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A Systematic Review of Literature and Meta-Analysis of the Cognitive Performance of Children with Autism Spectrum Disorder using the Wechsler Intelligence Scale for Children

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Supervisor: Adri Vorster

A research report submitted in partial fulfilment of the requirements for the degree of Master of Education by Coursework and Research Report in the field of Educational Psychology in the Faculty of Humanities, University of Witwatersrand, Johannesburg

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ABSTRACT

Autism Spectrum Disorder, which includes previous diagnostic terms such as Asperger Syndrome, Pervasive Developmental Disorder and High Functioning Autism, is a lifelong neurodevelopmental disorder that is characterised by persistent deficits in social communication, difficulties in interaction across multiple contexts, difficulties in non-verbal communicative behaviours, and the exhibition of unusual behaviours. Given that Autism Spectrum Disorder is a spectrum disorder, Autism Spectrum Disorder individuals experience different degrees of signs and symptoms. Given the nature of Autism Spectrum Disorder and the differing levels of severity, individuals also present with varying cognitive capabilities and subsequently cognitive abilities (strengths and weaknesses) when assessed on individual intelligence measures such as the Wechsler Intelligence Scale for Children, which has been revised multiple times since its inception in 1949. The purpose of this research study is to investigate the cognitive performance of Autism Spectrum Disorder children assessed on the Wechsler Intelligence Scale for Children. First, a systematic review was conducted of available literature and research studies focused on the cognitive performance of Autism Spectrum Disorder children who have been assessed on the Wechsler Intelligence Scale for Children, followed by a meta-analysis to investigate the extent to which the performance differences observed between Autism Spectrum Disorder children and typically developing peers, when measured on the Wechsler Intelligence Scale for Children, is meaningful. Although a systematic review of 49 published research studies was undertaken, the meta-analysis included only 12 studies which focused on comparing the cognitive performance of Autism Spectrum Disorder and typically developing children. The results revealed that children diagnosed with Autism Spectrum Disorder, Asperger Syndrome and High Functioning Autism performed the highest on the Perceptual Reasoning Index and the lowest on the Processing Speed Index. Although limited data are available on individuals diagnosed with Pervasive Developmental Disorder, they performed the highest on the Perceptual Organisation Index and the lowest on the Verbal Comprehension Index. The results also revealed that when taking into account all the diagnostic terms used, Autism Spectrum Disorder children performed the highest on the Block Design subtest, followed by the Similarities subtest. They performed the lowest on the Coding subtest, followed by the Comprehension subtest. The meta-analysis revealed that the means and standard deviation differences found among the various Wechsler Intelligence Scale for Children indices between Autism Spectrum Disorder and typically developing children revealed that the typically developing children who participated in the various studies

performed higher than Autism Spectrum Disorder children across all the Wechsler Intelligence Scale for Children indices except for the following: The High Functioning Autism children obtained a slightly higher mean Full-Scale IQ score than typically developing peers, with a higher mean Verbal Comprehension Index found on the part of the High Functioning Autism children. There is practical value in supporting Autism Spectrum Disorder children to reach their potential and minimising the impact of their diagnosis, as well as its accompanying difficulties on their scholastic progress and performance.

PLAGIARISM DECLARATION

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Title: A Systematic Review of Literature and Meta-Analysis of the Cognitive Performance of Children with Autism Spectrum Disorder using the Wechsler Intelligence Scale for Children

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LIST OF ABBREVIATIONS AND ACRONYMS

ASD	Autism Spectrum Disorder
CDC	Centers for Disease Control and Prevention
CHC	Cattell–Horn–Carroll
DSM-5-TR	Diagnostic and Statistical Manual of Mental Disorders (Fifth Edition, Text Revision)
FFD	Freedom from Distractibility Factor
FRI	Fluid Reasoning Index
FSIQ	Full-Scale IQ
HFA	High Functioning Autism
HFPDD	High Functioning Pervasive Developmental Disorder
PDD-NOS	Pervasive Developmental Disorder-Not Otherwise Specified
PIQ	Performance IQ
POI	Perceptual Organisational Index
PRI	Perceptual Reasoning Index
PSI	Processing Speed Index
VCI	Verbal Comprehension Index
VSI	Visual–Spatial Index
WAIS	Wechsler Adult Intelligence Scale
WHO	World Health Organisation
WISC	Wechsler Intelligence Scale for Children
WISC-V	Wechsler Intelligence Scale for Children – Fifth Edition
WMI	Working Memory Index

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CHAPTER 1: INTRODUCTION

1.1 Background to the Research Study and Rationale

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that primarily affects communication, social interaction and relationships, and behaviour (Rylaarsdam & Guemez-Gamboa, 2019). ASD is considered a spectrum disorder, which implies that the symptoms and severity can vary widely from person to person (Audras-Torrent et al., 2021). ASD children[1] may have difficulty understanding social cues, maintaining eye contact, and engaging in reciprocal conversations (Caron et al., 2004; Matsumoto et al., 2016). They may also struggle with developing and maintaining meaningful relationships with others, and may prefer to spend time alone rather than with peers (Kwok et al., 2015). ASD children may also exhibit repetitive behaviours, such as hand-flapping, rocking back and forth, and repeating phrases or words (Kercood et al., 2014). These behaviours may be comforting to the child, but can also interfere with their ability to engage in everyday activities fully. Among the difficulties experienced by ASD children are cognitive difficulties that require accurate identification so that appropriate support can be offered. In the identification of these difficulties, individual intelligence measures, such as the Wechsler Intelligence Scale for Children (WISC), are often used.

The WISC is a widely used psychological assessment measure, specifically an individual intelligence measure, which assesses cognitive abilities in children (De Jong, 2023). The WISC was first published by psychologist David Wechsler in 1949 as a way to assess the cognitive functioning of children between the ages of 6 years and 0 months, and 16 years and 11 months (Wechsler, 1949). Since its inception, the WISC has undergone several revisions to improve its accuracy, theoretical grounding, and relevance to modern-day cognitive and scholastic tasks. The current version of the assessment, namely the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V), was published in 2014. The WISC-V includes updated norms, which means that the assessment measure is based on a more current and representative sample of children (Wechsler, 2014). One application of the WISC is to assess the cognitive performance of ASD children. This application can provide valuable insights into the cognitive strengths and weaknesses experienced by ASD children, which can inform targeted interventions to support the scholastic functioning and progress of these children. Research has

[1] ASD children/ASD individuals is the preferred term used by Autism South Africa and is, therefore, used throughout the research report.

shown that ASD children often have uneven cognitive profiles, meaning that their abilities in different areas can vary widely (Mayes & Calhoun, 2003; Oliveras-Rentas et al., 2012; Stack et al., 2017). As an example, an ASD child may have strong verbal abilities, but struggle with visual–spatial skills. Alternatively, a child may have strong skills in quantitative and non-verbal reasoning, but struggle with social communication and verbal comprehension. The WISC is a useful tool for assessing children's cognitive abilities and identifying areas of strength and weakness (Kuehnel et al., 2019). The assessment includes several subtests that measure different cognitive abilities, such as verbal comprehension, visual–perceptual reasoning, and processing speed (Willcutt et al., 2013). By administering a variety of subtests, clinicians can gain a more detailed understanding of a child's cognitive abilities and tailor interventions to build strengths while addressing areas of weakness. In addition to identifying cognitive strengths and weaknesses, the WISC can also provide valuable information about the child's learning style and preferences.

However, in South Africa, limited research has been conducted on ASD children (Sefotho & Onyishi, 2021; Van Schalkwyk et al., 2021), with no published research studies having investigated their cognitive abilities when measured on individual intelligence measures such as the WISC. In an article published by Pillay et al. (2021), the importance of educational systems supporting ASD children in South Africa is highlighted; yet, in order to do so, it is important that their specific cognitive needs are met. With no published research studies on the cognitive abilities of ASD children in South Africa, including their cognitive strengths and difficulties, further research in this area is needed. However, before such research can be conducted and ASD children in South Africa can be assessed on the WISC to investigate their cognitive strengths and needs, it is important to understand what research has been done internationally. This can assist in the development and planning of South African studies on the assessment of ASD children. In addition, it can provide valuable information on the cognitive strengths and difficulties of ASD children, and their specific cognitive needs which should be met in inclusive classrooms so that their educational progress and functioning are supported. Taking this into consideration, the present research study aimed to systematically review international research studies that investigated the WISC cognitive performance of ASD children, and conducted a meta-analysis aimed at investigating the extent to which the performance differences observed between ASD children and typically developing peers, when measured on the WISC, is meaningful.

1.2 Aims

The aim of the present research study was to conduct a systematic review of international literature of published research studies which investigated the cognitive performance of ASD children, as measured by the WISC. The study was also aimed at conducting a meta-analysis to investigate the extent to which the performance differences observed between ASD children and typically developing peers, when measured on the WISC, is meaningful.

1.3 Research Questions

While considering the aim of the research study, the following research questions were presented:

1. What does a systematic review of literature reveal about international research that has been conducted to investigate the cognitive performance (abilities and difficulties) of ASD children when assessed on the WISC?
2. Does the cognitive performance of ASD children, as assessed by the WISC, differ meaningfully from that of typically developing peers?

1.4 Concept Clarification

1.4.1 Autism Spectrum Disorder

According to the Diagnostic and Statistical Manual of Mental Disorders (Fifth Edition, Text Revision) (DSM-5-TR) (American Psychiatric Association [APA], 2022), ASD is a lifelong neurodevelopmental disorder that is characterised by the following behaviours, namely persistent deficits in social communication, difficulties in interaction across multiple contexts, difficulties in non-verbal communicative behaviours, and the exhibition of unusual behaviours. Furthermore, the DSM-5-TR also includes the following specifiers: With or without an accompanying intellectual impairment, an accompanying language impairment, whether the ASD is associated with a known environmental factor or genetic or medical condition, with comorbid catatonia, or associated with another neurodevelopmental, mental or behavioural disorder.

1.4.2 Wechsler Intelligence Scale for Children

The WISC is an individual intelligence measure used to assess the cognitive performance of children between the ages of 6 years and 16 years and 11 months (Dale et al., 2021;). It has undergone many modifications since the original test released in 1949, with the

most recent version of the WISC, namely WISC-V, released in 2014 (Wechsler, 1949, 2014).

1.4.3 Intelligence and Cognitive Abilities

One of the most widely accepted definitions of intelligence was proposed by Gottfredson (1997), who defined it as an amalgamation of cognitive abilities, which include reasoning, problem-solving, planning, abstract thought, understanding complicated ideas, and experience-based learning. Cognitive abilities are brain-based features required to complete any task, regardless of the level of difficulty. As opposed to having much to do with actual information, cognitive abilities have more to do with the processes by which people learn, remember, solve problems, and pay attention. Specific neural networks support cognitive abilities (Johnson & Munakata, 2005). For instance, the frontal and temporal lobes (located behind the forehead) play a major role in memory abilities (Ritchey et al., 2015). Given the focus of the WISC, this research report is focused more closely on the following cognitive abilities, namely verbal comprehension, perceptual and visual–spatial reasoning, working memory, processing speed, and fluid reasoning.

1.5 Outline of the Research Report

1.5.1 Chapter 1

The first chapter introduced this research study, which is focused on the cognitive abilities and difficulties of ASD children, as measured by the WISC. The chapter provided a background to the research study, as well as the research rationale, followed by the research aims and questions. Clarification was given regarding three concepts that are used throughout the research report.

1.5.2 Chapter 2

The second chapter provides a detailed report on the available literature on the cognitive abilities and difficulties of ASD children using the WISC. The literature review is focused on the following areas, namely ASD, including research on the difficulties experienced by ASD children, the importance of the accurate identification and assessment of ASD children, the WISC, and South African research conducted with ASD children highlighting the need for future research.

1.5.3 Chapter 3

In this chapter, a detailed outline is given of the methodology that was used to conduct

this research report. The following sections are included in this chapter, namely the aims, research questions, research design, sample, study identification process, selection of cognitive domains, data analysis section, and ethical considerations.

1.5.4 Chapter 4

The fourth chapter is focused on presenting the results found in this research report. This is presented as tables and graphs to illustrate the various mean performances found across the various articles that were used in the systematic literature review and meta-analysis. Although a systematic review of 49 published research studies was undertaken, the meta-analysis included only 12 studies which was focused on comparing the cognitive performance of ASD and typically developing children.

1.5.5 Chapter 5

The fifth chapter is focused on discussing and interpreting the results reported in Chapter 4. The results of this research study are also interpreted in relation to previous literature.

1.5.6 Chapter 6

The sixth chapter is aimed at discussing the strengths and weaknesses of the current study. Possible recommendations for individuals working with ASD children are also considered.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

According to the DSM-5-TR (American Psychiatric Association [APA], 2022), ASD is a lifelong neurodevelopmental disorder that is characterised by the following, namely persistent deficits in social communication, difficulties in interaction across multiple contexts, difficulties in non-verbal communicative behaviours, and the exhibition of unusual behaviours. ASD has no single known cause (Constantino & Charman, 2016). The WISC-V is the latest version of the WISC assessment tool and is an individual intelligence measure that assesses a child's cognitive abilities across primarily five different cognitive domains (Flanagan & Alfonso, 2017). This literature review expands on these thoughts by firstly examining ASD as a neurodevelopmental disorder. Secondly, the cognitive difficulties experienced by ASD children will be highlighted and discussed. This includes an overview of their language, processing speed, working memory, and visual–spatial and fluid reasoning abilities. Thirdly, the literature review identifies some of the implications that cognitive difficulties have on ASD children's classroom performance. Lastly, the WISC is discussed in more detail, including a section on the link between the Cattell–Horn–Carroll (CHC) Theory and the various WISC-V indexes and subtests.

2.2 Autism Spectrum Disorder

2.2.1 Defining and Understanding Autism Spectrum Disorder

According to the DSM-5-TR (APA, 2022), Masi et al. (2017) defines ASD as being a complex, widespread and multifactorial neurodevelopmental condition, whereby the foundation for diagnosis is the observation of atypical behaviour, with diagnostic criteria emphasising limitations in social communication and interaction, and constrained, repetitive patterns of behaviour, interests or activities. Similarly, Stack et al. (2017) define ASD as a group of Pervasive Developmental Disorders (PPDs) that are distinguished based on specific differences and deficits in social communication and understanding. In addition to this, ASD individuals experience restricted interests and repetitive behaviours. Therefore, the common themes across literature in defining ASD surround the fact that it is a spectrum disorder and, therefore, the disorder presents itself in a multilayered way with the emphasis being placed on the individual's behaviours and socio-communicative skills.

A neurodevelopmental disorder such as ASD is defined as a disorder of the nervous system and, therefore, it affects the body's brain and nerves (D'Souza & Karmiloff-Smith,

2017). A variety of symptoms can be caused by structural, metabolic or electrical abnormalities in the brain, spinal cord, or other nerves (Tick et al., 2016). The DSM-5-TR (APA, 2022) and the ICD-11 (World Health Organisation [WHO], 2022) provide criteria to assist in the diagnosis of ASD. The DSM-5-TR criteria for the diagnosis of ASD are as follows, with the first domain stating that the individual should experience impairment in social interaction and communication, specifically with social and emotional reciprocity, non-verbal communication, as well as in creating and maintaining relationships (all three specifications need to be met). The second domain states that the individual should experience abnormal and repetitive behaviours, interests and activities. Two or more of the following behaviours need to be met, namely stereotyped speech and behaviour, resistance to change, hypersensitivity or hyposensitivity to sensory input, and/or fixated interests. The third domain states that these symptoms and behaviours need to be present in early childhood development. The fourth domain states that the difficulties experienced by the individual impacts everyday activities and their functioning in various areas. Lastly, the individual's symptoms and behaviours are not better explained by another disorder, such as Intellectual Developmental Disorder (APA, 2022).

The ICD-11 criteria for a diagnosis of ASD are similar. The first domain states that individuals experience prolonged difficulties in starting and maintaining social communication and interactions. These difficulties may be manifested in the following ways, namely inappropriate social communication and understanding of social cues, reduced non-verbal complimentary behaviours, a lack of social awareness, decreased empathy, and difficulties in building and maintaining social relationships. The second domain states that the individual experiences limited, consistent and rigid behavioural, interest or activity patterns. These behaviours may manifest in the following ways, namely increased distress and decreased adaptability when routine is broken, extreme compliance to rules, excessive repetitive behaviours, motor motions that are repetitive and stereotyped, hypersensitivity or hyposensitivity to sensory input, and/or strong fixations. The third domain states that these symptoms and behaviours need to be present in early childhood development. Lastly, the deficits are sufficiently severe to cause impairment in various areas of functioning (WHO, 2022).

As part of the stated diagnostic criteria, the DSM-5-TR (APA, 2022) has also developed three levels of severity to be considered in the diagnoses of ASD children. Individuals with a severity level of one need some assistance. When there is no support available to them, their repetitious behaviours, social skills deficits, and communication difficulties are more

pronounced and visible to others, and will increasingly impact their daily functioning. Therefore, while this group of ASD children may be able to express themselves verbally, they can struggle with and often show little interest in social interactions and conversations with others. Executive functioning difficulties are also present in that ASD children with a severity level of one often struggle with task switching, flexibility, planning and organisation. Individuals with a severity level of two need a significant amount of assistance. Even with appropriate support in place, their lack of social and communication skills, as well as their repeated behaviours, are visible to the casual observer and interfere quite significantly with their daily functioning. The latter is further hampered by significant execution functioning difficulties and struggles in managing change. Individuals with a severity level of three require extensive support. Their daily lives are significantly hampered by verbal and non-verbal social and communication difficulties, and atypical, repetitive behaviours. Difficulties with their executive functions, especially their inflexibility, cause extreme distress, especially when they are confronted with change (APA, 2022). These three severity levels once again emphasise the complexity of ASD and highlight the spectrum aspect of the disorder (Hoogenhout & Malcolm-Smith, 2017). In the same manner that individuals present and experience ASD in various ways, so too is the aetiology of the disorder ascribed to multiple factors.

ASD is not related to one specific cause, with ongoing research indicating that it is most likely the result of a combination of genetic and environmental risk factors (Masi et al., 2017). The Centers for Disease Control and Prevention (CDC) has identified several risk factors for ASD, some of which are hereditable, for example, chromosomal or genetic disorders, as well as family history; some are biological, for example, pregnancy or birth complications, as well as older-aged parents; and others are environmental, for example, exposure to harmful chemicals and air pollution during pregnancy (CDC, 2014). Given the complexity of the disorder and the fact that the symptoms and severity thereof vary so vastly, there are likely many factors that contribute to the development of the disorder.

Owing to its extreme genetic heterogeneity, ASD can result from both heritable and spontaneous gene variants (Tick et al., 2016). In the past 10 years, multiple genes have been found to play a role in the severe behavioural, social cognition, and speech deficits that ASD individuals frequently experience. However, these findings only account for 10%-20% of ASD cases, and individuals with the same pathogenic variants may experience various levels of ASD (Rylaarsdam & Guemez-Gamboa, 2019). Common and rare inherited variations have frequently been linked to research on the genetic causes of ASD. However, it has been found that additional, non-inherited genetic factors could be connected to trait variation (Kong et al.,

2018). Even though the complete aetiology of ASD is unclear, familial and twin studies show a high heritability rate of 60%-90%, suggesting a major genetic component in the development of the disorder (Pugsley et al., 2022). Similarly, a meta-analysis of twin studies conducted by Tick et al. (2016) found the estimated heritability of ASD to be in the range of 64%-90%. Therefore, the impact of genetics on the aetiology of ASD has largely been regarded as a probable contributing factor.

Through epigenetic mechanisms such as DNA methylation, changes in histone proteins, and expression of noncoding RNAs, environmental variables can influence the type and amount of gene expression without altering the DNA sequence. In this manner, they can be passed on to the next generation of cells or individuals (Perera & Herbstman, 2011). When developmental important genes are expressed differently during crucial stages of embryo development, it increases the chance of disorders with genomic imprinting, such as ASD (Foley et al., 2009; Wang et al., 2008). It has been suggested that none of the environmental variables alone can cause ASD; rather, a combination of environmental factors may contribute to its occurrence (Glasson et al., 2004). As a result, the primary explanation for the aetiology of ASD has been suggested as the interactions between susceptible genes and environmental factors.

Additional prenatal, natal and postnatal risk factors have also been identified as possible contributing factors to ASD. Prenatal risk factors, such as the pregnant mother's physical, mental and emotional well-being, as well as their financial situation, all have a significant impact on the development and health of a baby (Zhang et al., 2010). Mothers who are undernourished and struggle with their emotional and physical wellbeing are at risk of giving birth to a baby who experiences multiple difficulties, including ASD (Hisle-Gorman et al., 2018). One of the most important risk factors that have also been identified for ASD has been found as advanced parental age (Durkin et al., 2008; Lee & McGrath, 2015). Maternal and paternal ages greater than or equal to 34 have been linked to an increased chance of ASD in their children; however, in other studies, the association between ASD and the ages of both parents or even one parent has been disproved (Alter et al., 2011; Larsson et al., 2005; Reichenberg et al., 2006). A natal risk factor that has been investigated to contribute to the possible causes of ASD includes the umbilical cord being wrapped around the baby's neck at birth (Hisle-Gorman et al., 2018). Studies have found that this occurred significantly more frequently in ASD children (23,2%) compared to controls (6,3%), and it resulted in fetal anaemia, which can harm the developing brain and cause trauma to the newborn's central nervous system if the anaemia is severe or persistent enough (Gardener et al., 2011; Kolevzon et al., 2007; Zhang et al., 2010). Low birth weight, jaundice, and postnatal infection are some

of the most commonly considered postnatal risk factors (Gardener et al., 2011; Hultman et al., 2002). However, considering the prenatal, natal and postnatal risk factors, the postnatal risk factors were found to be the least concerning (Hisle-Gorman et al., 2018). Additional risk factors in the development of ASD that are continuously being investigated include environmental toxins, medications, pregnancy complications, and viral infections (Grabrucker, 2013; Masini et al., 2020). Regardless, the origin and evolution of ASD have been studied for many years, and yet it remains a controversial point of discussion with a multitude of contributing factors continually considered and researched.

It is important to be cognisant that while the DSM-5-TR (APA, 2022) refers to ASD, this term includes conditions that were previously considered separate. The term 'Autistic disorder' is often referred to as 'Classic Autism' (Simms, 2017). When individuals are classified as having an autistic disorder, they are often thought to experience significant language delays, have difficulty communicating with others, and display unusual behaviours (Simmons et al., 2009; Tierney et al., 2015). An additional intellectual disability may also be associated with an autistic disorder (Mefford et al., 2012). Asperger Disorder has been used to describe less severe symptoms than those thought to be associated with an autistic disorder (Foley-Nicpon et al., 2012). Social difficulties and unusual habits remain present; however, there is usually no intellectual disability or language impairment (Klila & Giuliani, 2021). Lastly, PDD, also known as 'atypical autism', is described as a condition in which a person exhibits some, but not all of the characteristics of Asperger Syndrome or an autistic disorder (Springer et al., 2013). There could be fewer and less severe symptoms, and the individual could experience communication and societal difficulties. However, according to the DSM-5-TR, these terms are no longer being used to describe individuals. Instead, all individuals who would previously have fallen under one of the above-mentioned terms are now described as having ASD.

2.2.2 Cognitive Difficulties Experienced by Autism Spectrum Disorder Children

Given the nature of ASD and the differing levels of severity, individuals present with varying cognitive capabilities and subsequently also cognitive strengths and weaknesses when assessed on individual intelligence measures such as the WISC. ASD individuals have a variety of skills and challenges, which can change over time (Dawson et al., 2008). Although some ASD individuals can live independently, others have significant needs and require ongoing care and assistance (Baker et al., 2019). ASD affects how people communicate and interact with the world (Matson et al., 2012). Language is subsequently often seen as being a significant

difficulty that is experienced by ASD individuals (Springer et al., 2013). However, each ASD individual has their own strengths and challenges. Regardless, the most common trait shared by almost all ASD individuals is difficulty in communicating and interacting with people (Oakley et al., 2022). Depending on the level of severity, this may be exhibited by not speaking at all, needing longer to process information, or not understanding facial expressions (Oakley et al., 2022). ASD individuals also engage in repetitive behaviour through recurring thoughts or behaviour (Masi et al., 2017). They sometimes display these repetitive behaviours out of enjoyment and other times, these behaviours help them to manage their anxiety (Kercood et al., 2014). ASD individuals may also find unexpected changes very distressing. Sensory overload is often also a significant challenge for ASD individuals, where noises, smells, and bright lights may become very painful and distressing (Hazen et al., 2014). These challenges can be very confusing for ASD individuals and, more so, ASD children who have not yet learned how to manage these challenges. These overwhelming challenges may lead to emotional meltdowns or shutdowns.

Along with the physical, emotional and social challenges experienced by ASD individuals, they also experience varying degrees of cognitive challenges. An individual's cognitive abilities are frequently impacted by ASD in a variety of ways and to differing degrees. ASD individuals commonly have cognitive strengths such as being able to pay close attention to fine detail (Bury et al., 2020). They may also experience cognitive challenges such as delayed executive function skills and difficulties in Theory of Mind (Hajri et al., 2022). Theory of Mind is the capacity to recognise that others do not possess our ideas and emotions. It also involves being able to acknowledge that other people have their own thoughts and emotions, and comprehending how those things influence both our own and their behaviour (Andreou & Skrimpa, 2020). Although Theory of Mind typically starts to show around the age of four years, its foundation is laid in infancy (Rakoczy, 2022). Challenges with Theory of Mind are considered the main reason why many ASD individuals frequently have difficulty in navigating social situations (Andreou & Skrimpa, 2020). The term 'executive function' describes the higher-order control mechanisms required to direct behaviour in a dynamic world (Zelazo, 2020). As mentioned earlier in the discussion of the severity levels, it is common for ASD individuals to experience challenges with the following, namely planning various tasks, using their working memory to hold onto information in order to use it again, sustaining attention and being able to shift their attention from one activity to the next, initiating tasks on their own, controlling their emotions and behaviour, and being flexible by adapting to changes to their routine (Braconnier & Siper, 2021; Hajri et al., 2022; Mitchell & Ropar, 2004).

The executive functions can be assessed using various assessments, with the WISC assessment tool being one of them.

2.2.3 Autism Spectrum Disorder and Language Abilities

Language plays a vital role in expression and communication (Berk, 2015). To communicate effectively, individuals need to be able to understand what others are saying to them (Gleason & Ratner, 2022). This can be described as receptive language, specifically verbal comprehension or listening comprehension (McIntyre et al., 2017). Effective communication also relies on the ability to express oneself using both words (oral expression) and gestures. This form of communication is known as expressive language (Cheung et al., 2022). Once individuals are able to make use of receptive and expressive language, it is also important for them to be able to use these language skills in ways that are seen as being socially appropriate. According to the DSM-5-TR (APA, 2022), in order for a child to be diagnosed with ASD, they need to experience persistent deficits in social communication and interactions across various contexts (APA, 2022). Therefore, one of the primary challenges that most often describes an ASD child is the difficulties they experience in the development of age-appropriate language skills (Oliveras-Rentas et al., 2012; Tierney et al., 2015).

The cognitive and social growth of ASD children affects their capacity for language and communication (Geurts & Embrechts, 2008). Some ASD children may be unable to communicate verbally, while others might have extremely limited verbal communication abilities (Brignell et al., 2018). Some ASD individuals may have large vocabulary sets and be able to discuss particular topics in great detail (Brignell et al., 2018). However, many ASD individuals struggle with word meaning (Dawson et al., 2008). Additionally, they may also struggle to interpret facial expressions and distinct verbal tones, as well as body language, appropriately (Mjosund et al., 2015). When these challenges are considered collectively, they have an impact on how well ASD children interact with others, particularly children their own age. ASD children who are able to express themselves verbally in age-appropriate ways may say things that are unrelated to the interactions they are having with other people (Geurts & Embrechts, 2008). An example of this may be that a child might continually count from one to five while engaging in a discourse unrelated to numbers. An ASD child may also constantly repeat phrases they have heard; a condition known as echolalia (Grossi et al., 2013). Some ASD children have high-pitched, sing-song voices or communicate in robotic ways (Matsumoto et al., 2016).

2.2.4 Autism Spectrum Disorder and Processing Speed Abilities

The amount of time it takes an individual to complete a mental task can be characterised by the cognitive ability of processing speed (O'Brien et al., 2020). Processing speed concerns how quickly a person can comprehend and respond to information, whether it be visual (letters and numbers), auditory (linguistic) or physical (movement). Slow processing speed means that some skills, such as reading, mathematics, listening and taking notes, or having conversations, will be more challenging than others (Dodonova & Dodonov, 2012). An individual with slow processing speed may also experience challenges with their executive functions as processing speed is linked to an individual's capacity to perform executive functions (Gordon et al., 2018). As a result, they might find it more difficult to plan, create objectives, make decisions, initiate tasks, focus and sustain attention.

Many social and non-social behavioural difficulties are seen in ASD. Slower processing speed is one of the cognitive abilities that can potentially unify the heterogenous profile of behaviours experienced by ASD individuals (Eack et al., 2013; Faja et al., 2009; Haigh et al., 2018). A dominant theory regarding the cognitive performance of ASD individuals is that they "process" their surroundings differently and exhibit a wide range of cognitive strengths and weaknesses (Lerner et al., 2013). It has been proposed that many ASD children are only able to process one stimulus at a time, which causes them to become excessively preoccupied with one activity or one aspect of their environment (Doi et al., 2021). This is frequently evident in the particular nuances or interests that ASD children pay attention to that are typically disregarded by others. Additionally, a delayed response to sensory integration may occur in ASD children as a result of their fragmented perception (Russo et al., 2010). Fragmented perception refers to the action of seeing things as parts, rather than as a whole concept (Smid et al., 2013). The fragmentation of the world is a reality for many ASD individuals. Owing to the difficulties experienced by ASD children to process large amounts of different information at once, they frequently struggle to "separate" a scene into discrete parts and understand the concepts, people and surroundings as parts of a larger context. They instead analyse "pieces" that happen to catch their attention (Russo et al., 2010). Therefore, the slower processing speed abilities seen in ASD individuals can be related to a number of underlying factors.

2.2.5 Autism Spectrum Disorder and Working Memory Abilities

Focus, following directions, and processing and responding to emotions are all daily tasks that require the use of executive functions such as working memory. Working memory is a short-term storage system with a finite capacity for holding onto information while

processing it mentally (Alloway & Alloway, 2010). Both working memory and other executive function abilities are essential for learning, working, relating, and other important daily tasks (Cornoldi & Giofrè, 2014).

Research suggests that in comparison to typically developing children controls, ASD individuals perform worse on tests of working memory, particularly when the tasks rely heavily on planning, spatial working memory, a heavy workload, increasing task complexity, and dual tasking (Kercood et al., 2014). A meta-analysis conducted by Wang et al. (2017), which focused specifically on the working memory capabilities of ASD individuals, found that they displayed general impairments in working memory. Notably, these individuals' visual–spatial working memory was more impaired when compared to their verbal/auditory working memory. Similarly, Zhang et al. (2020) found that ASD children experienced abnormalities in their visual–spatial working memory compared to typically developing children.

2.2.6 Autism Spectrum Disorder and Visual–Spatial Abilities

An individual's capacity to process visual stimuli, discern spatial relationships between objects, and visualise various situations or images is known as visual–spatial processing (Radan et al., 2020). Visual–spatial skills allow individuals to orient themselves within the space that they find themselves (Zhang et al., 2020). They can do so by taking in information from the world around them and by arranging that visual information in a specific way to make meaning of what they see. Visual–spatial processing difficulties may be a permanent weakness as they impair an individual's capacity to learn, as well as their ability to engage in daily activities (Liu et al., 2021). A child's academic success, emotional state, and life skills are all impacted by their weaknesses in this area. Common signs of visual processing difficulties include difficulty focusing on visual tasks; being easily distracted by excessive visual stimuli; difficulty with reading, writing, and Mathematics; as well as difficulty differentiating between letters, numbers, and symbols; frequent eye strain or rubbing; and a tendency to bump into objects in the environment (Yilmaz & Yilmaz, 2017).

Research has shown that ASD individuals display a variety of enhanced visual–spatial cognitive skills (Mitchell & Ropar, 2004). Additionally, it has been found that prior knowledge does not affect the visual–spatial abilities of ASD individuals as much as it does those who do not present with ASD (Falter et al., 2008). In this regard, ASD individuals may be able to evaluate a situation with greater objectivity. ASD individuals tend to focus on detail, which makes it difficult for them to see the underlying relationship between concepts, people and surroundings that would add to their understanding of context; however, this focus on detail

allows them to analyse a visual stimulus and find the detail in the broader stimulus (Falter et al., 2008). Simmons et al. (2009) compiled the findings of numerous studies and discovered that ASD individuals performed better on visual search tasks even when the task was made more difficult, such as in multiple conjunction searches. It has also been hypothesised that improved Figure Disembedding ability in ASD is caused by higher visual acuity (Brosnan et al., 2012). Figure Disembedding assesses the ability to locate various figures that are hidden within a larger shape (Damarla et al., 2010). This hypothesis was supported with the use of Functional Magnetic Resonance Imaging (fMRI). It was found that ASD individuals displayed less frontal brain activation while completing Figure Disembedding activities when compared to those of typically developing individuals (Damarla et al., 2010). These results indicate that ASD individuals do not need as many resources as typically developing individuals to perform visual–spatial tasks at the same level. However, in contrast to these findings, a study by Caron et al. (2004) found that ASD individuals did not display superior visual–spatial abilities when compared to typically developing individuals.

2.2.7 Autism Spectrum Disorder and Fluid Reasoning Abilities

A psychologist named Raymond Cattell split our conceptualisation of human intelligence into two categories, namely fluid reasoning and crystallised intelligence. The capacity to make use of previously acquired abilities and information is referred to as crystallised intelligence (Cattell, 1963). Utilising crystallised intelligence requires the recall of prior knowledge and abilities (Schipolowski et al., 2014). Fluid reasoning is the ability to think logically and to solve problems in new situations without heavy reliance on prior knowledge and learning (Partanen et al., 2020). The process of fluid reasoning entails recognising novel patterns. Examples of the application of fluid intelligence include the ability to solve puzzles, devise solutions to novel issues, identify trends in data, and engage in speculative philosophical thinking (Ferrer et al., 2009).

It has long been believed that fluid intelligence reaches its peak in an individual's late 20s before progressively declining. Although it is likely linked to the deterioration of neurological functioning, fluid intelligence may also deteriorate as one matures and uses it less frequently (Cacioppo & Freberg, 2018). Children's ability to analyse situations is improved by learning to comprehend and identify these patterns, which enhances both their academic and everyday performance (Ferrer et al., 2009). Children's ability to receive and process new knowledge is influenced by their capacity for fluid reasoning. It gives them the ability to handle complicated problems by thinking creatively. Therefore, fluid reasoning is a vital ability that

individuals make use of daily. Although there appears to be limited research in this regard, a study by Hayashi et al. (2008) found that children with Asperger Syndrome performed better than typically developing peers on activities that rely on fluid reasoning. Similarly, a study conducted by Chen et al. (2010) found that individuals with Asperger Syndrome, as well as those with Autism, display superior fluid reasoning performance.

2.2.8 The Implications of Autism Spectrum Disorder Children's Cognitive Difficulties on Classroom Performance

ASD is a multifaceted disorder that can have a significant impact on a child's cognitive and emotional growth, creating substantial challenges for them in school. Early identification and management are essential to reducing the extent to which ASD may create challenges in the classroom, especially with relation to cognitive functioning (Zwaigenbaum et al., 2015). ASD children can receive the information and assistance they need to build self-management skills that will help them manage the difficulties they may have in the classroom when they receive early diagnosis and intervention. It has been recommended that parents and caregivers communicate to young children about their difficulties in order to foster a sense of acceptance and to further their familiarity regarding their diagnosis (Lord et al., 2020). Additionally, early intervention ought to emphasise the importance of executive functioning abilities that will help them finish tasks in the classroom more readily, including abilities such as task initiation, self-monitoring, and set changing (Stahmer et al., 2005).

ASD individuals frequently struggle with interpersonal relationships and communication. These difficulties can make it challenging for ASD children to participate in group activities, participate in conversations, and follow the teacher's instructions in the classroom (Watkins et al., 2017). They could struggle to comprehend the social norms that apply in a school context, such as taking turns and non-verbal cues. This might subsequently result in ASD children having trouble understanding the directions given by teachers, which can impair their ability to accomplish assignments and comprehend what is being demonstrated in class (Weiss et al., 2011). Deficits in executive functioning may make it difficult to maintain sustained attention and focus on tasks that require the child to switch between projects, staying organised, and managing multiple thoughts (Shmulsky & Gobbo, 2013). These executive functioning abilities are crucial in the classroom, but can be challenging for certain ASD children to achieve. ASD children could have trouble keeping track of their assignments and organising their thoughts, or they might struggle to switch between work in several academic areas.

Although being diagnosed with ASD can affect a child's academic performance in a number of different ways, the cognitive and social difficulties it may bring about can be addressed with early detection and intervention. ASD children can receive the support and help that they need to progress in the classroom provided teachers are aware of the challenges that may occur, as well as possible strategies that can be used to address them.

2.3 Wechsler Intelligence Scale for Children

The first edition of the WISC was published in 1949 as a downward extension of an adult individual intelligence measure, called the Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1949). The WAIS has been normed to assess individuals from 16 years and 11 months to 90 years and 11 months (Siegel et al., 1996). Therefore, the WISC was created to assess individuals that are between 6 years 0 months and 16 years 11 months (Wechsler, 2014). The WISC has undergone many modifications since the original test. A revised edition was released in 1974 as the WISC-R and a third edition, namely the WISC-III, was published in 1991, followed by the production of the WISC-IV in 2003 (Canivez et al., 2018; Nader et al., 2015). The fifth edition, namely WISC-V, is the most recent edition of the WISC scales, which was published in 2014 (Wechsler, 2014). The various versions of the WISC have been redesigned to account for the Flynn effect. The Flynn effect refers to the increase in scores on standardised individual intelligence measures that have been shown throughout time (Williams, 2013). Research found that the increase in scores on individual intelligence measures was not merely limited to a group or nation, but that the manifestation of the increased scores was rather dependent on time and place (Wicherts et al., 2004). Therefore, the sequentially updated versions of the WISC ensured that the norms of these measures do not become outdated, as well as ensuring that they are representative of the current population. Modifications to the questions are among further upgrades and improvements to the WISC to decrease their bias against females, as well as individuals from minority groups (Giofrè et al., 2017; Watkins et al., 2021). Updated materials also ensured that the administration of the test is more useful and efficient. Therefore, the evolution of the various WISC versions has ensured more optimal and accurate testing.

The subtests of the WISC were originally categorised into two sections, namely Verbal and Performance. The Verbal section comprised the following subtests, namely General Information, General Comprehension, Arithmetic, Similarities, Vocabulary, and Digit Span. Whereas the Performance section comprised Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding, and Mazes (Kaufman, 1975).

The WISC-R was created as a result of a nearly 25-year analysis of the original WISC (Kaufman, 1979). The revised version encompassed several changes to the application and scoring of the subtests. The subtests containing Number Sequencing, Coding and Mazes were kept the same. However, the Picture Completion subtest was altered due to finding a need that it was necessary for the items of the subtests to be more attention-grabbing for the children while completing the subtest (Ottem, 1999). The same 12 subtests that were used in the WISC were used in the WISC-R. However, the order of application changed to the following, namely General Information, Picture Completion, Similarities, Picture Arrangement, Arithmetic, Block Design, Vocabulary, Object Assembly, General Comprehension, Coding, Digit Span, and Mazes (Slate et al., 1992). The primary goal of the WISC-III was to recreate the norms for the same age range as in the WISC-R (Kezer & Arik, 2012). Additional reasons for revising the WISC included strengthening the items, enhancing the content of the test and subtests, and handling the factor structure differently (Kezer & Arik, 2012).

The WISC-III was guaranteed to enhance the WISC-R while maintaining the basic structure and content of the WISC. This was done by incorporating modern and representative norms, better subtest floors and ceilings, new artwork and items sensitive to multicultural and gender differences, and improved factor structure (Little, 1992). The overall WISC-III was enhanced as the items were made to be more colourful than the previous versions. The items were also designed to be more sensitive toward racial and gender discrimination (Kezer & Arik, 2012). Although many of the WISC-III properties remained the same as in the WISC-R, some alterations were made to the structure of the assessment. The WISC-III brought with it a new subtest that measured processing speed. Additionally, four index scores were used in the WISC-III, namely the Verbal Comprehension Index (VCI), the Processing Speed Index (PSI), the Freedom from Distractibility Factor (FFD), and the Perceptual Organisation Index (POI) (Nader et al., 2015). The structure of the WISC-III comprised six subtests that formed part of the Verbal section and seven subtests that formed part of the Performance section (Little, 1992). The Number Sequence, Symbol Search and Mazes subtests were regarded as alternate subtests among these (Little, 1992).

Similar to the previous versions, the WISC-IV was revised for the age range six years and 0 months to 16 years and 11 months (Wechsler, 2003). The WISC-IV introduced a few significant changes in the subtests and the layout of the indexes. Four index scores were substituted for the performance and verbal IQ scores in accordance with the findings of earlier factor analyses (Baum et al., 2015). These four indexes included the VCI, the Perceptual Reasoning Index (PRI), the Working Memory Index (WMI), and the PSI (Wechsler, 2003).

The following subtest modifications were made from the WISC-III to the WISC-IV, namely the Object Assembly, Picture Arrangement and Mazes subtests that were in the WISC-III were excluded from the test in the fourth revision of the WISC (Baron, 2005). In addition to this, five new subtests were added to the WISC-IV. Therefore, the revised version included 15 subtests comprising 10 core subtests and five supplementary subtests. The three subtests that were removed from the assessment tool all measured an individual's problem-solving abilities. It was found that the Picture Arrangement and Object Assembly subtests relied heavily on response time and that the Mazes subtest had noticeably weak reliability and validity. It was, therefore, decided that it would be beneficial to remove these subtests (Baron, 2005; Donders, 1996). The following 15 subtests formed part of the WISC-IV, namely the VCI subtests, which comprised Similarities, Vocabulary, Comprehension, Information, and Word Reasoning; the PRI subtests, which comprised Block Design, Picture Concepts, Matrix Reasoning, and Picture Completion; the WMI subtests comprising Digit Span, Letter–Number Sequencing, and Arithmetic; and the PSI subtests comprising Coding, Symbol Search, and Cancellation (Wechsler, 2003). The changes made in the WISC-IV brought about positive and beneficial alterations that improved the validity of the assessment, replaced outdated items, updated the norm groups, and increased cultural fairness (Kaufman et al., 2006).

The most updated version, namely the WISC-V, is still normed for ages 6 years and 0 months to 16 years and 11 months (Wechsler, 2014). The revision goals for the WISC-V included updating the theoretical foundations, increasing user-friendliness, increasing developmental appropriateness of the measure for various cultural groups, improving the psychometric properties of the assessment measure, and enhancing its clinical utility (Flanagan & Alfonso, 2017; MacAllister et al., 2019; Raiford, 2017). The integrated features of the WISC-V include the following, namely that the WISC-V remains targeted and flexible by allowing one to select the relevant subtests to ensure that the referral question is addressed, that the WISC-V provides a measure that broadens the conceptual coverage of working memory and allows one to assess how well the individual is able to apply working memory in specific domains, both of which are essential for making recommendations, that the WISC-V can better evaluate a child who experiences expressive language difficulties, and lastly, that the WISC-V enables one to develop and evaluate hypotheses as to why a child may be experiencing difficulties in a particular cognitive area (Cormier et al., 2016; Flanagan & Alfonso, 2017; Holdnack et al., 2016; Weiss et al., 2019). Therefore, theoretically, the WISC has become more useful in targeting and answering specific questions related to a child's cognitive functioning and the abilities that underlie it. In terms of its structure, the WISC-V comprises five primary

indexes that measure specific cognitive abilities. These include the following, namely the VCI, Fluid Reasoning Index (FRI), Visual–Spatial Index (VSI), WMI, and PSI. Each of the five primary indexes is calculated based on a child's performance on two primary subtests per index (Wechsler, 2014).

2.3.1 The Cattell–Horn–Carroll Theory

The CHC Theory is a theoretical model that closely represents the foundational ideas of the WISC-V (Scheiber, 2016). It is based on a hierarchical model that conceptualises and divides a person's cognitive abilities across three layers or strata. The third stratum measures a person's general underlying cognitive functioning, represented by Spearman's general intelligence factor (*g*). While the second stratum represents 16 broad abilities, the first represents the further division of these broad abilities into more than 80 narrow abilities (Abu-Hamour & Al Hmouz, 2020).

The CHC Theory assists in interpreting the results of the WISC-V, with five of the broad abilities being represented by the five primary indexes, and the narrow abilities being represented and measured by specific subtests within these indexes (Zaboski et al., 2018). The VCI coincides with verbal comprehension and acquired knowledge or crystallised intelligence (*Gc*), the VSI coincides with visual processing (*Gv*), the FRI coincides with fluid intelligence (*Gf*), the PSI coincides with processing speed (*Gs*), and the WMI coincides with short-term and working memory (*Gsm*). In addition to those five broad abilities, the WISC-V also offers the option to yield a sixth (supplementary) scale, namely Symbol Translation, which is representative of long-term storage and retrieval (*Glr*). The Full-Scale IQ (FSIQ) corresponds to the Stratum III general ability factor or *g* (Beaujean et al., 2014; Breaux et al., 2017; Caemmerer et al., 2018; Grégoire, 2017).

According to the CHC Theory, the broad ability (G*c*) that encompasses the VCI comprises two narrow abilities, namely K0 (General Verbal Information) and VL (Lexical Knowledge) (Kaufman et al., 2016). The WISC-V VCI comprises the following primary subtests, namely Similarities and Vocabulary. The Similarities subtest assesses the capacity for verbal abstract thought and reasoning, as well as the understanding of links between concepts, ideas or symbols (Becker et al., 2021). The two narrow abilities that are assessed by the Similarities subtest includes lexical knowledge, as well as induction (which is typically a narrow ability of G*f*) (Flanagan & Alfonso, 2017). The Vocabulary subtest assesses one's capacity for comprehending and defining words. It measures a person's capacity for association and the ability to link concepts (Zayat et al., 2011). The narrow ability that is

assessed by the Vocabulary subtest is lexical knowledge (Flanagan & Alfonso, 2017).

According to the CHC Theory, the broad ability (G*v*) that encompasses the VSI comprises two narrow abilities, namely Vz (Visualisation) and MV (Visual Memory) (Kaufman et al., 2016). The WISC-V VSI comprises the following primary subtests, namely Block Design and Visual Puzzles. The Block Design subtest requires individuals to use red and white blocks to duplicate a design pattern that is depicted as a visual stimulus (Soto & Kraper, 2013). For the Visual Puzzles subtest, the individual is required to put the puzzle pieces in the right order to make the image that is displayed in the stimulus (Breaux et al., 2017). Both subtests require an individual to organise information and solve problems using their visual perception abilities. Therefore, both primary subtests measure the same narrow ability – Vz (Flanagan & Alfonso, 2017).

According to the CHC Theory, the broad ability (G*f*) that encompasses the FRI comprises three narrow abilities, namely I (Induction), RG (General Sequential Reasoning) and RQ (Quantitative Reasoning) (Kaufman et al., 2016). The WISC-V FRI comprises the following primary subtests, namely Figure Weights and Matrix Reasoning. The Matrix Reasoning subtest assesses an individual's ability to recognise relationships between patterns, whereas the Figure Weights subtest requires an individual to figure out which item from a group of items is unique and has the highest weighting. Both of these subtests are regarded as non-verbal and have a strong relationship to both academic success and overall intelligence (Lecerf & Canivez, 2018). The narrow ability that is assessed by the Matrix Reasoning subtest includes induction. The Figure Weights subtest assesses both RG and RQ (Flanagan & Alfonso, 2017).

According to the CHC Theory, the broad ability (G*s*) that encompasses the PSI comprises three narrow abilities, namely R9 (rate of Test-Taking), P (Perceptual Speed) and N (Naming Speed Quantity) (Kaufman et al., 2016). The WISC-V PSI comprises the following primary subtests, namely Coding and Symbol Search. On the Coding subtest, the individual is given a set of numbers and is required to complete a code correctly in a limited amount of time. To solve the code accurately, one must have the capacity to assimilate information fluidly and manipulate the given numbers (Mayes et al., 2017). The narrow ability that is assessed by the Coding subtest is R9 (Flanagan & Alfonso, 2017). On the Symbol Search subtest, the candidate is required to rapidly identify and compare symbols to determine which ones are similar and which ones are different. In order to draw logical conclusions and make judgements, this calls for both fluent processing and analytical thinking (Zaboski II et al., 2018). The narrow ability that is assessed by the Symbol Search subtest is P (Flanagan & Alfonso, 2017).

According to the CHC Theory, the broad ability (G*sm*) that encompasses the WMI comprises two narrow abilities, namely MS (Memory Span), and MW (Working Memory Capacity) (Kaufman et al., 2016). The WISC-V WMI comprises the following primary subtests, namely Picture Span and Digit Span. The Picture Span subtest evaluates sequencing and visual working memory, while the Digit Span subtest measures auditory working memory. The narrow abilities that are assessed by the Digit Span and Picture Span subtests both include MS and MW (Flanagan & Alfonso, 2017).

2.4 Conclusion

Given the complexity of ASD and the fact that the symptoms and the severity thereof vary so vastly, there may be many factors that contribute to the development of the disorder. ASD individuals have a variety of skills and challenges, which can change over time (Dawson et al., 2008). They also present a range of different cognitive abilities, strengths and weaknesses and, therefore, also varying cognitive profiles when assessed using individual intelligence measures such as the WISC. The cognitive difficulties experienced by ASD children may impact their classroom performance. It is, therefore, vital to have a clear understanding of their cognitive strengths and weaknesses in order to help them optimise their learning. As mentioned, this research study comprises a systematic review of the literature, followed by a meta-analysis of the cognitive performance of ASD children using the WISC. In light of this, this study intended to examine the cognitive performance of ASD children. The following chapter will give an overview of the procedure employed to conduct this research study.

CHAPTER 3: RESEARCH PROCEDURE AND METHODS

3.1 Introduction

This chapter provides an overview of the procedure that was followed to conduct the research study. First, the research aims are highlighted. Secondly, the research questions are discussed. This is followed by a discussion on the research design within which the study was conducted. Fourthly, a description of the articles is given, followed by a detailed discussion on the study identification process. The focus is then placed on the selection of cognitive domains that were analysed during the study.

3.2 Research Aims

The aim of the present research study was to conduct a systematic review of international literature of published research studies which investigated the cognitive performance of ASD children as measured by the WISC. In addition, the study also aimed to conduct a meta-analysis to investigate the extent to which the performance differences observed between ASD children and typically developing peers, when measured on the WISC, is meaningful.

3.3 Research Questions

While considering the aim of the research study, the following research questions were presented:

1. What does a systematic review of literature reveal about international research that has been conducted to investigate the cognitive performance (abilities and difficulties) of ASD children when assessed on the WISC?
2. Does the cognitive performance of ASD children, as assessed by the WISC, differ meaningfully from that of typically developing peers?

3.4 Research Design

First, a systematic review of the literature was conducted. Systematic literature reviews are carefully designed studies that use an organised and explicit process for determining, selecting and critically assessing the findings of studies related to a specific topic (Tawfik et al., 2019).

A meta-analysis was then conducted to compare the cognitive performance of ASD children with that of typically developing peers, as assessed by the WISC. A meta-

analysis is a quantitative, formal, epidemiological study design that is used to quantitatively and methodically evaluate prior research studies in order to draw conclusions about that collection of knowledge (Esmaili et al., 2010). When conclusions are drawn from a pattern of findings across several studies, such as those of a meta-analysis, they are supported by more convincing evidence than if they were drawn from a single research study (Ahn & Kang, 2018).

Meta-analyses and systematic literature reviews are useful methods for combining previous data, although they do have some methodological flaws. The possibility of publication bias, where studies with statistically significant results are more likely to be published, is a severe constraint because it could cause the effect size in the meta-analysis to be overestimated (Glasson et al., 2004). Furthermore, the included studies' quality can vary greatly, producing heterogeneity that could jeopardise the overall conclusions' validity (Masi et al., 2017). Researcher bias may be introduced throughout the study selection and data extraction processes, which might be subjective. The representation of the available evidence may also be incomplete if non-English research is excluded. The comparability required for a successful meta-analysis may also be hampered by inherent differences in study designs, demographics, and procedures among the included studies. These weaknesses were addressed in the present study in the following ways: Publication bias was accounted for by only including high-quality studies regardless of novelty or unexciting results (Tawfik et al., 2019). Heterogeneity was accounted for by having clearly defined inclusion and exclusion criteria. Although multiple researchers weren't involved in the study selection process, the methodology and decision-making process was clearly documented to enhance transparency and replicability.

3.5 Study Identification: Inclusion and Exclusion Criteria

The systematic review made use of a set of initial criteria to identify relevant articles according to their abstracts. The following initial inclusion criteria were used:

1. The full-text article was published in English.
2. The article reported on the cognitive performance of ASD children using any of the following search terms, namely 'Autism', 'Autism Spectrum Disorder', 'Asperger Syndrome/Disorder', 'High Functioning Autism (HFA)', 'Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS)' and 'High Functioning Pervasive Developmental Disorder (HFPDD)'.
3. The cognitive performance was measured using any of the WISC versions.
4. The article was published in a peer-reviewed journal.
5. The article made use of a quantitative or mixed-methods approach.

6. The article population comprised both males and/or females.
7. The article population's age range was between 6 years 0 months and 16 years 11 months.

Once the articles that met the initial inclusion criteria were identified and those that did not were excluded, they were screened by reading through the full text of the article using the following narrowing-down criteria:

1. The article included WISC scores comprising means and standard deviations.
2. The article clearly separated the WISC and WAIS scores if both instruments were used.

A total of 3691 children were included in the systematic review when taking into account all of the children across the 49 primary articles that were identified. Of the 3 691 children, 57,65% (*n* = 2128) were diagnosed as having ASD, 14,87% (*n* = 549) were diagnosed as having Asperger Syndrome (AS), 9,02% (*n* = 333) were diagnosed as having Autism, 7,5% (*n* = 277) were diagnosed as having HFA, 4,9% (*n* = 181) were diagnosed as having PDD-NOS and 6,04% (*n* = 223) were diagnosed as having HFPDD. Of the 49 articles, 12 were included in the meta-analysis as they involved comparisons between ASD children (*n* = 483, 39,82%) and children who were considered typically developing (*n* = 730, 60,18%).

3.6 Search Strategy

A search for published, peer-reviewed research studies that met the inclusion criteria were primarily undertaken on a number of databases, including *Pubmed*, *ERIC*, *EBSCO*, and *PsychInfo* databases. In this search, specific search terms and subject delimiters were used, including Autism Spectrum Disorder OR ASD OR pervasive developmental disorder OR Asperger disorder OR Autism* OR Asperger* OR Pervasive Development* OR autistic disorder OR Asperger syndrome **AND** WISC-* OR Wechsler Intelligence Scale OR Wechsler Intelligence Scale for Children. The initial search yielded 1 618 articles. The comprehensive databases yielded the results as follows, namely *Pubmed* (*n* = 689 articles), *ERIC* (*n* = 76 articles), *EBSCO* (*n* = 251 articles), and *PsychInfo* (*n* = 602 articles). A total of 163 duplicate articles were removed manually based on a title match method. Once the 163 duplicate articles were removed, 1 455 articles were screened and assessed for eligibility by means of reading through the abstracts of the articles using the above-mentioned initial inclusion criteria.

A total of 1 300 articles were excluded as they did not meet the initial inclusion criteria. Once these articles were excluded, 155 articles were assessed by manual review of the full text. Next, a thorough search was conducted by examining the reference lists of the 155 identified

articles to locate studies that were not included in the initial pool. A total of 11 additional studies were identified. Therefore, 166 articles were identified as meeting the initial inclusion criteria. The 166 articles were screened by means of reading through the full text of the article using the narrowing-down criteria. After applying the narrowing-down criteria, 117 articles were excluded. Forty-nine articles met all inclusion criteria and were included in the systematic review, with 12 of these being included in the meta-analysis.

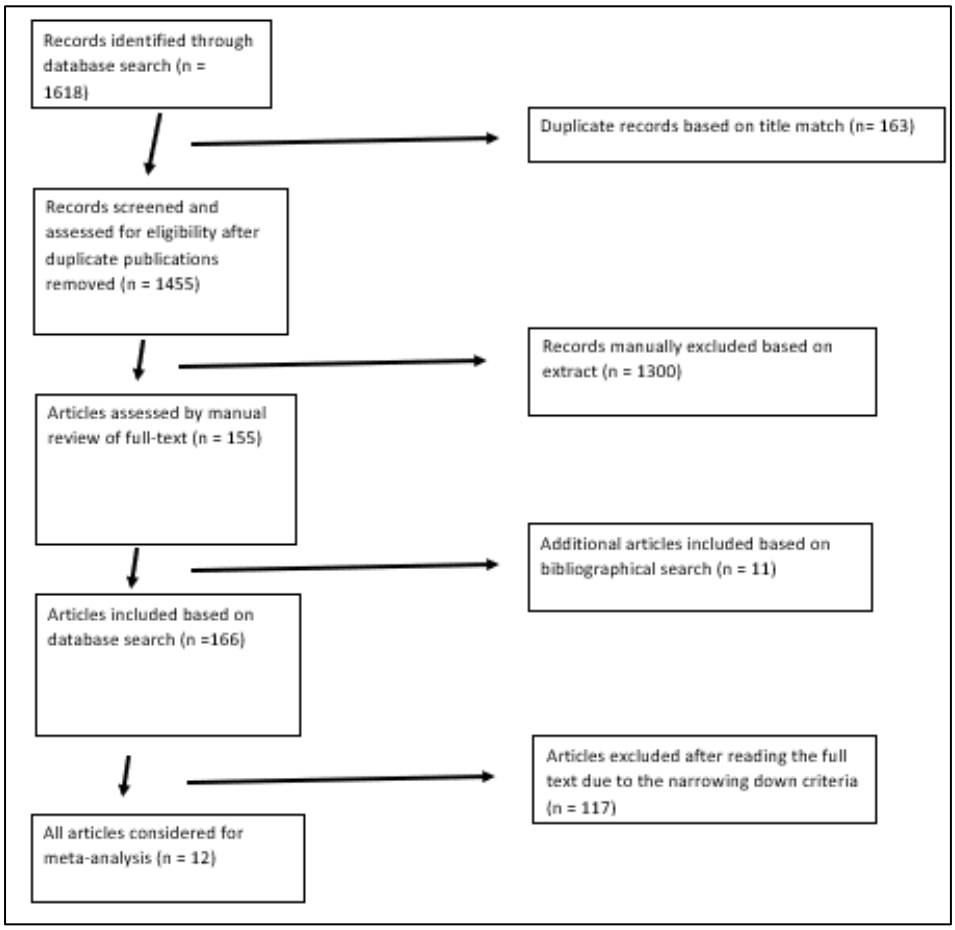


Figure 3.1: **Selection Criteria Procedure**

3.7 Selection of Cognitive Domains

As newer versions of the WISC were released, the indexes changed as each successive edition of the WISC had been re-normed. The subtests of the original WISC were organised into Verbal and Performance scales, and provided scores for Verbal IQ (VIQ), Performance IQ (PIQ), and Full-Scale IQ (FSIQ). The revised edition of the WISC featured the same subtests as the original WISC. The third edition introduced a new subtest to measure processing speed. Overall, the WISC-III provided scores for VIQ, PIQ, and FSIQ, in addition to the VCI, the POI, the FFD, and the PSI. The WISC-IV comprised 15 subtests which consisted of four

different indexes, namely the VCI, PRI, WMI, and PSI. Lastly, the WISC-V comprises the following indexes, namely the VCI, WMI, VSI, the Fluid Reasoning Index (FRI), and PSI. During the course of the systematic literature review, means and standard deviations for the following indexes were obtained, namely the VCI, WMI, PSI, FRI, VSI, PRI, FFD, and POI. Where available, the means and standard deviations of the FSIQ and PIQ were also included.

Together with the mentioned indexes, the systematic literature review also revealed 15 subtests, from various versions of the WISC, that were either a particular group of participants' highest or lowest-scoring subtests. These 15 subtests are mentioned and discussed in more depth below.

For Verbal Comprehension, which is a measure of a child's crystalised reasoning and language abilities, four subtests were identified (Muthoni, 2017; Toffalini et al., 2017):

1. Similarities: This subtest primarily measures a child's ability to apply verbal abstract reasoning in identifying the underlying conceptual relationship between two words. Within the context of CHC Theory, it, therefore, measures inductive reasoning, as well as lexical or word knowledge.
2. Vocabulary: This subtest primarily measures a child's word knowledge, learning ability, verbal expressive language, evidence of environmental stimulation, and the ability to retain knowledge. Within the context of CHC Theory, it, therefore, measures lexical or word knowledge.
3. Information: This subtest primarily measures a child's ability to recall long-term facts. It also measures a child's ability to acquire, retain and retrieve general factual knowledge. Within the context of CHC Theory, it, therefore, measures lexical or word knowledge.
4. Comprehension: This subtest primarily measures a child's understanding of general principles and social situations, knowledge of conventional standards of behaviour, and common knowledge. Within the context of CHC Theory, it, therefore, measures general verbal information, and lexical or word knowledge.

For Perceptual Reasoning and Visual–Spatial Reasoning, which is a measure of a child's visual–spatial abilities and visual–motor integration, two subtests were identified (Radan et al., 2020; Toffalini et al., 2017):

1. Block Design: This subtest primarily measures a child's non-verbal abstract reasoning ability, visual organisation and spatial perception with visual motor coordination. Within the context of CHC Theory, it, therefore, measures visual

processing.

2. Visual Puzzles: This subtest primarily measures a child's visual and spatial reasoning, mental rotation, visual working memory, and analysis and synthesis of abstract visual stimuli. Within the context of CHC Theory, it, therefore, measures visual processing.

For Fluid Reasoning, which is a measure of a child's ability to detect the underlying conceptual relationship among visual objects and to use reasoning to identify and apply rules, three subtests were identified (Dombrowski et al., 2021; Ferrer et al., 2009):

1. Matrix Reasoning: This subtest primarily measures a child's visual information processing, visual abstract reasoning, and visual inductive reasoning. Within the context of CHC Theory, it, therefore, measures induction.
2. Arithmetic: This subtest primarily measures a child's auditory short-term memory working with meaningful material and basic computational skills. Within the context of CHC Theory, it, therefore, measures, quantitative reasoning, and working memory capacity.
3. Picture Concepts: This subtest primarily measures a child's abstract categorical reasoning. Within the context of CHC Theory, it, therefore, measures, general verbal information and induction.

While the Figure Weights subtest has been included as a primary FRI subtest in the WISC-V, this was not identified as either a highest- or lowest-scoring subtest in the systematic literature review.

For Working Memory, which is the measure of a child's ability to register, maintain, and manipulate visual and auditory information in conscious awareness, two subtests were identified (Audras-Torrent et al., 2021; Toffalini et al., 2017):

1. Digit Span: This subtest primarily measures a child's ability to recall auditory short-term information, auditory sequencing, and the transformation of information through mental manipulation. Within the context of CHC Theory, it, therefore, measures, working memory capacity and memory span.
2. Letter–Number Sequencing: This subtest primarily measures a child's ability to mentally manipulate auditory information. Within the context of CHC Theory, it, therefore, measures working memory capacity.

Similar to the Figure Weights subtest, the Picture Span subtest has also been included in the

WISC-V as a subtest within the WMI; however, is not included here as it was not identified as either a highest- or lowest-scoring subtest in the systematic literature review.

For Processing Speed, which is a measure of a child's speed and accuracy of visual identification, decision-making, and decision implementation, two subtests were identified:

1. Coding: This subtest primarily measures a child's fine motor coordination, processing speed, visual scanning ability, short-term memory, learning ability, and cognitive flexibility. Within the context of CHC Theory, it, therefore, measures, rate of test taking.
2. Symbol Search: This subtest primarily measures a child's visual memory, cognitive flexibility, and visual discrimination. Within the context of CHC Theory, it, therefore, measures perceptual speed.

Two additional subtests were identified and included the following:

1. Picture Arrangement: This subtest primarily measures a child's motor reasoning and visual anticipation. Within the context of CHC Theory, it, therefore, measures induction.
2. Object Assembly: This subtest primarily measures a child's visual–motor skills in puzzle construction. Within the context of CHC Theory, it, therefore, measures visualisation.

Therefore, the 15 subtests mentioned above were found to be either the lowest-scoring or highest-scoring WISC subtest among ASD children.

3.8 Statistical Analysis: Systematic Review and Meta-Analysis

The systematic review yielded 49 articles which met the inclusion criteria to investigate the cognitive performance of children diagnosed with ASD as measured by the WISC. The data collected were captured on an Excel spreadsheet. Two annexures are included comprising the primary articles that were included in the systematic review. Annexure A provides a summary of the means and standard deviations of various indexes that were measured by different WISC versions. The number of participants (only those diagnosed with ASD) that were included in the studies, their ages, as well as the participants' diagnoses, are also included in the tables in the annexures. Annexure B provides a summary of the highest- and lowest-scoring subtests found among the 49 articles, as measured by various WISC versions. Additionally, Annexure C provides a summary of the 12 articles that were included in the meta-analysis comparing the cognitive performance of ASD to typically developing children using

various WISC versions. The data obtained were analysed using a Cohen's *d* formula, which rendered effect sizes. These effect sizes were interpreted according to the guidelines provided by Lakens (2013) where 0.2 = small effect, 0.5 = moderate effect, and 0.8 = large effect. The higher the effect size, the more practically meaningful the differences are. The information provided in Annexures A-C were used to examine and investigate the research questions.

3.9 Ethical Considerations

This systematic review and meta-analysis study was exempt from ethics approval as the researcher of this study collected and synthesised data from previous studies in which informed consent had already been obtained by the researchers. Although no ethics approval was required, a systematic review and meta-analysis research study follows the same ethical protocols as other studies. The research process must be thorough, make use of the high-quality data available, address the key research questions, provide an accurate statistical analysis, effectively communicate the findings, and produce beneficial outcomes (Izudi et al., 2018; Wager & Wiffen, 2011).

3.10 Conclusion

An outline of the procedure used to conduct this research study was given in the methods chapter. The study design, sample of participants, study identification process, cognitive domains used, as well as tables containing all of the analysed data were illustrated in this chapter. The following chapter is focused on the findings of this chapter, which informs the discussion chapter (Chapter 5).

CHAPTER 4: RESULTS

4.1 Introduction

An in-depth understanding of the information gathered during the systematic literature review and meta-analysis process is provided in this chapter. As part of the systematic literature review and in answering the first research question, the 49 primary articles that were selected as a result of meeting the inclusion criteria were tabulated and subsequently broken down and analysed to answer the relevant research questions. The data were analysed manually using Excel to create and calculate tables and graphs. To answer the second research question and to determine whether the cognitive performance of ASD children, as assessed by the WISC, differ meaningfully from that of typically developing peers, 12 articles were included in the meta-

analysis. The data obtained from these 12 articles were analysed with a Cohen's d formula. This allowed for the calculation of a Cohen's d effect size, which is an indication of the standardised difference between the mean scores obtained for ASD children and the mean scores obtained for their typically developing peers.

As noted in the tables mentioned in the previous chapter (Annexures A-C), not all the articles included results on all of the WISC indexes. Therefore, the information presented in tables and graphs in this chapter accounts for all the participants whose data was presented in the articles. The various indexes were measured by different versions of the WISC. First, the mean performance on various WISC indexes across all the diagnostic terms of ASD is provided. Secondly, the mean performance on various WISC indexes is analysed by examining each diagnostic term individually, namely ASD, Asperger Syndrome, PDD, and HFA. Thereafter, the highest- and lowest-performed subtests across all the diagnostic terms of ASD are examined. Finally, the Cohen's d effect sizes that were calculated as part of the meta-analysis are presented.

4.2 Mean Performance of all Autism Spectrum Disorder Children across Wechsler Intelligence Scale for Children Indexes

Table 4.1 presents the mean performance of the ASD children, diagnosed with various terms, who participated in the studies reported on in the 49 selected articles that were included in the systematic literature review. For each of the indexes, the mean performance of the ASD children were calculated (which are displayed first), as well as the mean standard deviations, listed here in descending order of performance. In the calculation of the ASD children's performance on the PRI, scores from 17 groups of participants were included. The average mean score for this index is 104.09 (*SD* = 15.14). In the calculation of the VSI, the scores of nine groups of participants were included (*M* = 99.39; *SD* = 16.95); in the VCI, the scores of 58 groups of participants (*M* = 97.32; *SD* = 14.57); in the POI, the scores of 12 groups of participants (*M* = 96.32; *SD* = 15.20); in the FRI, the scores of five groups of participants (*M* = 95.61; *SD* = 17.59); in the FSIQ, the scores of 62 groups of participants (*M* = 94.87; *SD* = 16.02); in the FFD, the scores of 12 groups of participants (*M* = 94.68; *SD* = 18.92); in the PIQ, the scores of 32 groups of participants (*M* = 94.19; *SD* = 16.23); in the WMI, the scores of 27 groups of participants (*M* = 93.79; *SD* = 16.27); and in the PSI, the scores of 37 groups of participants (*M* = 90.05; *SD* = 14.79). Therefore, overall, the highest-performing index when taking into account all four of the diagnostic terms was the PRI and the lowest-performing index was the PSI.

Table 4.1: The mean performance on various Wechsler Intelligence Scale for Children indexes across all the diagnostic terms for Autism Spectrum Disorder

	FSIQ	VCI	WMI	PSI	FRI	VSI	PRI	PIQ	FFD	POI
Performance*	94.87 (16.02)	97.32 (17.57)	93.79 (16.27)	90.05 (14.79)	95.61 (17.59)	99.39 (16.95)	104.09 (15.14)	94.19 (16.23)	94.68 (18.92)	96.32 (15.29)

**Performance is presented as the mean index score and standard deviation*

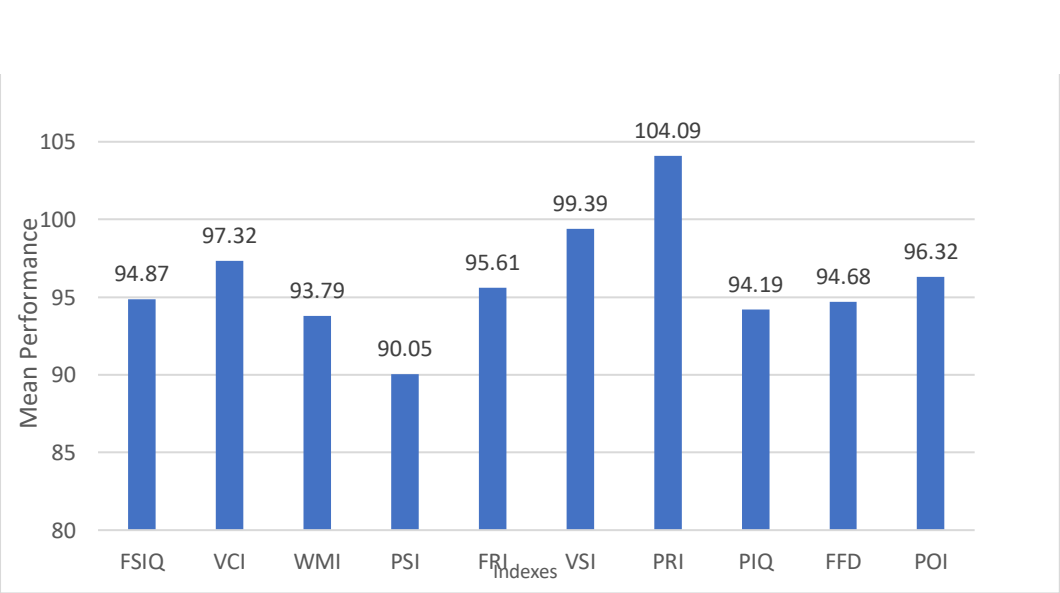


Figure 4.1: The mean performance on various Wechsler Intelligence Scale for Children indexes across all four diagnostic terms for Autism Spectrum Disorder

4.3 Mean Performance of Children Diagnosed with Autism Spectrum Disorder across Wechsler Intelligence Scale for Children Indexes

Table 4.2 considers the scores of children diagnosed specifically with ASD. The children's mean performance on the various indexes, as well as the mean standard deviations for each of these indexes, were calculated and are listed in descending order of performance. In the calculation of the PRI, the scores of 14 groups of participants (M = 100.39; SD = 15.39) were included; in the VSI, the scores of seven groups of participants (M = 96.86; SD = 17.47) were included; in the FRI, the scores of five groups of participants (M = 95.67; SD = 17.59) were included; in the VCI, the scores of 34 groups of participants (M = 92.47; SD = 18.55) were included; in the POI, the scores of five groups of participants (M = *91*.94; SD = 16.15) were included; in the WMI, the scores of 20 groups of participants (M = 91.83; SD = 16.93) were included; in the FSIQ, the scores of 34 groups of participants (M = 89.13; SD = 17.11)

were included; in the PIQ, the scores of 10 groups of participants (*M* = 86.61; *SD* = 17.52) were included; in the FFD, the scores of five groups of participants (*M* = 88.60; *SD* = 18.36) were included; and in the PSI, the scores of 25 groups of participants (*M* = 88.19; *SD* = 15.38) were included. Therefore, considering the available data, the highest-performing index when taking into account individuals diagnosed with ASD was the PRI and the lowest-performing index was the PSI.

Table 4.2: The mean performance on various Wechsler Intelligence Scale for Children indexes by individuals diagnosed with Autism Spectrum Disorder

	FSIQ	VCI	WMI	PSI	FRI	VSI	PRI	PIQ	FFD	POI
Performance*	89.13 (17.11)	92.47 (18.55)	91.83 (16.93)	88.19 (15.38)	95.61 (17.59)	96.86 (17.47)	100.39 (15.39)	86.61 (17.52)	88.60 (18.36)	91.94 (16.15)

**Performance is presented as the mean index score and standard deviation*

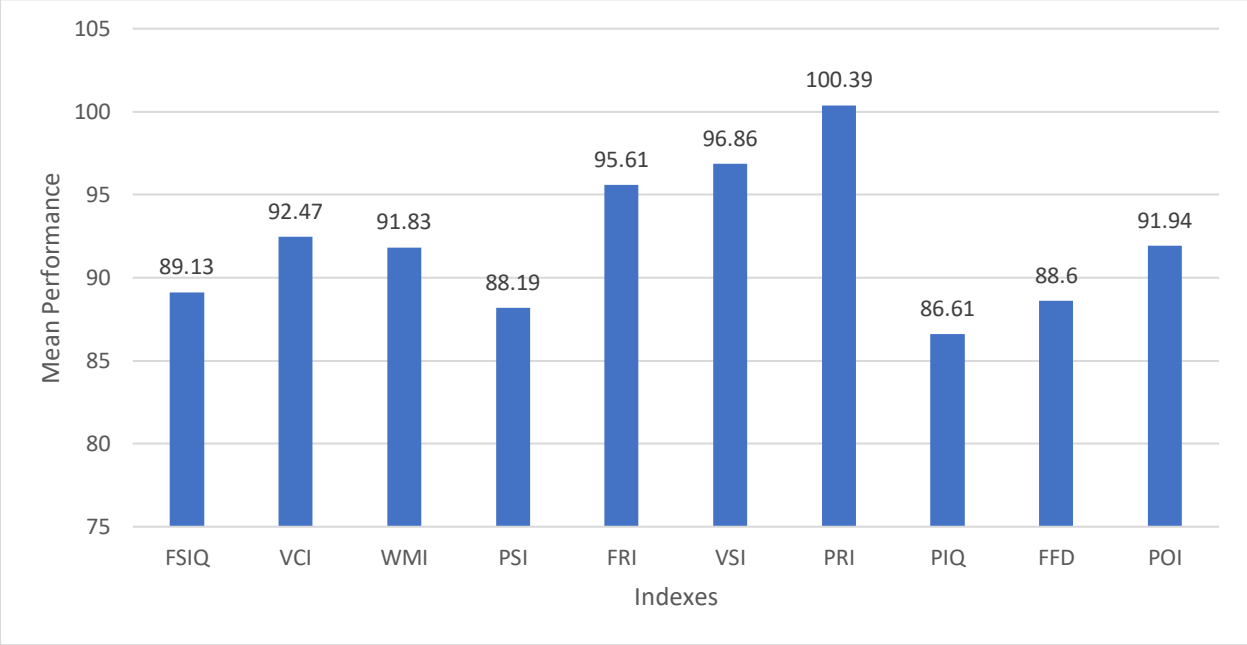


Figure 4.2: The mean performance on various Wechsler Intelligence Scale for Children indexes by individuals diagnosed with Autism Spectrum Disorder

4.4 Mean Performance of Children Diagnosed with Asperger Syndrome across Wechsler Intelligence Scale for Children Indexes

Table 4.3 considers information from all the articles that reported on participants who were diagnosed with Asperger Syndrome. The children's mean performance on the various indexes, as well as the mean standard deviations for each index was calculated and is reported

on in descending order. In the calculation of the PRI, the scores of one group of participants (*M* = 125.75; *SD* = 13.90) were included; in the VCI, the scores of 11 groups of participants (*M* = 110.05; *SD* = 15.79) were included; in the VSI, the scores of two groups of participants (*M* = 108.25; *SD* = 15.15) were included; in the FSIQ, the scores of 15 groups of participants (*M* = 103.33; *SD* = 15.37) were included; in the POI, the scores of two groups of participants (*M* = 101.80; *SD* = 16.15) were included; in the FFD, the scores of two groups of participants (*M* = 100.69; *SD* = 21.51) were included; in the WMI, the scores of three groups of participants (*M* = 100.33; SD = 13.18) were included; in the PIQ, the scores of 12 groups of participants (*M* = 96.70; *SD* = 17.05) were included; and in the PSI, the scores of four groups of participants (*M* = 89.87; *SD* = 12.30) were included. None of the articles that reported on children diagnosed with Asperger Syndrome included FRI scores. Therefore, considering the available data, the highest-performing index when taking into account individuals diagnosed with Asperger Syndrome was the PRI and the lowest-performing index was the PSI.

Table 4.3: The mean performance on various Wechsler Intelligence Scale for Children indexes by individuals diagnosed with Asperger Syndrome

	FSIQ	VCI	WMI	PSI	FRI	VSI	PRI	PIQ	FFD	POI
Performance*	103.33 (15.37)	110.05 (15.79)	100.33 (13.18)	89.87 (12.3)	NA	108.25 (15.15)	125.75 (13.9)	96.70 (17.05)	100.69 (21.51)	101.8 (14.92)

*Performance is presented as the mean index score and standard deviation

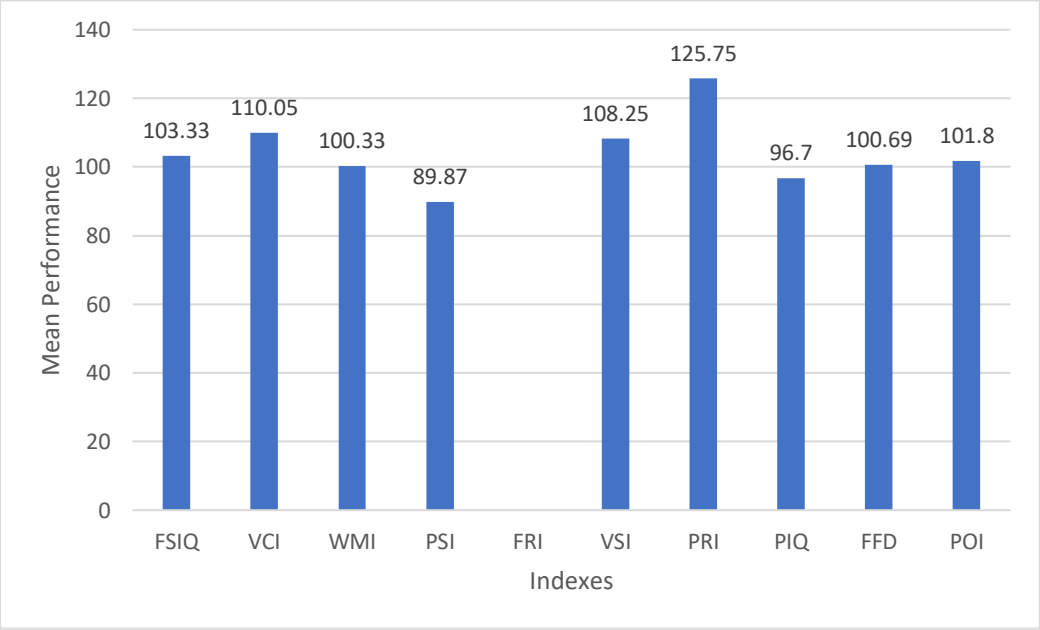


Figure 2.3: The mean performance on various Wechsler Intelligence Scale for Children indexes

by individuals diagnosed with Asperger syndrome

4.5 Mean Performance of Children Diagnosed with Pervasive Developmental Disorder across Wechsler Intelligence Scale for Children Indexes

Table 4.4 considers the performance of participants who were diagnosed with PDP across various WISC indexes. The mean performance on the various indexes, as well as the mean standard deviations for each index, was found to be the following, listed in descending order of performance: In the calculations of the POI, the scores of five groups of participants (*M* = 98.52; *SD* = 14.59) were included; in the FFD, the scores of five groups of participants (*M* = 98.36; *SD* = 18.45) were included; in the PIQ, the scores of five groups of participants (*M* = 97.91; *SD* = 14.56) were included; in the PSI, the scores of four groups of participants (*M* = 97.75; *SD* = 14.15) were included; in the FSIQ, the scores of five groups of participants (*M* = 95.88; *SD* = 14.42) were included; and in the VCI, the scores of five groups of participants (*M* = 95.26; *SD* = 17.19) were included. None of the articles included WMI, FRI, VSI or PRI scores for individuals diagnosed with PDD. Therefore, considering the available data, the highest-performing index when taking into account individuals diagnosed with PDD was the POI and the lowest-performing index was the VCI.

Table 4.4: The mean performance on various Wechsler Intelligence Scale for Children indexes

	FSIQ	VCI	WMI	PSI	FRI	VSI	PRI	PIQ	FFD	POI
Performance*	95.88 (14.42)	95.26 (17.19)	NA	97.75 (14.15)	NA	NA	NA	97.91 (14.56)	98.36 (18.45)	98.52 (14.59)

by individuals diagnosed with Pervasive Developmental Disorder

Performance is presented as the mean index score and standard deviation

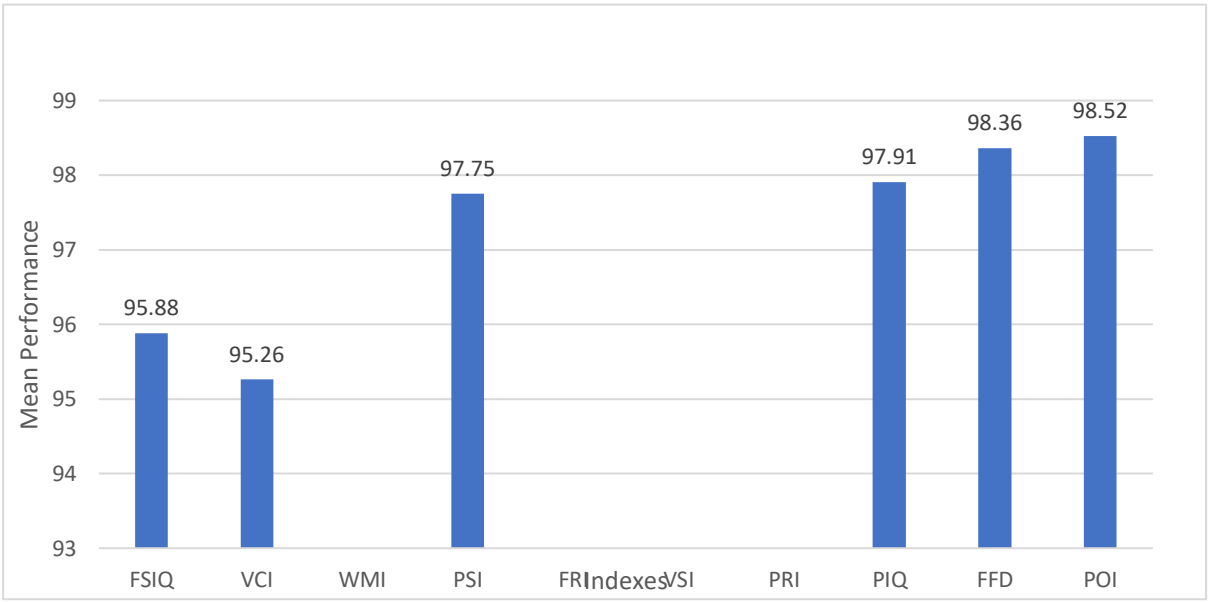


Figure 4.4: The mean performance on various Wechsler Intelligence Scale for Children indexes by individuals diagnosed with Pervasive Developmental Disorder

4.6 Mean Performance of Children Diagnosed with High Functioning Autism across Wechsler Intelligence Scale for Children Indexes

Table 4.5 considers all the articles that reported on participants who were diagnosed with HFA. The mean performance on the various indexes, as well as the mean standard deviations for each index was found to be the following, listed in descending order of performance: In calculating the PRI, the score of two groups of participants (M = 119.22; SD = 14.01) were included; in the FSIQ, the score of eight groups of participants (M = 101.91; SD = 13.89) were included; in the VCI, the score of eight groups of participants (M = 101.76; SD = 16.1) were included; in the PIQ, the score of four groups of participants (M = 100.30; SD = 13.29) were included; in the WMI, the score of four groups of participants (M = 98.64; SD = 15.26) were included; and in the PSI, the score of four groups of participants (M = 92.05; SD = 14.25) were included. None of the articles included FRI, VSI, FFD or POI scores for individuals diagnosed with HFA. Therefore, considering the available data, the highest-performing index when taking into account individuals diagnosed with HFA was the PRI and the lowest-performing index was the PSI.

Table 4.5: The mean performance on various Wechsler Intelligence Scale for Children indexes by individuals diagnosed with High Functioning Autism

	FSIQ	VCI	WMI	PSI	FRI	VSI	PRI	PIQ	FFD	POI
Performance*	101.91 (13.89)	101.76 (16.1)	98.64 (15.26)	92.05 (14.25)	NA	NA	119.22 (14.04)	100.3 (13.29)	NA	NA

**Performance is presented as the mean index score and standard deviation*

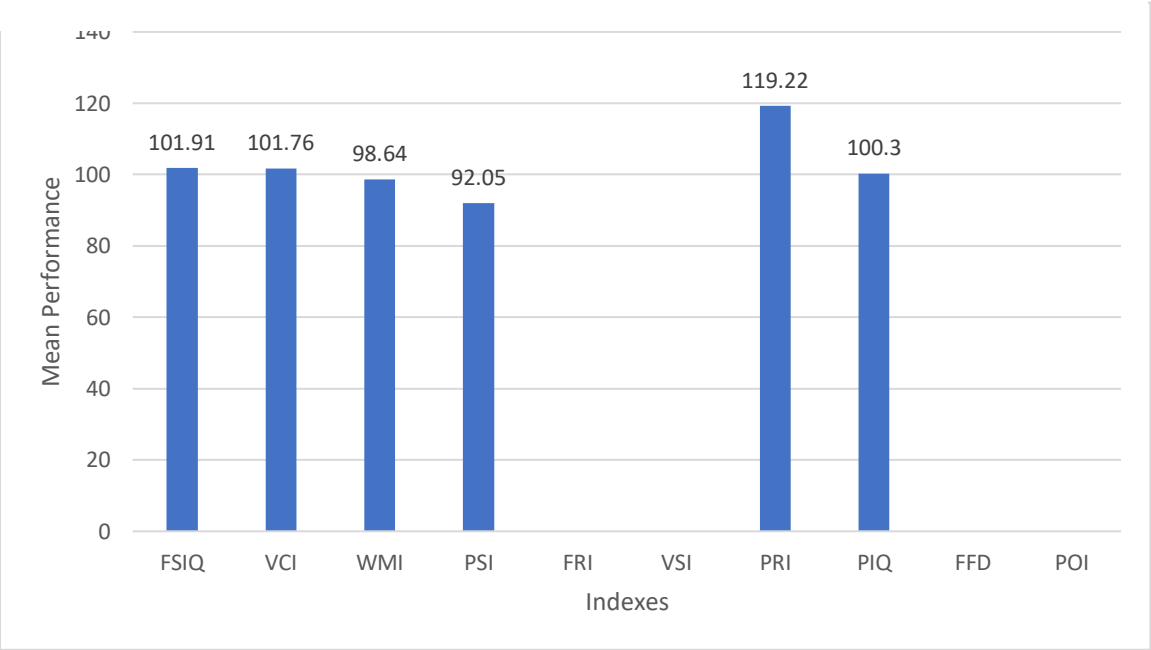


Figure 4.5: The mean performance on various Wechsler Intelligence Scale for Children indexes by individuals diagnosed with High Functioning Autism

4.7 Performance of Autism Spectrum Disorder Children on Specific Wechsler Intelligence Scale for Children Indexes

The graphs below separate the children's (diagnosed with various terms) performance across the different WISC-V indexes. By highlighting the children's performance on the different indexes, one is able to compare how individuals with various ASD diagnoses may have different cognitive profiles.

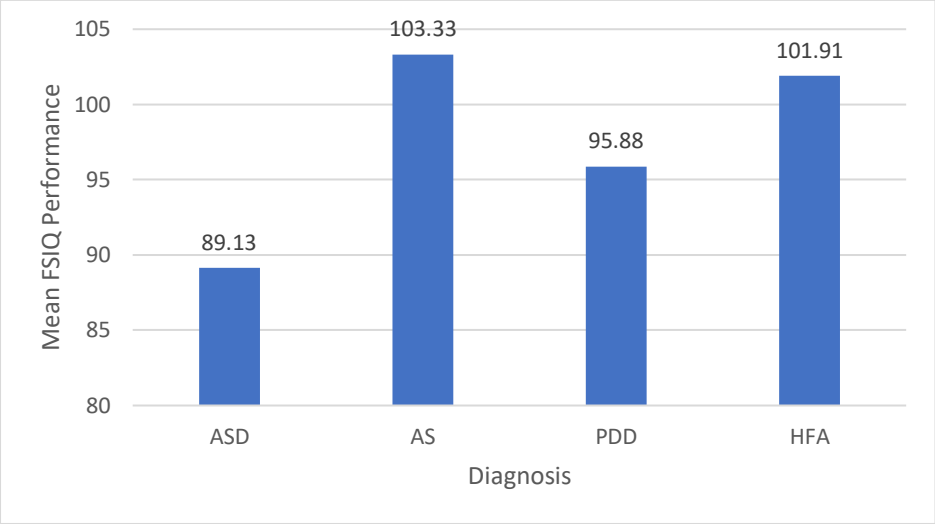


Figure 4.6: The mean Full-Scale IQ performance across all four diagnostic terms for Autism Spectrum Disorder

Based on the calculations done and the information presented in Figure 4.6, the highest average mean FSIQ score (*M* = 103.33) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with HFA (*M* = 101.91), children diagnosed with PDD (*M* = 95.88) and then children diagnosed with ASD (*M* = 89.13).

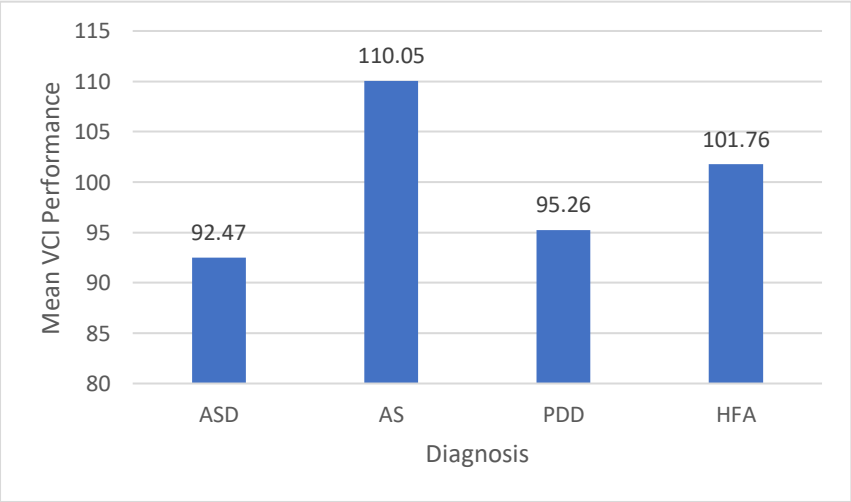


Figure 4.7: **The mean Verbal Comprehension Index performance across all four diagnostic terms for Autism Spectrum Disorder**

Based on the calculations done and the information presented in Figure 4.7, the highest average mean VCI score (*M* = 110.05) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with HFA (*M* = 101.76), children diagnosed with PDD (*M* = 95.26) and then children diagnosed with ASD (*M* = 92.47).

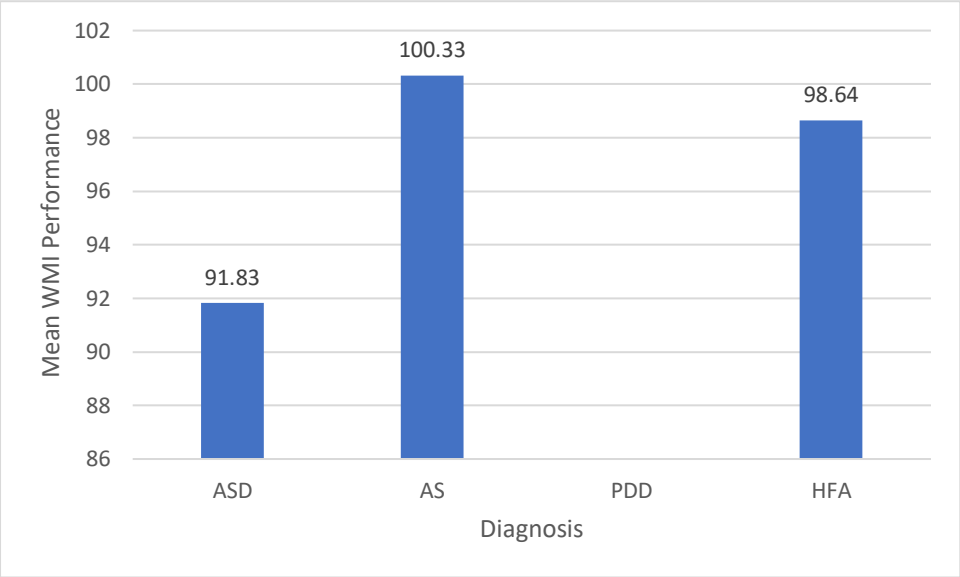


Figure 4.8: **The mean Working Memory Index performance across all four diagnostic terms for Autism Spectrum Disorder**

Based on the calculations done and the information presented in Figure 4.8, the highest average mean WMI score (*M* = 100.33) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with HFA (*M* = 98.64) and then children diagnosed with ASD (*M* = 91.83).

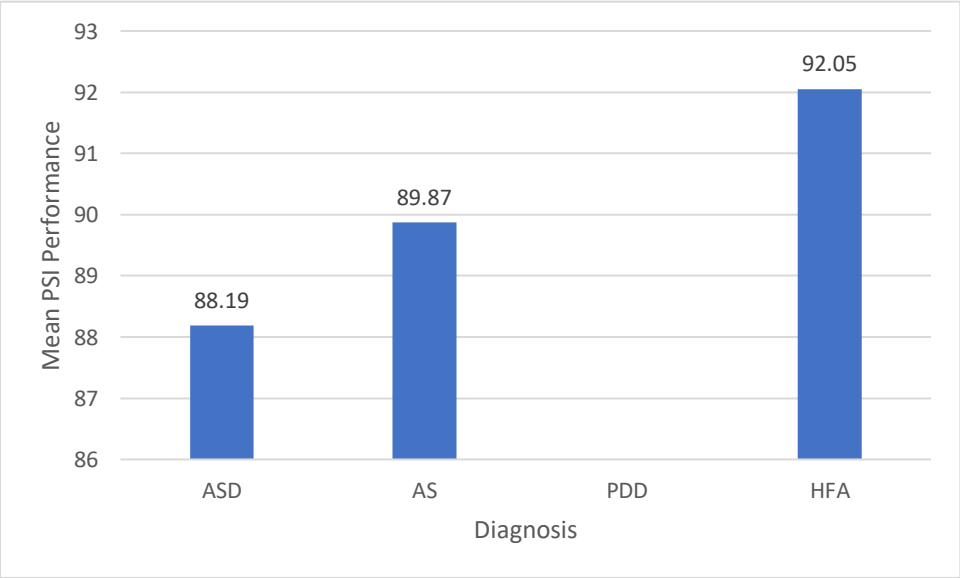


Figure 4.9: **The mean Processing Speed Index performance across all four diagnostic terms for Autism Spectrum Disorder**

Based on the calculations done and the information presented in Figure 4.9, the highest average mean PSI score (*M* = 92.05) was obtained by children diagnosed with HFA, followed by children diagnosed with Asperger Syndrome (*M* = 89.87) and then children diagnosed with ASD (*M* = 88.19).

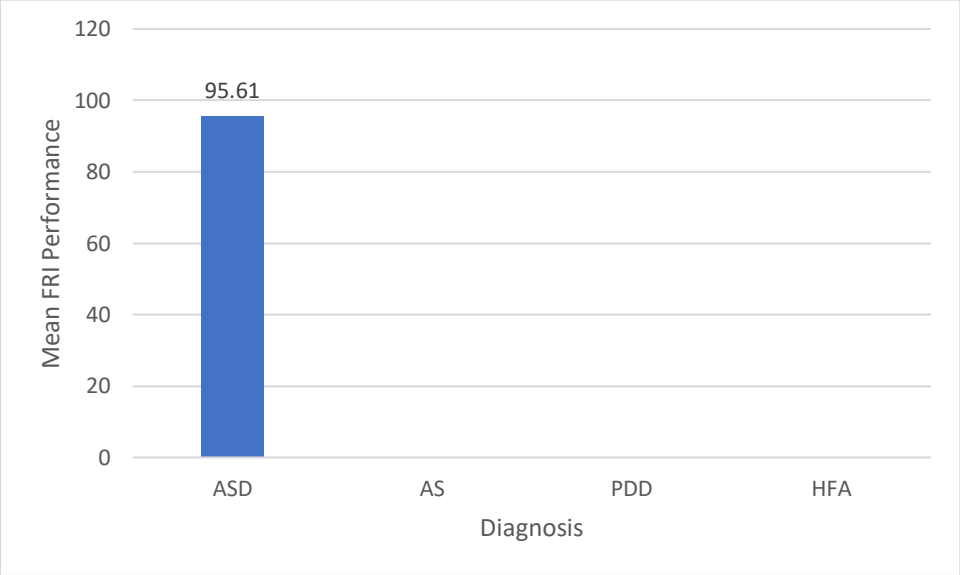


Figure 4.10: The mean Fluid Reasoning Index performance across all four diagnostic terms for Autism Spectrum Disorder

Based on the calculations done and the information presented in Figure 4.10, the only data captured for the average mean FRI score (*M* = 95.61) was obtained by children diagnosed with ASD.

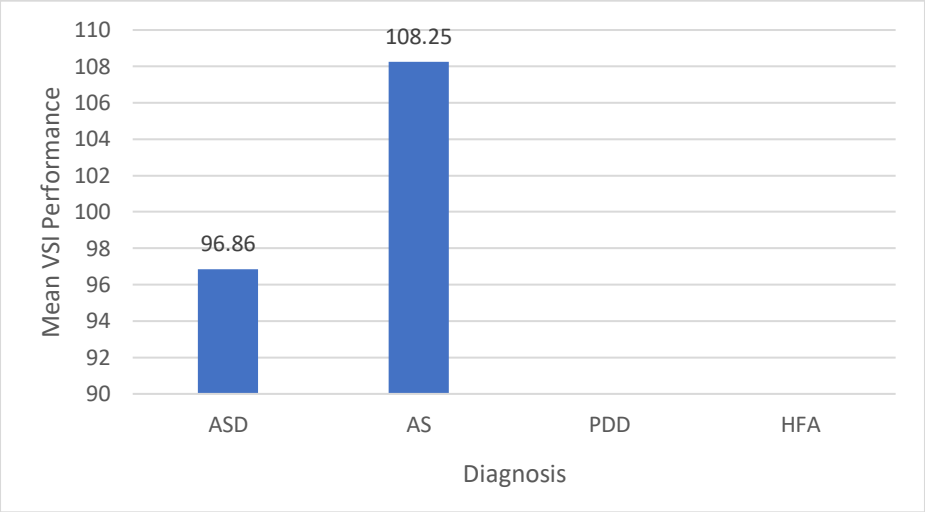


Figure 4.11: **The mean Visual–Spatial Index performance across all four diagnostic terms for Autism Spectrum Disorder**

Based on the calculations done and the information presented in Figure 4.11, the highest average mean FSIQ score (*M* = 108.25) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with ASD (*M* = 96.86).

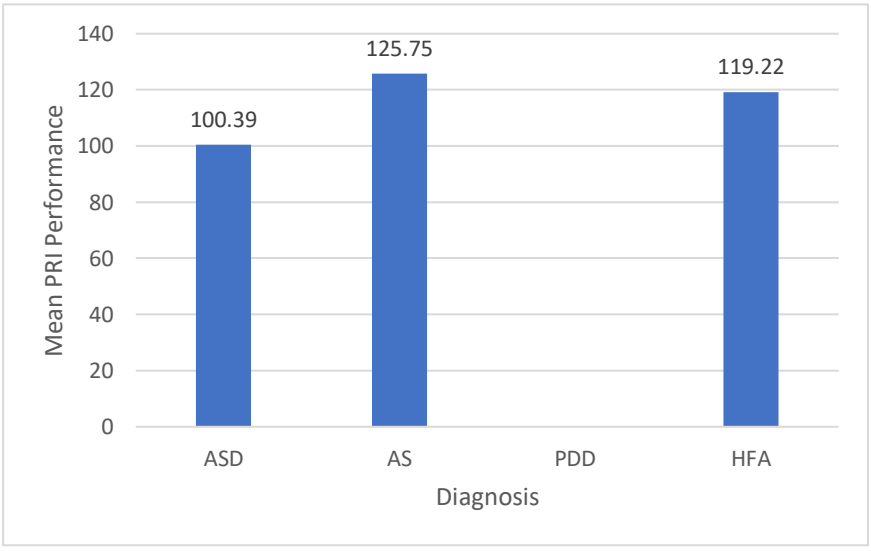


Figure 4.12: The mean Perceptual Reasoning Index performance across all four diagnostic terms for Autism Spectrum Disorder

Based on the calculations done and the information presented in Figure 4.12, the highest average mean PRI score (*M* = 125.75) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with HFA (*M* = 119.22) and then children diagnosed with ASD (*M* = 100.39).

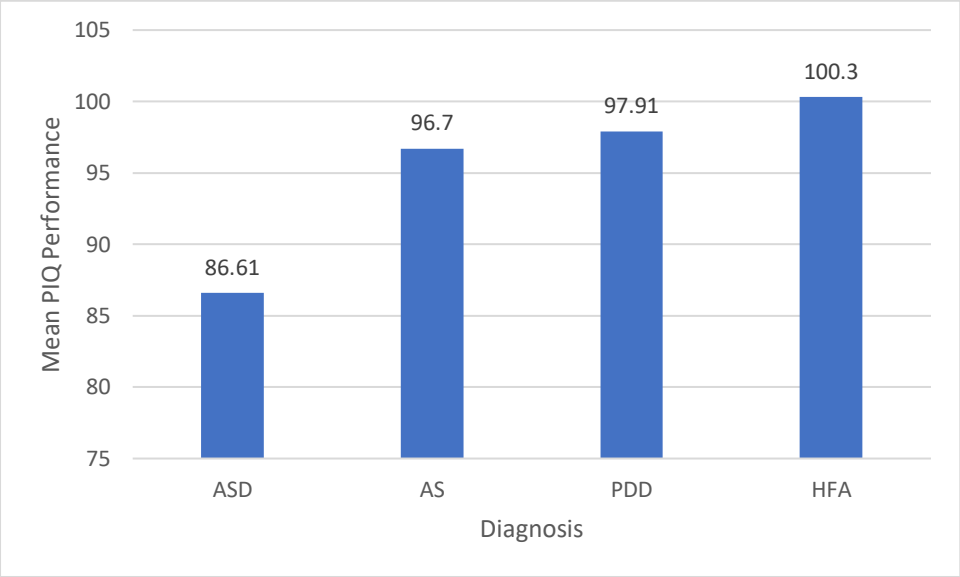


Figure 4.13: **The mean Performance IQ performance across all four diagnostic terms for Autism Spectrum Disorder**

Based on the calculations done and the information presented in Figure 4.13, the highest average mean PIQ score (*M* = 100.3) was obtained by children diagnosed with HFA, followed by children diagnosed with PDD (*M* = 97.91), children diagnosed with Asperger Syndrome (M = 96.7) and then children diagnosed with ASD (*M* = 86.61).

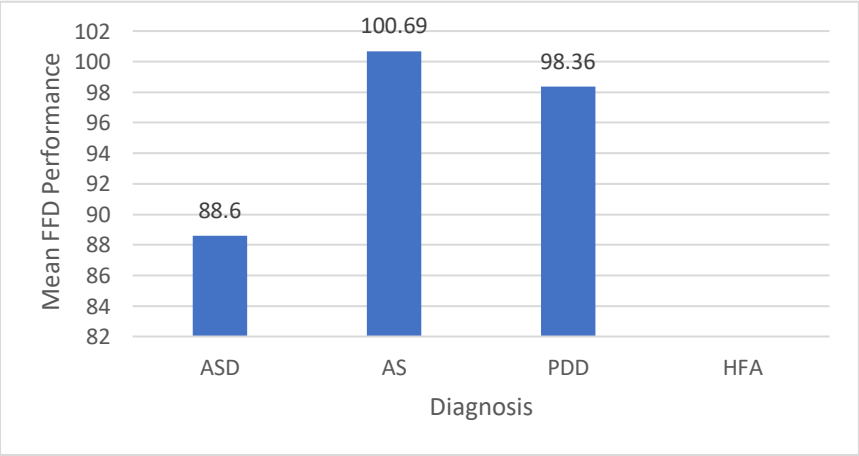


Figure 4.14: **The mean Freedom from Distractibility Factor performance across all four diagnostic terms for Autism Spectrum Disorder**

Based on the calculations done and the information presented in Figure 4.14, the highest average mean FFD score (*M* = 100.69) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with PDD (*M* = 98.36), and then children diagnosed with ASD (*M* = 88.6).

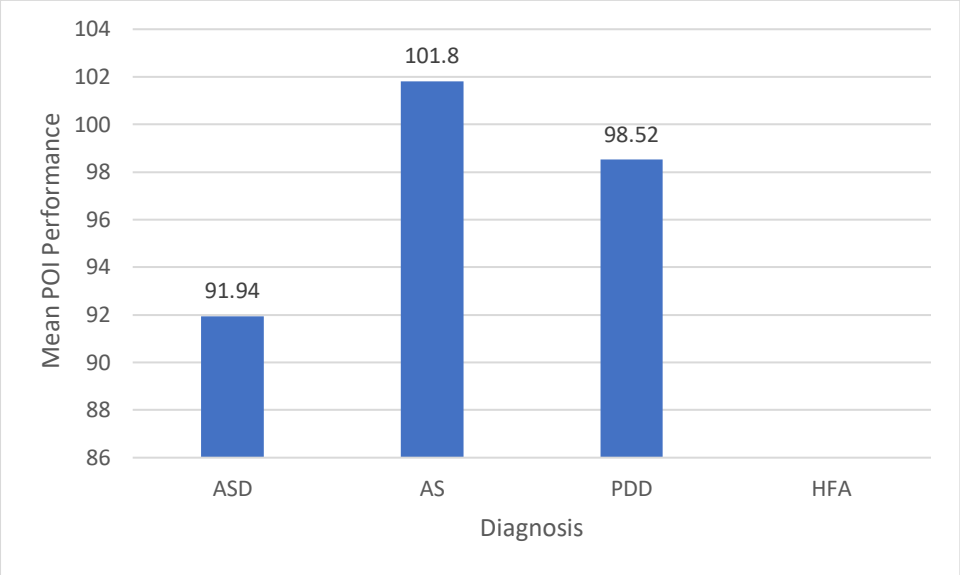


Figure 4.15: The mean Perceptional Organisational Index performance across all four diagnostic terms for Autism Spectrum Disorder

Based on the calculations done and the information presented in Figure 4.15, the highest average mean POI score (*M* = 101.8) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with PDD (*M* = 98.52) and then children diagnosed with ASD (*M* = 91.94).

As noted in the graphs above, individuals diagnosed with Asperger Syndrome performed the highest on the FSIQ, VCI, WMI, VSI, FRI, FFD and POI. Additionally, individuals diagnosed with HFA performed the highest on the PSI and PIQ. ASD individuals performed the lowest on all the indexes.

4.8 Performance of Individuals across the Four Diagnostic Terms for Autism Spectrum Disorder

The graph below displays the highest- and lowest-performed subtests across all four of the diagnostic terms for Autism Spectrum Disorder. By highlighting the highest- and lowest-performed subtests, one is able to compare how individuals with various ASD diagnoses may perform on these subtests that assess different cognitive abilities.

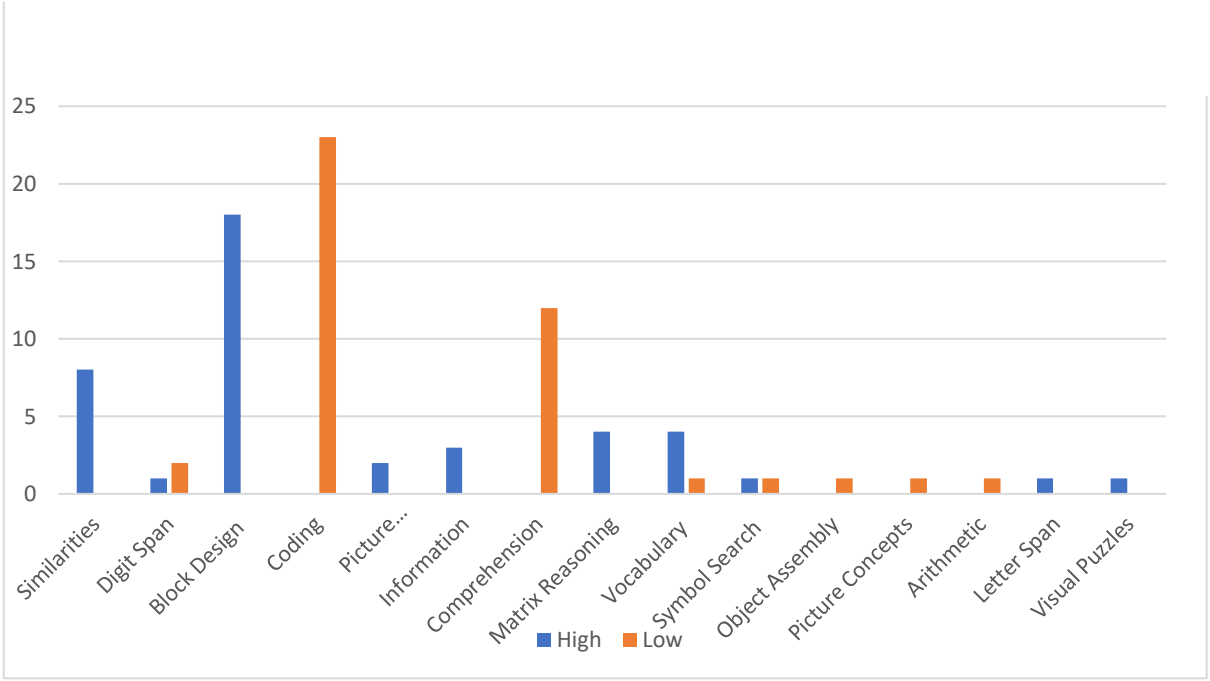


Figure 4.16: 3**The highest- and lowest-performed subtests across all four diagnostic terms for Autism Spectrum Disorder**

Based on the information presented in Figure 4.16, when considering all four of the diagnostic terms used across the 49 articles, the lowest-performed subtest was the Coding subtest, followed by the Comprehension subtest. The highest-performed subtest was the Block Design subtest, followed by the Similarities subtest.

4.9 A Meta-Analysis Comparing Autism Spectrum Disorder and Typically Developing Children

Based on the information in Annexure D, comparisons between the means and standard deviations of two groups of participants diagnosed with HFA and ASD, respectively, and their typically developing peers, revealed no large effect sizes when assessed on the WISC-R and WISC-III. However, a moderate effect size (d = -0.53) was noted in comparing the PIQ means and standard deviations of a group of ASD participants with typically developing peers. In this study, the mean of the ASD participants (M = 101.08) was lower than that of their typically developing peers (M = 108.44). The remaining score comparisons for this group of ASD participants and typically developing peers only revealed small effect sizes.

When comparing the WISC-IV means and standard deviations of eight groups of participants diagnosed with either HFA or ASD and typically developing peers, 19 large and

one moderate effect sizes were identified. Of the 19 large effect sizes that were found, four large effect sizes were noted in comparing the FSIQ means and standard deviations of ASD participants with typically developing peers (2016-study, d = -1.47; 2017b study, d = -0.81; 2019b study, d = -2.26; 2020 study, d = -2.35), and one large effect size (2017 a study, d = -1.05) in comparing the FSIQ means and standard deviation of a group of HFA participants with typically developing peers. The moderate effect size (d = 0.6) was found in a 2021 study which compared HFA participants with typically developing peers. In all instances where large effect sizes were identified, the means of the ASD and HFA participants were lower than their typically developing peers. In comparison, the mentioned 2021 study revealed a higher mean for the HFA participants (M = 110.16) than for their typically developing peers.

With reference to the VCI, five large effect sizes were noted in comparing the VCI means and standard deviations of groups of HFA and ASD participants with typically developing peers. The remaining effect sizes were all < 0.5. Of these, three large effect sizes (2016 study, d = -1.67; 2017b study, d = -0.98; 2019b study, d = -2.02) were noted in comparing the VCI means and standard deviations of ASD participants with typically developing peers and two large effect sizes (2017a study, d = -1.27; 2021 study, d = 0.84) noted in comparing the VCI means and standard deviations of HFA participants with typically developing peers. Again, within these groups, the means of the ASD and HFA participants were lower than that of typically developing peers, aside from the above-mentioned 2021 study, where the VCI mean of the HFA participants (M = 111) was higher than that of their comparison group (M = 103.15).

In comparing the means and standard deviations of groups of ASD participants with typically developing peers on the WMI, a large effect size (2019b study, d = -1.11) was noted in a study comparing the performance of specifically ASD participants with typically developing peers. The mean of the ASD participants (M = 85.2) was lower than that of their comparison group (M = 99.56). In addition, one moderate effect size was noted (2016 study, d = -0.76), with the mean WMI score of the ASD participants (M = 87) again lower than that of their typically developing peers (M = 99.9).

With reference to the PSI, six large effect sizes were noted in comparing the PSI means and standard deviations of groups of HFA and ASD participants with typically developing peers (2016 study, d = -1.29; 2017a study, d = -1.44; 2017b study, d = -1.01; 2019a study, d = -0.82; 2019b study d = -1.82; 2021 study d = -1.75). Of these six large effect sizes, four large effect sizes (2016 study, d = -1.29; 2017b study, d = -1.01; 2019a study, d = -0.82; 2019b study d = -1.82) were noted in comparing the PSI means and standard deviations of ASD participants

with typically developing peers and two large effect sizes (2017a study, d = -1.44; 2021 study d = -1.75) noted in comparing the PSI means and standard deviations of HFA participants with typically developing peers. Again, within these groups, the means of the ASD and HFA participants were lower than that of typically developing peers. The remaining effect size was a moderate effect size (2014 study, d = -0.71), with the mean PSI score of the ASD participants (M = 97.4) again lower than that of their typically developing peers (M = 105).

With reference to the PRI, two large effect sizes were noted in comparing the PRI means and standard deviations of groups of HFA and ASD participants with typically developing peers (2016 study, d = -1.09; 2019b study, d = -1.74). Both of these large effect sizes were noted in comparing the PRI means and standard deviations of ASD participants with typically developing peers. In addition, one moderate effect size was noted (2014 study, d = -0.68). The remaining effect sizes were all < 0.5. In all instances identified, the means of the ASD and HFA participants were lower than their typically developing peers.

When comparing the WISC-V means and standard deviations of two groups of participants diagnosed with either HFA or ASD and typically developing peers, seven large and three moderate effect sizes were identified. The remaining effect sizes were all < 0.5. With reference to the FSIQ, two large effect sizes were noted in comparing the FSIQ means and standard deviations of groups of HFA and ASD participants with typically developing peers (2021 study, d = -2.11; 2022 study, d = -0.91). Both of these large effect sizes were noted in comparing the PRI means and standard deviations of ASD participants with typically developing peers. In addition, one moderate effect size was noted (2021 study, d = -0.51). Again, within these groups, the means of the ASD participants were lower than that of typically developing peers.

With reference to the VCI, one large effect size was noted in comparing the FSIQ means and standard deviations of groups of HFA and ASD participants with typically developing peers (2021 study, d = -1.86) with the mean VCI score of the ASD participants (M = 80.4) again lower than that of their typically developing peers (M = 104.8). The remaining effect sizes were all < 0.5, with the means of the ASD and HFA participants being lower than their typically developing peers. With reference to the WMI, one large effect size was noted in comparing the WMI means and standard deviations of groups of HFA and ASD participants with typically developing peers (2021 study, d = -1.94), with the mean WMI score of the ASD participants (M = 77.6) being lower than that of their typically developing peers (M = 104.3). In addition, one moderate effect size was noted (2021 study, d = -0.68), with the mean

WMI score of the ASD participants (*M* = 95.4) being lower than that of their typically developing peers (*M* = 104.3).

With reference to the PSI, one large effect size was noted in comparing the PSI means and standard deviations of groups of HFA and ASD participants with typically developing peers (2021 study, *d* = -1.42), with the mean PSI score of the ASD participants (*M* = 89.4) being lower than that of their typically developing peers (*M* = 98). In addition, one moderate effect size was noted (2021 study, *d* = -0.55), with the mean PSI score of the ASD participants (*M* = 89.4) being lower than that of their typically developing peers (*M* = 98). With reference to the VSI, one large effect size was noted in comparing the VSI means and standard deviations of groups of HFA and ASD participants with typically developing peers (2021 study, *d* = -1.27), with the mean VSI score of the ASD participants (*M* = 82.8) being lower than that of their typically developing peers (*M* = 103.4). In addition, one small effect size was noted (2021 study, *d* = -0.18). With reference to the FRI, one large effect size was noted in comparing the FRI means and standard deviations of groups of HFA and ASD participants with typically developing peers (2021 study, *d* = -1.14), with the mean FRI score of the ASD participants (*M* = 100.9) being lower than that of their typically developing peers (*M* = 103.5). In addition, one small effect size was noted (2021 study, *d* = -0.19).

4.10 Conclusion

The results chapter provided an overview of the various cognitive abilities of individuals diagnosed with ASD, Asperger Syndrome, PDD and HFA. The mean performance on various WISC indexes was calculated and compared. Not all of the 49 articles included in the systematic literature review reported on every index and, therefore, only those that did report were used to calculate the relevant mean index performances. Although no data were available for some of the indexes, it was found that the different groups of ASD participants performed the highest on the PRI and the lowest on the PSI. These two indexes were found to be the highest- and lowest-performed indexes for three of the four diagnoses. It was found that individuals who were diagnosed with PDD performed the highest on the POI and the lowest on the VCI. However, it should be noted that there was no PRI data for this group. The mean performance across all the diagnostic terms indicated that individuals diagnosed with Asperger Syndrome and HFA had the highest cognitive profiles and those with an ASD diagnosis displayed the lowest cognitive performance. When comparing the subtests across all four diagnoses, it was found that the different groups of ASD participants performed the lowest on the Coding subtest, followed by the Comprehension subtest. In comparison, they

performed the highest on the Block Design subtest, followed by the Similarities subtest. Although 49 articles were included in the systematic literature review, only 12 articles were included in the meta-analysis comparing the means and standard deviations of different groups of ASD children with typically developing children. Within the meta-analysis, comparisons between the means and standard deviations of HFA and ASD children and their typically developing peers, using the WISC-R, WISC-III, WISC-IV and WISC-V, revealed a total of 26 large effect sizes, and five moderate effect sizes were identified in comparing the means and standard deviations scores of ASD children with typically developing children. The remaining score comparisons revealed only small effect sizes. The following chapter provides an in-depth discussion of the results found in the systematic literature review and the meta-analysis.

CHAPTER 5: DISCUSSION

5.1 Introduction

Numerous articles investigating the cognitive performance of ASD children have been written over the past few decades, with most being published from 2010 onwards. Professionals are also becoming more familiar with the disorder, which has assisted in an increase in literature on ASD profiles. There is a substantial amount of available literature on the cognitive profiles of ASD children and although some of the studies report similar findings, others found contradicting results. The cognitive profiles of ASD children remain a popular topic of discussion and investigation. Although there appears to be a lot of literature on the cognitive profiles of ASD children, there, however, seems to be no published systematic literature review and meta-analysis on the cognitive performance of children diagnosed with ASD using the WISC.

The primary aim of this research study was to gain a greater understanding of the cognitive performance of children diagnosed with ASD as assessed by the WISC. This was done by examining the vast literature available on ASD children. Furthermore, the study aimed to investigate ASD children's cognitive strengths and weaknesses when considering the different diagnostic terms used over the years. After a thorough review of available literature using various inclusion and exclusion criteria, 49 published articles were selected to form part of the initial review. Of this, 12 articles were included in a meta-analysis to compare the results of ASD children and typically developing peers.

The research study considered all the data presented in the 49 articles, as assessed by the various WISC versions. The WISC versions ranged from the WISC-R to the WISC-V. Additionally, across the 49 articles, four diagnostic terms were identified, namely ASD, Asperger Syndrome, PDD and HFA. Therefore, these diagnostic terms were used to investigate the children's cognitive performance. The mean scores for the different WISC indexes were accounted for from each article to calculate the overall means, as displayed in the results. It should be noted that not all the articles used in the systematic literature review and meta-analysis had data for all the indexes that were included in the study. Nonetheless, the children's performance across the following indexes were investigated, namely FSIQ, VCI, WMI, PSI, FRI, VSI, PRI, PIQ, FFD and POI, as well as the FSIQ. The highest- and lowest-performed subtests were also considered. Finally, the meta-analysis compared the results of various groups of ASD participants with typically developing peers to investigate the extent to which the performance differences observed between ASD children and typically developing peers,

when measured on the WISC, is meaningful. The following sections discuss the results found in order to answer the research questions. Within the context of the CHC Theory, discussed in Chapter 2, the discussion is divided across the different cognitive domains assessed.

5.2 The Overall General Cognitive Ability, as Captured by the Full-Scale IQ

The findings of the systematic literature review revealed that the mean FSIQ score of ASD children, across all four diagnostic terms, who participated in the various studies, fell within the Average range. Within the context of CHC Theory, this implies that their general underlying cognitive ability, as assessed by the WISC FSIQ, presents as age-appropriately developed. However, further analysis revealed that while the mean FSIQ scores of the different groups diagnosed with Asperger Syndrome, HFA and PDD fell in the Average range, the mean FSIQ score of children diagnosed specifically with ASD fell in the upper limits of the Low Average range. As such, the mean FSIQ score of the ASD children was, therefore, slightly lower than that of their counterparts diagnosed with Asperger Syndrome, HFA or PDD. In addition, results from the meta-analysis revealed strong and meaningful differences in the FSIQ means and standard deviations of seven of the 12 studies that included comparisons between ASD and typically developing children. Five of these compared the WISC performance of specifically ASD children and their typically developing peers (Dale et al., 2022; Li et al; 2017; Nader et al., 2016; Rabiee et al., 2019, Rabiee et al., 2020), one the WISC performance of ASD children with specified language impairments and typically developing children (Dale et al., 2021) and another, the WISC performance of HFA children and their typically developing peers (Li et al., 2017a). A moderately strong difference was also found in a study comparing the WISC FSIQ means and standard deviations of HFA children and typically developing peers (Operto et al., 2021). While the results from this study by Operto et al. (2021) revealed that the HFA children obtained a slightly higher mean FSIQ score than typically developing peers, the results from the remaining studies revealed higher mean FSIQ scores on the part of the typically developing children.

Therefore, despite the difficulties that ASD children present with in the literature (Dawson et al., 2008; Mjosund et al., 2015; Russo et al., 2010; Zhang et al., 2010), which can potentially impact their scholastic functioning, as discussed in Chapter 2, the results from a systematic literature review investigating their cognitive performance, as assessed by the WISC, indicate that their averaged underlying cognitive ability falls in the upper limits of the Low Average and Average ranges. However, with the meta-analysis revealing a number of meaningful differences when comparing the FSIQ performance of ASD and HFA to typically

developing children, predominantly in favour of the latter, there is still concern that the general underlying cognitive performance of ASD children are impacted by the difficulties related to their diagnoses. If one considers the large effect sizes that supported this finding, there is practical value in supporting ASD children to reach their potential and minimising the impact of their diagnosis and its accompanying difficulties on their scholastic progress and performance.

It is noteworthy that among the different diagnostic terms ascribed to children on the Autism spectrum, children with Asperger Syndrome obtained the highest FSIQ mean score. This can likely be attributed to the consensus that children with Asperger Syndrome display less severe symptoms than those thought to be associated with other ASD diagnoses (Chen et al., 2010; Foley-Nicpon et al., 2012; Spring et al., 2013). In comparison, children diagnosed with ASD obtained the lowest mean FSIQ score. As stipulated in the DSM-5-TR (APA, 2022), ASD can include children with varying levels of severity, which may have impacted the scores of this group of children.

While the WISC FSIQ provides an indication of a child's general underlying cognitive functioning, an analysis of different indexes and subtests provides a more in-depth look at their cognitive strengths and weaknesses, which needs to be considered in tailoring classroom interventions.

5.3 The Overall Language Abilities, as captured by the Verbal Comprehension Index

As noted in Chapter 2, in order for a child to be diagnosed with ASD, they need to experience persistent deficits in social communication and interactions across various contexts (APA, 2022). Therefore, one of the primary challenges that most often describes an ASD child is the difficulties they experience in the development of age-appropriate language skills. The findings of the systematic literature review revealed that the mean VCI score of ASD children, diagnosed with PDD, HFA and ASD, who participated in the various studies, fell within the Average range. The systematic literature review also revealed that the ASD children who participated in the various studies and who had been diagnosed with Asperger Syndrome performed within the High Average range on the VCI. This is a compelling finding as the literature noted in Chapter 2 suggests that children on the Autism spectrum display difficulties with language and the ability to recognise and express verbal cues (Saalasti et al., 2008). This may again emphasise the fact that children on the Autism spectrum display a wide range of cognitive abilities and difficulties. The participants who were diagnosed with PDD performed the lowest in the VCI. Within the context of CHC Theory, this implies that PDD, HFA and

ASD children's general verbal and lexical knowledge abilities are age-appropriately developed, whereas those diagnosed with Asperger Syndrome display a slightly more developed ability to access and apply acquired word knowledge. As such, the mean VCI score of the Asperger Syndrome children was, therefore, slightly higher than that of their counterparts diagnosed with Asperger Syndrome, HFA or PDD. Asperger Disorder has been used to describe less severe symptoms than those thought to be associated with the other diagnostic terms and could, therefore, act as an explanation for the results found (Foley-Nicpon et al., 2012).

In addition, results from the meta-analysis revealed strong and meaningful differences in the VCI means and standard deviations of six of the 12 studies that included comparisons between ASD and typically developing children. Four of these compared the WISC performance of specifically ASD children and their typically developing peers (Dale et al., 2021; Li et al., 2017b; Nader et al., 2016; Rabiee et al., 2019), with one being of the WISC performance of ASD children with specified language impairments and typically developing children (Dale et al., 2021). Two of these compared the WISC performance of specifically HFA children and their typically developing peers (Li et al., 2017a; Operto et al., 2021). The results from the studies revealed higher mean VCI scores on the part of the typically developing children. However, the study conducted by Operto et al. (2021) revealed a higher mean VCI on the part of the HFA children.

Furthermore, the Similarities subtest was found to be the second highest-performed subtest among ASD children. The Similarities subtest forms part of the core subtests that make up the VCI, therefore, it is interesting to note that the Similarities subtest was the second highest-performed subtest when the VCI posed as a difficulty for individuals diagnosed with PDD. This could be due to the fact that the number of individuals diagnosed with PDD was less than those diagnosed with the other diagnostic terms for ASD. Additionally, Springer et al. (2013) define PDD as a disorder that causes communication and societal difficulties. As noted in Chapter 2, Oliveras-Rentas et al. (2012) attributed the pattern of higher Similarities scores to the suggestion that ASD children can more consistently demonstrate their talents when asked to give succinct verbal responses or finish untimed, motor-free non-verbal tasks. The Comprehension subtest was found to be the second lowest-performed subtest among all the individuals accounted for across the 49 articles. The Comprehension subtest forms part of the VCI, but is not presently one of the two core subtests used to calculate the index. The Comprehension subtest is based on social comprehension. These difficulties may be attributed to deficits in the Theory of Mind, Weak Central Coherence, and Executive Functioning

(Doleras Calero et al., 2015; Hajri et al., 2022; Hoogenhout & Malcolm-Smith, 2017). Furthermore, Kuehnel et al. (2019) indicated that the Comprehension subtest was deemed to be the most challenging for children with ASD due to the language challenges that they experience.

Therefore, although the results from a systematic literature review investigating their cognitive performance, as assessed by the WISC, indicate that their averaged underlying language ability falls in the High Average and Average ranges, the meta-analysis revealed a number of meaningful differences when comparing the VCI performance of ASD and HFA to typically developing children, predominantly in favour of the latter. Therefore, there is still concern that the general underlying language performance of ASD children is impacted by the difficulties related to their diagnoses. Therefore, similar to the general cognitive performance, there was a greater difference in overall language abilities between ASD children and typically developing children than there was between HFA and typically developing children. These results could be explained by the fact that ASD involves different levels of severity and is, therefore, not such a homogeneous group as a group of children with HFA might be.

If one considers the large effect sizes found between the ASD and typically developing children related to their language abilities, it is expected that the language difficulties that ASD children experience may have an impact on their classroom performance. Therefore, there is practical value in supporting ASD children to reach their potential and minimising the impact of their diagnosis and its accompanying difficulties on their scholastic progress and performance.

5.4 The Overall Processing Speed Abilities, as Captured by the Processing Speed Index

The findings of the systematic literature review revealed that the mean PSI score of ASD children, across all four diagnostic terms, who participated in the various studies, fell within the lower limits of the average range. Within the context of CHC Theory, this implies that their ability to organise information and solve problems using their visual perception abilities, as assessed by the WISC PSI, presents as age-appropriately developed. However, further analysis revealed that while the mean PSI scores of the different groups diagnosed with Asperger Syndrome, ASD and HFA fell in the average range, the mean PSI score of children diagnosed specifically with HFA also fell in the average range, whereas the mean PSI score of children diagnosed specifically with ASD and Asperger Syndrome fell within the low average range. As such, the mean PSI score of the HFA children was, therefore, slightly higher than

that of their counterparts diagnosed with ASD or Asperger Syndrome. An HFA individual is often referred to as someone who may not struggle with cognitive difficulties, but may struggle with communication, emotion perception and expression, and social interaction (Klila & Giuliani, 2021). This may help to provide an explanation as to why their PSI is slightly higher than those of Asperger Syndrome and ASD individuals.

In addition, results from the meta-analysis revealed strong and meaningful differences in the PSI means and standard deviations of seven of the 12 studies that included comparisons between ASD and typically developing children. Five of these compared the WISC performance of specifically ASD children and their typically developing peers (Dale et al., 2021; Li et al., 2017b; Nader et al., 2016; Rabiee et al., 2019; Styck et al., 2019), with one being on the WISC performance of ASD children with specified language impairments and typically developing children (Dale et al., 2021) and another, the WISC performance of HFA children and their typically developing peers (Li et al., 2017a; Operto et al., 2021). A moderately strong difference was also found in two studies comparing the WISC PSI means and standard deviations of ASD children and typically developing peers (Dale et al., 2021; Matsuura et al., 2014). Although all the relevant studies revealed that the mean PSI scores and standard deviations were higher in favour of the typically developing children, there were stronger and more meaningful differences in the PSI means and standard deviations between ASD and typically developing children than there were between HFA and typically developing children. Therefore, supporting the finding that the HFA participants' ability to organise information and solve problems using their visual perception abilities are slightly stronger than those of the ASD children.

The findings from the systematic literature review also revealed that ASD children performed the lowest on the Coding subtest. As noted in Chapter 2, Mayes and Calhoun (2003) suggest that the low patterns of Coding performance can be attributed to ASD children experiencing difficulties with motor coordination. Alternatively, Hedvall et al. (2013) stated that low Coding performance could be due to difficulties with cognitive flexibility experienced by ASD individuals. As noted in the results of the systematic literature review, no matter how differently the children's diagnoses or degrees of intellectual functioning varied, low Coding levels were always present. Therefore, this pattern can be verified as a common cognitive trait across all ASD subtypes, but with varying degrees.

5.5 The Overall Working Memory Abilities, as captured by the Working Memory Index

The findings of the systematic literature review revealed that the mean WMI score of ASD children, across all four diagnostic terms, who participated in the various studies, fell within the Average range. Within the context of CHC Theory, this implies that the ability to register, maintain and manipulate information in conscious awareness, as assessed by the WISC WMI, presents as age-appropriately developed. Further analysis supported this finding as the mean WMI scores for each specific diagnostic term, namely Asperger Syndrome, HFA and ASD, also fell within the average range. The systematic literature review revealed that the highest average mean WMI score (M = 100.33) was obtained by children diagnosed with Asperger Syndrome, followed by children diagnosed with HFA (M = 98.64) and then children diagnosed with ASD (M = 91.83).

In addition, the results from the meta-analysis revealed strong and meaningful differences in the WMI means and standard deviations of only two of the 12 studies that included comparisons between ASD and typically developing children. Both of these compared the WISC performance of specifically ASD children and their typically developing peers (Dale et al., 2021; Rabiee et al., 2019), with one being of the WISC performance of ASD children with specified language impairments and typically developing children (Dale et al., 2021). Two moderately strong differences were also found in a study comparing the WISC WMI means and standard deviations of ASD children and typically developing peers (Dale et al., 2021; Nader et al., 2016), with one being of the WISC performance of ASD children without specified language impairments and typically developing children (Dale et al., 2021). The results from these four studies revealed higher mean WMI scores on the part of the typically developing children. This supports the literature noted in Chapter 2, with research conducted by Kercood et al. (2014), suggesting that in comparison to typically developing children controls, ASD individuals perform worse on tests of working memory, particularly when the tasks rely heavily on planning, spatial working memory, a heavy workload, increasing task complexity, and dual tasking. Therefore, these results suggest that although the ASD children who were reviewed as part of the systematic literature review and meta-analysis performed lower than typically developing children on the WMI, their working memory may still be age-appropriately developed.

It should be noted that the two strong and two moderate effect sizes revealed by the meta-analysis for the WMI are less than the other indexes included in the meta-analysis. This may be due to the fact that the studies included in the meta-analysis only made use of the Digit

Span and Letter–Number Sequencing subtests (assesses auditory working memory) and did not include the Picture Span subtest (assesses visual working memory). Research has shown that ASD individuals display impairments in both the auditory and visual working memory domains (Habib et al., 2019). Additionally, it has been found that ASD individuals' visual working memory is more severely impaired than their auditory working memory (Kercood, 2014; Wang et al., 2017). Therefore, the number of strong and meaningful differences in the WMI means and standard deviations between ASD and typically developing children may have been more if more studies that incorporated their performance on the Picture Span subtest were included.

5.6 The Overall Visual–Spatial and Fluid Reasoning Abilities, as captured by the Perceptual Reasoning Index, Visual–Spatial Index and Fluid Reasoning Index

The findings of the systematic literature review revealed that the mean PRI, VSI and FRI score of ASD children, across all four diagnostic terms, who participated in the various studies, fell within the Average range. Within the context of CHC Theory, this implies that their visual–spatial reasoning, integration and synthesis of part–whole relationships, attentiveness to visual detail, and visual–motor integration, as well as their ability to detect the underlying conceptual relationship among visual objects and to use reasoning to identify and apply rules, as assessed by the WISC PRI, VSI and FRI, presents as age-appropriately developed.

However, further analysis revealed that the mean PRI score of children diagnosed specifically with ASD fell within the Average range, whereas those diagnosed specifically with HFA and Asperger Syndrome fell within the High Average and Very High ranges, respectively. The mean FRI score of children diagnosed specifically with ASD fell within the Average range. The mean VSI score of children diagnosed specifically with ASD, as well as those diagnosed with Asperger Syndrome, also fell within the Average range. As such, the mean PRI scores of the HFA and Asperger Syndrome children were, therefore, slightly higher than those of their counterparts diagnosed with ASD. In addition, results from the meta-analysis revealed strong and meaningful differences in the PRI means and standard deviations of two of the 12 studies that included comparisons between ASD and typically developing children. Both of these compared the WISC performance of specifically ASD children and their typically developing peers (Nader et al., 2016; Rabiee et al., 2019). A moderately strong difference was also found in a study comparing the WISC PRI means and standard deviations of ASD children and typically developing peers (Matsuura et al., 2014). Similarly, results from the meta-analysis

revealed strong and meaningful differences in the VSI and FRI means and standard deviations of one of the 12 studies that included comparisons between ASD (with specified language impairments) and typically developing children (Dale et al., 2021). Therefore, no strong and meaningful differences in the PRI, VSI or FRI means and standard deviations were found between HFA and typically developing children. The results from the studies revealed higher mean PRI, VSI and FRI scores on the part of the typically developing children. The findings from the systematic literature review also indicated that the Block Design subtest was found to be the highest-performed subtest among ASD children.

As noted in Chapter 2, research by Mitchell and Ropar (2004) indicated that ASD children present with well-developed visual–perceptual and visual–spatial skills. Research has also shown that individuals who had been diagnosed with Asperger Syndrome perform better than typically developing children in activities that rely on fluid reasoning (Hayashi et al., 2008). Although the meta-analysis did not compare the performance of children diagnosed with Asperger Syndrome with typically developing children, the systematic literature review revealed that the participants diagnosed with HFA and Asperger Syndrome perform slightly higher than that of their counterparts diagnosed with ASD on perceptual reasoning tasks. Therefore, according to the CHC Theory, HFA and Asperger Syndrome individuals display a relative strength in visual–spatial abilities and visual–motor integration. If one considers these findings, there is practical value in supporting ASD children to reach their potential and use their strengths to minimise the impact of their diagnosis and its accompanying difficulties on their scholastic progress and performance.

5.7 Conclusion

It was found that ASD children perform the strongest on tasks that require visual–perception, visual–motor integration, as well as visuospatial processing and coordination abilities. Furthermore, it was found that ASD children performed the lowest on tasks that assessed their ability to organise information and solve problems using their visual–perception abilities, as well as tasks that required them to use their general verbal and lexical knowledge abilities. The systematic literature review also revealed that ASD children performed the highest on the Block Design subtest which assessed their visual processing, followed by the Similarities subtest which assessed their inductive reasoning, as well as lexical or word knowledge. Additionally, the systematic literature review revealed that ASD children performed the lowest on the Coding subtest which assessed their rate of test-taking, followed by the Comprehension subtest which assessed their understanding of general principles and

social situations. The means and standard deviation differences found among the various WISC indices between ASD and typically developing children revealed that the typically developing children who participated in the various studies performed higher than ASD children across all the WISC indices except for the following: The HFA children obtained a slightly higher mean FSIQ score than typically developing peers, with a higher mean VCI being found on the part of the HFA children. The following chapter is focused on the strengths and limitations of the research study. Recommendations for educational psychologists and others working with ASD children are also discussed.

CHAPTER 6: STRENGTHS, LIMITATIONS AND RECOMMENDATIONS FOR EDUCATIONAL PSYCHOLOGISTS AND OTHERS WORKING WITH ASD CHILDREN

6.1 Summary

The aim of the present research study was to conduct a systematic review of international literature of published research studies which investigated the cognitive performance of ASD children as measured by the WISC. In addition, the study also aimed to conduct a meta-analysis to investigate the extent to which the performance differences observed between ASD children and typically developing peers, when measured on the WISC, is meaningful. The systematic literature review found that ASD children who participated in the various studies performed the strongest on tasks that require visual–perception, visual–motor integration, as well as visuospatial processing and coordination abilities; and they performed the lowest on tasks that assessed their ability to organise information and solve problems using their visual perception abilities, as well as tasks that required them to make use of their general verbal and lexical knowledge abilities. The meta-analysis revealed that the typically developing children who participated in the various studies generally performed higher on the various WISC indices, except for the HFA children who obtained a slightly higher mean FSIQ score than typically developing peers, and the HFA children who obtained a higher mean VCI score than typically developing children.

6.2 Strengths

This study demonstrated the cognitive performance of children diagnosed with ASD using the WISC. The following strengths can be identified when taking the findings into account: This research study was able to compile and quantify the outcomes of various studies. Some of the studies incorporated into the systematic literature review displayed an inadequate number of participants in a specific subgroup. Through a systematic literature review and meta-analysis, this research study was able to not only gather information and results from numerous distinct studies, but also provide a clearer picture of the distinct subgroups. By identifying the effects of interest and lowering the possibility of false-negative results, this research study was able to overcome the limitation of small sample sizes in individual research.

This research study was also able to investigate discrepancies in the data and explain heterogeneity between the findings of various investigations. A systematic literature review is a more open-ended and subjective process that incorporates a methodological framework to

overcome the drawbacks and biases of conventional narrative reviews. The systematic procedure that was followed to find the articles in this research study ensured that various biases were overcome. The findings of this research study may potentially be able to assist parents, teachers and educational psychologists in understanding the cognitive performance of children diagnosed with ASD in order to implement interventions and support structures that will allow these children to perform at their optimal potential.

6.3 Limitations

Although the study made an important contribution to the understanding of ASD children's cognitive performance and may potentially be beneficial to those working with these children, the study also had some limitations. Only published research is included in a systematic literature review and specifically the meta-analysis; therefore, the true size of an effect might be overstated. The result is known as publication bias. As the outcome of the systematic literature review and meta-analysis depends on the studies included, considerable efforts should be taken to locate all relevant papers in order to reduce the effect of publication bias. Therefore, the first limitation of this research study is that the researcher performed the initial systematic literature review manually by themselves. This may have resulted in a few articles being missed. Instead of objectivity, a systematic literature review is based on shared subjectivity. When determining how similar research should be before being combined, frequently, some subjectivity is involved. Therefore, the second limitation is that the researcher chose the inclusion and exclusion criteria, as well as which articles fit these criteria. This may have resulted in some studies being included in this research report that do not have the same diagnostic standards, comorbidities, disorder severity, and geographic location of the individuals. A systematic literature review and conclusions of a meta-analysis will be prejudiced and unreliable if it uses poor-quality studies. Therefore, although the researcher explicitly searched for high-quality studies, there is no guarantee that all the included studies may have been added to the research study if a different researcher was involved.

6.4 Recommendations for Educational Psychologists and Others Working with Autism Spectrum Disorder Children

Although this study investigated the cognitive performance of children diagnosed with ASD using the WISC, it is important to consider children holistically when recommending ways to interact and work with them. ASD children need to be supported academically, socially as well as emotionally. The following are helpful ways in which an educational psychologist

can optimise their time working with an ASD client in order to help and support them best: It is vital for the psychologist to remain consistent with their client. As noted, ASD children like to have routine and order, and, therefore, it is important that the psychologist does not diverge from their therapeutic frame. ASD children may find it challenging to apply what they have been taught within the therapeutic setting to other areas of their lives. Therefore, the best way to reinforce learning is for the psychologist to create consistency in the therapy room. It would be beneficial for the psychologist to advise the child's parents of the techniques that have been used in the therapy room so that they can continue using them at home. When addressing challenging behaviours, it is also crucial for the psychologist to be consistent in their interactions with the child. Positive reinforcement can be very beneficial for children with ASD. It may be beneficial for the psychologist to reward good behaviour in the session by giving the child stickers. It is also very important for the psychologist to pick up on non-verbal cues during the therapy session. This can provide the therapist with a lot of information about the ASD child. For instance, their body language, sounds they make, and gestures they use may all convey significantly more information than what they say. Some ASD children are hypersensitive to certain sensory stimuli (Hazen et al., 2014). Therefore, if psychologists understands what affects their client, they may end up having a more successful therapy session. The techniques used by psychologists can be used by parents and teachers too.

As noted in the findings of this research study, ASD children performed the highest on the PRI and POI, and the lowest on the PSI and VCI. This information may be beneficial for parents and teachers to know when working with ASD children. It is important to focus on a child's strengths, and in the case of ASD children, it would be their ability to work with visual information. High levels of perceptual reasoning may favour "learning by doing" or by making use of visual aids for learning. Children whose strengths can be found in perceptual reasoning perform better when they are given visual instructions and information rather than auditory stimuli. Learning occurs most effectively when written, modelled or diagrammed teaching is combined with visual materials for those with visual–spatial intelligence. Therefore, when working with ASD children, it would be beneficial to present instructions and information to them visually. In terms of addressing the difficulties that ASD children experience with processing speed and verbal comprehension, it would be beneficial to repeat instructions and tasks to them, allow them more time to complete tasks, provide them with paper to work out problems, read books and stories to them that they find interesting, and practise non-verbal communication with them. Therefore, by considering an ASD child holistically, educational psychologists, teachers and parents are able to provide these children with optimal

support.

6.5 Recommendations for Future Studies

For future studies, the findings of the systematic literature review and meta-analysis on the cognitive performance of children ASD utilizing the WISC highlight several areas that warrant attention. To improve the generalizability of results, researchers should give the most thought to including bigger sample sizes that represent a range of age groups and degrees of ASD severity. Investigations should use rigorous techniques, outlining precise diagnostic standards and standard WISC versions, to address potential bias and heterogeneity. For appropriate interpretation, it is also crucial to look into any potential cultural biases in the WISC evaluation, especially for different populations. Researchers, medical professionals, and educators working together can promote a more thorough understanding of the cognitive profiles of individuals with ASD, assisting with targeted therapies and support methods.

6.6 Conclusion

This chapter provided a conclusion on the research findings by highlighting the strengths and limitations of the research study. In addition, potential recommendations for educational psychologists and others working with ASD children were discussed. The findings indicated that ASD children have relative strengths and weaknesses, which are dependent on the diagnostic terms used to describe the severity level of their signs and symptoms. This will contribute to the knowledge of ASD children’s cognitive performance.

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Annexure A: Description of studies included in the systematic literature review reporting on cognitive performance of children diagnosed with Autism Spectrum Disorder using the Wechsler Intelligence Scale for Children

Study No	Author, Year	No of participants	Age	Diagnosis	Test used	FSIQ:	VCI:	WMI:	PSI:	FRI:	VSI:	PRI:	PIQ:	FFD:	POI:
1	Assouline et al., 2012	59	6 - 16 yr	ASD	WISC-IV	NA	125.08 (15.1)	111.33 (13.73)	96.57 (15.71)	NA	NA	123.73 (13.32)	NA	NA	NA
2	Audras-Torrent et al., 2021	121	6 - 16 yr	ASD	WISC-V	98.9 (15.7)	100.8 (20.2)	94 (13.6)	93.2 (14)	102 (14)	102.2 (14.6)	NA	NA	NA	NA
3	Barnhill et al., 2000	37	6-14 yr	Asperger	WISC-R; WISC-III	98.20 (21.23)	99.32 (21.55)	NA	NA	NA	NA	NA	96.72 (20.58)	NA	NA
4	Baum et al., 2015	40	10-16 yr	ASD	WISC-IV	78.81 (19.38)	83.49 (20.41)	76.38 (21.00)	77.79 (15.95)	NA	NA	87.55(20.11)	NA	NA	NA
5	Bodner et al., 2014	37	8-16 yr	ASD	WISC-III	56.51 (31.83)	60.76 (29.5)	NA	NA	NA	NA	NA	51.14 (31.81)	NA	NA
6	Bruin et al., 2006	76	6 - 12 yr	PDD	WISC-R	89.58 (19.38)	92.4 (17.04)	NA	NA	NA	NA	NA	91.37 (20.82)	85.32 (19.34)	91.79 (20.24)
		13	6 - 12 yr	Autism	WISC-R	83.62 (22.63)	89.77 (23.73)	NA	NA	NA	NA	NA	80.77 (20.86)	83.31 (26.59)	82.69 (21.44)
		11	6 - 12 yr	Asperger	WISC-R	102.91 (24.12)	109.18 (18.37)	NA	NA	NA	NA	NA	97.91 (21.52)	91.27 (26.12)	101.5 (19.64)
7	Charman et al., 2011	127	9 - 14 yr	ASD	WISC-III	75.5 (20.7)	75.9 (20)	NA	NA	NA	NA	NA	79.7 (22.1)	NA	NA
8	Dale et al., 2021	32	6 - 16 yr	ASD-NL	WISC-V	98.3 (17.4)	102.5 (14.4)	95.4 (16.8)	89.4 (18.4)	100.9 (17.5)	100.7 (17.1)	NA	NA	NA	NA
		30	6 - 16 yr	ASD-L	WISC-V	76.3 (19.1)	80.4 (18.2)	77.6 (19.4)	75.8 (19)	84.3 (20.6)	82.8 (22.2)	NA	NA	NA	NA
9	Dale et al., 2022	58	6 -16 yr	ASD	WISC-V	87.7 (21.21)	96.69 (19.17)	NA	NA	NA	NA	NA	NA	NA	NA
10	Dolores Calero et al., 2015	45	7 - 13 yr	Asperger	WISC-IV	109.45 (10.27)	118.55 (9.99)	93.84 (10.69)	98.08 (11.67)	NA	115.19 (14.39)	NA	NA	NA	NA
11	Ehlers et al., 1997	40	6-15 yr	Asperger	WISC-R	102.5 (21)	108.4 (21.3)	NA	NA	NA	NA	NA	95.6 (21.7)	NA	NA
		40	6-15 yr	Autism	WISC-R	78.8 (14)	81.3 (16.8)	NA	NA	NA	NA	NA	80.1 (14.2)	NA	NA
12	Foley-Nicpon et al., 2012	47	6 - 16 yr	HFA	WISC-IV	120.29 (9.18)	118.56 (13.93)	111.11 (13.53)	102.33 (15.34)	NA	NA	123.44 (12.07)	NA	NA	NA
		41	6 - 16 yr	Asperger	WISC-IV	124.89 (13.59)	130.60 (15.19)	114.45 (13.84)	91.40 (15.53)	NA	NA	125.75 (13.9)	NA	NA	NA
13	Giofre et al., 2019	50	6 - 16 yr	ASD	WISC-IV	73.70 (19.72)	75.92 (20.33)	74.50 (21.36)	80.34 (17.99)	NA	NA	89.28 (18.87)	NA	NA	NA
14	Goldstein et al., 2008	137	8 - 14 yr	Asperger	WISC-R; WISC-III	98.13 (15.22)	NA	NA	NA	NA	NA	NA	96.39 (14.79)	NA	NA
15	Hayashi et al., 2008	17	6 - 12 yr	Asperger	WISC-III	96.7 (15.3)	NA	NA	NA	NA	NA	NA	91.5 (19.3)	NA	NA
16	Kim & Song, 2020	49	6 - 15 yr	ASD	WISC-IV	89.92 (16.88)	93.33 (18.52)	96.04 (17.83)	85.16 (15.16)	NA	NA	94.39 (18)	NA	NA	NA
17	Koyama & Kurita, 2008	28	6 - 16 yr	Asperger	WISC-III	102.1 (9.3)	103 (15.7)	NA	93 (12.7)	NA	NA	NA	99.8 (10.3)	110.1 (16.9)	102.1 (10.2)
		78	6 - 16 yr	PDD	WISC-III	101 (12)	99.6 (17)	NA	99.4 (13.2)	NA	NA	NA	102.4 (12.3)	104.5 (16)	103.1 (12.8)
18	Koyama et al., 2006	27	6 - 16 yr	PDD	WISC-III	94.9 (12.9)	89.9 (16.6)	NA	98 (13.5)	NA	NA	NA	101 (12.6)	98.4 (19.4)	101.9 (13.1)
19	Koyama et al., 2007	36	6-16 yr	Asperger	WISC-R; WISC-III	98.3 (14.1)	101.2 (17.5)	NA	NA	NA	NA	NA	95.4 (14.5)	NA	NA
		37	6-16 yr	HFA	WISC-R; WISC-III	94.6 (13.5)	92.8 (18.2)	NA	NA	NA	NA	NA	97.9 (15.1)	NA	NA
20	Koyama et al., 2009	26	6 - 16 yr	PDD (female)	WISC-III	97.9 (13.6)	100 (17.2)	NA	101.1 (13.1)	NA	NA	NA	96.6 (12.4)	101 (19.8)	95.8 (12.4)
		116	6 - 16 yr	PDD (male)	WISC-III	96 (14.2)	94.4 (18.1)	NA	92.5 (16.8)	NA	NA	NA	98.2 (14.7)	102.6 (17.7)	100 (14.4)

Author, Year	No of participants	Age	Diagnosis	Test used	FSIQ:	VCI:	WMI:	PSI:	FRI:	VSI:	PRI:	PIQ:	FFD:	POI:
Kuehnel et al., 2019	48	6 - 15 yr	ASD	WISC-IV	NA	89.98 (19.77)	NA	NA	NA	NA	NA	NA	NA	NA
	48	8 - 16yr	ASD	WISC-V	NA	95.06 (18.92)	NA	NA	NA	NA	NA	NA	NA	NA
Kumazaki et al., 2015	20	6 - 9 yr	ASD (female)	WISC-III	97.5 (13.6)	98.2 (14.8)	NA	102.1 (10.7)	NA	NA	NA	98.3 (12.7)	98.6 (17.3)	98.2 (14.7)
	26	6 - 9 yr	ASD (male)	WISC-III	97.6 (13.5)	95.4 (16.4)	NA	99.3 (11.1)	NA	NA	NA	98.5 (11.3)	101.1 (18.9)	100.8 (12.6)
Kuriakose, 2014	23	7 - 15 yr	ASD	WISC-IV	80 (20.9)	80.7 (25.1)	81 (21.6)	79 (17.5)	NA	92.2 (19.4)	NA	NA	NA	NA
Li et al., 2017	31	6 - 16 yr	ASD	WISC-IV	94.68 (20.82)	94.71 (22.96)	93.74 (19.82)	88.9 (17.29)	NA	NA	100.16 (19.78)	NA	NA	NA
Li et al., 2017	32	6 - 16 yr	HFA	WISC-IV	94.44 (20.53)	94.34 (22.67)	93.28 (19.67)	88.81 (17.01)	NA	NA	NA	NA	NA	NA
Linnenbank et al., 2022	101	6-16 yr	Autism	WISC-IV	99.84 (13.23)	103.59 (13.23)	96.63 (14.84)	91.68 (13.26)	NA	NA	104.87 (14.82)	NA	NA	NA
Manjiviona et al., 1999	35	6 - 16 yr	Asperger	WISC-R	102.6 (18)	NA	NA	NA	NA	NA	NA	102 (19.9)	NA	NA
	21	7 - 15 yr	Autism	WISC-R	88.6 (15.3)	NA	NA	NA	NA	NA	NA	89.6 (14.6)	NA	NA
Matsuura et al., 2014	11	6 - 16 yr	ASD	WISC-IV	105.4 (14.3)	103.1 (17.3)	111.6 (16.6)	97.4 (10.2)	NA	NA	103.9 (12.2)	NA	NA	NA
Mayes & Calhoun, 2003	21	6-15 yr	ASD (IQ<80)	WISC-III	67 (10)	73(11)	NA	67 (13)	NA	NA	NA	NA	65(11)	74 (15)
	42	6-15 yr	ASD (IQ ≥ 80)	WISC-III	103 (16)	107 (16)	NA	94 (16)	95 (18)	NA	NA	NA	95 (18)	104 (17)
Mayes & Calhoun, 2008	54	6 - 14 yr	HFA	WISC-IV	101 (19)	107 (19)	89 (15)	85 (18)	NA	NA	115 (16)	NA	NA	NA
Mouga et al., 2016	224	6 - 16 yr	ASD	WISC-III	87.28 (21.06)	88.38 (21.08)	NA	82.84 (18.8)	NA	NA	NA	91.06 (20.98)	NA	NA
Nader et al., 2015	51	6 - 16 yr	Autism	WISC-III	90.6 (12.6)	88.9 (15.2)	NA	NA	NA	NA	NA	94.9 (12)	NA	NA
	15	7 - 15 yr	Asperger	WISC-III	99.4 (9.1)	104.2 (8)	NA	NA	NA	NA	NA	95 (14.2)	NA	NA
	51	7 - 15 yr	Autism	WISC-IV	90.7 (12.4)	85.6 (16.1)	87.8 (16.9)	91.5 (14.1)	NA	105.8 (13.3)	NA	NA	NA	NA
	15	7 - 15 yr	Asperger	WISC-IV	98.3 (12.4)	110.5 (10.5)	92.7 (15)	85.2 (9.3)	NA	101.3 (15.9)	NA	NA	NA	NA
Nader et al., 2016	25	6 - 16 yr	ASD	WISC-IV	87.8 (15.7)	83.6 (16.7)	87 (20.5)	87.8 (13.8)	NA	NA	101.5 (17.5)	NA	NA	NA
Noterdaeme et al., 2010	57	6-16 yr	Asperger	WISC	104.1 (14.3)	113.3 (18.5)	NA	NA	NA	NA	NA	96.5 (16.2)	NA	NA
	55	6-16 yr	HFA	WISC	94 (9.6)	97.6 (12.4)	NA	NA	NA	NA	NA	92.8 (11.6)	NA	NA
Nyden et al., 2001	20	6 - 11 yr	Asperger	WISC-III	106.8 (15.8)	NA	NA	NA	NA	NA	NA	97.1 (16.9)	NA	NA
Okada et al., 2022	138	7 - 16 yr	ASD	WISC-IV	95.2 (15.4)	99.1 (17.1)	94.8 (17.6)	88.7 (14.3)	NA	NA	99.1 (15.8)	NA	NA	NA
Oliveras-Rentas et al., 2012	56	6 - 16 yr	ASD	WISC-IV	97.55 (19.8)	99.02 (21.08)	95.61 (18.23)	87.68 (16.36)	NA	NA	104.23 (18.17)	NA	NA	NA
Operto et al., 2021	19	6 - 16 yr	HFA	WISC-IV	110.16 (10.17)	111 (10.27)	101.16 (12.84)	92.05 (6.64)	NA	NA	NA	NA	NA	NA
Penuelas-Calvo et al., 2021	84	6 - 16 yr	ASD	WISC-IV	106 (21.73)	112.88 (23.21)	102.88 (20.92)	94.69 (18.48)	NA	NA	104.38 (18.98)	NA	NA	NA
Planche & Lem, 2012	15	6-10 yr	HFA	WISC-III	98.07 (16.28)	89.13 (17.56)	NA	NA	NA	NA	NA	109.07 (13.52)	NA	NA
	15	6-9 yr	Asperger	WISC-III	105.53 (16.87)	112.33 (17.10)	NA	NA	NA	NA	NA	96.53 (14.74)	NA	NA

Author, Year	No of participants	of Participa	Diagnosis	Test used	FSIQ:	VCI:	WMI:	PSI:	FRI:	VSI:	PRI:	PIQ:	FFD:	POI:
Rabiee et al., 2019	30	6 - 16 yr	ASD	WISC-IV	85.63 (12.51)	86.7 (19.18)	85.2 (15.43)	93 (14.49)	NA	NA	93.2 (11.87)	NA	NA	NA
Rabiee et al., 2020	30	8 - 16 yr	ASD	WISC-IV	85.63 (12.51)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Siegel et al., 1996	81	6 - 16 yr	PDD	WISC-III	96.02 (14.49)	NA	NA	NA	NA	NA	NA	96.6 (13.69)	NA	NA
Stack et al., 2017	134	6 - 15 yr	ASD	WISC-IV	97.84 (13.93)	101.67 (15.7)	94.36 (15.89)	91.96 (14.6)	NA	NA	101.32 (13.13)	NA	NA	NA
Stephenson et al., 2021	349	6 - 16 yr	ASD	WISC-V	90.41 (17.53)	95.50 (17.16)	88.71 (16.39)	84.15 (16.77)	95.86 (17.84)	97.05 (16.80)	NA	NA	NA	NA
Styck et al., 2019	79	6 - 16 yr	ASD	WISC-IV	91 (18.3)	94.4 (19.7)	92.1 (18.2)	84.9 (17.5)	NA	97.3 (18.9)	NA	NA	NA	NA
Williams et al., 2006	56	8 - 15 yr	Autism	WISC-III	104.13 (15.09)	NA	NA	NA	NA	NA	NA	102.07 (14.63)	NA	NA
Williams et al., 2008	69	6 - 16 yr	HFA	WISC-R; WISC-III	102.68 (12.88)	103.65 (14.77)	NA	NA	NA	NA	NA	101.43 (12.92)	NA	NA
Zayat et al., 2011	55	6-16 yr	ASD	WISC-IV	NA	101.4 (16.6)	NA	NA	NA	NA	97.8 (2.9)	NA	NA	NA

Annexure B: Description of studies included in the systematic literature review reporting on the highest- and lowest-performed subtests

Author, Year	Diagnosis	Test Used	Highest Scoring Subtest	Lowest Scoring Subtest
Assouline et al., 2012	ASD	WISC-IV	NA	NA
Audras-Torrernt et al., 2021	ASD	WISC-V	Similarities: 10.5 (3.8)	Digit Span: 8.5 (2.6)
Barnhill et al., 2000	Asperger	WISC-R; WISC-III	Block Design: 11.03 (4.34)	Coding: 7 (3.03)
Baum et al., 2015	ASD	WISC-IV	NA	NA
Bodner et al., 2014	ASD	WISC-III	NA	NA
Bruin et al., 2006	PDD Autism Asperger	WISC-R WISC-R WISC-R	Picture Arrangement: 9.8 (3.59) Similarities: 8.77 (4.36) Information: 13.36 (3.85)	Digit Span: 7.32 (3.37) Coding: 5.77 (3.75) Coding: 6.55 (4.7)
Charman et al., 2011	ASD	WISC-III	Picture Arrangement: 8.4 (5.2)	Comprehension: 4.7 (3.6)
Dale et al., 2021	ASD-NL ASD-L	WISC-V WISC-V	NA NA	NA NA
Dale et al., 2022	ASD	WISC-V	NA	NA
Dolores Calero et al., 2015	Asperger	WISC-IV	Similarities: 15.83 (2.83)	Coding: 8.15 (2.68)
Ehlers et al., 1997	Asperger Autism	WISC-R WISC-R	Similarities: 12.3 (4.6) Block Design:9.1 (3.1)	Coding: 7.8 (4.3) Coding: 5.5 (3.7)
Foley-Nicpon et al., 2012	HFA Asperger	WISC-IV WISC-IV	Matrix Reasoning: 15.25 (3.19) Vocabulary: 15.57 (2.5)	Coding: 9.5 (2.92) Coding: 7.36 (3.25)
Giofre et al., 2019	ASD	WISC-IV	NA	NA
Goldstein et al., 2008	Asperger	WISC-R; WISC-III	NA	NA
Hayashi et al., 2008	Asperger	WISC-III	NA	NA
Kim & Song, 2020	ASD	WISC-IV	Block Design: 10.48 (3.85)	Coding: 7.3 (3)
Koyama & Kurita, 2008	Asperger PDD	WISC-III WISC-III	NA NA	NA NA
Koyama et al., 2006	PDD	WISC-III	Block Design: 12 (3.8)	Comprehension: 6.5 (3.4)
Koyama et al., 2007	Asperger HFA	WISC-R; WISC-III WISC-R; WISC-III	Digit Span: 11.8 (3) Block Design: 12 (3.9)	Coding: 7.5 (2.7) Comprehension: 6.2 (2.9)
Koyama et al, 2009	PDD (female) PDD (male)	WISC-III WISC-III	Information: 11.2 (4.1) Block Design: 11.6 (3.5)	Comprehension: 8.1 (3.6) Vocabulary: 7.8 (3.2)

Author, Year	Diagnosis	Test Used	Highest Scoring Subtest	Lowest Scoring Subtest
Kuehnel et al., 2019	ASD	WISC-IV	NA	NA
	ASD	WISC-V	NA	NA
Kumazaki et al., 2015	ASD (females)	WISC-III	Symbol Search: 10.8 (2.4)	Object Assembly: 8.1 (3.4)
	ASD (males)	WISC-III	Block Design: 11.6 (3.1)	Coding: 8.5 (2.6)
Kuriakose, 2014	ASD	WISC-IV	Block Design: 9.5 (2.9)	Comprehension: 4.9 (4.5)
Li et al., 2017	HFA	WISC-IV	Block Design: 12.31 (4.02)	Coding: 7.66 (3.17)
Li et al., 2017	ASD	WISC-IV	Block Design: 12.29 (4.08)	Coding: 7.65 (3.22)
Linnenbank et al., 2022	Autism	WISC-IV	NA	NA
Manjiviona et al., 1999	Asperger	WISC-R	Block Design: 12.6 (4.2)	Coding: 7.6 (3.5)
	Autism	WISC-R	Block Design: 10.2 (2.9)	Coding: 6 (3.9)
Matsuura et al., 2014	ASD	WISC-IV	Block Design: 12.2 (3.1)	Picture Concepts: 8.7 (2.5)
Mayes & Calhoun, 2003	ASD (IQ<80)	WISC-III	NA	NA
	ASD (IQ ≥ 80)	WISC-III	NA	NA
Mayes & Calhoun, 2008	HFA	WISC-IV	Matrix Reasoning: 13.1 (3)	Coding: 6.6 (4)
Mouga et al., 2016	ASD	WISC-III	Block Design: 10.11 (3.98)	Comprehension: 6.43 (3.36)
Nader et al., 2015	Autism	WISC-III	Block Design: 12.2 (3.5)	Comprehension: 5.2 (3)
	Autism	WISC-IV	Matrix Reasoning: 11.7 (2.9)	Comprehension: 5.8 (3)
	Asperger	WISC-III	Vocabulary: 13.3 (3.2)	Coding: 6.4 (3)
	Asperger	WISC-IV	Vocabulary: 13.3 (3.2)	Coding: 6.7 (1.9)
Nader et al., 2016	ASD	WISC-IV	NA	NA
Noterdaeme et al., 2010	Asperger		Information: 12.6 (3.3) & Similarities: 12.6 (2.9)	Coding: 8.1 (2.8)
	HFA		Information: 10.7 (2.5)	Comprehension: 7.3 (2.4)
Nyden et al., 2001	Asperger	WISC-III	Vocabulary: 15.1 (4.3)	Symbol Search: 7.5 (3.4)
Okada et al., 2022				
Oliveras-Rentas et al., 2012	ASD	WISC-IV	Similarities: 11.75 (3.7)	Coding: 7.34 (3.63)
Operto et al., 2021	HFA	WISC-IV	NA	NA
Penuelas-Calvo et al., 2021	ASD	WISC-IV	NA	NA
Planche & Lem, 2012	HFA		Block Design: 12.47 (2.39)	Arithmetic: 6.07 (2.6)
	Asperger		Block Design: 13.47 (3.14)	Coding: 4 (2.8)

Author, Year	Diagnosis	Test Used	Highest Scoring Subtest	Lowest Scoring Subtest
Rabiee et al., 2019	ASD	WISC-IV	Matrix Reasoning: 10.76 (2.67)	Comprehension: 5.03 (3.46)
Rabiee et al., 2020	ASD	WISC-IV	Letter Span: 10.5 (3.31)	Arithmetic: 3.43 (3.34)
Siegel et al., 1996	PDD	WISC-III	Block Design: 11.33 (3.72)	Comprehension:7.47 (4.05)
Stack et al., 2017	ASD	WISC-IV	Similarities: 11.92 (2.83)	Comprehension: 8.71 (3.25)
Stephenson et al., 2021	ASD	WISC-IV	Visual Puzzles: 9.85 (3.15)	Coding: 6.63 (3.22)
Styck et al., 2019	ASD	WISC-IV	Similarities: 10 (3)	Coding: 7 (3.8)
Williams et al., 2006	Autism	WISC-III	NA	NA
Williams et al., 2008	HFA	WISC-R; WISC-III	NA	NA
Zayat et al., 2011	ASD	WISC-IV	NA	NA

Annexure C

Description of studies included in the meta-analysis reporting on the comparison between Autism Spectrum Disorder and typically developing children's cognitive performance using the Wechsler Intelligence Scale for Children

Study No	Author, Year	No of participants	Age	Diagnosis	Test used	FSIQ:	VCI:	WMI:	PSI:	FRI:
1	Bodner et al., 2014	37	8-16 yr	ASD	WISC-III	104.46 (16.70)	107.08 (17.00)	NA	NA	NA
		48	8-16 yr	TD	WISC-III	110.19 (11.28)	110.38 (10.92)	NA	NA	NA
2	Dale et al., 2022	58	6 -16 yr	ASD	WISC-V	87.7 (21.21)	96.69 (19.17)	NA	NA	NA
		62	6-16 yr	TD	WISC-V	103.60 (12.85)	104.48 (12.18)	NA	NA	NA
3	Styck et al., 2019	79	6 - 16 yr	ASD	WISC-IV	91 (18.3)	94.4 (19.7)	92.1 (18.2)	84.9 (17.5)	NA
		216	6 - 16 yr	TD	WISC-IV	95.4 (11.5)	95.5 (11.4)	93.0 (11.8)	96.3 (12.4)	NA
4	Matsuura et al., 2014	11	6 - 16 yr	ASD	WISC-IV	105.4 (14.3)	103.1 (17.3)	111.6 (16.6)	97.4 (10.2)	NA
		19	6 - 16 yr	TD	WISC-IV	111.8 (13.4)	107.5 (11.9)	109.1 (17.2)	105.0 (10.9)	NA
5	Williams et al., 2008	69	6 - 16 yr	HFA	WISC-R; WISC-III	102.68 (12.88)	103.65 (14.77)	NA	NA	NA
		72	6 - 16 yr	TD	WISC-R; WISC-III	103.35 (8.26)	103.75 (8.90)	NA	NA	NA
6	Nader et al., 2016	25	6 - 16 yr	ASD	WISC-IV	87.8 (15.7)	83.6 (16.7)	87 (20.5)	87.8 (13.8)	NA
		22	6 - 16 yr	TD	WISC-IV	110.3 (14.8)	112.8 (18.3)	99.9 (11.9)	105.3 (13.2)	NA
7	Li et al., 2017	32	6 - 16 yr	ASD	WISC-IV	94.44 (20.53)	94.34 (22.67)	93.28 (19.67)	88.81 (17.01)	NA
		39	6 - 16 yr	TD	WISC-IV	111.38 (11.29)	117.36 (13.32)	100.69 (12.94)	108.28 (15.22)	NA
8	Li et al., 2017	31	6 - 16 yr	ASD	WISC-IV	94.68 (20.82)	94.71 (22.96)	93.74 (19.82)	88.9 (17.29)	NA
		48	6 - 16 yr	TD	WISC-IV	106.96 (10.07)	112.56 (14.21)	98.98 (11.10)	105.10 (15.06)	NA
9	Operto et al., 2021	19	6 - 16 yr	HFA	WISC-IV	110.16 (10.17)	111 (10.27)	101.16 (12.84)	92.05 (6.64)	NA
		20	6 - 16 yr	TD	WISC-IV	104.60 (8.30)	103.15 (8.46)	103.30 (8.42)	103.00 (5.84)	NA
10	Rabiee et al., 2019	30	6 - 16 yr	ASD	WISC-IV	85.63 (12.51)	86.7 (19.18)	85.2 (15.43)	93 (14.49)	NA
			6 - 16 yr	TD	WISC-IV	110.87 (9.62)	118.27 (10.99)	99.56 (9.78)	115.43 (9.71)	NA
11	Dale et al., 2021	32	6 - 16 yr	ASD-NL	WISC-V	98.3 (17.4)	102.5 (14.4)	95.4 (16.8)	89.4 (18.4)	100.9 (17.5)
		30	6 - 16 yr	ASD-L	WISC-V	76.3 (19.1)	80.4 (18.2)	77.6 (19.4)	75.8 (19)	84.3 (20.6)
			6 - 16 yr	TD	WISC-V	105.0 (11.9)	104.8 (11.6)	104.3 (12.1)	98.0 (14.7)	103.5 (12.7)
12	Rabiee et al., 2020	30	8 - 16 yr	ASD	WISC-IV	85.63 (12.51)	NA	NA	NA	NA
		30	8 - 16 yr	TD	WISC-IV	111.87 (9.62)	NA	NA	NA	NA

Study No	Author, Year	No of participants	Age	Diagnosis	Test used	VSI:	PRI:	PIQ:	FFD:	POI:
1	Bodner et al., 2014	37	8-16 yr	ASD	WISC-III	NA	NA	101.08 (17.07)	NA	NA
		48	8-16 yr	TD	WISC-III	NA	NA	108.44 (10.97)	NA	NA
2	Dale et al., 2022	58	6 -16 yr	ASD	WISC-V	NA	NA	NA	NA	NA
		62	6-16 yr	TD	WISC-V	NA	NA	NA	NA	NA
3	Styck et al., 2019	79	6 - 16 yr	ASD	WISC-IV	97.3 (18.9)	NA	NA	NA	NA
		216	6 - 16 yr	TD	WISC-IV	99.7 (12.5)	NA	NA	NA	NA
4	Matsuura et al., 2014	11	6 - 16 yr	ASD	WISC-IV	NA	103.9 (12.2)	NA	NA	NA
		19	6 - 16 yr	TD	WISC-IV	NA	111.9 (11.6)	NA	NA	NA
5	Williams et al., 2008	69	6 - 16 yr	HFA	WISC-R; WISC-III	NA	NA	101.43 (12.92)	NA	NA
		72	6 - 16 yr	TD	WISC-R; WISC-III	NA	NA	102.69(8.21)	NA	NA
6	Nader et al., 2016	25	6 - 16 yr	ASD	WISC-IV	NA	101.5 (17.5)	NA	NA	NA
		22	6 - 16 yr	TD	WISC-IV	NA	110.7 (12.4)	NA	NA	NA
7	Li et al., 2017	32	6 - 16 yr	ASD	WISC-IV	NA	NA	NA	NA	NA
		39	6 - 16 yr	TD	WISC-IV	NA	NA	NA	NA	NA
8	Li et al., 2017	31	6 - 16 yr	ASD	WISC-IV	NA	100.16 (19.78)	NA	NA	NA
		48	6 - 16 yr	TD	WISC-IV	NA	102.71 (11.20)	NA	NA	NA
9	Operto et al., 2021	19	6 - 16 yr	HFA	WISC-IV	NA	NA	NA	NA	NA
		20	6 - 16 yr	TD	WISC-IV	NA	NA	NA	NA	NA
10	Rabiee et al., 2019	30	6 - 16 yr	ASD	WISC-IV	NA	93.2 (11.87)	NA	NA	NA
			6 - 16 yr	TD	WISC-IV	NA	113.23 (11.14)	NA	NA	NA
11	Dale et al., 2021	32	6 - 16 yr	ASD-NL	WISC-V	100.7 (17.1)	NA	NA	NA	NA
		30	6 - 16 yr	ASD-L	WISC-V	82.8 (22.2)	NA	NA	NA	NA
			6 - 16 yr	TD	WISC-V	103.4 (14.5)	NA	NA	NA	NA
12	Rabiee et al., 2020	30	8 - 16 yr	ASD	WISC-IV	NA	NA	NA	NA	NA
		30	8 - 16 yr	TD	WISC-IV	NA	NA	NA	NA	NA

Annexure D

Comparisons between Autism Spectrum Disorder and typically developing children

WISC-R & WISC-III																							
Yr of Study	*N*	Diagnosis	*M*	FSIQ *SD*	*d*	VCI *M*	VCI *SD*	*d*	*M*	PIQ *SD*	*d*												
2008	69	HFA	102.68	12.88	-0.06	103.65	14.77	-0.01	101.43	12.92	-0.12												
	72	TD	103.35	8.26		103.75	8.9		102.69	8.21													
2014	37	ASD	104.46	16.7	-0.41	107.08	17	-0.24	101.08	17.07	-0.53												
	48	TD	110.19	11.28		110.38	10.92		108.44	10.97													
WISC-IV																							
Yr of Study	*N*	Diagnosis	*M*	FSIQ *SD*	*d*	VCI *M*	VCI *SD*	*d*	*M*	WMI *SD*	*d*	*M*	PSI *SD*	*d*	*M*	PRI *SD*	*d*						
2014	11	ASD	105.4	14.3	-0.47	103.1	17.3	-0.31	111.6	16.6	0.15	97.4	10.2	-0.71	103.9	12.2	-0.68						
	19	TD	111.8	13.4		107.5	11.9		109.1	17.2		105	10.9		111.9	11.6							
2016	25	ASD	87.8	15.7	-1.47	83.6	16.7	-1.67	87	20.5	-0.76	87.8	13.8	-1.29	101.5	17.5	-1.09						
	22	TD	110.3	14.8		112.8	18.3		99.9	11.9		105.3	13.2		110.7	12.4							
2017a	32	HFA	94.44	20.53	-1.05	94.34	22.67	-1.27	93.28	19.67	-0.45	88.81	17.01	-1.44									
	39	TD	111.38	11.29		117.36	13.32		100.69	12.94		108.28	15.22										
2017b	31	ASD	94.68	20.82	-0.81	94.71	22.96	-0.98	93.74	19.82	-0.35	88.9	17.29	-1.01	100.16	19.78	-0.17						
	48	TD	106.96	10.07		112.56	14.21		98.98	11.1		105.1	15.06		102.71	11.2							
2019a	79	ASD	91	18.3	-0.32	94.4	19.7	-0.08	92.1	18.2	-0.07	84.9	17.5	-0.82	97.3	18.9	-0.17						
	216	TD	95.4	11.5		95.5	11.4		93	11.8		96.3	12.4		99.7	12.5							
2019b	30	ASD	85.63	12.51	-2.26	86.7	19.18	-2.02	85.2	15.43	-1.11	93	14.49	-1.82	93.2	11.87	-1.74						
	30	TD	110.87	9.62		118.27	10.99		99.56	9.78		115.43	9.71		113.23	11.14							
2020	30	ASD	85.63	12.51	-2.35																		
	30	TD	111.87	9.62																			
2021	19	HFA	110.16	10.17	0.6	111	10.27	0.84	101.16	12.84	-0.2	92.05	6.64	-1.75									
	20	TD	104.6	8.3		103.15	8.46		103.3	8.42		103	5.84										
WISC-V																							
Yr of Study	*N*	Diagnosis	*M*	FSIQ *SD*	*d*	VCI *M*	VCI *SD*	*d*	*M*	WMI *SD*	*d*	*M*	PSI *SD*	*d*	*M*	VSI *SD*	*d*	*M*	FRI *SD*	*d*			
2021	32	ASD-NL	98.3	17.4	-0.51	102.5	14.4	-0.19	95.4	16.8	-0.68	89.4	18.4	-0.55	100.7	17.1	-0.18	100.9	17.5	-0.19			
	30	ASD-L	76.3	19.1	-2.11	80.4	18.2	-1.86	77.6	19.4	-1.94	75.8	19	-1.42	82.8	22.2	-1.27	84.3	20.6	1.14			
	124	TD	105	11.9		104.8	11.6		104.3	12.1		98	14.7		103.4	14.5		103.5	12.7				
2022	58	ASD	87.7	21.21	-0.91	96.69	19.17	-0.49															
	62	TD	103.6	12.85		104.48	12.18																

Note. 0.2 = small effect, 0.5 = moderate effect, 0.8 = large effect