The achievement gap: The discrepancy between intellectual ability and academic achievement in children with autism

Jessica Howse

D.Clin.Psy thesis (Volume 1), 2019

University College London

UCL Doctorate in Clinical Psychology

Thesis declaration form

I confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature:

Name: Jessica Howse

Date: 24/09/2019

Overview

This thesis focuses on the academic achievement of children with autism, specifically the discrepancy between their intellectual ability and academic achievement. This discrepancy will be explored in detail, as well as what factors predict it.

The thesis starts with a conceptual introduction (Part 1) which provides a narrative of the existing literature on the academic achievement of children with autism. In addition, limitations of, and gaps in, the literature is discussed and key areas for future research focus are outlined.

The empirical research paper (Part 2) focuses on the discrepancy between intellectual ability and academic achievement, and thus the academic underachievement, of children with autism. It uses secondary data derived from them Millennium Cohort Study; a UK national longitudinal survey. Once underachievement has been established, this project will go on to explore the child, family and school factors that are predictive of this ability-achievement discrepancy.

The critical appraisal (Part 3) allows for a number of reflections on the process of carrying out this project. In particular it will explore the methodological and practical challenges faced when carrying out secondary data analysis. In addition, the variability of autism symptom presentation and how this impacts the generalisability of research findings will also be discussed.

Impact Statement

This project intends to increase understanding of how children with autism spectrum conditions (hereafter "autism") are performing in school. Specifically it will explore the Key Stage One academic achievement of these children and the child, family and school factors that influence the discrepancy between children's intellectual ability and their academic achievement. The expertise, knowledge and insight gained during this research will provide benefits for future researchers, as well as for individuals with autism and those that support them. Examples of the potential impact of this research are discussed below.

Firstly, this study will benefit academia by demonstrating methodology which increases the generalisability of research findings to the wider autism population. This is the first UK study to use a national longitudinal survey in order to investigate the discrepancy between intellectual ability and academic achievement in children with autism. Doing this will not only ensure a large sample size, but will also increase the likelihood of having a representative sample; thus improving the possible generalisability of the results. In addition, this research is one of only two studies to use an ecologically valid measure of academic achievement to explore the educational attainment of children with autism. Using a real-life measure of achievement commonly used in schools will further increase the generalisability and usefulness of the findings. Hopefully using this methodology in our research will demonstrate the importance of increasing external validity and promote the use of similar methods in future research. Furthermore this research will benefit academic by raising the profile of the Millennium Cohort Study amongst autism researchers and encourage others to utilise this data source.

Secondly, this research will have an impact on our understanding of the educational outcomes of children with autism. It is amongst the first UK studies to consider the underachievement of these children and will hopefully provide insight into how individuals, families and schools can support children with autism to reach their academic potential. Academic outcomes have been found to predict subsequent employment, as well as quality of life outcomes in children with autism (Keen, Webster & Ridley, 2016). Therefore gaining further understanding on this is vital. Previous research has demonstrated dissatisfaction from those within the autism community with regards to a lack of research that will make a difference to individuals' day-to-day lives (Pellicano, Dinsmore & Charman, 2014). One area requested for future research is how to ensure children receive the right educational support in order to reach their potential (Pellicano, Dinsmore & Charman, 2014). We are therefore hopeful that this project will be well received by the autism community. Understanding the academic achievement of children with autism and how to reduce possible underachievement and promote successful outcomes will be beneficial for individuals with autism as well as the families and teachers that support them.

References

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Acknowledgements

I would like to thank my supervisors Dr Will Mandy and Dr Emily Midouhas for their support and guidance throughout this project. Their contributions have been invaluable and I have thoroughly enjoyed working with them.

In addition I would like to express my gratitude to the UK Data Service and the Millennium Cohort Study for providing the data for this project. In particular I would like to thank the huge number of participants, families, teachers and researchers who were involved in the Millennium Cohort Study. Without the time and effort they dedicated to providing and collecting data, this project would not have been possible.

Lastly, I would like to thank my family and friends for their unwavering support throughout this project and during my doctorate. The advice and encouragement provided, as well as distractions when needed, were invaluable. Thank you in particular to my parents for always believing in me and for their continued love and support.

Part 1: Conceptual Introduction

The academic achievement of children with autism

Abstract

A narrative review was used to explore how children with autism spectrum conditions (hereafter "autism") are performing in mainstream school. The review starts by introducing autism; discussing the presentation and symptoms experienced, as well as challenges faced, by individuals with this condition. In addition it reviews factors that determine successful outcomes for these children, with particular focus on recent research that has highlighted school experience, including academic achievement, as one such factor.

This narrative review then goes on to examine the current literature on the academic achievement of children with autism. In particular it gives an overview on the academic profiles of children with autism, including their performance in reading, writing, and mathematics tasks. Additionally it compares the academic achievement of children with autism to typically developing peers. It then considers the predictors of academic achievement in children with autism, with particular focus on IQ and autism symptomology.

The narrative review ends with a discussion of the limitations of the current literature as well as gaps in knowledge and understanding. It provides suggestions for future research; asserting the motivation and rationale behind the empirical research paper.

Introduction

Autism is a lifelong neurodevelopmental condition estimated to occur in 1.0 - 1.5% of the British school-based population (Baron-Cohen et al, 2009). Reported prevalence of autism has increased over recent years. Early estimates identified fewer than 10 in 10,000 children with autism while current research suggest these rates have risen to around 110 per 10,000 (Matson & Kozlowski, 2011). Furthermore, more recent research using parent-reports of autism diagnosis has suggested that prevalence of autism in US children aged 3 to 17 years is 2.5% (Kogan et al, 2018). While the exact cause of the increased prevalence is unknown, much literature cites increased public awareness, changes in identification processes and reduced age of diagnosis to be responsible, rather than a true increase of the condition (Rice at al, 2012).

Autism is more commonly diagnosed in boys than girls with research citing a male-to-female ratio of three to one in high quality epidemiological studies (Loomes, Hull & Mandy, 2017). Core features of autism, as outlined in the Diagnostic and Statistic Manual Fifth Edition (DSM-5), include poor social interaction and communication as well as repetitive or stereotyped, and sensory, behaviours (American Psychiatric Association, 2013). Individuals with autism may have deficits across several domains including executive function (Hill, 2004), central coherence (Frith, 1989), social cognition (Baron-Cohen, Leslie & Frith, 1985), and language (Howlin, 2003). Associated features of autism include motor deficits (such as clumsiness or odd gait), disruptive and challenging behaviour, and emotional difficulties (such as anxiety or depression) (American Psychiatric Association, 2013). Children with more severe autism may also have intellectual impairment and/or language impairment (American Psychiatric Association, 2013).

Individual outcomes for children with autism are variable. While most continue to experience problems with interpersonal relationships, employment, social relationships and mental health in adulthood (Howlin, Goode, Hutton & Rutter, 2004), some are able to develop skills and adaptive behaviour and go on to experience success in these areas (Levy & Perry, 2011). Current research aims to understand how to better support children to achieve best possible outcomes.

Autism in education

Due to the nature of autism, many children with the condition face higher levels of difficulties in school compared to typically developing (TD) peers. Reduced social communication and interaction abilities mean that children with autism are often vulnerable to bullying and social exclusion (Attwood, 2006). Struggling to understand and communicate with others can also lead to disagreements and challenging behaviour and increased risk of school exclusion (Barnard, Prior & Potter, 2000). Furthermore, the school environment itself can be difficult for students with autism. Lack of order and predictability in school can lead to considerable stress (Humphrey & Lewis, 2008) and intense sensory stimuli, such as high noise levels in the classroom, can leave autistic students feeling overwhelmed and distracted (Myles & Simpson, 1998). These difficulties can lead to reduced ability to regulate emotions and increased symptoms of anxiety and depression (Macintosh & Dissanayake, 2006).

One growing area of interest is how children with autism are doing in school and the impact of school experiences on academic achievement and future outcomes (Burgess & Gutstein, 2007). Many children with autism face difficulties in school which can negatively impact school achievement and subsequent employment, independent living and quality of life outcomes (Keen, Webster & Ridley, 2016). Understanding more about how children with autism are performing academically at school, as well as which factors predict this, is therefore important for understanding how to ensure successful outcomes for children with autism.

Existing review of the literature

Keen and colleagues (2016) were among the first to complete a large scale review of this topic, providing an overview of the literature up until 2015. They reviewed 19 papers, all of which provided data on the academic achievement of children with autism. The key findings from this review are outlined and considered below.

Academic profile of children with autism

One of the areas of interest for Keen and colleagues (2016) was the academic profile of children with autism, including any areas of strength or weakness. Six papers included in their review focused on this (Griswold, Barnhill, Smith-Myles, Hagiwara & Simpson, 2002; Jones et al, 2009; Mayes-Dickerson & Calhoun, 2003a; Mayes-Dickerson & Calhoun, 2003b; Myles, Simpson & Becker, 1994; Troyb et al, 2014). In general the studies found that academic ability varied between participants, with some performing significantly above and others significantly below what was expected. When exploring academic profiles, the studies looked at reading, writing, and maths achievement separately. Overall, reading achievement was generally found to be in the average range and in accordance with IQ for individuals with autism with average or higher ability (IQ >80). For individuals with lower ability (IQ<80), basic reading achievement scores were above expected and appeared to be a relative strength. However, at a subtest level, reading comprehension scores were often low and incongruent with IQ, suggesting reading comprehension might be a weakness for children with autism (Jones et al, 2009; Mayes-Dickerson & Calhoun, 2003a; Troyb et al, 2014).

In general, the studies included in Keen and colleagues (2016) review did not find a discrepancy between IQ and writing achievement. However, two studies did conclude that scores from the written expression subtest of the Wechsler Individual Achievement Test (WIAT) were often lower than expected, based on IQ, and also lower than the other writing subtests (Mayes-Dickerson & Calhoun, 2003a; Mayes-Dickerson & Calhoun, 2003b).

The studies found mathematical achievement to be positively correlated with IQ but, at an individual level, there was sometimes variation in this. Discrepancies were noted for some participants between predicted mathematical achievement based on IQ scores and actual achievement, with scores either significantly lower or higher than expected (Griswold et al, 2002; Myles et al, 1994).

Comparing the academic achievement of children with autism and TD peers

Another aspect of the literature reviewed by Keen and colleagues (2016) was how the academic achievement of children with autism compares to that of TD peers. Four studies explored this and in general they found that children with autism have poorer academic performance than TD peers. Ashburner, Ziviani ad Rodger (2010) found high rates of teacher-rated academic underachievement in children with autism (54%) compared to TD students (8%). Mayes-Dickerson and Calhoun (2007) reported children with autism performed worse than TD peers on word reading, reading comprehension, numerical operation and written expression tests. Furthermore, children with autism above age 13, scored worse than TD peers on comprehension and interpretive tasks (Minshew, Goldstein, Taylor & Siegel, 1994). In contrast, children with autism aged less than 13 were found to do as well as, or better than, TD peers on procedural and mechanical tasks (e.g. spelling and computation) (Goldstein, Minshew & Siegel, 1994), which might suggest that academic underperformance could be more of a problem for children with autism as they get older. As children age, work becomes more complicated and may require greater use of complex skills such as social cognition, the ability to use inferences, and the ability to integrate meaningful information. These skills require both linguistic processing and social understanding; areas children with autism often find difficult. Perhaps this makes it harder for children with autism to keep up with TD peers as they get older.

These findings must be discussed with caution, however, as studies generally did not match participants on IQ. Instead t-tests were used during analysis to determine whether there were significant differences between the autism and TD groups. While most did not find a significant difference, Mayes-Dickerson and Calhoun (2007) found that their autism group and TD group did differ significantly in terms of their IQ, therefore steps had to be taken during their analysis to ensure this did not impact their results. While these steps during analysis helped to control for IQ differences and remove bias, they are not as effective as matching participants on IQ during sampling.

Predictors of academic achievement

Another area explored by the literature included in Keen and colleagues (2016) review was predictors of academic achievement in children with autism. The majority of the literature examined child characteristics, including autism symptomology and IQ, as possible predictors of academic achievement, while a small amount of research focussed on educational setting as a possible environmental predictor.

Studies exploring the impact of autism symptomology generally found that, after controlling for IQ, autism severity was related to academic achievement (Eaves & Ho, 1997). In terms of autism traits, sensory seeking behaviours and social skills were found to be predictive of academic achievement (Ashburner, Ziviani & Rodger, 2008; Estes, Rivera, Bryan, Cali & Dawson, 2011). However, in contrast, Manti, Schole and van Berckelaer-Onnes (2011) found that teacher and parent reports suggested no association between autism symptom reduction and subsequent academic growth. Perhaps this suggests that autism symptomology alone is not predictive of academic achievement.

Studies that looked at IQ generally found it to be a strong predictor of academic achievement in children with autism (Mayes-Dickerson & Calhoun, 2008; Venter, Lord & Schopler, 1992). Furthermore, Assouline, Foley-Nicpon and Dockery (2012) found that using IQ to predict academic achievement in children with autism is just as effective as it is to predict achievement in TD peers.

In relation to educational setting, Kurth and Mastergeorge (2010) concluded that students placed in inclusive settings showed higher achievement than those placed in specialist, self-contained classrooms. However, in contrast, a study by Eaves and Ho (1997) did not find a similar relationship between academic achievement and educational setting. As children spend a high proportion of time in school, it is surprising that research has not focussed on additional school-based environmental factors that might be predictive of academic achievement.

One limitation of the above literature is the methodology used to measure academic achievement. All the studies relied on standardised assessments of academic achievement, such as the WIAT or the Woodcock-Johnson Tests of Achievement. While these provide useful and controlled ways to measure achievement, they are not commonly used by schools due to the professional input and interpretation required. This has potential impact on the ecological validity of the literature.

Current review of the literature

Despite highlighting some interesting patterns in the academic achievement of children with autism, Keen and colleagues (2016) suggested that the lack of literature available at the time limited possible conclusions and left gaps in knowledge. Since this review was published, there has been an increase in research focusing on academic achievement in children with autism. Therefore this conceptual introduction will now identify and summarize relevant papers published after the review of Keen and colleagues (2016), and relate them to the findings of that review. This will provide a comprehensive overview of the literature on academic achievement of children with autism.

Strategy used to search the literature

The PsychINFO (Ovid interface) database was searched on the 12th March 2019 using a combination of the following descriptors: ‘autis* or asperger* or “pervasive developmental” or autism or ASD’ and ‘“academic performance” or “academic achievement” or grade* or attainment’ and ‘school* or educat* or class* or college*’. A date limit was applied to access papers from 2015 onwards in order not to duplicate papers included in the Keen review. The initial search resulted in 269 papers, after the removal of duplicates.

Inclusion and exclusion criteria

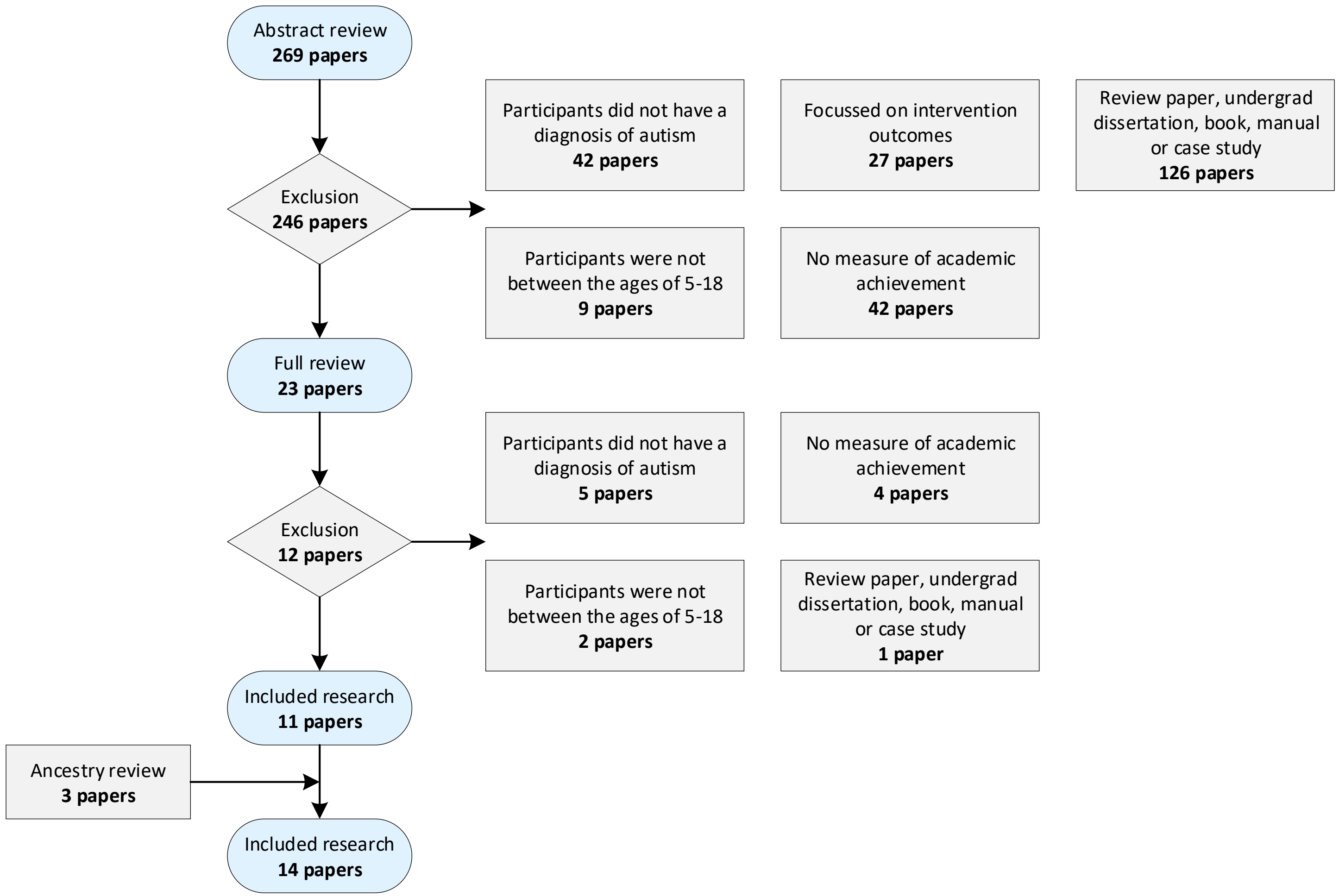
Studies were included in this conceptual introduction if the focus of their research was the academic achievement of children with autism. Studies were excluded if their focus was primarily intervention outcomes or if they were a review paper, undergraduate paper, book, manual or case study.

Procedure

Using the criteria above, the titles and abstracts of 269 papers were screened, resulting in the exclusion of 246 papers. Reasons for exclusion were: participants did not have a diagnosis of autism (42), participants were not between the ages of 5-18 (9), the focus of the paper was primarily on intervention outcomes (27), the paper did not include a measure of academic achievement (42), the paper was a review, undergraduate dissertation, book, manual, or case study (126).

The remaining 23 papers were reviewed and a further 12 were excluded because: the paper did not include a measure of academic achievement (4), participants did not have a diagnosis of autism (5), participants were not between the ages of 5-18 (2), the paper was a review, undergraduate dissertation, book, manual, or case study (1). Ancestry search of the remaining 11 papers, by reviewing any additional relevant research referenced by them, found a further 3 papers that met the inclusion criteria. See Figure 1.1 for an overview of the search procedure. Information on participants, purpose of study, measures used and key findings for the included 14 papers is highlighted in Table 1.1.

Figure 1.1:
The procedure used to review the literature concerning the academic achievement of children with autism



Measure of academic achievement

The studies included in this conceptual introduction, as well as those included in the review by Keen and colleagues (2016), used a wide range of measures to assess academic achievement. The most commonly used measures include the Wechsler Individual Achievement Test (WIAT; Wechsler, 2005) and the Woodcock-Johnson Tests of Achievement (WJ-II-ACH; Woodcock, McGrew & Mather, 2001). The WIAT is a test of academic achievement used with children and young people under the age of 16 years old. It examines functioning on a range of subtests across four areas: Reading, Mathematics, Written Language and Oral Language. The WJ-II-ACH includes 22 subtests to assess academic skills in reading, mathematics and writing, as well as oral language abilities and academic knowledge.

Other measures used by studies included in this conceptual introduction are: the Gray Oral Reading Test (Wiederholt & Bryant, 2012), the Differential Abilities Scale (Elliot, 1990), the Test of Auditory Processing Skills (Martin & Bronswell, 2005), the Wide Range Achievement Test (Wilkinson, 1993), the Neale Analysis of Reading Ability (Neale, 1999), the Set of Diagnostic Tests of Literacy Skills (Caravolas & Volin, 2005), the Little Star Test (Kucharska et al, 2014), the Test of Word Reading Efficiency (Torgesen, Wagner & Rashotte, 2012), the Clinical Evaluation of Language Fundamentals (Semel, Wiig & Secord, 2003), the Cognitive Developmental Skills in Arithmetic (Desoete & Roeyers, 2006), the Arithmetic Number Facts Test (de Vos, 1992), the Comprehensive Test of Phonological Processing (Wagner, Torgesen & Rashotte, 1999), and the Test of Mathematical Abilities (Brown, Cronin & McEntire, 1994). See Table 1.2 for a full list of measures used to assess academic ability. One study included in this review utilised students

National Curriculum results, rather than using a standardised measure, as an indicator of academic achievement (Waddington & Reed, 2017).

Table 1.1:

Participant characteristics, purpose of study, measures of academic achievement, additional variables, and key findings of the studies included in this conceptual introduction

Author (year)	**Sample size**	**Participant data (age, mean IQ, recruitment)**	**Purpose of study**	**Measures of academic achievement**	**Additional variables measured as potential predictors**	**Key findings: Academic profile**	**Key findings: Predictors of academic achievement**
McCauley et al (2018)	44 children with autism (38 male, 6 female). 36 TD children (23 males, 13 females).	IQ = >75 Recruited from the University of California (UC) Davis MIND Institute database.	To investigate the association between self-concept and actual achievement in mathematics and reading.	Wechsler Individual Achievement Test-III (Numerical Operations & Problem Solving subtests) Gray Oral Reading Test (5th edition).	Academic Self Concept was measured by Marsh Self-Description Questionnaire-II (Marsh SDQ-II, Marsh, 1992).	No difference in academic self-concept between autism and TD.	Mathematic self-concept positively predicted mathematic achievement in autism and TD groups. Reading self-concept significantly predictive of reading achievement in TD but there were no associations for children with autism. This research suggests that children have accurate self-concepts in mathematics but not in reading.
Nasamran, Witmer & Los (2017)	170 children with autism (136 male, 34 female).	80% male Age 13-18 Secondary data analysis from the National Longitudinal Transition Study	To investigate academic achievement and social skills in children with autism and whether they predict	Woodcock-Johnson Tests of Achievement III (Passage Comprehension, Applied Problems, Social Science, and Science subtests).	Social skills: Social Skills Rating System- Parent Form (Gresham & Elliot, 1990). Postsecondary success: defined as being enrolled/ graduated from postsecondary institution. Employment success:	Participant scores on WJ-III generally fell in the low average range compared to peers. Passage Comprehension/ Applied Problems Score were in the Low-Average range compared to same age peers. Social Science and	Academic achievement was a significant predictor of postsecondary educational success and overall success. Social skills were a significant predictor of postsecondary educational

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
		(USA).	postsecondary education, employment, overall success, and independent living.		defined as holding a current paid job since leaving high school and within the past two years of the interview. Overall success: defined as experiencing postsecondary educational and/or employment success. Independent living: defined as living independently from parent/ guardian and not in assisted care.	Science scores were in the Average Range. 60% sample experienced postsecondary educational success. 40% experienced employment success. 15% were considered to be living independently.	success, employment success, and independent living.
St. John, Dawson & Estes (2018)	32 children with autism	Average age = 9.46 years FSIQ 70+ Recruited from a larger, longitudinal study of development in autism (USA).	To examine the relationship between executive function and mathematical achievement.	Differential Ability Scale (Verbal Ability, Nonverbal Ability, Spatial Ability, and General Conceptual Ability subtests).	Executive function: A-not-B with Invisible Displacement (A-not-B ID) task (Diamond, Prevor, Callender & Druin, 1997) and the Spatial Reversal task (Kaufmann, Leckman & Ort, 1990).		Better executive function at age 6 was related to higher mathematics achievement. Executive function at age 6 was not related to spelling or word reading at age 9.
Grimm, Solari, McIntyre, Zajic &	65 children with autism (55 male, 10	Age 8-16 years. FSIQ 70+	Longitudinal study examining the development	Test of Auditory Processing Skills (Auditory Reasoning subtest)		Shape of trajectories for reading comprehension was nearly identical, but autism group performed	

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
Mundy (2017)	female). 37 TD children (24 male, 13 female).	Recruited from the local community via a research tracking system and word of mouth (USA).	of linguistic and reading comprehension skills in children with autism	Gray Oral Reading Test (5th edition)		significantly lower than the TD group. Autism and TD groups had different shaped trajectories for linguistic comprehension; TD showed nearly linear development but autism group did not, instead declined at the 3rd time point (30 months after start of the study) and did not reach the same overall level of achievement as TD peers. This suggests there may be a point at which linguistic comprehension skills for students with autism might not continue to develop.	
Kim, Bal & Lord (2018)	111 children (71% male). 74 had autism, 37 had a language disorder or	Participants were drawn from a longitudinal study of 213 children referred to diagnostic agencies for possible autism	To examine patterns of academic achievement in elementary and high school children with autism.	Wide Range Achievement Test-3 The Neale Analysis of Reading Ability	Cognitive skills: Wechsler Abbreviated Scale of Intelligence (WASI: Wechsler, 1999), Wechsler Intelligence Scale for Children (WISC-II; Wechsler, 1991), Differential Abilities Scale (DAS: Elliott, 1990), and the	Lower IQ group showed consistently lower achievement scores than the Higher IQ group for both autism and TD children Within autism group, 74% (at age 9) and 92% (age	Children who remained in general education/ inclusion classrooms showed higher achievement than those in special educational classrooms. FSIQ at age 3 significantly

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
	Intellectual Disability, and 11 were TD.	(USA).			Mullen Scales of Early Learning (Mullen, 1995). Expressive language: the Vineland Adaptive Behaviour Scale (Sparrow, Balla & Cicchetti, 2005). Class placement (general education or special education classroom). Hours parent spent at home conducting structured teaching intervention (based on TEACCH intervention) was measured using parent diaries and interviews.	18) showed discrepancy between ability and achievement in at least one academic domain.	predicted WRAT achievement scores (on arithmetic, word reading, and spelling) at ages 9 and 18. Parent participation in intervention by age 3 predicted better achievement at age 9 and 18.
Waddington & Reed (2017)	108 children with autism (90 male and 18 female).	5-17 years old Recruited through four local authorities in the South East of England.	To examine educational provisions for children with autism, using local authority archives.	National curriculum results	Portage (a skills-based intervention for families who have children with additional needs) Hours of learning support assistant Speech and language Therapy Social skills training		Children in specialist school performed better in English than those in mainstream schools, however there were no further differences in academic performance across the provisions; suggesting inclusion itself does not have a significant impact on academic success.

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
					Socio-economic status Autism severity School provision (mainstream or special education schools)		Autism severity did not have an impact on national curriculum outcomes (no comparison group – children might have been performing significantly below the average level). Hours of access to learning support assistant were negatively correlated with academic outcomes for children in mainstream schools. Access to speech and language therapy had significant positive impacts on academic achievement.
Sotakova & Kucharska (2017)	20 children with autism (16 male and 4 female).	Average age of 129 months Random sampling across the Czech Republic.	To examine the relationship between social skills and reading performance in children with autism.	Set of Diagnostic Tests of Literacy Skills (One Minute Reading Test & Non-word Reading Test). The Little Star test	Social skills: Strange Stories test (O'Hare, Bremner, Nash, Happé & Pettigrew, 2009).		Social skills were found to be predictive of reading and listening comprehension.

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
Miller et al (2017)	26 children with autism (22 male and 4 female).	Aged 8 years to 10 years and 11 months. Recruited from a larger, federally funded project at an American University.	To characterise achievement profiles of children with autism, to identify associations between cognitive, adaptive, and social functioning and academic abilities, and to examine potential preschool predictors of school-age academic achievement.	Wechsler Individual Achievement Test -II	Intellectual ability: the Mullen Scales of Early Learning (Mullen, 1995), the Differential Ability Scales (DAS-II; Elliott, 2007). Adaptive functioning: the Vineland Adaptive Behaviour Scales (VABS; Sparrow, Balla & Cicchetti, 1984). Autism severity: Childhood Autism Rating Scale (CARS; Schopler, Reichler & Renner, 1988).	Children with autism demonstrated greater impairment in reading comprehension compared to word reading ability.	Intellectual functioning and social communication skills at age 8-10 significantly predicted academic achievement. Participants with greater autism severity had lower academic abilities (especially in reading comprehension, numerical operations and mathematical reasoning). IQ accounted for significant variance in academic achievement. Cognitive, adaptive and social functioning account for a significant proportion of variance (33-73%) in school-age academic ability.
McIntyre et al (2017)	81 children with autism (66 male, 15 female)	Age 8-16 year FSIQ>75 Recruited through local	To examine reading performance of students with autism and whether	The Test of Word Reading Efficiency Clinical Evaluation of Language Fundamentals	IQ: Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011). Autism symptom severity: ADOS-2 (Lord et al, 2012).	Four distinct reading profiles emerged. (1) Readers with comprehension disturbance (2) Readers with global disturbance (3) Readers	Reading comprehension scores were highest when autism symptomology was lowest. Readers with severe global disturbance, who showed worst

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
		community school districts, a university research tracking system, and word of mouth (USA).	this is influenced by autism symptom severity.	Expressive vocabulary. Test of Auditory Processing Skills (Auditory Reasoning subtest) The Gray Oral Reading Test (5th edition)		with severe global disturbance (4) Average readers.	linguistic and reading comprehension achievement, had significantly higher levels of autism symptomology than children in the average and global disturbance reading groups.
Oswald et al (2016)	27 adolescents with autism (21 male, 6 female). 27 TD adolescents (21 male, 6 female).	FSIQ>80 Recruited through the University of California (UC) Davis MIND Subject Tracking database, the MIND Facebook page and flyers in local schools.	To examine giftedness vs. disability on mathematical performance in children with autism and to assess which cognitive and clinical factors predict this.	Wechsler Individual Achievement Test-III	IQ: Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011). Working memory: subtests from the Wide Range Assessment of Memory and Learning (WRAML2; Sheslow & Adams, 2003). Test anxiety: Behavioural Assessment System for Children (BASC-2: SRP-A; Reynolds & Kamphaus, 2004).	5.5 times as many students with autism (22%) evidenced a mathematics learning disability compared to mathematical giftedness (4%).	Perceptual reasoning, verbal ability, and test anxiety all predicted mathematical performance. Working memory did not predict mathematical performance.

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
Titeca, Roeyers, Loeys, Ceulemans & Desoete (2015)	121 children with autism (101 male and 20 female).	6-10 years old IQ = 80+ Recruited through the Flemish Ministry of Education and Training.	The purpose was to examine whether grade 1-4 HFA children scored differently from age-adequate norms on different mathematical domains.	Cognitive Developmental Skills in Arithmetic tests Arithmetic Number Facts Test	Autism symptom severity: the Social Responsiveness Scale (SRS; Roeyers, Thys, Druart, de Schryver & Schittekatte, 2011).	Children with autism show reduced procedural calculation abilities in first grade but tend to improve in later grades. Children with autism show age-adequate, or superior, performance on explicitly presented word/ language problems. Both first and fourth grade children with autism performed below average on time competence.	
Wei, Christiano, Yu, Wagner & Spiker (2015)	130 children with autism	Aged 6-9 years old Secondary data analysis from the Special Education Elementary Longitudinal Study (USA).	To explore academic achievement and growth trajectories of subgroups of children with autism.	Woodcock Johnson-III (Letter Word Identification, Passage Completion, Applied Problems & Calculation) Comprehensive Test of Phonological Processing (Rapid Letter Naming).	Social skills: the Social Skills Rating System – parent version (SSRS; Gresham & Elliott, 1990). Functional, social, and conversational skills and health condition- measured by parent responses. Demographic characteristic including annual household income and mothers' education level.	The autism group was approximately 1 SD below the national average for TD population on all the measures of academic achievement. 38.5% of sample had a higher achieving profile; they performed around national average of TD children on all academic measures, apart from Rapid Letter Naming.	The higher achieving group had significantly better educated mothers and came from higher-income households.

Author (year)	Sample size	Participant data (age, mean IQ, recruitment)	Purpose of study	Measures of academic achievement	Additional variables measured as potential predictors	Key findings: Academic profile	Key findings: Predictors of academic achievement
May, Rinehart, Wilding & Cornish (2015)	64 children with autism (32 male, 32 female) 60 TD children (30 male, 30 female).	Aged 7-12 years. Children with autism were recruited from a 'volunteer register' at the Monash University Centre and from private clinics. TD children were recruited from a Melbourne Primary School	To explore how literacy, numeracy and attentional skills develop over one year in primary school aged children with autism.	Wechsler Individual Achievement Test-II	Intellectual functioning: Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2005), and the Wechsler Abbreviated Scales of Intelligence (WASI; Wechsler, 1999). Short-term memory: the Auditory Processing Test (APT; Rowe, Pollard & Rowe, 2006). Attention switching ability: the Wilding Attention Tasks (WATT; Wilding, Munir & Cornish, 2001).	Cognitively able children with autism exhibited intact word reading and mathematics performance. No difference in word reading attainment in children with autism and TD children over the two time points. Children with autism performed similarly to TD children on mathematical tasks. Verbal IQ was significantly lower in children with autism.	Attentional components correlated significantly with word reading and mathematics performance in autism children only. Verbal IQ was a significant predictor of both word reading and mathematical achievement across the groups.
Bae, Chiang & Hickson (2015)	20 children with autism (18 male, 2 female). 20 TD children (13 male, 7 female).	IQ>80 Recruited from general education public schools, PTA networks, and autism support groups (USA).	To examine the difference in word problem solving performance between children with autism and TD peers.	Test of Mathematical Abilities Mathematical Word Problem Solving Test Wide Range Achievement Test.	IQ: Kaufman Brief Intelligence Test (BIT-2; Kaufman & Kaufman, 2004).	TD children showed significantly higher word problem solving ability than children with autism.	

Table 1.2:

Measures used to assess academic achievement in the studies included in this conceptual introduction

Academic achievement measure	Measure overview	Reliability and validity of measure	N studies in this review that used the measure	N studies in Keen review that used the measure
Wechsler Individual Achievement Test (WIAT; Wechsler, 2005)	The WIAT is a test of attainment used with children under the age of 16 years old. The WIAT examines functioning on a range of subtests across four areas: Reading, Mathematics, Written Language, and Oral Language.	- Validity correlations = .60-.82 (Burns, 2010) - Reliability coefficient = .91-.98 (Burns, 2010)	4	6
Woodcock Johnson Tests of Achievement (WJ-III-ACH; Woodcock et al, 2001)	The WJ-III-ACH includes 22 subtests designed to assess academic skills in reading, mathematics, writing, oral language, and academic knowledge. It is advertised for use with people aged from 2 to 90 years old.	- High concurrent validity (Schrank, Mather & McGrew, 2014) - Reliability coefficient = .81-.94 (Woodcock et al, 2007)	2	8
Gray Oral Reading Test (GORT; Wiederholt & Bryant, 2012)	The GORT measures oral reading abilities including; rate, accuracy, fluency, and comprehension and provides an overall reading index. The GORT can be used with individuals between the ages of 6 and 23 years.	- Reliability coefficients exceed .90 and reliability across subgroups within the normative sample is consistent (Wiederholt & Bryant, 2012) - Strong evidence to suggest GORT-5 has content, construct and criterion-related validity (Hall & Tannebaum, 2013)	3	0
Differential Ability Scale (DAS; Elliot, 1990)	The DAS includes 20 subtests to measure cognitive ability and achievement in children aged from 2 years to 17 years. The DAS provides an overall general conceptual ability score.	- Reliability for general conceptual ability ranges from .90-.95 and reliability coefficients range from .70-.92 across the subtests (Gordon & Elliott, 2001) - Evidence supports construct and concurrent validity of the DAS (Elliott, 1990; Keith 1990; Wechsler, 1991)	1	1

Academic achievement measure	Measure overview	Reliability and validity of measure	N studies in this review that used the measure	N studies in Keen review that used the measure
Test of Auditory Processing Skills (TAPS; Martin & Bronswell, 2005)	The TAPS includes 9 subtests which assess children's auditory processing abilities. The TAPS can be used with children aged from 4 to 18 years.	- Reliability coefficients range from .72-.96 (Martin & Bronswell, 2005) - Moderate concurrent validity (.54) (Martin & Bronswell, 2005) -	2	0
Wide Range Achievement Test (WRAT; Wilkinson, 1993)	The WRAT is a test of achievement, measuring academic skills in reading, spelling and mathematics. It can be used with individuals aged from 5 to 94 years.	- Reliability coefficient ranges from .85-.95 (Jantz et al 2015)	2	1
Neale Analysis of Reading Ability (NARA; Neale, 1999)	The NARA measures children's reading achievement, measuring the accuracy, comprehension, and rate of reading in children ages between 6 – 12 years.	- Reliability is between .84 - .91 (Nation & Snowling, 1997)	1	1
Set of Diagnostic Tests of Literacy Skills (Caravolas & Volin, 2005)	The Set of Diagnostic Tests of Literacy Skills includes several subtests, such as the One-minute Reading Test and the Non-word Reading Test, to assess reading ability in students aged 7 to 10 years old.	_	1	0
Little Star Test (Kucharska et al, 2014)	The Little Star test measures reading comprehension by asking students to answer 12 questions after listening to a recorded story.	_	1	0
Test of Word Reading Efficiency (TOWRE; Torgesen et al, 2012)	TOWRE contains two subtests that measure word reading skills, including accuracy and fluency, in individuals aged 6 to 24.	- Reliability coefficients exceed .90 (Tarar, Meisinger & Dickens, 2015) - Strong evidence for content, criterion, and construct is presented in the manual (Tarar et al, 2015) -	1	1

Academic achievement measure	Measure overview	Reliability and validity of measure	N studies in this review that used the measure	N studies in Keen review that used the measure
Clinical Evaluation of Language Fundamentals (CELF; Semel et al, 2003)	The CELF assesses language skills in children from 6 to 21 years old. It is designed to determine a child’s strengths and weaknesses as well as identify deficits.	- Reliability coefficients are estimated between .83 - .90 (Betz, Eickhoff & Sullivan, 2013). - Sufficient content, construct, and concurrent validity is cited in the manual (Semel et al, 2003)	1	0
Cognitive Developmental Skills in Arithmetic (CDR; Desoete & Roeyers, 2006)	The CDR included several subtests designed to assess procedural calculation and word/language problem solving abilities	- Cronbach’s alphas were between .89 and .93, depending on age of the child (Desoete & Roeyers, 2006)	1	0
Arithmetic Number Facts Test (TTR; De Vos, 1992)	The TTR is a timed arithmetic test. It assesses students’ ability and knowledge of addition, subtraction, multiplication, and division.	- Cronbach’s alpha of .90 (Desoete, Ceulemans, De Weerdt & Pieters, 2012).	1	0
Comprehensive Test of Phonological Processing (CTOPP; Wagner et al, 1999)	The CTOPP assesses phonological awareness, phonological memory, and rapid naming abilities in individual from 4 to 24 years.	- The CTOPP manual reports a high degree of reliability and validity, including content, construct, and criterion validity (Mitchell, 2001).	1	0
Test of Mathematical Abilities (TOMA; Brown et al, 1994)	The TOMA measures three aspects of mathematics in order to assess students’ performance and mastery of mathematical skills. Areas measured include attitude toward mathematics, understanding of the language of mathematics, and familiarity with mathematical concepts and terminology used in everyday life.	- Reliability coefficients exceed .80 (Brown et al, 1994). - Good content and criterion validity are reported by the authors (Brown et al, 1994).	1	0

Note. Abbreviation: N refers to number.
Abbreviation: Keen review refers to Keen et al’s (2016) review.

Findings

Academic profile of children with autism

Several studies included in this conceptual introduction focussed on describing the academic abilities of children with autism, in particular any areas of relative academic strength or weakness. Specific findings relating to reading, writing, and mathematical abilities are discussed below. One important overarching finding from this literature however is that children with autism tend to show poorer performance, compared to their other attainments, on academic tasks that require reasoning, the ability to make inferences, social cognition, and the use of abstract knowledge (Kim et al, 2018; Miller et al, 2017; Nasamran et al, 2017). This impacts upon both reading and mathematical tasks (e.g. the Reading Comprehension task from the WIAT, in which children respond to literal and inferential comprehension questions, and the Mathematical Reasoning from the WIAT, which assesses ability to reason mathematically). In addition, children with autism show significantly poorer performance on these tasks than TD peers (Bae et al, 2015; Grimm et al, 2017). This finding is consistent with our understanding and theories of autism. In particular, poorer performance in these areas may be explained by coexisting executive functioning difficulties (the term used for higher level cognitive processes such as planning, problem solving, working memory, cognitive flexibility, and verbal reasoning), weak central coherence (the ability to understand wider contexts), and impaired theory of mind (the ability to understand others mental states).

Another important finding from the literature is that differences between expected and actual achievement scores, based on intellectual ability, have been noted for children with autism. For example, Kim and colleagues (2018) reported that most children with autism in their sample (74% at age 9 and 92% at age 18) showed notable discrepancy between ability and achievement in at least one academic domain. When looking at their full sample all together, which included children with language disorder, intellectual disability, autism, and no diagnosis, Kim and colleagues (2018) identified a smaller proportion of children with discrepancy between IQ and achievement (66% at age 9 and 77% at age 18). The authors suggest this implies that discrepancy is more frequent in children with autism. In addition, Wei and colleagues (2015) suggest that, while in general, children with autism perform at a level below national average on all academic achievement measures (about one standard deviation), individual performance can vary and discrepancies between ability and actual achievement can arise. The authors suggest that this highlights the need for targeted interventions to support the academic achievement of children with autism.

Reading profile

The studies reviewed in this conceptual introduction tended to show that children with autism show poorer performance on reading comprehension tasks. Nasamran and colleagues (2017) found the passage comprehension tasks of the WJ-III-ACH to be in the low-average range for children with autism. In addition to this, both Kim et al (2018) and Miller et al (2017) found that children with autism tend to score higher on word reading, than reading comprehension, tasks. Reading comprehension relies on more complex skills such as social cognition, the ability to make inferences and the ability to integrate meaningful information. Poor reading, or passage comprehension, in children with autism is suggestive of impairments in linguistic processing as well as social understanding (McIntyre at al, 2017). For example, the ability to understand characters’ intentions, generate inference and understand narrative elements relies on an understanding of social norms and knowledge; something children with autism may lack. Furthermore, weak central coherence, and the tendency to focus on details rather than overall meaning, may mean that children with autism have difficulty integrating information with background knowledge and may struggle to gain an overall understanding of a piece of text (Norbury & Nation, 2011; Pellicano, 2010). This finding is supported by previous literature included in Keen and colleagues (2016) review which also suggests that reading comprehension is a relative weakness for children with autism (Jones et al, 2009; Mayes-Dickerson & Calhoun, 2003a; Troyb et al, 2014).

In addition to the above, studies included in this review and in Keen and colleagues (2016) review, highlighted discrepancies in reading ability among children with autism. Research by Kim and colleagues (2018) found reading ability varied on an individual level, noting discrepancies between ability and achievement in children with autism. Forty one percent of children with lower IQ (<85) showed unusually high achievement in word reading at age 9. Meanwhile, 16% of children with higher IQ (IQ>85) were found to have lower word reading achievement than expected. Discrepancies in reading ability and achievement were also noted in studies included in the Keen et al (2016) review (Assouline et al, 2012; Estes et al, 2011; Griswold et al, 2002; Jones et al, 2009; Mayes-Dickerson & Calhoun, 2003a, 2003b; Myles et al, 1994; Troyb et al, 2014).

Writing profile

Studies included in this conceptual introduction also highlighted discrepancies in writing ability among children with autism. Kim and colleagues (2018) noticed similar discrepancies in ability and achievement in children with autism on spelling tasks. Forty one percent of children with lower IQ (<85) showed unusually high achievement in spelling at age 9. While, 16% of children with higher IQ (IQ>85) were found to have lower spelling achievement than expected. Discrepancies in spelling ability and achievement were noted in a study by Estes and colleagues (2011) included in the review by Keen and colleagues (2016).

Mathematics profile

Literature included in this conceptual introduction has found that children with autism show poorer performance on mathematical tasks that require reasoning and abstract knowledge, with better relative performance on tasks requiring the ability to analyze and solve maths problems. This finding supports the theory that the executive functioning skill of problem solving is more impaired than rote numerical skills in children with autism (Minshew et al, 1994; Troyb et al, 2014). Miller and colleagues (2017) found that Math Reasoning subtest scores from the WIAT-II fell in the 'borderline' range whereas Numerical Operations subtest scores were slightly better and fell in the 'low average' range. Similarly to this, Nasamran and colleagues (2017) found that, on the Applied Problems subtest of the WJ-III-ACH (which is comparable to the Numerical Operations subtest), children with autism generally performed in the low average range. This finding that children with autism show numerical operations scores which are significantly higher than mathematics reasoning scores, was noted in research included in the review by Keen and colleagues (2016) (Jones et al, 2009).

In addition, another key finding from the recent literature is that, overall, children with autism generally have 'average' or 'below average' mathematical skills. This contrasts the stereotypical view that children with autism have enhanced mathematical abilities. Oswald and colleagues (2016) found that five times as many children with autism showed a mathematics learning disability compared to a mathematical giftedness. In addition, Titeca and colleagues (2015) found evidence to suggest that children with autism show reduced procedural calculation abilities in first grade but intact fact retrieval tasks that rely on rote memory rather than mathematical ability. Similarly, studies included in Keen and colleagues (2016) review found that, in general, mathematics achievement for individuals in higher ability groups (IQ>70) fell in either the ‘average’ or ‘below average’ range (Estes et al, 2011; Griswold et al, 2002; Mayes-Dickerson & Calhoun, 2003b; Myles et al, 1994; Troyb et al, 2014).

Discrepancies in mathematical ability among children with autism were noted in research included in this conceptual introduction. Kim and colleagues (2018) observed discrepancies in ability and achievement in children with autism on arithmetic tasks. Forty one percent of children with lower IQ (<85) showed unusually high achievement in arithmetic at age 18, while, 16% of children with higher IQ (IQ>85) were found to have lower than expected arithmetic achievement at age 9. Discrepancies in mathematical ability and predicted achievement were also noted in studies included in Keen and colleagues (2016) review (Estes et al, 2011; Jones et al, 2009).

Comparing academic achievement of children with autism to TD peers

Three studies in this review specifically focussed on comparing the academic achievement of children with autism to TD peers. Specific differences in reading and mathematical ability are discussed below. Overall, the studies included in this conceptual introduction, along with research included in Keen and colleagues (2016) review, support the theory that children with autism show poorer performance than TD children on tasks requiring reasoning, abstraction, and understanding.

In terms of reading ability, the literature supports the theory that children with autism show poorer performance compared to TD peers on comprehension tasks. Grimm and colleagues (2017) concluded that, while reading comprehension trajectories were nearly identical for both autistic and TD children (who had IQ >70), children with autism achieved significantly lower than TD groups on reading comprehension tasks. In addition, children with autism and TD peers had different linguistic comprehension trajectories, with children with autism not reaching the overall level of achievement as TD peers. Despite Grimm and colleagues (2017) ensuring participants in both groups had IQ greater than 70, as IQ was not controlled further by matching participants from both groups on IQ, the validity of their findings is unclear and must be discussed with caution. In contrast to the findings on reading comprehension, May et al (2015) found that the trajectories for word reading in children with autism and TD peers were similar, with no difference in word reading attainment. Word reading tasks rely on straightforward word recognition skills and May and colleagues (2015) suggest these skills are intact in children with autism.

In terms of mathematical ability, the findings from the literature are consistent with the theory that children with autism tend to show poorer relative performance on academic tasks that require reasoning, the ability to make inferences, social cognition, and the use of abstract knowledge. May and colleagues (2015) concluded that trajectories for numerical operations performance, in which children solve basic geometry, algebra and calculus questions, were similar for autism and TD children, with no significant difference in numerical operations achievement. In contrast, Bae and colleagues (2015) examined word problem solving, an important mathematic component requiring the use of mental representation and reading comprehension skills to solve an abstract calculation (Boonen, Koning, Jolles & van der Schoot, 2016). They found children with autism showed poorer performance than TD peers.

Predictors of academic achievement

Several studies included in this conceptual introduction and in Keen and colleagues (2016) review, focussed on factors that predict academic achievement in children with autism. Most studies focussed on child factors, with IQ and autism severity being the most widely reported on. However, some studies also explored the impact of parental and environmental factors on academic achievement.

Child-related predictors

The literature yields five important conclusions about what child-related factors predict academic achievement. First, IQ is a significant predictor of academic achievement in children with autism. Three studies included in this search explored the relationship between academic achievement and IQ, and concluded that IQ is a significant predictor (Kim et al, 2018; May et al, 2015; Miller at al, 2017). Miller and colleagues (2017) concluded that IQ accounted for a significant variance in academic achievement in their sample of children with autism. IQ was found to be particularly predictive of word reading and reading comprehension. The authors concluded that IQ is the best predictor of academic achievement and is able to explain the variance in academic ability more so than factors such as autism symptoms or severity. In addition, May and colleagues (2015) found that IQ predicted academic achievement on both reading and mathematical tasks for children with autism as well as it did for TD children. Building on this, Kim and colleagues (2018) found that, overall, full scale IQ (FSIQ) significantly predicted achievement scores on the WRAT across all academic domains, including arithmetic, word reading, and spelling, for children with autism and TD peers. Children with higher IQ consistently showed higher achievement scores compared to children with lower IQ. In addition to this, children with higher FSIQ also showed greater improvement in academic abilities from age 9 to 18. These findings, along with similar findings from research included in Keen and colleagues (2016) review (Assouline et al, 2012; Eaves & Ho, 1997; Mayes-Dickerson & Calhoun, 2008; Venter et al, 1992) provide a large amount of evidence to conclude that IQ predicts academic achievement in children with autism.

Second, despite the correlation between IQ and achievement, some children with autism still show discrepancies between their IQ and their academic achievement. Kim and colleagues (2018) identified that most of the children with autism in their sample (74% at age 9 and 92% at age 18) showed discrepancy between their IQ and academic achievement in at least one academic domain. Additional research has suggested that approximately 60% of children with autism show achievement profiles that are lower than expected based on IQ, while a similar number show achievement profiles that are higher than expected (Estes et al 2011). Higher rates of discrepancy have been found in children with autism compared to TD peers. Ashburner and colleagues (2010) found that teacher-rated academic underachievement in children with autism was 54% compared to 8% for TD students. Together, this research suggests that the relationship between IQ and academic achievement is not always straightforward, especially in children with autism. This finding is important as it highlights the need to assess individual strengths and weaknesses in order to establish how best to support each child with autism and enable them to reach their academic potential.

Third, autism severity is a significant predictor of academic achievement. Four studies included in this search explored the effect of autism severity on academic achievement (McIntyre at al, 2017; Miller et al, 2017; Sotakova & Kucharski, 2017; Waddington & Reed, 2017). Miller and colleagues (2017) found evidence to suggest that autism severity predicted WIAT-II reading and mathematics scores; children in their sample with more severe autism showed poorer achievement scores. In addition to this, McIntyre and colleagues (2017) concluded that autism severity is negatively associated with reading ability. They found that reading comprehension scores, in their sample of children with autism, were highest when autism symptomology was lowest. One widely reported aspect of autism symptomology is social skills deficits. Sotakova & Kucharski (2017) examined the impact of this on academic achievement and found evidence to suggest that performance on comprehension and linguistic tests was related to the social skills of the children in their sample. These findings are consistent with those reported in Keen and colleagues (2016) review which also concluded that autism severity predicts academic achievement (Ashburner et al, 2008; Eaves & Ho, 1997; Estes et al, 2011). In particular, Ashburner and colleagues (2008) suggest that increased symptoms of, and difficulties with, sensation seeking and auditory filtering are negatively associated with academic achievement. However, in contrast to the above research Waddington and Reed (2017) did not find evidence to suggest that autism severity impacted academic success. The authors speculated that this finding may be due to their sample consisting of children with autism who were performing at very low levels, and significantly below average, on the national curriculum. Perhaps, if their sample also included higher achievers, this finding would be different. Some research included in Keen and colleagues (2016) review also found evidence against autism symptomology as a predictor of academic achievement (Estes et al, 2011; Manti et al, 2011). Taken together, these findings suggest that while autism severity is a predictor of academic achievement, it is not always consistent and cannot explain the variance in academic achievement as effectively as IQ can (Miller et al, 2017).

Fourth, executive function is a significant predictor of mathematical achievement in children with autism. St. John and colleagues (2018) explored the relationship between executive function and academic achievement in children with autism. They found that early executive function skills (at age 6) were related to higher maths achievement and could be used to explain the variance in maths achievement better than IQ could. However, executive function skills at age 9 could not be used to predict maths achievement. In addition, executive function at both ages 6 and 9 did not predict spelling or reading achievement. The authors suggest that early implementation of interventions to improve executive functioning and cognitive flexibility in children with autism may lead to better academic outcomes later on.

Fifth, academic self-concept is a significant predictor of academic achievement. McCauley and colleagues (2018) examined the relationship between academic self-concept, a student's perception of his/her academic capabilities, and academic achievement in children with autism. While they found no difference in self-concept between children with autism and TD peers, self-concept was predictive of mathematical and reading performance in TD students but only predictive of mathematical achievement in children with autism. The authors understand this finding in relation to the type of feedback children receive in these subjects. It is perhaps easier to evaluate competency, and your own abilities, in maths as it is based on correct or incorrect answers. Whereas it may be harder for children with autism to understand how to be competent in reading as marking criteria is not based on correct on incorrect answers, making it harder to gauge own abilities. This is consistent with our understanding of the rigid, rule-following characteristics many individuals with autism possess.

Environmental predictors

As of yet, there has been very little research into the environmental factors that predict academic achievement in children with autism, despite the fact that these are recognised to be important in the TD population (Baker, Bridger & Evans, 1995). Gaining a better understanding of environmental factors is vital as they are more likely to be modifiable and therefore possible targets for intervention. In the review conducted by Keen and colleagues (2016), educational setting was the only environmental factor explored. Following their review, the authors acknowledged the lack of literature investigating environmental predictors of achievement and concluded that, given the amount of time children spend at school, understanding school based factors is essential. We would also argue that the literature exploring family or parental factors is even more limited and under-researched. Gaining an understanding of these factors could contribute a great deal to our knowledge of predictors of academic achievement in children with autism and subsequently how to best support these individuals to reach their academic potential. Since Keen and colleague's (2016) review, environmental factors have been explored further in the recent literature. These studies reiterate the importance of the environment and have made three useful conclusions.

First, maternal education and socioeconomic status are significant predictors of academic achievement. Wei and colleagues' (2015) research found four distinct profiles in children with autism: higher-achieving, hyperlexia, hypercalculia, and lower-achieving. When examining demographic differences across groups, they found that children with a higher-achieving profile had significantly better educated mothers and came from higher income households. This is in line with research in TD populations evidencing the association between academic achievement and socioeconomic status (SES). Family SES directly impacts upon achievement at school in terms of increasing availability of resources at home but also indirectly impacts achievement by providing the social capital, or social connections, that are important for academic success (Sirin, 2005). Wei and colleagues' (2015) research importantly highlights that this association between SES and academic achievement is also evident in families with children who have autism.

Second, school support is a significant predictor of academic achievement. Waddington and Reed (2017) explored the impact of different types of support in school on academic achievement and educational outcomes. Firstly, they found that, for children in mainstream schools, hours of support from a learning support assistant (LSA) was negatively correlated with academic achievement, regardless of autism severity. This finding has been replicated previously and research has criticised LSA support as it decreases the challenges and lowers the expectations of the child, and the teacher is often less involved with the student if LSA support is in place (Ainscow, 2000; Osborne & Reed, 2011). However, it is worth noting that LSA support is usually allocated based on the additional needs of the child, and autism severity is only one aspect of this. Therefore the negative correlation between LSA support and academic achievement could be explained by children with LSA support having lower levels of academic achievement to begin with, rather than low academic achievement being a product of LSA support. More research is needed to fully understand the impact of support on academic achievement in children with autism. Secondly, the authors noted that access to support from Speech and Language Therapy (SLT) positively impacted upon academic achievement across all subjects, regardless of autism severity. The authors suggest that SLT improves communications, behaviour, and peer interactions, which in turn has a positive impact on academic achievement and outcomes (Durrand & Carr, 1992; McGee, Almeida, Sulzer-Azaroff & Feldman, 1992).

Third, school type has been found to be inconsistent as a predictor of academic achievement. One study included in this search explored school factors and their relationship to academic achievement of students with autism. Waddington and Reed (2017) aimed to compare the effect of school type on academic achievement. They included children with autism who were placed in mainstream or specialist schools that had National Curriculum outcomes, therefore reducing the impact of severity. Children in specialist schools were found to perform better in English than those in mainstream school, however there were no further differences in academic achievement. The authors concluded that school type itself does not have a significant impact on academic achievement. This finding is consistent with a paper included in Keen and colleagues' (2016) review (Eaves & Ho, 1997). However, in contrast, another paper included in Keen and colleagues' (2016) review found evidence to suggest that children placed in inclusive settings showed higher achievement than those places in specialist schools (Kurth & Mastergeorge, 2010). Overall, findings on the impact of class type on academic achievement appear to be inconclusive and inconsistent.

Methodological limitations

The above findings must be interpreted with caution due to several methodological limitations of the existing literature. These limitations are discussed below.

First, all but one of the studies included in this conceptual introduction and all the studies included in Keen and colleagues' (2016) review, relied on standardised assessments of academic achievement. While these provide useful and controlled ways to measure achievement, they require professional input for administration, scoring, and interpretation and are therefore not commonly used by schools. This has potential impact on the ecological validity of the literature. All primary schools in England use National Curriculum assessment, referred to as Statutory Assessment Tests (SATs) to assess the attainment of pupils. SATs include a combination of testing and teacher assessment in order to track students' achievement against expected rates. For research to be relevant and useful, it needs to be applicable to real-life settings. Waddington and Reed's (2017) research is the only existing literature in this field to use National Curriculum scores as a measure of academic achievement. It could be argued that using these scores helps to make research more relevant, applicable, and useful for children, schools and families. More research using these real-life measures of achievement are needed in order to fully understand how children with autism are performing academically at school.

Second, the measurement of IQ and attainment by previous literature may lack construct validity. IQ and attainment tests may not be measuring distinct criteria and instead might be influenced by autistic symptoms such as: noise sensitivity, anxiety, rigidity and dislike of change. For example, if a child struggles with changes to their environment and routine, attainment tests (such as the WIAT) that are completed in an unfamiliar lab or clinical setting might produce lower achievement scores than key stage tests that are completed in the child's usual school environment, thus questing the construct validity of clinic-based attainment measures. Another example might be the impact of handwriting difficulties on assessment validity. Research suggests that children with autism often experience significant handwriting difficulties, producing fewer legible letters and words and making more errors with size and formation than TD children (Fuentes, Mostofsky & Bastian, 2009; Hellinckx, Roeyers & van Waelvelde, 2013). Reduced performance on written elements of cognitive tests (e.g. the coding subtest of the WISC) may therefore highlight a symptom of autism rather than reduced cognitive ability. It is important to consider the construct validity of IQ and attainment measures when interpreting findings.

Third, many of the studies included in this conceptual introduction, and in Keen and colleagues (2016) review, lack representative samples. Research often recruited children from their local communities using local authorities, schools and clinics to advertise and find volunteers to participate. This method of volunteer, or opportunity, sampling is prone to bias as the sample selected may not be representative of the wider population. Furthermore, many of the studies that selected participants from their local community had small sample sizes (the number of participants in each study ranged from 15-118 with an average of 55 participants). This is problematic as findings may not be generalisable to the wider population. In contrast, far fewer studies employed random sampling techniques to ensure a nationally representative sample. Nasamran et al (2017) and Wei et al (2015) were the only studies included in this conceptual introduction to do this. Both used American national longitudinal surveys to draw their samples from. Not only does this allow for the best chance of an unbiased, representative sample but it also increases the chance of a greater sample size as a larger population is being sampled (Nasamran and colleagues' study included 170 children with autism and Wei and colleagues' study included 130 children with autism). Future research into the academic achievement of children with autism should prioritise using sampling techniques and methods that ensure the sample is representative of, and therefore generalisable to, the wider population.

Fourth, many of the studies included in the review by Keen and colleagues (2016) and this conceptual introduction lack suitable and appropriate control groups (in fact only one third of the studies included this). For studies simply reporting the academic profiles of children with autism, this may be less of a problem. However, for the studies reporting on predictors of academic achievement, or the underachievement of children with autism, having a control group is essential to establish whether the finding is unique for children with autism or applicable to TD children also. For example, Ashburner and colleagues (2010) found higher rates of teacher-rated academic underachievement in children with autism (54%) compared to TD students (8%). Having this control group enables us to identify that academic underachievement is more prevalent in the sample with autism and therefore implies that there is something specific to children with autism that means they are not able to achieve their academic potential. Knowing this will help us direct further research and support for these children. In contrast, Kim and colleagues (2018) reported that most children with autism in their sample (74% at age 9 and 92% at age 18) showed discrepancy between ability and achievement in at least one academic domain. They compared this to the proportion of children in their full sample that also showed a discrepancy (66% at age 9 and 77% at age 18). However, this full sample included a mix of children with a language disorder or intellectual disability (n=26), autism (n=74), and no diagnosis (n=11) and thus does not serve as a clear control group. Without having a suitable control group to compare to, these figures lack context and meaning as we are unable to ascertain how this discrepancy level compares to other populations and therefore whether it is unusual or not. In addition to including a control group, it is important that controls are matched with the target sample so as not to risk the validity of any findings. Most of the studies that included control groups either matched participants on variables such as age, gender, and IQ, or used t-tests to ensure that there were no significant differences between the groups on these areas. However, not all of the existing literature did this. It is important for future research to include this so we can ensure that any differences found between the academic achievement of children with autism and TD peers is valid and not actually due to a difference in other variables, such as gender or age.

Fifth, the majority of the studies in this introduction, and the studies included in Keen and colleagues (2016) review, fail to acknowledge the impact of environmental factors on the academic achievement of children with autism, despite these being well researched in the TD population. While it is important to explore child-factors that impact upon academic achievement, understanding environmental factors such as family-based and school-based factors is also necessary, especially given the amount of time children spend in these settings. In terms of interventions and support offered to children with autism, school based interventions may also be the most practical and efficient way of reducing underachievement, therefore consideration of these is vital (Baker et al, 1995). Research in TD populations has found that combined models which incorporate child, family and school variables give the most robust understanding of academic underachievement (Baker et al, 1995). As is the case for TD students, variables from all of these areas need to be considered in order to fully conceptualise and understand the academic underachievement of children with autism. This will allow us to understand how to intervene successfully and support these children to reach their academic potential. Future research needs to bear this in mind when exploring predictors of academic achievement in children with autism.

Summary

This conceptual introduction sought to further explore and understand the academic achievement of children with autism. Taken together with Keen and colleagues' (2016) review, the existing literature helps to outline the academic profile of children with autism, compare achievement between children with autism and TD peers, and suggest variables that can be used to predict the academic achievement of children with autism.

Existing literature has focussed on exploring predictors of academic achievement. The majority of the research has explored child factors, such as IQ and autism severity, that predict academic achievement with recent research expanding to look at a few environmental factors also. While child factors are obviously important to consider, in order to know how best to support children to reach their academic potential, it is also useful to explore environmental factors, including parental factors and school factors, that predict academic achievement. Environmental factors are often less static. Therefore knowing which environmental factors predict discrepancy between ability and achievement will help us to know how to make changes to the environment and provide tailored support for children with autism in order to reduce rates of under-achieving and help children to reach their potential.

While insight into predictors for academic achievement is important, what would be interesting to explore however, is which factors predict the discrepancy between intellectual ability and academic achievement and thus the academic underachievement of children with autism. While existing literature has already begun to suggest a discrepancy between ability and achievement, few studies have measured this underachievement in a rigorous way and used it as an outcome measure. In addition, existing research has often failed to include representative samples, suitable control groups, and ecologically valid measures and consequently these findings have to be interpreted with caution. Using underachievement as an outcome measure would enable us to focus on those children with autism who show discrepant ability and achievement to investigate what factors predict this. Knowing this will help us to be better equipped in supporting children to meet their expected potential but also to provide us with insight into how to help children with autism achieve over and above what is expected from them.

Bearing this in mind, it is therefore important for future research to continue to explore the discrepancy between intellectual ability and academic achievement in children with autism. Once this discrepancy has been established and examined, research should investigate which child, parental, and school factors predict the discrepancy in order to understand how to best support children with autism to reach their academic potential. This will not only have a positive impact on educational and subsequent employment outcomes, but also on independent living and quality of life outcomes (Keen et al, 2016).

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Part 2: Empirical Research Paper

The achievement gap: The discrepancy between intellectual ability and academic achievement in children with autism

Abstract

Aims: To investigate the academic underachievement of children with autism by examining the discrepancy between intellectual ability and academic achievement. In addition, this project sought to investigate individual, family and school-related variables associated with academic underachievement in children with autism.

Method: This study involved secondary data analysis, drawing its sample from the Millennium Cohort Study. Our sample included 226 children with autism and two control groups of 106 children with Attention Deficit/Hyperactivity Disorder (ADHD) and 7,159 typically developing (TD) children. Overall Key Stage 1 (KS1) attainment scores, as well as KS1 attainment scores on a subject basis for reading, writing, mathematics and science were used as measures of academic achievement. We created a "KS1 performance discrepancy score" to estimate the gap between KS1 scores and standardised IQ scores in order to measure academic underachievement. Variability in KS1 performance discrepancy scores across diagnostic groups (autism, ADHD and TD) was explored. In addition, correlations between this outcome measure and possible predictor variables were investigated for the autism sample.

Results: A significant difference was found to indicate that children with autism, who undertake KS1 assessments, underachieve academically compared to TD peers. No significant difference was found between autism and ADHD samples or between ADHD and TD samples, suggesting academic underachievement is significantly more prevalent in children with autism. Further analysis showed that the children in our autism sample had significantly greater underachievement, in writing and mathematics. Analysis of predictor variables provided limited information on child, family and school factors associated with academic underachievement of children with autism.

Conclusions: The underachievement of children with autism was evidenced using a nationally representative sample and an ecologically valid measure of academic achievement. This finding relates specifically to children who have undertaken KS1 assessments. Robust control groups suggest significant underachievement is not evident in TD or ADHD child populations. Future research is needed to explore further what factors predict this underachievement. Knowing this will allow us to provide tailored support to these individuals and increase the likelihood of successful educational, employment and subsequent quality of life outcomes.

Introduction

Autism is a lifelong neurodevelopmental condition. It is characterised in the Diagnostic and Statistic Manual, Fifth Edition (DSM-5) as a dyad of impairments in: (1) social and communication difficulties and (2) fixed interests and repetitive or stereotyped behaviours (American Psychiatric Association, 2013). Autism is referred to as a spectrum condition as the severity of symptoms can vary between individuals (Worley & Matson, 2012). Additional difficulties commonly experienced by people with autism include emotional and behavioural problems, speech and language difficulties, motor deficits and feeding and eating problems (Maskey, Warnell, Parr, Le Couteur & McConachie, 2013). Individuals with more severe autism may also have intellectual impairment (American Psychiatric Association, 2013).

Prevalence rates of diagnosed autism have recently been estimated at 2.5%, based on parent reports of US children aged 3 to 17 years old (Kogan et al, 2018). Reported prevalence has increased over recent years with early estimates identifying fewer than 10 in 10,000 individuals with the condition (Matson & Kozlowski, 2011). Increased public awareness, changes in identification processes and reduced age of diagnosis are thought to be responsible for the increase in prevalence, rather than a true increase of the condition (Rice at al, 2012). Autism is more commonly diagnosed in boys than girls, with high-quality epidemiological research citing a male-to-female ratio of three to one (Loomes, Hull & Mandy, 2017). The average age of diagnosis in UK children has been found to be 89 months (Crane, Chester, Goddard, Henry & Hill, 2015).

Individual outcomes for children with autism are variable. While most continue to experience problems with interpersonal relationships, employment, and mental health in adulthood (Howlin, Goode, Hutton & Rutter, 2004), some are able to increase skills and adaptive behaviour and go on to experience success in these areas (Levy & Perry, 2011). One growing area of interest is children's academic outcomes as these have been found to predict subsequent employment, independent living, and quality of life outcomes (Keen, Webster & Ridley, 2016).

Academic achievement in children with autism

Previous literature has explored factors that predict academic achievement in children with autism. The most widely reported of these include IQ and autism severity (Kim, Bal & Lord, 2018; May, Rinehart, Wilding & Cornish, 2015; McIntyre at al, 2017; Miller at al, 2017; Sotakova & Kucharski, 2017). Additional factors found to impact academic achievement are executive function (St. John, Dawson & Estes, 2018), academic self-concept (McCauley et al, 2018), maternal education and socioeconomic status (Wei Christiano, Yu, Wagner & Spiker, 2015) and speech and language therapy support in school (Waddington & Reed, 2017). Interventions targeting some of these factors may help to support children with autism and increase their academic functioning.

The discrepancy between intellectual ability and academic achievement

Children with autism may show discrepancy between their intellectual ability, estimated using IQ, and academic achievement, with some children underachieving academically despite having average intellectual abilities. Estes, Rivera, Bryan, Cali & Dawson (2011) found significant discrepancies between actual and expected academic achievement in 60% of the children with autism in their sample. A similar study by Ashburner, Ziviani & Rodger (2010) found that 54% of students with autism, aged between 6 and 10 years, underperformed academically compared to only 8% of their typically developing (TD) peers. In addition, Kim and colleagues (2018) found that most children with autism (74% at age 9 and 92% at age 18) showed discrepancy between ability and achievement in at least one academic domain. Even individuals with less severe autism have been found to show poorer performance than their TD peers in some areas (Troyb et al, 2014).

Methodological limitations of this literature mean that current findings on the discrepancy between intellectual ability and academic achievement in children with autism should be interpreted with caution. Reliance on standardised assessments of academic underachievement has implications on the ecological validity and usefulness of findings. Previous studies have used measures such as the Woodcock-Johnson Test of Achievement (Woodcock, McGrew & Mather, 2001), the Achenbach System of Empirically Based Assessment (Achenbach & Rescorla, 2001), the Differential Ability Scales (Elliott, 1990) and the Wide Range Achievement Test (Wilkinson, 1993) to measure academic achievement (Ashburner et al, 2010; Estes et al, 2011; Kim et al, 2018; Troyb et al, 2014). While offering controlled measurement, these kinds of assessments are not commonly used by schools and therefore do not give a completely accurate indication of real-life academic achievement in a classroom environment. Furthermore, the sampling techniques used in previous research limit the validity and generalisability of findings on the discrepancy between intellectual ability and academic achievement. Small sample sizes, such as 28 (Ashburner et al, 2010) or 30 children with autism (Estes et al, 2011) have an implication on power as they are only sufficient to detect larger effects (Troyb et al, 2014). In addition, the use of unsuitable control groups questions the reliability and usefulness of some of these findings. While Ashburner and colleagues (2010) helpfully compared their finding of an ability-achievement discrepancy in children with autism against a control group of TD children, Kim and colleagues (2018) used their full sample, including children with language disorder, intellectual disability, autism and no diagnosis, as a control group. Without suitable control groups, the findings on the discrepancy between intellectual ability and academic achievement in children with autism lack specificity.

Gaining an accurate understanding of the discrepancy between intellectual ability and academic achievement in children with autism is vital as research has suggested that academic underachievement could have a significant negative impact on children. Not only might it lead to reduced self-esteem and motivation (Ashburner et al, 2010), but it can also impact upon later life as success in school provides children with important skills needed for independent living and meaningful career choices (Estes et al, 2011). Research also suggests that academic underachievement may lead to children feeling unprepared for further educational or vocational courses, earlier school drop-out, poorer job prospects, and worse health outcomes (Dianda, 2008; Paunesku et al, 2015). Understanding the discrepancy between ability and achievement, and the reasons why some children with autism may not meet expected academic levels, is therefore important in order to know how to best support these individuals and ensure successful outcomes.

Predictor variables associated with ability-achievement discrepancy

Little is known currently about what factors influence the potential discrepancy between ability and achievement in children with autism. However, previous literature has identified factors that influence academic underachievement in TD children. Research has grouped these into individual, family, and school-related factors (Baker, Bridger & Evans, 1995). It would be interesting to explore which factors influence the discrepancy between ability and achievement in children with autism. Holding the biopsychosocial model in mind as a guiding theoretical perspective (Engel, 1977), research should seek to explore how child-related predictor variables (psychological factors) and family and school-related predictor variables (social factors) interconnect with autism (biological factor) to influence discrepancy in intellectual ability and academic achievement. Discussed below are examples of predictor variables that would be interesting to investigate further. These variables were identified by reviewing the TD literature and consulting clinical staff (see methods for further explanation of this process).

Predictor variables relating to the child

There are numerous variables that have been identified within the TD literature as predictors of academic underachievement. Seven child-related predictor variables are discussed below.

One, self-regulation is a significant predictor of academic achievement in TD children. The lower students' self-regulation abilities, the more likely they are to underachieve academically (McCoach & Siegle, 2003). Self-regulation is a strong predictor of TD students' academic grades, accounting for 19% of the variance (McCoach and Siegle, 2001). In addition, research has found self-regulation to be better than IQ at predicting TD students' academic grades, suggesting that poor self-regulation abilities may account for why some students achieve below their academic potential (Duckworth & Seligman, 2005).

Two, psychological wellbeing is a significant predictor of academic achievement in TD children (McLeod & Kaiser, 2004; Riglin, Frederickson, Shelton & Rice, 2013). Lower achieving children report higher levels of psychological distress (Ansary & Luthar, 2009). A study by Rothon and colleagues (2009) found psychological wellbeing, as measured by the Strengths and Difficulties Questionnaire, to be negatively associated with GCSE achievement in boys and girls.

Three, emotional symptoms predict academic achievement (Rothon et al, 2009). A recent meta-analysis of 26 studies found a significant relationship between emotional problems and poor school attainment (Riglin, Petrides, Frederickson, & Rice, 2015). Emotional problems are consistently associated with concurrent academic achievement, however the longitudinal relationship is less clear (Riglin et al, 2015).

Four, conduct problems significantly influence academic achievement in TD children (Richards & Abbot, 2009; Riglin et al, 2013). Specifically, the presence of conduct problems increases the likelihood of academic underachievement in childhood and adolescence (Moilanen, Shaw & Maxwell, 2010).

Five, inattention, hyperactivity and impulsivity are well established and longitudinal predictors of academic achievement in TD children (Brennan, Shaw, Dishion & Wilson, 2012; Merrell & Tymms, 2001). In fact, ADHD symptoms are one of the strongest correlates of academic achievement (Duncan et al, 2007).

Six, prosocial behaviour has a strong positive impact on later academic achievement in TD children (Malecki & Elliott, 2002). Caprara, Barbaranelli, Pastorelli, Bandura & Zimbardo (2000) found that prosocial behaviour accounted for 35% of the variance in later academic achievement in their sample.

Seven, peer relationship problems increase the risk of academic underachievement in TD children (Woodward & Fergusson, 2003). Several longitudinal studies have shown that TD children who are rejected by peers in early childhood are more likely to show poorer academic achievement, in academic grades as well as classroom work, later on (O'Neil, Welsh, Parke, Wang & Strand, 1997; Kupersmidt & Coie, 1990).

Predictor variables relating to the family and parents

Previous research has also identified several family and parent-related variables that predict academic underachievement in TD children. Three of these factors are discussed below.

One, maternal education significantly predicts academic achievement in TD children. Sektnan, McClelland, Acock and Morrison (2010) found that low maternal education had significant negative effects on mathematics, reading, and vocabulary achievement in six and seven year olds. Lower maternal education may result in mothers being unable to provide educational support to their children at home and may also mean mothers are less likely to highlight the importance of school commitment (Ou & Reynolds, 2008).

Two, parental involvement is a significant predictor of academic achievement in TD children (Jeynes, 2005). Previous research has defined three aspects to parental involvement: participation in school, communication between parents and school and completing educational activities at home that influence the child's development, such as reading to the child (Bakker, Denessen & Brus-Laeven, 2007). Lack of parental involvement leads to poor academic achievement, specifically lower test scores (Faires, Nichols & Rickelman, 2000) and more learning problems (Bakker et al, 2007).

Three, parental interest in child's education has an important influence on academic outcomes of TD children (Hill & Taylor, 2004; See & Gorard, 2015). Parental interest in education, through the use of motivation and support, is a significant predictor of academic achievement (Feinstein & Symons, 1999). Both maternal interest (Flouri, 2006) and paternal interest (Hango, 2007) have been found to predict academic achievement.

Predictor variables relating to school

School-related predictors of academic underachievement in TD children have also been identified. Five such factors are discussed below.

One, TD children who have experience of being bullied have poorer academic outcomes. A study by Gutman and Feinstein (2008) found that being a victim of bullying was significantly related to lower KS1 scores. In addition, research conducted by Meschi and Vignoles (2010) found that children who experienced bulling at age 14 had significantly lower GCSE scores at 16 compared to peers who had not been bullied. Being bullied may lead to difficulties attending to and focussing on school work and an increased frequency of school truancy which in turn negatively impact learning and academic achievement (Ma, Phelps, Lerner & Lerner, 2009).

Two, research into the impact of additional classroom support on the academic achievement of TD children has provided inconsistent results. Some research suggests learning benefits from having additional support, such as a teaching assistant (TA), in the classroom (Miller, 2003). However other research suggests that the presence of a TA or learning support assistance reduces academic achievement as it decreases challenges and lowers the expectations of the child and results in less involvement from the class teacher (Ainscow, 2000; Osborne & Reed, 2011).

Three, noise exposure, including environmental noise and noise outside or inside the classroom, affects TD children’s learning and academic performance.

Environmental noise, such as from road traffic, has been found to affect levels of attention and performance and reduce the learning trajectories of children (Shield & Dockrell, 2008). In addition, external classroom noise has been found to negatively impact performance on standardised assessment tests of literacy, mathematics and science (Shield & Dockrell, 2008). Furthermore, increased noise levels in classrooms has been found to negatively affect students' number, word and letter recognition (Maxwell & Evans, 2000).

Four, there is some evidence that reduced class sizes positively impacts on academic achievement of TD children (Slavin, 1989). An early meta-analysis conducted by Glass, Cahen, Smith and Filby (1982) concluded that reducing class size has a positive impact on academic performance. However, achievement differences found by previous research are only slight and effect sizes are often small (Slavin, 1989). With some inconsistencies in the impact of reduced class size on achievement, it is important for future research to consider this further.

Five, teacher absence and use of supply cover impacts TD children's academic performance. Inconsistent instructions from different teachers compromises children's learning opportunities and lessons delivered by substitute teachers are often less informative and educational (Ford & Moore, 2013). Children with autism often struggle with change in routine (Happé & Frith, 2005) so the impact of teacher absence and supply cover may be heightened in this population.

The present study

The present study will investigate academic achievement in children with autism. Specifically it will focus on the discrepancy between children's intellectual ability and their academic achievement. Our understanding of this discrepancy and how it differs across children with different diagnostic statuses is limited so this will be explored in a robust way. Particular focus will be on ensuring samples are nationally representative, that suitable control groups are used and that finding are ecologically valid and sit within an educational context. In addition, factors that may influence the ability-achievement discrepancy will also be identified. The study will aim to address the following research questions:

1) Do children with autism show discrepancy between intellectual ability and academic achievement compared to children with ADHD and TD peers? Is this discrepancy evident across all academic subjects, including reading, writing, mathematics and science?
2) What child, parental, and school-related variables are associated with the discrepancy between intellectual ability and academic achievement in children with autism?

Methods

Data source

This study used data from the UK's Millennium Cohort Study (MCS), a longitudinal birth cohort study drawing its sample from a subset of births in the UK from the 1st September 2000 until the 11th of January 2002. Approximately 19,000 children were successfully recruited to participate in this study. Data collection so far has occurred over six time points: when the children were aged nine months (sweep 1), three years (sweep 2), five years (sweep 3), seven years (sweep 4), eleven years (sweep 5), and fourteen years (sweep 6). Ethical approval for the MCS was gained from the NHS Multi-Centre Ethics Committees and parents gave informed consent before interviews took place. For full details on ethical approval, see Table 2.1.

Additional ethical approval for the analysis in the present study was sought and granted in March 2018 from the University College London Research Ethics Committee (REC) (project ID: 12509/001).

Table 2.1:

MCS ethical approval 2000-2015

Survey	**Age**	**Year**	**Approval**	**Reference number**
MCS1	9 months	2000/2001	South West MREC	MREC/01/6/19
MCS2	3 years	2003/2004	London MREC	MREC/03/2/022
MCS3	5 years	2005/2006	London MREC	05/MRE02/46
MCS4	7 years	2007/2008	Yorkshire MREC	07/MRE03/32
MCS5	11 years	2011/2012	Yorkshire and The Humber – Leeds East	11/YH/0203
MCS6	14 years	2014/2015	National Research Ethics Service & London REC	13/LO/1786

Study sample

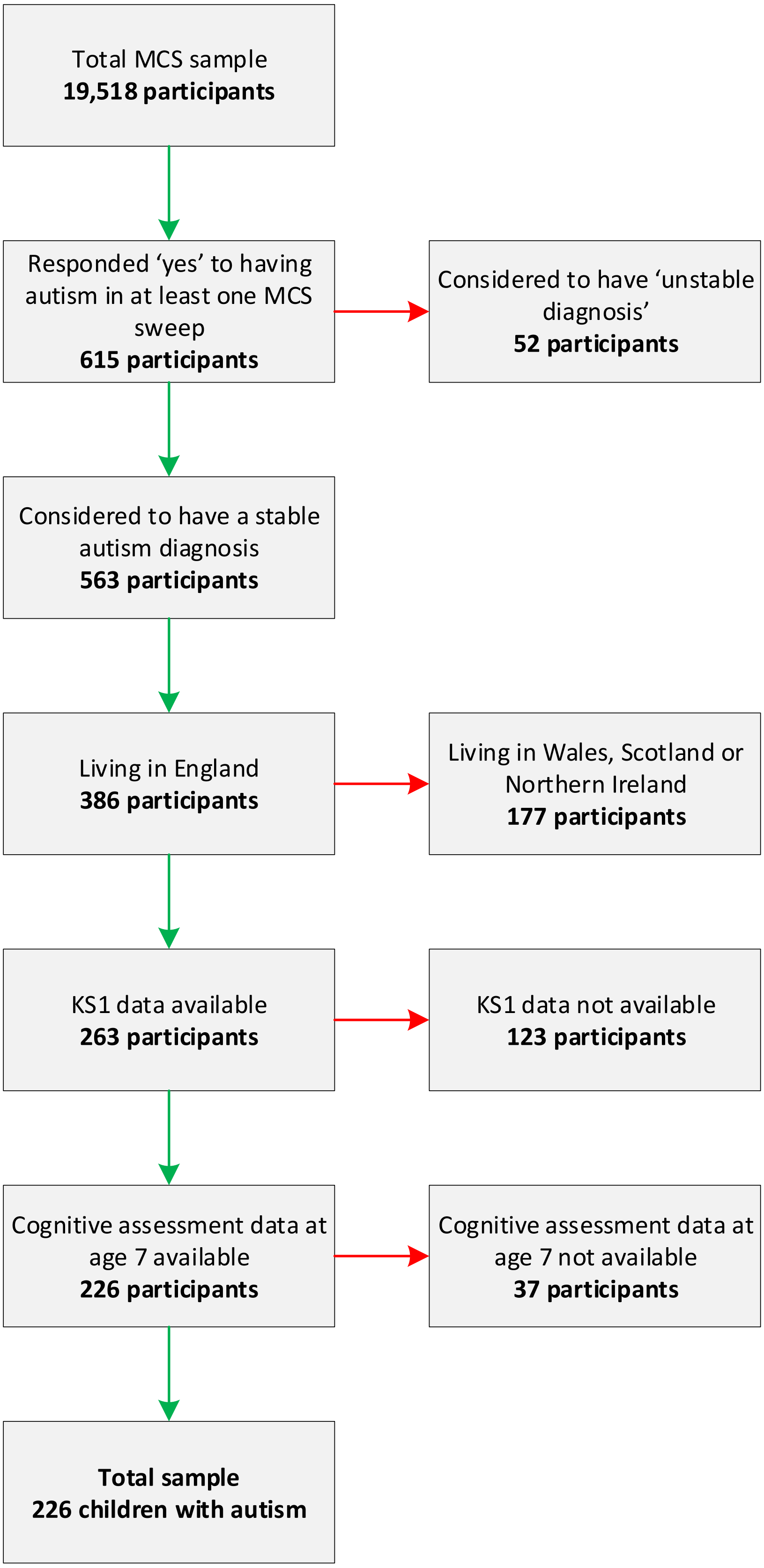
Our sample comprised children from the MCS who had been reported by their main parent/carer to have a diagnosis of autism. Parents were asked during sweep 3, 4, 5, and 6 to respond to the question "Has a doctor or health professional ever told you that (cohort child) has autism, Asperger's syndrome or autistic spectrum disorder?" From the total MCS sample, over 85% of participants gave a response to this question (Russell, Rodgers, Ukoumunne & Ford, 2014). Autism diagnosis was determined by a 'yes' response having been recorded in at least one sweep. The only exceptions to this were for children who had a 'yes' response at sweep 3 (age five) but a 'no' response in subsequent sweeps as it was felt that these were likely children who had been misdiagnosed in early childhood. Similarly, if children had a 'yes' response in previous sweeps but a 'no' response at sweep 6 (age

14), they were not included in the autism sample as it was unclear whether these children had a diagnosis of autism or not. Data were coded as missing where a response of ‘I don’t know’ or ‘not applicable’ was recorded.

In order to be included in our sample, children needed to have Key Stage 1 (KS1) data as this served as our measure of academic achievement. Due to differing educational assessment practices across UK countries, only children living in England were able to be included in the sample. In addition, to be included, children were required to have cognitive assessment data at age seven so this could be compared against KS1 data (also from age seven) and thus control for any effects of age. In the cases of twins and triplets, only the first born child was included as the MCS does not provide separate unique identifiers for twins and triplets. Using this method, a total of 226 children with a diagnosis of autism were included in our final sample. Figure 2.1 illustrates this sampling process in more detail.

Figure 2.1:

Illustration of the autism sample



We also included two control groups in this research, 106 children with ADHD and 6,827 TD children. Similar to the process for identifying participants with autism, ADHD diagnosis was determined by parents' giving a "yes" response in at least one sweep to the question "Has a doctor or health professional ever told you that (cohort child) has Attention Deficit/ Hyperactivity Disorder (ADHD)?" Sixty seven children were identified as having comorbid autism and ADHD. These children were included in the autism sample as there are high ADHD comorbidity rates, ranging from 40-83%, in the general child autism population (May et al, 2018). Including individuals with comorbid autism and ADHD therefore makes the autism sample representative and generalisable. Children with comorbid autism and ADHD were not included in the ADHD sample in order to avoid duplication of participants. Therefore our ADHD sample represents children who have ADHD but no reported autism diagnosis. TD children were included in our sample if parents had always given "no" responses, across all sweeps, to the questions about autism and ADHD. In order to be included in the ADHD and the TD samples, children needed to have KS1 data and have cognitive assessment data at age seven years.

Sample bias

Before progressing with analysis, it is important to consider possible sample bias and how the sample used in this research compares to the wider population. Different issues are discussed below, with specific focus on the autism sample as this was the main sample used in this research. One consideration is whether the age of autism diagnosis in our sample appears consistent with that of previous literature. Daniels and Mandell (2013) reviewed the literature on age of diagnosis and found median age to range from 36 to 82 months. In addition, Crane and colleagues (2015) suggest that the mean age of diagnosis in UK children is 89 months (approximately

7.4 years old). In the sample included in this research, the highest proportion of children received a diagnosis sometime between sweep 4 and sweep 5, when the children were between seven and eleven years old (see Table 2.2). While this is roughly in line with the literature, it is perhaps somewhat older than we would expect. Later age of diagnosis is associated with milder autism symptom severity (Zwaigenbaum et al, 2019) and perhaps this indicates reduced levels of autism severity in our sample.

An additional consideration is whether the gender ratio of the autism sample is in line with population prevalence research. While the DSM-5 informs us that autism is diagnosed four times more in males than females (American Psychiatric Association, 2013), recent high-quality epidemiological research suggests a male-to-female ratio of three to one might be more accurate (Loomes et al, 2017).Our total autism sample also shows a three to one gender ratio with 172 boys and 54 females (see Table 2.2). Therefore we can conclude that the gender ratio of our sample is representative of the wider autism population.

Table 2.2:

The number of children in our sample who were first identified as having autism in each sweep

Sweep	**Number of children who were first reported as having autism in each sweep**			**Cumulative total sample size**
	Male	**Female**	**Total**	
MCS3 (age 5)	23	3	26	26
MCS4 (age 7)	25	6	31	57
MCS5 (age 11)	69	24	93	150
MCS6 (age 14)	55	21	76	226
Total sample	172	54	226	226

A further issue to consider is how using KS1 scores as a measure of academic achievement affects the representativeness of our autism sample. The design of this study centred on being nationally representative and generalisable. However, only including children who have KS1 data limits this. There is high variability in symptom presentation and severity in autism (Worley & Matson, 2012), which makes it harder to generalise research findings to individuals. It is likely that the children missing KS1 data did not undertake KS1 assessments. Perhaps these individuals have lower IQ and/or higher autism symptom severity and were therefore not able to access the KS1 curriculum and undertake KS1 assessments.

Demographic information can be used to compare the group of children without KS1 data to our sample of children with autism. Differences between these groups would question the generalisability of our research findings to the wider autism population. One difference between these groups is the gender ratio. Out of the 123 children missing KS1 data, 97 were male and 26 were female. This 4:1 male-female ratio is greater than the 3:1 ratio of our sample, suggesting that there is a higher proportion of boys without KS1 data. A further difference between these groups is the age of diagnosis. Children without KS1 data appeared to receive a diagnosis of autism at a younger age than the children included in our sample (see Table 2.3). Children with autism presenting with more severe impairments tend to be diagnosed earlier, at a younger age (Mandell, Novak & Zubritsky, 2005). In addition, children with autism are more likely to receive an early diagnosis if they are male or have an IQ of 70 or lower (Shattuck et al, 2009). This supports the above hypothesis that the children without KS1 data, who were excluded from our sample, may have higher autism symptom severity and/or lower IQ. Not including these individuals therefore creates bias within our sample. It is important to remember going forward that our sample population is specifically representative of English autistic children who undergo KS1 assessment and grading.

Table 2.3:

Comparing the age of diagnosis of our autism sample to the children without KS1 scores who were excluded from our sample.

Sweep	**Children without KS1 data**		**Our sample of children with autism**	
	N	**%**	**N**	**%**
MCS3 (age 5)	35	28	26	11
MCS4 (age 7)	18	15	31	14
MCS5 (age 11)	39	32	93	41
MCS6 (age 14)	31	25	76	34

Measures

Academic achievement

To measure academic achievement, participants' Key Stage One (KS1) attainment scores were used. KS1 covers children in years one and two when they are aged between five and seven years old. At the end of KS1, teachers use teacher assessment judgements to report on students' progress. Each child is given an overall attainment point score, as well as point scores on a subject-to-subject basis for reading, writing, mathematics and science. Scores are based on standardised performance in Statutory Assessment Tests (SATs) in mathematics and reading and also take into account performance throughout the year, using concrete evidence from classwork. KS1 attainment scores are standardised with a minimum possible score of 85 and a maximum possible score of 115. A score of 100 is average and indicates that the child is achieving in line with age expectations.

Key stage assessments were introduced following the 1988 Education Reform Act in order to standardise the assessment of children's performance and are viewed as a valid measure of academic achievement (Withey & Turner, 2013). The use of KS1 attainment scores to measure academic achievement, as opposed to using one-off achievement assessments conducted by researchers, increases the ecological validity of this research.

KS1 attainment scores were accessed for this research from the National Pupil Database as part of the MCS' linked educational data. Educational data is deemed to be secure so the researcher had to undergo special access training and examination in order to access this.

Intellectual ability

The MCS used several different cognitive assessments, at different time points, to measure children's intellectual ability. In order to gain an overall measure of general intelligence (IQ), principle component analysis was used to estimate regression factor scores. This technique of using multiple, well-validated, cognitive assessments has been established as a valid measure of underlying general intelligence (Flouri, Midouhas & Joshi, 2015).

The cognitive assessments included in our analysis are discussed below and highlighted in Table 2.4. In order to control for age, only the cognitive assessment measures used at sweep 4 (age seven) were used to derive the IQ score as these were compared against KS1 scores, from when the children were aged seven.

Table 2.4:

Cognitive assessments used in the MCS

Cognitive Assessments		MCS2 (Age 3)	MCS3 (Age 5)	MCS4 (Age 7)	MCS5 (Age 11)	Ability/ process measured
BSRA-R		√				'Readiness' for formal education
BAS	Naming Vocabulary	√	√			Expressive verbal ability
	Pattern Construction		√	√		Spatial problem solving
	Picture Similarities		√			Non-verbal reasoning
	Word Reading			√		Reading skills
	Verbal Similarities				√	Reasoning skills
NFER				√		Mathematical skills and knowledge
CANTAB CGT					√	Problem solving ability

The British Ability Scales (BASII; Elliott, Smith & McCulloch, 1996) include twelve core sub tests of intellectual ability and educational achievement. The BASII has demonstrated both high test-retest reliability and good construct validity as a measure of intellectual ability (Elliot, Smith & McCulloch, 1997). The BASII has also been found to correlate with the Wechsler Intelligence Scale (Cook, 1988).

The National Foundation for Educational Research (NFER) Progress in Maths Test was used in sweep 4 (age seven) to assess children's mathematical skills and knowledge. Children complete a series of calculations read aloud covering topics such as numbers, shapes, measurement, and data handling. While this tool is often used to measure progress in school, it has also been used by previous research as an indication of cognitive skills (Flouri, Midouhas & Joshi, 2015). Therefore the researchers agreed to include it in the analysis.

Predictors of the discrepancy between intellectual ability and academic achievement

This study explored different factors hypothesised to influence the discrepancy between intellectual ability and academic achievement of children with autism. The MCS used parental, teacher and child interviews and questionnaires, along with validated measures, to gather data. Specific measures used, that are of interest to this study are detailed below.

Possible predictor variables were identified by searching TD child literature for factors that have been found to significantly influence underachievement. In addition a focus group was conducted in an inner city Child and Adolescent Mental Health Service with seven members of clinical staff from a neurodevelopmental team. Staff members (four clinical psychologists, two psychiatrists, and one assistant psychologist) were asked to hypothesise, based on their clinical experience, what factors they think may predict the discrepancy between intellectual ability and academic achievement in children with autism. Possible predictors identified included classroom support, comorbid mental-health, noise levels at school, experience of being bullied, presence of sensory sensitivities, rigidity, executive functioning and time management skills. Once a list of possible predictors was identified from the existing literature and the focus group, the MCS data was searched to identify which of these predictors had been measured. Using this strategy, 16 variables were identified. These are highlighted in Table 2.5 and discussed below.

Table 2.5:

Predictor variables

Predictor variable	Supporting reference from TD literature	Predicted Relationship	How the predictor was measured	Reported by
		Child-related predictor variables		
Self-regulation	Duckworth & Seligman (2005)	Increased self-regulation, reduced underachievement	Child Social Behaviour Questionnaire (CSBQ)	Parent report
Overall psychological wellbeing	McLeod & Kaiser (2004)	Increased wellbeing, reduced underachievement	Strengths and Difficulties Questionnaire (SDQ)	Parent report
Emotional symptoms	Rothon et al (2009)	Increased emotional symptoms, increased underachievement	Strengths and Difficulties Questionnaire (SDQ)	Parent report
Conduct problems	Metsäpelto et al (2015)	Increased conduct problems, increased underachievement	Strengths and Difficulties Questionnaire (SDQ)	Parent report
Hyperactivity	Brennan et al (2012)	Increased hyperactivity, increased underachievement	Strengths and Difficulties Questionnaire (SDQ)	Parent report
Pro-social behaviour	Caprara et al (2000)	Increased prosocial behaviour, reduced underachievement	Strengths and Difficulties Questionnaire (SDQ)	Parent report
Peer problems	Woodward & Fergusson (2003)	Increased peer problems, increased underachievement	Strengths and Difficulties Questionnaire (SDQ)	Parent report
		Parent-related predictor variables		
Maternal education	Sektnan et al (2010)	Higher level of maternal education, reduced underachievement	Whether mother had a university degree by the time child was 7 or not	Parent report
Parental involvement	Jeynes (2005)	Increased parental involvement,	Frequency with which main parent	Parent report

Predictor variable	**Supporting reference from TD literature**	**Predicted Relationship**	**How the predictor was measured**	**Reported by**
		reduced underachievement	reads to child	
Maternal interest in child's education	Flouri (2006)	Increased maternal interest, reduced underachievement	Teacher reports of whether mother appeared interested in the child	Teacher report
Paternal interest in child's education	See & Gorard (2015)	Increased paternal interest, reduced underachievement	Teacher reports of whether father appeared interested in the child	Teacher report
		School-related predictor variables		
Being bullied	Ma et al (2009)	Increased experience of being bullied, increased underachievement	Question from SDQ 'is picked on or bullied by other children?'	Parent report
Extra support	Klem & Connell (2004)	Increased support at school, reduced underachievement	Teacher report as to whether child receives additional help/ support	Teacher report
Learning environment – noise	Shield & Dockrell (2008)	Increased noise in the classroom, increased underachievement	Teacher report on noise environment outside classroom	Teacher report
Class size	Slavin (1989)	Increased class size, increased underachievement	Teacher report on class size	Teacher report
Teacher absence and turnover	Ford & Moore (2013)	More days of supply cover used, increased underachievement	Teacher report on days of supply cover used per term	Teacher report

Predictor variables relating to the child

Self-regulation was measured by the Child Social Behaviour Questionnaire (CSBQ; Hartman, Luteijn, Serra & Minderaa, 2006) which was designed to assess social behaviour problems in individuals with autism. It has been shown to have good internal consistency (=.76-.94), inter-rater reliability (=.75-.89) and test-retest reliability (r =.80-.90) (De Bildt et al, 2009). Parents were asked to complete the independence and self-regulation subscale questions during the parent interview in surveys 2 (age three), 3 (age five) and 4 (age seven).

Overall psychological wellbeing was measured by the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). The SDQ has shown to function as well as longer-established questionnaires, such as the Rutter questionnaires (Elander & Rutter, 1995; Klasen et al, 2000) and has been shown to have satisfactory reliability and validity (Garcia-Cortazar, Mazaira & Goodman, 2000; Goodman, 2001; Goodman, Renfrew & Mullick, 2000). In surveys 2 (age three), 3 (age five) and 4 (age seven) parents were asked to consider the 25 statements from the SDQ concerning their child. As well as using the SDQ to gain a measure of overall psychological wellbeing, we also used it to look at the five different subscales as possible predictors: emotional symptoms, conduct problems, hyperactivity, pro-social behaviours and peer problems.

Predictor variables relating to the parent and family

Maternal education was measured by whether the mother had a university degree by the time the child was seven or not.

Parental involvement was measured by the frequency with which the main parent reads to the child, ranging from 1 ‘everyday’, to 5 ‘not at all’. Parents were asked to respond to this question during sweeps 2 (age three), 3 (age five) and 4 (age seven). Previous literature has also focussed on reading as a measure of parental involvement (Bakker & Denessen, 2007).

Parental interest in a child’s education was measured by teacher report in sweep 5 (age 11) as to whether the child’s mother and father appeared ‘very interested', 'fairly interested', 'neither interested or disinterested', 'fairly uninterested' or 'very uninterested' in their child. Previous literature has also chosen to measure parent interest by teacher report (Flouri, 2006).

Predictor variables relating to school

Experience of being bullied was measured by parental response to the question from the SDQ 'Cohort child is picked on or bullied by other children?' Responses were taken during sweeps 2 (age three), 3 (age five), and 4 (age seven).

Additional support was measured by the MCS in sweep 4 (age seven) by teacher report as to whether the child receives additional help or support, such as support in class by a TA or family member. We also looked at whether children had a statement or educational healthcare plan (EHCP).

Noise of the learning environment was measured by teacher report during sweep 4 (age seven) to which phrase best describes the noise outside the classroom – 'continuous and is a problem', 'continuous but not a problem', 'intermittent and is a problem', 'intermittent but not a problem' or 'is usually quiet outside the classroom'.

Class size was measured using teacher responses at sweep 4 (age seven) to the question how many children are in the cohort child's class.

Supply cover was measured using teacher report of how many days of supply cover had been used in the current term. This question was asked of teachers during sweep 4 (age seven) of the MCS.

Statistical Analysis

The first step in the statistical analysis was to prepare the MCS data sets. This involved cleaning the data, linking data sets, identifying and removing duplicate data, identifying and selecting variables of interest, coding the data, and exporting the data into the statistical package being used for further data analysis (STATA).

The second step in the statistical analysis was to derive KS1 performance discrepancy scores for autism, ADHD and TD samples. Principle component analysis was used to derive a latent 'g' variable, based on the intellectual ability assessments used in the MCS. Using multiple, well-validated, cognitive assessments has been established as a valid measure of the underlying general intelligence factor ('g') (Flouri et al, 2015). These scores were then transformed into standard IQ scores with a mean of 100 and a standard deviation of 15 (Hanscombe et al, 2012). KS1 data were used as a measure of academic achievement. Overall KS1 point scores, as well as individual point scores in maths, science, reading and writing, were standardised with a mean of 100 and a standard deviation of 15. These scores were then subtracted from our 'g' variable to give an overall KS1 performance discrepancy score as well as KS1 performance discrepancy scores on a subject-to-subject basis for maths, science, reading and writing. Scores of zero indicated no discrepancy between intellectual ability and academic achievement. Scores greater than zero indicated KS1 performance discrepancy where participants achieved higher than expected based on their intellectual ability. Scores less than zero indicated KS1 performance discrepancy where participants achieved lower than expected based on their intellectual ability.

The third step in the statistical analysis was to establish whether KS1 performance discrepancy scores differed for autism, ADHD and TD samples. A one-way analysis of variance (ANOVA), followed up with post-hoc tests, was used to determine the variation in overall KS1 performance discrepancy scores. A two-way mixed effects ANOVA was used to assess variation in KS1 performance discrepancy scores for each subject.

The fourth step in the statistical analysis was to conduct exploratory analysis with our predictor variables. A correlation matrix was generated in order to determine which variables show a relationship with overall KS1 performance discrepancy, as well as KS1 performance discrepancy for each subject. At this stage, it was important to consider power of correlations and to conduct a power analysis. Due to varying sample sizes for each of the predictor variables, we can conclude that overall the analysis had sufficient sample size to detect a standardised effect (correlation coefficient) of between 0.20 and 0.30 at 80% power (Cohen, 1988).

The fifth step in the statistical analysis was to run a regression analysis with the variables that were found to be related to KS1 performance discrepancy scores during the correlation analysis. Any predictor variables that met the .05 significance threshold during bivariate correlations would be entered into the regression analysis. This would enable us to identify unique predictors of the discrepancy between intellectual ability and academic achievement.

Results

Intellectual ability and academic achievement- descriptive statistics

Our sample comprised 226 children with autism, 106 children with ADHD, and 6,827 typically developing (TD) children. We used children's IQ scores along with KS1 scores in order to measure the KS1 performance discrepancy between intellectual ability and academic achievement. Table 2.6 shows means, standard deviations, and ranges for IQ and KS1 point scores across autism, ADHD, and TD samples.

Table 2.6:

Means, standard deviations, and ranges for IQ and KS1 attainment scores across autism, ADHD, and TD samples

	N	IQ			KS1 Overall point score			KS1 Reading point score			KS1 Writing point score			KS1 Maths point score			KS1 Science point score		
		Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
Autism	226	92.37	16.26	76.06	90.13	17.46	75.73	91.50	16.72	62.87	89.84	17.65	66.18	90.71	17.49	71.45	92.32	17.76	74.80
ADHD	106	89.36	17.78	78.06	88.61	17.38	75.73	89.92	17.89	62.87	87.57	17.21	66.18	88.37	18.13	71.45	93.19	15.69	74.80
TD	6827	100.46	14.76	91.03	101.11	13.96	82.04	100.99	14.16	83.83	101.10	14.10	66.18	101.04	13.99	95.27	100.88	14.17	74.80
Total sample	7159	100.04	14.96	91.03	100.58	14.34	82.04	100.52	14.46	83.83	100.54	14.50	66.18	100.53	14.38	95.27	100.50	14.42	74.80

Note. Abbreviations: SD refers to standard deviation

IQ

A one-way ANOVA was used to compare IQ scores for the three groups of participants: children with autism, children with ADHD and TD children. This analysis found significant group differences; $F(2, 7157) = 60.470$, $p<0.001$, $\eta_p^2 = .017$, suggesting that diagnostic status successfully predicts the variation in IQ. Further post-hoc tests, namely Bonferroni, were carried out to explore where this variation comes from. Children with autism had lower average IQs than TD children ($p<0.001$, $d=0.52$). Similarly, children with ADHD had, on average, lower IQs than the TD children ($p<0.001$, $d=0.68$). No significant difference was found between children with autism and ADHD ($p=.254$, $d=0.18$). See Table 2.6 for means.

KS1 Overall Point Score

A one-way ANOVA was used to compare overall KS1 point scores for the three groups of participants: children with autism, children with ADHD and TD children. This analysis was found to be significant; $F(2, 7157) = 104.700$, $p<0.001$, $\eta_p^2 = .028$, suggesting that diagnostic status successfully predicts the variation in overall KS1 point score. Further post-hoc tests, namely Bonferroni, were carried out to explore where this variation comes from. Bonferroni tests are suitable for unequal sample sizes so this was selected as an appropriate post-hoc test (Shingala & Rajyaguru, 2015). Children with autism had lower KS1 point score on average than TD children ($p<0.001$, $d=0.69$). Similarly, children with ADHD had, on average, lower KS1 point scores than TD children ($p<0.001$, $d=0.79$). No significant difference was found between children with autism and ADHD ($p<.99$, $d=0.09$). See Table 2.6 for means.

Effect of KS1 subject

A two-way mixed effects ANOVA (using a 3X4 design) was run on our total sample of 7159 participants to examine the effect of diagnostic status and key stage subject on KS1 attainment point score. The between factor, diagnostic status, had three levels: autism, ADHD and TD, while the within factor, key stage subject, had four levels: reading, writing, maths and science. The analysis found a significant main effect of diagnostic status, X^2 (2, N=28,632) = 208.56, $p<.001$. There was also a significant main effect of subject, X^2 (3, N=28,632) = 45.94, $p<.001$. The ANOVA also found a significant interaction between diagnostic status and subject on KS1 attainment point score, X^2 (6, N=28,632) = 52.89, $p<.001$.

Simple main effects showed that TD children achieve significantly higher KS1 attainment scores than children with autism and ADHD in reading (p<.001), writing ($p<.001$), maths ($p<.001$), and in science ($p<.001$). These findings are illustrated in Figure 2.2. Pairwise comparisons were used to further investigate within group effects of subject performance. For the autism sample, KS1 writing attainment scores were found to be significantly lower than reading attainment scores ($p=.016$), science attainment scores were significantly higher than writing attainment scores ($p<.001$), and science attainment scores were significantly higher than maths attainment scores ($p=.020$). For the ADHD sample, science attainment scores were significantly higher than reading ($p<.001$), writing ($p<.001$) and maths ($p<.001$) attainment scores, and writing attainment scores were significantly lower than reading attainment scores ($p=.021$). For the TD sample, there were no significant differences between subjects. These findings are shown in Table 2.7.

Figure 2.2:

Key Stage 1 Attainment Scores by Diagnostic Status and Subject

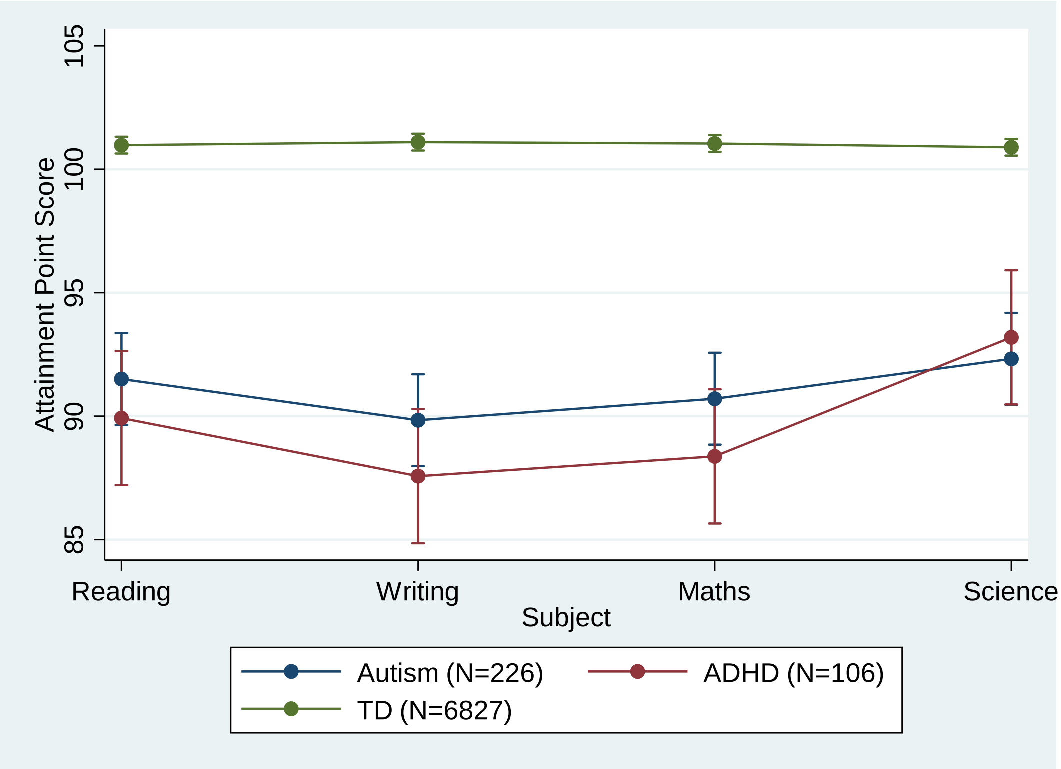


Table 2.7:

Pairwise comparisons between KS1 subjects for autism, ADHD and TD samples.

	N	**Writing vs. Reading**			**Maths vs. Reading**			**Science vs. Reading**			**Maths vs. Writing**			**Science vs. Writing**			**Science vs. Maths**		
		Z	**Sig.**	**CI**	**Z**	**Sig.**	**CI**	**Z**	**Sig.**	**CI**	**Z**	**Sig.**	**CI**	**Z**	**Sig.**	**CI**	**Z**	**Sig.**	**CI**
Autism	226	-2.40	.016*	-3.03 -.31	-1.15	.252	-2.16 .57	1.17	.240	-.55 2.18	1.25	.21	-.49 2.24	3.57	p<.001**	1.12 3.85	2.32	.020*	.25 2.98
ADHD	106	-2.32	.021*	-4.35 -.36	-1.53	.127	-3.54 .44	3.22	p<.001**	1.28 5.26	0.79	.43	-1.19 2.79	5.53	p<.001**	3.63 7.61	4.74	p<.001**	2.83 6.81
TD	6827	.970	.333	-.13 .37	.530	.598	-.18 .32	-.690	.492	-.34 .16	-.440	.66	-.30 .19	-1.66	.098	-.46 .04	-1.21	.225	-.40 .09

Note. Abbreviations: *Z* refers to standard score, Sig. refers to significance level, CI refers to confidence interval.
Significance *p<.05. **p<.001

The discrepancy between intellectual ability and academic achievement

An overall KS1 performance discrepancy score, but also a KS1 performance discrepancy score on a subject basis for reading, writing, maths, and science, was calculated for each participant. Both KS1 and IQ scores were standardised with a mean of 100 and a standard deviation of 15. KS1 scores were then subtracted from IQ to give a KS1 performance discrepancy score. Scores of zero indicate no discrepancy between cognitive ability and academic achievement. Scores greater than zero indicate a KS1 performance discrepancy where participants achieved higher than expected, based on their cognitive ability. Scores less than zero indicate a KS1 performance discrepancy where participants achieved lower than expected, based on their cognitive ability. Table 2.8 shows the means, standard deviations, and ranges for KS1 performance discrepancy scores across autism, ADHD, and TD samples.

Table 2.8:

Means, standard deviations, and ranges for KS1 performance discrepancy scores across autism, ADHD, and TD samples.

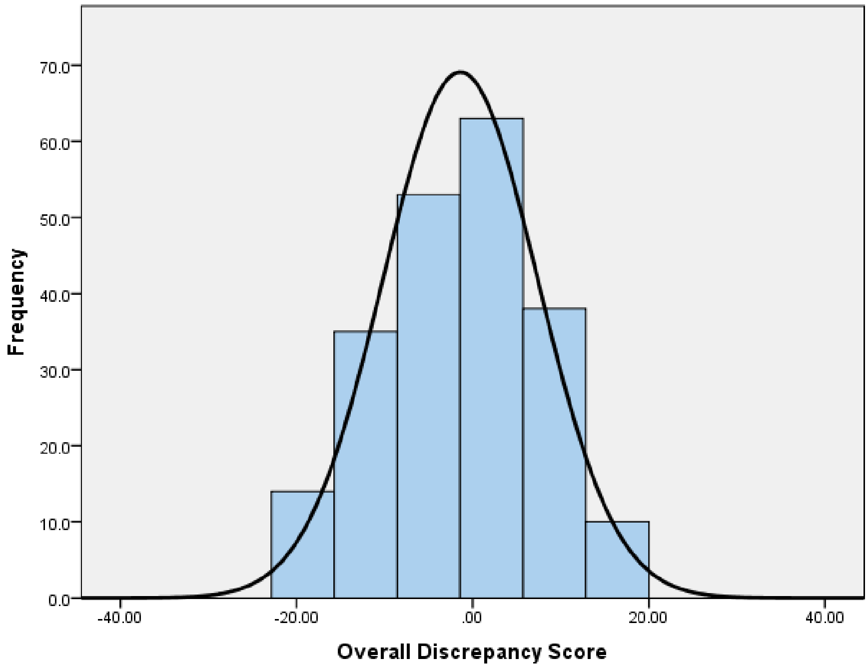
	N	Overall discrepancy			Reading discrepancy			Writing discrepancy			Maths discrepancy			Science discrepancy		
		Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
Autism	226	-2.25	10.50	63.98	-0.87	11.78	67.61	-2.540	12.54	64.94	-1.67	11.86	75.22	-0.06	13.10	92.59
ADHD	106	-0.75	13.24	83.72	0.57	14.79	84.31	-2.79	12.70	71.08	-0.98	14.50	76.83	3.87	16.11	106.24
TD	6827	0.60	10.67	84.03	0.47	11.54	87.86	0.58	12.05	96.59	0.53	11.33	98.10	0.37	13.53	104.20
Total sample	7159	0.49	10.72	90.18	0.42	11.61	95.25	0.45	12.09	96.59	0.44	11.40	98.10	0.41	13.56	109.53

Note. Abbreviations: SD refers to standard deviation

For children with autism, overall KS1 performance discrepancy scores showed skewness of -.540 (SE = .162) and kurtosis of .723 (SE = .322). The z value of -3.33 is greater than the threshold of 3.29 (which is used for medium sample sizes greater than 50 and less than 300) therefore we can conclude this variable is non-normal (Kim, 2013). However as this non-normal distribution is only marginal, it was decided that the data did not need transforming. The histogram shown in Figure 2.3 supports the view that any deviation from normality is very subtle and will not impact on the validity of findings. For children with ADHD, overall KS1 performance discrepancy scores showed skewness of .162 (SE = .235) and kurtosis of 1.454 (SE = .465). The z value of .069 is less than the threshold of 3.29 and therefore we can conclude this variable is normally distributed (Kim, 2013). For TD children, overall KS1 performance discrepancy scores were normally distributed with skewness of -.177 (SE = .030) and kurtosis of .338 (SE = .059). As indicated when working with large sample sizes greater than 300, the absolute skew value is less than the threshold of 2 and therefore we can conclude this variable is normally distributed (Kim, 2013).

Figure 2.3:

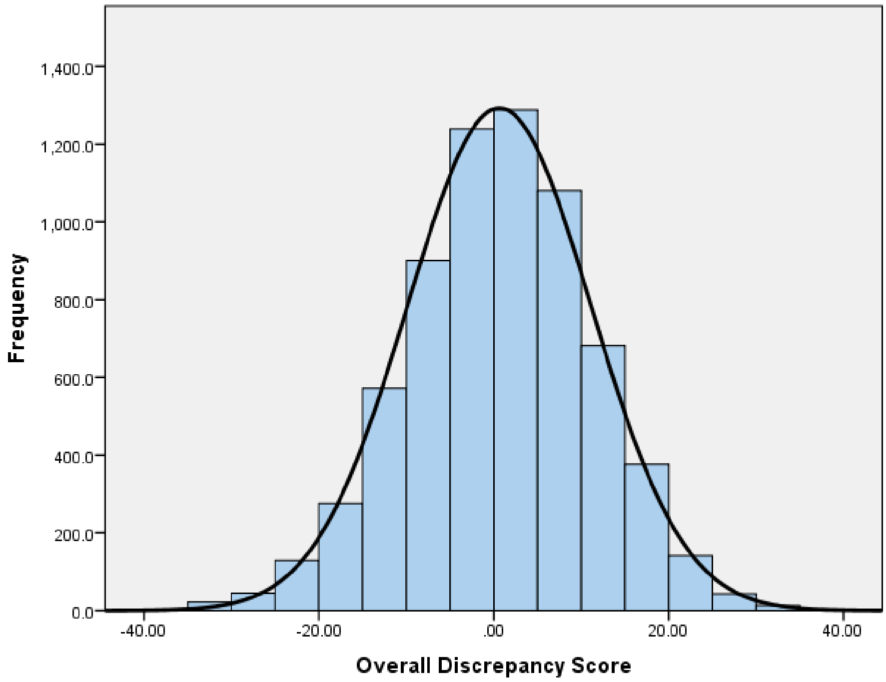
Histogram showing the distribution of overall KS1 performance discrepancy scores for children with autism



The histograms in Figure 2.3 and Figure 2.4 illustrate the distributions of KS1 performance discrepancy scores for children with autism and TD children. In both histograms, outliers had to be removed to ensure that the data adhered to the UK data service's '10 cell count rule', thus remaining confidential and non-identifiable so that they could be released from the secure lab. These outliers were not excluded from analysis. Due to the small sample size, the histogram showing KS1 performance discrepancy scores for children with ADHD was not able to be released from the secure lab as it did not adhere to the UK data service's '10 cell count rule'.

Figure 2.4:

Histogram showing the distribution of overall KS1 performance discrepancy scores for TD children



Overall KS1 performance discrepancy scores

A one-way ANOVA was used to compare overall KS1 performance discrepancy scores for the three groups of participants: children with autism, children with ADHD and TD children. This analysis was found to be significant; $F(2, 7156) = 8.452$, $p<0.001$, $\eta_p^2 = .002$ suggesting that diagnostic status predicts variation in overall KS1 performance discrepancy score. Post hoc Bonferroni tests showed that children with autism scored lower than TD children ($p<0.001$, $d=0.27$), meaning that children with autism were more likely to underachieve academically at KS1. No significant difference was found between children with autism and ADHD ($p=0.701$, $d=0.13$) or between children with ADHD and TD children ($p=0.597$, $d=0.11$). See Table 2.8 for means.

Subject KS1 performance discrepancy scores

A two-way mixed effects ANOVA (using a 3x4 design) was run on our total sample of 7,159 participants to examine the effect of diagnostic status and key stage subject on KS1 performance discrepancy scores. The between factor, diagnostic status, had three levels: autism, ADHD and TD, while the within factor, key stage subject, had four levels: reading, writing, maths and science. The analysis found a significant main effect of diagnostic status, X^2 (2, N=28,632) = 6.39, p<.05. There was also a significant main effect of subject, X^2 (3, N=28,632) = 45.96, p<.001. The ANOVA also found a significant interaction between diagnostic status and subject on KS1 performance discrepancy score, X^2 (6, N=28,632) = 53.11, p<.001. The stata “contrast” command was used to conduct post-hoc analysis of within group pairwise comparisons. Children with autism had significantly lower KS1 performance discrepancy scores, and therefore greater underachievement, in writing (p=.002) and maths (p=.039). Children with ADHD show significantly greater KS1 performance discrepancy scores, and thus more overachievement, in science (p<.001).

Simple main between-group effects showed us that TD children achieve significantly higher than children with autism in writing (p<.001) and in maths (p=.008). In addition, children with ADHD achieve significantly higher than children with autism in science (p=.007). These findings are illustrated in Figure 2.5. Pairwise comparisons were used to investigate within-group effects. For the autism sample, KS1 performance discrepancy scores for writing were found to be significantly lower than reading (p=.016), indicating greater underachievement in writing than reading. KS1 performance discrepancy scores for writing were found to be significantly lower than science (p<.001), indicating greater underachievement in writing than science. KS1 performance discrepancy scores in mathematics were significantly greater than science (p=.020), indicating greater underachievement in mathematics than science. For the ADHD sample, KS1 performance discrepancy scores in science were significantly greater than reading (p<.001), writing (p<.001) and mathematics (p<.001), indicating greater overachievement in science than reading, writing, and mathematics. KS1 performance discrepancy scores for writing were significantly less than reading (p=.020), indicating greater underachievement in writing than reading. For the TD sample, there were no significant differences between subjects. These findings are shown in Table 2.9.

Figure 2.5:

Overall KS1 Performance Discrepancy Score by Diagnostic Status and Subject

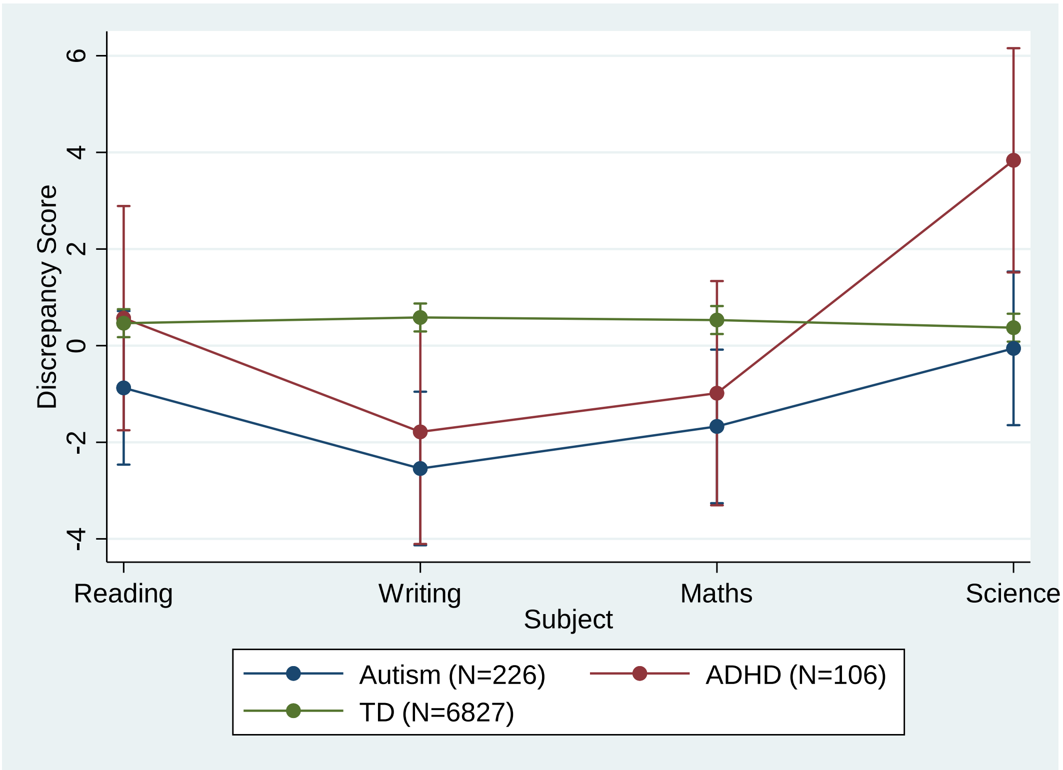


Table 2.9:

Pairwise comparisons between subject KS1 performance discrepancy scores for autism, ADHD and TD samples.

	N	Writing vs. Reading			Maths vs. Reading			Science vs. Reading			Maths vs. Writing			Science vs. Writing			Science vs. Maths		
		Z	**Sig.**	**CI**	***Z***	**Sig.**	**CI**	***Z***	**Sig.**	**CI**	***Z***	**Sig.**	**CI**	***Z***	**Sig.**	**CI**	***Z***	**Sig.**	**CI**
Autism	226	-2.40	.016*	-3.03 -.31	-1.15	.251	-2.16 .57	1.18	.242	-.55 2.18	1.25	.210	-.49 2.23	3.58	p<.001**	1.12 3.85	2.32	.020*	.25 2.98
ADHD	106	-2.32	.020*	-4.34 -.31	-1.53	.126	-3.54 .44	3.22	p<.001**	1.28 5.26	0.79	.430	-1.19 2.79	5.54	p<.001**	3.63 7.61	4.75	p<.001**	2.83 6.81
TD	6827	.940	.349	-.13 .37	.520	.606	-.18 .31	-.760	.448	-.34 .15	-.420	.674	-.30 .19	-1.69	.090	-.46 .03	-1.27	.203	-.41 .09

Note. Abbreviations: *Z* refers to standard score, Sig. refers to significance level, CI refers to confidence interval.
Significance *p<.05. **p<.001

Predictor variables

Following calculation of KS1 performance discrepancy scores and establishing that children with autism show significantly lower KS1 performance discrepancy scores, and therefore greater underachievement, compared to peers, Pearson's correlations were used to ascertain which predictor variables are associated with KS1 performance discrepancy score. These correlations are presented in Table 2.10.

When performing correlations it is important to consider type 1 error, the chance of incorrectly detecting a significant effect and rejecting the null hypothesis (Cohen, 1992). Statistical analyses designed to correlate numerous variables from a single dataset are more likely to see significant correlations caused by chance alone than studies that only include two variables (Knudson & Lindsey, 2014). Therefore it is likely that our analysis is at risk of type 1 error. We chose to keep our significance threshold at a standard level of 0.05, rather than lowering the significance threshold to reduce risk of type 1 error and therefore we need to maintain appropriate caution when interpreting our findings.

For children with autism, four predictor variables were shown to have a significant relationship with KS1 performance discrepancy score. One, conduct problems at age three was shown to have a significant positive correlation with overall KS1 performance discrepancy score; $r(206)=.14$, $p<.05$, writing discrepancy score; $r(206)=.14$, $p<.05$, and science discrepancy score; $r(206)=.18$, $p<.05$. Surprisingly, this relationship suggests that the more conduct problems a child with autism has at age three, the less they underachieve overall and in writing and science when aged seven years.

Two, self-regulation at age five was shown to have a significant negative correlation with KS1 reading discrepancy; $r(215)=-.14$, $p<.05$. Unexpectedly, this suggests that children with higher self-regulation at age five show more underachievement in reading.

Three, parental involvement at age seven was shown to have a significant negative correlation with writing discrepancy score; $r(226)=-.14$, $p<.05$. In contrast to theoretical prediction, this suggests that children with more parental involvement show more underachievement in writing.

Four, having a statement/ educational health care plan (EHCP) was shown to have a significant positive correlation with science discrepancy score; $r(94)=.21$, $p<.05$. This suggests that children with a statement/ EHCP show less underachievement in science.

Table 2.10:

Correlations between KS1 performance discrepancy scores and predictor variables for the autism sample

Predictor Variables		N	Overall discrepancy		Writing Discrepancy		Reading discrepancy		Maths discrepancy		Science discrepancy	
Child variables			*r*	*Sig.*	*r*	*Sig.*	*r*	*Sig.*	*r*	*Sig.*	*R*	*Sig.*
Emotional symptoms	Age 3	205	.056	.423	.079	.261	.079	.259	.056	.428	.023	.744
	Age 5	215	.026	.708	.054	.432	.004	.959	.040	.558	.046	.504
	Age 7	224	.036	.590	.079	.236	.053	.430	.037	.582	.041	.543
Conduct problems	Age 3	206	**.142**	**.042***	**.144**	**.038***	.075	.282	.098	.106	**.187**	**.007***
	Age 5	215	.008	.901	-.034	.616	-.014	.838	.043	.535	.121	.078
	Age 7	224	-.031	.641	-.094	.163	-.051	.450	.027	.686	.101	.134
Hyper- activity	Age 3	202	.102	.149	.067	.340	.132	.060	.106	.135	.131	.063
	Age 5	215	.022	.754	-.050	.465	.069	.312	.067	.325	.129	.059
	Age 7	224	-.051	.448	-.102	.127	.029	.665	-.001	.984	.082	.223
Peer problems	Age 3	201	-.024	.735	-.030	.671	-.032	.648	.048	.502	-.072	.307
	Age 5	215	.027	.695	.071	.301	-.012	.862	.048	.488	.005	.944
	Age 7	224	-.131	.051	-.096	.150	-.101	.132	-.044	.510	-.087	.193
Pro-social	Age 3	202	-.001	.993	.003	.969	.032	.648	-.051	.475	.014	.839
	Age 5	219	.036	.596	-.005	.942	.067	.324	-.010	.886	.041	.544
	Age 7	223	.078	.248	.082	.221	.088	.188	.002	.976	.000	.995
Total difficulties	Age 3	197	.123	.085	.101	.160	.099	.167	.136	.057	.126	.077
	Age 5	215	.030	.665	.009	.898	.025	.719	.072	.293	.110	.109
	Age 7	224	-.062	.357	-.074	.270	-.019	.781	.005	.946	.046	.494
Self- regulation	Age 3	207	-.018	.792	-.001	.984	-.096	.170	-.063	.364	.004	.957
	Age 5	215	-.044	.521	-.062	.364	**-.142**	**.037***	-.082	.231	-.018	.791
	Age 7	217	.100	.142	.018	.791	.030	.664	.048	.482	.029	.669

Predictor variables		N	Overall discrepancy		Writing discrepancy		Reading discrepancy		Maths discrepancy		Science discrepancy	
Family variables			*r*	*Sig.*	*r*	*Sig.*	*r*	*Sig.*	*r*	*Sig.*	*R*	*Sig.*
Parental involvement	Age 3	206	-.115	.098	-.126	.071	-.112	.108	-.073	.295	.023	.651
	Age 5	219	-.017	.800	-.046	.494	-.025	.715	-.058	.395	.115	.089
	Age 7	226	-.116	.083	**-.139**	**.037***	-.103	.123	-.089	.181	-.033	.626
Maternal interest		160	-.061	.442	-.039	.622	-.030	.709	-.031	.697	.043	.592
Paternal interest		160	-.018	.819	.077	.333	.004	.965	-.066	.407	.024	.767
Maternal education		226	-.036	.593	.001	.988	.032	.637	-.023	.734	.058	.387

Predictor variables		N	Overall discrepancy		Writing discrepancy		Reading discrepancy		Maths discrepancy		Science discrepancy	
School variables			*r*	*Sig.*	*r*	*Sig.*	*r*	*Sig.*	*r*	*Sig.*	*R*	*Sig.*
Bullied	Age 3	195	.073	.311	.026	.719	.028	.700	.125	.080	.074	.301
	Age 5	195	.033	.644	.034	.642	-.015	.831	.075	.300	.016	.822
	Age 7	204	-.030	.670	-.039	.581	-.010	.888	-.008	.912	.006	.931
Class size		91	-.102	.337	-.085	.422	.090	.398	-.203	.053	-.196	.063
Supply cover		84	.074	.504	-.022	.845	-.038	.729	.059	.596	.156	.156
Classroom noise		91	.055	.602	.063	.554	-.021	.844	.085	.421	-.008	.938
Support in class from TA		142	-.085	.313	-.140	.098	-.016	.852	.001	.989	.070	.408
Support in class from family member		142	-.037	.661	-.079	.352	-.142	.092	.002	.981	.101	.230
Statement/ EHCP		94	.197	.056	.161	.122	.133	.202	.051	.628	**.214**	**.038***

Note. Abbreviations: r refers to correlation coefficient, Sig. refers to significance level.
Significance *p<.05.

Following the exploratory analysis of predictor variables, bivariate correlations that were found to be significant at the 0.05 level were entered into a regression analysis in order to identify unique predictors of the discrepancy between intellectual ability and academic achievement in children with autism. Regression analysis was used to explore predictors of overall KS1 performance discrepancy but also KS1 performance discrepancy scores on a subject basis for writing, reading, maths, and science. The results from these multiple linear regressions are presented below.

Writing discrepancy

The enter method of multiple linear regression was carried out to determine the effect of conduct problems at age three and parent involvement at age seven on writing discrepancy scores of children with autism. $R^2 = .040$, suggesting that only 4% of the variance in writing discrepancy can be explained by these two factors. The result ($F(2, 203) = 5.289$, $p<.05$) demonstrates that this model is significant. It was found that conduct problems at age three significantly predicted writing discrepancy scores ($\beta=.17$, $p<.05$) as did parent involvement at age seven ($\beta=-.17$, $p<.05$).

Science discrepancy

The enter method of multiple linear regression was carried out to determine the effect of conduct problems at age three and whether the child has a full statement of SEN on science discrepancy scores of children with autism. $R^2= .048$, suggesting that only 4.8% of the variance in science discrepancy can be explained by these two factors. The result ($F(2, 86) = 3.218$, $p<.05$) demonstrates that this model is significant. It was found that whether a child has a full statement of SEN or not significantly predicted science discrepancy scores (β=.22, $p<.05$). Conduct problems at age three were not found to be significant ($p=.235$).

Discussion

This research explored the discrepancy between intellectual ability and academic achievement in a sample of children with autism. The results of this research will be discussed below, as well as a consideration of strengths and limitations of the study and recommendations for future research.

Summary and interpretations of results

Discrepancy between intellectual ability and academic achievement

The first research question this study sought to address was whether children with autism show a discrepancy between intellectual ability and academic achievement compared to peers. Specifically, we looked at a particular population of children who were able to access the KS1 curriculum and undertake KS1 assessments. The results indicate that these children with autism show mean overall KS1 performance discrepancy scores of -2.25 (where scores less than zero indicate participants achieved lower than expected based on their intellectual ability). This suggests that the children with autism in our sample do show a discrepancy between intellectual ability and academic achievement; specifically they appear to be underachieving academically. This finding builds on that of previous research that highlights significant discrepancies between the actual and expected academic achievement of children with autism (Estes et al, 2011).

Analysis of overall KS1 performance discrepancy scores indicate a significant difference between children with autism and TD peers, with children with autism showing significantly greater underachievement. No significant differences were found between children with autism and children with ADHD or between children with ADHD and TD children, suggesting academic underachievement is significantly more prevalent in our autism population. The observed effect size for this analysis was very small (η_p^2 =.002), indicating sufficient power to detect small effects, and thus limiting risk of Type II error. It is important to note, that while the discrepancy observed for children with autism is statistically significant, the size of the discrepancy found was small (less than one standard deviation). This may have implications on the clinical meaningfulness of results. In addition, while no significant differences were found between children with ADHD and TD children, or between children with ADHD and autism, the small sample size of our ADHD group limited the power of this analysis and the ability to detect effects. Additional research is needed with larger sample sizes before conclusions can be made about the discrepancy between intellectual ability and academic achievement in children with ADHD.

Additional analysis was used to examine the impact of different key stage subjects (reading, writing, mathematics and science) on KS1 performance discrepancy scores. This found a significant interaction between diagnostic status and subject. In particular the analysis highlighted that children with autism show significantly lower KS1 performance discrepancy scores, and therefore more underachievement, in writing and mathematics, compared to TD children. Exploration of within-group effects highlighted that children with autism are more likely to underachieve academically in writing compared to reading/ science and they are more likely to underachieve in mathematics compared to science. This analysis suggests that children with autism particularly struggle to achieve their academic potential in writing and mathematics compared to other KS1 subjects. This underachievement was not seen in children with ADHD or TD children. This finding accords with previous literature which suggests that children with autism are more likely to show a specific learning disability in written expression or mathematics, compared to reading or spelling tasks (Mayes-Dickerson & Calhoun, 2006). Mayes-Dickerson and Calhoun (2006) found that 60% of their sample showed a specific learning disability in written expression tasks, while 23% showed a specific learning disability in mathematics tasks and only 6% and 9% showed a specific learning disability in reading and spelling tasks.

Predictors of academic underachievement

Our second research question was to establish which child, parental, and school-related variables are associated with the discrepancy between intellectual ability and academic achievement in children with autism. While the correlation and regression analysis identified four variables associated with KS1 performance discrepancy scores, these should be interpreted with caution as the effects are small, the risk of Type 1 error is high, and the results are not in line with our predictions. These findings are discussed below.

Conduct problems at age three were shown to have a significant positive correlation with overall KS1 performance discrepancy scores and KS1 writing performance discrepancy scores. This result suggests that the more conduct problems a child has at age three, the less they underachieve overall and in writing. It is well established in TD literature that the presence of conduct problems increases the likelihood of academic underachievement in children and adolescents (Moilanen et al, 2010; Richards & Abbot, 2009; Riglin et al, 2013). Therefore it is surprising that our results suggest the opposite for children with autism. One possible explanation for this finding is that it is a false positive (due to the large number of correlations performed) and therefore not reliable.

In addition, self-regulation at age five demonstrated a significant negative correlation with reading discrepancy. This suggests that children with higher self-regulation abilities at age five show more underachievement in reading. Again, this result is not as we would expect. Numerous research with TD children has identified that students with lower self-regulation abilities are more likely to underachieve academically (McCoach and Siegle, 2001; McCoach & Siegle, 2003). In addition, research has identified self-regulation to be better than IQ at predicting students' academic grades (Duckworth & Seligman, 2005). It is therefore surprising that our results suggest the opposite for children with autism. As this finding contradicts that of previous literature, it should be interpreted with caution as it may suggest a false positive result.

An alternative hypothesis for our findings on conduct problems and self-regulation is that children presenting with more obvious difficulties in young childhood may be more likely to be identified earlier and receive the additional support needed to help them achieve their academic potential. It is well established in the literature that early identification and intervention is greatly beneficial for difficulties in school (O'Shaughnessy, Lane, Gresham & Beebe-Frankenberger, 2003). Children who show signs of conduct problems at age three or poor self-regulation abilities at age five may be more likely to be identified to be in need of, and provided with, additional support by teachers. Perhaps children with autism who do not present with such obvious difficulties are not provided with the interventions and support needed in order to cope with the demands of school and reach their academic potential and are therefore more likely to show academic underachievement.

Looking at conduct problems specifically, many interventions have been developed that combat and reduce these kinds of antisocial behaviours (Walker, Ramsey & Gresham, 2004). For example, ‘First Steps to Success’ has been used as a beneficial intervention for children in reception who show early signs of antisocial behaviour (Walker, Kavanaugh, Stiller, Golly & Severson, 1998). Teachers are particularly keen to identify and reduce antisocial behaviours and conduct problems early on as when children get older, these kinds of challenging and problematic behaviours disrupt classroom learning, threaten student safety and overwhelm the teachers (Walker et al, 2004). Early intervention not only reduces current difficulties children present with, but it also reduces the risk of disruptive and behavioural problems in later childhood which in turn has a positive impact on learning and academic achievement (Walker et al, 2004). For children with autism, conduct problems are often conceptualised as secondary symptoms that have a communicative function and develop when the primary symptoms (e.g. difficulties with social interaction) are not addressed (Koegel, Koegel, Ashbaugh & Bradshaw, 2013). Through early identification and support these problems can be reduced or eliminated and replaced with more positive functional behaviours (Horner, Carr, Strain, Todd & Reed, 2002). Children who do not show obvious difficulties and are not identified earlier on may miss out on this support.

Early self-regulation difficulties may also lead to increased support and intervention. Self regulation refers to an individuals’ ability to regulate, and use effective coping strategies, in order to manage their emotional reactions (Jahromi, Bryce & Swanson, 2012). Self-regulation skills are critical for academic success and many school-based interventions have been designed to improve children's self-regulation abilities (Schmitt, McClelland, Tominey & Acock, 2015). Poor self-regulation is particularly concerning in children with autism as they may be more likely to engage in inadequate coping strategies when managing difficult feelings, such as frustration (Konstantareas & Stewart, 2006). Promoting and teaching children with autism successful self-regulation skills may encourage the use of constructive coping strategies which, in turn, may help them to cope with demands at school and meet expected academic levels. Children who do not show evidence of poor self-regulation may miss out on support and intervention.

It would be interesting for future research to further investigate this hypothesis that children with autism who present with more obvious difficulties in early childhood are provided with the support and interventions needed in order to cope with school demands and reach their academic potential. Quantitative methodology could be used to ascertain whether early conduct problems/ poor self-regulation and later academic achievement is mediated by intervention. Alternatively, qualitative research methods exploring teachers' experiences of which children with autism are provided with additional support, and the reasons for this, may help us to understand why some children are not achieving in line with academic expectations.

Another significant variable, identified by correlation analysis, was having a statement/ educational health care plan (EHCP). This was shown to have a significant positive correlation with science discrepancy score. This suggests that children with autism with a statement/ EHCP show less underachievement in science. This may support the hypothesis discussed above in relation to conduct problems that perhaps children with obvious difficulties are given additional support and intervention which helps them reach their academic potential. EHCPs, as summarised in the Children and Families Act 2014, are legal documents provided by the child's local authority outlining a child's special education needs, the support they require and the desired outcomes. With an EHCP secured, the local authority provides additional funding to the child's school so they can more easily put in place adequate support. Perhaps children with autism who do not present with such obvious difficulties are not provided with the same interventions and support needed for them to reach their academic potential. This notion that early presentation of obvious difficulties (such as conduct problems) leads to increased support and intervention (such as an EHCP) is just one hypothesis suggested by the data. In order to assess whether there is a significant interaction between these two variables, future research could use additional regression analysis to assess mediation effects.

A further variable identified by our analysis was parental involvement at age seven which was found to have a significant negative correlation with writing discrepancy score. This suggests that children with more parental involvement show more underachievement in writing. Again, this result is not as we would expect. TD literature has identified that a lack of parental involvement leads to poor academic achievement (Bakker et al, 2007; Faires et al, 2000; Jeynes, 2005). There was a substantial risk of type 1 error in our analysis therefore this finding should be viewed with caution as it may be indicative of a false positive result.

An alternative hypothesis for our finding on parental involvement centres on reverse causality. Perhaps if a child is struggling with literacy at school, parents become more involved in order to provide assistance and support. Watkins (1997) suggests that the relationship between parental involvement and academic achievement is more likely to be bidirectional. Parents involved in Watkins' (1997) research were more likely to be involved when their children displayed low achievement. In order to explore this hypothesis further, qualitative analysis could be used to gain insight into the experiences and opinions of parents. This methodology would provide an opportunity for these individuals to explain the motivation and rational behind their involvement and allow researchers to gain a fuller understanding of the link to academic achievement.

Limitations of this research

It is essential to consider possible methodological and process issues that may limit and reduce the reliability of the findings from this project. Limitations are discussed below.

Type 1 error

Firstly, the use of multiple correlations during predictor analysis may have increased the observed number of significant correlations caused by Type 1 error. This may account for some of the findings discussed above that contradict the previous literature. When using a significance threshold of 0.05, for every 100 correlations performed, you would expect 5 false positives. This project performed 180 correlations so Type 1 error may account for some of the confusing findings on predictor variables. While the relative frequency remains the same, if more correlations are performed, a higher number of significant results may be attributed to chance alone (Cohen, 1992; Knudson & Lindsey, 2014). All reported correlations will require replication before they could be considered likely to be genuine.

Arbitrary significance thresholds

Secondly, the significance threshold used may impact on the reliability of the findings on predictor variables. P values, first introduced by Fisher (1925), calculate the probability of observing your findings (or more extreme ones) if the null hypothesis was to be true. A p value of 0.05 has been widely used throughout the literature to indicate statistically significant results (Nuzzo, 2014). However, critics argue that this level is arbitrary and can lead to misinterpretation of significance (Field, 2005). In order to be more confident in interpreting significance of results, we could use more hypothesis driven theories. While this research used TD literature and professional opinions from clinical staff to identify possible predictors of academic underachievement, it would have been useful to explore the opinions and experiences of individuals with autism. This may have led to greater insight into the association between predictor variables and academic underachievement for this population, enabling us to be more confident in interpreting significance of results.

Insufficient sample size

Thirdly, insufficient sample sizes may explain our inability to accurately identify predictors of the discrepancy between intellectual ability and academic achievement. While initially our autism sample appeared large, this was reduced at each stage of analysis (from missing KS1 or cognitive data to missing data on predictor variables). While our sample size was sufficient to detect effects between 0.20 and 0.30 at 80% power, we would have needed over 780 participants to detect an effect of 0.10 at 80% power during correlation analysis (Cohen, 1988). Perhaps this indicates that there are no predictor variables having a large effect on the ability-achievement discrepancy of children with autism. Instead there could be many variables having a very small effect which cumulatively lead to the academic underachievement of children with autism. If this is the case, a much larger sample of children with autism will be needed to investigate this further.

Generalisability of results

Fourthly, the heterogeneity of autism and our study design may reduce the generalisability of our research findings to the wider autism population. Symptom severity and presentation varies between individuals with autism (Worley & Matson, 2012). This in itself makes it difficult to generalise population findings to specific individuals. In addition, we further reduced generalisability by selecting a subgroup of children with autism who underwent KS1 assessment. It is likely that individuals with higher symptom severity and comorbid intellectual impairment may not access KS1 curriculum and undergo assessment. These individuals are therefore unlikely to be represented in our sample .It is important to bear this in mind when interpreting results.

Validity of the derived IQ measure

Fifthly, the number of cognitive ability tests used to derive our IQ variable, and the validity of these measures, may impact the validity of our KS1 performance discrepancy score. Our measure of IQ was derived from standardised assessments of cognitive ability that were available in the MCS. Only three measures were available in sweep 4 however, limiting the accuracy of IQ measurement. In addition to this, one of the measures used was The National Foundation for Educational Research (NFER) Progress in Maths Test. While this tool has been used by previous research as an indication of cognitive skills (Flouri, Midouhas & Joshi, 2015), it is also often used to measure progress in school. If this test is more likely to be measuring school achievement and progress as a concept, rather than intellectual ability, it questions the validity of our derived IQ measure and subsequent KS1 performance discrepancy scores. It is important to hold in mind this possible limitation of IQ measurement when interpreting results.

Strengths of this research

As well as possible limitations to this study, there are also important strengths to bear in mind, in particular the use of a nationally representative sample and an ecologically valid measure of academic achievement.

Nationally representative sample

This is the first UK study to use a national longitudinal survey in order to investigate the discrepancy between intellectual ability and academic achievement in children with autism. One great strength of using a national longitudinal survey to access our sample is that the participants are more likely to be nationally representative and therefore research findings are more easily generalised to the wider population. In order to check the representativeness of our sample, we considered two sample characteristics. Firstly, we considered the gender ratio of our autism sample to see if it was representative of the wider population. Our total autism sample shows approximately a three to one gender ratio with 172 boys and 54 females. This is consistent with recent high quality epidemiological research (Loomes et al, 2017) and therefore we can conclude that the gender ratio of our sample is representative of the wider autism population.

Secondly, we considered age of autism diagnosis. The mean age of diagnosis in UK children has been identified as 89 months (approximately 7.4 years old) (Crane et al, 2015). In our sample, the highest proportion of children appeared to receive a diagnosis sometime between sweep 4 and sweep 5 (when the children were between 7 and 11 years old). As we do not have data on the exact age of diagnosis, we cannot tell exactly what age these individuals were diagnosed but it appears to be roughly in line with the literature. A slightly older age of diagnosis, which our sample might have, could indicate milder autism symptom severity (Zwaigenbaum et al, 2019). However, as we were only using children who had KS1 attainment scores, we would expect children with very high autism symptom severity to be excluded from this sample anyway. Therefore our sample appears representative of English children with autism who are able to access the academic curriculum to a sufficient level to be given KS1 scores

Ecologically valid measure of academic achievement

A second strength of this research was using KS1 attainment scores as a measure of academic achievement. Previous research has mainly relied on the use of standardised assessments of academic achievement, such as the Woodcock-Johnson Test of Achievement (WJ-II-ACH; Woodcock et al, 2001). These kinds of measures are not commonly used in schools as they require professional input for administration, scoring and interpretation. This calls into question how applicable their findings are to real life situations. This research is one of only two studies that have sought to address this using school KS1 attainment scores as a measure of academic achievement to increase ecological validity. Having a real life measure of academic achievement is essential to understanding whether children with autism are underachieving in school and therefore how we can support them to reach their academic potential. Academic underachievement has direct implications for educational and employment outcomes and subsequently on independent living and quality of life outcomes (Keen et al, 2016) therefore it is vital we use real life measures used by schools to comprehensively explore this issue.

Conclusions

The discrepancy between intellectual ability and academic achievement in children with autism was evidenced using a nationally representative sample and an ecologically valid measure of academic achievement. Robust control groups suggest a significant discrepancy is not evident in TD or ADHD child populations. For children with autism, academic underachievement is more prevalent in writing and mathematics.

These findings suggest that there is something specific to children with autism who undertake KS1 assessments that means they are at a significantly greater risk of underachieving academically and not meeting expected academic levels according to their intellectual ability. Future research is needed to explore what factors predict this underachievement. Knowing this will allow us to provide tailored support to these individuals. This research has evidenced the need for future research to have much larger sample sizes, so that small effects can be sufficiently detected.

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Part 3: Critical Appraisal

The achievement gap: The discrepancy between intellectual ability and academic achievement in children with autism

Introduction

This critical appraisal considers some of the methodological, practical and conceptual issues faced whilst conducting this research as well as key learning points to take forward. In particular it focuses on the strengths and limitations of secondary data analysis, the challenges of working with sensitive data within the bounds of confidentiality and how the heterogeneity of autism may influence the generalisability of research findings. It will then go on to discuss the impact of this project and indicate directions for future research.

Secondary data analysis

Using secondary data analysis in research has several advantages. Bypassing participant recruitment has positive implications on time and monetary resources. In addition, using a nationally representative data set, the Millennium Cohort Study (MCS), enabled this research to access a larger sample of participants than would have been possible by independent recruitment methods. However, there are some methodological limitations and practical issues to using secondary data which were encountered while conducting this research. These will be discussed below.

When reflecting on the use of secondary data analysis for this project, it is important to take into account my prior research experience, which includes limited secondary data analysis, in the form of service evaluation and audits. This was also the first time I have undertaken research using a national longitudinal survey. Starting this project with limited prior experience meant that the methodological limitations and practical issues I discuss in this appraisal were not expected nor planned for. This resulted in time delays and a need to adapt approaches as I went along. As acknowledged by Clarke & Cossette “time loss and considerable frustration may result if researchers begin secondary data analysis without an awareness of the distinctive methodological and practical challenges involved" (Clarke & Cossette, 2000, p.109). In future, the knowledge I have acquired will be beneficial when conducting further research using secondary data analysis.

Original study aims and measurements used

One limitation to using secondary data is that the variables examined and the measures used have been chosen by someone else, thus affecting the possible remit of future research. The collaborators involved in planning the data content for the MCS came from a range of disciplines with expertise in demography, developmental psychology, economics, epidemiology, geography, midwifery, paediatrics, public health, social psychology and sociology (Joshi & Fitzsimons, 2016). Their goal was to create a multi-purpose longitudinal dataset aiming to cater for a diverse range of research needs. The downside of this is that the measures used are unlikely to specifically match what future researchers need, limiting the scope of possible projects. It is also unlikely that each measurement tool used then will be the best and most recent tool available for secondary data analysis projects. Therefore it is imperative for researchers undertaking secondary data analysis to ensure the psychometric properties of any assessment measures used are strong (Clarke & Cossette, 2000). This was something this study needed to do, in particular when considering the cognitive assessment measures available within the MCS. While the psychometric properties for the cognitive measures (e.g. The British Ability Scales; BASII; Elliott, Smith & McCulloch, 1996) included in this project were strong, they may not have been selected if conducting independent primary research.

Another example of this difficulty was the way autism was measured in the MCS. Parents were asked to respond to the question "Has a doctor or health professional ever told you that (cohort child) has autism, Asperger's syndrome or autistic spectrum disorder?" during each sweep. As this question is subjective, incorrect answers could have been given which would impact the reliability and validity of this measure. For example, parents could be unaware of their child's diagnosis or their child could have undiagnosed autism. In addition, parents may not wish to disclose the diagnosis or parents could disagree with the diagnosis or use of labels and choose not to acknowledge it. There is also the risk that parents may have misunderstood the question. A more accurate way of measuring autism would be to conduct a multimodal assessment involving expert discussion of information from multiple sources, such as the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DeLavore & Risi, 1999) and The Autism Spectrum Quotient-Children's Version (AQ-Child; Auyeung, Baron-Cohen, Wheelwright & Allison, 2008). However, this method is not often used in research as it is more expensive and time consuming, leading to lower response rates. Due to the limitations of multimodal assessment, parental report is a common way of assessing autism in epidemiological studies. Research has identified that parental report of clinically-diagnosed autism and direct assessments of autism are mostly comparable, leading to identification of similar individuals (Blumberg et al, 2013). Therefore, despite possible difficulties, we can be confident the autism sample identified by the MCS is reliable.

Lack of responses, data discrepancies and inadequate recording

Another drawback to using secondary data is the issue of discrepancies within the data itself. While conducting this research it became apparent that there were inconsistencies in the way information had been collected and recorded across survey sweeps. This resulted in additional time delays checking and tidying the data to ensure accuracy. Guidelines on secondary data analysis suggest that it is important for the original study researchers to be available to answer questions and explain record-keeping processes (Clarke & Cossette, 2000). Due to the size of the MCS and my inexperience with secondary data analysis, I did not consider this to be feasible. However, if I had attempted to do so, perhaps this would have provided useful insight on the discrepancies within the data and enabled me to utilise the data more efficiently. This will be important to bear in mind when conducting further secondary data analysis projects in the future.

In addition to the above, another difficulty that arose when using the existing data set was the way that some information had been recorded in the MCS. For example, the MCS researchers decided that participant unique identifiers (IDs) would identify the family rather than the individual child. This meant that for families with twins, triplets, or multiple siblings born within the sample year, there was only one unique ID used for multiple children. This proved challenging for our research as there were duplicate IDs, with different data, that had to be checked to ensure that the right data were attributed to the right child. In order to reduce possible errors, we chose to only include in our research the first child from families where there were multiple children. Ensuring data was matched correctly and removing duplicates was time consuming and also led to a reduced sample size. If we had collected the data ourselves, we would have been able to make sure it was formatted into a more accessible and easy to use way for our specific research needs.

A further difficulty encountered was a lack of responses available for some of our predictor variables, thus reducing our sample size. This is a common problem that faces longitudinal research, with increased frequency of non-response and drop-out as cohorts age (Plewis, 2007). The amount of data that the MCS attempted to collect may have also impacted this as respondents may not have felt they had the time to complete all aspects of the research. Long interviews, lengthy questionnaires, and frequent data collection may introduce subtle selection bias as only the most motivated individuals will provide data on all measurements requested, with less motivated individuals only providing the minimum (Clarke & Cossette, 2000). Studies that focus on and prioritise collection of only a few variables will have more time to follow up and ensure participants stay motivated to provide data on all variables of interest. The scope of the data collection for the MCS was so large, and involved collecting data from multiple persons for each child (including the child itself, siblings, both parents and teachers), that doing this would not have been feasible. For example, one of our predictor variables of interest was class size. In theory this is a very straightforward variable that could be collected from parent or teacher report or accessing educational records. However, we only had data on this variable for 91 out of the 226 children in our sample with autism, a response rate of only 40%. If we had conducted our own research for this project, rather than using secondary data analysis, we could have ensured that as much effort as possible went into collecting data on specific variables of interest. In doing this, response rate may have improved which in turn would have had a positive impact on sample size and the subsequent power of our research. If collecting own data is not feasible, future research should consider employing methods to tackle missing data, such as maximum likelihood missing values (Little & Rubin, 2002). This analysis would enable missing data values to be estimated and should be pursued as a strategy in future research should a similar problem arise.

Attrition and drop outs

Another methodological limitation to longitudinal research is the loss of participants during follow-up, with reports suggesting successful recruitment at follow-up varies between 30% and 80% (Fischer, Dornelas & Goethe, 2001). The MCS had a complex pattern of participant involvement with attrition, re-entry and a small number of late entrants. Refusal to participate, non-contact, and emigration all contributed to non-responses across each sweep (Connelly & Platt, 2014). While the response rate at sweep one was 72% (Plewis, 2007), by the fifth sweep of the MCS, only 54% of families had participated in all five surveys, and approximately 20% had participated intermittently (Joshi & Fitzsimons, 2016). Loss of participants in longitudinal research is a serious problem as it can lead to biased samples. Individuals leading more stable lives, with better outcomes, are likely to be the ones that continue to engage in research meaning samples are often not representative (Fischer et al, 2001). In the MCS, parent non-responders were more likely to be younger, from minority ethnic groups, have fewer educational qualifications and have lower income (Plewis, 2007). In addition, the risk of attrition has been found to be higher in adolescents who have experienced significant life events, require additional support at school, and are in contact with mental health services (Pérez, Ezpeleta & Domenech, 2007). This has direct implications on our research and suggests that the children included in our sample might not be truly representative of the varying levels of severity of autism in the general population, impacting the ecological validity and generalisability of our findings.

Summary

Despite the difficulties discussed above, there are several advantages to using the MCS for secondary data research, which made it a suitable method for this project. In particular, these included the ability to access large sample sizes, the benefit to time and monetary resources and the ability to investigate longitudinal effects. In selecting a national longitudinal survey, we hoped to achieve a sample that was representative of the UK autism population however sample design (such as selecting KS1 scores as a measure of academic achievement) and sampling bias from non-responders impact the generalisability and ecological validity of findings. In future, awareness of both the advantages as well as methodological limitations discussed above will ensure that secondary data analysis projects are better prepared for and executed.

Secure data and confidentiality

Another aspect of this project that caused some practical issues was accessing the KS1 data which was deemed to be sensitive and therefore held within the UK Data Service's Secure Lab. In order to access this, I underwent special licence access training and examination. Once access had been granted, I was required to perform all analysis in isolation from a secure room within the Institute of Education. Results from the statistical analysis had to be written in the secure room and satisfy disclosure checks before they were allowed to be released. This led to time delays and also meant that presentation of some of the findings had to be compromised in order to satisfy confidentiality regulations. For example, the histograms presented in the empirical paper had to have bars merged, or binned, to satisfy the UK Data Service's '10 cell count rule'. As the ADHD sample was too small, it was not possible to successfully merge histogram bars to adhere to the '10 cell count rule' so this histogram was omitted from our findings.

Maintaining confidentiality and security of participants' data is a priority and not adhering to these rules could betray participants and damage public trust in researchers (Kaiser, 2009). The MCS decided KS1 data required a higher level of security as, if combined with other aspects of data, it would increase the risk of identifying participants. While the security procedures detailed above are an important step in helping to maintain confidentiality, they require researchers to undergo extra work in order to access and use the data. If I had known in advance the amount of time it would take for me to gain access to the data, and the amount of checks needed to have statistical findings released, I may not have chosen to undertake this research project. Reflecting on this raises an interesting dilemma for researchers about the importance of maintaining participant confidentiality while at the same time considering its impact on the utility of data and not wanting to discourage research on certain ‘hard to access’ topics.

Variability of autism

Another aspect of this research to consider is the variability in symptom presentation of children with autism and the impact this may have on the generalisability of findings to the whole autism population. Autism is referred to as a spectrum condition as the severity of symptoms can vary between individuals (Worley & Matson, 2012). In addition, while core features of autism are experienced by most and are critical to achieving a diagnosis, additional symptoms such as speech and language difficulties, motor deficits and/or feeding difficulties are only experienced by some individuals (Maskey, Warnell, Parr, Le Couteur & McConachie, 2013). This variability in autism is apparent both within and between individuals (Towgood, Meuwese, Gilbert, Turner & Burgess, 2009) and has implications on the generalisability of research findings.

One methodological dilemma that needs to be considered is the decision by our study to include within the autism sample children who have comorbid ADHD. This decision was made based on the evidence of high ADHD comorbidity rates, ranging from 40-83%, in the general autism population (May et al, 2018). Therefore it was decided that including the 67 individuals with comorbid diagnoses, approximately 30% of our sample, would be representative of the general autism population and increase the generalisability of our findings. In addition to this, we made deliberate efforts not to reduce our sample size, recognising the impact this would have on power. However, including these individuals further increased the heterogeneity of our sample and may have, in turn, reduced the generalisability of our findings.

Bearing the above in mind, while research findings on autism are undeniably useful in helping us to develop our understanding of the autism phenotype, it is important for researchers not to use these findings to make assumptions about individuals. Being explicit about the characteristics of your sample and the severity of their symptoms will help reduce unhelpful assumptions and stereotypes that everyone with autism presents in the same way (Davidson & Henderson, 2010). In this project, the use of KS1 assessments as a measure of academic achievement further limited the generalisability of findings. Only individuals who undertook KS1 learning and assessment were included in our sample. Children with autism who do not sit KS1 assessments are likely to have higher symptom severity and/or have lower intellectual functioning. Therefore our findings cannot be applied to all individuals with autism and just provide insight into a subgroup of autistic children, who have undergone KS1 assessment and grading.

Impact and future directions

There has been a sizeable increase in the amount of funding designated to autism research in the UK over the last decade (Pellicano, Dinsmore & Charman, 2013). It is important we ensure the research being undertaken increases our understanding of autism and is helpful to those with the condition. Individuals within the autism community have expressed concern regarding a lack of research which will lead to positive impacts on the day-to-day lives of those with autism (Pellicano, Dinsmore & Charman, 2014). There is hope that research will provide insight and knowledge to enhance the lives of autistic individuals and those that support them (Insel & Daniels, 2011). One specific area requested is how to ensure children get the right support and education in school to reach their full potential (Pellicano et al, 2014). The knowledge gained from this project regarding the academic underachievement of children with autism is undoubtedly an important first step to understanding this. However, further research is still needed on predictors of academic underachievement. Once predictors have been identified, this knowledge can be translated into strategies to support children with autism in reaching their academic potential and in turn achieving successful life outcomes (Keen, Webster & Ridley, 2016).

It is disappointing, and surprising given the rigorous process to identify possible predictor variables, that our analysis provided limited information on the child, family and school factors associated with academic underachievement. Going forward, we would suggest future research employs qualitative methodology to explore the opinions of multiple stakeholders (parents, teachers and individuals with autism). Interviewing these individuals may provide useful insight into associated predictor variables. Qualitative analysis allows for in-depth focus on the experiences of individuals and may be better suited for understanding the complex associations and processes involved (Ritchie & Lewis, 2003). The first step in undertaking qualitative research may be to use 'participatory research' (Cornwall & Jewkes, 1995). In this project, we used TD literature and professional opinions to identify possible predictors of academic underachievement rather than incorporating the views of people within the autism community. Using participatory research to gather the views of autistic people would have helped determine which predictor variables needed more detailed focus and may have led to greater insight into the association between predictor variables and academic underachievement. Using participatory research techniques would also ensure research remains relevant and useful for individuals within the autism community (Fletcher-Watson, 2019; Long, Panese, Ferguson, Hamill & Miller, 2017). It will be important to consider these issues when conducting future research.

Conclusion

Carrying out this research project has given me greater awareness of the challenges in carrying out secondary data analysis and the resulting compromises that have to be made. In addition, I have experienced how difficult it is to ensure findings are generalisable and therefore how important it is to be specific about the research population. Despite designing this project to ensure findings would be representative of, and generalisable to, the wider autism population, the heterogeneity of autism and the decision to limit our sample to children who have undertaken KS1 assessments inadvertently compromised this.

This project successfully demonstrates the academic underachievement of children with autism. However it is disappointing that our analysis of predictor variables provided limited information on the child, family and school factors associated with this. Identifying possible predictor variables is essential to providing those within the autism community support and strategies to ensure children with autism meet their academic potential and go on to experience success in other areas. Therefore further research on this topic is warranted. We would advise future researchers to consider using qualitative methods in order to gather in-depth views and opinions from relevant stakeholders. Doing this would increase our understanding of the complex association and processes involved in the academic underachievement of children with autism.

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Appendices

Appendix I: Ethics approval document

UCL RESEARCH ETHICS COMMITTEE
OFFICE FOR THE VICE PROVOST RESEARCH

12th March 2018

Dr Will Mandy
Department of Clinical, Educational and Health Psychology
UCL

Dear Dr Mandy

Notification of Ethics Approval with Provisos
Project ID/Title: 12509/001: Family, school and child factors that influence the discrepancy between cognitive ability and educational achievement in children with autistic spectrum conditions compared to peers

I am pleased to confirm in my capacity as Joint Chair of the UCL Research Ethics Committee (REC) that I have ethically approved your study until 1st August 2019.

Ethical approval is subject to the following conditions:

Notification of Amendments to the Research
You must seek Chair's approval for proposed amendments (to include extensions to the duration of the project) to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing an 'Amendment Approval Request Form' http://ethics.grad.ucl.ac.uk/responsibilities.php

Adverse Event Reporting – Serious and Non-Serious
It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator (ethics@ucl.ac.uk) immediately the incident occurs. Where the adverse incident is unexpected and serious, the Joint Chairs will decide whether the study should be terminated pending the opinion of an independent expert. For non-serious adverse events the Joint Chairs of the Ethics Committee should again be notified via the Ethics Committee Administrator within ten days of the incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Joint Chairs will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

Final Report
At the end of the data collection element of your research we ask that you submit a very brief report (1-2 paragraphs will suffice) which includes in particular issues relating to the ethical implications of the research i.e. issues obtaining consent, participants withdrawing from the research, confidentiality, protection of participants from physical and mental harm etc.

In addition, please:

- ensure that you follow all relevant guidance as laid out in UCL's Code of Conduct for Research: http://www.ucl.ac.uk/srs/governance-and-committees/resgov/code-of-conduct-research
- note that you are required to adhere to all research data/records management and storage procedures agreed as part of your application. This will be expected even after completion of the study.

With best wishes for the research.

Yours sincerely

[redacted]

Professor Michael Heinrich
Joint Chair, UCL Research Ethics Committee

Cc: Jessica Howse & Dr Emily Midouhas