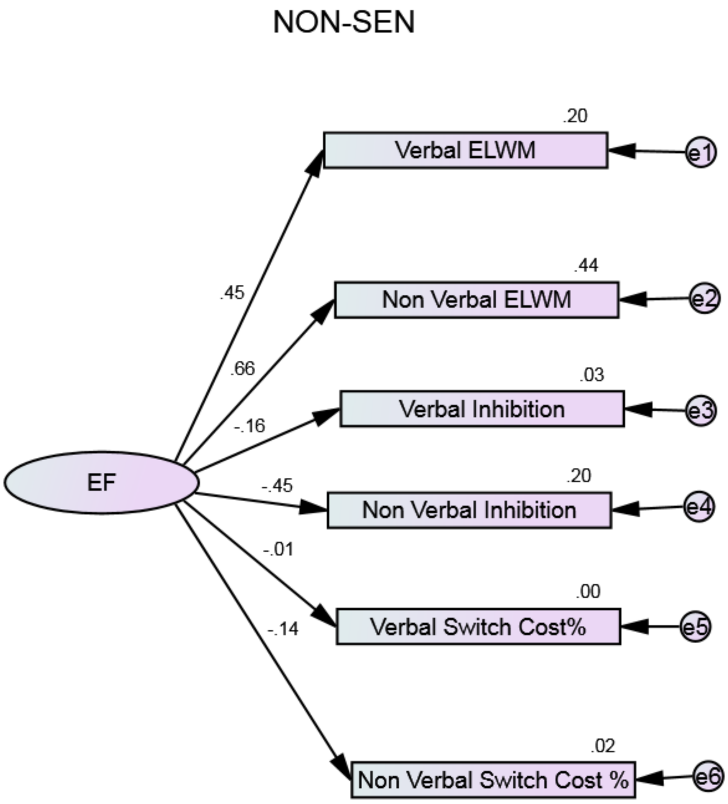


Figure 5.6 (above) One Factor EF (Model 1) Non-SEN

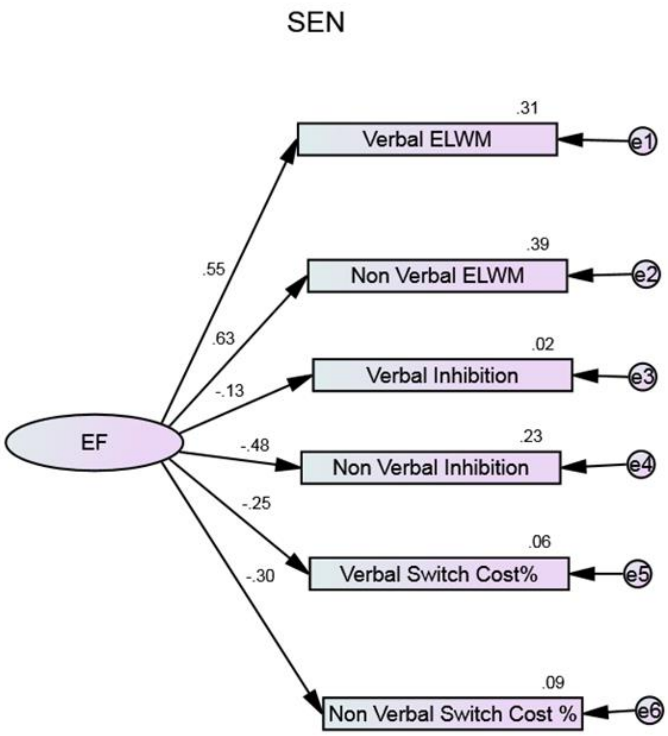


Figure 5.7 (above) One Factor EF (Model 1) SEN

5.4.2 Two-factor Models

All two-factor models were acceptable for the Non-SEN group with very little to choose in models' goodness-of-fit to the data (AIC index). In contrast, only one SEN group model produced an admissible solution (Model 2b). Models 2a and 2c returned covariance matrices that were not positive definite. The sample data was therefore a poor fit to the models, generating theoretically defined matrices containing zero or negative eigenvalues. The following section considers the best-fitting two-factor models for each group.

5.4.2.1 Non-SEN Best Two-Factor Model Fit - Model 2a: Inhibition-Switching and Working Memory

This was the best fitting two-factor model for the Non-SEN group (χ^2 = 3.560, χ^2/df = .44, p = .89) with a modest correlation coefficient between factors of -0.62. In absolute terms (χ^2 = 3.560) it was a better fit than the one-factor model (χ^2 = 5.383) and because the initial fit did not require error variance adjustments, it is considered the best overall fitting model (see Figure 5.8 below). This model shows the importance of working memory in the Non-SEN group as a separate process from inhibition and switching which are linked together. The two factors are moderately inter-related (-.62). Factor loadings showed non-verbal EWM to be a better indicator of working memory (non-verbal; .71, verbal .45). In turn, working memory accounted for 50% of the variance in non-verbal EWM. Inhibition and switching are shown to be linked structurally and functionally, although factor loadings show inhibition to be the better indicator, specifically non-verbal inhibition (.66) as opposed to verbal inhibition (.26). The factor also accounted for 44% of the variance in non-verbal inhibition as opposed to a minimal amount (.07%) in verbal inhibition. This model therefore shows EWM and inhibition to contribute most to EF processes in the Non-SEN group with non-verbal modalities more important than verbal. Inhibitory processes appear to support switching.

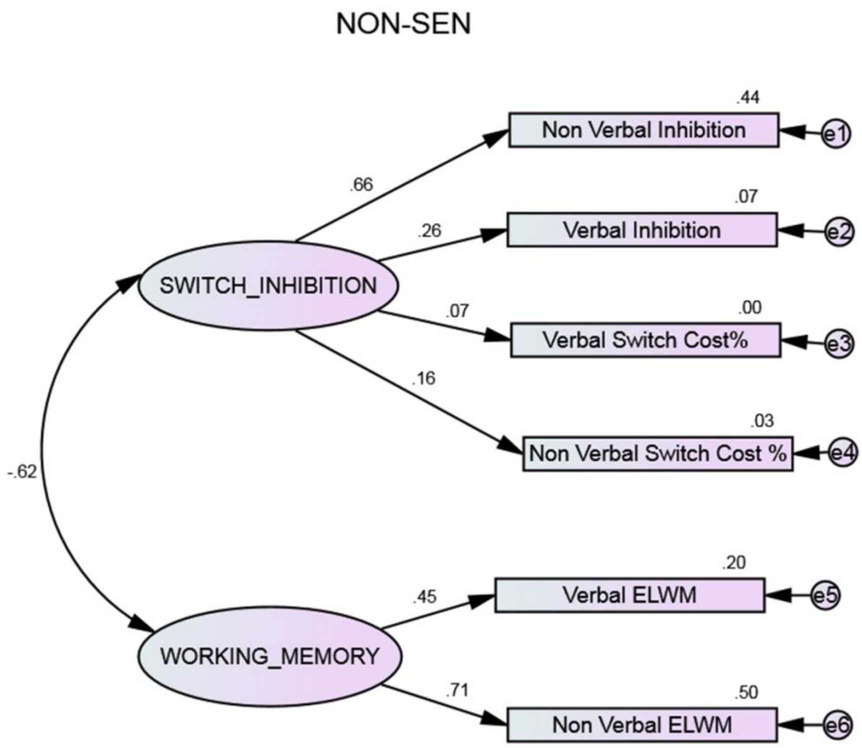


Figure 5.8 (above) Best Fitting Non-SEN Model Two-Factor Model 2a

5.4.2.2 SEN Best Fitting Model 2b: Inhibition-Working Memory and Switching

This was the best fitting (only admissible) two-factor model for the SEN group (χ^2 = 5.059, χ^2/df = .63, p = .75). However, the association between factors (-0.75) was strong, again implying close links between the different forms of EF, particularly as 'Switching', a separate factor, had weak loadings from both modalities (non-verbal .32, verbal .25) and accounted for minimal amounts of variance (non-verbal 10%, verbal 0.6%). As inter-related functions within the same factor, working memory and inhibition, loadings were moderate and similar for EWM (non-verbal .64, verbal .54) and non-verbal inhibition (-.49) but minimal for verbal inhibition (-.09). This factor accounted for 41% of variance in non-verbal EWM but less influence on verbal EWM (30%). Non-verbal modalities were again more relevant as the factor accounted for 24% of variance in non-verbal inhibition (non-verbal inhibition 1%).

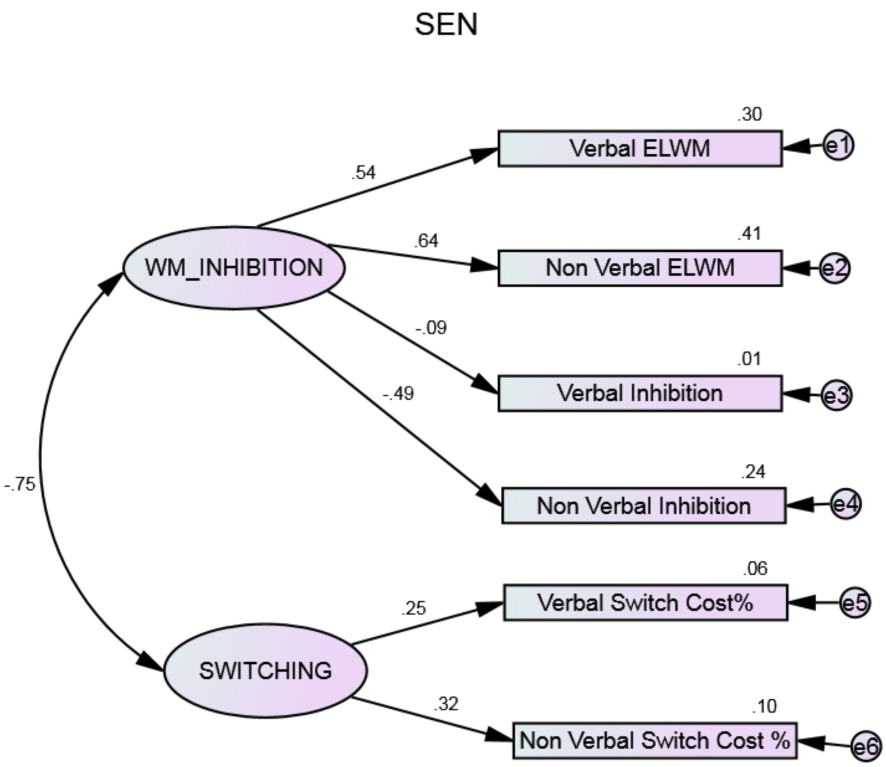


Figure 5.9 (above) Best Fitting Two-Factor SEN Model: Model 2b

The remaining sections consider the fit of the remaining models.

5.4.2.3 Model 2c: Switching-Working Memory and Inhibition

This was the *least acceptable* two-factor model for the Non-SEN group (χ^2 = 3.632, χ^2/df = .45, p = .89) and *inadmissible* for the SEN group.

5.4.3.1 Model 3a: Theoretical Three Correlated Factors Model

The solution for the theoretical benchmark model was *inadmissible* in both groups as correlation matrices were not positive definite. In fact, the switching measures failed to load on a latent factor in the Non-SEN group and correlations between the latent factors in the SEN group were extreme, e.g., ‘Working Memory’ and ‘Inhibition’ -2.55. Consequently, no adjustments were made to try and improve the fit to this theoretical model.

5.4.3.2 Model 3b: Unity/Diversity Model

This model was attempted as an alternative to Model 3a as factors were specified as uncorrelated. Adjustments to the error variances on all latent variables enabled the model to be statistically acceptable for both groups. However, Model 3b returned the poorest fit of all models for the Non-SEN group (χ^2 = 5.646, χ^2/df = .58, p = .81) and a comparatively, though not statistically significantly, worse fit for the SEN group (χ^2 = 8.472, χ^2/df = .84, p = .58).

5.4.3.3 Model 3c: Three Independent Factors

This produced the lowest absolute fit value for the Non-SEN group, but the model required error variance on the 'Switching' factor to be adjusted to enable an acceptable fit to the data (χ^2 = 3.436, χ^2/df = .49, p = .84). In contrast, this was the poorest fit of all models for the SEN group, significantly worse than that for the Non-SEN group and required adjustments to 'Working Memory' and 'Inhibition' factors for a solution (χ^2 = 14.726, χ^2/df = 1.84, p = .06).

To summarise, the theoretical three factor structural organisation was not the best solution for students aged 11 to 14 years with no identified learning issues (Non-SEN) or the SEN group. A two-factor model with working memory a separate dimension was a better fit for the Non-SEN group whilst in the SEN group the best model showed switching to fit as a separate dimension. However, parsimony required the one-factor model to be selected for both groups as the fit was statistically no worse than that of the relevant best fitting two-factor model. EF as a unitary function explained the data best for young people aged 11-14 years, with and without identified learning needs.

5.5 Model Discussion

Previous work with Non-SEN samples suggested that, due to ongoing maturation of EF development until early adulthood, the organizational structure of EF in younger adolescents aged 11 to 14 years would differ from both Miyake's (2000) model of adult EF organization and that of younger age groups. Due to lack of consistency across studies, however, it was unclear whether a one, two or three factor organizational structure would be appropriate. The organizational structure of the SEN group was expected to differ from that of the Non-SEN group as the range of developmental disorders and risk factors diagnosed in individuals with SEN are associated with differing patterns of impaired EF. As such, it was expected that the structural profile of this group would have different relational patterns to that of the Non-SEN group.

The next two sections contain descriptions of the structural organizations of the Non-SEN and SEN groups in relation to the two research questions that were identified in the introduction. These are followed by broader discussion of methodological issues arising from the results. The first model is the unitary one factor model.

5.5.1 Model 1: One EF Factor

This was identified as the best fitting model on grounds of *parsimony* for both groups: Non-SEN χ^2 = 5.383, χ^2/df = .58, p = .80; SEN χ^2 = 5.228, χ^2/df = .58, p = 0.81, returning the lowest AIC index (Non-SEN 29.38, SEN 29.22). A multi-group comparison confirmed group invariance and therefore *a lack of difference between groups in the organization of EF* (chi-square difference statistic; 4.571, df = 5, p = 0.47). As figures 5.10 and 5.11 show below, working memory and non-verbal inhibition were the best indicators of EF in both groups with factor loadings (standardized regression weights): verbal EWM - Non-SEN .45, SEN .55; non-verbal EWM – Non-SEN .66, SEN .63; non-verbal inhibition – Non-SEN -.45, SEN -.48). Although EF explained about 44% of the variance in non-verbal EWM and 20% for verbal EWM and non-verbal inhibition respectively in the Non-SEN group, this was less in the SEN group (non-verbal EWM 39%, verbal EWM 31% and non-verbal inhibition 23%).

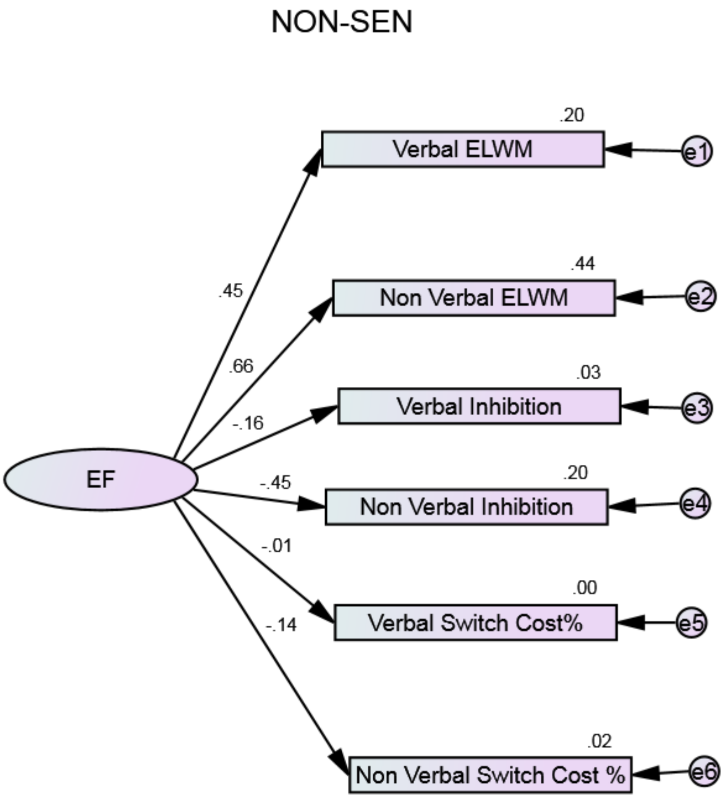


Figure 5.10 (above) One Factor EF (Model 1) Non-SEN

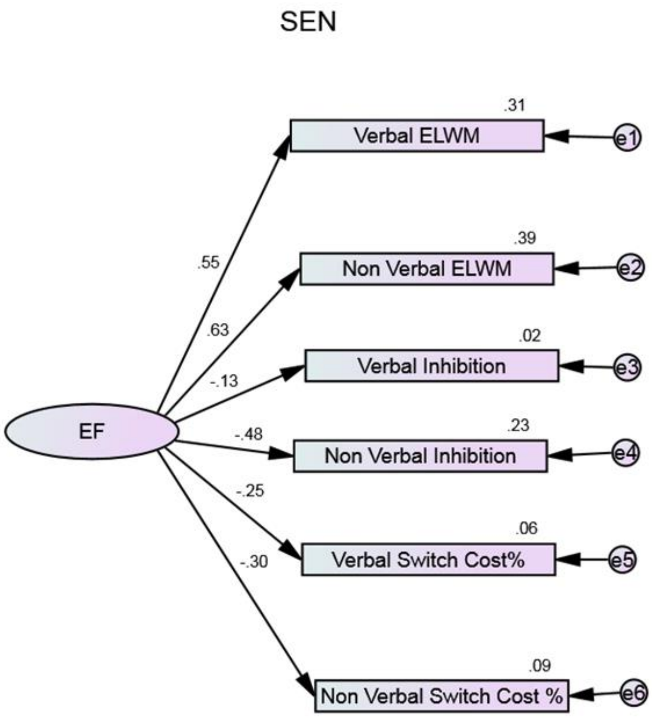


Figure 5.11 (above) One Factor EF (Model 1) SEN

5.5.2 Two-factor Models

All two-factor models were acceptable for the Non-SEN group with very little to choose in models' goodness-of-fit to the data (AIC index). In contrast, only one SEN group model produced an admissible solution (Model 2b). Models 2a and 2c returned covariance matrices that were not positive definite. The sample data was therefore a poor fit to the models, generating theoretically defined matrices containing zero or negative eigenvalues. The following section considers the best-fitting two-factor models for each group.

5.5.2.1 Non-SEN Best Two-Factor Model Fit - Model 2a: Inhibition-Switching and Working Memory

This was the best fitting two-factor model for the Non-SEN group (χ^2 = 3.560, χ^2/df = .44, p = .89) with a modest correlation coefficient between factors of -0.62. In absolute terms (χ^2 = 3.560) it was a better fit than the one-factor model (χ^2 = 5.383) and because the initial fit did not require error variance adjustments, it is considered the best overall fitting model (see Figure 5.12 below). This model shows the importance of working memory in the Non-SEN group as a separate process from inhibition and switching which are linked together. The two factors are moderately inter-related (-.62). Factor loadings showed non-verbal EWM to be a better indicator of working memory (non-verbal; .71, verbal .45). In turn, working memory accounted for 50% of the variance in non-verbal EWM. Inhibition and switching are shown to be linked structurally and functionally, although factor loadings show inhibition to be the better indicator, specifically non-verbal inhibition (.66) as opposed to verbal inhibition (.26). The factor also accounted for 44% of the variance in non-verbal inhibition as opposed to a minimal amount (.07%) in verbal inhibition. This model therefore shows EWM and inhibition to contribute most to EF processes in the Non-SEN group with non-verbal modalities more important than verbal. Inhibitory processes appear to support switching. This model is consistent with that of Lee and colleagues findings of structural organisation in 11-14 year olds (Lee et al., 2013)

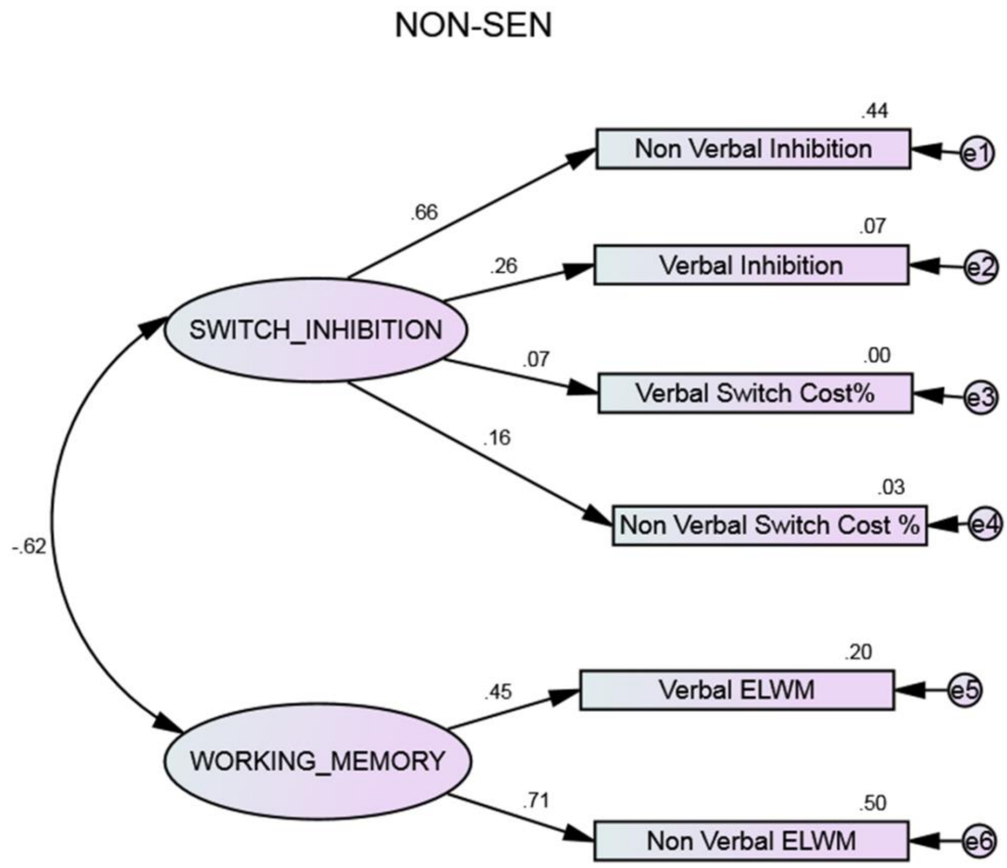


Figure 5.13 (above) Best Fitting Non-SEN Two-Factor Model: Model 2a

5.5.2.2 SEN Best Fitting Model 2b: Inhibition-Working Memory and Switching

This was the best fitting (only admissible) two-factor model for the SEN group (χ^2 = 5.059, χ^2/df = .63, p = .75). However, the association between factors (-0.75) was strong, again implying close links between the different forms of EF, particularly as ‘Switching’, a separate factor, had weak loadings from both modalities (non-verbal .32, verbal .25) and accounted for minimal amounts of variance (non-verbal 10%, verbal 0.6%). As inter-related functions within the same factor, working memory and inhibition, loadings were moderate and similar for EWM (non-verbal .64, verbal .54) and non-verbal inhibition

(-.49) but minimal for verbal inhibition (-.09). This factor accounted for 41% of variance in non-verbal EWM but less influence on verbal EWM (30%). Non-verbal modalities were again more relevant as the factor accounted for 24% of variance in non-verbal inhibition (non-verbal inhibition 1%).

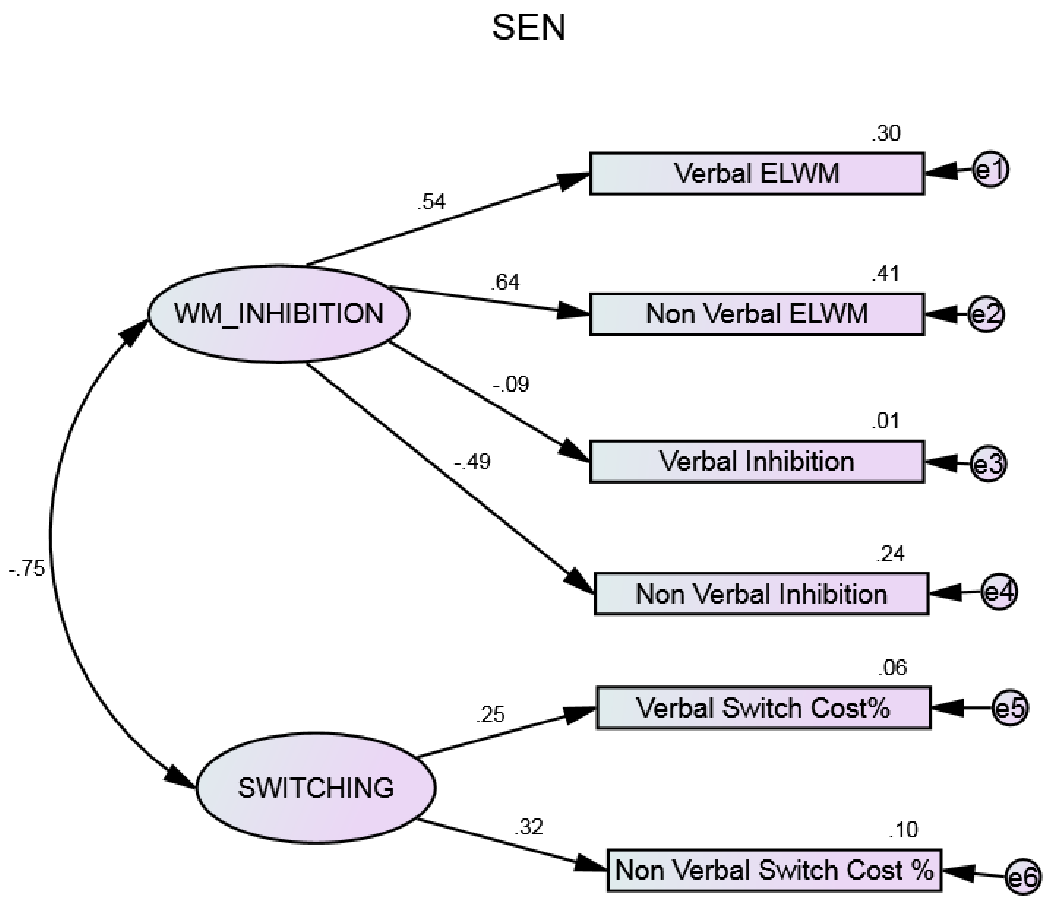


Figure 5.14 Best Fitting Two-Factor SEN Model: Model 2b

The remaining sections consider the fit of the remaining models.

5.5.2.3 Model 2c: Switching-Working Memory and Inhibition

This was the *least acceptable* two-factor model for the Non-SEN group (χ^2 = 3.632, χ^2/df = .45, p = .89) and *inadmissible* for the SEN group.

5.5.2.4 Model 3a: Theoretical Three Correlated Factors Model

The solution for the theoretical benchmark model was *inadmissible* in both groups as correlation matrices were not positive definite. In fact, the switching measures failed to load on a latent factor in the Non-SEN group and correlations between the latent factors in the SEN group were extreme; for example: ‘Working Memory’ and ‘Inhibition’ -2.55. Consequently, no adjustments were made to try and improve the fit to this theoretical model.

5.5.3.2 Model 3b: Unity/Diversity Model

This model was attempted as an alternative to Model 3a as factors were specified as uncorrelated. Adjustments to the error variances on all latent variables enabled the model to be statistically acceptable for both groups. However, Model 3b returned the poorest fit of all models for the Non-SEN group (χ^2 = 5.646, χ^2/df = .58, p = .81) and a comparatively, though not statistically significantly, worse fit for the SEN group (χ^2 = 8.472, χ^2/df = .84, p = .58).

5.5.3.3 Model 3c: Three Independent Factors

This produced the lowest absolute fit value for the Non-SEN group, but the model required error variance on the ‘Switching’ factor to be adjusted to enable an acceptable fit to the data (χ^2 = 3.436, χ^2/df = .49, p = .84). In contrast, this was the poorest fit of all models for the SEN group, significantly worse than that for the Non-SEN group and required adjustments to ‘Working Memory’ and ‘Inhibition’ factors for a solution (χ^2 = 14.726, χ^2/df = 1.84, p = .06).

To summarise, the theoretical three factor structural organization was not the best solution for years 11-14 with no identified learning issues (Non-SEN) or the SEN group. A two-factor model with working memory a separate dimension was a better fit for the Non-SEN group whilst in the SEN group the best model showed switching to fit as a separate dimension. However, parsimony required the one-factor model to be selected for both groups as the fit was statistically no worse than that of the relevant best fitting two-factor model. EF as a unitary function explained the data best for young people aged 11-14 years, with and without identified learning needs.

5.6 General Discussion

In the general discussion the answers to the two research questions are considered first. This is followed by a more general evaluation of the implications of the findings for the understanding of the structure of EF in early adolescence.

5.6.1 EF Organizational Structure in the Non-SEN Group

The first research question concerned whether confirmatory factor analysis supports a one, two or three factor EF structure in students aged 11-14 years with no identified learning difficulties. The results showed that the most parsimonious, statistically acceptable model involved EF as a single dimension (Model 1). However, acknowledging the trade-off between parsimony and how well models fit the statistical parameters, the model that best fitted these statistical criteria was a two-factor structure with 'Switching and Inhibition' forming one latent variable and 'Working Memory' (EWM) a separate dimension (Model 2a). This was consistent with similar findings for this age group in the Lee et al., (2013) Model 2a. As Lee and colleagues describe switching as the suppression of an obsolete mental set in favour of a new one, this implies that inhibition is integral to flexible thinking in the Non-SEN group. Overall, no clearly preferable best fitting model emerged from the alternative two-factor models as these were all statistically acceptable, as were the three-factor models in terms of chi-square non-significance. Three-factor EF structure for the Non-SEN group could not be considered appropriate, however, since the model parameters required adjustments before statistical acceptance was obtained.

5.6.2 EF Organizational Structure in the SEN Group

The second research question concerned whether EF structure was similarly organized between the Non-SEN and SEN groups. As with the Non-SEN group, the unitary dimension (Model 1) was the *most parsimonious* of the statistically acceptable model for both groups, implying structural configuration was similarly organized. Model

2b emerged as the only acceptable two-factor model with ‘Inhibition and Working Memory’ loading on one factor and ‘Switching’ forming the separate dimension.

The shared configuration of inhibition and working memory in the SEN group suggests an important aspect of EF, controlled attention, may be less mature in the SEN group compared with the Non-SEN group, that is, if it is assumed that lack of differentiation suggests immaturity. This interpretation is consistent with the notion of weak or delayed maturity in attentional control (Anderson et al., 2001, Anderson, 2002) which, in terms of Miyake’s model, may be impeding the development of EWM as a separate function. Indeed, the moderate loadings for verbal (.54) and non-verbal (.64) EWM with non-verbal inhibition (-.49) appear to support this. The findings also suggest that switching might be an important independent form of EF which has a separate influence on cognition and behaviour from EWM and inhibition. So, while the Non-SEN preferred two-factor model showed common processing across inhibition and switching to be important in supporting working memory, for the SEN group, working memory and inhibition require shared resources in relation to good switching ability.

A three factor structure was statistically not acceptable, contrary to findings from Rose and colleagues’ study of 11 year olds from a sample characteristically vulnerable to developing SEN in later childhood (Rose et al., 2011). However, as that study found non-executive processing speed to account for much of the inter-correlation among executive functions, this may have influenced the emergence of three distinct EFs. The next section considers issues with model interpretation which require consideration in relation to the SEN group.

5.6.3 Issues with Model Interpretation

An unexpected finding was the emergence of switching as an independent latent variable in Model 2b, the best statistical fitting model for the SEN group. Theory suggests that the identification of this ability as separate from other components implies switching to be a different dimension to the other forms of EF and previous analyses have indicated that switching was not significantly different in the two groups and also in other investigations (Kirke-Smith et al., 2014), making it an area of relative strength (Chapter 4). This model was also acceptable for the Non-SEN group, whose switching performance was relatively weak in comparison with other EF components, so it is possible that this model is more indicative of task characteristics than structural organization. This explanation is supported by the non-significant group differences in switching task performance reported in the previous chapter and also in other investigations (Kirke-Smith et al., 2014). As discussed in the introduction, methods of measuring 'switching' have been criticised (St. Clair-Thompson and Gathercole, 2006, Xu et al., 2013). Thus, according to Preacher (2006), it is important to be able to distinguish between a model's good fit due to a theory's genuine predictive ability as opposed to its inherent ability to fit data arising from *unrelated processes* and *random error* (Preacher, 2006). For example, task impurity was highlighted by Rabbitt (1996) whereby tasks used to measure EF system performance characteristics may simply reflect task demands, e.g., inhibition, and consequently have poor construct validity, particularly if the task demands can be met by other, hypothetically independent constructs within the system architecture (Rabbitt, 1996). Rabbitt suggested an example whereby, operationally and logically, 'switching' and 'inhibition of habitual responses' appear to be very similar concepts.

The two latent variables in the SEN group preferred model (2b) were highly inter-related (-.75) while the loadings on the switching factor were extremely weak (.25; .32), suggesting that the parameters lacked stability. As research has shown that task switching performance has a relatively long developmental trajectory, with maturity ongoing at age 13 (Davidson et al., 2006), it is improbable for this EF to be differentiated in a sample characterised by developmental delay or deficit. In contrast, the preferred two-factor model for the Non-SEN group (Model 2a) showed Switching and Inhibition to share resources which is more consistent with Davidson's arguments relating to ongoing maturity and temporary flux in inhibitory performance. So, although model 2b appears to imply that 'Switching' is a mature, independent function in the SEN group, this finding has caveats.

The next section considers how the models support the notion of EF in a state of transitory flux in this age group.

5.6.4 EF Organization in Transition in Younger Adolescents

The analysis of EF structure in the Non-SEN group helps explain the range of findings about structural organization discussed in the introduction to this chapter where different factor configurations were reported across different studies. In the present investigation acceptable models were derived across all factor specifications and equivalent two-factor models. Evidence of a three-factor structure for the Non-SEN group was weak, although the combined age group of 11-14 years may have masked potential differentiation in the older students.

The overall message is that, as no single model accounted for the data as a definitive EF structural organization in typical learners, a process of ongoing development towards differentiation is the most likely explanation for the data. If separate components are to emerge, this might be indicated by the fact that the independent factors (3c) and unity/diversity (3b) models were statistically acceptable following adjustments to error variances during model specification. This would suggest organization is neither unitary nor diversified, as proposed by Wu and colleagues (Wu et al., 2011) but *transitional* in younger adolescents. Three areas of change support the notion of transition towards improved 'executive abilities' during adolescence: frontal structure development, increased levels of processing speed afforded by myelination and greater efficiency resulting from synaptic pruning of unused connections (Blakemore and Choudhury, 2006b, Blakemore, 2012). A transitional hypothesis is also supported by the fact that there was little to differentiate the two-factor models in terms of fit, with all producing absolute goodness of fit chi-square indices below that of the unitary Model 1, which was selected as the simplest model to explain the data. As structural organization between cognitive processes was not obvious, parsimony requires the single factor model to be identified as statistically the best fitting model.

Even so, as EF in younger adolescents is defined as a period of developmental flux, Non-SEN model configurations support findings by Lee, whereby a two-factor structure is appropriate up to age 13 but a *clearly* differentiated three-factor structure does not emerge before 15 years (Lee et al., 2013).

5.7 Conclusion

To summarise, all models were statistically acceptable for the Non-SEN group. This lack of clarity cannot be attributed to sample size as a larger sample was used than in most studies. Furthermore, the extensive model testing and range of statistical parameters support the preferred explanation that both unity and diversity are features of EF organizational structure during an age-related stage of transitional flux in EF development. Although evidence for undifferentiated abilities was strong, a two-factor model (2a) with working memory separable from shared inhibitory and switching abilities had good predictive ability from a statistical and theoretical perspective. The independence of working memory in the Non-SEN group further supports the importance of this EF for learning. Evidence for a clear three-factor structure was not found and there was no clear evidence that EF structure in the SEN group was different to that of typical learners as the unitary model was acceptable for both groups. Although switching emerged as a separate component in the SEN group, implying relative maturity, this finding is contrary to theory, previous findings and subject to methodological caveats. This raises questions regarding the validity of switching as a separate EF component.

CHAPTER 6

Executive Function Behaviours as Assessed by the BRIEF: Group Differences and Reliability

6 Introduction

Chapters four and five provided a discussion of differences between the Non-SEN and SEN groups in EF task performance and structural organisation from a cognitive perspective involving a structured assessment. Daily activities at school and home, however, also place different behavioural demands on younger adolescents. Existing evidence suggests that the move from primary to secondary school requires students to acquire increasingly flexibility in adapting to varying teacher styles and subject diversity (Jacobson et al., 2011). This move also imposes increased expectations on students to continue to develop effective self-regulated learning strategies (Meltzer, 2007, Denckla, 2007). Similarly, as children move into adolescence, their home life may become less structured. This is thought to reflect subjective parental expectations that young adolescents will develop behaviours that signal increased autonomy and self-sufficiency (Mahone et al., 2002b, Hughes et al., 2009, Semrud-Clikeman et al., 2010). For students identified with SEN, however, acquiring these behaviours may be problematic or subject to developmental delay.

Accordingly, the study reported in this chapter investigates the EF behaviours which could prevent successful goal-oriented outcomes in the negotiation of daily life. Problem (or maladaptive) behaviours may therefore represent differences arising from delayed or deficient EF cognitive processes. Parents, teachers of the students in the SEN and Non-SEN groups and the students themselves completed a short version of the Behavioural Rating Inventory of Executive Function (BRIEF) questionnaire (Gioia, Isquith, Guy, & Kenworthy, 2000, as described in Chapter 2) comprising the ‘inhibit’, ‘shift’ and ‘working memory’ sub-scales. These are the terms used in the questionnaire and are retained to distinguish between the terms used to denote the EF performance components of inhibition, EWM and switching (Chapters 4 and 5).

Few studies have examined EF behaviours as assessed by the BRIEF in the 11-14 years' age-group and there are no known studies investigating the SEN population which triangulate the different perspectives of students (typical learners and SEN students), teachers and their parents, as this study does. Previous investigations across a range of clinical populations and age groups have generally found that teachers and parents report greater levels of maladaptive EF behaviours in clinical groups compared with typical individuals. These studies are summarised in Table 6.1 below and they attest to the usefulness of the BRIEF as a tool that can be used to evaluate executive functioning across a wide range of developmental and acquired neurological disorders (Gioia et al., 2002b). The clinical populations investigated in studies in Table 6.1 include a range of disorders which may be represented in the SEN population.

As can be seen from Table 6.1, however, lack of agreement between respondent groups is frequently reported regarding the nature and extent of the difficulties (Happé et al., 2006, Hughes et al., 2009, Silver, 2012, Cuperus et al., 2014). Such inconsistencies between informant groups' views raise two issues, namely; informant accuracy and the nature of the EF behaviours as stable traits that occur as general responses across environments, or as states that occur in response to situation-specific demands. If EF behaviours are stable traits, then good inter-rater agreement is more likely, and there is evidence to suggest that this might occur where a developmental difficulty exacerbates patterns of maladaptive behaviours which are observable in different contexts but graduated in response to situational demands (Mares et al., 2007, Soriano-Ferrer et al., 2014). In contrast, if the behaviours are states then they are more likely to manifest differently according to situational demands, so parents would observe different patterns and extremes to teachers.

Table 6.1 Previous Studies which have used the BRIEF to investigate EF behaviours

Authors	Ages	Sample Population	Respondents	Between rater agreement
Alloway et al (2009)	5-11	Working Memory Impairments	Teacher	N/A
Anderson et al (2002)	5-18	Brain Disease	Parent	N/A
Bakar et al (2011)	6-11	ADHD	Parent and Teacher	PCA: Two factor structure (behavioural regulation/metacognition) similar for parents and teachers
Byerley & Donders (2013)	11-16	Adolescents with traumatic brain injury (TBI)	Self	N/A
Cuperus et al (2014)	5-12	Specific Language Impairment	Teacher and Parent	Rating agreement for high levels of difficulty in ‘working memory’ and agreement that clinical group worse than control
Epstein et al (2007)	8-12	Asperger Syndrome	Parent	N/A
Gathercole et al (2008)	9/10	Working Memory Issues	Teacher	Inhibit, Shift and Working memory scales all in clinical range
Gilotty et al (2002)	6-17	Autism Spectrum Disorder	Parent	N/A
Gioia et al (2002)	6-16	TBI, reading disabilities, ASD, ADHD	Parent	N/A
Gross et al (2014)	6-16	Foetal alcohol syndrome	Parent	N/A
Hughes et al (2008)	11-18	Specific language impairment	Self and Parent	Adolescents’ self-ratings better than parents’, but SLI self-ratings worse than controls, 57% of parents of SLI rated abilities in clinical range
Mahone et al (2001)	6-16	ADHD and/or Tourette Syndrome	Parent	N/A
Mahone et al (2002)	11-18	Spina Bifida	Self and Parent Parent	Self-ratings worse than parents’, ‘inhibit’, ‘shift’; parents showed less relative concern with overt behavioural problems or emotional disorders; good convergent (moderate

				correspondence) and discriminant validity N/A
Mares et al (2007)	5-15	ADHD	Teacher and Parent	Small correlations between raters, teacher ratings more severe and above clinical levels for working memory and inhibit, parents' clinical for working memory
McCandless & O'Laughlin (2007)	5-13	ADHD	Parent and Teacher	Discriminant Analyses: statistically significant: working memory for ADHD vs Non-ADHD; inhibit for ADHD sub-types; parents - ADHD-combined most impaired in working memory but ADHD inattentive non-sig vs Non-ADHD teachers – working memory > parents for ADHD inattentive
Rosenthal et al (2013)	4-18	Autism Spectrum Disorder	Parent	N/A
Semrud-Clikeman et al (2010)	9-16	Autism Spectrum Disorder/ADHD	Parent and Teacher	Inter-rater congruence not reported as purpose was to identify group differences.
Soriano-Ferrer et al (2014)	7-11	ADHD	Parent and Teacher	Good agreement but teachers rated more severely
Steward et al (2013)	11-16	ADHD	Self and Parent	ADHD self-raters more positive than parents (positive illusory bias effect) – inter-rater congruence: discrepancy scores: self- *T* scores subtracted from parents'
Sullivan & Riccio (2007)	9-15	Discriminative for ADHD	Teacher and Parent	All correlations statistically significant $p < .05$; moderate degree of consistency between the parents and teachers
Toplak et al (2009)	13-18	ADHD	Parent and Teacher	Parents and teachers rated at mostly clinical significance, good intra-rater consistency but inter-rater not reported

Wilson & Donders (2011)	11-16	Adolescents with TBI	Self and Parent	Moderately correlated, parents more severe, clinical group might underestimate degree of executive dysfunction due to organic based lack of deficit awareness

Although Table 6.1 indicates inconsistencies in relation to the degree of agreement between respondent pairings using the BRIEF, the SEN group had poorer EF task performance than the Non-SEN group and therefore the following section draws on existing study findings which suggest that differences may also be expected in EF (adaptive) behaviours as assessed by the BRIEF. The issue of discrepancies between rater groups using the BRIEF is then examined in terms of rater bias and the nature of EF behaviours as stable traits or context-dependent changing states.

6.1 Differences between SEN and Non-SEN groups in BRIEF Answers

The analyses reported in Chapters 4 and 5 revealed differences between the SEN and Non-SEN groups in EF which was assessed from task performance. Thus, it might be expected that teacher, parent and self- ratings would show similar differences if there was consistency between the performance assessments and these three sets of BRIEF ratings.

ASD, ADHD and reading disabilities are frequently included in the SEN group and each of these diagnostic categories were included in the original validating studies of the BRIEF (Gioia et al., 2000b, Guy et al., 2004) (see Chapter 2). Previous studies using the BRIEF have also established that parental ratings of the behaviours of children with developmental disorders show disorder-specific EF behavioural characteristics: children with ASD are judged to have poor flexibility; ADHD subtypes with inhibitory deficits and reading disorders with working memory deficits (see Table 6.1). It is expected therefore, that parents' and possibly teacher as well as self-ratings of SEN students will indicate greater concerns regarding EF behaviour problems across the sub-scales 'working memory', 'inhibit' and 'shift' than those of Non-SEN parents. An examination of the validation process of the BRIEF in the next section elaborates on these expectations of elevated concerns from parents and teachers of the SEN group.

6.1.1 Intra- and Inter-Rater Consistency when using the BRIEF

The internal structure of the BRIEF was validated (Gioia et al., 2002b) in a sample of children who had mixed clinical diagnoses including those represented in the SEN population (ADHD, ASD, learning difficulties, epilepsy, mood disorders) using confirmatory factor analysis (CFA). The eight sub-scales of the full-scale inventory were found to be non-overlapping across three separate factors, which corresponded to the Unity and Diversity Model (Miyake and Friedman, 2000) and related to Barkley's theory of EF and ADHD (Barkley, 1997). Thus, in Gioia's validation study, the three sub-scales used in this study ('inhibit', 'shift' and 'working memory') loaded on three separate, but inter-related factors as follows: 'inhibit' on a factor named Behavioural Regulation (conceptualized as inhibition of external behaviour), 'shift' on a factor named 'Emotional Regulation' (conceptualized as internalized emotional control and flexibility) and 'working memory' on a factor named Metacognition (conceptualized as reconstitution). The relationships between factors were described as close by the authors and were indicative of the interrelated nature of the processes: Behavioural Regulation and Emotional Regulation $r = .84$; Emotional Regulation with Metacognition $r = .63$ and Metacognition with Behavioural Regulation $r = .64$. As a rating scale, the BRIEF was considered to have greater ecological validity and generalizability than performance measures (Gioia et al., 2000b). This suggests that there will be good consistency for the ratings of each of the respondent groups, evidenced as significant correlations between the BRIEF EF sub-scales.

As shown in Table 6.1, however, correlations between teacher and parent groups show less consistency and these range from low to moderate (McCandless and O' Laughlin, 2007, Mares et al., 2007, McCauley et al., 2010). For example, McCandless (2007) found that according to BRIEF ratings, parents reported more problems with behavioural regulation whereas teachers reported more problems with working memory and other cognitive deficits (McCandless and O' Laughlin, 2007), this might be expected as the demands of home life and learning are not the same.

Related to this, more negatively biased BRIEF ratings have been reported by parents of children with ADHD compared with ratings by parents of typical developing children (McCandless and O' Laughlin, 2007, Mares et al., 2007), even after excluding excessively high scores for ADHD children as indicated by the ‘negativity validity’ scale (Steward et al., 2014). Parental ratings indicating clinical levels of developmental disorder have also been reported for specific language impairment (SLI) (Hughes et al., 2009), foetal alcohol syndrome (Gross et al., 2014) and ASD (Rosenthal et al., 2013). Parents of adolescents with spina bifida-related developmental difficulties, including executive dysfunction, were found to identify more problems with immature self-regulation and mental flexibility (Mahone et al., 2002b); skills that become increasingly relevant to the achievement of independence during adolescence.

Comparative studies of adolescents’ self-ratings in relation to parental ratings using the BRIEF have generally found self-ratings to be more positive (Hughes et al., 2009, Byerley and Donders, 2013, Steward et al., 2014) but the nature as well as scale of concerns can differ between parents and adolescents. For example, Mahone (2002) found that while parents’ concerns regarding adolescents with ADHD focused on metacognitive difficulties, the adolescents reported more problems with behavioural regulation. The authors suggested that negative feedback from parents to earlier difficulties relating to behavioural inhibition may have coloured adolescents’ self-perceptions (Mahone et al., 2002a)

6.1.2 Summary

Previous studies of different clinical populations suggest the likelihood of SEN students having elevated levels of maladaptive behaviours compared with typical learners.

Thus, differences are expected between Non-SEN and SEN groups' self-ratings on the BRIEF scales 'inhibit', 'working memory' and 'shift'. Parents' and teachers' concerns are expected to be more negative for the SEN group than for the Non-SEN group. Similarly, within the SEN group, parent and teacher ratings are predicted to differ from adolescents' self-ratings either because adolescents may underestimate the extent of difficulties, or because their estimations are based on previous negative feedback. Social desirability bias may also be a contributing factor in self-ratings as well as a general tendency for these to be more positive. The research questions are given below.

6.2 Research Questions

1. **Were there differences in ratings between the Non-SEN and SEN groups on the BRIEF scales 'inhibit', 'working memory' and 'shift' as reported in self-; teacher and parent ratings?**
2. **Did the BRIEF subscales show intra- and inter-rater agreement for self-, teacher and parent ratings of adolescents in Non-SEN and SEN groups?**

6.3 Method

6.3.1 Participants

The BRIEF was completed by all of the 138 Non-SEN students (ages 11 years to 14 years 11 months; mean 12 years 8 months) and all of 132 SEN students (ages 11 years to 14 years 11 months; mean 12 years 4 months) who completed the EF performance tasks described in Chapters 4 and 5. Following screening for outliers on the BRIEF, one Non-SEN participant was excluded with self-rated scores above 60 across all subscales (1*SD* ≥ mean of 50). Form teachers (approached at SENCOs' discretion) and parents were invited to complete the BRIEF teacher/parent questionnaires. Completed forms were returned by; 39% of parents of Non-SEN students and 46% of parents of SEN students; teachers completed BRIEF forms for 53% of Non-SEN students and 83% of SEN students. To maximise the number of participants, a number of the analyses were not conducted on the whole sample but on sub-groups and details are given about these numbers in the relevant sections. As described in Chapter 2, all students, parents and teachers formally consented to participate in this study; were provided with information that outlined its nature and purpose and understood that the data they provided would be confidential. Their right to withdraw at any stage was explained and any data provided would be destroyed if they did this.

6.3.2 Materials

The Behavioural Rating Inventory of Executive Function (BRIEF) (Gioia et al., 2002a, Isquith et al., 2013).

The materials are described in more detail in Chapter 2 (Methods). To minimise demands on respondents' time, only three behavioural scales corresponding to core EF domains were selected from the inventory. The 'inhibit' scale measures the ability to control impulses and stop one's own behaviour at the appropriate time. 'Shift' assesses the ability to move freely from one situation, activity, or aspect of a problem to another as the situation demands. 'Working memory' assesses the ability to hold information in mind in order to complete an activity. The language of the BRIEF is accessible to young people and it has been specifically designed as an age-appropriate tool for use with potentially vulnerable adolescents, for example:

'I forget what I am doing in the middle of things.'

'I get out of my seat at the wrong times.'

The copy of the questionnaire presented to students is in Appendix 8.

Furthermore, teacher ratings are not compromised by the length of time a teacher has known the student (Baron, 2000). BRIEF scores are age and gender standardized with a *T* score mean of 50 and a standard deviation of 10, with higher scores reflecting *greater* executive dysfunction (Anderson et al., 2002). According to the BRIEF manual, scores above 60 indicate cause for concern and the clinically significant range is defined as a *T* score above 65.

6.3.3 Procedure

Students completed the BRIEF in their class during a single lesson, together with the RPM. It was not possible to administer these measures to individuals in an individual, clinical type of setting for practical reasons. Students read the questionnaire themselves and explanations of key words such as ‘absentminded’ and ‘impulsive’ were given by the researcher from a scripted definition. SEN students were assisted as necessary by the researcher.

6.4 Results

6.4.1 Research Question 1

Do parents’, teachers’ and adolescents’ self-ratings for the Non-SEN group differ from those for the SEN group on BRIEF sub-scales ‘inhibit’, ‘shift’ and ‘working memory’?

One-sample t-tests confirmed that all three groups of respondents (i.e., teachers, parents and student self-ratings), for the SEN group, gave significantly higher ratings than 50 which is the standardised mean for the BRIEF (see Table 6.2). This occurred for the three forms of EF (‘shift’, ‘inhibit’ and ‘working memory’). Above average scores on the BRIEF indicate what is termed maladaptive behaviours. For the Non-SEN group, the same analyses revealed that the scores were significantly below 50 or there was no significant difference.

BRIEF ratings were then entered into three separate multivariate analyses of variance (MANOVA) for self-, parent and teacher ratings to detect differences between the SEN and Non-SEN groups. Separate analyses were conducted because sample sizes differed across respondents. ‘Non-SEN/SEN Group’ was the between-subject factor with the BRIEF executive function ratings (Inhibit *T*-score, Shift *T*-score and Working Memory

T-score) as the dependent variables in the three analyses. There was a significant difference between groups (Non-SEN versus SEN) based on student *self-ratings* for the BRIEF ($F_{(2,264)} = 18.513$, $p < 0.001$, Wilks' $\Lambda = .826$, $\eta^2 = .174$), *teacher ratings* ($F_{(2,178)} = 16.650$, $p < 0.001$, Wilks' $\Lambda = .781$, $\eta^2 = .219$) and *parent ratings* ($F_{(2,109)} = 22.933$, $p < 0.001$, Wilks' $\Lambda = .631$, $\eta^2 = .387$). The significant differences from the MANOVA justified further one-way ANOVA analyses on each separate BRIEF sub-scale for Non-SEN/SEN group differences for each set of respondents. All sub-scales showed significantly elevated scores for the SEN group compared to the Non-SEN group by all respondents (Table 6.2 below).

Table 6.2 T-Test and ANOVA results for Non-SEN/SEN group differences for the BRIEF

	Non-SEN Means (*SD*)	**Non-SEN *T*-Test CF 50**	**SEN Means (*SD*)**	**SEN *T*-Test CF 50**	**ANOVA**	
					***F**	$^a\eta^2$
Student Self-Ratings for BRIEF *(n = 137 for Non-SEN, n = 131 for SEN)*						
Inhibit *T*-Score	47.50 (*9.81*)	-2.99**	52.02 (*11.13*)	2.08*	12.485*	.045
Shift *T*-Score	46.04 (*9.63*)	-4.81***	55.54 (*11.47*)	5.53***	54.080*	.169
Working Memory *T*-Score	48.60 (*10.71*)	-1.53	55.82 (*11.34*)	5.867***	28.691*	.097
Teacher Ratings for BRIEF *(n = 73 for Non-SEN, n = 109 for SEN)*						
Inhibit *T*-Score	49.51 *(10.12)*	-.42	59.06 *(16.06)*	5.88***	20.354*	.102
Shift *T*-Score	48.96 *(8.22)*	-1.08	60.02 *(14.86)*	7.04***	33.495*	.157
Working Memory *T*-Score	53.16 *(9.15)*	2.95**	67.68 *(16.36)*	11.28***	47.428*	.209
Parent Ratings for BRIEF *(n = 53 for Non-SEN, n = 60 for SEN)*						
Inhibit *T*-Score	50.21 *(8.64)*	.17	61.63 *(15.31)*	5.88**	23.002*	.172
Shift *T*-Score	46.38 *(9.70)*	-2.72**	63.02 *(16.95)*	5.94**	39.572*	.263
Working Memory *T*-Score	43.62 *(9.11)*	-5.09**	60.95 *(12.84)*	6.60**	66.764*	.376

T-Test: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Negative *t* means ratings obtained were greater than the norm
**F* univariate test statistic: significant at $p < 0.001$ Bonferroni adjusted
[a]Eta squared is reported to show the proportion of the variance in each sub-scale that is attributable to 'group'

In BRIEF self-ratings, the greatest between group disparities were for 'working memory' and 'shift' scales. Teachers' and parents' ratings showed the same order of behaviour difficulty for the SEN group across the scales ('working memory' > 'shift' > 'inhibit') although teachers rated each scale at more elevated levels of difficulty.

As there were large standard deviations for the respondents' ratings of the SEN group (see Table 6.2), intra-rater consistency was examined for each of the respondent groups. Measured by Cronbach's alpha, where α of .6 to .7 indicates acceptable reliability and .8 or higher indicates good reliability (Cronbach, 2004 cited by Huizinga and Smidts, 2011), internal consistency was good: .815 (Non-SEN self-ratings); .829 (SEN self-ratings); .886 (teachers for Non-SEN); .788 (teachers for SEN); .811 (parents for Non-SEN) and .853 (parents for SEN).

A further analysis was conducted to examine the proportions of SEN students with levels of problem behaviours equal or above two scores which are indicative of cause for concern (scores ≥ 60 = 1 *SD* from mean scores of 50) or clinically significant (scores ≥ 65 = 1.5 *SD* from mean) respectively (Table 6.3 below). Across all three respondent groups 'inhibit' was the form of EF with the lowest proportion of scores in the cause for concern or clinical range (i.e., equal to or greater than 60) with 'working memory' having the highest proportion of these scores, and 'shift' being between 'inhibit' and 'working memory'.

As might be expected the smallest proportion of these maladaptive scores were identified by the SEN students themselves, but even with this group over a third identified themselves as having difficulties with 'shift' and 'working memory' (39% and 40% respectively). Teachers identified more students with scores equal to or greater than 60 with 'shift' and 'working memory' being particularly high (51% and 60% respectively).

Parents gave the highest proportion of SEN students with scores equal to or greater than 60, with nearly or just over half of their children being identified in this range. Thus, all three groups of respondents identified high levels of difficulties with EF behaviours in their BRIEF ratings. Inspection of the Non-SEN group self-ratings revealed that 14% had scores equal to or above 60 for ‘inhibit’, 10% for ‘shift’ and 15% for ‘working memory’. Where teachers were concerned, 12.5% of Non-SEN students had scores above the cause for concern level for ‘inhibit’ and ‘shift’ while 14% were rated with elevated scores for ‘working memory’. In contrast, parent ratings for the Non-SEN group showed 15% to have elevated scores for ‘inhibit’, 11% for ‘shift’ and 4% for ‘working memory’. The disparity between parents of the Non-SEN group and their own self-ratings and teacher ratings for ‘working memory’ implies that ‘working memory’ skills are perceived as being of greater concern in the school context than home. Higher proportions of Non-SEN students considered themselves to have greater levels of difficulty with ‘shift’ than teachers or parents.

Table 6.3 Proportions of SEN students with elevated levels of problem behaviours in the BRIEF according to respondent type

SEN Respondent Group	***T* = 60 – 64 Cause for Concern**		***T* ≥ 65 Clinical**		
Self-Ratings *n* = 131	***n***	**%**	***n***	**%**	***Total %***
Inhibit	20	15	16	12	27
Shift	23	18	27	21	39
Working Memory	18	14	35	27	41
Teachers *n* = 109					
Inhibit	13	12	29	22	34
Shift	6	6	49	45	51
Working Memory	5	5	60	55	60
Parents *n* = 60					
Inhibit	7	12	22	37	49
Shift	4	7	27	45	52
Working Memory	6	10	28	47	57

6.4.1.1 Were there differences between the three respondent types in their BRIEF rating of the SEN group or of the Non-SEN group?

Further analysis was conducted to examine whether there were group differences in ratings according to *type of respondent* (Table 6.4 below) with a separate analysis on the SEN and the Non-SEN groups. As not all teachers and parents completed the BRIEF, data was only available for 28 Non-SEN and 50 SEN students that provided information for the same participant across all three respondent groups. The mean ratings for the BRIEF scales obtained from the three types of respondents are given in Table 6.4 below. A series of 3 (respondent: self-, teacher, parent) x 2 (group: Non-SEN, SEN) repeated measures analyses confirmed a statistically significant difference for the effect of 'respondent' on 'Inhibit': ($F_{(2,152)} = 10.177$, $p < 0.001$, $\eta^2 = .118$) and 'Working Memory': ($F_{(2,152)} = 14.623$, $p < 0.001$, $\eta^2 = .161$) but 'Shift' was non-significant. The effect of 'group' was significant for 'Inhibit': $F_{(1.76)} = 20.816$, $p < 0.001$, $\eta^2 = .215$), 'Working Memory': $F_{(1.76)} = 63.671$, $p < 0.001$, $\eta^2 = .456$) and 'Shift': $F_{(1.76)} = 49.539$, $p < 0.001$, $\eta^2 = .395$). A respondent by group interaction was present for 'Inhibit': ($F_{(2,152)} = 4.697$, $p < 0.05$, $\eta^2 = .058$) and 'Working Memory': ($F_{(2,152)} = 5.328$, $p < 0.001$, $\eta^2 = .066$).

Table 6.4 Mean Ratings and Standard Deviations of Three Respondent Groups in Relation to Non-SEN and SEN Groups for Inhibit, Shift and Working Memory

BRIEF SCALE	NON-SEN *n* = 28 Means *(SD)*			SEN *n* = 50 Means *(SD)*		
	Self	Teacher	Parent	Self	Teacher	Parent
Inhibit	46.71	46.50	50.86	50.46	60.58	61.64
	(9.6)	*(5.16)*	*(9.25)*	*(11.91)*	*(14.42)*	*(15.24)*
Shift	45.96	46.89	45.79	55.24	58.96	61.38
	(9.70)	*(6.30)*	*(8.34)*	*(11.46)*	*(12.79)*	*(13.19)*
Working Memory	46.71	50.50	45.79	54.64	70.34	61.38
	(8.5)	*(5.66)*	*(8.34)*	*(12.54)*	*(15.08)*	*(13.19)*

Figures 6.1 and 6.2 (below) illustrate the nature of the significant interactions for inhibit and working memory. In the case of 'inhibit', for the Non-SEN group, the teachers

and students gave a rating that was more positive about inhibition than the parents. For the SEN group, the teachers and parents gave a more maladaptive score to the SEN group than was given in their self-ratings. In the case of working memory, the ratings for the Non-SEN group were reasonably similar, with the most maladaptive ratings being given by the teachers. For the SEN group, the teacher ratings for SEN ‘working memory’ were well above the threshold of 65 for clinical significance and t-tests showed that teachers’ ratings were significantly more severe than those of parents (t = 3.768 df = 49** two-tailed). Further analyses of significant differences between the three respondent groups are presented in the next section.

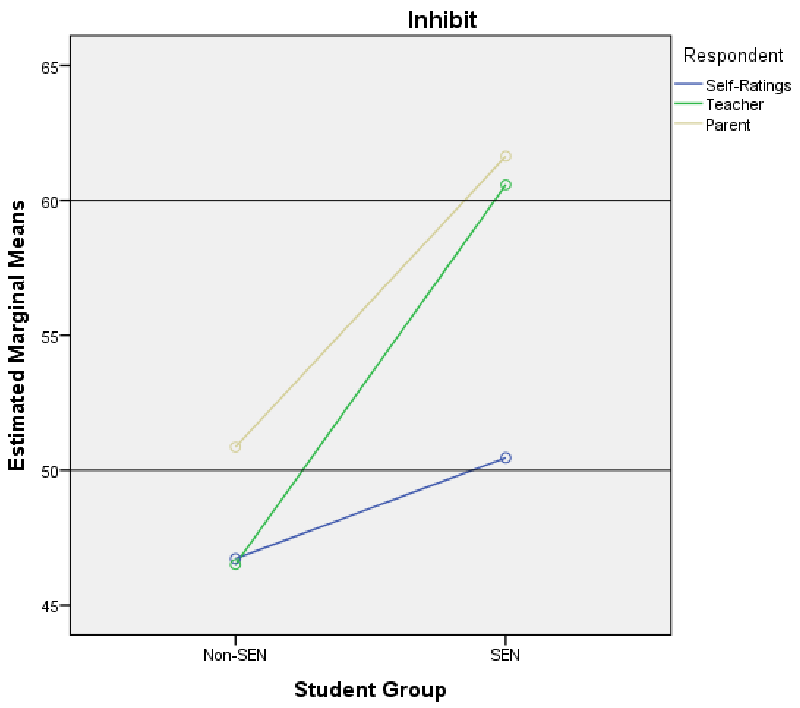


Figure 6.1 Repeated measures - respondent ratings for ‘inhibit’

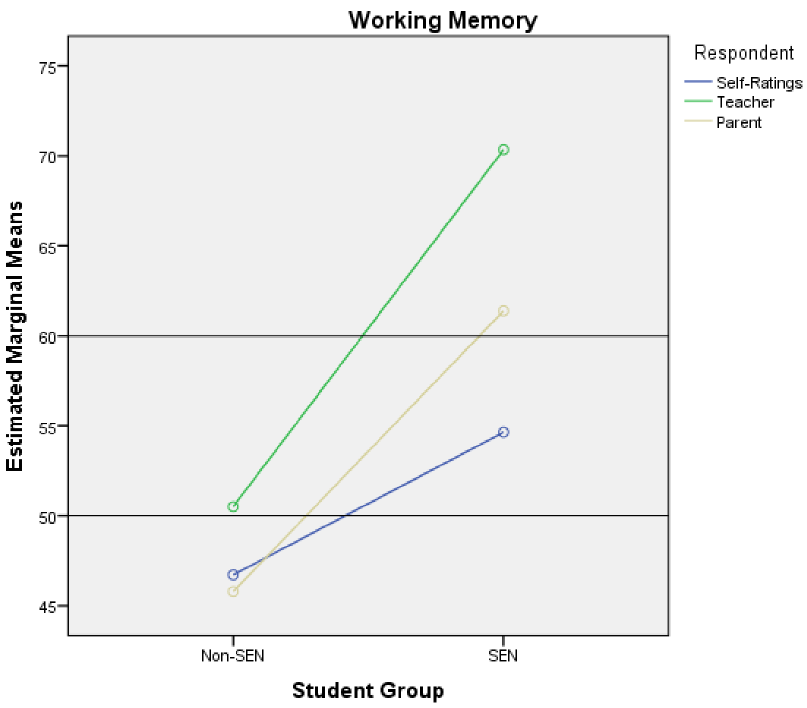


Figure 6.2 Repeated measures - respondent ratings for ‘working memory’

NB: The reference lines are set at the scale mean of 50 and at 60 as identified as a cause for concern (1 *SD* > mean).

6.4.1.2 Students’ Self-Judgements Compared to Teachers or Parents

To assess whether students rated themselves more positively than parents or teachers, post-hoc paired t-tests were conducted. These confirmed that SEN students rated themselves more positively: for ‘inhibit’ than their parents ($t = -4.599$, $df = 59$, $p < 0.001$, two-tailed) and their teachers ($t = -4.907$, $df = 108$, $p < 0.001$, two-tailed). Similarly, SEN group ratings were more positive for ‘working memory’ than those of parents ($t = -2.786$, $df = 59$, $p < 0.01$, two-tailed) and teachers ($t = -6.974$, $df = 108$, $p < 0.001$, two-tailed).

The Non-SEN group’s self-ratings were significantly more positive than those of their parents for ‘inhibit’ ($t = -2.922$, $df = 52$, $p < 0.001$, two-tailed) and for ‘working memory’ to those of their teachers ($t = -3.456$, $df = 72$, $p < 0.001$, two-tailed).

6.4.2 Research Question 2

Did the BRIEF subscales show intra- and inter-rater agreement for self-, teacher and parent ratings of adolescents in Non-SEN and SEN groups?

Correlations for sub-scale ratings for each separate respondent group (intra-rater) agreement are presented in Table 6.5 below which shows moderate (r = 0.5 to 0.8) associations across sub-scales for each of the respondent groups, indicating good internal consistency and collinearity between sub-scales.

Table 6.5 Pearson sub-scale correlations for each respondent group for the BRIEF

	SELF-RATINGS	
Non-SEN (n = 137)	Inhibit	Shift
Shift	.477**	-
Working Memory	.670**	.633**
SEN (n = 131)		
Shift	.625**	-
Working Memory	.566**	.659**
	TEACHER	
Non-SEN (n = 73)	Inhibit	Shift
Shift	.651**	-
Working Memory	.757**	.783**
SEN (n = 109)	Inhibit	Shift
Shift	.481**	-
Working Memory	.564**	.618**
	PARENT	
Non-SEN (n = 53)	Inhibit	Shift
Shift	.641**	-
Working Memory	.583**	.550**
SEN (n = 60)	Inhibit	
Shift	.628**	Shift
Working Memory	.697**	.700**

**Significant at $p < .01$

Pearson's bi-variate correlations were then calculated to examine levels of agreement between respondents for the three forms of BRIEF (Table 6.6 below).

Table 6.6 Inter-rater agreement on BRIEF as indicated by Pearson Correlations

	Teacher and Student	Parent and Student	Teacher and Parent
Non-SEN			
Inhibit	.257*	.241	.187
Shift	.295*	.407**	.151
Working Memory	.219	.212	.178
SEN			
Inhibit	.357**	.185	.447**
Shift	.211*	.181	.288*
Working Memory	.116	.086	.299*

*Significant at $p < .05$ two-tailed
**Significant at $p < .01$ two-tailed

The results above showed that, despite good intra-rater agreement, there were differing patterns and levels of agreement between the three respondent groups, the strongest agreement being between the teachers and parents for the SEN group and the lowest two agreements were between teacher and parent for the Non-SEN groups and parent and student for the SEN group.

6.5 Discussion

The analyses presented in this chapter addressed three research questions concerning; SEN and Non-SEN differences, whether different respondent groups provided similar ratings of the two groups of students, and whether there was intra- and inter-rater agreement. A discussion of the results for each research question is presented below.

6.5.1 Differences between the Non-SEN and SEN groups according to ratings given self-, teacher and parent.

For the SEN group the BRIEF ratings from the three response types were significantly more maladaptive than the questionnaire average T-score of 50, this occurred for all three scales of ‘inhibit’, ‘shift’ and ‘working memory’. In contrast, for the Non-SEN group, there was no significant difference between these scores, or the group had a lower score than 50 (indicating more adaptive EF behaviours than average). These findings were consistent with those from previous research that has investigated the BRIEF in relation to disability (see Table 6.1). The findings were also consistent with the findings of group differences between the same SEN and Non-SEN students on performance EF tasks reported in Chapters 4 and 5.

A high proportion of the SEN group had scores for the three executive scales which were above 59, which means the scores were a cause of concern or at clinical levels. The self-ratings provided the lowest proportion of scores above 59, but even the self-rating indicated that over a third of SEN students identified themselves as having difficulties in ‘shift’ behaviours and ‘working memory’ (39% and 40% respectively). Teachers identified a greater proportion of SEN students with scores over 59, with ‘shift’ and ‘working memory’ being particularly high (51% and 60% respectively). Parents reported the highest proportion of SEN students with scores over 59, with nearly or just over half of their children being identified in this range on all three scales. Thus, all three groups of respondents identified high levels of difficulties with EF behaviours in their BRIEF ratings. These findings are similar to the analyses in Chapter 4 where a relatively high proportion of the SEN group were performing below 1 standard deviation from the performance of the Non-SEN group.

In addition, there were significant differences between the SEN and Non-SEN groups according to the ratings by the three respondent groups for the ‘inhibit’, ‘shift’ and ‘working memory’ sub-scales of the BRIEF. These findings were expected as many previous studies have documented a difference between specific groups of students with disabilities and typical developing groups of students (see Table 6.1), and from the analysis of the performance EF assessments in Chapter 4. Not only were there significant differences between groups, but in a number of comparisons there was a large effect size, indicating that the difference between groups was a large one. There were particularly large effect sizes for ‘shift’ comparisons for all three respondent groups, and large effect sizes for ‘working memory’ for the teachers and parents.

Thus, three types of analysis indicated that the SEN students had more maladaptive EF behaviours according to the BRIEF ratings than the Non-SEN group. This was based on comparisons with the expected average for the BRIEF scales, the proportion of scores over 59, and a direct comparison of the rating scores for the two groups.

6.5.2 Differences in the BRIEF ratings given by the three respondent groups

Analyses were conducted to investigate whether there were differences in the size of the ratings given by the three respondent groups to the SEN and to the Non-SEN students. It was anticipated that there would be more positive self-ratings made by the SEN and Non-SEN students and this was the case. In relation to the Non-SEN students, significantly lower self-rating scores (i.e., more adaptive) were found for ‘inhibit’ in comparison to their parents, and significantly lower scores of ‘working memory’ in comparison to their teachers. For the SEN students, significantly lower scores were found for ‘inhibit’ and ‘working memory’ than the ratings of their parents and of their teachers. Thus, both groups had more positive views about themselves than the two groups of adults, and this was more general across all three forms of EF for the SEN students than for the Non-SEN students. Lack of perceived difficulties with ‘inhibit’ and with ‘working memory’ processes implies that students, and especially the SEN students, might have overestimated their own ability in social and academic situations, contrary to evidence from criteria reflecting actual competence, such as task performance or parent/teacher reports, consistent with previously reported findings (Owens et al., 2007, Steward et al., 2014).

As discussed in the introduction to this chapter, previous studies using specific clinical populations have generally found a similar differences in parent-child pairings as in teacher-child pairings whereby self-ratings are more positive by the children and young people (Hughes et al., 2009, Steward et al., 2014). This is consistent with lack of deficit awareness, positive illusory bias (PIB) (Mahone et al., 2002b, Wilson et al., 2011, Steward et al., 2014) and executively controlled self-monitoring (Gioia et al., 2002a). Thus, developmental delay in the acquisition of self-regulatory and self-reflexive skills could offer an explanation for the more positive SEN group's estimations of their own executive functioning (Anderson, 2002, Rueda et al., 2005, Checa et al., 2008). However, it should be acknowledged that some SEN students may have had a poor self-concept (Hughes et al., 2009) and this could be a negative influence on ratings of students struggling with skills of increasing relevance for independence during adolescence, namely, self-regulation and mental flexibility.

Working memory was the teachers' greatest concern; this finding is consistent with previous studies and appears to reflect context-specific professional values (McCandless and O' Laughlin, 2007, McCann et al., 2013). The results were also consistent with the study by Mares (Mares et al., 2007) which reported teacher ratings for 'working memory' were well above the threshold for clinical concern in a sample of students with ADHD.

For the SEN and Non-SEN groups, parents did not always rate their children more positively than teachers. This findings does not support the suggestion that parents rate their children more positively than teachers (see Table 6.4) (Mares et al., 2007, McCandless and O' Laughlin, 2007, Soriano-Ferrer et al., 2014). Mares et al (2007) suggested such an effect might occur for 'inhibit' because the home environment is more accommodating and tolerant than the demanding requirement for self-regulation in the school context. The findings in this study, however, contrast with Mares' explanation and suggest that the unstructured home environment could be less helpful for adolescents (Epstein et al., 2008).

A limitation of these analyses was the relatively small proportion of students in both groups where there was a BRIEF rating provided by all three types of respondents.

Although the sample size of both groups was about 130, the response rate to the parental questionnaires as might be expected was relatively low; with potential problems in the transmission and return of the questionnaires by the students and lack of time by the parents to fill in the questionnaires. Similarly, there was a relatively low response rate for the Non-SEN students by teachers and this is likely to reflect the time-consuming nature of entering the information about each class student in the questionnaire. Despite these limitations it is reassuring that the means presented for the ratings presented for the larger sample are similar to those used in the repeated measures analyses.

To summarise, the findings indicate that the students gave more positive self-ratings than their parents or their teachers, and there were indications that the SEN group was more likely than the SEN group to be more positive than their teachers and parents. Teachers and parents are likely to base their ratings on different situations and contexts, and the biggest difference between these two groups was the more negative ratings of 'working memory' by the teachers of the SEN group.

6.5.3 Intra- and inter-rater agreement on the BRIEF subscales

Previous factor analyses on the structure of the BRIEF have identified the three EF sub-scales used in this investigation (Gioia et al., 2002b, but see Huizinga and Smidts, 2011 two factors found). Furthermore, as described in the Methods section above, the analyses by Gioia indicated that the three sub-scales were significantly correlated with one another. The analyses in this chapter showed that for each type of respondent there were significant correlations between all three forms of EF identified by the BRIEF, thereby revealing reasonable internal consistency of the scales. The correlations ranged in size from .49 to .78. Thus, the correlations were not so high to suggest the same concept was being assessed or so low as to suggest the three EF abilities were unrelated. This ambiguity may also question the ability of the BRIEF to separately measure the components. The findings are, however, consistent with the unity and diversity model of Miyake et al. (2000).

As expected from the findings of previous investigations the correlations between different raters of the same EF construct were much weaker. Only for the parent and teacher ratings of SEN students were all three EF scales significantly correlated. In contrast, for Non-SEN students none of these ratings were significantly correlated. The latter effect may be due to less variance in the Non-SEN group or more care taken by parents and/or teachers in rating the SEN group due to awareness of difficulties. There were also significant correlations between the ratings of students and teachers of ‘inhibit’ and of ‘shift’ and this occurred in both groups of students, but similar correlations for ‘working memory’ were non-significant. It is difficult to know why there was this pattern of significant correlations. There are a number of possible explanations (see Bernstein and Waber, 2007; Mahone et al., 2002b), but further research is needed to better understand these processes involving differences in the ratings of the SEN and Non-SEN groups, but relatively low agreement between the different raters. Some of the issues will be addressed in the next chapter.

6.6 Conclusion

Analyses were conducted on the BRIEF ratings of ‘inhibit’, ‘shift’ and ‘working memory’. Ratings were provided by the SEN students, Non-SEN students, parents and teachers. The SEN group received significantly more maladaptive ratings of all three EF behaviours than the Non-SEN group, and these differences were present for student self-ratings, parents and teachers. In addition, a high proportion of the SEN group received ratings that were a cause of concern or at clinical levels. These findings replicate previous research with other groups of students with disabilities (Gioia et al., 2002a, Mahone et al., 2002b) and suggests that students with SEN experience significant difficulties applying EF skills in everyday life, consistent with findings of weaker EF processing in task performances.

Comparisons between the three type of raters (students, parents and teachers) revealed that the students gave more positive ratings of their EF behaviours than teachers and parents. These findings provide further information about how adolescents perceive the extent of their own experiences of maladaptive EF behaviours in comparison to observations by *two* sets of respondents; teachers and parents. In addition, the analyses revealed that teachers were particularly concerned with the working memory of students with SEN, as has been found previously (Gathercole et al., 2008). As in previous research, significant correlations were found between all of the three EF scales of the BRIEF, implying good internal consistency (Huizinga et al., 2011, Gioia et al., 2002). The findings were also consistent with the unity and diversity model of Miyake et al (2000). There were, however, low correlations between the ratings of the same students by different groups of raters. This replicates previous findings (Mares et al., 2007) and will be investigated further in the next chapter.

CHAPTER 7

The Relations Between the Strengths and Difficulties Questionnaire and the BRIEF and Between the Performance EF Scores and the BRIEF

7 Introduction

A concern identified in the first Chapter of this thesis was the nature of teachers' understanding of what SEN means, particularly in terms of how disruptive behaviours are interpreted in the classroom (see Chapter 1, Section 1.1.3). As the SEN group have consistently been found to have poorer EF than the Non-SEN group in previous chapters, one aim of the research reported in this chapter was to investigate whether there also are group differences in teachers' judgements of conduct dysregulation as measured by the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2001). Related to this was the wish to investigate whether there were relations between the ratings teachers have given to students on the SDQ and their ratings of EF from the BRIEF. This is of interest as previous research suggests that disruptive behaviours in the classroom may be indicative of impaired executive functioning, rather than poor conduct, as indicated by wilful infringements of classroom rules, for example (Morgan et al., 2000, Waber et al., 2004, Meltzer, 2007, Gathercole et al., 2008, Alloway et al., 2009b, St Clair-Thompson et al., 2010, Lupton et al., 2010, Meltzer, 2010, Rogers et al., 2011). The second aim of the research was to investigate whether there were relationships between the predictors of the BRIEF behavioural ratings from the performance assessments of EF and from the SDQ. These two aims are discussed below.

7.1 SDQ, BRIEF and Behavioural Links

A study discussed in the previous chapter (McKinney and Morse, 2012) reported that children with lower EF are more likely to show disruptive behaviour symptoms compared to children with higher EF. As Anderson's model (Chapter 1, Section 1.2.3ii) showed, the range of adaptive outcomes which are likely to be affected by poorer attentional control and self-regulation could include; cognitive flexibility, goal setting and information processing. Anderson maintained that difficulties in these domains can manifest as dysfluent communication, impulsivity or hypo-activity (sluggish cognitive tempo Barkley, 2012) which may be interpreted as laziness, task incompletion and procedural mistakes. In younger adolescence, these difficulties are likely to have emotional consequences which can manifest as intransigence (Rosenthal et al., 2013) or poor self-esteem if not understood appropriately (Hughes et al., 2009). According to Rosenthal, intransigence may be the outcome of frustration and incapacity in meeting demands based on age-related expectations (Rosenthal et al., 2013), and aversive experiences of not fitting in with the classroom environmental and social dynamics (see Chapter 1, Section 1.1.5, Sonuga-Barke, 2005). In short, if teachers interpret EF difficulties as conduct issues with disciplinary implications, this can have a deleterious impact on student self-belief, which can lead to mental well-being issues (Rosenthal et al., 2013, Granader et al., 2014, Lawson et al., 2015). Thus, the first issue to be addressed was whether teachers rated SEN students as having more problematic behaviours than their Non-SEN peers, as rated by the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2001).

The SDQ was chosen to assess these problematic behaviours because it is an established clinical assessment of a young person's mental well-being (Goodman, 2001) and is a tool available to schools to identify possible underlying causes of persistent disruptive or withdrawn behaviours. It can be used to address the SEN(D) Code of Practice (2014, Section 6.21) requirement to investigate underlying factors such as undiagnosed learning difficulties, difficulties with communication or mental health issues. The SDQ consists of sub-scales which index problem behaviours which might be observed by teachers or parents (as well as self-ratings) relating to hyperactivity, conduct problems, emotional symptoms, peer problems as well as positive social behaviours. Happé et al., (2006), for example, used the SDQ to investigate parent and teacher ratings of behavioural problems in boys (11 to 16 years) diagnosed with either ASD or ADHD and found elevated scores (greater difficulties) in both groups for peer problems. Emotional symptoms were reported for the ADHD group and prosocial behaviours in both groups were poorer than in typical developing adolescents. They also found correlations between EF performance measures of inhibition on the 'Go/No Go' response selection task with the SDQ sub-scale 'hyperactivity' for the ASD group and between EF flexibility with SDQ 'emotional symptoms' for the ADHD group (e.g., Happé et al., 2006). Links between hyperactivity and conduct problems have also been found in children with poorer reading, which suggests that broader behavioural issues may arise as a consequence of coping with cognitive barriers to learning (Adams et al., 1999, Adams and Snowling, 2001, see also Sonuga-Barke, 2005 in relation to adaptation to the constraints of a developmental or learning disorder in Chapter 1).

A further aim in the current study was to investigate whether the scales of the BRIEF, as a measure of EF, and of the SDQ as a measure of behavioural difficulties were significantly related. Teacher judgements of maladaptive EF behaviours in the SEN group using the BRIEF, as reported in the previous chapter, are likely to be informed by the range and degree of educational needs issues described in the SEN Code and tracked academic attainment levels (Gathercole et al., 2008). In contrast, teachers' SDQ answers are likely to reflect their interpretations of the students' behaviours in response to classroom rules, which reflect the school code for maintaining an optimal learning environment. As rules reflect age-appropriate expectations for encouraging students to take responsibility for their behaviour and learning, it is likely that students whose self-regulatory capacities are immature, as suggested in the SEN group's elevated EF behavioural scores, are more likely to behave in ways that may be interpreted as disruptive. Thus, if teachers' judgements on the SDQ sub-scales reflect disruptive conduct concerns and the BRIEF is a better measure of general behavioural impairment than EF (McAuley et al., 2010), then it is expected that there will be good agreement between the BRIEF and SDQ.

There are various reasons to expect a relationship between the BRIEF and SDQ ratings. According to the theoretical perspectives about EF examined in Chapter 1, Part 2, the ability to ignore distractions and maintain focus are essential in the classroom context and inhibitory processes are fundamental to successful goal-oriented outcomes (Roberts, 1996, Barkley, 1997, Anderson, 2002, Baddeley, 2012). Morgan, for example, reported that students with adequate abilities (as measured by standardized assessments) who had been referred for learning difficulty assessment showed inattentive behaviours as a result of being overwhelmed by the demands of increased processing complexity ('on-line processing' in contrast to automatic routines), not because of disruptive intent (Morgan et al., 2000). McKinney & Morse (2012) claim that children with disruptive behaviour disorders (DBDs) often have difficulties in executive function behaviours, such as initiating and regulating goal-directed behaviour, perceiving and encoding cues in the environment and controlling impulses. As the study found that children with lower EF were more likely to show disruptive behaviour symptoms compared to children with higher EF, this suggests that a similar effect is likely to be found for the SEN group. McKinney concluded that the disruptive behaviours were attributable to poorer problem-solving and/or communication skills (McKinney and Morse, 2012). McKinney & Morse's findings suggest that poorer EF processing skills will show agreement with the BRIEF ratings as indicative of maladaptive goal-directed behavioural outcomes *and* to the broader indicators of behavioural dysregulation measured by the SDQ.

7.1.2 Relations between EF Performance Measures and the BRIEF

According to the commonality assumption, the same components measured by EF performance and the BRIEF should involve the same underlying construct and should therefore correspond directly (Toplak et al., 2008, Toplak et al., 2013). A meta-analytic review of 20 studies comparing performance EF assessments and the BRIEF which was conducted by Toplak et al (2013), however, suggests otherwise. The review involved: 13 child samples, 7 clinical, 2 non-clinical, and 11 combined clinical and non-clinical samples and revealed that only 24% of correlations between EF performance and BRIEF to be statistically significant and, with a median of $r = 0.19$, the strength of the associations, as suggested by Laerd Statistics (https://statistics.laerd.com/statistical-guides/pearson-correlation-coefficient-statistical-guide.php) were small (Toplak et al., 2013).

As there is little evidence in the literature supporting direct links between EF performance and BRIEF behaviour ratings, this raises the question of whether the BRIEF may be tapping broader behaviour difficulties as considered in the previous section. Low associations between performance and behavioural manifestations of EF prompted McAuley (2010) to query whether the BRIEF was more strongly associated with measures of EF impairment or general behavioural concerns. This suggested the final research question of whether EF performance or the SDQ was a better predictor of the BRIEF. If the SDQ is a better predictor then this will suggest that the teachers' BRIEF scores may in part be a reflection of disruptive student behaviours rather than EF abilities.

7.1.3 Summary and Research Questions

This aim of this chapter is to first, examine teacher ratings on the SDQ in relation to the Non-SEN and SEN groups to identify whether there were differences in judgements of disruptive and other behaviours seen by the teachers.

The analysis of relations between EF performance and the BRIEF for the SEN group, as measured by self- and teacher ratings, will contribute to understanding these different forms of measurement, as previous research has found little congruence between cognitive processing performance and the behavioural outcome aspects of EF. Also, by identifying the relative contributions of EF performance and the SDQ as predictors of the BRIEF it is hoped to better understand these different forms of assessment. To maximise the sample size, the analyses addressing the second and third research questions focused on the SEN group which had the highest number of self-ratings and teacher ratings.

The research questions are therefore:

1. Are there differences in teacher ratings on the SDQ for Non-SEN and SEN students?
2. Are there significant relationships between EF performance and the BRIEF for the SEN group, as measured by self- and teacher ratings?
3. What is the better predictor of BRIEF ratings by SEN students and by teachers: EF performance or teacher ratings of the SDQ?

7.2 Method

SEN group participants were those described in the previous chapter who had provided BRIEF self-ratings. Completed BRIEF questionnaires were obtained from teachers for 109 SEN students. Teachers completed The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997b, Goodman, 2001) for 73 (53%) of Non-SEN and 103 (79%) of SEN students.

The SDQ is a clinical tool for assessing the mental health of children aged 3-16 years and is made up of four sub-scales based on medical diagnoses from the DSM-IV and ICD-10 classification schemes (Hobbs, Little, & Kaoukji, 2007). These indicate emotional symptoms, conduct problems, inattention-hyperactivity and peer problems and combine to give a broad overall measure of mental health, together with a pro-social sub-scale (Goodman, 2001). Only teachers completed the SDQ as the SENCOs expressed concerns that parents and students would find some of the questions distressing or offensive, for example; *I am often accused of lying or cheating* (self) or *Often fights with other children or bullies them* (parent). As a clinical diagnostic inventory, the SENCOs did not feel it would be appropriate for general distribution on the grounds it could compromise sensitive relationships with some of the more vulnerable families who were reluctant to engage with the schools on pastoral or welfare issues. Teachers completed questionnaires for Non-SEN students on a goodwill basis in acknowledgement of the demands on their limited time. Cronbach's alpha on the SDQ showed moderate reliability for the Non-SEN group (.546) and good for the SEN group (.759).

The results for first question relating to differences between the Non-SEN and SEN groups from teacher ratings of the SDQ are reported first.

7.3 Results

7.3.1 Research Question 1

Were there differences in teacher ratings on the SDQ for Non-SEN and SEN students?

A two-group (Non-SEN, SEN) x 6 measures (emotional symptoms, conduct problems, hyperactivity score, peer problems, prosocial scale and total difficulties) one-way analysis of variance (ANOVA) on teacher ratings of the SDQ returned significant differences between groups for all scales apart from the pro-social scale. The pro-social scale measures consideration towards others, readiness to share, helpfulness if another is upset or hurt, kindness to others and willingness to volunteer to help others. Table 7.1 below presents the statistically significant variable findings (prosocial scale excluded as non-significant).

Table 7.1 Group Differences for the SDQ Teacher Rated Scales

Teacher Ratings for SDQ	Non-SEN Means (*SD*) *n* = 73	SEN Means (*SD*) *n* = 103	*$F_{(5)}$	η^2
Emotional Symptoms	0.29 *(.79)*	1.67 *(2.15)*	27.030*	.134
Conduct Problems	0.22 *(.89)*	1.39 *(2.18)*	18.784*	.097
Hyperactivity Score	1.29 *(2.02)*	3.56 *(3.09)*	30.133*	.148
Peer Problems	0.55 (*1.18)*	1.78 *(2.16)*	19.555*	.101
Total Difficulties	2.34 *(3.41)*	8.34 *(7.36)*	42.163*	.195

Expected mean 11-15year olds based on the manual: total score 6.3, emotional symptoms 1.3, conduct problems 0.9, hyperactivity 2.6, peer problems 1.4.

Pearson's bivariate correlations between the SDQ scales and the BRIEF for the Non-SEN group and for the SEN group showed fewer significant associations for the Non-SEN group, with moderate to strong links (where, according to Laerd Statistics: https://statistics.laerd.com/statistical-guides/pearson-correlation-coefficient-statistical-guide.php medium strength of association is indicated by *r* between .3 to .5 and large from .5 to 1.0) between: 'emotional symptoms' and 'peer problems' (*r* = 0.53** two-tailed); 'hyperactivity' with 'conduct problems' (*r* = 0.69** two-tailed). In contrast, two-tailed significant correlations were found for the SEN group between all scales apart from the prosocial scale. Thus, correlation with 'emotional symptoms' was found for: 'conduct problems' (*r* = .32**), 'hyperactivity' (*r* = .40**) and 'peer problems' (*r* = .60**). In addition, 'conduct problems' agreed with 'hyperactivity' (*r* = .64**) and with 'peer problems' (*r* = .32**).

As the Non-SEN group was not included in the remaining research questions which included the BRIEF, Pearson correlations were examined for levels of agreement between the teacher BRIEF ratings for the Non-SEN group and teacher rated SDQ for these students (the lower sample size made regression analysis questionable). Significant though moderate to weak correlations (two-tailed) were found for BRIEF sub-scales as follows: BRIEF 'inhibit' with SDQ 'conduct problems' (*r* = .34**) and SDQ 'hyperactivity' (*r* =.30*); BRIEF 'shift' with SDQ 'conduct problems' (*r* =.24*) and SDQ 'hyperactivity' (*r* =.32**); and BRIEF 'working memory' with SDQ 'conduct problems' (*r* =.26*), SDQ 'hyperactivity' (*r* = .26*) and SDQ 'peer problems' (*r* = .36**).

Table 7.2 Correlations for Teacher Ratings on the SDQ and BRIEF for Non-SEN and SEN Groups

NON-SEN (*n* = 73 both measures)	1 Emotional	2 Conduct	3 Hyper	4 Peer	5 Prosocial
Emotional Symptoms	1				
Conduct Problems	.107	1			
Hyperactivity Score	.121	.685**	1		
Peer Problems	.529**	.189	.084	1	
[a]Prosocial Score	-.217	-.435**	-.617**	-.487**	1
BRIEF Inhibit	.108	.548**	.718**	-.070	-.497**
BRIEF Shift	.566**	.242*	.520**	.346**	-.553**
BRIEF Working Memory	.216	.287*	.714**	-.002	-.500**

SEN (*n* = 103 SDQ, 109 BRIEF)	1 Emotional	2 Conduct	3 Hyper	4 Peer	5 Prosocial
Emotional Symptoms	1				
Conduct Problems	.319**	1			
Hyperactivity Score	.391**	.641**	1		
Peer Problems	.592**	.315**	.439**	1	
[a]Prosocial Score	-.089	-.546**	-.535**	-.374**	1
BRIEF Inhibit	.213*	.745**	.749**	.299**	-.494**
BRIEF Shift	.648**	.484**	.523**	.439**	-.270**
BRIEF Working Memory	.417**	.406**	.725**	.368**	-.267**

*Significant at $p < .05$ two-tailed
**Significant at $p < .01$ two-tailed
[a]High Prosocial score means better skills

7.3.2 Data Preparation for Research Questions 2 and 3

To answer Research Questions 2 (Were there significant relationships between EF performance and the BRIEF?) and 3 (What was the better predictor of BRIEF ratings: EF performance or teacher SDQ ratings?) hierarchical multiple regressions were conducted on two separate data sets; the first set included the SEN BRIEF self-ratings and the second set included the Teacher BRIEF ratings for the SEN group.

In each of these regressions one of the BRIEF sub-scales was the dependent variable (e.g., SEN self-rating of ‘inhibit’). The regression analyses involved three steps. At Step 1, a verbal and non-verbal EF performance measure was entered which matched the BRIEF dependent variable (e.g., verbal and non-verbal inhibition were entered at Step 1 in relation to BRIEF ‘inhibit’). This allowed assessment of the correspondence between the most directly related dimensions on the performance assessments and the same scale of the BRIEF.

At Step 2 the remaining EF performance assessments were entered. In these analyses, inhibition, switching and EWM were included as well as a composite measure of verbal fluency (average score for accuracy in the phonemic and semantic category variables). Non-verbal fluency was omitted to restrict the number of variables in the analyses. Step 2 of the analysis was designed to detect whether there were further relationships between the performance measures and the BRIEF. At Step 3 the Teacher SDQ ratings were entered (‘hyperactivity’, ‘conduct problems’, ‘peer problems’ and ‘emotional symptoms’). Prosocial behaviour was not included again to restrict the number of variables and because teacher ratings of prosocial behaviour did not discriminate between groups. Step 3 of the analysis enabled the significant predictors of the dependent variable (i.e., BRIEF behavioural rating) to be identified from all the EF performance measures and the SDQ subscales, and in this way address research question 3. Separate regression analyses were carried out using ‘inhibit’, ‘shift’ and ‘working memory’ from the BRIEF as the dependent variables. Six regression analyses were conducted, three for the SEN student self-ratings of the BRIEF and three for the teacher ratings of the BRIEF.

Key statistical checks (Durbin-Watson, tolerance/VIF statistics, Cook’s/Mahalanobis distances, standardized DFbetas, plots of standardized residuals/predicted standardized values, standardized residuals, partial plots) suggested the absence of multicollinearity and cases with undue influence. Raw scores were converted to z-scores so that all measures had a mean of zero. Correlations for the SEN Self-Rated BRIEF and the EF performance and SDQ variables are presented in Table 7.3 below. The same information for the Teacher Rated BRIEF on the SEN group is presented in Table 7.4.

Table 7.3 Pearson's Correlation Coefficients for EF Performance, SDQ and BRIEF for the SEN Group (Self Ratings)

	***n* = 131 EF Performance, *n* =103 SDQ, *n* = 131 BRIEF SEN GROUP Self-Ratings**																
	VARIABLES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	**Verbal Inhibition**	1															
2	**Non-Verbal Inhibition**	.054	1														
3	**Verbal Switching**	.139	.116	1													
4	**Non-Verbal Switching**	.041	.073	-.144	1												
5	**Verbal EWM**	.013	**-.231****	-.099	-.149	1											
6	**Non-Verbal EWM**	-.150	**-.292****	-.068	**-.192***	**.289****	1										
7	**Verbal Fluency**	.158	**-.192***	**.310****	**-.138**	**.309****	**.168***	1									
8	**SDQ Emotional Symptoms**	.017	**.282****	-.015	.092	-.130	-.122	-.049	1								
9	**SDQ Conduct Problems**	.041	.010	-.111	.025	.145	-.067	.016	**.319****	1							
10	**SDQ Hyperactivity**	.048	.126	-.100	.067	-.059	**.-194***	-.045	**.391****	**.641*****	1						
11	**SDQ Peer Problems**	,-.011	**.285****	-.058	.085	**-.300****	**-.208***	**-.218***	**.592*****	**.315****	**.439*****	1					
12	**BRIEF SR Inhibit**	.086	-.011	.069	.008	.028	.046	.073	.114	**.230***	**.240****	.116	1				
13	**BRIEF SR Shift**	.004	.142	**.231***	.007	-.072	**-.178***	.048	.158	-.012	.112	.039	**.625****	1			
14	**BRIEF SR Working Memory**	.029	.003	.084	-.067	-.122	-.042	-.003	**.238****	.067	.088	.120	**.566****	**618****	1		
15	**BRIEF Teacher Inhibit**	.083	.105	-.126	.074	.107	-.114	.077	**.213***	**.745*****	**.749*****	**.745*****	**.357****	**.481****	.013	**1**	
16	**BRIEF Teacher Shift**	.069	**.157***	-.040	.061	-.002	-.133	.093	**.648*****	**.484*****	**.523*****	**.439*****	**.201***	**.211****	.187	**.481****	**1**
17	**BRIEF Teacher Working Memory**	.118	**.250****	-.049	.115	-.090	**-.245****	-.009	**.417*****	**.406*****	**.725*****	**.368*****	.181	.175	.116	**.564****	**.618****

***Significant at $p < .001$ one-tailed **Significant at $p < .01$ one-tailed, *Significant at $p < .05$ one-tailed

Table 7.4 Pearson's Correlation Coefficients for EF Performance, SDQ and BRIEF for the SEN Group (Teacher Ratings)

	***n* = 131 EF Performance, *n* =103 SDQ, *n* = 109 BRIEF (Teacher Rated) SEN GROUP**																
	VARIABLES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	**Verbal Inhibition**	1															
2	**Non-Verbal Inhibition**	.054	1														
3	**Verbal Switching**	.139	.116	1													
4	**Non-Verbal Switching**	.041	.073	.144	1												
5	**Verbal EWM**	.013	**-.231****	-.099	-.149	1											
6	**Non-Verbal EWM**	-.150	**-.292****	-.068	-.192	.289	1										
7	**Verbal Fluency**	.158	**-.192***	**.310****	**-.138***	.309	.168	1									
8	**SDQ Emotional Symptoms**	.017	**.282****	-.015	.092	-.130	-.122	-.049	1								
9	**SDQ Conduct Problems**	.041	.010	-.111	.025	.145	-.067	.016	**.319****	1							
10	**SDQ Hyperactivity**	.048	.126	-.100	.067	-.059	-.194	-.045	**.391****	**.641*****	1						
11	**SDQ Peer Problems**	-.011	**.285****	-.058	.085	**-.300****	-.208	-.218	**.592*****	**.315****	**.439*****	1					
12	**BRIEF SR Inhibit**	-.002	-.045	.069	.008	.028	.019	.073	.114	**.230***	**.240****	.116	1				
13	**BRIEF SR Shift**	.004	.142	**.223***	.007	-.072	-.129	.048	.158	-.012	.112	.039	**.625****	1			
14	**BRIEF SR Working Memory**	.029	.003	.084	-.067	-.122	-.068	-.003	**.238****	.067	.088	.120	**.566****	**618****	1		
15	**BRIEF Teacher Inhibit**	.145	.117	-.128	.074	.057	-.114	-.126	.016	.077	**.213***	**.745*****	**.357****	**.481****	.013	**1**	
16	**BRIEF Teacher Shift**	.117	.157	-.043	.098	-.002	-.133	.093	**.648*****	**.484*****	**.523*****	**.439*****	**.201***	**.211****	.187	**.481****	**1**
17	**BRIEF Teacher Working Memory**	.118	**.263****	-.057	.124	-.108	**-.245****	-.009	**.417*****	**.406*****	**.725*****	**.368*****	.181	.175	.116	**.564****	**.618****

***Significant at $p < .001$ one-tailed **Significant at $p < .01$ one-tailed, *Significant at $p < .05$ one-tailed

7.3.3 Research Question 2

Are there significant relationships between EF performance and the BRIEF for the SEN group, as measured by self- and teacher ratings?

7.3.3.1 BRIEF: SEN Self-Ratings

For SEN self-ratings, statistically significant associations between corresponding performance measures and the BRIEF were limited to EF switching performance with BRIEF 'shift' (see Table 7.2). Standardized coefficients for Step 1 showed only the contribution of verbal switching to be significant (standardized BETA $\beta = .250$, $t = 2.562$, $p < 0.05$), but the level of agreement was low ($r = .231$). There was therefore limited support for the assumption of commonality between performance and behaviour ratings of the same EF construct where SEN self-ratings were concerned. The influence of verbal switching was retained when the remaining EF performance variables were added at Step 2 ($\beta = .264$, $t = 2.448$, $p < 0.05$) and it was the only variable to show agreement with the BRIEF at Step 2. Higher verbal switching cost was therefore associated with higher instances of behavioural inflexibility.

7.3.3.2 BRIEF Teacher Ratings for the SEN Group

Again, correspondence between EF performance and the BRIEF was limited to one construct, in this instance 'working memory' (see Table 7.3). Significance was confined to non-verbal working memory ($\beta = -.239$, $t = -2.363$, $p < 0.05$), but the level of agreement was relatively low ($r = -.245$). This negative relationship suggests that better scores in working memory performance are associated with fewer instances of maladaptive working memory behaviours. Non-verbal working memory was no longer a significant predictor at Step 2 with the addition of the remaining performance EF measures, but non-verbal inhibition was a significant predictor ($\beta = .222$, $t = 2.151$, $p < 0.05$). This suggests that greater error scores in EF non-verbal inhibition performance were associated with greater instances of teacher judgements of maladaptive 'working memory' behaviours. As with

SEN self-ratings there was limited support for the assumption of commonality with few, relatively low associations between EF performance and the BRIEF.

7.3.4 Research Question 3

What is the better predictor of the BRIEF for SEN self- and teacher ratings: EF performance or teacher ratings of the SDQ?

The third research question addresses the issue of whether specific measures of executive function or the SDQ ratings of behavioural disruption and impairment (McAuley et al., 2010) were the better predictor of the BRIEF. This question is addressed in Step 3 of the regression analyses. The tables which are presented include the regression coefficient statistics for each separate BRIEF dependent variable in research question 3 are Tables 7.5, 7.6, 7.7 (SEN Self-Ratings) and Tables 7.8, 7.9 and 7.10 (Teacher Ratings for the SEN group.

Table 7.5 Regression Coefficients and Model Changes for BRIEF 'Inhibit' (SEN Self-Ratings)

BRIEF SEN Self-Ratings *n* = 103							
DEPENDENT VARIABLE BRIEF INHIBIT		**Model 1**		**Model 2**		**Model 3**	
STEP AND MEASURE	**PREDICTOR VARIABLES**	***β***	***t***	***β***	***t***	***β***	***t***
1 EF Performance Corresponding Component	Verbal Inhibition	-.002	.000				
	Non-Verbal Inhibition	-.045	-.451				
2 EF Performance Measures	Verbal Inhibition			-.018	-.176		
	Non-Verbal Inhibition			-.042	-.386		
	Verbal Switching			.120	1.070		
	Non-Verbal Switching			-.079	-.743		
	Verbal EWM			.073	.646		
	Non-Verbal EWM			-.024	-.212		
	Verbal Fluency			.001	.010		
3 SDQ	Verbal Inhibition					-.026	-.258
	Non-Verbal Inhibition					-.081	-.733
	Verbal Switching					.169	1.517
	Non-Verbal Switching					-.097	-.936
	Verbal EWM					.072	.617
	Non-Verbal EWM					.022	.202
	Verbal Fluency					-.010	-.088
	Emotional Symptoms					.023	.183
	Conduct Problems					.101	.746
	Hyperactivity Score					.186	1.338
	Peer Problems					.054	.393
R^2 Change in Step 1 = .002; Step 2 = .022; Step 3 = .085; Total R^2 accounted for by the model = .109							

Table 7.6 Regression Coefficients and Model Changes for BRIEF 'Shift' (SEN Self-Ratings)

BRIEF SEN Self-Ratings *n* = 103							
DEPENDENT VARIABLE BRIEF SHIFT		**Model 1**		**Model 2**		**Model 3**	
STEP AND MEASURE	**PREDICTOR VARIABLES**	***β***	***t***	***β***	***t***	***β***	***t***
1 EF Performance Corresponding Component	Verbal Inhibition	**.250**	**2.562***				
	Non-Verbal Inhibition	-.132	-1.352				
2 EF Performance Measures	Verbal Inhibition			**.264**	**2.448***		
	Non-Verbal Inhibition			-.157	-1.550		
	Verbal Switching			-.114	-1.141		
	Non-Verbal Switching			.053	.503		
	Verbal EWM			.056	.519		
	Non-Verbal EWM			-.156	-1.456		
	Verbal Fluency			-.018	-.160		
3 SDQ	Verbal Inhibition					**.283**	**2.620****
	Non-Verbal Inhibition					-.174	-1.720
	Verbal Switching					-.116	-1.161
	Non-Verbal Switching					.005	.046
	Verbal EWM					.076	.667
	Non-Verbal EWM					-.143	-1.328
	Verbal Fluency					-.047	-.409
	Emotional Symptoms					.205	1.645
	Conduct Problems					-.145	-1.104
	Hyperactivity Score					.192	1.419
	Peer Problems					-.110	-.829

R^2 Change in Step 1 = .070; Step 2 = .036; Step 3 = .049; Total R^2 accounted for by the model = .054

Table 7.7 Regression Coefficients and Model Changes for BRIEF 'Working Memory' (SEN Self-Ratings)

BRIEF SEN Self-Ratings n = 103							
DEPENDENT VARIABLE BRIEF WORKING MEMORY		**Model 1**		**Model 2**		**Model 3**	
STEP AND MEASURE	**PREDICTOR VARIABLES**	***β***	***t***	***β***	***t***	***β***	***t***
1 EF Performance Corresponding Component	Verbal Inhibition	-.114	-1.102				
	Non-Verbal Inhibition	-.035	-.342				
2 EF Performance Measures	Verbal Inhibition			-.112	-1.002		
	Non-Verbal Inhibition			-.058	-.525		
	Verbal Switching			-.075	-.723		
	Non-Verbal Switching			.015	.141		
	Verbal EWM			.101	.902		
	Non-Verbal EWM			-.108	-1.027		
	Verbal Fluency			.010	.084		
3 SDQ	Verbal Inhibition					-.111	-.953
	Non-Verbal Inhibition					-.054	-.482
	Verbal Switching					-.076	-.741
	Non-Verbal Switching					-.047	-.421
	Verbal EWM					.123	1.105
	Non-Verbal EWM					-.129	-1.239
	Verbal Fluency					-.015	-.131
	Emotional Symptoms					**.275**	**2.138***
	Conduct Problems					.032	.238
	Hyperactivity Score					.004	.030
	Peer Problems					-.072	-.526
R^2 Change in Step 1 = .017; Step 2 = .023; Step 3 = .059; Total R^2 accounted for by the model = .099							

Table 7.8 Regression Coefficients and Model Changes for BRIEF ‘Inhibit’ (Teacher Ratings)

BRIEF Teacher Ratings for SEN ***n*** **= 103**							
DEPENDENT VARIABLE BRIEF INHIBIT		**Model 1**		**Model 2**		**Model 3**	
STEP AND MEASURE	**PREDICTOR VARIABLES**	***β***	***t***	***β***	***t***	***β***	***t***
1 EF Performance Corresponding Component	Verbal Inhibition	.077	.101				
	Non-Verbal Inhibition	.779	1.018				
				.057	.561		
2 EF Performance Measures	Verbal Inhibition			.140	1.323		
	Non-Verbal Inhibition			.117	1.073		
	Verbal Switching			-.129	-1.188		
	Non-Verbal Switching			-.200	-1.833		
	Verbal EWM			.046	.446		
	Non-Verbal EWM			.148	1.285		
	Verbal Fluency						
3 SDQ	Verbal Inhibition					. 028	.495
	Non-Verbal Inhibition					.115	1.850
	Verbal Switching					.044	.675
	Non-Verbal Switching					.000	.000
	Verbal EWM					-.079	-1.269
	Non-Verbal EWM					.009	.157
	Verbal Fluency					.123	1.866
	Emotional Symptoms					-.173	**-2.413***
	Conduct Problems					.451	**5.966*****
	Hyperactivity Score					.492	**6.301*****
	Peer Problems					.045	.594

R^2 Change in Step 1 = .017; Step 2 = .067; Step 3 = .636; Total R^2 accounted for by the model = .686

Table 7.9 Regression Coefficients and Model Changes for BRIEF 'Shift' (Teacher Ratings)

BRIEF Teacher Ratings for SEN *n* = 103							
DEPENDENT VARIABLE BRIEF SHIFT		**Model 1**		**Model 2**		**Model 3**	
STEP AND MEASURE	**PREDICTOR VARIABLES**	***β***	***t***	***β***	***t***	***β***	***t***
1 EF Performance Corresponding Component	Verbal Inhibition	-.049	-.490				
	Non-Verbal Inhibition	.068	.677				
2 EF Performance Measures	Verbal Inhibition			-.137	-1.253		
	Non-Verbal Inhibition			.076	.739		
	Verbal Switching			.028	.279		
	Non-Verbal Switching			.189	1.780		
	Verbal EWM			.040	.366		
	Non-Verbal EWM			-.111	-1.022		
	Verbal Fluency			.184	1.594		
3 SDQ	Verbal Inhibition					-.038	-.481
	Non-Verbal Inhibition					.017	.229
	Verbal Switching					.019	.258
	Non-Verbal Switching					.020	.251
	Verbal EWM					.061	.735
	Non-Verbal EWM					-.047	-.602
	Verbal Fluency					.135	1.623
	Emotional Symptoms					**.498**	**5.467*** **
	Conduct Problems					.168	1.757
	Hyperactivity Score					**.197**	**1.994***
	Peer Problems					.034	.346

R^2 Change in Step 1 = .006; Step 2 = .071; Step 3 = .473; Total R^2 accounted for by the model = .495

Table 7.10 Regression Coefficients and Model Changes for BRIEF 'Working Memory' (Teacher Ratings)

BRIEF Teacher Ratings for SEN *n* = 103							
DEPENDENT VARIABLE BRIEF WORKING MEMORY		**Model 1**		**Model 2**		**Model 3**	
STEP AND MEASURE	**PREDICTOR VARIABLES**	***β***	***t***	***β***	***t***	***β***	***t***
1 EF Performance Corresponding Component	Verbal Inhibition	-.020	-.200				
	Non-Verbal Inhibition	**-.239**	**-2.363***				
2 EF Performance Measures	Verbal Inhibition			-.027	-.249		
	Non-Verbal Inhibition			-.171	-1.620		
	Verbal Switching			.086	.865		
	Non-Verbal Switching			**.222**	**2.151***		
	Verbal EWM			-.151	-1.418		
	Non-Verbal EWM			.096	.960		
	Verbal Fluency			.117	1.044		
3 SDQ	Verbal Inhibition					.004	.045
	Non-Verbal Inhibition					-.063	-.836
	Verbal Switching					.069	.982
	Non-Verbal Switching					.123	1.623
	Verbal EWM					-.044	-.585
	Non-Verbal EWM					.051	.721
	Verbal Fluency					.067	.835
	Emotional Symptoms					.148	1.697
	Conduct Problems					-.103	-1.122
	Hyperactivity Score					**.715**	**7.530*****
	Peer Problems					-.039	-.421

R^2 Change in Step 1 = .060; Step 2 = .064; Step 3 = .536; Total R^2 accounted for by the model = .586

7.3.4.1 Regression Analyses Predicting the BRIEF from SEN Self-Ratings: Comparison of SDQ and Performance EF

For the SEN group's self-ratings, the pattern found for Step 3 was similar to those of Steps 1 and 2 (research question 2), with verbal switching cost the only variable predicting the BRIEF self-rating of 'shift' (see Tables 7.5-7). The standardized Beta coefficient for this relationship was .28, indicating that agreement between verbal and behavioural flexibility was moderate ($\beta = 0.28$, $t = 2.62$, $p < 0.05$). No SDQ variables were significant predictors of BRIEF 'shift' for SEN self-ratings. For BRIEF 'working memory', however, there was a significant relationship between teacher SDQ 'emotional symptoms' and BRIEF 'working memory' (see Table 7.7), albeit with a relatively low standardized Beta coefficient and moderate level of significance ($\beta = 0.27$, $t = 2.14$

$p < 0.05$).

7.3.4.2 Regression Analyses Predicting Teacher EF Ratings from the BRIEF: Comparison of SDQ and Performance EF

In contrast to the SEN self-ratings, a number of the Teacher rated SDQ variables were significant predictors for the Teacher rated BRIEF (Tables 7.8-10). The three variables that were significant predictors were 'emotional symptoms', 'conduct problems' and 'hyperactivity'. All three of these variables from the SDQ predicted the teacher ratings of 'inhibit' with the standardized Beta coefficients being particularly high for 'conduct problems' ($\beta = 0.45$, $t = 5.97$, $p < 0.001$) and 'hyperactivity' ($\beta = 0.49$, $t = 6.30$, $p < 0.001$). The negative coefficient for 'emotional symptoms' ($\beta = -0.17$, $t = -2.41$, $p < 0.001$) indicates that SDQ ratings for 'emotional symptoms' were related to lower BRIEF ratings of difficulties with behavioural inhibition. The valance of the correlation between these variables was positive ($r = .213$, $p < .05$) indicating that higher 'emotional symptoms' were related to poorer behavioural inhibition. This is supported by the positive relationship between SDQ 'emotional symptoms' and EF non-verbal inhibition performance (which was negatively scored). Looking at the relations between SDQ 'emotional symptoms' and EF non-verbal inhibition performance, however, there was a positive relationship at a greater level of significance ($r = .274$, $p < .01$). This association between 'emotional symptoms' and non-verbal inhibition is more nuanced as it indicates a link more specifically with motor inhibition.

SDQ 'emotional symptoms' were significantly related to BRIEF 'shift' with a high Beta coefficient ($\beta = 0.49$, $t = 5.47$, $p < 0.001$). Although 'hyperactivity' also was significantly related to BRIEF 'shift' the coefficient was low ($\beta = 0.19$, $t = 1.99$, $p = 0.049$). Higher scores in 'emotional symptoms' and 'hyperactivity' were therefore predictive of teacher ratings of 'shift' which involves greater difficulties with flexible behaviours. In addition, in the case of BRIEF 'working memory', teacher SDQ ratings of ‘hyperactivity’ were strongly predictive with high Beta coefficient and statistical significance ($\beta = 0.71$, $t = 7.53$, $p < 0.001$).

7.3.5 The Predictive Contributions of EF Performance and the SDQ

To understand the extent to which each *form* of measurement, EF performance or the SDQ, contributed to predicting the BRIEF, the ANOVA statistics for the regression models relating to the SEN self- and teacher ratings were examined.

The Step 2 (EF performance) and Step 3 (SDQ) ANOVA statistics for the SEN BRIEF *self-ratings* were all non-significant (‘inhibit’; $F_{11,102} = 1.01$, ‘shift’; $F_{11,102} = 1.53$ and ‘working memory;’ $F_{11,102} = .91$), indicating that neither the EF performance nor the SDQ models had overall predictive influence. Instances of agreement were due to the contribution of individual variables.

In contrast, the final Step 3 regression models for *all teacher* rated BRIEF constructs were strongly significant (‘inhibit’; $F_{11,102} = 21.29$, ‘shift’; $F_{11,102} = 10.10$ and ‘working memory’; 11.70 respectively, all $p < 0.001$). While the SDQ was therefore a significant predictor of teacher BRIEF ratings, in contrast none of the EF performance models were predictive of any of the BRIEF construct ratings by teachers at Step 3. Therefore, teacher ratings of SEN students’ behavioural difficulties as measured by the SDQ and the BRIEF showed more agreement than either SEN students’ EF performance and BRIEF self-ratings or their EF performance and BRIEF teacher ratings.

7.4 Discussion

The findings relevant to each of the research questions are discussed in sequence and then there is a consideration of explanations for the poor relations between performance EF and the BRIEF, and close relations between teacher SDQ ratings and their BRIEF ratings.

7.4.1 Differences between SEN and Non-SEN groups in Teacher SDQ ratings

As outlined in the introduction to this chapter, previous studies have reported that the early secondary school years are potentially stressful for students who experience difficulties meeting expectations of increased independence and self-regulated flexibility (Morgan et al., 2000, Meltzer, 2007). The first research question addressed in this chapter concerned differences between the SEN and Non-SEN groups in behaviours indicative of conduct dysregulation as measured by the SDQ. As expected, differences were found in teachers ratings using the SDQ between the SEN and Non-SEN groups. These findings extend previous research which has shown higher SDQ scores in children and young people with disabilities (Happé et al., 2006, Adams et al., 1999, 2001) to the broader population of younger adolescents with SEN.

7.4.2 Relations between SDQ scales with the BRIEF

For the SEN group, all correlations were significant between BRIEF and SDQ scales. The highest correlations were between BRIEF 'inhibit' and two SDQ scales; 'conduct problems' and 'hyperactivity'. The BRIEF authors (Gioia et al., 2002a) consider that 'working memory' and 'inhibit' scales have the greatest overlap with diagnostic criteria for inattentive and hyperactive–impulsive types of ADHD, respectively. The widespread significant correlations in both groups support McKinney (2012) in that students with poorer EF were more likely to show disruptive behaviours compared to those with better EF (McKinney and Morse, 2012). It should be noted, however, that the teachers made both the SDQ and the BRIEF ratings so there is a possibility of both halo and negative-halo effects (Abikoff et al., 1993, Adams et al., 1999).

7.4.3 The Relations between EF Performance and the BRIEF

The third research question concerned correspondence between EF performance measures and the BRIEF, and whether patterns of agreement between EF measures differed between SEN self-ratings and teachers' reports. The analyses revealed that the correspondence between EF performance and the BRIEF for the *same* construct was limited to one variable for each of the self- and teacher ratings. Verbal switching cost scores for the SEN group had a significant association with the student self-evaluations of ‘shift’ (problems with behavioural flexibility), whilst performance on the non-verbal EWM tasks were significantly related to the teacher BRIEF ‘working memory’ ratings. Thus, there was limited support for the expectation that EF performance and the BRIEF tapped the same underlying construct, as predicted by the commonality assumption.

There were very few further significant associations between EF performance and the BRIEF identified in Step 2 of the analyses, and those identified were of moderate strength and significance with different patterns for the self-ratings and teacher reports. Verbal switching continued to be a significant predictor at Step 2 in relation to SEN ratings of ‘shift’. However, non-verbal inhibition rather than ‘working memory’ became a significant predictor of teacher ratings of ‘working memory’. The latter finding suggests that EWM and ‘inhibit’ shared variance with ‘inhibit’ being a more important predictor of general working memory behaviours as assessed by the BRIEF.

This set of findings are consistent with previous studies investigating agreement between EF performance and the BRIEF measures of ‘inhibit’, ‘shift’ and ‘working memory’ (Mahone et al., 2002a, Anderson et al., 2002, Toplak et al., 2008, Alloway et al., 2009b). As like-for-like associations were limited to single constructs which differed between self- and teacher versions of the BRIEF, the commonality assumption was not supported.

7.4.4 Predictors of the BRIEF: Comparing Performance Measures of EF and the SDQ

The predictive influence of EF performance measures, as indicated by the ANOVA summaries in the regression analyses, was limited to verbal switching for SEN ratings of BRIEF ‘shift’. In contrast, all component models for the addition of SDQ teacher ratings were significant. This indicates that, where teacher ratings of the BRIEF were concerned, the SDQ was a better predictive tool.

Several scales of the SDQ and EF performance measures significantly predicted the BRIEF ratings, but different patterns were found for SEN self-ratings and teacher ratings. For the SEN group self-ratings, the only two significant predictors at Step 3 were EF performance in verbal switching in predicting BRIEF 'shift' and SDQ 'emotional symptoms' predicted BRIEF 'working memory'. In contrast, for the Teacher BRIEF ratings, three SDQ variables were significant predictors across the three analyses. These were: 'emotional symptoms', 'conduct disorder' and 'hyperactivity' as predictors of BRIEF 'inhibit'; 'emotional symptoms' and 'hyperactivity' as predictors of BRIEF 'shift' and 'hyperactivity' as a predictor of BRIEF 'working memory'. Thus, the SDQ scales were better predictors than the performance EF scores of the BRIEF teacher ratings.

7.4.5 Explanations of the Relationships between Performance EF, SDQ and BRIEF

In this section several explanations for the findings related to research questions 1 and 3 will be considered. First it may be useful to summarise the main features of the relevant findings. The correlations between the teaching ratings of the SDQ and of the BRIEF revealed that most were significant for the Non-SEN group and all were significant for the SEN group. The regression analyses revealed that there were few significant relationships between the performance measures of EF and the BRIEF ratings of the SEN group or of the teachers. The regression analyses also revealed that there were few significant relationships between the teacher SDQ ratings and the SEN self-ratings from the BRIEF. In contrast, there were a number of significant relationships between teacher ratings of 'emotional symptoms', 'conduct disorder' and 'hyperactivity' in relation to teachers' BRIEF ratings. Thus, the main features of these findings were a lack of relationships between EF performance and the BRIEF, contrasted by significant relationships between the teacher ratings of the SDQ and the BRIEF.

There are a number of possible explanations for the lack of correspondence between the performance measures and the BRIEF. One of these concerns error of measurement in the performance EF tasks. These include task impurity (Anderson, 2002; Jurado & Rosselli, 2007), artificiality and lack of ecological validity (Rabbitt, 1996, Gioia et al., 2002b, Anderson, 2002). Consequently, although the BRIEF identified behaviours consistent with impairment in EF, it may be tapping different constructs within the executive function domain to those assessed in performance tasks (Anderson et al., 2002).

Referring back to the review of 20 studies investigating links between EF performance and the BRIEF (Toplak et al., 2013), the authors proposed that the two forms of EF measure are capturing different levels of cognition. These underlying constructs are the ‘efficiency of cognitive abilities’ by performance tasks and ‘success in goal pursuit’ by the BRIEF. Applying this theory to the current findings suggests that although the SEN group performed worse than the Non-SEN group in the EF performance tasks (Chapter 4), the structured, supported framework of the relatively short tasks may have had a facilitating effect on skills at a cognitive level which did not marry with individuals’ successful goal pursuit in unstructured contextual situations as assessed by the BRIEF (see Chapter 6).

Alternatively, lack of self-awareness may be an issue for the SEN group and this age-group in general as self-regulatory skills are still developing (Rueda et al., 2005, Karbach et al., 2014). Thus, individuals may have difficulty estimating instances of behavioural difficulties precisely or even lack awareness that a particular behaviour is problematic (Barkley, 1996b). However, this cannot be a complete explanation for the lack of EF performance-BRIEF relationships as these also occurred with teacher ratings of the BRIEF.

Another explanation for the lack of correspondence between performance EF and the BRIEF and the significant relationships between the teachers’ SDQ and BRIEF ratings has been identified by McAuley (2010), who investigated links between the BRIEF Behavioural Regulation/Emotional Regulation indices (which includes the sub-scales ‘inhibit’ and ‘shift’) and the Metacognition Index (which includes ‘working memory’) with cognitive, behavioural and academic measures in sixty boys (6-15 years) diagnosed with attention deficit. They found the BRIEF indices were strongly related to teacher (and parent) ratings of behavioural disruption and impairment but neither was associated with scores on the performance-based tasks of EF. The researchers concluded that it was unclear whether the BRIEF is more closely related to general measures of behavioural disruption and impairment or to specific measures of executive function (McAuley et al., 2010). The lack of EF performance predictors of the BRIEF (verbal switching for SEN self-ratings excepted) is consistent with this explanation. Furthermore, if the BRIEF reflects problematic behaviours in general, this may be an explanation of a lack of significant relationships between performance EF and the BRIEF, at least for teacher ratings.

Concerns regarding conduct issues and emotional problems which were identified by Happé (Happé et al., 2006) in parent and teacher ratings of adolescents with ADHD or ASD were also found in the teacher SDQ ratings. Links between the SDQ ratings for ‘emotional symptoms’ and the BRIEF ‘shift’ ratings suggest that inflexibility has specific implications for younger adolescents with SEN regarding their adaptation to the demands of secondary school life. Furthermore, the concern SEN students themselves showed in their ratings of ‘shift’ was mirrored in teacher ratings, possibly indicating ways in which intransigence might reflect both the capacity to cope as a learner and the impact on the learning environment (Sonuga-Barke, 2005, Meltzer, 2007). The link between teacher ratings of SDQ ‘hyperactivity’ and their ratings of BRIEF ‘shift’ also suggest a behaviour management issue whereby students’ inability to focus may have a negative influence on teacher ratings on the BRIEF and SDQ. Previous research has found disruptive behaviours to be influenced by negative halo effects in teacher ratings where conduct has disciplinary implications. Thus, Abikoff and colleagues (1993) showed that teachers classified problematic behaviours associated with ADHD, hyperactivity and conduct disorder accurately but when behaviours characteristic of oppositional defiance were included in assessments of ADHD or hyperactivity, ratings were more severe (Abikoff et al., 1993). Given that the strongest relationships between the BRIEF and SDQ were for teacher ratings of 'hyperactivity', 'conduct problems' and 'emotional symptoms', this explanation needs serious consideration.

7.5 Conclusion

Comparisons of the teacher SDQ ratings of SEN and Non-SEN groups revealed significantly higher levels of problematic behaviours in the SEN group. Significant correlations were found between the SDQ subscales and the BRIEF ratings by both the SEN students and by the teachers, indicating that the two scales were related. In contrast, few significant relationships were found between the performance EF tasks and the BRIEF which was consistent with previous research (Toplak et al., 2012). These findings were extended by regression analyses that revealed few significant relations between EF performance or SDQ variables and the SEN self-ratings from the BRIEF, but a number of significant relations between the Teacher ratings from the BRIEF. Various explanations for these findings have been considered.

CHAPTER 8

Predicting SEN Status

8 Introduction

In previous chapters, differences between the SEN and non-SEN groups have been described. The findings suggest there were significant differences between the groups although also a degree of overlap. In this chapter the aim is to investigate relationships between variables. Part of these analyses aim to identify components of EF that independently predict SEN status (i.e., whether or not a student is identified as having SEN), and are therefore indicative of less effective skills which may be characteristic of the SEN population. Targeting these EFs in support interventions could thereby benefit students across the SEN spectrum. The analysis will also ascertain whether standardized tests of reading, specifically decoding (TOWRE), receptive vocabulary (BPVS) and non-verbal reasoning (RPM) or EF measures are more effective in predicting EF status. Henceforth, the standardized tests will be abbreviated to RVR to indicate ‘reading’, ‘vocabulary’ and non-verbal ‘reasoning’ respectively.

A related issue is what happens to predictive influence contributed by EF to *SEN status* if EFs provide the underpinning capacity which results in reading, vocabulary and non-verbal reasoning abilities. If this is the case, then shared variance between EF and RVR could alter the nature of unique EF predictors of SEN status when RVR abilities are subsequently introduced to logistic regression analyses. The findings of this chapter could be useful for teachers who are assessing the nature of difficulties of students whose progress is cause for concern. The identification of SEN status by means of quick and easy to administer EF assessments (as are both BRIEF and performance measures and RVR assessments), could complement existing diagnostic methods.

The following sections discuss issues which have informed the approach taken in the chapter. These include: the paucity of studies investigating EF in the younger adolescent SEN population; and the message from Chapter 3, that average scores in standardized tests do not preclude the possibility of underlying processing impairments. Accordingly, the final section discusses a specific study which identifies the characteristics of a group of learners who risk being ‘under the radar’ for their underlying learning difficulties on account of adequate scores in standardized assessments. The next section explains why, in the absence of relevant findings from previous studies, tapping into teacher knowledge and student experiences is a useful starting point, an issue which relates to the use of the BRIEF as an assessment of EF.

8.1 EF, Ability and Predicting SEN Status

As far as is known, the predictors of SEN status in younger adolescents between 11 to 14 years of age have not been investigated. Extensive database searches, including Academic Search Complete and Google Academic, did not return any studies which included all three elements of RVR, EF, SEN or SEND (including physical disabilities).

The potential relevance of EF to SEN status is illustrated by research by Morgan (2000) who explored the characteristics of children aged 7 to 11 years who, despite average scores in standardized ability tests, had been referred for evaluation of school difficulties. These children’s cognitive and behavioural characteristics were examined for group differences with two other groups; typical learners and low attainers with learning impairment diagnoses. Morgan suggested neither high parent/teacher expectations alone nor IQ or reading abilities could account for the learning difficulties of the referred group. However, the referred group showed processing impairments in common with the learning impaired group in measures which tapped complex information processing (synonymous with EWM), automaticity (as in inhibitory processing) and fluency (verbal and non-verbal) fluency (Morgan et al., 2000). Thus, Morgan’s study suggests that, not only might EF components relating to EWM, inhibition and fluency tasks predict SEN status, but it describes the characteristics of a group of learners who may have underlying information processing capacity impairments, despite adequate learning ability scores in standardized tests.

Furthermore, a consistent finding in extensively researched clinical developmental disorders are varying patterns of EF deficits on performance tasks (see Chapter 1 for discussion). Some individuals in the SEN group had diagnoses of ADHD, SLI and ASD (see Chapter 3 for details), which suggests a relation between EF and SEN status might be expected. The BRIEF may also provide significant predictors of SEN status. Students' insights and teacher knowledge are key sources of information but, as found in Chapter 6, there was little agreement between student and teacher BRIEF ratings of 'inhibit', 'shift' and 'working memory'. Self-ratings identified 'shift' as the EF behavioural construct of greatest difficulty, whereas teacher ratings of 'working memory' behaviours were most concerning. This suggests that predictors of SEN status using the teacher BRIEF might differ from those using the BRIEF Self-Ratings (SR). Accordingly, two sets of logistic regressions were conducted, one using the BRIEF Self-Ratings (SR) and one using the Teacher BRIEF. This also had the advantage of maximising the variable to participant ratio in the analyses.

The BRIEF SR is an important source of information as it measures students' recognition and evaluation of the extent of any maladaptive EF behaviours they experience in school. So, predictors of SEN status from the dataset using BRIEF self-ratings is likely to be influenced by the subjective accuracy or otherwise of students' self-awareness (see Chapter 6). In contrast, the teacher ratings will be expected to have higher reliability and validity because of the reliance of the educational system upon teachers' perceptions of learning behaviour in scoring profiles of attainment. Where BRIEF teacher ratings are concerned, 'working memory' has been found to be of particular concern (Gathercole et al., 2008), and thereby potentially indicative of SEN status. This pattern for more severe ratings of 'working memory' has been found in a range of studies (Toplak et al., 2008, Dajani et al., 2016, Gerst et al., 2017) and suggests that teachers recognise a range of EF maladaptive behaviours related to 'working memory' as barriers to learning (see Chapter 6). So, although teacher BRIEF ratings for 'working memory' are expected to predict SEN status, the contribution of 'shift' and 'inhibit' is less clear.

It is also less clear how RVR will relate to SEN status due to the broad range of individual scores reported in Chapter 3. Cognitive research has presented insights into ways in which EF and general reasoning ability ('G') as represented by the RVR assessments, interact as part of an efficient processing system. Two distinct aspects of general reasoning ability (G) described by Engle and colleagues (1999) are fluid (G*f*) and crystallized (G*c*). G*f* refers to the ability to solve novel problems and adapt to new situations and is thought to be non-verbal and relatively culture free. This suggests that EF might be the mechanism which underpins fluid ability. In contrast, crystallized intelligence, G*c* refers to acquired skills and learned knowledge and depends on educational and cultural background. Tests that measure G*f* include Ravens Progressive Matrices (RPM), as used in this study, while G*c* includes measures of vocabulary and acquired general knowledge (Engle et al., 1999; p. 5). It should be noted that cognitive research defines G in relation to 'intelligence' as a broader concept, whereas the abilities studied in this thesis are educationally contextualized.

A study by Kyllonen and Christal (1990) found strong correlations (.80 to .90) between factors indicative of working memory and reasoning. Consequently, Engle et al argued that working memory capacity (WMC) may be the psychological mechanism responsible for G*f*. They also considered controlled attention to be the primary influence contributing to the relationship between measures of working memory and G*f* (Engle et al., 1999). Subsequently, a latent variable analysis by Conway and colleagues' (2002) found complex span tasks to predict G. A core aspect of complex span tasks (such as the listening recall task used in this study to assess EWM) is the recruitment of an executive attention-control mechanism to combat interference during concurrent storage and processing (Conway et al., 2002). As noted in the theoretical overview in Chapter 1 Part 2 (sections 1.2.2 and 1.2.3.1 and 1.2.3.2), this is consistent with the views of EF which propose that inhibitory processes have a key role in suppressing unwanted information, thereby supporting efficient processing within the limited capacity EWM. As complex span tasks also include verbal or spatial processing, they appear to encapsulate relations between cognitive ability (G), working memory capacity (WMC) and inhibition (Conway et al., 2003). Conway et al., (2003) subsequently reviewed research investigating working memory and its relation to general intelligence (G) and estimated that WMC accounts for one-third to one-half of the variance in G (Conway et al., 2003). Thus, robust associations may be expected between working memory and RVR abilities. It is not clear how inhibition might predict RVR as theory and evidence from neuroscience suggest that the brain regions which process inhibitory demands are separate to those which mediate complex information, as processed by EWM and switching (Duncan, 2010, Hampshire et al., 2010).

8.1.1 EF Predictors of SEN Status in the Presence of RVR Abilities

As explained in the previous section, the BPVS and RPM standardized assessments relate to two forms of intelligence: acquired knowledge (crystallized intelligence G*c*) and the ability to solve unfamiliar problems (fluid intelligence G*f*) (Brydges et al., 2012). As to whether EFs might *retain* predictive influence on SEN status if RVR measures are included in the logistic regression analyses, two studies offer insights. Both studies modelled predictive relations between the core EF components of inhibition, updating/EWM and shift/switch with fluid *(*G*f)* and crystallized intelligence (G*c)*. In the first study, Friedman (Friedman et al., 2006) used structural equation modelling and a sample of young adults to investigate the predictive relations of these three EFs with the BPVS (G*c* or crystallized intelligence) and RPM (G*f* or fluid intelligence). Initial confirmatory factor analysis of three EF latent variables and the two factors representing G*f* and G*c* respectively, found G*f* and G*c* significantly correlated (.62 $p < .001$). Inhibition and shifting correlated with G*c* (both at .31 $p < .05$) and updating with G*f* and G*c* (.64 and .68 $p < .05$ respectively). However, when correlations between EFs were controlled, structural equation models revealed that updating still predicted *Gf* (.74 $p < .05$) and G*c* (.79 $p < .05$), but the contributions of inhibition and shifting were non-significant. Also, the SEM model showed a reduction in the correlation between G*f* and G*c* (.17 $p < .05$), indicating that the EF components, particularly updating, accounted for a significant portion of the original Confirmatory Factor Analysis (CFA) correlation. These findings indicated the importance that working memory capacity, particularly updating ability, exerts on both G*f* and G*c* (Friedman et al., 2006).

Further indicators of the influence of working memory capacity as a predictor of IQ (measured by the Ravens Advanced Progressive Matrices – RAPM) was found in a structure equation model (SEM) using pairs of non-verbal (digit and figure) EF measures of updating, inhibition and shifting by Duan et al., (2010). Using a relatively small sample of 61 Chinese children aged 11 and 12 years, the study found the path coefficient between updating and intelligence to be significant, sharing about 35% of the variances, ($p < .01$), as was inhibition and intelligence, although shared variance was much less, at about 19%. When the correlations among EF measures were controlled, however, only the correlation between updating and intelligence remained significant. There were limitations to the Duan et al., (2010) study as only non-verbal measures were used and because the RAPM is not normed for Chinese samples, raw, not standardized, scores were used (Duan et al., 2010). It has, however, been suggested that working memory capacity may be analogous to fluid intelligence where recall accuracy is concerned (Unsworth, 2009, Unsworth et al., 2014, Redick et al., 2016). If this is the case, then it might be expected that EWM variance may be partially accounted for by RVR abilities.

Brydges (2012) replicated the Friedman study with a sample of children aged 7 to 9 years and, in contrast to Friedman, found no differentiation between the EF components (model of best fit therefore being unitary EF, as found in Chapter 5 for the SEN group). Brydges' results showed EF to account for nearly all the association between the two intelligences (Brydges et al., 2012). This suggests that EF performance measures found to predict SEN status prior to the addition of RVR abilities may not retain influence once competition from the RVR abilities is introduced in a regression. Especially if the RVR scores are used in the identification of SEN, reading abilities being the most likely candidate for this, given that these can readily be informally identified by teachers and the importance of literacy to the education process.

Alloway's (Alloway, 2009) study examined the predictive power of working memory and IQ in children identified with 'moderate learning difficulties' (MLD). Working memory capacity, assessed using the Listening Recall measure (as used in this thesis for the verbal EWM task) and domain-specific knowledge (reading and maths) at ages 7-11, but *not IQ*, were significant predictors of learning two years later (9-13 years). The relevance of Alloway's findings for this chapter is that the students selected for Alloway's study were made on the basis of learning issues in school, not clinical diagnosis, as with the SEN group in this thesis.

To summarise, Friedman's study findings found updating (EWM) was the only EF to contribute uniquely to the BPVS and RPM, with the interpretation being that not all EFs are related to 'intelligence' in young adults. Alloway also found relations between working memory and later attainment in children with MLD, but IQ was not a predictor. In older children, however, Brydges found broader contributions from EF to abilities. This suggests that there will be shared variance between EWM and these abilities which might absorb the contribution of EWM as a predictor of SEN. In fact, Diamond (2013) concluded from a review of the literature that G*f* can be regarded as being completely synonymous to *complex* executive abilities of reasoning and problem-solving (Diamond, 2013).

8.1.2 EF as Predictors of RVR

The following sections examine studies which have found links between each of the learning abilities and EF processes. These are useful insights about whether shared variance is likely to diminish EF predictive influence on SEN status. The first RVR assessment considered is the TOWRE, followed by the BPVS and finally the RPM.

8.1.3.1 TOWRE

Literacy is fundamental to achievement and this section considers information from studies investigating the characteristics of young learners who are poor readers (Altemeier et al., 2006, Booth and Boyle, 2009, Booth et al., 2014). Although significant associations between EF and reading/spelling skills have been reported (Walda et al., 2014, for example), it cannot be assumed that depressed scores in a verbal EF task alone is sufficient to account for literacy difficulties. For example, Booth and Boyle (2014) examined reading skills in children (mean age 10 years 6 months) with a range of reading abilities typically found in mainstream classrooms. They found reading ability was significantly predicted by the children's inhibitory skills on a non-verbal task. Booth's results were important in suggesting the role of inhibition in predicting reading skills in relation to children with no obvious reading difficulties as well as the counterintuitive nature of the non-verbal influence (Booth and Boyle, 2009). These findings suggest non-verbal inhibition is likely to share variance with the TOWRE.

Other studies have reported different predictive patterns, however. Thus, Christopher and colleagues (2012) investigated both working memory and inhibition as predictors of decoding using the TOWRE. They found working memory was a significant predictor after full-scale IQ was controlled for, but not inhibition. A more recent study by Messer and colleagues (Messer et al., 2016a) investigated the predictive capacity of EF on decoding in typical young learners and a group with language impairments. They found that, prior to accounting for verbal age (as opposed to chronological age), verbal tasks in working memory, fluency, inhibition (and planning) predicted decoding. However, following the introduction of variables measuring non-executive processing speed and verbal age equivalence (to adjust to the normative age for the task scores), working memory (EWM) was no longer a significant predictor.

The studies above suggest that EF performance measures of verbal EWM, verbal fluency and inhibition might share variance with the TOWRE and other assessments of literacy. The next section considers receptive vocabulary (BPVS).

8.1.3.2 BPVS

Academic database searches with interchangeable application of the terms ‘vocabulary’, ‘BPVS’, ‘EF’, ‘executive function’, ‘learning ability’, ‘working memory’, ‘inhibition’, ‘fluency’ and ‘switching’ did not return any directly relevant studies while those identified tended to concern relations of EF with either a specific clinical population or attainment scores in academic domains, such as English and mathematics.

Even so, relations between vocabulary and a number of relevant abilities have been reported. Tombaugh et al., (1999) found associations between verbal semantic fluency and vocabulary in a normative study stratified by age and education (r = .52, p <.001). Correlations at the <.05 level were reported between inhibition and vocabulary in a study by Georgiou (Georgiou and Das, 2018) which investigated direct and indirect effects of executive function on reading comprehension in young adults. It might be expected, therefore, that predictive contributions to SEN status by verbal fluency and inhibition may be shared with the BPVS.

8.1.3.3 Non-Verbal Reasoning (RPM)

The processing demands of the RPM suggest a broader range of EFs might share variance with non-verbal reasoning but there is uncertainty as the task is *visual* and more content free than standardized IQ tests. It is nonetheless likely that EF predictors of the RPM may include verbal as well as non-verbal tasks.

Fry and Hale (2000) and others have hypothesized that those individuals who obtain higher scores on the RPM are those individuals who are best able to develop, maintain, and manage problem-solving goals in working memory (Fry and Hale, 2000, Redick et al., 2012, Unsworth et al., 2014). These processing demands are consistent with Engle's assertion that working memory capacity (as in EWM) may be the psychological mechanism responsible for reasoning ability*, mediated by controlled attention which includes the inhibition of dominant responses* (Engle et al., 1999). The importance of language in problem solving has also been indicated in a study by Robinson and colleagues who reported a correlation between semantic verbal fluency and the RPM at a high level of statistical significance ($r = .61$ $p < .001$) (Robinson et al., 2012). Consequently, EWM, inhibition and verbal fluency may share variance with the RPM.

Where switching is concerned, previous studies have found links between switching and RVR to be non-significant (Henry et al., 2012, Kirke-Smith et al., 2014), although the task specific demands of the RPM suggest that cognitive flexibility (switching) may be involved. In contrast, a latent variable analysis by van der Sluis (van der Sluis et al., 2007) found separate shifting (i.e. switching) and updating (EWM) factors to be related to non-verbal reasoning. In fact, sustained attention switching has been shown to be related to reading and writing achievement in at-risk writers (Altemeier et al., 2006). The developmental trajectory of switching in the EF structural organisation of younger adolescents, however, suggests switching may not be independent of EWM (Davidson et al., 2006). To summarise, the complex processing demands of the RPM are likely to relate to a range of EF processes, including fluency, inhibition and EWM. The role of switching appears less clear.

8.1.4 Summary and Research Questions

Previous studies suggest a range of EFs may predict SEN status, including inhibition, EWM and fluency, together with BRIEF 'working memory'. It is not clear if EF predictors of SEN status will retain independent influence after the inclusion of RVR although research suggests patterns of shared variance between EF performance measures and RVR are likely to diminish the extent and possibly nature of EF predictors of SEN status. The research questions were as follows.

Research Question 1: To what extent can SEN status be predicted by tests and ratings of EF and RVR?

Research Question 2: Do the EF variables continue to predict SEN status when the RVR abilities are included in the analysis?

8.2 Results

Two separate sets of binary logistic analyses were conducted to identify predictors of SEN status. The first set contained the combined BRIEF self-ratings of the Non-SEN and SEN groups. Age was included as a predictor in the first block of the logistic regression analyses in order to account for increased knowledge in older students in the age range of 11 to 14 years. The second set consisted of the Teacher BRIEF ratings for the combined Non-SEN and SEN groups. Two analyses were conducted to maximise the participant to variable ration.

8.2.1 Regression using BRIEF Self-Ratings

The dependent variable was 'Group' (Non-SEN = 137, SEN = 131). Four blocks of information were entered using raw scores for consistency as standardized scores were not available for some EF performance variables.

Block 1: Chronological Age (months) to adjust for age differences

Block 2: Self-Rating BRIEF, including:

- Inhibit, Cognitive Shift (C), Behavioural Shift (B), Working Memory (Raw scores for BRIEF 'Shift' give separate scores for cognitive and behavioural flexibility)

Block 3: Verbal and Non-Verbal EF Performance measures of:

- Inhibition, Switching Cost, EWM and Fluency

Block 4: RVR:

- TOWRE, BPVS, RPM

The entry sequence for the variables reflects the twofold focus of the analyses, i.e., the contribution of EF variables to predicting SEN status and interest in how RVR variables influence predictions. The omnibus tests of model coefficients for these regressions (which indicate whether a current model is significantly better at explaining data variance than the previous model) showed significant gains ($p < 0.0001$). Tables 8.1 and 8.2 below show variable correlations and model changes for the BRIEF SR regression followed by presentation of the results. This structure is then repeated for the Teacher BRIEF regression.

Table 8.1 Correlations between Age, RVR and EF (BRIEF Self Ratings for Non-SEN and SEN groups)

	***n*= 268**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	**Age**	1														
2	**BPVS**	.314**	1													
3	**TOWRE**	.287**	.502**	1												
4	**RPM**	.189**	.573**	.483**	1											
5	**Verbal Inhibition**	-.122*	-.081	-.100	.010	1										
6	**N-V Inhibition**	-.160**	-.368**	-.378**	-.461**	.127*	1									
7	**Verbal Switching**	.024	-.021	.033	-.082	.120*	.141*	1								
8	**N-V Switching**	-.135*	-.153*	-.195**	-.162**	.060	.167**	.073	1							
9	**Verbal Fluency**	.186**	.476**	.559**	.449**	-.030	-.284**	.237**	-.194**	1						
10	**N-V Fluency**	.241**	.247**	.353**	.296**	.103	-.246**	.007	.147*	.400**	1					
11	**Verbal EWM**	.077	.365**	.391**	.447**	-.058	-.330**	-.077	-.190**	.439**	.322**	1				
12	**N-V EWM**	.125*	.371**	.331**	.500**	-.162**	-.394**	-.089	-.205**	.371**	.198**	.434**	1			
13	**BRIEF SR Inhibit**	.106	-.061	-.121*	-.157*	.090	.055	.093	.025	-.093	-.022	-.087	-.088	1		
14	**BRIEF SR Shift Behaviour**	-.059	-.219**	-.274**	-.325**	.106	.173**	.226**	.111	-.158**	-.111*	-.115*	-.189**	.518**	1	
15	**BRIEF SR Shift Cognitive**	-.011	-.282**	-.256**	-.326**	-.001	.216**	.103*	.050	-.277***	-.227**	-.169**	-.255**	.525**	.528**	1
16	**BRIEF SR WM**	.047	-.166*	-.224**	-.238**	.047	.115	.055	.022	-.170***	-.170**	-.184**	-.171**	.641**	.569**	.528**

* = *p* < .05, ** = *p* < .01 two-tailed

Table 8.2 Model Changes for Binary Logistic Regression: BRIEF Self-Rating

MODEL and MEASURE	VARIABLES	BRIEF SR Model 1		Model 2		Model 3		Model 4	
		B	***Odds ratio***	***B***	***Odds ratio***	***B***	***Odds ratio***	***B***	***Odds ratio***
1 AGE	Age in Months	**-.040**	**.961*****	**-.049**	**.952*****	-.033	.968	-.014	.986
2 BRIEF SR	Inhibit			-.006	.994	.026	1.026	.036	1.037
	Shift B			**.352**	**1.422*****	**.468**	**1.597*****	**.417**	**1.518****
	Shift C			**.177**	**1.193***	.034	1.034	.072	1.074
	Working Memory			.038	1.039	-.014	.986	-.035	.966
3 EF Performance	Verbal Inhibition					**.085**	**1.089***	.070	1.072
	Non-verbal inhibition					**.136**	**1.146***	.021	1.022
	Verbal switching					.014	1.014	.016	1.016
	Non-verbal switching					.020	1.020	.013	1.013
	Verbal EWM					-.158	.854	-.127	.881
	Non-verbal EWM					-.104	.902	-.057	.945
	Verbal fluency					**-.172**	**.842*****	-.081	.922
	Non-verbal fluency					-.105	.900	-.053	.949
4 RVR	BPVS							-.009	.991
	TOWRE							**-.066**	**.936*****
	RPM							-.073	.929
-2 Log likelihood		358.58		296.23		203.22		153.72	
		$\chi2 = 12.81$, df = 1, $p < 0.0001$		$\chi2 = 75.17$, df = 5, $p < 0.0001$		$\chi2 = 168.17$, df = 13, $p < 0.0001$		$\chi2 = 217.68$, df = 16, $p < 0.0001$	
Nagelkerke R Square		6%		33%		62%		74%	
Hosmer and Lemeshow Test		$p = 0.38$		$p = 0.51$		$p = 0.27$		$p = 0.47$	
Classification accuracy		55%		74%		83%		88%	

*$p < .05$, ** $p < .01$, *** $p < .001$

The results for each of the BRIEF SR models are presented below. The probability of a variable predicting SEN status is defined by the OR. If the OR is greater than 1, then SEN status (A) and the predictor variable (B) are associated in the sense that, compared to the absence of B, the *presence* of B raises the odds of A. Conversely, if the OR is less than 1, then A and B are negatively related and the presence of one event reduces the odds of the other event. To be clear about the direction of effect of the results, the likelihood of being in the SEN group is represented by an odds ratio above 1, a negative *B* lowers the odds of being in the SEN group, as shown in the effect of *increase* in Age (similar to a negative association). *Better performance* (higher scores) in the following variables *lowers* the odds of being in the SEN group (odds ratio below 1): BPVS, TOWRE, RPM, EF performance in Fluency and EWM. In contrast, *poorer performance*, which is indicated by *high scores* which *increase* the odds of being in the SEN group include: inhibition, switching cost, BRIEF variables.

Model 1

'Age', entered as the first Block, was statistically significant (*OR* .96**) but was not a good predictor of SEN status, only accounting for 6% of variance (Nagelkerke R Square) with 55% classification accuracy. According to Holmes (2010), acceptable levels of classification range between 70% and 90%.

Model 2

Adding the BRIEF SR in Block 2 improved the model considerably. There were significant contributions from 'Age' (*OR* .58**) and 'BRIEF' Shift (Behaviour: *OR* 1.42***; Cognitive: *OR* 1.19*), explaining 33% of variance with 74% classification accuracy.

Model 3

As 'EF performance' variables were introduced into the regression analysis, 'Age' became a non-significant predictor. In contrast, 'BRIEF' Shift Behaviour maintained a high level of significance with a minimal change in odds ratio (*OR* 1.60***), suggesting an important predictive role for this EF behaviour. Three 'EF performance' variables were also significant predictors, including; Verbal Fluency (*OR* .84***) and Inhibition (Verbal: *OR* 1.09*; Non-Verbal: *OR* 1.15*). The 'EF performance' variables improved model statistics further, accounting for 62% of variance and accuracy of 83%.

Model 4

As the RVR variables were added, the EF performance variables predictors of the previous entry (verbal and non-verbal inhibition, verbal fluency) did not retain their independent influences. The final predictors of SEN status were: BRIEF Shift B (*OR*: 1.52**, *CI* 1.16/1.98) where higher scores increased the odds of being in the SEN group and TOWRE (*OR*: .94***, *CI* .96/1.03) where higher scores lowered the odds of being in the SEN group. This final model (Chi-Square = 217.68, $df = 16$, $p < 0.0001$) correctly predicted 90% of Non-SEN and 86% of SEN cases (overall accuracy 88%) with 74% of variance explained. The analyses were repeated for the Teacher BRIEF and tables 8.3 and 8.4, presented below, show correlations and model changes for the Teacher BRIEF logistic regression, followed by model results.

Table 8.3 Correlations between Age, RVR and EF (Teacher BRIEF for Non-SEN and SEN groups combined)

	n = 182	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Age**	1													
2	**BPVS**	.314**	1												
3	**TOWRE**	.287**	.502**	1											
4	**RPM**	.189**	.573**	.483**	1										
5	**Verbal Inhibition**	-.122*	-.081	-.100	.010	1									
6	**N-V Inhibition**	-.160**	-.368**	-.378**	-.461**	.127*	1								
7	**Verbal Switch**	.024	-.021	.033	-.082	.120*	.141*	1							
8	**N-V Switch**	-.135*	-.153*	-.195**	-.162**	.060	.167**	.073	1						
9	**Verbal Fluency**	.077	.365**	.391**	.447**	-.058	-.330**	-.077	-.190**	1					
10	**N-V Fluency**	.125*	.371**	.331**	.500**	-.162**	.394**	-.089	-.205**	.434**	1				
11	**Verbal EWM**	.186**	.476**	.559**	.449**	-.030	-.284**	.237**	-.194**	.439**	371**	1			
12	**N-V EWM**	.241**	.247**	.353**	.296**	.103	-.246**	.007	.147*	.322**	.198**	.400**	1		
13	**BRIEF Inhibit**	-.197**	-.297**	-.229**	-.372**	.203**	.174*	-.047	.143	-.076	-.194**	-.055	.079	1	
14	**BRIEF Shift**	-.018	-.249**	-.244**	-.380**	.178*	.268**	-.007	.166*	-.151*	-.217**	-.124	-.038	.601**	1
15	**BRIEF WM**	-.244**	-.407**	-.422**	-.468*	.235**	.339**	-.066	.247**	-.275**	-.324**	-.271**	-.102	.708**	.721**

* = $p < .05$, ** = $p < .01$ two-tailed

Table 8.4 Model Changes for Binary Logistic Regression: TEACHER BRIEF

		TEACHER BRIEF							
BLOCK and MEASURE	**VARIABLES**	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
		B	***Odds ratio***	***B***	***Odds ratio***	***B***	***Odds ratio***	***B***	***Odds ratio***
1 AGE	Age in Months	**-.082**	**.921*****	**-.088**	**.915*****	**-.085**	**.918****	-.058	.944
2 BRIEF Teacher	Inhibit			-.019	.981	.122	1.130	.141	1.152
	Shift			**.179**	**1.196***	.151	1.163	**.259**	**1.296***
	Working Memory			**.114**	**1.121***	-.007	.993	-.110	.896
3 EF Performance	Verbal Inhibition					-.003	.997	-.061	.941
	Non-verbal inhibition					**.188**	**1.207***	.137	1.147
	Verbal switching					.011	1.011	.010	1.010
	Non-verbal switching					**.042**	**1.043***	.030	1.030
	Verbal EWM					-.231	.794	-.075	.927
	Non-verbal EWM					-.091	.913	-.067	.935
	Verbal fluency					**-.129**	**.879****	-.043	.958
	Non-verbal fluency					**-.159**	**.853***	-.058	.944
4 RVR	BPVS							-.006	.994
	TOWRE							**-.077**	**.926*****
	RPM							-.056	.945
-2 Log likelihood		214.13 $\chi2 = 31.00$, df = 1, $p < 0.0001$		171.19 $\chi2 = 73.93$, df = 4, $p < 0.0001$		126.43 $\chi2 = 118.71$, df = 12, $p < 0.0001$		96.49 $\chi2 = 148.65$, df = 15, $p < 0.0001$	
Nagelkerke R Square		21%		45%		65%		75%	
Hosmer and Lemeshow Test		$p < 0.01$		$p < 0.01$		$p = 0.86$		$p = 0.83$	
Classification accuracy		67%		71%		82%		90%	

*$p < .05$, ** $p < .01$, *** $p < .001$

8.2.2 Regression using Teacher BRIEF

In this analysis there were 73 participants identified as non-SEN and 109 identified as having SEN. The omnibus tests of model coefficients were again significant for each block ($p < 0.0001$). The relevant correlations and statistics are in tables 8.3 and 8.4 above. As for the SEN self-rated BRIEF regression, the odds ratio or probability of a variable predicting SEN group membership, is explained through the example of 'Age'. Thus, an increase in Age (indicated by negative *B*) lowers the odds of being in the SEN group. Similarly, *better performance* (higher scores) *lowers* the odds of being in the SEN group and the odds ratio is therefore *below 1* for the following measures: BPVS, TOWRE, RPM, EF performance in Fluency and EWM. In contrast, *poorer performance*, which is indicated by *high scores increase the odds* of being in the SEN group. These measures include; inhibition, switching cost, BRIEF variables.

Model 1

The introduction of 'Age' in Block 1 produced an odds ratio of .921***, but the initial model statistics had a low level of predictive power (21%) and poor classification accuracy of 67%.

Model 2

After adding the Teacher 'BRIEF' variables at Block 2, 'Age' continued to be a significant predictor (*OR* .915***). Significant contributions came from two Teacher 'BRIEF' variables; 'shift' (*OR* 1.196*) and 'working memory' (*OR* 1.121*). As the Teacher 'BRIEF' does not distinguish between cognitive and behavioural aspects of 'shift', the lower level of significance for the combined construct suggests this to be less important from teachers' perspective. Block 2 explained variance increased to 45% and classification accuracy to 71%.

Model 3

The addition of 'EF performance' variables resulted in the Teacher 'BRIEF' predictors having reduced significance. Despite this, predictive power for Model 3 increased to 65% with an acceptable level of accuracy (82%). Significant 'EF performance' contributions included Fluency (Verbal: *OR*: .88**; Non-Verbal: *OR*: .85*), Non-Verbal Inhibition (*OR*: .1.21*) and Non-Verbal Switching (*OR*: 1.04*).

Model 4

At Block 4 the 'RVR' variables were added. As with the BRIEF SR analyses, the final model for Teacher BRIEF showed just two predictors of SEN status: the TOWRE (*OR*: .93***, *CI* .89, .96), where lower scores indicated poorer ability, and 'shift' (*OR*: 1.30*, *CI* 1.03/1.63) where greater levels of difficulty, indicated by high scores increase the odds of being in the SEN group. The two regressions were also similar in the final model goodness-of-fit statistics ('BRIEF' SR: Chi-Square = 217.68, $df = 16$, $p < 0.0001$, 'Teacher' BRIEF: Chi-Square = 148.65, $df = 15$, $p < 0.0001$), suggesting both models to be relatively stable. The Teacher 'BRIEF' correctly predicted 86% of Non-SEN and 92% of SEN classification (overall accuracy 90%) with 75% of variability explained (details in Table 8.4 above).

The next section examines the implications for the unique predictors of SEN status in Model 3 when the RVR measures are added in Model 4. The first section looks at model changes for the BRIEF SR regressions, followed by the Teacher BRIEF.

8.2.3 Research Question 2: Do the EF variables continue to predict SEN status when the RVR abilities are included in the analysis?

8.2.3.1 Changes from Model 3 EF predictors with addition of RVR abilities in Model 4: BRIEF SR

BRIEF 'shift' showed very little change in model statistics from Model 3 to Model 4 when the RVR variables were introduced (see Table 8.2), retaining a strong predictive influence on SEN status, in contrast with the EF performance predictors. Specifically, Model 3 shows that EF performance in verbal and non-verbal inhibition and in verbal fluency significantly predicted SEN status. Verbal fluency in Model 3 had a high level of statistical significance (p < 001). There was a reduction from Model 3 to Model 4 in *B* values for verbal fluency (-.172 to -.081), and in those for verbal and non-verbal inhibition (.085* to .070; .136* to .021 respectively) and all these predictors became non-significant. This suggests shared variance with one or more of the RVR variables, and the TOWRE as a significant predictor in model 4, might have contributed to the EF measures' reduced significance in predicting SEN status.

The next section examines changes in Models 3 and 4 for the Teacher BRIEF regression.

8.2.3.2 Changes from Model 3 EF predictors with addition of RVR abilities in Model 4: Teacher BRIEF

Model 3 shows that EF performance in non-verbal inhibition, non-verbal switching and in verbal and non-verbal fluency were significant predictors of SEN status, but these significant relations were no longer present in Model 4 following competition from the RVR abilities (see Table 8.3). The most noticeable changes in *B* values were for verbal and non-verbal fluency (-.129** to -.043 and -.159** to -.058 respectively). In contrast, the reduction in *B* values for verbal inhibition and non-verbal switching (.188* to .137 and .042* to .030 respectively) was minimal. These patterns of change appear to suggest that fluency shared more variance with RVR than non-verbal inhibition and non-verbal switching.

8.2.3.3 Summary of Logistic Regressions

There were similarities between the BRIEF SR and Teacher analyses; namely the same two predictors of SEN status were found in Model 4; TOWRE and BRIEF 'shift' (behavioural flexibility). Also, EF performance predictors in Model 3 lost significance when competition from the RVRs was introduce in Model 4. Finer grained examination of the model changes suggests that not all EF performance measures share variance with RVR to the same extent.

8.3 Discussion

The research question addressed the issue of identifying EF and RVR predictors of SEN status which could have practical value as supplementary measures for diagnosing learning impairment. A subsidiary issue was whether EF predictors retained independent influence on SEN status after the contribution of RVRs. These two issues are addressed in the following sections.

8.3.1 What were the Predictors of SEN Status at Step 4 with all variables included?

The results showed only two significant predictors of SEN status at Step 4, the ‘shift’ rating from the BRIEF and the TOWRE. The strongest predictor was BRIEF ‘shift,’ concerning EF behaviours regarding changes to activity, routine and environment. This is consistent with Checa and colleagues’ view that individual differences in self-regulatory systems in younger adolescents are central to understanding processes of learning and social adjustment (Checa et al., 2008). The second predictor was the TOWRE, a measure of decoding and therefore expected to influence SEN status as a marker of literacy competence, reflecting teachers’ knowledge of age-related expectations.

BRIEF ‘shift’, as a subjective measure of behaviour, was an unexpected predictor, and explanations for this finding are now considered. The transition to secondary school at Key Stage 3 (11 to 14 years) presents considerable adaptive challenges for all learners. Expectations of independent learning, larger peer groups, different teaching styles with varying classroom rules and novel environments, such as laboratories, may be disorienting without an appropriate capacity for self-reflective, focused attention and flexibility (Zelazo and Muller, 2002, Bernstein and Waber, 2007, Denckla, 2007, Meltzer, 2007). The BRIEF ‘shift’ construct relates to these issues as it contains items about getting upset by a change in plans/teacher/activity/routines and getting used to new situations/classes/groups/friends. These difficulties are likely to influence students' perceptions of their ability to 'fit' in the demanding context of secondary academic and social dynamics. As behavioural inflexibility is potentially disruptive to classroom learning, these could impact teacher judgements accordingly (Lupton et al., 2010). Such social vulnerability is consistent with previous studies investigating EF behaviours in young people with SLI (Hughes et al., 2009, Durkin and Conti-Ramsden, 2010, Cuperus et al., 2014, Pauls and Archibald, 2016). Furthermore, as reported in Chapter 6, the findings about student self-ratings indicated self-awareness of their difficulties with behavioural flexibility; an issue which was also identified by the teacher ratings. As the capacity for self-regulation and reflection is still developing in younger adolescents (Anderson et al., 2001, Davidson et al., 2006), difficulties with behaviours indicative of 'shift' in the post-primary context may become apparent in students with no previously identified learning needs (Meltzer, 2010) as well as individuals with diagnoses (Rueda et al., 2005, Rueda et al., 2010).

The above results concern the final model (4) predictors of SEN status whereas the next section discusses the EF performance predictors of SEN status in model 3. Since teachers already have information regarding students' reading attainment levels, model 3 is very informative as it offers new information to further inform teachers' approaches to intervention and/or differentiation.

8.3.2 Which EF Performance Measures Predict SEN Status at Step 3 (before the addition of RVR)?

At Step 3, SEN status was significantly predicted by EF measures of verbal fluency in the BRIEF SR and teacher regression analyses; verbal and non-verbal inhibition only in the BRIEF SR analysis; and non-verbal inhibition and non-verbal switching only in the BRIEF teacher analysis.

Verbal fluency was expected to contribute to SEN status as the sub-components of the verbal fluency task (phonemic and category fluency) have been found to relate to language ability in children with specific language impairment and in typical learners (Henry et al., 2015a). Verbal fluency is a complex processing skill as it requires the capacity to search, retrieve and generate words according to a rule (Henry et al., 2015a). The absence of EWM as a predictor was unexpected but the updating aspect of EWM is arguably a fundamental mechanism of complex processing so one explanation for the lack of predictive influence may be due to shared variance with verbal fluency.

The predictive importance of inhibition cannot be underestimated in view of previous study findings. Inhibitory skills were reported by Booth and Boyle (2009) as important for readers of all abilities (Booth and Boyle, 2009). In this respect, Henry and colleagues (Henry et al., 2015a) suggested that inhibition might be the automatic mechanism underpinning error monitoring, thereby complementary to fluency. This explanation is also consistent with Messer and colleagues (Messer et al., 2016a) who reported verbal inhibition to predict decoding ability (TOWRE) in students with a language impairment.

Non-verbal switching also predicted SEN status in the teacher BRIEF analysis. Although non-verbal switching has not been found to differentiate groups in studies of developmental disorders (e.g., SLI Henry et al., 2012), it is possible that, as a processing mechanism which *underpins* fluency (as with inhibition and ELWM in the context of complex processing and automaticity) there is shared variance contributing to important aspects of language production (Morgan et al., 2000).

8.3.3 Summary of Predictors of SEN status

The EF predictors of SEN status prior to the contribution of RVR include the components of automaticity and complex processing which Morgan (Morgan et al., 2000) claims are the basis of a common difficulty between students with no identified learning impairment and those diagnosed with learning difficulty. These Step 3 EF performance predictors contribute towards understanding why those with adequate learning abilities do not meet academic expectations, particularly if language proficiency is an attainment criterion (Botting, 2005, Wetherell et al., 2007). The complex processing and automaticity theory (Morgan et al., 2000) could potentially be the basis of an intervention programme which aims to boost EF skills as a system which supports fluency skills. A focus on fluency would target key curricular areas at Key Stage 3, namely; literacy, speech and language skills. Furthermore, a focus on complex processing and fluency could potentially support individuals across the ability spectrum where information processing difficulties are suspected. Fluent application of language in reading and writing underpin academic attainment (Altemeier et al., 2006) so, crucially, if difficulties are left unidentified, this could prevent any student from reaching their potential, particularly as more complex use of language is expected towards national examination preparation years of Key Stage 4 (Waber et al., 2003).

The important message, then, is that EF performance predictors of SEN status, prior to the contribution of RVR, appear to capture important aspects of language production which are underpinned by complex processing and automaticity.

8.4 Conclusion

There were two significant predictors of SEN status; an objective measure of literacy skills (TOWRE) and subjective self- or teacher ratings of BRIEF ‘shift’. The latter captures the capacity to behave flexibly in situations where successful adaptation requires compliance with classroom expectations, peer integration and ability to cope with varying curricular contexts. Together, these predictors span the contextual demands of daily school life in secondary education *for every student*. Two of the EF predictors of SEN status (prior to RVR inclusion), verbal fluency and inhibition, are fundamental contributors to literacy competence in reading and language, which are increasingly requisite for academic success in secondary education. Verbal fluency, underpinned by EF mechanisms which interact as a system of complex processing and automaticity, may be the source of a *common difficulty* shared by underachieving typical learners and those identified with learning difficulties.

CHAPTER 9

Discussion

9 Introduction

This chapter reviews the findings in relation to the research questions identified in Chapter 1. Subsequently, the findings from the six investigations are re-visited with assessments of how they relate to each of the research questions and related theory, previous findings and what they contribute to the literature. A summary section then examines practical issues of how the EF profile of the SEN population has relevance in terms of diagnostic assessment, applied learning skills and adaptive behaviours in the classroom environment. One of the objectives of the study was to contribute towards teacher understanding of potential underlying EF issues which might be relevant in their observations of students' learning attitude and conduct. The importance of this relates to teachers' interpretations of their observations which may mean that difficulties arising from EF impairment may be recorded on a student's record of progress and attainment tracking (PAT) as conduct related cause for concern. In this chapter, limitations of the research will be acknowledged in the relevant sections, as will ideas for future research. The thesis concludes with a final summary.

This thesis reports an investigation of the executive function (EF) characteristics of younger adolescents aged 11-14 years who had been identified as having Special Educational Needs (termed SEN at the time of data collection). SEN reflects a broad spectrum of problems, including physical or sensory difficulties, emotional and behavioural difficulties, or difficulties with speech (Alloway, 2009). SEN categories of provision address individual difficulties accessing the academic curriculum and learning environment. While individual education plans register a primary area of need, support is also tailored to include any additional issues identified within the SEN categories of provision which are contributory factors in a student's failure to thrive. Reilly described syndromes as frequently heterogeneous and complex conditions whereby capacities can vary for each cognitive skill (Reilly et al., 2014). This description can also be applied with greater force to the SEN population where the focus is on individual needs within a common framework of additional learning support at graduated levels of severity.

Part One of the Introduction in Chapter 1 described the complexity of the SEN population as representing a range of additional needs, as well as a proportion of individuals with clinical diagnoses of developmental disorders which research has shown to have overlapping patterns of EF impairment. Since EF is not routinely assessed when individuals' progress is failing to meet expected targets and cause for concern, this suggested that there were likely to be gaps in teachers' understanding of the nature of difficulties that can contribute to poor attainment and adaptation to the educational environment. Gilger and Kaplan (2001) exemplify this issue with the assertion that the boundaries between clinically defined developmental disorders and learning difficulties are not clear cut. They discuss a broad range of difficulties linked to attention problems (ADHD) which overlap with most SEN specific learning difficulty categories, including language impairment, motor problems, social skills deficits and reading disorder (which also co-occurs with dyscalculia or mathematics disorder (Leather and Henry, 1994, Willcutt et al., 2013) (Gilger and Kaplan, 2001). The implications of such complex profiles in the classroom environment is that misattributions of behaviours can occur by teachers, whereby behavioural manifestations of underlying impairment are interpreted as breaches of conduct and of a disciplinary nature. The impact of EF impairment in affecting a student's classroom and learning environment were indicated in Anderson's Four Domain Model of EF (see Chapter 1 Part 2 section 1.2.3.2), which showed how poor inhibition and self-regulation could exert a cascading effect on inter-related cognitive processes and adaptive behaviours. Clear links between EF and attainment are evidenced in previous studies and this provided the motivation to investigate the nature of EF characteristics in the SEN population in comparison with their typical learning peers with no identified additional needs. To emphasise the value of this research, the literature searches returned few studies where the SEN population, as opposed to students within sub-categories of the SEN Code of Practice, was the focus of investigation.

Thus, literature searches identified a plethora of clinically oriented studies of EF in specific developmental and learning disordered groups but there was limited reference to the SEN population and no studies focused on EF in younger adolescents identified with SEN. This made it difficult to predict the nature of EF in the multi-faceted SEN group and therefore the thesis followed a logical approach whereby each successive chapter builds on findings from the previous chapter. This chapter presents the main research questions, motivations and findings. The first set of research questions (1a to 1d) examined group differences between the main Non-SEN and SEN groups and between the SEN sub-groups.

9.1 Research Questions and Findings

9.1.1 Research Question 1

Research Question 1a

Are there differences between adolescents identified with SEN and not identified with SEN in receptive vocabulary, decoding and non-verbal reasoning?

The motivation for measuring these academic related abilities was to establish baseline information on individual and group profiles, using assessments that were independent of the protocols used by schools to identify potential SEN. This was needed because schools used different measures to identify learning issues and, because a proportion of students received additional support related to pastoral concerns, it could not be assumed that the SEN group would have poorer abilities than their Non-SEN peers. The results showed that where the main Non-SEN and SEN groups were concerned, statistically significant differences were found for all abilities but there was a degree of overlap where some individuals in both groups performed unexpectedly by having higher or lower abilities than would be expected (e.g., above standardized scores of 115 or below 85) in one or more of the standardized assessments. In other words, the range of scores for SEN students included a proportion with *above average* abilities while a small proportion of Non-SEN individuals had scores which were *below average* in one or more of the standardized assessments, yet no concerns had been identified regarding ability to learn. This suggested there was an underlying factor which *supported* learning in some students with poorer abilities but was *less effective* in some students with adequate abilities.

Despite the range of individual scores and uneven patterns across the standardized assessments, differences between the three SEN sub-groups were not statistically significant. Individual students with SEN who performed in the high typical range were, however, in the school identified support tiers (i.e., School Action, School Action +), consistent with their difficulties being less severe than those with statements. Overall, the absence of statistical difference between the SEN sub-group standardized results suggested that the schools were identifying learning issues appropriately, but it might have been expected that the students with statements would have had significantly lower scores. These findings suggest that differences between the three forms of SEN might not be as great as often supposed.

The largest gap between Non-SEN and SEN students was in the TOWRE measure of sight reading where the objective is to read as many whole words as accurately as possible from a list in 45 seconds. The SEN group mean of 84 was one standard deviation below the mean of 100 scored by the Non-SEN group. In contrast, the phonemic reading scores for the SEN group, which requires phonetic decoding, were better with a mean of 91. This test requires reading as many ‘non-words’, which conform to phonetic ‘sounding out’ rules, as possible in 45 seconds. One possible explanation for the better phonetics decoding scores is that the focus on phonetics in primary school reading programmes and in remedial support strategies may have made this decoding method a preferred choice for those SEN group students with poorer reading. Consequently, if reading skills remain unconsolidated in secondary school, then slower readers may not have *fully* made the transition to whole word decoding and habitually resort to phonetics, which may be unhelpful if exceptions to the rule remain unlearned (e.g., Ruth Miskin phonetics programme for older children). Where EF is concerned, this is useful information as unpicking words phonetically is likely to incur a higher demand on processing capacity. Similarly, SEN group scores in the RPM were greater than one standard deviation below the norm (100). This task is also likely to incur a high processing demand as it demands visuo-spatial inductive reasoning to create a rule from the limited set of available information available.

Research Question 1b

Are there differences between adolescents identified with SEN and not identified with SEN in EF as assessed by EWM, inhibition, switching and fluency?

Having established the general intellectual difference in Chapter 3, the motivation for Chapter 4 was to explore the specific nature of the EF performance profile in the two main groups and the SEN sub-groups. The results showed that on all measures; inhibition, EWM, switching and fluency, all with verbal and non-verbal measures, there were significant differences between the Non-SEN and SEN groups, with the exception of verbal switch. This latter finding was surprising in view of the poorer performances in the other EF components, but two explanations are possible. First, it could have been a reliability issue attributable to measuring ‘cost’ as a difference score rather than a directly observable process (Henry et al., 2012) and in this respect the non-significant difference is consistent with non-significant findings in previous studies (Henry et al., 2012, Leonard et al., 2015, Henry et al., 2015, Messer et al., 2016). Alternatively, the task of finding suitable exemplars from the required categories (fruit and furniture) may have been similarly difficult for both groups, masking their actual switching abilities.

Where performance across verbal and non-verbal modalities was concerned, effect sizes showed SEN students found tasks equally difficult (non-verbal inhibition excepted), implying that impaired EF may be an important cognitive characteristic of the SEN group, independent of modality. These results did not, however, establish whether poorer EF is independent of language ability. This is an important point since Messer concluded that 'concurrent language ability does not differentially affect performance on tasks selected to assess verbal and non-verbal EF' (Messer et al., 2018; p. 8). As with the standardized assessments SEN sub-group performances were not significantly different apart from non-verbal inhibition. For these analyses, two SEN groups were formed; school identified (SI) students receiving school-initiated support and an additional intervention (AI) group, which included those receiving external specialist teaching services interventions and those with statements. The additional intervention group performed worse than the entry level, school identified group.

Having investigated differences between the Non-SEN and SEN groups, the proportions of SEN students with *below average scores* were calculated for each EF task and results showed proportions ranged from 16% (verbal EWM) to 33% (non-verbal inhibition) with proportions for other tasks mostly between 25% and 30%. Measures of verbal fluency, non-verbal fluency and non-verbal inhibition showed highest proportions of below average SEN performances (verbal fluency: phonemic 24%, semantic 29%, basic design fluency: 31%, category design fluency 32% and non-verbal inhibition: 33%). These poorer EF performances add to the profile of poorer decoding and non-verbal reasoning abilities in the SEN group. Two thirds of SEN students, however, had scores within average ranges based on the sample of Non-SEN and SEN students, which raises the question of the relevance of EF to their school activities.

A cluster analysis on the whole sample extended these findings. It revealed one fifth of SEN students achieved scores similar to higher performing Non-SEN students, with better skills in the majority of EF tasks, including: verbal fluency, verbal and non-verbal inhibition, verbal and non-verbal switch and verbal and non-verbal EWM. At the other extreme, the poorest performing cluster comprised solely of SEN students who presented with generally poor EF skills. This was, however, a very small percentage of the SEN population; a mere 4.5% of the sample of the five clusters. Finer grained analyses of cluster homogeneity revealed a sub-set of Non-SEN and SEN students characterized by better non-verbal fluency, non-verbal inhibition, and phonemic fluency. The implications of impaired non-verbal inhibition and generative fluency skills are discussed in the overview section as they are repeated in different analyses.

A recurring theme revealed by cluster analysis was the overlap in performances between SEN and Non-SEN groups. Analysis of the clusters showed the extent of individual differences with a few SEN students being included with Non-SEN peers at the higher end of the spectrum of EF skills (cluster 4), but overall there was an increasing proportion of SEN students across the mid-range mixed clusters to the lowest performing cluster (9). These students (all SEN) had profiles which suggested general impairments across verbal and non-verbal modalities.

As the SEN group was so varied in the range of issues being supported, this was an opportunity to discern the extent to which those with no identified diagnosis of SEN performed poorly. One of the issues identified in Chapter 1 Part 2 was that of students who fail to thrive in the secondary environment, despite having coped adequately in primary school. Previous studies suggest that the greater demands for independence in secondary school can overwhelm students with less efficient EF capacities and these difficulties may have been dormant in the structured and sheltered primary environment (Bernstein and Waber, 2007, Meltzer, 2007). Alternatively, Johnson (2012) argued that children with stronger EF skills in early life are better able to compensate for ‘atypical’ development in other brain systems early in life, and are therefore less likely to receive a diagnosis when difficulties become apparent when greater demands are placed on untested cognitive processes, such as expectations of greater independence in learning and self-organisation in secondary education. Thus, four students in the school identified category of support (SI) had no diagnosis of additional need but were in the lowest performing score range across the majority of EF tasks and two of these students also had below average scores in all three standardized ability assessments. This suggests there is a small proportion of individuals identified by schools as vulnerable to failure in the broader school environment who have significant barriers to learning that may involve poor EF abilities.

The lack of between SEN group differences in EF indicates that the students identified as most in need of support did not necessarily have poorer EF. These findings are consistent with previous studies which suggest that differences in EF performance may not be easily discernible in mixed profile groups (Pickering and Gathercole, 2004, Jeffries and Everatt, 2004) and are consistent with the findings about RVR.

Research Question 1c

Are there differences between adolescents identified with SEN and not identified with SEN in the structural organization of EWM, inhibition and switching?

Having established both the general intellectual (Chapter 3) and EF profiles (Chapter 4) *between* the non-SEN and SEN populations, the motivation for Chapter 5 was to understand more about the relationship of EF sub-components *within* non-SEN and SEN populations. The models of EF structure were predicated on Miyake's triad of core EF components; inhibition, working memory (EWM) and switching. The results showed that for Non-SEN, a two-factor EF structure was best predicted by a model where switch/inhibition and working memory were differentiated. For SEN, two-factor EF structure was best predicted by a model where working memory/inhibition and switch were differentiated. Referring to the EF task results for non-verbal switching though, the effect size was minimal (η^2 = 0.052) which is consistent with a large degree of group overlap so the suggestion of different EF structures related to SEN and non-SEN groups should be treated with caution. The possibility that a separate switching factor is an anomaly needs to be considered as a seminal study of EF development (Davidson et al., 2006) found that cognitive flexibility (switching between rules), even with memory demands minimized, showed a longer developmental progression, with 13-year-olds still not at adult levels. This suggests that EF abilities may not be fully developed and specialized in early adolescence.

The recent study by Messer et al., (2018) (see also St. Clair-Thompson and Gathercole, 2006), however, found inhibition to be a separate factor to EWM and switching in children of a slightly younger age group with no cognitive impairment. The two-factor structure found in Messer et al., (2018) used tasks similar to those in the current study and was interpreted as indicative of a transitory period between the single factor and three factor stage of differentiation. The Non-SEN two-factor best fit model reported in Chapter 5 is, however, informative for SEN support as it indicates areas of linked need with relations between inhibition and switch (again consistent with the ongoing development of cognitive flexibility), while working memory involves a separate component.

Because the statistical indicators showed a single factor structure to be the most parsimonious model for the SEN group, this was considered to be the most appropriate, consistent with Brydges (Brydges et al., 2012). A unidimensional structure and inter-dependent organisation of EF in the SEN group is interesting as this model is consistent with a developmental view of delayed trajectories. Thus, the EF components support a general processing system (consistent with Miyake's concept of common EF) with specialist processing consistent with Miyake's concept of common EF. The lack of differentiation in younger adolescents, even with clinical and educational diagnoses, supports the argument against modularity, i.e., that from a developmental perspective, functionally independent modules are untenable with the prolonged process of EF maturation (D'Souza and Karmiloff-Smith, 2011). Throughout the thesis, questions about modularity have been key themes and this is a very important point. Thus, the models for the Non-SEN and SEN groups reveal differences as degrees of maturity in an inter-related and inter-dependent EF system. Where the SEN group is concerned, the impact of developmental disorders on a dynamically emergent EF system appears to be immaturity in relation to the SEN group. In the Non-SEN group, the models are indicative of transitional, age-appropriate changes in the configuration of the EF system towards increased separability as an on-going process until maturity in early adulthood (Diamond and Amso, 2008, Thomas et al., 2009, D'Souza and Karmiloff-Smith, 2011, Diamond, 2013).

Research Question 1d

Are there differences between the SEN and non-SEN groups in EF as assessed by reports using the BRIEF?

As EF behaviour is de-contextualised in the performance tasks, these may not generalise to EF behavioural manifestations in the unstructured context of everyday life. The results of the BRIEF questionnaire showed significant group differences between the self-ratings of the Non-SEN and SEN group in their opinions regarding the nature and extent of maladaptive behaviours for each of the constructs. These findings were consistent with those of Chapter 4, where statistically significant differences between these two groups were found in performance assessments of EF In terms of the BRIEF, Non-SEN students' self-ratings were just below the normative mean of 50 for each of the constructs; 'inhibit', 'working memory' and 'shift'. In contrast, the greatest extent of noticeable differences between Non-SEN and SEN students' self-ratings were shown by the effect sizes for each component, with greatest disparity found for behaviours indicative of 'shift', (effect size of 0.9) and 'working memory'(effect size 0.65), both with means of

56. Where teacher ratings of the SEN group were concerned, all the constructs were judged at elevated levels of difficulty of one standard deviation above the mean ('inhibit' 59; 'shift' 60, a score indicating cause for concern, and the score of 68 for 'working memory' was above the level of clinical concern indicated by scores of 65 and above). Where the greatest extent of disparity in teachers' judgements of maladaptive behaviours for Non-SEN and SEN groups were concerned, 'working memory' had the largest score gap with an effect size of 1.14. This is consistent with previous studies of the BRIEF where teachers have rated problems with working memory at clinical levels (McCandless and O' Laughlin, 2007, Mares et al., 2007, Toplak et al., 2008, Cuperus et al., 2014). The findings showed that each respondent group judged the impact of maladaptive behaviours of each construct differently with different constructs being rated as more concerning than others where each respondent group was concerned. The results indicated that SEN students have some insights of the nature of their problems and how they impact daily life, particularly in situations requiring cognitive and behavioural flexibility. Compared with teacher and parent ratings, however, the SEN students underestimated the extent of the difficulties (i.e., ratings by parents and teachers were more severe). This is consistent with Anderson's account of how immature self-regulatory processes in conjunction with inhibition can compromise a range of goal-oriented outcomes (outlined in Chapter 1, Part 2). Alternatively, it may mean that parents and teachers have unrealistic expectations of behavioural independence in younger adolescents with SEN.

The BRIEF ratings of self-, teachers and parents enabled the opinions of the different respondents to be triangulated, which, to my knowledge, has not been done previously where younger adolescents are concerned. This exercise gave some insight to issues of rater bias and accuracy which has been reported in the literature (Fisher et al., 2014). As predicted, SEN parents' ratings showed that they viewed the severity of their adolescent's maladaptive EF behaviours as equally concerning across all the constructs, and thereby a *general* EF issue. The general, cross-domain nature of parents' elevated ratings is consistent with previous studies investigating EF behaviours in children with developmental disorders, such as ADHD or ASD (Epstein et al., 2008, Hutchison et al., 2016). These studies found a cycle whereby the self-regulatory difficulties of the children influenced parenting style (more authoritarian), which in turn increased behavioural difficulties and parental stress. In contrast, teachers' elevated ratings for 'working memory' and 'shift' may have reflected the impact of these behavioural aspects of EF on classroom activities.

The results also suggest that the impact of poor self-regulation and self-awareness may have different contextual implications, dependent on expectations of age-appropriate behaviours in different situations. Consequently, the combined impact of negative judgements in home and school life could heighten vulnerability in SEN students for negative self-perception and mental well-being (Epstein et al., 2008, Hughes et al., 2009, Rosenthal et al., 2013, Granader et al., 2014, Lawson et al., 2015).

The issue of whether the BRIEF and EF performance measures assess the same thing (Toplak et al., 2012) was particularly pertinent in relation to the anomalous switch factor found for SEN in the structural relations in Chapter 5 and so the second research question concerned the nature of relationships between performance EF, BRIEF and SDQ.

9.1.2 Research Question 2

Research Question 2a

What are the relations between EF as measured by performance and the BRIEF?

To first address this research question multiple regression analyses were conducted to ascertain if performance measures on specific EF tasks were associated with the corresponding BRIEF constructs. The first step of the regression identified agreement between verbal and non-verbal EF performance measures corresponding to the same BRIEF sub-scale while step two identified relationships between remaining verbal and non-verbal EF performance measures and the BRIEF. These analyses were important because a study by Toplak and colleagues (2008) found that EF performance on inhibition overlapped all three BRIEF constructs, 'inhibit', 'shift' and 'working memory', implying that EF performance tasks and behavioural ratings may not be measuring the same thing. Where SEN self-ratings were concerned, there was very limited support for agreement between performance and behavioural measures as the only statistically significant associations between corresponding performance measures and the BRIEF were limited to performance in verbal switching and behavioural 'shift', albeit with a low level of agreement ($r = .231$). This finding is relevant as few (if any) studies have examined the relevance of generative language skills for adaptive EF behaviours and this association suggests that intransigent behaviours are related to the ability to think flexibly.

Where teacher ratings of the BRIEF for the SEN group was concerned, there was an inverse relationship between EF performance in non-verbal EWM and maladaptive working memory behaviours in the BRIEF, also with a low level of agreement ($r = -.245$). The relationship indicated that *better* scores in non-verbal EWM performance are associated with fewer instances of maladaptive working memory behaviours (see Table 7.2 in Chapter 7). The overall lack of correspondence (commonality) between EF performance and BRIEF ratings of the same construct was consistent with Toplak's (2013) meta-analysis where a mere 24% of the 286 relevant correlations reported in these studies were statistically significant, suggesting that the measures tap different levels of cognition, defined by Toplak as processing efficiency and success in goal pursuit (Toplak et al., 2013). The lack of robust associations between EF performance and the BRIEF led to the question of whether the behaviours measured in the BRIEF are more indicative of general measures of behavioural disruption and impairment or to specific measures of EF (McAuley et al., 2010). As ratings are subjective opinions, accuracy in terms of rater understanding of the nature of the construct being measured and bias through over- or under-estimation of occurrences were addressed in Chapter 6. The conclusion had been that teachers were the more accurate raters with the explanation that their judgements were based on age-defined norms and objective professional expectations of appropriate behaviour.

Research Question 2b

What are the relations between the BRIEF and the SDQ?

It was important to investigate how teachers judged the nature and extent of maladaptive behaviours in the classroom as such observations inform decisions about whether or not a student's progress is cause for concern and might benefit from support or remedial interventions (see Chapter 1 Part One). In the introduction, studies were examined which suggested that teachers' priorities regarding classroom management and behavioural rule infringements may be interpreted as disciplinary concerns with failure to take into account that there may potentially be an underlying cognitive impairment to explain why certain maladaptive behaviours manifest. Therefore, the data presented an opportunity to examine two related issues: first, the extent to which teacher ratings of maladaptive EF behaviours were related to their ratings of clinically defined constructs tapping disordered conduct and second, to ascertain whether EF performance or the SDQ was a better predictor of the BRIEF.

In Chapter 6, no significant group differences in teachers' SDQ prosocial ratings for the SEN group were detected, implying that SEN students were considered as socially supportive as Non-SEN students. When examined in conjunction with the BRIEF, however, SDQ prosocial ratings were significantly correlated with all the BRIEF scales for both groups, suggesting that higher (more maladaptive) BRIEF scores were associated with poorer social behaviours. This suggests that poorer self-regulation of inhibitory behaviours, inflexibility and failures with 'remembering to remember' are likely to have broader consequences in how teachers interpret a student's attitude towards others in the learning environment (Hughes et al., 2009). Since attitude and behavioural conduct are assessed as part of the progress tracking process so if teachers misinterpret EF impairment as conduct issues then a student's academic record may include inappropriate negative comments.

An interesting finding in the patterns of problem behaviours in the Non-SEN group identified by teachers were links between inflexibility (BRIEF shift) and *all* the SDQ constructs as well as 'peer problems' with 'emotional symptoms.' This suggests that issues with inflexibility may be age-related if observable in younger adolescent learners of all abilities. Furthermore, if the link between peer problems and emotional symptoms in the Non-SEN group is indicative of the type of issues younger adolescents manifest in the academic environment, then there are potential implications for mental well-being, particularly where social integration and self-perception is concerned (Hughes et al., 2009, Sonuga-Barke, 2005). Teachers' ratings also associated the SDQ constructs 'hyperactivity' with 'conduct problems' in the Non-SEN group which suggests that disruptive behaviours in typical learners are likely to be considered as a disciplinary issue. The message from teacher ratings of EF behaviours and conduct dysregulation is that teachers might not discriminate between observed behaviours to discern underlying difficulties which require different types of intervention.

Where the SEN group was concerned, all teacher rated BRIEF constructs were associated with all SDQ constructs, suggesting that maladaptive EF behaviours could have significant consequences in terms of how teachers perceive students through associations with a range of broader problems, including: emotional symptoms, conduct problems, hyperactivity, peer problems and lower prosocial attitudes. It is, however, important to note that the causal direction could be the other way and therefore, establishing the causal direction of effect could be a useful topic for further investigation.

The extensive links between the BRIEF and SDQ constructs, in contrast to the paucity of EF performance and BRIEF associations, led to consideration of whether EF performance or SDQ better predicted the BRIEF (McAuley et al., 2010). The results of hierarchical regressions reported in Chapter 7 showed the teacher rated SDQ to be a better predictor of teacher ratings of the BRIEF than EF performance measures, which is consistent with McAuley's view that the BRIEF is more a measure of general impairment than EF per se (McAuley et al., 2010). An alternative explanation, however, may be negative halo effects whereby teachers are rating some students low on the BRIEF and by extension, the SDQ. This suggests that maladaptive EF behaviours have broader implications for student well-being if they are associated with disruptive behaviours and consequently more likely to be judged as disciplinary concerns. Thus, as ratings report subjective judgements, then teacher *perceptions* of classroom behaviours may not distinguish between underlying EF issues and conduct dysregulation. This is an important distinction as the former has the neurological underpinnings of brain function whereas the latter may be perceived as within the wilful control of the individual.

Nonetheless, the correlations between the BRIEF and SDQ were, in fact, consistent with the BRIEF authors' (Gioia et al., 2002) view that 'working memory' and 'inhibit' scales have the greatest overlap with diagnostic criteria for inattentive and hyperactive–impulsive types of ADHD, respectively. This pattern of correlations also supports McKinney's (2012) findings that children with poorer EF were more likely to show disruptive behaviour symptoms compared to those with better EF (McKinney and Morse, 2012). Chapters 6 and 7 therefore present key findings which suggest that behaviours associated with self-regulatory skills and attentional control could underpin both socio-emotional and academic success, both of which are fundamental concerns for younger adolescents (Rueda et al., 2010, Durkin and Conti-Ramsden, 2010).

The final research question was motivated by the complex web of findings, particularly the extent of overlap between Non-SEN and SEN (as well as the SEN sub-groups) in the measures to ascertain if any of the standardized assessments and EF measures used in the study have utility in predicting SEN status. If so, then these measures could potentially supplement teacher assessments of SEN issues. A subsidiary issue was whether EF predictors retained independent influence on SEN status after the contribution of the standardized assessments of decoding, vocabulary and non-verbal reasoning (RVR). The selected analysis, binary logistical regression, was also used to assess how accurate the SEN classification placements were.

9.1.3 Research Question 3

Which measures of EF and academic related abilities (decoding, vocabulary and non-verbal reasoning) predict SEN status?

Earlier chapters had identified a myriad of relationships between EF components as separate foci of interest. Related to this a key objective was to identify which variables would be most relevant in the SEN support context, first as potential tools in SEN assessment to supplement existing protocols and second, as targets for interventions aiming to boost EF skills in students with SEN.

Among the predictions in the binary logistic regression were EF performance variables of inhibition, EWM and fluency. These variables had been chosen on evidence of impairment in these processes in 'at risk' groups, especially EWM, and academic attainment (Bull and Scerif, 2001, Gathercole and Pickering, 2001, Gathercole et al., 2004a, Blair and Diamond, 2008, Alloway and Alloway, 2010, Aarnoudse-Moens et al., 2013, Messer et al., 2016b, Vandenbroucke et al., 2017). As EF cognitive processes were expected to predict the academic related abilities, however, it was unclear if any would retain influence once the academic related abilities were added to the regression

All performance measures and BRIEF EF constructs were expected to contribute to self-regulatory aspects of learning (Anderson, 2002) but the main concern was whether task performance or self/teacher ratings of the BRIEF were better predictors. For example, from the theories examined in the first chapter, the fundamental influence of inhibition (and attentional control) on complex processing by EWM and switching (Roberts, 1996, Barkley, 1997, Anderson, 2002) suggested that EF performance in inhibition would be predictive of SEN status while teacher ratings clearly indicated an important role for behavioural 'working memory' and 'shift'. When all variables were added to the regression for the BRIEF *self-rating* analysis, the surprising finding was that only the BRIEF 'shift' (behaviour) and the TOWRE predicted SEN status. Furthermore, these same variables were predictive in the final teacher BRIEF model. The predictive capacity of the TOWRE was not unexpected as it constituted a marker of literacy and reading efficiency which is fundamental to SEN. In contrast, the influence of BRIEF 'behavioural shift' was unexpected. Part of the reason for these findings could be that the TOWRE assessment of decoding was so closely related to SEN status that the EF measures which were significant predictors at earlier stages of the analysis were no longer the most important predictors and accounted for less variance in SEN status. It also seems likely that because some of the EF measures are predictors of literacy, e.g., inhibition (Altemeier et al., 2006, Booth and Boyle, 2009, Booth et al., 2014), that there was shared variance which was 'captured' by the TOWRE.

As the self-ratings of 'shift' and the teacher ratings of 'shift' were both significant predictors, this gives a degree of confidence that this is an important EF characteristic in relation to SEN status. Consequently, it is useful to unpack what behaviours are used to assess 'shift' in the BRIEF. The following are questions on the BRIEF concerning 'shift', e.g., has trouble accepting a different way to solve a problem with schoolwork, friends, tasks; gets upset by unexpected changes in plans or getting used to new situations concerning routines, foods, places, teacher, activities.

As the above statements show, the indices for ‘shift’ in the self-rating version of the BRIEF measure aspects of cognitive and behavioural inflexibility, including the ability to move freely from one situation, activity or aspect of a problem to another as the circumstances demand. A typical secondary school day will involve around five or six changes in location for different subjects and each day will follow a different timetable. Students are expected to arrive in their new lesson fully prepared for the subject requirements as specified in the classroom rules by each teacher. Lessons generally take a three-part format with introduction, main topic and plenary and students are expected to change focus and switch to a different approach (e.g., reading, writing, listening, collaborative group/partner work) quickly and efficiently to maximise learning time. These demands are likely to be challenging for students whose self-organisation or adaptive skills are not as developmentally mature as age-related expectations require. The authors (Guy et al., 2004) state that inefficient problem solving and difficulties changing focus are indicators of mild deficit and that more severe difficulties are indicated by perseverative behaviours and marked resistance to change.

Where EF performance predictors of SEN status prior to competition from RVR abilities were concerned, similar findings were found for teacher and self-rating BRIEF models and included both modalities for inhibition, and fluency, while non-verbal switching was also predictive in the teacher BRIEF. Overall, the binary classifications for SEN status placement showed 90% accuracy overall in the final teacher BRIEF model (86% for Non-SEN and 92% for SEN).

9.4 Summary of Findings

Please refer to Figure 9.1 (below) which is a radar graph showing the effect sizes for the measures used in the thesis and is a quick visual reference of between-group differences.

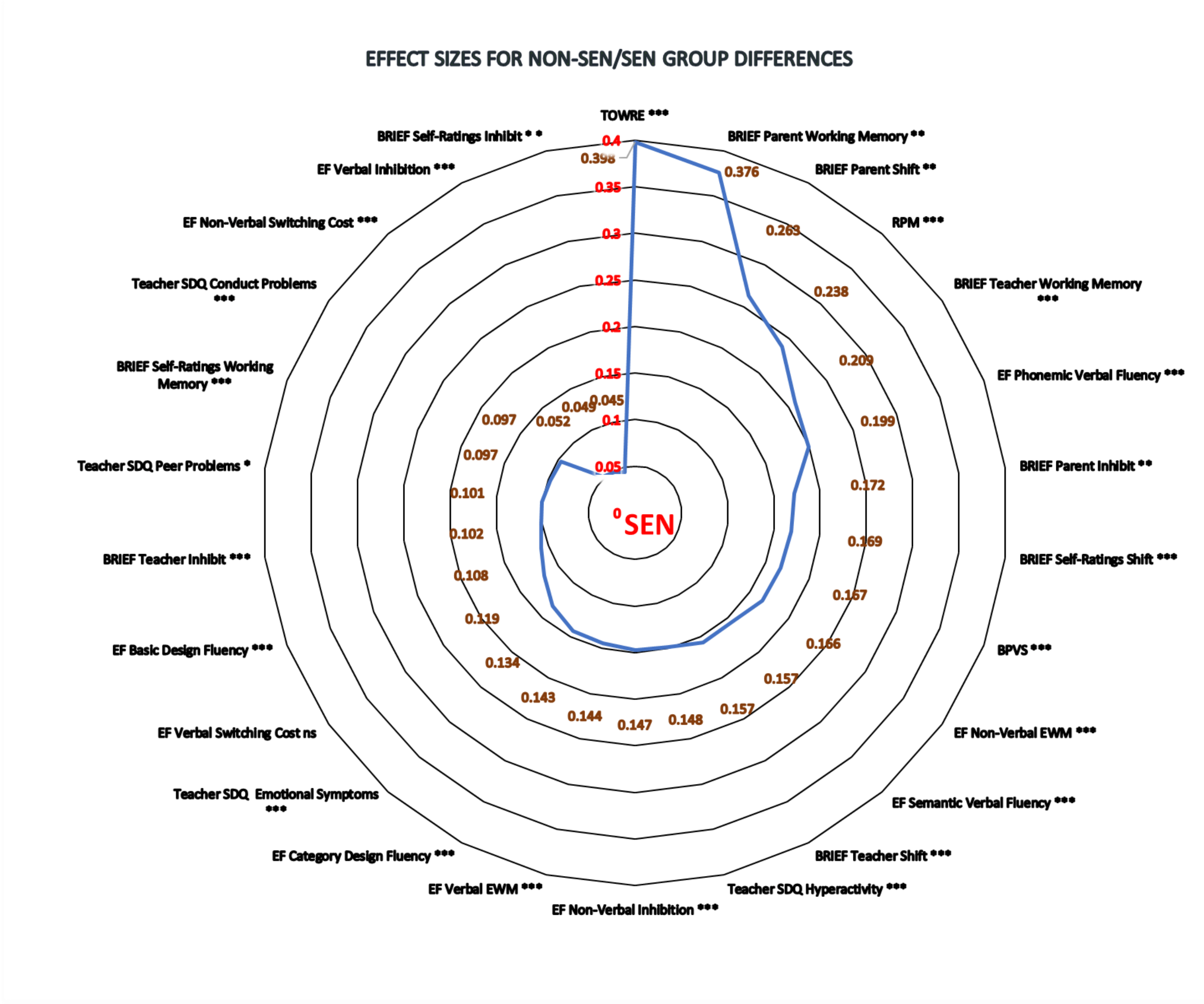


Figure 9.1 Radar graph showing effect sizes for each of the measures against SEN group scores set at zero

Group differences between the Non-SEN and SEN groups were found for the standardized assessments of decoding (TOWRE), receptive vocabulary (BPVS) and non-verbal reasoning (RPM) but not all students with SEN had below average academic related abilities. Students with more complex profiles receiving the highest level of support did not, however, necessarily perform worse than those receiving school-initiated interventions. Group differences between Non-SEN and SEN groups were also found for all EF performance tasks in verbal and non-verbal modalities (apart from verbal switch) and the poorest EF scores in SEN students were found for non-verbal inhibition, verbal EWM and both measures of fluency. The most appropriate model of EF structural organization in the SEN group was an undifferentiated model, interpreted as indicative of relative immaturity in the EF developmental trajectories, particularly as the best fitting SEN two-factor model showed inhibition and EWM to be inter-related, which is a factor structure previously found in much younger children aged 7.7 years (van der Ven et al., 2013). Group differences were also found in EF behavioural ratings (BRIEF) across all respondent groups (self-, teacher and parent) but lack of agreement between respondent groups regarding the extent of difficulties was consistent with previous studies (Sullivan and Riccio, 2007, Bexkens et al., 2013, McCann et al., 2013). Teachers rated ‘working memory’ and ‘shift’ as particularly concerning for the SEN group while ‘shift’ was considered most problematic by the SEN group. There was little evidence of agreement between EF performance and the BRIEF as only EF switching performance and BRIEF ‘shift’ were directly correlated, supporting the argument that the measures tap different levels of cognition; processing efficiency and success in goal pursuit (Toplak et al., 2013). The SDQ was a better predictor of the BRIEF than EF performance, suggesting that the BRIEF was a better measure of behavioural disruption and impairment than specific measures of EF (McAuley et al., 2010). Correlations between the BRIEF and SDQ for teacher ratings of the SEN group were significant for all constructs, possibly attributable to negative halo effects or alternatively, teachers’ expectations of conduct for minimizing disruption. Although verbal and non-verbal fluency, verbal and non-verbal inhibition and non-verbal switch were significant predictors of SEN status prior to the inclusion of the RVR assessments, final model predictors only included BRIEF ‘shift’ and decoding. One explanation was that EF variance was absorbed by the RVR abilities which suggested that

EF could have an important role in underpinning academic related abilities. It was not surprising that the TOWRE retained unique predictive influence, considering the importance of literacy and norm-related expectations which teachers are aware of.

9.5 Findings: Links to Theory and Implications for Education of Students with SEN

The section starts with a brief outline of the links between the findings of the thesis and the theories of Barkley and Anderson (see Chapter 1). Then there is consideration of the complex findings concerning the prediction of SEN status in relation to educational processes.

In Chapter 1, Barkley's ideas about the significance of inhibitory processes were discussed. The findings in Chapter 7 about relations between BRIEF and SDQ as well as the findings from the logistic regressions in Chapter 8 suggest the importance for the SEN group of what might be described as within and between task management. Inhibition, 'shift', switching and fluency were all identified as significant predictors of SEN status and all these assessments seem to involve some form of task management. Furthermore, these characteristics were identified in both performance and BRIEF measures, in both verbal and non-verbal performance measures, and in self- and teacher ratings. These findings are consistent with Barkley's emphasis on the importance of inhibition processes in ADHD, and the way that impairments to inhibition can have a cascading effect on other abilities. Furthermore, the findings also are consistent with Anderson's model in that attentional control is believed to affect cognitive flexibility, goal setting and information processing, and these three abilities might be expected to be impaired in the SEN group. Anderson identifies inhibition as an aspect of attentional control, although the other significant predictors of SEN status involving 'shift', switching and fluency could all be argued to include some aspects of attentional control.

Why might within and between task-management by students be an important predictor of SEN status? One possible reason is that student self-management of tasks is important in classroom settings so students maintain an appropriate focus to enable new information to be acquired, students who do not have this ability are likely to fall behind in their educational progress, as described by Anderson (see Chapter 1). A second related possibility is that poor task management is associated with disruptive classroom behaviours which draws attention to a student's limitations and makes them more likely to be identified as having SENs. A degree of support for the second possibility about task management and disruptive behaviours comes from the finding of relationships between the teacher BRIEF ratings and the SDQ subscales in Chapter 7. In these analyses the two highest correlations were between BRIEF 'inhibit' with SDQ 'conduct disorder' and 'hyperactivity', both of which are likely to be relevant for classroom management. In addition, teacher ratings of 'shift' had high correlations with both these SDQ subscales. Similar findings have been reported in two studies of behavioural characteristics in younger adolescents aged 11-14 years with diagnosis of a rare syndrome (Hartshorne et al., 2005, Nicholas, 2005). A range of autistic-like characteristics (attention issues, inflexibility and communication difficulties) were found which explained the behavioural difficulties (Hartshorne et al., 2005) and parent and teacher ratings from the BRIEF identified similar EF behavioural difficulties to those found for the SEN group, namely; vulnerability to attention issues and behavioural inflexibility (Nicholas, 2005). Hartshorne (2005) concluded that these behavioural difficulties indicated lack of developmental preparedness for age-appropriate expectations. Thus, there is evidence that poor EF as identified in the BRIEF may be related to behavioural problems in class. However, future research is needed to untangle this complex web of causality where there may be bidirectional effects. In addition, there is the possibility that attention-related disruptive behaviour and EF related abilities, rather than cognitive ability, might need to be the focus of investigation (see also Rogers et al., 2011).

Although task management processes were significantly related to SEN status, EWM was not a significant predictor. This is despite previous findings indicating that EWM is a key cognitive ability and is related to measures such as IQ (Redick et al., 2012, Unsworth et al., 2014, Redick et al., 2016). Further, it should be noted that teacher ratings of the 'working memory' of the SEN group were at the level of clinical significance, which is consistent with EWM being a difficulty for students with SEN. The reason may simply be that general task management processes are more important for young adolescents' educational progress than cognitive abilities involving time limited information processing, so that task management is the significant predictor of SEN status.

The analyses in this thesis also indicated that there was significantly poorer SEN than Non-SEN scores on all EF performance tasks (apart from verbal switching); the three measures with the largest differences between the groups were non-verbal inhibition, verbal fluency and non-verbal switching. Similarly, the analysis of the BRIEF answers in Chapter 6 indicated that there were significant group differences in 'inhibit', 'working memory' and 'shift', with the largest impairment being reported for 'working memory' by teachers and 'shift' by SEN students. Thus, all aspects of EF appeared to be impaired in the SEN group, suggesting this to be a common characteristic, despite the heterogeneity indicated by the mix of support needs. A substantial proportion (47%) of students had below average (<86) standardized assessment scores (BPVS; 45%, RPM 53%, TOWRE 43%) but across the SEN group, individual profiles showed uneven patterns whereby some abilities were more adequate than others. A similar characteristic was found in EF performance where different patterns were found across components and modalities. These patterns are similar to those found in developmental disorder syndromes which are defined by common characteristics (such as meeting statutory support criteria where the SEN population is concerned) but individuals present with a dissimilar strengths and difficulties across the diagnostic criteria. Further, the proportion of SEN students with EF performance scores below average ranged from 33% for non-verbal inhibition, 32% for non-verbal basic design fluency, 31% for non-verbal category design fluency, 30% for semantic verbal fluency, 24% for phonemic verbal fluency and non-verbal switching cost to 18% for non-verbal ELWM, 17% for verbal inhibition and 16% for verbal ELWM. The proportions of SEN students with below average EF performance in each of the skills is a concerning characteristic as these are likely to have a detrimental effect on students' capacity to apply literacy and numeracy skills effectively in tasks.

These findings about group differences suggests that interventions involving EF could reasonably target the whole EF system (Rowe et al., 2019) rather than components of the EF system such as EWM (Henry et al., 2014). It should, however, be acknowledged that certain EF components may be more effective targets for intervention than others. Based on the logistic regressions in Chapter 8 the following, as significant predictors of SEN status, would be expected to be especially effective: 'shift' behaviours, inhibition and fluency.

Thus, the findings from this thesis are consistent with theories about the way EF processes have consequences for classroom behaviours. The findings also provide information about the forms of EF which predict SEN status, which appear to be EF abilities related to cognitive and behavioural flexibility and task management. In addition, the findings suggest that attention needs to be paid to whether SEN support should be focused on behavioural or cognitive processes.

9.6 Limitations and Future Research

The sample sizes for Non-SEN and SEN groups were not large enough to investigate causal pathways between EF performance in both modalities, BRIEF and IQ related abilities of vocabulary, decoding and non-verbal reasoning through structural equation modelling. This would be a useful development of the current thesis if a large enough sample were to facilitate separate models for Non-SEN and SEN groups. Also, this was a cross-sectional study so a longitudinal study with a follow-up as students reach the end of compulsory education might be informative, as would the structural organization of EF in both groups as the transition towards adult independence and self-direction begin. A further limitation of this study, which relates to task impurity issues, was the possibility that the use of language may have influenced non-verbal EF processing tasks. Thus, Barkley's notion of reconstitution and fluency offers possibilities for investigating how individuals with and without SEN process non-verbal EF tasks.

9.7 Conclusion

This large-scale investigation with 298 participants has provided insights into the executive functions (EF) of adolescents aged to 11 to 14 years who met statutory criteria for Special Educational Needs. This is an under-researched population and no previous study appears to have investigated this topic in this age group.

The findings produced consistent evidence of differences between SEN students and typical learning peers in a battery of valid and reliable measures, including; standardized assessments of vocabulary, decoding and non-verbal reasoning; verbal and non-verbal EF performance and triangulated questionnaire data tapping behavioural manifestations of EF processes. In contrast, few significant differences were found between the three sub-groups in the SEN classification, which implied that the SEN group was more homogeneous than the categories of provision suggested. Although some students had higher or lower scores than expected on the basis of their SEN status, a common feature to be noted was inconsistency in SEN students' skill patterns in different components and modalities, as might be expected in individual profiles within a syndrome.

Although parents, teachers and adolescents with SEN differed in the value they placed on each of the items in the BRIEF, the concerns were judged at levels greater than average across contexts, implying that the difficulties were stable traits which manifest on a more or less gradation which was context-dependent. Although both the performance EF tasks and the BRIEF aim to assess EF, the relationship between these two sets of measure was poor as has been reported in previous reviews (Toplak et al., 2012). This may be because the two assessments involve different contexts. However, both sets of measures were significant predictors of SEN status in some of the steps of the logistic regression analyses. Furthermore, the significant predictors involved activities where managing task engagement was an important component of the assessments (e.g. inhibition, shift, switching and fluency). These findings about significant predictors relate to theories which emphasise the importance of inhibitory processes (Barkley, 1997, Anderson, 2002). The findings about group differences suggest that a general targeting of EF abilities in SEN students may be helpful, particularly those that relate to task management issues. In terms of inclusion, a final message is that better understanding of the implications of EF immaturity for self-regulation, communication and social integration may be a way of promoting engagement and fostering self-belief in the capacity to learn effectively and thrive in secondary school. As all teachers are teachers of SEN, so all students have individual strengths and difficulties which may require additional support at some point in their educational journey. As this thesis has shown that EF skills are fundamentally important for both the cognitive and behavioural aspects of school life, the final message has potential relevance to all students, particularly those embarking on their secondary school education.

APPENDIX 1: Ethics Application for Study

HUMAN RESEARCH ETHICS COMMITTEE (HREC) PROFORMA

To apply for HREC review of your research ethics protocol, please complete and email this proforma to Research-Rec-Review@open.ac.uk.

If you have any queries about completing the proforma please look at the Research Ethics website, in particular the FAQs - http://www.open.ac.uk/research/ethics/FAQs.shtml.

The submission deadline for applications is **every Thursday** at **5.30pm** when they will be assessed for completeness and then sent to the HREC Review Panel. Once an application has been passed for review you should receive a response within 10 working days.

All general research ethics queries should be sent to Research-Ethics@open.ac.uk, or call the **HREC Secretary, ☎ 01908 654858**.

Please complete all the sections below – deleting the inserted instructions.

Project identification and rationale

Title of project REF: 1117

An investigation of cognitive challenges experienced by lower attaining adolescents in mainstream education.

Abstract

The research aims to identify psychological barriers to learning by comparing the performance of lower attaining adolescents with that of their peers on tasks measuring aspects of thinking skills (executive functions) and to explore how specific difficulties impact on their identity as learners. Teachers and pupils will complete similar standardised questionnaires enabling comparison of different perspectives of the challenges individual pupils experience in managing their learning. Pupils will complete short tasks measuring attention, memory and mental flexibility skills, then answer questions relevant to each task to identify particular strategies and specific difficulties. A key focus is to give pupils a voice to articulate what matters to them; how the challenges they experience in the learning environment shape beliefs of their ability to succeed and influence classroom relations.

Project personnel and collaborators

Investigators

Give names and institutional attachments of all persons involved in the collection and handling of individual data and name one person as Principal Investigator (PI). Normally, Research students should normally name themselves as Principal Investigator and will need to provide evidence of their primary supervisor's endorsement by email to Research-REC-Review@open.ac.uk. This needs to be received before, or at the same time, the application is submitted, preferably with the relevant REC reference number, or there may be a delay in the application being processed.

Principal Investigator/ (or Research Student):	Jennifer Kearvell-White
Other researcher(s):	
Primary Supervisor (if applicable)	Prof D Messer (OU), Prof L Henry (London South Bank University), Dr Henrik Danielsson (Linkoping University, Sweden).

Research protocol

Literature review

Inclusive education requires teachers in mainstream secondary classrooms to address the challenge of providing an appropriate learning environment for pupils identified with a range of Special Educational Needs (SEN), from speech, language and communication disorders to emotional/behavioural difficulties, all of varying degrees of severity (Hulme and Snowling, 2009). A large body of research indicates that, as well as specific impairments, individuals may also experience general cognitive difficulties affecting attention, memory and self-organisation skills (grouped under the umbrella term 'executive functions'). However, very little research has been conducted with younger adolescents who consistently underachieve in the absence of a clinical diagnosis. From a clinical neuropsychological perspective, Denckla (1996) describes such pupils as "bright…. untroubled by any modular, domain-specific information processing deficits, yet unable to function as 'good students'. As a child reaches adolescence, the capacity for self-organisation and strategic thinking is crucial for meeting academic potential while difficulties in coping can have damaging effects on motivation and identity as a learner. The proposed study therefore asks four questions. First: in what ways do the thinking skills of lower attaining adolescents differ from those of higher achieving peers and peers with Special Educational Needs arising from specific developmental disorders? Second: How do teachers rate the performance of lower attaining pupils compared with higher achieving peers? Third: To what extent does teachers' understanding of individual pupils' difficulties match that of the individual's own self-ratings of difficulties? Fourth: How do individuals' specific difficulties affect their identity as learners?

By using standardized or established tasks which measure specific aspects of executive functioning, this study employs the experimental methodology of prior work. Tasks tapping verbal and non-verbal means of processing information will identify similarities and differences in performance patterns between lower achieving individuals and their higher achieving peers, as well as specific SEN clinical groups.

Historically, the neuropsychological approach investigating the effects of acquired damage to the brain's frontal lobes has informed knowledge of how attention, memory and executive functions systematically influence thinking skills (Parkin, 1996). Individuals with prefrontal brain damage characteristically present with rigid and inflexible habitual behaviours, lack of inhibition, failure to shift focus in response to changing requirements and distractibility. Research in developmental disorders has tried to map behaviours associated with distinct disorders to patterns of impaired thinking skills with varying success, but evidence increasingly suggests working memory and attention to be the foundations of adaptive and flexible thinking. Research on working memory (the capacity to hold in mind and manipulate information) suggests that, because working memory is a limited capacity system, the capacity to over-ride dominant impulses (inhibition) is intrinsic to its operation (Pennington, 1995). Supporting evidence indicates that problems of inattention are associated with weak working memory (Gathercole et al, 2006, 2009). Barkley (1997) argued that working memory and the manipulation of knowledge for problem solving and creative thinking are dependent on the capacity to delay an immediate, automatic response to a stimulus in order to allow a consciously moderated response to be generated. The links between attention, memory and controlled thinking are therefore essential for successful learning.

Recent research investigating whether children with language difficulties process information in the same way as typical developing children suggests the organisation of processing in language disorders is different to that of typical developing individuals. (Messer, Henry & Nash, 2010). Their study also suggests links between working memory/inhibition with mechanisms involving grammar. This present study will include verbal and non-verbal measures to assess whether there is a processing bias in typical but lower attaining individuals and SEN pupils. As the focus of previous executive function research has been mainly experimental, there is less understanding of what weak executive skills mean to the individual and the effect on their identity as a learner, This study proposes to address this gap in the literature by exploring pupils' beliefs and experiences, thereby offering a broad based, integrated overview of thinking skills of adolescents in Key Stage 3 mainstream education.

The study will be the first to use a triangular, integrated approach to data analysis. Pupils' self-reported ratings of their cognitive skills compared with that of their teachers will identify mutual areas of concern and differences in terms of what matters from the dual perspectives of learner and teacher. Pupils' subjective perceptions of strengths and weaknesses will be verified by their performance patterns on specific tasks, as well as the extent to which their performance is mirrored by self-awareness of useful strategies and areas of difficulty. In addition, teachers will provide their professional opinions on ways in which lower achieving pupils as a cohort differ from their more able peers in classroom performance and prioritise the cognitive functions that, if weak, present the greatest barriers to learning. In total, the data will provide a unique snapshot overview of individual and group learning skills at Key Stage 3 in mainstream English secondary schools.

Methodology

A quantitative approach will be employed, but pupils will be asked to comment on aspects of their task and learning experiences.

Teachers and pupils will complete questionnaires targeting specific elements of executive function. For this study, sets of items concerning working memory, inhibition and monitoring have been selected from the BRIEF (Behaviour Rating Inventory of Executive Function) which is a standardised questionnaire that has been used in a large number of investigations. The Teacher and Pupil Self-Rating Questionnaires are attached.

During sessions of up to one hour (possibly two sessions if individuals require it) pupils will undertake short engaging tasks that assess verbal and non-verbal abilities together with a selection of standardized tasks of inhibition, executive loaded working memory (verbal and non-verbal) and switching. The verbal and non-verbal ability tasks will include the British Picture Vocabulary Scales (BPVS) where, for each question, the researcher says a word and the pupil responds by selecting the picture (from four options) that best illustrates the word's meaning. In the Test of Word Reading Efficiency (TOWRE) the pupil reads a list of words and non-words as quickly as possible and in the Matrices from the British Ability Scales (BASII), pupils have to identify the correct designs which form the missing item from a series of matrices. To assess executive functioning, the Inhibition (Walk-Don't Walk) and switching (Creature Counting) tasks will be from the Test of Everyday Attention for Children (TEA-Ch). These visual tasks resemble board games where, in Walk-Don't Walk the pupils have to trace a path with their fingers, listening for a tone that signifies go or stop. In Creature Counting pupils have to count animals in an ascending or descending manner depending on the position of a set of arrows. These will be followed by quick verbal fluency tasks, where pupils will generate as many words as they can think of in one minute that start with certain letters of the alphabet and words from two different categories (fruit and furniture) alternately for one minute (based on the Delis-Kaplan Verbal Fluency Task). The verbal executive loaded working memory task will be Listening Recall where, as the researcher reads a series of short sentences that may or may not make sense, the pupil says whether the sentence is true or false then recalls all final words in the sentences once the trial set is completed. The non-verbal task is the Odd One Out Test (Henry, 2001), presented as a powerpoint display to help sustain pupil's interest. The pupil is asked to identify the odd one out of a series of shapes then recall their position on the screen.

Teachers will voluntarily complete two questionnaires. The first questionnaire requires rating the performance of lower attaining pupils as a cohort against their peers on a wide range of thinking skills and the second requires them to rate individual pupils they teach in more depth but across fewer categories. (Appendix 1- information and consent sheets and teacher questionnaire, Appendix 2 – information and consent sheet with pupil self-rating questionnaire).

Data will be subjected to a range of statistical analyses as appropriate using SPSS software.

Participants

Sampling will consist of lower attaining 11-14 year old adolescents and teachers in a mainstream Key Stage 3 school in Leicestershire (extended to further schools dependent on participation).Teachers will be invited to complete a generic questionnaire and consenting teachers will also complete similar questionnaires rating the cognitive performance of participating pupils. In addition, a control group of higher ability pupils will be recruited. All pupils will have English as their primary language.

Recruitment procedures

Pupils on schools' Register of Special Educational Needs will be included as well as individuals not on the SEN register who are working at least one level below the norm for their year group in English and/or maths. Selection will be discussed with the Special Educational Needs Co-Ordinators and, if applicable, form tutors to identify and eliminate any individuals for whom participation might be psychologically harmful. Control group participants will be recruited from those working at levels equal to or above the national norm for their year group in English or maths. These individuals will be matched by age and gender to the pupils in the SEN group. Teachers will be invited to participate on a voluntary basis by the Special Educational Needs Co-Ordinators of participating schools.

Consent

Letters will be sent to parents/carers of identified pupils inviting their son/daughter to participate in the study (Appendix 3). The letter will request parents to discuss the study with their child to find out if the child has any objections to participating. Parents will be asked to contact me directly by phone/ email or to leave a reply slip in the school office if they do not wish the child to participate. This opt-out process is appropriate on the basis that the study uses low risk procedures that children are familiar with as part of school activities (British Psychological Society Ethics Guidelines, 2011). Additionally, the research will take place in school in familiar surroundings under close collaboration with SENCOs and with permission of teachers, taking particular account of the sensitive nature of working with vulnerable young people.

Pupils will be given appointment times by the SENCO and prior to starting will have the reasons for the study explained to them, emphasising that the tasks they will undertake are not tests but to be regarded as games. They will then be asked if they have any questions and would like to proceed. They will be informed they can halt the process and leave at any time, and then will sign a form acknowledging they understand the process and are willing to go ahead. They will begin by completing the questionnaire as a separate task during form time. During the experimental session, tasks will be interspersed with breaks and a chat about how they're feeling. At the end of the session they will be thanked and given a debriefing sheet to take away and share with their parents, explaining in an accessible manner how attention, memory and thinking skills shape learning. The information sheet will include contact details. Individual data will not be shared with members of staff and children will be asked not to discuss the study with any friends in order to keep participants open minded. Staff and parents will get generic feedback on findings as a whole at the end of the study with assurance that all individual data has been destroyed.

Teachers will be informed of the study during a staff briefing and given an information sheet outlining the purpose of the research. The sheet will include my OU email contact address for any individuals who do not wish to participate. Each participating teacher will complete a questionnaire on thinking skills, rating the performance of lower attaining pupils as a cohort against that of their higher achieving peers. Teachers of pupils in the experimental groups will also complete a questionnaire rating individual pupils' performance. These questionnaires might be completed as part of a staff professional development twilight session.

Location(s) of data collection

The data will be collected in the participating schools during the school day with permission in writing from Headteachers and consent of teachers for pupils to miss part of their lessons. The research is educational and the appropriate location is in school with the support of staff.

Schedule

This study will take place over the next 6-9 months, it is anticipated most of the research will be conducted in the spring term (January to March). The tasks will be completed in one hour long session although two shorter sessions may be required depending on participant needs. Teachers will complete questionnaires either at their convenience across a week (discrete reminders given mid-week to prompt completion) or during a timetabled twilight session (at school discretion).

Key Ethics considerations

Published ethics and le.g al guidelines to be followed

BERA, BPS

Data Protection

Data will be protected in accordance with the DP Act. All tapes will be wiped as soon as data has been analysed. Electronic records on memory stick and tapes will be kept secure in a safe in the researcher's house.

Recompense to participants

Pupils will receive a reward in accordance with schools' positive behaviour policy under the guidance of the SENCO (e.g. paper certificate for taking part and a merit token which can be redeemed for stationery in the school shop).

Deception

There will be no withholding of information from participants, misrepresentation or deception in the study process.

Risk of harm to participants

No participant will be approached if parent or child has informed the researcher they do not wish to take part. All participants will be invited to participate by letter to parents/carers following detailed discussion with the SENCO. Any potential participant whose background gives doubt or reason to suppose participation will be harmful for psychological wellbeing will be rejected as unsuitable and not approached under any circumstances. The researcher has years of experience teaching adolescents in this age group with Special Educational Needs and is well aware of the sensitive nature of all dealings with vulnerable young people. The researcher is a member of the British Psychological Society and has enhanced CRB Clearance.

Debriefing

At the end of each session pupils will be asked if they have any questions about the study and at the end of the first session will be given an information sheet to take home giving an outline of the science supporting attention, memory and cognitive functions. No reference will be made to clinical disorders and explanations will be given in broad terms regarding typical experiences. If there is a need for support as a result of participation, parents/carers will be asked to contact the SENCO in the first instance who will then contact me with arrangements for a meeting if necessary. Generic feedback on findings as a whole will be sent in writing to each school with the offer to follow up with a presentation if requested. The findings will be presented with reference to relevant contemporary research with indications of areas for future study.

Project Management

Research organisation and Funding

Please provide details of the principal funding body (internal or external). If your project is part of a bid for external funding enter your RED Form reference number below. For further guidance contact your Faculty Research Administrator (FRA) or refer to the Research Grants and Contracts website.

EU/OU Funded Studentship

Red Form Ref No.: ______________________

Other project-related risks

Research risks will be minimised through clear lines of communication with teaching staff and parents/carers. The study will be made as relaxing and enjoyable as possible for pupils and informative and useful for teaching staff. Efforts to maintain excellent relations with schools will be paramount with all requests by staff strictly adhered to.

Benefits and knowledge transfer

Pupil participants will gain insights of how cognitive processes affect learning and influence behaviour as learners with teachers gaining an overview of ways in which the cognitive performance of lower attaining pupils differs from that of their peers to impact self-identity and relations in the learning environment. The study will have wider relevance for teaching and pupil learning support interventions in mainstream education at Key Stage 3. Further investigation founded on the findings of this study will extend understanding of how individuals may be helped through awareness of compensatory strategies and targeted interventions.

Declaration

I declare that the research will conform to the above protocol and that any significant changes or new ethics issues will be raised with the HREC before they are implemented.

In order to adhere to OU governance guidelines, brief information on OU research approved by the HREC will be added to the Research Ethics website. Please indicate below if you are happy for the following data to be made public:

HREC reference number	Project title	Faculty	Approval date	Type of HREC approv

I agree that the above information relating to my research can be added to the Research Ethics website. Yes/ (please delete as appropriate)

Name: Jennifer Kearvell-White

Unit/Faculty:	CREET/FELS
Telephone	+441908858169 (ext 55523)
E-mail	Jennifer.kearvell-white@open.ac.uk
Signature(s) (this can be the typed name(s) of investigator(s) if an electronic copy is submitted (which is preferred)	J A Kearvell-White
Date:	22 December, 2011

Once your research has been completed you will need to complete and submit a final report to the HREC. You will be prompted for this by the HREC on the date you enter below.

Proposed date for final report: November, 2012

APPENDIX 2

Parental Consent: Amend Opt-in to Opt-Out Request to Ethics Committee

To: Dr D Banks, Ethics Committee, OU

From: J Kearvell-White

3 March, 2012

Parental consent requirement for study: HREC/2011/#1117/1

In recent weeks I have been visiting a number of secondary schools to discuss their participation in my study. According to teachers in the schools, it appears that the parental opt-in requirement for student participation is problematic and would result in extremely low responses for the following reasons:

1. SEN students are unreliable in remembering to hand letters to parents and to return them to the school.
2. Parents of SEN students can be unreliable in returning the letter to school.

This means that a number of students and/or parents who would otherwise have been happy to participate will not be given the opportunity because of the opt-in consent procedure.

3. Parents of SEN students are accustomed to their child being assessed in various educational contexts and/or receiving interventions from external agencies like Specialist Teaching Services and do not expect to be approached for consent as they regard it as part of the on-going in-school support package.
4. SENCOs perceive the study tasks as no different to the type of activities the students participate in during their daily learning.

In terms of school procedures, opt-in letters are generally reserved for activities taking part off school premises. For in-school initiatives, Departments generally send out letters informing parents that a particular activity will be happening in school and that their child will be involved and request active opt-out if they do not want their child involved. SEN

Co-ordinators maintain a core register of vulnerable students who require more active consent arrangements.

SENCOs have responded extremely positively to the proposed study and can see benefits for their students in participating, but all expressed concern at the proposed opt-in procedure. They feel the students who would benefit most from the process in terms of doing something different and interacting in a scientific study will not be given the opportunity to take part. As such, I was wondering if it would be possible to use 'assumed opt-in' for parental consent with a specific opt-out requirement. SENCOs feel parents are more likely to return a consent refusal indicating their wish of *not* wanting their child involved in the study.

I would also like to draw attention to the following ethical considerations – using the British Psychological Society Ethical Guidelines which were reformulated by John Oates who was a past chair of the OU ethics committee.

Decisions about ethical matters should be guided by the degree of risk to children/students and the degree to which the procedures depart from typical activities within the school. The tasks that I am using are low risk as these are paper and pencil activities. In addition, as mentioned above, the tasks are similar to many school activities. The study procedure is discussed in detail with SENCOs to ensure participants will enjoy the experience as individuals and feel they have made a positive contribution to research. The Headteacher, teachers and SENCOs, who act in loco parentis, will have given their permission for the students to take part in the study. In addition, SENCOs will review the information and consent form to ensure all the students can understand the procedure and terms of participation. In addition, I will read the document with each student to ensure the content is covered and ask if they fully understand or have any questions before asking them if they want to go ahead. The students themselves will be asked to give their informed consent and this will be recorded by their written signature.

APPENDIX 3: Letter to Parents and Opt-Out Consent Slip

The Open University
Walton Hall
Milton Keynes
MK7 6AA

Faculty of Education and Language Studies
Centre for Childhood, Development and Learning

Telephone (01908) 858169
Direct Line (01908) 55523
Fax (01908) 858868
E-mail: jennifer.kearvell-white@open.ac.uk

January 2012

Dear Parent/Carer

[redacted] has given permission for me to carry out research at [redacted] and so I would like to invite your child to help me with this study. I am looking at thinking skills and how these relate to pupils' identity as learners at Key Stage 3. I am conducting this doctoral research as part of an international project which involves Prof David Messer, Prof Lucy Henry and Dr Henrik Danielsson.

The study consists of two one-to-one sessions with me of up to 45 minutes each. These will involve a brief questionnaire and a series of short word games and tasks. I am confident that pupils will find the process enjoyable and interesting. They will also gain unique insight in the science informing the study with an opportunity to ask questions at the end.

The research conforms to British Educational Research Association ethical guidelines. The data will be treated with strictest confidence and your child's anonymity will be assured. No information provided by individual pupils will be discussed or shared with anyone other than my university supervisors.

Not every child will take part in the study because of the design and sampling requirements. If your child takes part then he or she will be given information about what will happen, then asked if they are willing to take part, and if willing, asked to sign the form which is enclosed. Your or your child can decide to withdraw from the study at any time and all information will be erased or destroyed.

The study will take place in school later this term. If you ***do not*** wish your child to take part, or if he or she does not wish to join in the study, please notify me directly at my Open University email address (above) or ask your child to return the slip below to the school office. You can also contact myself or my supervisor David Messer on 01908 654752 if there are any issues you would like to raise.

Thank you.

Mrs J Kearvell-White MBPsS, MSc (PRM) Open University

Reply slip…………………………………………………………………………….………

I do not want………………………………… Form………. to take part in the research.

Signed……………………………….Print………………………………..……………

APPENDIX 4: Teacher Consent Letter

Learning Strengths and Difficulties of Lower Achieving Pupils

This study is about potential cognitive challenges lower attaining students may face in the learning environment. The aim is to harness your professional experience to identify the impact on whole class learning and for the individual concerned. The study involves completion of a questionnaire relating to a range of behaviours that impact learning and asks teachers to rate the performance of a particular student they teach or mentor. Participating students will complete a corresponding self-rating questionnaire and responses will be compared to identify similarities and differences in beliefs.

All data will be treated in strictest confidence in accordance with the Data Protection Act. Access to your responses will be restricted to the OU researcher and supervisors for analysis purposes in the first instance. Please indicate below if you are happy for access also to be given to the SENCO. You are free to withdraw from the study at any time and any data collected will be destroyed. Please contact me on my Open University email address if you have any queries: Jennifer.kearvell-white@open.ac.uk

If you are happy to participate in the study, please give your consent below.

………

Teacher consent slip

I am happy to take part in this study investigating the thinking skills of lower achieving pupils. I do so voluntarily and understand I am free to withdraw at any stage.

I agree/do not agree to my questionnaire responses being shared with the SEN Co-Ordinator.

Name…………………………………………………………………………………Date:………………

Signature……………………………………………………………………………………………………

APPENDIX 5: Data Access Agreement

It is acknowledged by the researcher that data collected for the purposes of a PhD thesis may be of interest to the Special Educational Needs Co-Ordinators of participating schools in terms of reflecting on and improving current assessment procedures and understanding of individual needs. On this basis, the researcher agrees to allow disclosure of data on the following understanding:

1. The data was collected by a non-clinically qualified student researcher for different purposes and under different conditions to those of clinical or educational psychology assessments. As such, scores should not be compared with clinical norms.
2. Data should be used for information only and not to influence current or future interventions for a particular student.
3. Data shall not be disclosed to any other member of staff, parent or visitor to the school in any capacity without the written, informed consent of the student.
4. Data shall be destroyed in accordance with school's Data Protection Policies.

I have read the above conditions of data disclosure and agree to the terms described.

Signed…….

Print Name……………………………………………………………………………… Date:……………………….…………….

Role:…………………………………………………… School:……………………………………………………………….…

APPENDIX 6: Participant Debriefing Information

What was that all about, then?

This study is looking at thinking skills including attention, memory and mental flexibility from a lot of different angles. For example, scores from tasks tapping certain aspects of thinking skills don't tell us much about how it feels to be doing the task, whether it's easy or quite hard or plain frustratingly impossible! So, it is helpful to ask the person who has just done the task what it was like for them. You don't necessarily think about memory, attention and mental flexibility when your teacher is giving instructions or setting a task that requires a plan, so questionnaires are useful in finding out what strengths and difficulties with these processes might be like in terms of learning behaviours. They also tell us about the impact of these behaviours and how they make students feel about themselves as learners. Everyone is different with different patterns of skills. Some people are good with words and language or 'verbal skills' and others are better at 'non-verbal skills' - seeing pictures in their mind to solve problems. Some are good at both. Completing word games and puzzles aimed at either word or visual skills builds a picture of individual patterns of strengths. However, these skills need attention and memory to act as the engine driving the action!

Think about 'attention' and what it means to you. You may think of 'attention' as that feeling you get when your teacher asks the class to 'pay attention'. You may feel yourself having to make an effort to listen or think carefully about the steps given in instructions and to make an even bigger effort to stop all those distracting little thoughts that come into your mind and can prevent you actively concentrating, like 'I'm really hungry – I wonder what's for lunch…'

Your brain is a dynamic piece of equipment that is able to take you through complicated sequences of events without you being aware of the decisions being made. However, with a flick of the 'conscious effort switch', you can take over from this automatic pilot and actively take control, thinking things through or making an alternative choice. For example, when you finally get in the lunch queue and your hand automatically picks up the plate of chips (which you *always* have), a prompting thought; ‘lunch-time detention/drama rehearsal’ might come into mind and you remember you need to be somewhere else today – no time for chips! Your memory has triggered your prefrontal cortex (brain bit) to inhibit (squash back) a pre-potent (strongly automatic) response (choosing chips), enabling you to take alternative action by planning a quicker meal that allows you to get to that important one-off appointment in time. Your working memory is continually ticking over, keeping information in mind and responding to little cues that link past events to future ones. If your brain hadn’t used its ‘executive function’ skills (triggering attention to over-ride automatic actions and using working memory to co-ordinate an alternative plan) your day would have been ruined.

<u>The Tasks</u>

1. **Walk/Don’t Walk and Day/Night Attention Tasks.** These games require you to stop automatic responses – either in response to a sound or as a verbal answer. Unfortunately, brains are lazy and prefer automatic responses to having to make an effort. Your brain’s lazy response is to carry on with the same action or response. Change the rules and there is now confusion in your brain with a battle between the automatic response and the required response. You had to actively pay attention to give the right answer. The task tests how efficient you are at ignoring an automatic impulse by concentrating on the required response. Not easy.
2. **Listening Recall and Odd-One-Out Working Memory Tasks.** These are really cunning and make your memory work very hard. Think of everything your poor brain has to keep ‘on-line’ here. First, it has to listen to a sentence, understand the meaning of the sentence and form a judgement about it while also, and this is the cunning bit, keeping in mind the last word of every sentence to repeat back at the end. Phew. It makes your brain hurt just thinking about it. This task is similar to many everyday events your brain takes care of for you, like actively solving little on-going problems such working out how much the sweets you buy on your way home come to and how much change (if any!) you should get. The Odd-One-Out task is a non-verbal, visuo-spatial version (visuo as in using your eyes and spatial as

in spaces). Having to process language and images while keeping your 'which one was it' choices in mind is very hard work for your working memory and tests your executive functions to the limit (well, perhaps not…everyone is different, after all).

3. **Words, Categories and Dots** – This is a task that involves quick thinking using language and visuo-spatial skills. Quick thinking is called mental fluency and being able to swap easily between two forms of activity is called 'shift' or switching. You might think this task was really easy compared with having to keep all that information in mind for working memory, but your brain was working just as hard. Again, brains can be lazy or just set in their ways and find coping with change difficult. Having to think up new words or swap categories needs your brain to keep updating what it's just done so that you don't repeat yourself and at the same time flick through your store of words to find new answers. It's the same with keeping track of shapes and forming new ones – hard work.

The trouble with brains is, sometimes they just don't think!

Thank you for taking part in my study. I hope you enjoyed yourself and have learnt something about how your brain works. Remember, you're the boss and sometimes your brain needs reminding of the fact!

APPENDIX 7: Exemplar Participant Certificate (not actual participant)

The Open University

Congratulations!

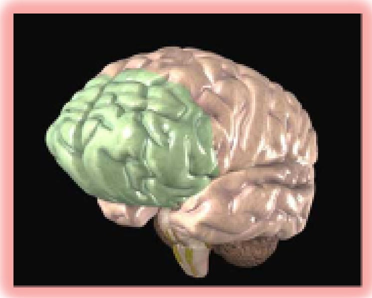
This is to certify that

PhD BRAINBOX CHALLENGE 2012

KATIE SMITH

....

successfully survived all the games, puzzles and tasks and has made a genuine contribution to scientific knowledge.



Thank you

Professor D Messer
J Kearvell-White
Doctoral Researcher

APPENDIX 8: Student Questionnaire

The Open University

Pupil Learning Questionnaire

Below are a set of statements that describe young people's behaviour. Your task is to indicate whether ***you*** have had any problems with these behaviours over the past six months.

- If the behaviour has ***never*** been a problem for you in the last 6 months, circle the letter ***N***.
- If the behaviour has ***sometimes*** been a problem for you in the last 6 months, circle the ***S***.
- If the behaviour has ***often*** been a problem for you in the last 6 months, circle the ***O***.

Please respond to all the statements by circling a letter for each one.

Your Name ………………………………………………………………………………… Form…………………………………….

Date of Birth ……………………………………………………………………………… Male/Female

	STATEMENT	NEVER	SOMETIMES	OFTEN
1 i	I interrupt others.	**N**	**S**	**O**
2 sc	I have trouble thinking of a different way to solve a problem when I get stuck.	**N**	**S**	**O**
3 i	I act too wild or 'out of control'.	**N**	**S**	**O**
4 sc	I have trouble coming up with different ways of solving a problem.	**N**	**S**	**O**
5 w	When I am given three things to do, I remember only the first or last.	**N**	**S**	**O**
6 w	I change topics in the middle of a conversation.	**N**	**S**	**O**
7 sb	It bothers me when I have to deal with changes (routines, foods, places).	**N**	**S**	**O**
8 w	I forget what I am doing in the middle of things.	**N**	**S**	**O**
9 i	I am impulsive.	**N**	**S**	**O**
10 i	I blurt things out.	**N**	**S**	**O**
11 i	I talk at the wrong time.	**N**	**S**	**O**
12 w	I make careless errors.	**N**	**S**	**O**
13 w	I have a short attention span.	**N**	**S**	**O**
14 i	I get out of my seat at the wrong times.	**N**	**S**	**O**
15 i	I have trouble sitting still.	**N**	**S**	**O**

16 sc	I try the same approach to a problem over and over, even when it does not work.	**N**	**S**	**O**
17 w	I have trouble with jobs or tasks that have more than one step.	**N**	**S**	**O**
18 w	I am absentminded.	**N**	**S**	**O**
19 w	I forget to hand in my homework, even when it's completed.	**N**	**S**	**O**
20 i	I talk too loudly.	**N**	**S**	**O**
21 i	I get in other peoples' faces.	**N**	**S**	**O**
22 sb	I get disturbed by an unexpected change (such as teacher, daily activity).	**N**	**S**	**O**
23 w	I have trouble staying on the same topic when talking.	**N**	**S**	**O**
24 w	When I am sent to get something, I forget what I am supposed to get.	**N**	**S**	**O**
25 sc	I have trouble accepting a different way to solve a problem with schoolwork, friends, tasks etc.	**N**	**S**	**O**
26 i	I have problems waiting my turn.	**N**	**S**	**O**
27 i	I don't think of consequences before acting.	**N**	**S**	**O**
28 sb	I get upset by a change in plans.	**N**	**S**	**O**
29 i	I think or talk out loud when working.	**N**	**S**	**O**
30 i	I get out of control more than my friends.	**N**	**S**	**O**
31 w	I have trouble remembering things, even for a few minutes (such as directions, phone numbers).	**N**	**S**	**O**
32 sb	I have trouble changing from one activity to another.	**N**	**S**	**O**
33 w	I forget instructions easily.	**N**	**S**	**O**
34 sb	I have trouble getting used to new situations (such as classes, groups, friends).	**N**	**S**	**O**
35 sc	I get stuck on one topic or activity.	**N**	**S**	**O**

Thank you for your time and effort in completing this questionnaire!

APPENDIX 9: SEN Group Standardized Ability Characteristics

SEN Students with Scores in the Typical Range (85 – 115)

Thirty-two (24%) SEN students achieved scores in the average and/or above average grades in *all* standardized assessments. Looking at scores in the 85 -115 range, ten of these SEN students were in the SA sub-group, eight in SA+ and two had Statements. These characteristics are presented below.

Characteristics of SEN Students with Standardized Scores 85 to 115

SUPPORT TIER	SUPPORT CATE.G ORY	TOTAL *n*
School Action (SA)	Moderate Learning Difficulties (MLD)	3
	Specific Learning Difficulties (SLD)	2
	Dyslexia/Literacy	1
	Non-Specified	4
School Action Plus (SA+)	Young carer/behavioural issues	1
	Behaviour	1
	Specific Learning Difficulties (SLD)	1
	Speech, Language and Communication Difficulties (SLCN)	2
	Moderate Learning Difficulties (MLD)	2
	Non-Specified	1
Statement	Specific Learning Difficulties (SPLD)	1
	Speech, Language and Communication Difficulties (SLCN)	1

These profiles show that many SEN students with average levels of ability had issues associated with language, literacy and moderate learning difficulties. The characteristics of SEN students with *high typical* abilities follow.

SEN High Typical Assessment Performances (116+)

There were SEN students at School Action and School Action+ in the sample who had scores above 116 in at least one of the standardized assessments. None of the statemented students were in this category. Seven SEN students performed exceptionally well in the BPVS, three in the TOWRE and four in the RPM but none presented above average ability across all assessments, indicating less consistent patterns of ability. The data is presented below in order of SEN level of additional need.

SUPPORT CATEGORY	SEN TIER	BPVS	RPM	TOWRE
Non-Specified	SA	121	*	124
Non-Specified	SA	123	*	*
Non-Specified	SA	121	*	*
Non-Specified	SA	*	*	119
Non-Specified	SA	*	*	122
Moderate Learning Difficulties	SA	122	*	*
Specific learning difficulties	SA	120	130	*
Cerebral Palsy	SA	*	120	*
Specific learning difficulties	SA	*	125	*
Speech, language, communication	SA+	133	*	*
Specific learning difficulties	SA+	116	*	*
Literacy, numeracy, epilepsy	SA+	*	140	*
		Mean/*SD*	**Mean/***SD*	**Mean/***SD*
		122.30/*5.21*	**128.75**/*8.53*	**121.67**/*2.51*

***** Typical Range (85 – 115)

The presence of a student at the entry level tier of support (SA) with school identified Moderate Learning Difficulties (MLD) and an exceptionally high BPVS score is worth noting and is elaborated in the discussion. Five of the higher ability SEN students were also on the *lowest tier* of intervention with *no specific educational need* attribution. This would suggest that either performance attainment tracking (PAT) or pastoral issues had flagged cause for concern and targeted progress was being actively monitored. Difficulties with literacy (specific learning difficulties) were the most prevalent needs of the remaining students and, as would be expected, above average performance was not found for decoding in these students. The findings about this group show that there were some students on the SEN register who had a typical profile of abilities on the RVR standardized assessments.

Summary of Typical Abilities in the SEN Group

SEN ability patterns across the standardized assessments were uneven. The highest percentage of high ability scores was on the BPVS. The SEN students with the strongest abilities were in the entry level group (SA) and had no identified issues, suggesting that these students may have had issues of a more pastoral nature. Overall, few SEN students had above average skills in non-verbal reasoning and decoding so these appear to be weaker abilities compared with Non-SEN students.

SEN Below Average Abilities

Atypical SEN Abilities: Standardized Scores 1SD below the Mean (≥70≤84)

Means in the category where scores were *above 70 and below 84* were well below 84 in all assessments, indicating that these students had particularly low literacy and non-verbal abilities. These students represented 36% of the SEN group for the BPVS, 36% for the TOWRE and 39% for the RPM.

Atypical SEN Below Average SEN Abilities (≥70≤84) in Two or More Standardized Assessments

Eight SEN students had scores below 84 and above 70 *in all three* assessments, suggesting general difficulties. This number included two students with statements of Autism Spectrum Disorder (ASD). The remaining six were at the entry level of provision (SA); five of whom had no identified difficulties and one had behavioural issues. This suggests there was a small group of six students flagged by teachers with issues which are causing concern but of no obvious origin.

Fourteen students were in this 'below 84 and above 70' score category in *two* assessments, including seven at SA, six at SA+ and two with a statement. Eleven of these students had extremely low scores (below 2SD) in non-verbal reasoning. Characteristics of these SEN students are presented below.

Atypical Extremely Low SEN Abilities: Scores 2SD below the Mean (<69)

Eight per cent of the SEN group were two standard deviations below the norm (<69) for the BPVS and TOWRE and 14% for the RPM. These means were appreciably below 69, suggesting these students had distinct disabilities with greater incidence in the non-verbal reasoning assessment (RPM). The characteristics of these extremely low SEN ability students are presented below, showing the RPM to have the *highest* incidence of extremely low scoring SEN students.

≤69 in One Assessment	Student Diagnosis	No of Students	SEN Tier
RPM	Moderate Learning Difficulties (MLD)	1	SA
	Specific Learning Difficulties	1	SA
	Behaviour Difficulties	1	SA
	No Specified Difficulties	5	SA
	Moderate Learning Difficulties (MLD)	2	SA+
	Attachment Disorder	1	SA+
	Non-verbal Learning Difficulties	1	SA+
	Cerebral Palsy	1	Statement
TOWRE	Specific Learning Difficulties	1	SA
	No Identified Difficulties	1	SA
	Speech, Language and Communication Difficulties	1	SA+
BPVS	***No SEN student was extremely weak in vocabulary alone***		

≤69 in Two Assessments	Student Diagnosis	No of Students	SEN Tier
BPVS and TOWRE	No Identified Difficulties	1	SA+
RPM and TOWRE	Foetal Alcohol Syndrome	1	Statement
BPVS and RPM	Premature Birth Medical Issues	1	Statement
≤69 in Three Assessments	Moderate Learning Difficulties	1	SA

Only one student, categorised at School Action with Moderate Learning Difficulties, performed below 2 SD in *all* standardized tests, suggesting general learning impairment.

Of the Non-SEN group, ten per cent of Non-SEN students were below average (scores below 85) in the BPVS, 9% on the RPM and 2% on the TOWRE but scores were only just below the 'typical' boundary (85) in the BPVS and TOWRE but the mean score of 74 for the RPM was considerably weaker. All these students were in the older (13/14) age range and from the same school. Non-SEN status implies that expected levels of attainment were being maintained by these students.

APPENDIX 10: Step 2 Standardized Coefficients for Predictors of the BRIEF in Chapter 7

DEPENDENT VARIABLE		SEN SELF RATINGS *n* = 103			SEN TEACHER RATINGS *n* = 103		
BRIEF Inhibit		**Beta**	***t***	**Sig**	**Beta**	***t***	**Sig**
EF Task	*Verbal Inhibition*	*-.026*	*-.258*	*.797*	*.028*	*.495*	*.622*
	Non-Verbal Inhibition	*-.081*	*-.733*	*.466*	*.115*	*1.850*	*.068*
	Verbal Switching	*.169*	*1.517*	*.133*	*.044*	*.675*	*.502*
	Non-Verbal Switching	*-.097*	*-.936*	*.352*	*.000*	*.000*	*1.000*
	Verbal EWM	*.072*	*.617*	*.539*	*-.079*	*-1.269*	*.208*
	Non-Verbal EWM	*.022*	*.202*	*.840*	*.009*	*.157*	*.876*
	Verbal Fluency	*-.010*	*-.088*	*.930*	*.123*	*1.866*	*.065*
Teacher SDQ	Emotional Symptoms	*.023*	*.183*	*.855*	-.173	-2.413	.018*
	Conduct Problems	*.101*	*.746*	*.458*	.451	5.966	.000**
	Hyperactivity	*.186*	*1.338*	*.184*	.492	6.301	.000**
	Peer Problems	*.054*	*.393*	*.695*	*.045*	*.594*	*.554*
BRIEF Shift							
EF Task	Verbal Switching	.283	2.620	.010**	*-.038*	*-.481*	*.632*
	Non-Verbal Switching	*-.174*	*-1.720*	*.089*	*.017*	*.229*	*.819*
	Verbal Inhibition	*-.116*	*-1.161*	*.249*	*.019*	*.258*	*.797*
	Non-Verbal Inhibition	*.005*	*.046*	*.963*	*.020*	*.251*	*.802*
	Verbal EWM	*.076*	*.667*	*.506*	*.061*	*.735*	*.464*
	Non-Verbal EWM	*-.143*	*-1.328*	*.188*	*-.047*	*-.602*	*.548*
	Verbal Fluency	*-.047*	*-.409*	*.683*	*.135*	*1.623*	*.108*
Teacher SDQ	Emotional Symptoms	*.205*	*1.645*	*.103*	.498	5.467	.000**
	Conduct Problems	*-.145*	*-1.104*	*.272*	*.168*	*1.757*	*.082*
	Hyperactivity	*.192*	*1.419*	*.159*	.197	1.994	.049*
	Peer Problems	*-.110*	*-.829*	*.410*	*.034*	*.346*	*.730*
BRIEF Working Memory							
EF Task	*Verbal EWM*	*-.111*	*-.953*	*.343*	*.004*	*.045*	*.964*
	Non-Verbal EWM	*-.054*	*-.482*	*.631*	*-.063*	*-.836*	*.406*
	Verbal Inhibition	*-.076*	*-.741*	*.461*	*.069*	*.982*	*.329*
	Non-Verbal Inhibition	*-.047*	*-.421*	*.675*	*.123*	*1.623*	*.108*
	Verbal Switching	*.123*	*1.105*	*.272*	*-.044*	*-.585*	*.560*
	Non-Verbal Switching	*-.129*	*-1.239*	*.219*	*.051*	*.721*	*.473*
	Verbal Fluency	*-.015*	*-.131*	*.896*	*.067*	*.835*	*.406*
Teacher SDQ	Emotional Symptoms	.275	2.138	.035*	*.148*	*1.697*	*.093*
	Conduct Problems	*.032*	*.238*	*.812*	*-.103*	*-1.122*	*.265*
	Hyperactivity	*.004*	*.030*	*.976*	.715	7.530	.000**
	Peer Problems	*-.072*	*-.526*	*.600*	*-.039*	*-.421*	*.675*

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