# Exploring Word Recognition and Listening Comprehension Abilities of Children with Autism who are Non-verbal

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# Exploring Word Recognition and Listening Comprehension Abilities of Children with Autism who are Non-verbal

Sharon Arnold

Submitted to Swansea University in fulfilment of the requirements for the Degree of Doctor of Philosophy, *Swansea University*, 2021.

## Abstract

The aim of this thesis was to begin to fill the research gap relating to children with autism who are non-verbal and the impact this has on school provision for reading-related skills. The first study aimed to establish provision for children with autism who are non-verbal, in terms of the kinds of reading assessment which are currently employed in additional learning needs (ALN) settings. A further aim was to explore the views of educational practitioners concerning the usefulness of these assessments. The study revealed that the reading test most employed in ALN settings is the New Salford Reading Test (NSRT). Attitudes of practitioners relating to the use of this test with children with autism who are non-verbal were not positive. An issue raised regarding the reading assessments identified in the study was that their requirement for verbalisation would act as a barrier for children with ASD who are non-verbal. We then aimed to measure the word recognition and listening comprehension abilities of children with autism who are non-verbal, employing a modified multiple-choice test format that removed the requirement for verbalisation. Results demonstrated, that when compared to the paper-based NSRT, the modified test format could be a good assessment for children with autism who are non-verbal. Continuing to develop methods of assessment for children with autism who are non-verbal will help us to learn more about this under-researched population and improve educational practices for this cohort.

Keywords: word recognition; listening comprehension; reading ability; non-verbal reading test; ASD; reading assessments.

# DECLARATIONS AND STATEMENTS

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed  (candidate)

Date: 16th March 2021

**STATEMENT 1**

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

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Date 16th March 2021

**STATEMENT 2**

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed  (candidate)

Date 16th March 2021

# CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

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## DEFINITIONS OR ABBREVIATIONS

| | |
|---|---|
| ABC | Autism Behavior Checklist |
| ALN | Additional Learning Needs |
| ANCOVA | Analysis of covariance |
| ANOVA | Analysis of variance |
| ASD | Autistic Spectrum Disorders |
| DSM | Diagnostic and Statistical Manual |
| HSD | Honestly Significant Difference |
| ICD | International Classification of Diseases |
| IQ | Intelligence Quotient |
| NARA | Neale's Analysis of Reading Ability |
| NAS | National Autistic Society |
| NSRT | New Salford Reading Test |
| PECS | Picture Exchange Communication System |
| PIQ | Performance Intelligence Quotient |
| PRIQ | Perceptual Reasoning Intelligence Quotient |
| SD | Standard Deviation |
| SE | Standard Error |
| SEN | Special Educational Needs |
| US Dept. of HHS | United States Department of Health and Human Services |
| VIQ | Verbal Intelligence Quotient |
| WISC | Wechsler Intelligence Scale for Children |
| WASI | Wechsler Abbreviated Scale of Intelligence |

# CHAPTER 1

## Patterns of Reading Ability in Children with Autism

*Children with Autism Spectrum disorder are the focus of this thesis, which aims to explore the potential of children with autism, who are non-verbal, within the area of reading ability. Reading is a term used to describe a set of complex skills, involving a range of cognitive processes. So, to be clear, the specific skills we intend to examine are context-free word recognition and listening comprehension. The term 'context-free word recognition' is borrowed from Gough and Tumner (1986) who argue that word recognition, as a part of decoding ability, is a necessary element of the reading process. Listening comprehension refers to the ability to listen and comprehend spoken language and is important for reading comprehension (Nation & Snowling, 2004; Wise et al., 2007). Little is known about the abilities of children with autism who are non-verbal (Tager-Flusberg & Kasari, 2013) and their literacy potential. Twenty years of practice as a school-based educational practitioner informs the view of the author that many of this population are readers or at least potential readers. It is the role of the research detailed in this thesis to demonstrate that this is theoretically possible.*

### 1.1. Autistic Spectrum Disorders

Autism is as complex and multifaceted as the children who make up this population and is far from fully understood. In this first chapter, prior to any consideration of academic ability, it is important to consider the shifting definitions, as well as academic and social perceptions, which shape attitudes towards this population and their potential for learning. Children with autism who are non-verbal are discussed, with particular attention paid to the issue of definition, which can be problematic due to the wide variation of abilities and symptoms displayed in this cohort. It is possible that children with autism who are non-verbal may be non-

verbal for a variety of reasons which are likely to differ within the population. To try to come up with a single definition, therefore, could quite possibly mean seeking homogeneity where there is none to be found. Attempting to define children with autism as either 'high functioning' or 'low functioning' is also inaccurate and unhelpful. Children with autism tend to display uneven learning profiles and this is evident in research related to reading-related skills. Reading theories, therefore, are discussed with a view to the examination of possible barriers to reading which may exist for the population of children who have autism. A barrier that was once thought to exist, articulation, is discussed to demonstrate that lacking an ability to verbalise does not rule out the possibility that a child with autism who is non-verbal can develop reading skills. Implications for practice and the focus of this thesis are also expressed.

### 1.1.1 Shifting definitions of autism

Although there are other views, Leo Kanner in 1943, and Hans Asperger in 1944, independent of each other, are associated with the first published accounts of autism (Frith, 1989, p.7). Both authorities believed that present from birth, this fundamental disorder gave rise to highly characteristic problems. Originally as a reference to a basic disturbance in schizophrenia, the term 'autistic' had already been introduced by the psychiatrist Eugen Bleuler in 1911. He used the term to describe a narrowing of relationships that involved a withdrawal from social life and into the self (Frith, 1989, p.7). The term 'autism' is a compound word that comes from the Greek words 'aut-', which means self, and '-ism', which implies orientation, or state; and together this describes little interest displayed in others. Both Kanner and Asperger described cases of such children, who seemed unable to engage in effective social relationships and in contrast to Bleuler's definition, this deficit appeared to have been present from the beginning of the child's life. Thus, the emergence of the term 'early infantile autism' which tends to be avoided in current academic literature as this term may wrongly suggest a condition that someone may 'grow out of' when current knowledge is that this condition is one that is life-long (DSM-5; American Psychiatric Association, 2013).

Kanner published his paper entitled 'Autistic Disturbances of Affective Contact' in the now extinct journal *Nervous Child*, in which he presented the cases of 11 children he believed to have autism. Common features he identified were 'autistic aloneness', a 'desire for sameness', and 'islets of ability'. Hans Asperger described children who did not make eye contact and displayed a 'poverty of facial expressions and gestures' with a use of language that always appeared to be abnormal or unnatural (Frith, 1989, pp. 8-10).

As a possible explanation for autism, Kanner came up with the phrase, 'refrigerator mother', a notion that later became attached to the work of the psychoanalyst Bruno Bettleheim in the 1960s. The theory posited that at the root of the 'autism problem' were mothers who failed to bond with their children. The mother's 'coldness' towards their offspring was therefore identified as the source of the child's inability to socially interact with their world. An interesting parental perspective on this topic, which highlights the 'everyday' impact academic theory can have on people with a diagnosis and their families, can be found in 'A Tiger by the Tail', written by Berthajane Vandegrift, the mother of a son with Autism Spectrum Disorder (2001).

In the 1970's and 1980's the notion of a 'triad of impairments' i.e. social interaction, social language, and social imagination, (Wing & Gould, 1979) as diagnostic criteria for autism, gained currency. The 'triad of impairments' was the result of a seminal paper written by Lorna Wing and Judith Gould, which reported on a large epidemiological survey drawing on a screened sample of 914 children, and detailed data from 132. Features of autism were grouped into three categories: social interaction, communication, and imagination. The study noted a typical presentation of skills in all three areas, demonstrated by the interaction styles of children with autism, and repetitive and stereotyped behaviours which were evident, among other things, in an unusual style of play. Later work (Shah et al., 1982, cited by Fletcher-Watson, 2019, p.18) demonstrated evidence of these three features of autism for adults with autism. These three features became known as the 'triad of impairments' (Fletcher-Watson, 2019, p.18). This view of the nature of autism strongly influenced thinking about diagnostic systems (e.g. DSM-IV-TR; American Psychiatric

Association, 1994), although the methodological approaches carried out in the original work that fed into the notion of the triad has been criticized (Reed, 2016, p.41). The introduction of the DSM -5 saw a move away from the triad of impairments and five different disorders detailed in DSM IV-TR (Autism, Asperger's syndrome, Rett syndrome, Childhood Disintegrative Disorder, and PDD-NOS) to the one spectrum condition. The current definition is that of a developmental disorder, which has varying degrees of severity, and is classified by marked delays and challenges in social communication, social interaction and restricted, repetitive patterns of thought and behaviour. Sensory sensitivities and sensory integration issues are also a factor (DSM 5; American Psychiatric Association, 2013, cited by Fletcher-Watson & Happé, 2019, p. 30-32).

Discussions around diagnostic criteria are far from just academic conjecture. How autism is defined impacts on estimates of prevalence (Fombonne, 2003; Williams, Higgins & Brayne, 2006), the design and delivery of interventions and service provision. The language we use can also shape how we view autism spectrum disorder, which can have practical, emotional, and psychological consequences for people with autism, their families, and communities (Bagatell 2010; Kenny et al., 2016).

### 1.1.2 Societal definitions of autism

Members of the autism community i.e. people with autism, their family, friends, and broader support networks, often disagree about how autism should be described. Differences in people's ideologies and the personal and social factors which influence them, impact on the language they use to describe autism. This is due, in part, to the disability rights movement (Kenny et al., 2016), which was born out of frustration with disability being seen as something that needs fixing. The movement argues that the medical model of disability perpetuates a perception that people with disabilities are unfortunate victims of circumstance. A perception that they believe, has the power to evoke unwanted pity and take away autonomy from the person who is disabled in a way that is de-humanising. As an alternative, they

promote a socially inclusive view which suggests that how society views disability can be more disabling than the disability itself!

In the autism community, a specific topic of discussion is around the terms that should be used to describe Autism Spectrum Disorders and the use of 'person-first language'. The idea behind person-centred language is that by using language that puts the person first, we promote the view of a person being more than a summation of their disorder or disability. This idea is not limited to the autism community or even to disability. For example, a child who is in the care of a local authority, rather than being referred to as a 'looked after child' would be a 'child looked after'. Not everyone agrees with the use of person-first language. Disability-first language aligns with those who view their own (or another's) diagnosis to be an integral part of their identity. Under the heading 'autism is not an appendage', the autism activist Jim Sinclair (1999, p.1) argues, 'there's no normal child hidden behind the autism… it is pervasive, it colours every experience, every sensation, perception, thought, emotion, and encounter, every aspect of existence… it is not possible to separate the autism from the person.' It has also been argued that person-first language may inadvertently accentuate stigma (Gernsbacher, 2017). It has been suggested that person-first language, rather than an equalizer, tends to be used more for those with disabilities than those without and is more often for children with disabilities than adults with disabilities. Further, the grammatical formation of person-first sentences which violate a common principle that a positive adjective would usually precede a noun, could in itself be discriminatory (Kenny et al., 2016). For example, it wouldn't be common to refer to a hard-working student as a student who is hardworking or a beautiful person as a person who has beauty!

There is also no consensus with regard to the terms we use to describe autism. Kenny et al. (2016) analysed the responses of 3470 members of the autistic community including the professionals who work within it, to an online survey designed to elicit responses concerning acceptable ways to describe this condition. The most preferred terms were 'autism', 'on the autism spectrum', and 'autism spectrum disorder'. For professionals 'person with autism' was a preferred choice, however, this did not align with the views of the autism community, who were likely

to choose the term ‘autistic’. Very few participants with autism would advocate the term ‘low functioning autism’ (just less than 10%) although there was far less objection to ‘high functioning autism’ (just over 35%). ‘Low functioning’ is a label used to classify individuals on the autism spectrum, who exhibit behaviours associated with intellectual disability. This can manifest as learning disability, language functioning deficits, and deficits in practical and social skills (Matson & Shoemaker, 2009). This label stands in contrast to that of ‘high functioning’, which is attributed to those with an ASD diagnosis who function cognitively, though not socially, at a ‘typical’ or even higher than ‘typically average’ level in terms of academic skills and language functioning (Eagle, Romanczyk & Lenzenweger, 2010; Fombonne, 2003; Langthorne & McGill, 2008; Munson et al. 2008).

There was little agreement within the community either with regards to whether autism should be referred to as a condition, a disorder, or a disability. While some participants with autism expressed the view that the term disability is disabling, others demonstrated concern that removing terms disorder and disability from discourse would only serve to underplay the problems and struggles faced by some people with autism and their families. Further still, it was acknowledged that such labels can be a necessary compromise to ensure adequate access to services. It should also be acknowledged that there are people with autism who don’t see their autism as a deficit at all, but as a gift (Jackson, 2002, p.19).

Whether we consider autism from an academic, professional, or personal standpoint, how we think and talk about this condition is a complex topic. There are implications for the autistic community which can be both positive or negative, and there is important debate around the issue of well-meaning practices which can prove to be inadvertently divisive.

### 1.1.3 Autism prevalence and co-occurring conditions

According to the most recent data (CDC, 2018), approximately 1 in 59 children is diagnosed with ASD. Boys are four times more likely to be diagnosed than girls, and ethnic and socioeconomic groups have not been shown to be an influencing factor in terms of prevalence. This could be viewed as a dramatic rise from 50 years ago when studies (e.g. Lotter 1966; Wing & Gould, 1979) found approximately 5 cases of autism in every 10,000 members of the general population. However, it is advisable to treat prevalence estimates with caution. There is no standardisation of autism survey methodology (Fombonne, 2018). Therefore, surveys employed in studies are likely to have unique design features that could be a reflection of the authorities that commission them, health, or educational services for example. Case definitions are also likely to vary (Fombonne, 2018; Williams et al., 2006), with some studies utilising electronic records of diagnosis, some relying on special education eligibility, questionnaires, in-clinic assessments, or even a combination of modalities.

This makes unclear estimates of prevalence and the possibility of prevalence escalation, possible explanations of which have also included over-diagnosing (Fombonne, 2018), increase in diagnostic services, increased awareness of health and educational practitioners, changes in diagnostic criteria (Williams et al., 2006), and changes in reporting practices (Hansen, Schendel & Parner, 2015). In a National Statistics Report, the US Department of Health and Human Services (Zablotsky, Black, Maenner, Schieve & Blumberg, 2014) noted that revised question ordering and a change in approach to asking about developmental disabilities (including autism) **affected** prevalence estimates for these conditions.

In addition to core areas of altered functioning for individuals with ASD, there are many co-morbid and secondary conditions (Reed, 2016, p.33). These are conditions that would not form part of any clinical assessment of the nature and severity of autism, but they are commonly exhibited by individuals with autism. Just a few conditions which commonly co-occur with autism are anxiety (Bellini, 2006; Bradley, Summers, Wood & Bryson, 2004; White & Roberson-Nay, 2009) depression (Bradley et al., 2004), attention deficit (Mayes, Calhoun, Mayes &

Molitoris, 2012) motor impairment (Ming, Brimacombe & Wagner, 2007), and epilepsy (Canitano, 2007; Tuchman 2017). It is estimated that between 65 and 85% of people with autism also have a learning disability (Matson & Shoemaker, 2009; Obrien & Pearson, 2004).

### 1.1.4 Social interaction and communication

**Table 1.1** DSM-5 Criteria for Autism Spectrum Disorder; social communication and interaction

| **Autism Spectrum Disorder 299.00 (F84.0)** |
|---|
| Diagnostic Criteria |

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history (examples are illustrative, not exhaustive, see text):

1. Deficits in social-emotional reciprocity, ranging for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions or affect; to failure to initiate or respond to social interaction.
2. Deficits in non-verbal communicative behaviours used for social interaction, ranging, for example, from poorly integrated verbal and non-verbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to total lack of facial expressions and non-verbal communication.
3. Deficits in developing, maintaining and understanding relationships, ranging for example, from difficulties adjusting behaviour to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers

C. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities, or may be masked by learnt strategies in later life)

D. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.

E. These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and Autism Spectrum Disorder frequently co-occur; to make comorbid diagnosis of Autism Spectrum Disorder and intellectual disability, social communication should be below that expected for general developmental level.

Table1.1 is the diagnostic criteria in DSM-5 which relates to social communication and interaction. Each feature, however, can manifest in very different ways in each individual. For example, a deficit in communication for someone diagnosed with autism could mean that they are predominately without speech, or they may speak by imitating (echoing) the speech of others. Another person may have fluent speech while lacking an understanding of inferential language or have an atypical approach to conversational rules. On a social level, one person may seem quite oblivious to others or appear unmotivated to engage in social interaction while another may have a desire for social interaction, but lack understanding of social rules typically involved when doing so (Fletcher-Watson & Happé, 2019, p.33).

Language delays and abnormalities are common in autism (Snowling & Hulme, 2007, p. 410). Even when speech is fluent, most children with autism have problems with the use of language, and most are considered to have pragmatic language impairments (Bishop & Norbury 2002; Snowling & Hulme, 2007, p.410). Pragmatic language impairments refer to difficulties experienced with the social or conversational use of language. Children with ASD may display atypical eye-contact behaviour (Senju & Johnson, 2009) have difficulty in the interpretation and use of nonverbal behaviours (Fletcher-Watson & Happé 2019, p.31) or understanding the mental states and intentions of others (Baron-Cohen, 1999). They may also struggle to understand their own emotions or interpret the emotions expressed by others, this can lead to the display of emotional responses which appear to be socially inappropriate or ill-matched to the scenario or setting of the interaction (Baron-Cohen 1988; Fletcher-Watson & Happé 2019). Individuals with autism may have difficulty with initiating or sustaining conversations, or lack the important social ability to tailor their style of communication to the needs of a communicative partner (Tager-Flusberg, Joseph & Folstein, 2001; Tager-Flusberg, Lord and Paul 1995; Wilkinson, 1998).

Language skills amongst the autistic population are highly variable (Kjelgaard & Tager-Flusberg, 2001) looked at language functioning of children between the ages of 4 and 14 with a diagnosis of autism. While some of those

children exhibited language skills in a range within typically developing norms, others demonstrated language skills that were significantly below age expectations. Some variation was accounted for by differences in IQ scores, however, there was a wide range of language abilities across the IQ spectrum, suggesting that language skills can be independent of IQ in children with ASD.

Hudry et al. (2010) considered the language abilities of pre-school children with autism, with a particular focus on the comparison of expressive and receptive language skills. When compared to standardised age norms, for this group of 152 participants, there was marked impairment in both receptive and expressive language. However, when receptive and expressive language scores were compared, the impairment was more pronounced in receptive language skills. Maljaars, Noens, Scholte and Van Bercelaer-Onnes, (2012) found a similar pattern when they compared the receptive and expressive language abilities of children with autism who were considered to be 'low functioning' to children who are typically developing, and to children with intellectual disability (ID) who did not have a diagnosis of ASD. This pattern was reversed for the two groups who did not have a diagnosis of ASD.

Boucher, Mayes, and Bigham, (2008) argue that in children with ASD, language impairment and ID are in fact derived from a pervasive impairment of declarative memory and Rapin and Dunn (2003) draw attention to auditory input abnormalities, providing a possible biological explanation of 'language disorder' in children with autism.

Language development in ASD, therefore, is extremely variable and there are likely to be subgroups of individuals within the autism spectrum that exhibit "distinct language profiles" (Tager-Flusberg, Paul & Lord, 2005, p.2). Communication issues can range from no speech at all to fluent speech when communication deficits may more likely be evident in the pragmatic use and understanding of language. Receptive language skills are also often delayed and/or deviant in children with autism. Language skills can be independent of IQ in children with ASD.

### 1.1.5 Restricted repetitive patterns of thought and behaviour

**Table 1.2**. DSM-5 Criteria for Autism Spectrum Disorder; restricted repetitive patterns of thought and behaviour

| **Autism Spectrum Disorder 299.00 (F84.0)** |
|---|
| Diagnostic Criteria |
| B. Restricted, repetitive patterns of behaviour, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive; see text): |
| 4. Stereotyped or repetitive motor movements, use of objects, or speech (e.g. simple motor stereotypes, lining up of toys or flipping objects, echolalia, idiosyncratic phrases). |
| 5. Insistence on sameness, inflexible adherence to routines, or ritualised patterns or verbal nonverbal behaviour (e.g. extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take the same route or eat food every day). |
| 6. Highly restricted, fixated interests that are abnormal in intensity or focus (e.g. strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interest). |
| 7. Hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment (e.g. apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement). |

Table 1.2 is the diagnostic criteria in DSM-5 relating to restrictive repetitive patterns of thought and behaviour. Again, each feature is likely to manifest in very different ways in an individual. Further, they cover a wide range of behaviours that are not unique to children with autism. For example, restrictive repetitive play behaviours such as lining up toys, hand flapping, and narrow interests are commonly displayed by two-year-olds (Honey, Leekam, Turner & McConachie, 2007). However, a clinician or educational practitioner observing similar behaviour in an 8-year old, may well suspect the presence of autism. That said, these behaviours vary

widely in complexity and function and so not every person with autism is compelled to line things up or carry out repeated actions on objects. For some, a narrowing of interests can mean an intense focus on a specific topic or specialized subject. In this way how restrictive repetitive patterns of thought and behaviour manifest, could be connected to patterns of ability. This idea links with 'weak central coherence' theory (Frith, 1989) which suggests an autistic cognitive style that limits the ability to 'see the bigger picture' due to an overt focus on attention to detail. This attention to detail paired with a desire for repetition can result in expert and highly specialized knowledge or skills for some members of the autistic community. However, attention to detail could also be considered a source of anxiety. For example, somebody without as much attention to detail is unlikely to get particularly stressed about minute changes in the environment as they are unlikely to notice them.

A further suggestion by way of explanation for restricted repetitive patterns of behaviour is linked to social deficits experienced by persons with autism. In this way, this kind of behaviour is viewed as a manifestation of anxiety, "a response to the experience of operating in a social world which is hard to comprehend" (Fletcher-Watson & Happé, 2019, p.74). There is some evidence to support this account as measures of anxiety have been shown to correlate with measures of restricted repetitive patterns of thought and behaviour which could be underlined by an "intolerance of uncertainty" (Wigham, Rodgers, South, McConachie & Freeston, 2015).

It's important to consider the opinions of the autistic community when defining interests as 'rigid' or 'restricted'. Luke Jackson, the (then) young author of *Freaks Geeks and Asperger's Syndrome* (2002, p.47) highlights this issue with his question-answer statement, 'When is an obsession not an obsession? When it's football.' This said, the debilitating nature of restricted repetitive patterns of thought and behaviour for some, need also be acknowledged. A need for sameness can be very distressing when things can't stay the same. Self-injurious behaviour also falls into the domain of restrictive repetitive patterns of thought and behaviour (Fletcher-Watson & Happé, 2019, p. 74).

### 1.1.6 Educational provision

There is ongoing debate concerning the rights driven approach (Reed & Osborne, 2014) of including children with SEN into mainstream settings as a first option, to avoid discrimination (Reed, 2016, p.261). Education options for children with autism in the UK are likely to fall into one of three categories (Aljuneid & Frederickson, 2011):

> Mainstream school and curriculum, with slight (if any) modifications made to the provision in the form of behavioural support, timetable modifications or modifications to the teaching approaches. Currently, approximately 72% of children with autism in the UK attend mainstream provision (O'Hagan, Bond & Hebron, 2021).
>
> Mainstream school with additional support. Additional support is likely to be in the form of 1:1 support from a teaching assistant at certain points in the day, reduced class size, or the use of specialized pedagogies to support progression in learning and behaviour.
>
> Special school or special education provision. Children with autism who attend special school are likely to be children who have also been diagnosed with moderate to severe learning disability which impacts on adaptive functioning. Special educational needs schools (also referred to as additional learning needs schools) provide an adapted curriculum that emphasizes communication needs, as well as functional and vocational skills.

All local-authority-maintained schools in England and Wales have educational objectives that are aligned to the national curriculum (Department for Education, 2015; Welsh Government, 2019). Therefore, a child with autism in the UK is most likely to attend a mainstream school, unless autism is accompanied by moderate or severe learning disability which impacts on adaptive functioning.

### 1.2 Children with Autism who are Non-verbal

The ASD population is made up of approximately 25 – 30% of children, who are considered to be non-verbal, due to a lack of spontaneous speech (Autism Speaks, n.d.; Derweedt, 2013; Plesa Skwerer, Brukilacchio & Tager-Flusberg, 2016). Children with autism who are classified as non-verbal are likely to have a very small repertoire of words, which will vary in number from child to child, but is likely to be around twenty to thirty words or less (Kasari, Brady, Lord & Tager-Flusberg, 2013). Any phrases the child or young person does produce will be limited to specific contexts, related to very particular needs, or are an imitation of something he/she has overheard. This kind of "repetition of words and phrases" is defined as echolalia (Bondy & Frost, 2001, p.20). There does appear to be some agreement that a general description of non-verbal or minimally verbal, would be that of a child with little or no spontaneously spoken language when they reach school age (Plesa Skwerer et. al., 2015; Tager-Flusberg & Kasari, 2013). It is currently estimated that around 25 - 30% of the ASD population fits this description (Derweedt, 2013; Plesa Skwerer et.al. 2016). Although some children are preverbal and may well go on to develop language abilities (Anderson et. al., 2007) others, despite intervention, will continue to be non-verbal (Rose, Trembath, Keen & Paynter, 2016), possibly for the duration of their school career and beyond.

The reasons why some children with autism develop speech, some after significant speech delay, and others continue to be non-verbal into adulthood, remain unclear (Bondy & Frost, 2001; Distefano et al., 2016; Kasari, Brady, Lord & Tager-Flusberg, 2013; Tager-Flusberg & Kasari, 2013). The explanation for a child who has autism being non-verbal can also differ between children. This, and the level of diversity in speech fluency presentation, are no doubt the main contributing factors for this lack of clarity. Some causational factors for speech deficit, however, have been identified, and these have included biological issues present at conception or occurring during gestation (Bondy & Frost, 2011, p 21). Apraxia of speech, which is an issue with fine oral motor movement (Buekelman & Mirenda 1998) can also be an issue for speech development. Generally, however, as a group, children with ASD do not usually display any distinct problems with structural aspects of speech

production (tongue, lips, palate, etc.) or motor aspects of speech production i.e. fine oral motor movement (Bondy & Frost, 2011, p.21). This said, there is evidence that the ability of pre-school children to make fine oral-motor movements offers some prediction of later speech fluency for children with autism, as it does for typically developing children (Amato & Slavin 1998, cited by Gernsbacher 2008).

Gernsbacher and colleagues (2008), for example, investigated the oral and manual motor skills of toddlers to predict speech fluency in later life (teenage). One possible cautionary factor when interpreting the results of this study relates to the age of the participants. Although the research focus for the study was 'infant and toddler motor skills', the youngest age of participants in the study was 7 years 11 months. The information about motor development was therefore reliant on the recall of caregivers who provided interviews. Two measures were taken by the researchers to counteract this problem. Firstly, to prompt recall, a 'landmark-based interview technique' (Loftus & Marburger, 1983) was employed. This technique is used to prompt detailed memory through a focus on salient life events during the interview. Further, in a follow -up study, the researchers verified information provided during caregivers interviews with the use of home video footage of participants of the time discussed during interviews. However, there is still some possibility that the caregivers' knowledge of the child's diagnosis could have coloured their recall.

Results from the study demonstrated a distinction between the oral motor and manual motor skills of toddlers of children with autism and those who were typically developing. These early skills were said to correlate with later speech fluency. Further studies have identified connections between manual motor, oral motor, and speech and language development (LeBarton & Iverson, 2013; Belmonte et al., 2013).

In a study carried out by Wodka, Mathy, and Kalb (2013) involving 535 children with autism. 70% of the children involved in the study were said to achieve phrase speech after the age of 4 and 47% achieved fluent speech. Researchers cited cognitive and social factors, that is, nonverbal IQ (as tested using a range of

intelligence quota measures) and levels of social engagement, as the main predictors of speech acquisition for this cohort.

Selective mutism (SM) is an anxiety disorder, "characterized by a consistent failure to speak in specific social situations in which there is an expectation of speaking" (American Psychological Association, 1994; 2013, cited by Steffenburg, Steffenburg, Gillberg & Billstedt, 2017). Literature suggests that SM is a co-morbid feature of autism for some children with ASD (Steffenburg et al., 2017). However, systematic clinical trials for this are limited in number, and prevalence rates are unclear (Gillberg & Billstedt, 2000). It is beyond the scope of this chapter to carry out an in-depth analysis of the broad and complex nature of selective mutism. Suffice to say, that should SM be the underlying explanation for why a child with autism is minimally verbal, ramifications for this for learning and reading would be different than for the child whose lack of fluent speech can be explained by an oral motor issue and different again if there is a biological or neurological condition.

A study by Port et al. (2015) used information from Magnetoencephalography (MEG), which is a functional neuroimaging technique for mapping brain activity by recording magnetic fields produced by electrical currents that occur naturally in the brain. From this information, they showed differences in cortex activation between children who were preverbal and those who were non-verbal. This suggests the possibility of preverbal and non-verbal as sub-groups of children with autism who are non-verbal.

Not enough is currently known for this kind of sub-grouping to be included in any current formal classification. However, it is important to note that many children who begin formal education as non-verbal or minimally verbal do go on to develop speech (Wodka et al., 2013). Distefano and Kasari (2016), posit that the pre-linguistic skills of joint attention, basic gestures and vocalization may distinguish children who have the potential to become verbal from children who they define as 'minimally verbal' i.e. in that they have "levelled off or greatly slowed in terms of their expressive language development". According to a review (Wodka et al., 2013) in which the assessment records of 535 children with autism who did not have

flexible phrase speech by the age of 4 were analysed, 70% of children attained phrase or fluent speech by the age of 8. Phrase speech, as a common milestone of speech development, is defined as "using non-echoed three-word utterances that sometimes involve a verb and are spontaneous meaningful word combinations". Fluent speech is the "ability to use complex utterances to talk about topics outside of the immediate physical context" (Kennedy Krieger Institute, 2012; sciencedaily.com).

In response to the issues of defining common terminology for describing levels of spoken language ability, Tager-Flusberg et al. (2013) suggest a framework for describing spoken language acquisition in ASD which has five stages. These stages are preverbal communication, first words, word combinations, sentences, and complex language. This may resolve some issues in terms of how we can describe children who are non-verbal in a more informative way than preverbal, non-verbal/minimally verbal, or verbal. However, how language develops in children who are typically developing forms the basis for this framework. For example, children in the phase of preverbal communication would "communicate using preverbal intentional communication through vocal (babble) and gestural means…". The complex nature of spoken language development for children with autism can mean that even when a child with autism acquires some form of spoken language, this acquisition is not likely to develop smoothly or linearly (Bondy & Frost, 2001, p.20). This aspect of speech development in children with ASD could be problematic when attempting to apply any developmental frameworks that are rooted in typical development.

While some children who are non-verbal or minimally verbal will fit into the generalised description cited in the opening of this section in that they demonstrate a repertoire of twenty to thirty words or less, children who present with echolalic speech patterns can also be classified as non-verbal. Echolalia has been characterised in two forms, immediate echolalia and delayed echolalia Immediate echolalia involves the repetition of words that have just been spoken by another, whereas delayed echolalia is the utterance of words that have been heard some time in the past (Charlop, 1983; Prizant & Rydell, 1984). Strictly speaking, for

intervention and education purposes, children whose speech can be categorised as echolalic are considered non-verbal. This is largely due to the notion that echolalia is a non-functional form of speech (Prizant & Duchan, 1981). However, this is a controversial area as other researchers believe that, for some children with autism, echolalia serves a functional purpose; in that, it is indicative of an intent to socially interact (Prizant & Rydell, 1984). There is also a belief that children with echolalic speech patterns show potential for the use of spoken words with communicative intent when appropriate intervention is employed (Fox et al., 2004).

As we have seen, there is no clear definition for the term non-verbal, a term often used interchangeably with preverbal and minimally verbal and there continues to be no clear definition for any of these terms. There being no agreed definition will have consequences for what we can know about prevalence and is also a problem when comparing research findings. For example, in their study relating to first-word acquisition, Koegel, Shirotova, and Koegel (2009) used participant criteria of "no functional words or object label correspondence". However, Goods, Ishiiima, Chang, and Kasari (2013), used the criteria of "less than 10 spontaneous functional and communicative words", in a study relating to intervention for children with autism who are minimally verbal. Further examples are Paul, Campbell, Gillbert and Tsiouri (2013), "spontaneously expressive vocabulary of fewer than 15 words", Muchetti (2013), "spontaneous vocabulary of 20 or fewer words", and Kasari, Brady, Lord & Tager-Flusberg (2013) who used the criteria of "less than 20 words used during a 20-minute naturalistic interaction". Tager-Flusberg and Kasari (2013), cite other studies with a variety of definitions employed also.

For the research carried out as part of the current thesis, we use the above definition attributed to Plesa Skwerer (2015) as a general guide. That is, a child with little or no spontaneously spoken language when they reach school age (Plesa Skwerer et. al., 2015. As we have seen from a review of the literature, it would not be currently possible to know the underlying reasons for why the children who participated in our study were non-verbal. However, an important aspect when grouping participants was the information provided by the schools. This is because school-definition will impact on education provision, especially when teachers plan

reading instruction. The kinds of assessment employed to test reading ability is also usually a school-based decision (WG, 2019; DfE, 2013).

Terms in the literature that have not been helpful to describe the cognitive styles of children with autism who are verbal and non-verbal are 'high functioning' and 'low functioning'. These are not official diagnostic criteria but terms which Prizant (2012) describe as 'pseudo-diagnostic categories. There is much literature relating to children with autism that uses the terms 'high' and 'low functioning' to describe either cognitive ability, verbal-linguistic skills, or a mixture of both (Prizant, 2012). This kind of classification is inaccurate on many levels. Firstly, even within the domains of cognition of language, there is a continuum of abilities demonstrated which cannot be dichotomized. Secondly, children with autism often display an 'uneven profile' with verbal and cognitive skills that do not correlate (Prizant, 2012). Further, and possibly more damaging, is that the application of these 'pseudo-diagnostic categories' to both cognitive and verbal-linguistic skills in children with autism has led to these terms being used as descriptions of autism and worse, children themselves. To demonstrate, the researcher typed the words 'high functioning', 'autism', and 'reading' together into Google Scholar search engine (scholar.google.uk). Of the first ten results displayed, titles of peer-reviewed research published as recently as 2017 (McIntyre et al., 2017) were displayed. Four of the titles contained the term 'high functioning autism' and four titles used the terms 'high functioning students/children/adolescents'. When the word 'high' was replaced with 'low' two titles displayed the term 'low functioning autism' (Chakrabarti, 2017; Simpson & Bui, 2016), one used the term ' verbal low functioning' (Maljaars et al., 2011) and three used the term 'high functioning autism' (Baron-Cohen et al., 2001; Goldstein et al., 2001; O'Connor & Klein, 2004).

Children who are on the autistic spectrum who are also non-verbal are often associated with the term 'low functioning' (Gernsbacher et al., 2008) or assumed to have a low IQ (Tager-Flusberg & Kasari 2013). However, even if the label were helpful, we don't know enough about the abilities of children who are non-verbal to attribute them as 'high' or 'low functioning'. There is evidence of variability in measures of the nonverbal intelligence of children with autism who are non-verbal

(Munson et al., 2008) and there is a likelihood that this cohort will be disadvantaged on any speech-based measures of intelligence (Gernsbacher, et al., 2008). As was demonstrated by the Google scholar search, labels tend to become attached not just to the condition but to the person themself. To label a child with autism who is non-verbal as a 'low functioning child' only serves to lower the expectations and aspirations we have for these children. The terms high functioning and 'low functioning' are not only a false dichotomy, therefore, but potentially very harmful.

## 1.3 Reading

### 1.3.1 Reading theories

Reading is a complex set of skills, which when they interact, enable us to translate symbols into words from which we derive meaning (Perfetti, Landi & Oakhill, 2005). To be considered effective readers, children need to be able to decode words and understand their meaning in isolation and context (Huemer & Mann, 2010). There is no single model of reading. Most models are concerned with particular elements (perceptual or cognitive), phases (beginning or competent), or modes of reading (oral or silent) (Susanto, 2020).

The role of the reader will differ, depending on the theory. 'Bottom-Up' processes describe the behaviourist view of reading, which focuses on the reader as a passive recipient of information. Reading is a linear process, whereby readers decode a text word by word, linking words into phrases and then sentences (Samuels & Kamil, 1988, cited by Pardede, 2010). Teaching reading through phonics i.e. an emphasis on sounds that make up words, is an example of a bottom-up approach to reading. Top-down, cognitive views of reading and interactive views, propose a much more active role for the reader. Reading is not just about extracting meaning from written text, but a process of connecting information in the text with the knowledge the reader brings (Pardede, 2010). The reader's engagement with the text

is crucial to this process. Closely related to this is schema theory, which is an interactive model of reading (Susanto, 2020). Schema theorists differentiate formal schemata (knowledge about the structure of a text) from content schemata (knowledge about the subject matter of a text) (Pardede, 2010). Prior knowledge of both schemata enables us to form mental connections between this knowledge and the information we read. Anderson and Pearson (1984) describe this as finding a "mental home" for the information in the text. This implies that without the necessary schemata to be activated by the text we are reading, our understanding of what we read is, at best, limited. Pre-reading activities that involve learning new vocabulary across a range of situations and contexts is one example of a teaching method derived from this theory.

When we talk about reading then, we can see that reading is not just about words on a page, but describes a whole range of processes that must take place so that small units of sound are transformed into information that needs to be interpreted and understood. The ultimate goal of reading, therefore, is to extract meaning, this is referred to as reading comprehension. Reading comprehension can be broken down into two necessary components, decoding and linguistic comprehension ((Parliamentary Office of Science and Technology, 2009). The idea that reading comprehension is the joint product of printed word identification and listening comprehension was first asserted by Gough and Tumner (1986) as the simple view of reading. This framework has been used to explain individual differences in reading in children with and without developmental disorders (Bishop & Snowling, 2004; Catts, Adlof & Weisner, 2006). Lervag, Hulme, and Melby-Lervag's longitudinal study (2018) offered support for the simple view of reading because, in their study, listening comprehension and decoding together with their interaction explained almost all variance in reading comprehension.

With regards to the interaction between word decoding and listening comprehension, Lervag, Hulme, and Lervag (2018) suggest that without adequate decoding skills, oral language skills and listening comprehension cannot sufficiently be engaged to achieve reading comprehension. Therefore, for good decoders, listening comprehension becomes more predictive of how well they will understand

written text. For poor decoders, the improvement of decoding skills will lead to a better understanding of text. In their meta-analysis of the relationship between decoding and reading comprehension, Garcia & Cain (2014) found a strong concurrent relationship between decoding and reading comprehension which became weaker in older age groups, when the correlation between listening comprehension and reading becomes stronger.

There is long-standing debate with regards to how children should be taught to decode, however, elements of reading instruction for decoding are phonological awareness and phonics. Phonemic awareness (a subset of phonological awareness) is the ability to recognise and manipulate phonemes. Phonemes are the smallest units of sounds that make up a language. Phonemes combine to make syllables and words (Whalon, Otaiba & Delano, 2009). Phonics relate to the ability to understand the letter-sound relationships in reading and spelling which assists with the decoding of text (Whalon et al., 2009). Other elements of reading instruction are vocabulary which is about knowing the meaning of words and fluency, the ability to read accurately with sufficient speed (Chard, Vaughan & Tyler, 2002). Approaches to comprehension are varied and multi-level and include teaching at word level i.e. vocabulary, sentence-level (grammar, punctuation, syntax, etc.) and text or passage level (engaging with and extracting meaning from passages of text) (Point, 2004).

### 1.3.2. Reading theories and speech

Despite some early claims of a correlation between reading ability and speech production (Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967; Barsch & Rudell, 1962), current theories of reading do not feature a direct role for speech. However, research has sought to consider the impact of speech impairment on some aspects of reading with regards to the barriers to learning which may exist for children whose speech is impaired. Aspects of particular interest for the study of children with speech and language impairments include articulation, internal speech, letter knowledge, phonological processing, linguistic ability, working memory, and general cognitive ability (Ferreira, Rőnnberg, Gustafson, Wengelin (2007).

Ferreira, Rőnnberg, Gustafson, Wengelin (2007) considered these aspects of reading in their study of children with congenital impairment of speech and motor function. To explore the cognitive and linguistic skills for this group of children, a battery of reading-related tests was employed which focused on word reading, sentence reading, letter knowledge, phonological awareness, and phonological auditory discretion. Where speech was identified as a factor, this was particular to sound rehearsal and reading aloud. Auditory discrimination i.e. phonological awareness was the main predictor of reading difficulties and while participants who struggled with speech articulation found speech errors disruptive when reading, some of these participants were able to read well despite severe problems with articulation. When Carol and Snowling (2004) examined the reading abilities of children who had delayed speech but average language development, the link identified between speech impairment and reading difficulties was in the area of phonological awareness and processing.

Catts (1993) measured the prerequisite reading abilities and performance on standardised reading tests of three groups of children: those with receptive language impairment (some of which also had issues around articulation), some with expressive language impairment, and a group of children with articulation problems who did not demonstrate any language problems. Receptive language is our ability to understand spoken language, whereas expressive language is the use of words, sentences, gestures, etc. to convey meaning. Group comparisons related to phonological awareness, rapid automized naming (vocabulary), word recognition, and performance on standardised reading tests. From results, Catts concluded that articulation ability alone was unrelated to reading achievement. In fact, the children in the study whose primary issues were with articulation, demonstrated reading ages with expected developmental norms on the word identification and word attack subtests from the Woodcock Reading Master Tests – Revised (Woodcock, 1987) and the Gray Oral Reading Test – Revised (GORT – R; Weiderholt & Bryant, 1986). These results lend support from the results of Bishop and Adams (1990) who also failed to find a relationship between articulation and reading impairment. Both studies did, however, find a relationship between reading difficulties and impaired language development.

What these studies demonstrate, is that while impaired speech may be disruptive to the process, issues with articulation do not rule out the development of skills involved in decoding or listening comprehension for children whose speech is impaired. For children with autism who are non-verbal, however, we don't know the underlying reason why they are non-verbal. This makes it all the more difficult to predict which aspects of reading, if any, are likely to offer the most challenges for this cohort. For example, fine oral motor manipulation issues may produce, not insurmountable, barriers for phonological awareness. However, if the underlying issue relates to cognition, then difficulties with all aspects of reading may be a fair assumption. The more we know about the abilities of children with autism who are non-verbal, the more enlightened we can become about the reasons why some children with autism are non-verbal and others have fluent speech. As a result, interventions will be more informed and, therefore, targeted.

There is some evidence in support of the benefits of targeted literacy interventions for children with autism who are non-verbal. Goh et al. (2013) provided targeted intervention for a group of 18 children with autism who were minimally verbal. They focused on reading-related skills which included functional non-content words (e.g. the, she, who, was etc.), visual sequencing (helps us to know dog is a word while gdo is not), as well as the ability to answer questions (in writing) relating to past-tense scenarios, and express ideas relating to scenarios beyond the immediate present. They concluded that "the acquisition of reading and writing skills may be possible even in some of the most severely affected children with ASD even in the absence of functional speech". Serret at al. (2017) also noted promising results following specific and targeted literacy intervention, as minimally verbal participants in their study, were able to acquire literacy skills, and transfer the learning to novel literacy materials.

However, the current situation is that we have very little information concerning this population and there is a tendency for children who are non-verbal to be excluded from much reading-related research**.** When Nally et al., (2018) carried out their analysis of reading abilities for children with autism, the children who participated in the study; ages ranging from approximately three to seventeen, were

described as “a nationally representative sample of 110 children with ASD”. However, explicit in the participant recruitment criteria, was a requirement to be able to “vocally echo a minimum of two words”. The authors reasoned that this was to ensure that “reading skills were detectable”. Fourteen prospective participants were excluded from the study, as they could not meet the criteria. When we consider that 30% of children with autism are likely to be non-verbal, it is difficult to uphold the researchers’ claim of a “nationally representative sample of 110 children with ASD”.

Looking specifically at the relationship between word recognition ability and phonemic awareness, Smith Gabig (2010) found that for children with autism, phonemic awareness does not appear to be related to word reading ability. In this study, to compare reading performance, children with autism were matched to their peers of a similar age who are typically developing. To take part in the study, participants needed to have “functional verbal ability at the phrase or sentence level”. This was defined by the researcher as “the intentional use of language beyond single word requesting, commenting, or greeting”.

These studies are not cited with an intention to be over critical of their methods, but as a way to highlight a seemingly obvious, yet unaddressed issue, in that currently, there appears to be no means of detecting the reading abilities of children with autism who are non-verbal. Nation et al. (2006) explored ‘patterns of reading ability in children with autism’. Their recruitment criteria specified “language skills sufficient enough to allow them to participate in our study”. The instruction provided to clinicians during the recruitment process was to “refer children they considered to have measurable language skills, however minimal”. While the criteria refer to language skills and not verbal ability, the three measures of reading employed in the study, all had a requirement to ‘read aloud’ for levels of reading accuracy to be determined. A natural assumption here then would be, that children with ASD who are non-verbal, would be excluded from taking part in the study. Where a requirement for a certain level of verbal ability, therefore, is not explicit in the criteria, it does tend to be implicit in the tests used to measure reading accuracy (Ricketts, et.al., 2013; Zuccarello et.al., 2015). There are two possible explanations for this, and either or both could ring true. Either, researchers are

excluding children with autism who are non-verbal form their samples because they underestimate their potential for reading. Or, they have simply not developed suitable methods of assessments which can accommodate individuals who are unable to vocalize.

Tager Flusberg et al. (2017) discuss several considerations for conducting research with participants with ASD who are non-verbal, which they describe as an "extremely difficult enterprise". Challenging behaviours exhibited by participants, for example, will often lead to a lack of compliance, which may demand some serious thought around ethical considerations relating to consent. However, there are also several points of discussion relating to methodology and considerations that can be made by researchers concerning suitable adjustments being made to the environment and procedure to be more inclusive for participants who are non-verbal. Tager-Flusberg et al. (2017) call attention to "a pressing need to extend autism research beyond the more accessible verbally fluent individuals". However, there is an added complication for researchers interested in reading patterns as standardised reading tests come with a requirement to be able to read words aloud. This is clearly a barrier for those children who are unable to articulate.

Of further interest would then be, if we were able to detect skills associated with reading in children with autism who are non-verbal, would their patterns of reading ability align with patterns of reading ability for children with autism who are verbal?

## 1.4 Reading and Children with ASD

Three highly influential theories have been used to explain the cognitive processing style often seen in children with autism. As we have already seen from the diagnostic criteria, ASD is a complex disorder and so these three theories alone cannot provide a full explanation for all facets of ASD. However, they do provide a useful lens through which to view the cognitive profiles of children with ASD, and as such, have been used to explain the specific and unique difficulties children with

autism may experience when learning skills, including reading (Carnahan, Williamson & Christman, 2011; El Zein, Solis, Vaughn, McCulley, 2013; Nguyen, Leytham, Schaefer Whitby, & Gelfer, 2015). These theories are weak central coherence theory (Frith, 1987), the Theory of Mind (ToM) hypothesis (Baron-Cohen, 1995), and Executive Dysfunction Theory (Pennington, 1997).

Loosely described, weak central coherence theory describes an inability to derive overall meaning from details, or an inability to see the 'bigger picture'. This can lead to difficulties with understanding main ideas or explaining salient points (Happe, 2005; Williamson et al., 2009). Theory of Mind hypothesizes that a ToM deficit, or 'mindblindness', creates an inability to interpret events by taking account of the mental states, desires, and beliefs of others (Baron-Cohen, 1995; Frith, 1987). Executive functions are a set of cognitive processes that incorporate interrelated processes responsible for purposeful, goal-directed behaviour (Anderson, 2002). Executive Dysfunction Theory proposes that, amongst other things, executive dysfunction will impact on self-awareness, flexibility, and planning and organization skills (Attwood, 2007). Collectively, these three theories have been related to some of the difficulties experienced by students with ASD in organizing, connecting, and monitoring the content of text to derive appropriate meaning from it, as well as issues with making use of prior knowledge, or understanding of social situations through which to interpret it (El Zein, Solis, Vaughn, McCulley, 2013). Poor oral language skills (Bishop & Snowling, 2004; Catts & Kamhi, 2005) and social understanding (Ricketts, Jones & Happé, 2013) in this population show them to be at high risk of experiencing reading difficulties.

### 1.4.1. Oral language skills and listening comprehension

Ricketts, Jones & Happé (2013) considered the reading comprehension skills of a group of adolescents with an autism diagnosis, viewed through the lens of the 'Simple View of Reading', with the additional consideration of the role social functioning. In an investigation of the predictive factors of reading comprehension ability, they posited that the simple view of reading holds true for readers who have a diagnosis of ASD, in that variations in reading comprehension could be explained by

oral language and word recognition skills. However, they also stated that, once these factors were accounted for, social impairment remained a significant contributing factor in predicting reading comprehension for this population. Therefore, they concluded that for children with autism, word recognition, oral language, and social impairment can constrain reading.

In discussing the results of the study, the authors note, "Consistent with the Simple View of Reading, we found that both word recognition and oral language comprehension were unique predictors of reading comprehension. In addition, we demonstrated that the social impairments in ASD… were significant predictors of reading comprehension". Taking account of top-down and interactive models of reading, however, and the influence of the knowledge that the reader brings to reading (Pardede, 2010), it could be that social deficit or lack of social schema from which to draw on, might impact on reading comprehension for any reader, with of course children with ASD being a very high- risk group. Further, it could be argued that social understanding, rather than 'in addition to' word recognition and oral language comprehension, does, in fact, inform listening comprehension. While it is generally agreed that the Simple View of Reading offers a sound explanation of the reading process, the nature of the language skills that provide the foundation for listening comprehension requires further study (Lervag et al., 2018). Due to the nature of language and social deficit associated with a diagnosis, studying the reading patterns of children with autism could provide valuable insight into this matter.

Asberg Johnels, Carlson, Norbury, Gillberg, and Miniscalco (2019) took a longitudinal approach to the investigation of reading profiles and predictors of reading ability in children with ASD. Around the age of 3, children were assessed on a range of measures of language ability, cognitive level, adaptive functioning, and autism diagnostic tools by a multidisciplinary team at the neuropsychiatry clinic from which they were recruited. The second wave of the study was a school-age follow up. Participants with a mean age of 8 (6.6 – 9.8) were assessed in reading, language, and cognition. Half of the sample was deemed to be 'poor readers', in that their scores were below average in the areas of word recognition and reading

comprehension. This was the group that had demonstrated more 'autistic behaviours' during initial neurodevelopmental screening before the age of 3. A further two subgroups were also identified in this population. Approximately 34% of the overall population of participants were pronounced to be skilled readers i.e. participants who demonstrated abilities in word recognition/decoding and reading comprehension in line with age-related norms. However, approximately 19% were readers who demonstrated appropriate word recognition abilities, but poor reading comprehension skills. When these results were considered in line with neurodevelopmental screening which had been carried out prior to the age of 3, there was no difference identified in ASD severity or social skills. Contrary to the results from Ricketts et al., (2013) for the sample, poor language skills were the only factor identified as a predictor of poor reading comprehension.

There were, however, some differences between the two studies in terms of methodology. Research carried out by Ricketts et al. (2013) was focused on adolescents, whereas Asperg Johnels et al., (2019) concentrated on children at two points in time. The first wave of assessments occurred around the age of 3 and participants in the follow- up tests were no older than 9 years 8 months. Therefore, participants in the studies were at different stages of development. As we know the developmental pathways for children with autism are not smooth (Bondy & Frost, 2001,p. 21) and it can be difficult to know the impact of age on linguistic, cognitive, and social profiles for this cohort. We also know that in children who are typically developing, the cognitive demands on processes which support listening comprehension and reading comprehension change over the course of development (Lervag et al., 2018). Further, while we don't have enough information on the backgrounds of the participants in either study to testify to the depth of the cognitive linguistic or social experiences, we can say that in the older group, there would likely have been more of them!

There were also numerous differences in the assessments used for reading-related skills. For example, the measure of oral language comprehension in Asperg Johnels' study was the Reynell Developmental Language Scales – III (RDLS; Edvards, Fletcher, Garman, Hughes & Letts, 1997), whereas Ricketts et al. made use

of ‘Strange Stories’ tasks, developed by Happé, (1994) and the ‘Do Triangles Play Tricks?’ developed by Abell, Happé and Frith (2000), which is a task in which the participant is encouraged to attribute mental states to animated shapes. The Happé Strange Stories Test (Happé, 1994) was designed specifically to test understanding of mental states or ToM (Joliffee & Baron-Cohen, 1999) and assesses inferential skills, and motivational mental states such as those involved in pretence, persuasion, and lies. The RDLS is a test that is based on typically developing norms. Language comprehension measures include some single-word comprehension, such as understanding of nouns prepositions and verbs, as well as measures of early inference skills (Simons, 2013). However, most items assess the comprehension of sentences that include abstract concepts of increasingly complex grammatical structures, as well as the ability to follow simple and complex instructions (Kjellmer et al., 2012). Therefore, the level and nature of understanding required to complete the tasks were likely to be different between these two studies and it is possible that participants were drawing on different cognitive processes in order to complete them.

Reading and language comprehension assessments often vary across studies. It can, therefore, be difficult to ascertain where the cognitive demand lies and which, if any, deficits may confound our interpretation of the results. As has already been established, children with autism have distinct cognitive profiles, and this could mean that we need to exercise caution when interpreting results from norm-referenced tests. For example, the inability to follow a simple instruction may involve listening comprehension skills which in turn impacts reading comprehension but is also likely to place some demand on working memory (Just & Carpenter, 1992) and executive function. Correlations with executive dysfunction and reading comprehension issues have been identified (Locascio, Mahone, Eason & Cutting, 2010). In a study which made use of the RDLS assessment tool to assess the language comprehension abilities of children with ASD who did not have intellectual disability, Kjellmer et al. (2012) found that for this cohort, there was little correlation between verbal IQ and language comprehension and even less between nonverbal IQ and language comprehension. The researchers involved in this study posit that undetected SLI (specific language impairment) may be a further confounding

variable for this population and suggest that our understanding of the cognitive functioning needs to be informed by the inclusion of detailed linguistic assessments. Tager-Flusberg (2006) also emphasised the possible impact of the presence of language impairment as they found similarities in phonological processing deficits in children in their study categorised as having language impairment cooccurring with autism.

Participant recruitment was also a differentiating factor between the two studies under discussion. Ricketts et al. (2013) based on their recruitment strategy on the diagnosis of autism in line with DSM-V criteria. However, Asperg Johnels et al. (2019) focused on autism symptomology as measured by two diagnostic tools: The Autism Diagnostic Observation Schedule (ADOS; Lord, et al., 2000) and the Autism Spectrum Screening Questionnaire (ASSQ; Ehlers, Gillberg & Wing, 1999) which uses parent ratings. As a result, 5 participants in the study did not meet DSM-V criteria for autism by the second wave of assessments but were still included in the study. Even when the same diagnostic criteria is used for recruitment, high variability in the individual characteristics of children with autism can make it very difficult to generalise results.

Nation, Clarke, Wright, and Williams (2006) found wide variation when they looked at patterns of reading ability for children with ASD, however, they also identified a link between poor reading comprehension and poor oral language skills. Further, of the 20 readers who achieved word reading levels within or above age-related norms, half demonstrated poor reading comprehension skills. While the wide variation in reading patterns within the autistic community make it difficult for us to be able to predict the reading style of a child with autism, what we can say, is that links identified between reading and language put children with autism, who are likely to have some form of language deficit, at high risk of reading difficulties. We also know that while some children with autism can have word identification and reading comprehension skills which are well aligned, word reading ability does not guarantee effective reading comprehension skills for many of this population.

### 1.4.2 Hyperlexia

A profile of good or even precocious word recognition ability, accompanied by poor reading comprehension skills is commonly associated with ASD (O'Connor & Klein, 2004). In the literature, this is usually referred to as a 'hyperlexic reading style' or 'hyperlexia'. A term first introduced by Silberberg and Silberberg (1968), hyperlexia refers to word reading ability which is at a much higher level than an individual's general cognitive functioning. Some distinctions have been made between hyperlexia, as in precocity and preoccupation with word reading that goes unsupported by comprehension (Healy, Aram, Horwitz & Kessler, 1982) and a 'hyperlexic reading style', which refers to a paradoxical combination of good word identification with poor comprehension. Although children with ASD demonstrate considerable variation in strengths and areas of difficulty in reading ability (Nation et al, 2006), associations have been made between both hyperlexia or a 'hyperlexic reading style' and ASD (Nation et al., 2006; O'Connor & Klein, 2004; Zuccarello et al., 2015).

A case study by Atkin and Lorch (2006) offers an individual example of how a child with autism and hyperlexia may present. Named Paul for the purpose of the study, the participant was a four-year-old boy with a diagnosis of autism. It is of note, that with a mental age of around one and half years, severely restricted social skills, and no spontaneous speech, Paul would likely be classified as being at the 'low functioning' end of the autism spectrum. Although Paul had no spontaneous speech, he showed an early interest in printed text (newspapers for example) and would verbalise some words that he recognised. This reading behaviour was interpreted as indicating that, rather than the mechanical decoding of print, some level of linguistic processing of text was taking place. Due to Paul's limited speech, his comprehension was difficult to determine, but taking into account his mental age it was assumed that his reading ability would likely be in excess of his reading comprehension ability. Procedures used in the study are not always clear. A range of methods were used to gauge Paul's reading skills. Some relied on verbalisation, and so it could be argued that measures used might be an under-estimation of Paul's reading ability, for example, verbal identification of single words and pseudo-words.

Other methods were nonverbal i.e. matching pictures and photographs to written sentences.

Hyperlexia tends to be associated with children on the autistic spectrum who are 'high functioning' (O'Connor and Klein, 2004) and so one argument that has been made (Newman, Macomber, Naples, Babitz, Volkmar & Grigorenko, 2007) is that hyperlexia may not be a distinct phenomenon at all, but a reading style of 'high functioning' individuals with autism. Paul's case cited above, makes some interesting points for the reader to consider, as being a four-year-old with a mental age of 18 months, Paul would not likely be considered 'high functioning'. Further, Paul fit the definition of non-verbal in that he had a limited repertoire of words and did not use speech spontaneously.

### 1.4.3 Emergent literacy

Differences in academic styles between children who are typically developing and children with ASD are not just apparent in reading performance, but also prior to the formal reading stage, in the period that has come to be defined as 'emergent literacy' (Sulzby & Teale, 1991). Emergent literacy is the term used to refer to the skills, knowledge, and attitudes that serve as developmental prerequisites to reading and writing (Whitehurst & Lonigan, 1998). Oral language skills may be one such prerequisite, other skills can include but are not limited to, print-concept knowledge (knowledge of what books, printed text, and written language are, and how they function to convey meaning), alphabetic knowledge and phonological awareness (Westerveld, et al., 2017).

Although there is an awareness that some children with ASD are at high risk of never developing the ability to read (Vacca, 2017) research into emergent literacy skills for this population is limited. Westerveld, et al., (2017) investigated the early reading skills of children with autism through a meta-analysis of the results of studies with English speaking children between the ages of 3 and 8, who had a diagnosis of ASD and had not commenced formal reading instruction. Added to this

inclusion criteria was the requirement that the study should include at least one task relating to emergent literacy skills in the procedure.

The authors carried out their search in January 2014 and just three studies were identified, representing a total of 170 children with ASD. Results of their analysis indicated that print-concept knowledge was an area of difficulty for children with ASD, which could not be explained by oral difficulties alone. Also, while children with ASD appeared to show relative strengths in their alphabetic knowledge, there was evidence of difficulties in phonological awareness. Alphabet knowledge refers to an ability to identify the letters of the alphabet, print-concept knowledge refers to children's knowledge about the way books and print are organized and phonological awareness relates to an awareness of the sounds that exist within words.

Dynia, Lawton, Logan, and Justice (2014) and Dynia, Brock, Logan, Justice, and Kaderavek (2016) considered emergent literacy skills of pre-school children with ASD when compared to their peers who are typically developing. When they first looked at alphabet knowledge, it appeared that children with ASD outperformed their typically developing peers in this arena. Alphabet knowledge was also found to be an area of relative strength in Lanter, Watson, Erickson, and Freeman (2012) and Davidson and Weismer (2013). However, a more longitudinal approach taken by Dynia et al., (2016) demonstrated that rather than outperforming, children with ASD were more likely to have alphabetical skills which were comparable to those of their peers who are typically developing. The time period for results covered three data sets taken between the autumn term of pre-school and the spring term of kindergarten. This suggests, that prior to 'formal' teaching, children with ASD had more advanced alphabetic knowledge than their peers who are typically developing, but that this advantage was eradicated by time and /or teaching intervention. It was also noted that at the start of school, results for alphabetical knowledge in the group of children with ASD were more varied than those for children who are typically developing.

In terms of print-concept knowledge, results from both the 2014 and 2016 studies showed that children with ASD underperformed when compared to their

typically developing peers for print-concept knowledge. It should be noted that in both studies, the measure employed for print-concept knowledge was the Pre-school Word and Print Awareness (PWPA; Justice Bowles & Skibbe 2006, cited by Dynia et al., 2014 & 2016) assessment tool. While the assessor reads a story with the participant, the participant is asked questions relating to the organization of the print. Therefore, the measure is reliant on the ability of the participant to accurately interpret verbal questions. Previous links have been made with auditory processing deficits and autism (O'Connor, 2012) and auditory processing deficits, reading-related issues, and autism (Sharma, Purdy & Kelly, 2009). Perhaps this result is not surprising, however, if we consider that executive function skills, those skills which enable us to select and recall relevant information, plan and organize our thinking, significantly contributes to emergent literacy skills (Shaul & Schwartz, 2014) and executive function deficit has been strongly associated with a diagnosis of ASD (Autism Speaks, n.d.).

### 1.4.4 Phonological awareness

Smith Gabig (2010) looked at phonological awareness in a sample of 14 school-aged children with ASD, matched to 10 of their typically developing peers. The focus of the study was specifically on the relationship between phonological awareness and word recognition. In the study, the children with ASD demonstrated average to above-average word recognition abilities. There were no group differences were found in both word recognition and nonword recognition tasks, though there was a statistical bias towards sight word reading over non-word reading for the ASD group. Group differences were, however, identified for phonological awareness. Whereas children who are typically developing received standard scores that fell within expected performance levels for their age, scores for children with ASD were below average. Therefore, for this study, phonological awareness, and word recognition ability for children with ASD could not be linked.

Nation et al. (2006) also found no link between phonological awareness and word recognition, with an ability to sight-read, but not decode, also evident. However, for their sample, scores for nonword reading were also below population

norms. Weak central coherence theory (Frith, 1987) could offer some explanation for why phonological awareness is not a good predictor of reading for children with ASD. To read a word phonologically, one would need to have the ability to connect the parts (phonemes) to see the bigger picture (word). Weak central coherence has also been linked to reading comprehension difficulties in children with autism (Quan, 2014, p.16)

Nally, Healy, Holloway & Lydon (2018) carried out an analysis of reading abilities in children with autism. Participants were split into younger and older age groups to analyse component reading skills of word reading, phonological awareness, reading rate, comprehension, nonword decoding, and vocabulary. Results for this sample of children with ASD, demonstrated impaired reading across components, with dysfunction particularly evident in comprehension, i.e. 82% of participants and phonological awareness i.e. 62% of participants, scoring in the lowest possible range on standardised tests. Similar to Dynia et al., (2014, 2016) strengths were identified in alphabetic knowledge.

What these studies demonstrate, is a tendency for children with autism to differ from children who are typically developing in how they learn to read. Phonics and phoneme awareness may not be as important to the developing reader who has autism, as they may be to a child who is typically developing. This has implications for education settings and how teachers approach early reading skills for children with autism. A multi-method approach, which employs a combination of strategies including phonics and sight word reading, therefore, is often advised (Mirenda, 2003; Vacca, 2007).

## 1.5 Current Thesis

So far, we have seen that language deficit and deviation as a core feature of ASD places children with autism at a high risk of experiencing reading-related issues. For children who possibly fall into the broadly termed 'high functioning' classification, such issues are likely to be around reading comprehension. That might be the social aspects of comprehension or impaired reading comprehension coupled with in-tact word reading ability. These children are usually referred to as having 'hyperlexia' or a 'hyperlexic reading style'. However, there is a great deal of variation in the reading profiles of children with ASD, with some children able to read and understand with a level of competency that is matched to their age developmental norms. Further, some children with ASD show an ability to sight-read words which is out of step with their phonological awareness, and others still who do not achieve the skill of reading at all. There is some evidence that reading relating issues for children with autism can be traced back to the emergent literacy phase and this could be linked to the severity of co-occurring dysfunction, in executive function for example.

A sub-group of children whose reading abilities we know very little about are children with autism who are non-verbal. The development of speech production for children with autism varies greatly and we don't currently understand why some children develop fluid speech, even after speech delay, and others continue to be largely non-verbal. Some children have echolalic speech patterns, and there continues to be debate around what communicative intent could be behind such patterns of speech. Further, there are many different possibilities for why children with autism may be non-verbal and a chance that the explanation may differ from child to child. Among other things, fine oral motor manipulation issues, cognition, and social engagement have been explored as possible predictors of speech in this population. Knowing more about the reading abilities of children who are non-verbal could provide valuable knowledge about cognitive development for this population.

However, this isn't just an issue for academic research. In the UK, children with ASD who fit into the broad category of 'low functioning' are likely to be educated in settings which form part of special educational needs schools (Reed & Osborne, 2014). Therefore, not only the severity of ASD, but also the level of intellectual capability, is likely to impact educational placement (Eaves & Ho, 2008; Reed, Osborne, & Waddington, 2009.) Around 60 to 70% of children with autism in the UK will be educated in a mainstream setting (Ambitious About Autism, n.d.; Reed, 2016, p. 264). Whether the setting is specific for children with additional learning needs or a mainstream setting, literacy instruction forms a major part of the national curriculum (Department for Education, 2013; Welsh Government, 2019) and a major part of this instruction relates to reading. For a teacher, assessment of individual progress and achievement allows evaluation of the effectiveness of such instruction. However, teachers are in no better position to detect the reading skills of children with ASD who are non-verbal, than those academic researchers previously cited.

The Interagency Autism Coordinating Committee (IACC) has cited a dearth of knowledge about children with ASD who are non-verbal (US Department of Health and Human Services, 2011 & 2016) and this was highlighted by Tager-Flusberg and Kasari (2013), who in response to a National Institute of Health workshop convened to address this issue, refer to those with ASD who are 'minimally verbal' as 'the neglected end of the spectrum'. Bal et al., (2018) considered how we might define 'meaningful outcomes' from the provision for the ASD population. Amongst other considerations, they highlighted a lack of developmentally appropriate measures available to assess children with autism who are minimally verbal. The focus of this thesis is an attempt to begin to fill this gap.

# CHAPTER 2

## Reading Assessments for Students with ASD: A survey of summative reading assessments used in special education schools in the UK

### 2.1 Abstract

Schools have an obligation to assess the literacy skills of their students, and the provision of reading instruction to students includes the ability to measure progress in this area. However, the design of reading tests includes the ability not only to read words but the ability to verbalise them. This presents a particular challenge for practitioners working with students with Autism Spectrum Disorders (ASD) who can be non-verbal in many cases. How this issue is generally overcome is currently unknown. A survey was developed, in the form of an online multiple-choice questionnaire, to determine which tests are currently being used in the UK to assess the reading abilities of students who are non-verbal and to examine the opinions of the education practitioners who use them, concerning their suitability. Using the schools web directory, e-mail invitations were sent to 1,050 special educational needs schools across the UK, and 70 schools responded to the invitation. Respondents' suggested that the majority of practitioners hold little faith in the ability of current reading assessments to provide an accurate picture of reading ability for students who have ASD, and this holds particularly true for those who are non-verbal. One purpose of educational assessment is to establish a baseline of students' ability to plan for lifelong learning and achievement. If there is an inability on the part of schools to accurately assess the reading abilities of ASD students who are non-verbal, then it would be fair to assume that this could have a negative impact on the provision of learning opportunities for this population.

## 2.2 Rationale

According to the most recent data (CDC, 2018), approximately 1 in 59 children is diagnosed with ASD. Boys are four times more likely to be diagnosed than girls, and ethnic and socioeconomic groups have not been shown to be an influencing factor in terms of prevalence. However, it is advisable to treat prevalence estimates with caution. There is no standardisation of autism survey methodology with regards to design or case definition (Fombonne, 2018; Williams et al., 2006), with some studies utilising electronic records of diagnosis, some relying on special education eligibility, questionnaires, in-clinic assessments or even a combination of modalities.

It is estimated that there are around 1 in 100 people with an Autism Spectrum Disorder (ASD), and roughly 25% to 30% of this population are non-verbal when they reach school age (Plesa Skwerer, Jordan, Brukilacchio, and Tager-Flusberg, 2015). Difficulties experienced by the population with ASD include impairments in the areas of social interaction, social communication, and restricted and repetitive behaviours, as well as abnormal responses to sensory input (DSM-5; Wing, Gould, and Gillberg, 2013). Associated problems for those with ASD, which are not necessarily core to the diagnosis of ASD, have also been proposed by a wide range of researchers (see Eagle, Romansczk, and Lenzenwger, 2010; Jordan, 2013; Srivastava and Schwartz, 2014), and many of these relate to intellectual and language functioning (Frith, 1989; Matson and Shoemaker, 2009).

A common term for those whose cognitive and language abilities are less impaired is ‘high functioning’, whereas those with poorer language and cognitive abilities are referred to as ‘low functioning’ (O’Connor and Klein, 2004). In the UK, children with ASD who fit into the broad category of ‘low functioning’ are likely to be educated in settings which form part of special educational needs schools (Reed and Osborne, 2014). Therefore, not only the severity of ASD, but also the level of intellectual capability, is likely to impact on educational placement (Eave and Ho, 2008; Reed, Osborne, and Waddington, 2009). In fact, only around 29% of children with ASD are now educated in special school settings (Ambitious about Autism, 2014).

The government makes statutory guidance available for these special educational needs (SEN) settings in the form of codes of practice (Nasen, 2014). Education for students with ASD is governed by such codes of practice, and these guidelines apply to pupils with ASD who are non-verbal. A code of practice in education sets out the statutory obligations and the role of the Local Authority, as well as the responsibilities of the school in supporting both pupils and parents. Whilst codes of practice are individual to England, Scotland, Wales, and Northern Ireland, they all carry a common theme of access and inclusion. Each local authority across the UK is responsible for ensuring that SEN pupils are afforded equal access to the national curriculum. The national curriculum is a set of standards and subjects taught at each key stage, and delivery of the national curriculum is a statutory requirement for local authority schools (Department for Education, 2013).

Literacy instruction forms a major part of the national curriculum (Department for Education, 2014; Welsh Government, 2014). Assessment of individual progress and achievement allows evaluation of the effectiveness of such instruction. Summative assessments of reading ability, such as the New Salford Reading Test NSRT; McCarty & Lallaway, 2012) and Neale's Analysis of Reading Ability (NARA; Neale, 1989), aim to provide an estimation of reading age. This estimation allows teachers to monitor the progress of their pupils, and plan for their future attainment. In most cases, the pupils will be asked to read aloud a set of sentences and/or paragraphs that have been graded in terms of their difficulty. Once a certain number of errors have been made, the test is stopped, and a reading age for that pupil is recorded. A literature search for reading tests tailored towards those with special educational needs, with a particular focus on children who are minimally verbal, revealed no reading tests specific to this population appeared to be in common use. In fact, in terms of research relating to the reading abilities of school-aged children with ASD who are non-verbal or minimally verbal, there appears to be very little conducted, which has been noted by previous studies and reviews (see Muchetti 2013; Tager-Fusberg & Kasarri 2013). There is currently a lack of clear definitions for the terms 'non-verbal', 'minimally verbal', 'preverbal, or 'verbal' (Tager-Fusberg and Kasari, 2013). For the purpose of this study, 'non-verbal' refers to children who have reached school-aged children with little or no

spoken language that is used spontaneously for communication (Plesa Skwerer, Jordan, Brukilacchio and Tager-Flusberg, 2015), as opposed to' verbal' – children of the same age who use words spontaneously for the purposes of communication.

The relationship between the ability to speak and the ability to read is not a simple one (Bishop and Adams, 1990; Ferreira, Ronnberg, Gustafson, et.al., 2007). Although delay in functional language is considered to be associated with ASD (e.g., Vacca, 2007), and a great number of children with ASD are also diagnosed with severe learning difficulties (Matson and Shoemaker, 2009), it does not automatically follow that the inability to speak goes hand in hand with an inability to read. For example, Diehl (2006) posited that children with ASD may display delayed phonological development, but that cognitive development may otherwise be intact. A further set of studies have highlighted the diverse nature of reading abilities within the ASD population (e.g., O'Connor and Perry, 2004; Frith and Snowling, 1993; Happe, 1997; Snowling and Frith, 1983,). Therefore, there is enough research to suggest that having ASD and being non-verbal does not rule out the possibility of having the ability to read, even if that ability cannot be accessed through traditional reading assessments.

Thus, the research previously cited, suggests that there are clear distinctions between the ability to speak and the ability to read, especially in pupils with ASD. However, these distinctions are not reflected in the popular forms of reading assessment, such as the NSRT and NARA, which require an ability to verbalise words to access the tests and, hence, establish a reading age. One suggested use of the NSRT is as a "screening test, for use with pupils with suspected reading or learning difficulties" (McCarty & Lallaway, 2012). This would, of course, only be possible for detecting reading or learning difficulties in children who are verbal and may well exclude many pupils with ASD who are non-verbal, but reading-competent, from being assessed. In turn, this may severely disadvantage those pupils in terms of planning their access to the national curriculum.

Therefore, the present study was performed to evaluate the current situation in UK special schools with regards to the assessment of reading abilities of pupils with ASD, with a particular focus on those pupils with ASD who are non-verbal. The first aim of the survey was to explore which tests are most likely to be used to

assess the reading abilities of students with ASD in SEN classrooms, and whether or not this differed from tests being used for students who do not have ASD. Of particular interest, was the kind of tests being employed to test the reading abilities of students with ASD who are non-verbal. The second aim of the survey was to explore the teacher's views with regards to the suitability of these tests for students with ASD, again, with a particular focus on the students with ASD who are non-verbal.

## 2.3 Method

### 2.3.1 Participants and recruitment

Special Educational Needs schools were selected to receive an email inviting them to complete the online questionnaire. SEN schools were targeted for this survey as it is uncommon for students who are minimally verbal to be educated in a mainstream setting. Further, students with ASD who are cognitively able would likely be able to access traditional reading assessments, and the purpose of this study was to evaluate provision for those students who would be likely to fall outside of this demographic. E-mail addresses were obtained from an online directory of SEN schools (schoolswebdirectory), and an e-mail was sent to the headteacher, or the school administration, e-mail address. The initial e-mail contained information with regards to the study, and a request that a member of staff be selected to take part in the survey. Thus, participants were practicing professionals working in special schools across the UK. The initial e-mail invitations were sent out to 1,050 schools across the UK, of which 70 schools responded, and all of these responses contained enough data to be used in the analysis of responses. **After the initial e-mail was sent, reminder emails were sent every two weeks.**

### 2.3.2 Ethical considerations

Schools were notified at the outset that there was no obligation to complete any of the questionnaires, and they were provided with information about how they could ensure that they received no further e-mails from the researcher concerning this topic. Data was collected anonymously, and no information relating to schools'

identities, or the identities of staff members completing the questionnaire, were collected, or stored. Consent was provided by participants selecting the 'next (I consent)' button on the front page of the survey. Participation in the survey was voluntary. Ethical approval for the study was gained from the Department of Psychology, Swansea University Ethics Committee.

### 2.3.3 Survey design

The Reading Assessments for ASD Students Survey consisted of an online questionnaire, which had a total of 18 questions, with a free text box for additional comments at the end. A multiple-choice method was selected for each of the questions, to ensure comparable quantitative data could be obtained (appendix A). Questions 1 to 4 related to basic information about the education settings. Questions 5 to 11 were about the nature of the students in the school. Questions 12 to 16 sought to identify the current procedures in place for testing students reading abilities and the names of any summative reading tests being employed.

The final section of the questionnaire (questions 17 and 18) focused on the professional opinions of participants with regards to the suitability of the tests for use with students who have ASD. This was broken down into two sections: students with ASD, and students with ASD who are non-verbal. The options for the students with ASD section were: Assessments provide a very accurate picture of reading ability for the majority of students with ASD; Assessments give some idea of reading ability for students with ASD but need improvement; Assessments are not fit for purpose for students with ASD. The options for the students who are non-verbal section were: Assessments provide a very accurate picture of reading ability for the majority of students with ASD; Assessments give some idea of reading ability for students with ASD but need improvement; Assessments are not fit for purpose for students with ASD; We don't have non-verbal students with ASD. Space was provided at the end of the questionnaire for any further comments participants wanted to make.

### 2.3.4 Procedure

Data was collected via an online questionnaire, provided by Webquest server, and analysed using the statistical analysis software package SOFA Statistics, version 1.4.3. From the initial invitation e-mail sent to 1,050 special schools across the UK, to the final e-mail announcing the deadline for closure, the questionnaire was available online for six months. The e-mail address of the researcher was included in every e-mail sent, and it was made specific that this address could be used to request help or further information about the study. None of the schools contacted the researcher for help, although 3 participants indicated an interest in participating in further studies. All 70 responses contained enough information to be included in the analysis; that is, they provided a sufficient amount of information for relevant comparisons to be made.

## 2.4 Results

All responses were from institutions that fitted the criteria of being SEN schools or SEN provisions attached to mainstream schools. Due to the anonymity of the data, the researcher was unable to determine the geographical position of the schools, other than that they were in the UK. The sizes of the schools, in terms of numbers of pupils, are displayed in Figure 2.1, which reveals that most of the schools had between 51 and 150 pupils.

***Figure 2.1***

*Population Sizes of Schools who Participated in the Survey*

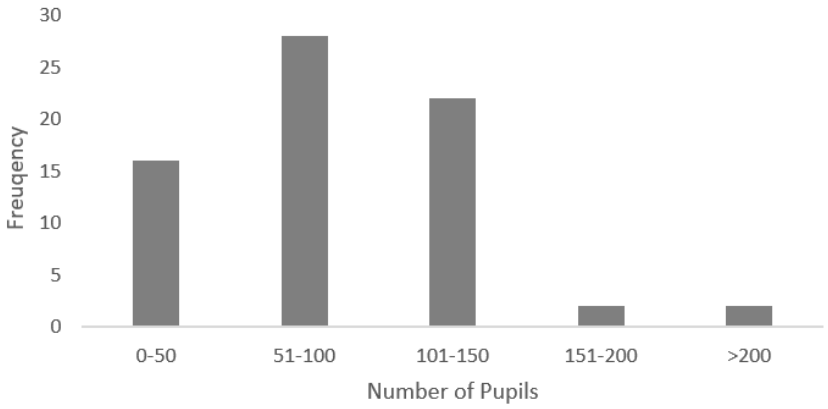
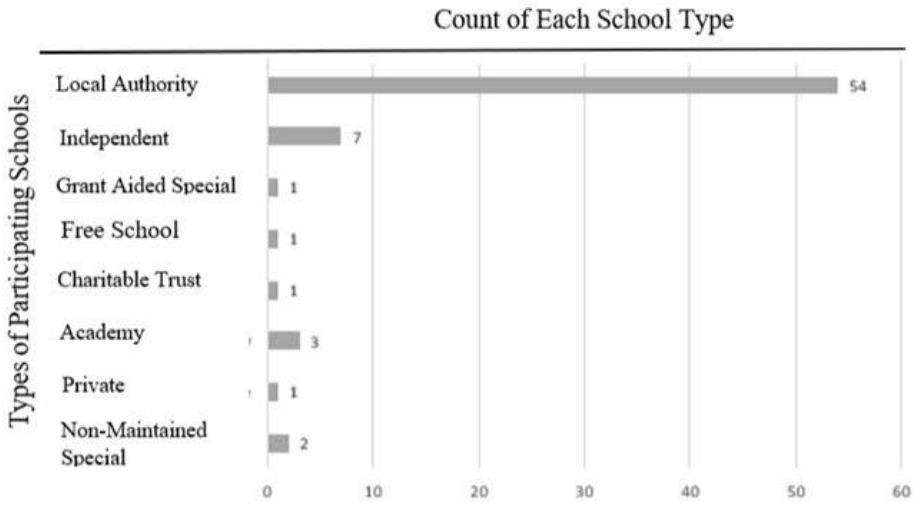


***Figure 2.2***

*Types of Schools who Participated in the Survey*




The nature of the participating schools was also examined, and these data are shown in Figure 2.2. Inspection of these data reveals that the majority of the schools (77%) were local authority schools. The remaining schools were non maintained special schools, private schools, academies, charitable trusts, free schools, grant-aided special schools, and independent schools. No school had Welsh as a first language.

All but 3 of the schools declared that 100% of their students were classed as SEN. The 3 that did not declare 100% SEN were Additional Needs/Mainstream combined schools. With regards to ASD prevalence, all participating schools stated that they had pupils with a diagnosis of ASD. The lowest percentage of pupils with ASD in a school was 5%. However, 15 out of the 70 schools that participated had 100% of ASD students. In addition, 61 out of 70 schools stated that they had students who were mostly non-verbal or had severe communication difficulties. 35 schools had ASD students who were considered to be 'high functioning'.

**Table 2.1**

Most Popular Reading Tests Reported in SEN Settings

| | | |
|---|---|---|
| Reading Assessments | No Test | 30 |
| | Salford Reading Test | 12 |
| | Neale's Analysis of Reading Ability | 10 |
| | National Foundation for Educational Research | 7 |
| | Wechsler Individual Achievement Test | 3 |
| | PIVATS | 2 |
| | Edinburgh Reading Test | 1 |
| | Herberton | 1 |
| | National Curriculum | 1 |
| | New Group Reading Test | 1 |
| | Wide Range Achievement Test 4 | 1 |
| | York Assessment of Reading for Comprehension | 1 |

Frequency counts of the identified reading tests most commonly being used by respondents were converted to percentages of the schools that had responded. The most commonly reported reading test was the Salford Reading Test, being used by 17.1% of schools. This was closely followed by Neale's Analysis of Reading Ability at 14.3%. The third most popularly reported test was the National Foundation for Educational Research, with 10% of schools employing this test. However, 30 out of the 70 SEN schools that participated (i.e. 42.9%), did not use a reading test at all. No school declared the use of a reading test that was being employed exclusively with their students who have ASD.

In answer to questions relating to the National Reading Tests, which have only been introduced in Wales, 6 schools said that the tests were applicable for their settings. However, all 6 had disapplied all students from the test. To qualify for disapplication, a student must be performing at a level way below what would be expected for his/her chronological age.

**Table 2.2a**

Suitability of Most Popular Reading Tests for Students with ASD

| | | test not fit for purpose | | test gives some idea of reading ability | | test gives a very accurate picture of reading ability | |
|---|---|---|---|---|---|---|---|
| | | Freq | Row% | Freq | Row% | Freq | Row% |
| Reading Assessments | NARA | 5.0 | 50.0% | 5.0 | 50.0% | 0.0 | 0.0% |
| | NFER | 1.0 | 14.3% | 6.0 | 85.7% | 0.0 | 0.0% |
| | NO TEST | 13.0 | 43.3% | 13.0 | 43.3% | 4.0 | 13.3% |
| | OTHER | 2.0 | 18.2% | 7.0 | 63.6% | 2.0 | 18.2% |
| | SRT | 2.0 | 16.7% | 8.0 | 66.7% | 2.0 | 16.7% |

**Table 2.2b**

Suitability of Most Popular Reading Tests for Students with ASD who are Non-verbal

| | | test not fit for purpose | | test gives some idea of reading ability | | test gives a very accurate picture of reading ability | |
|---|---|---|---|---|---|---|---|
| | | Freq | Row% | Freq | Row% | Freq | Row% |
| Reading Assessments | NARA | 3.0 | 30.0% | 7.0 | 70.0% | 0.0 | 0.0% |
| | NFER | 2.0 | 28.6% | 5.0 | 71.4% | 0.0 | 0.0% |
| | NO TEST | 3.0 | 10.0% | 21.0 | 70.0% | 3.0 | 10.0% |
| | OTHER | 5.0 | 45.5% | 5.0 | 45.5% | 0.0 | 0.0% |
| | SRT | 5.0 | 41.7% | 5.0 | 41.7% | 0.0 | 0.0% |

The final section of the questionnaire focused on the professional opinions of participants with regards to the suitability of the tests for use with ASD students. The data for the most popular choices were analysed to determine the professional opinions of the participants with regards to the suitability of tests for use with ASD and non-verbal ASD students, and these data are displayed in Tables 2a and 2b.

The New Salford Reading Test was the most popular reading test: about 17% of respondents expressed the opinion that the test gave a very accurate picture of ability for ASD students, and 67% felt that the test gives some idea of reading ability for ASD students but requires improvement. However, about 17% felt that the test is not fit for purpose. For ASD students who are non-verbal, 42% expressed the opinion that the test is not fit for purpose, and only 17% agreed that it gives a very accurate picture of ability.

In terms of Neale's Analysis of Reading Ability, 50% of participants felt that the NARA was not fit for purpose for students with ASD, and 50% agreed that it gives some idea of ability but requires improvement. No participants felt a very accurate picture of reading ability could be gained using the NARA. All of the participants who work with pupils with ASD who are non-verbal felt that the NARA is not fit for purpose for these pupils.

No participants agreed that the NFER can give a very accurate view of reading ability when used with students who have ASD: 85% felt that the test gives some idea of ability, while 14% were of the opinion that the test is not fit for purpose. This latter figure rose to 74.4% for those working with pupils who are non-verbal, which represents 100% of the participants who use the NFER with pupils who are non-verbal.

It should be noted that 43% of participants stated that they do not use a summative reading test: 64% of these felt that the systems they have in place give some idea of ability, but need improvement; 17% agreed that these systems are not fit for purpose, and 17% felt that they were getting a very accurate picture of reading ability for their pupils who have ASD. In terms of pupils with ASD who are non-verbal, 42% felt that their systems were not fit for purpose; 17% agreed that they were getting a very accurate picture of ability for students who are non-verbal; and 42% of participants not using a reading test, were not working with students who have ASD and are non-verbal.

***Figure 2.3a***

*Distribution of Percentages of ASD Pupil Populations Reported by Participating Practitioners*

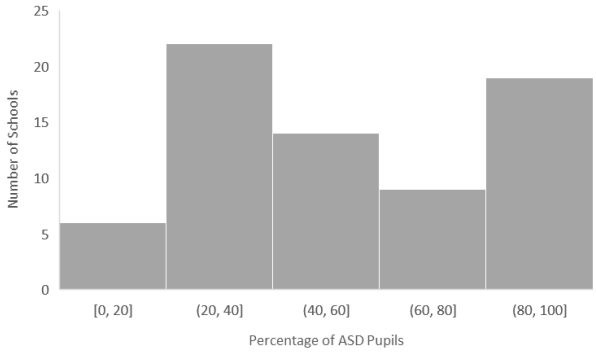



***Figure 2.3b*** *Distribution of Percentages of Non-verbal ASD Pupil Populations Reported by Participating Practitioners*

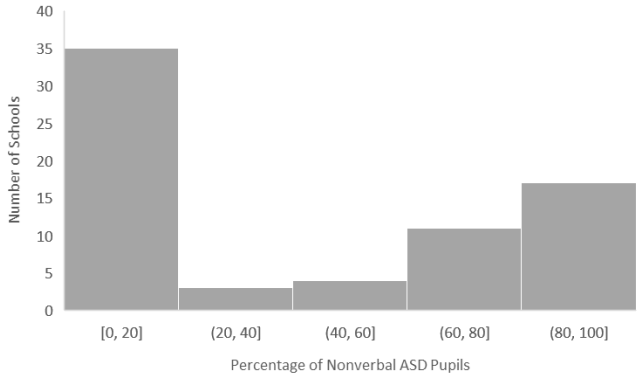



Figure 2.3a and 2.3b shows the cumulative proportion of the sample that reported having different percentages of pupils with ASD in their school (left panel), and the cumulative proportions of the sample with different proportions of pupils with ASD who are non-verbal (right panel). These data were used to assess whether these factors had any impact on the degree to which various reading tests were

thought to be fit for purpose or not, as it was thought that exposure to different populations of pupils with ASD might impact this assessment. To this end, the sample was split at the mean for numbers of pupils with ASD in that school. This produced a lower numbers group (mean number of pupils with ASD = 58.26 $\pm$ 30.25, range 0-56), and a higher numbers group (mean number of pupils with ASD = 58.26 $\pm$ 30.25, range 60-100). The numbers of participants in these groups who had assessed the suitability of the tests that they were using as not fit for purpose, or as moderately or fit for purpose, was calculated. For the lower numbers group, the figure for not fit for purpose was 15/38, and this figure for fit/moderately fit for purpose was 23/38. For the higher numbers group, the figure for not fit for purpose was 8/32, and for fit/moderately fit for purpose the figure was 24/32. Analysis of these data using a 2x2 chi-square (low/high numbers versus not fit/fit) indicated that this factor had no impact on the opinions of practitioners with regards to the suitability of the tests they were using, $\chi 2 = 0.81$; df 1; p=0.37.

The sample was also split at the mean for numbers of pupils with ASD in the school who are non-verbal. This produced a lower numbers group (mean number of pupils with ASD who are non-verbal = 42.2 $\pm$ 39.31, range 0-35), and a higher numbers group (mean number = 42.2 $\pm$ 39.31, range 50-100). The numbers of these groups who had assessed the suitability of the tests they were using as not fit for purpose, or as moderately or fit for purpose, was calculated. For the lower numbers group, the figure for not fit for purpose was 7/38, and this was 16/38 for fit/moderately fit for purpose. For the higher numbers group, the figure for not fit for purpose was 16/32, and for fit/moderately fit for purpose the figure was 16/32. Analysis of these data using a 2x2 chi-square (low/high numbers versus not fit/fit) revealed that there was a statistically significant difference between the groups that were above and below the mean. $\chi 2 = 6.49$; df 1; p=0.01, with those with the higher population were more likely to give the opinion that the tests they were using were not fit for purpose.

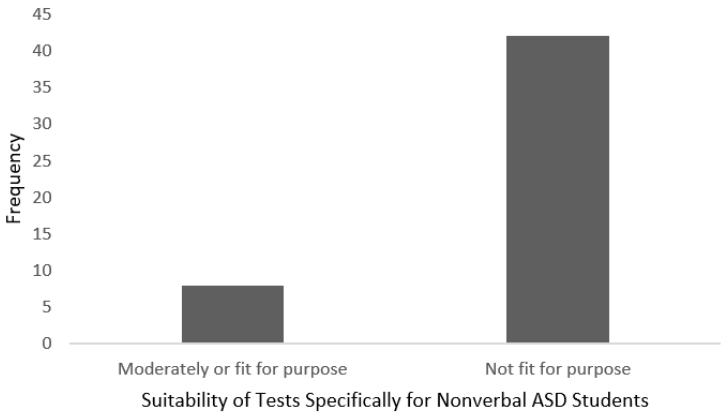
The above data analysis examined the question of the suitability of tests for students with ASD. Analysis showed that a higher population of students with ASD did not make it more or less likely that participants would be of the opinion that the tests were not fit for purpose. However, participants who worked within schools

with a higher proportion of students with ASD who are non-verbal were more likely to express the opinion that the tests were not fit for purpose.

Further analysis looked at the question of test suitability for students with ASD who are non-verbal specifically. The requirement was that only the answers of those schools with a population of ASD students who are non-verbal be included in the data analysis. The results analysed were responses in relation to the suitability of the tests for specific use with students with ASD who are non-verbal.

***Figure 2.4***

*Opinions of Practitioners with a Non-verbal ASD Population Relating to the Suitability of Tests Specifically for Pupils who are Non-verbal*




Regarding students who are non-verbal, 50/70 of the participating schools had a population of ASD students who are non-verbal; range 2-100%. In response to the question of suitability of the tests for use specifically with students with ASD who are non-verbal, 8/50 gave the opinion that the test was moderately or fit for purpose. 42/50 gave the opinion that the test was not fit for purpose (see Figure 2.4). The question of suitability specifically for students with ASD who are non-verbal was only open to those participants with a non-verbal population. The remaining 20 schools selected NA (not applicable) for this section. The sample of 50 was split at the mean for numbers of ASD pupils who are non-verbal in the school. This

produced a lower numbers group (mean number of pupils with ASD who are non-verbal = 40.71 $\pm$ 28.31, range 2-40), and a higher numbers group (mean number = 40.71 $\pm$ 28.31, range 45-100). Analysis of these data using a 2x2 chi-square (low/high numbers versus not fit/fit) revealed that there was not a statistically significant difference between the groups that were above and below the mean. $\chi 2$ = 0.02; df 1; $p$=0.87.

## 2.5 Discussion

The present study was performed to evaluate the current situation in UK schools with regards to the assessment of the reading abilities of pupils with ASD, with a particular focus on those pupils who are non-verbal. The first aim of the survey was to find out which tests are most likely to be used to assess the reading abilities of students with ASD in SEN classrooms, and whether or not this differed from tests being used for students who are not on the ASD spectrum. Of particular interest, were the kinds of tests being employed to evaluate the reading abilities of non-verbal pupils with ASD. The second aim of the survey was to explore teachers' views of the suitability of these tests for students with ASD, again with a particular focus on the student with ASD who is non-verbal.

The New Salford Reading Test was reported to be the most used reading test by the SEN schools that participated in the study. However, even though it was the most popular test for general SEN and ASD school populations, only a relative few practitioners felt that NSRT provides an accurate picture of reading ability when used with pupils with ASD, and nearly three-quarters of practitioners working with no pupils with ASD who are non-verbal felt that the test was not fit to be used with this population. The other two prominently used reading tests were the NARA and the NFER. However, none of the practitioners felt that these tests provide an accurate picture of reading ability for pupils with ASD or pupils with ASD who are non-verbal. Thus, the current survey demonstrates that the majority of practitioners who are making use of reading tests for students with ASD lack faith in the tests'

abilities to provide an accurate picture of these students' abilities. This is even more so for those practitioners working with students with ASD who are non-verbal.

With regards to the percentage of populations, it was found that those with a higher number of students with ASD were neither more nor less likely to deem the reading tests unsuitable as those with a lower number of students with ASD. However, with regards to students with ASD who are non-verbal, those with a greater population of students who are non-verbal were more likely to say that the tests were not fit for purpose. Therefore, although practitioners working with students with ASD were not wholly confident in the tests' ability to provide a very accurate picture of reading ability for these students, the issue for students who are non-verbal, would appear to be further pronounced.

This was further demonstrated by the responses of the schools with a population of students with ASD who are non-verbal concerning the tests' suitability for use specifically students with ASD who are non-verbal. In this instance, 84% were of the opinion that the reading tests they are currently employing, are not fit for purpose.

The development of literacy skills is one of the uppermost aims of education, not only as a life skill but also because it provides access to all other curriculum areas (Department for Education, 2014). Mucchetti (2013) advocates the creation of "effective curricula, including literacy interventions, for students with autism". However, when developing a curriculum for any student, it would make sense to have a way to measure its effectiveness, and the assessment of individual ability, and tracking their progress, fulfils that role. Speaking on behalf of the communications charity, chief executive Virginia Beardshaw comments: "If a child cannot speak, they will be unable to read and write" (I CAN, 2014). This view may unfortunately be a reflection of current general attitudes in education, which could well ensure that pupils who are non-verbal will continue to be excluded from an 'inclusive education system'. An obvious difficulty for students who are non-verbal is that even if they are able to read the words contained in the test materials, they will be unable to verbalise them, making this form of assessment inaccessible.

Research that has focused on ASD and intellectual disability has shown that people with ASD are a distinct group, not only in terms of social behaviours but also

in terms of their patterns of intellectual functioning (Matson and Shoemaker, 2009). For example, Munson (Munson et al., 2008) who carried out a study involving 456 children, was able to identify multiple IQ subgroups as well as variations in cognitive strengths and weaknesses. Due to the heterogeneous nature of ASD, assessment of reading ability is not likely to be a straightforward matter. Some children with ASD never demonstrate any reading skills (Vacca, 2007), however, numerous case studies describe some with ASD who have exceptional reading ability (Turketaub 2004, Grigorenko 2002; Nation, 2006). Research into the reading ability of those with ASD has tended to focus on those who can be described as 'high functioning' (Nation, Clarke & Wright, 2006). In contrast, with regards to the ASD population who are non-verbal, there is relatively little research.

The main implication of these findings is that practitioners working with students who are non-verbal have no knowledge base on which to draw. Further, for those practitioners who state that the summative tests available to them are not fit for purpose, there appears to be no alternative being offered. Whilst teachers may resort to their own methods of assessment, one could argue that these are professionals being made to make the best of a bad situation. The danger then, is that students who are non-verbal, but have an ability to read, may be underrepresented in whole-school data; with therefore no provision being made for these skills to be further developed, or suitable adjustments being made to the curriculum. It is whole-school data that inform schools' self-evaluation procedures and therefore plans for school improvement. Since literacy provides access to the rest of the curriculum, the negative impact of this could be pervasive in terms of a child's whole education. A possible solution to this would be further research (Arnold & Reed, 2016) which is inclusive of students with ASD who are non-verbal; resulting in the development of a reading test which is comparable to traditional methods, but accessible for all.

A limitation of the survey was the relatively low response rate. Only 70 schools responded to the invitation to complete the survey. For the purpose of generalisation, there is a need to interpret the results of the current study with caution. This said since all schools reported a percentage of students with ASD, students with severe communication difficulties and those to be considered 'high functioning', in the researcher's opinion the sample was a good representation of

SEN schools in the UK. Making the survey anonymous meant that we were unable to identify which schools took part. Therefore, we were unable to ascertain any impact that geographical location may have on the choice of tests. Perhaps the ability to state the geographical area would be a useful addition to any future survey.

Due to the way in which the survey was distributed, via e-mailing the link to the headteacher, there was an assumption that all those who participated were practitioners working with students with ASD in educational settings. It would have been useful to clarify the exact nature of the role that participants played within these settings, to ensure they had full adequate knowledge of all systems employed by their settings.

In summary, the findings of this survey indicate that practitioners do not have a reliable means for assessing the reading abilities of children with ASD, this is particularly true for students with ASD who are non-verbal. While it may seem common sense, or obvious, that a student who is non-verbal would not be able to access a reading test that requires verbal output; the results of this survey would imply that, despite this, the situation in SEN schools in the UK is not currently being addressed.

# CHAPTER 3
# Measuring the Word Recognition Abilities of Children with ASD using a Traditional Paper-Based and Modified Test Formats

## 3.1 Abstract

Approximately 30% of school-aged children with Autism Spectrum Disorder (ASD) are non-verbal (i.e. individuals of school age with little or no spontaneous spoken language). Most reading tests require verbalisation, which may under-estimate reading ability in this group. To determine word recognition abilities of children with ASD who are non-verbal (age range: 5yrs. to 18 yrs.), a modified multiple-choice form of reading assessment, comparable to the widely used 'New Salford Reading Test' was created. Three groups were tested: verbal ASD (*n*=31) non-verbal ASD (*n*=40); and verbal non-ASD with a statement of special educational needs (*n*=32). All participants took part in three tests: the traditional version of the New Salford Reading test, a modified multiple-choice version of the test presented on touch screen, and the same modified version presented using eye gaze tracking facility. Word recognition scores were calculated using NSRT materials (WRS) and results for all three groups compared. Percentage of words correct (PWC) were also calculated and results compared for all three groups

The scores of students with ASD who are non-verbal were much lower than those of verbal ASD when tested with the paper version of the scale, but this difference was eradicated when the modified version was employed. Results were most promising for this group when the touchscreen version of the modified test was employed. These results suggest that the use of the modified test may offer a good assessment of the context-free word recognition abilities of children with ASD who are non-verbal.

## 3.2. Rationale

Approximately 30% of those with Autism Spectrum Disorder (ASD) have little or no spoken language when they reach school age (Plesa Skwerer, Jordan, Brukilacchio, and Tager-Flusberg, 2015a). In 2011, the Interagency Autism Coordinating Committee published its strategic plan (US Dept. of HHS & IACC, 2011), in which it was concluded that more research was needed into interventions for the population of people with ASD who are non-verbal. In the light of this report, Tager-Flusberg and Kasari (2013a) highlighted the paucity of research relating to this population, specifically referring to children with ASD who are minimally verbal, as the 'neglected end of the spectrum'. In 2016, the message from the Interagency Autism Coordinating Committee was the same, with the addition of a recommendation for the development of more 'teacher-implemented' testing and interventions to be based in school settings (US Dept. of HHS & IACC, 2016). The primary aim of the current report is to fill one of these gaps in current knowledge and describe a non-verbal modified multiple-choice reading test designed for this population.

There is some disagreement concerning the precise definition of the term 'non-verbal' in the literature, and this term is often used interchangeably with the term 'minimally verbal' (Tager-Flusberg and Kasari, 2013). This will also be the case with the current study, as the use of these terms will depend on the research considered. In terms of meaning, the current study uses the term non-verbal to represent a population of children who are of or above school age but have little, or no, expressive spoken language abilities used spontaneously for the purpose of communication. This definition can also be found in Plesa Skwerer et.al. (2015), as a generally agreed term for this cohort.

With regards to methods of assessment employed in schools to test reading Arnold and Reed (2016) investigated tests employed in additional learning needs (ALN) settings for use with pupils who have ASD who are non-verbal. The results of the survey indicated that the most popular formats for reading assessment used were those that carry a requirement to verbalise the sentences being read. The results of the survey indicated that none of the educational practitioners who took

part believed that these reading tests provide an accurate picture of reading ability for their students with ASD who are non-verbal.

While it is likely that practitioners working with students who are non-verbal may develop their own ad-hoc methods of reading assessment and instruction, this lack of formal summative assessment remains of concern. What schools choose to measure can be a reflection of what they choose to value. Assessment data forms part of school self-evaluation which informs the plans for school improvement. The school improvement plan will set out how resources are allocated, and which interventions are employed. Therefore, students with ASD who are non-verbal that are not represented in the data, are likely to be excluded from receiving appropriate interventions. Perhaps it might be considered 'common sense' that schools using tests that require verbalisation are likely to be excluding those without the ability to verbalise. It would, therefore, be reasonable to wonder why such a deficit goes unaddressed.

Although generally, there is a lack of research relating the ASD population who are non-verbal, it is not known whether this cohort is very likely to fall into the 'low functioning' category of ASD. This label is used to describe individuals on the spectrum who exhibit behaviours associated with intellectual disability, which can manifest as learning disability, language functioning deficit and deficits in practical and social skills (Matson & Shoemaker, 2009). This stands in contrast to the label of 'high functioning', which is attributed to those with ASD who function cognitively, though not socially, at a 'typical' or even higher than 'typically average' level in terms of academic skills and language functioning (Eagle, Romanczk & Lenzenweger, 2010; Fombonne, 2003; Langthorne & McGill, 2008; Munson et.al., 2008). However, it is also possible that, in relation to the assessment of abilities of the ASD population who are non-verbal, such terms may lower expectations of children considered to be 'low functioning'. In essence, there may be an assumption that, since a child with ASD who is non-verbal is likely to be 'low-functioning' it matters little that school does not have a reading test. A second aim of the current study is to investigate if this is a reasonable assumption.

There is evidence to suggest that children with ASD who have higher intelligence scores are more likely to learn to talk than those with lower scores

(Westerveld, Trembath, Shellshear & Paynter, 2016). However, since speech is not considered to be essential to phonological coding (Foley & Pollatsek, 1999; Reed, Howell, Sackin, Pizzimenti & Rosen 2003), this wouldn't necessarily translate into a lack of ability to read. In fact, a range of studies has highlighted the diverse nature of reading abilities within the ASD population (Frith & Snowling, 1986; Happe, 1997; Snowling and Frith 1986a; O'Connor & Klein, 2004). The research question which the current study set out to answer therefore was if we remove the requirement to verbalise from a standardised reading test, will children with ASD who are non-verbal demonstrate the skill to **recognise words** in a way that is similar to their verbal counterparts with and without a diagnosis of ASD,

Reading is best described, not as a single skill, but as a set of skills which when they interact, enable us to translate symbols into words from which we derive meaning (Perfetti, Landi and Oakhill, 2005). In terms of what we aimed to measure in the current study, we shall borrow the phrase 'context-free word recognition' from Gough & Tunmer (1986). The New Salford Reading Test was identified as the most popular test being used in ALN schools in the Arnold and Reed (2016) study, and, therefore, this was the test chosen to deliver. A comprehension test accompanies the New Salford Reading Test, and results relating to this element of the test are discussed in the next chapter (chapter 4) of this thesis.

Taking account of the recommendations made by the Interagency Autism Coordinating Committee in 2016, this study was designed, and implemented, by a teacher with 18 years of experience working with children with ASD, and all testing was carried out in school settings. Three groups of special school students were involved in the study: verbal ASD, non-verbal ASD, and a non-ASD group who had a diagnosis of additional learning needs. Assessments delivered were the NSRT in its original paper-based format and a modified multiple-choice version of this test. The modified test was designed for the purpose of this study and delivered using both touch screen technology, and eye gaze technology.

For the modified version of the test to be accessible to participants who were non-verbal, a multiple-choice format was a necessary option. Therefore, corrections for guessing and the implications of multiple-choice formats are later discussed. In the interests of ease of access, the test was designed to run digitally, and PowerPoint

format was chosen on the basis that it is generally versatile and readily accessible software in most school settings. In terms of accessibility, a further consideration was a participant's likely ability to use touch-screen technology. While it was assumed that most participants would have previously been given the opportunity to interact with touch-screen facilities, particularly as the use of interactive whiteboards, iPads and tablets are commonplace in school settings now, research has demonstrated that children with autism can experience difficulties with fine-motor abilities which can have an adverse effect on pointing skills (Baht, Landa & Cole, 2011; Fournier, Hass, Naik, Lodha & Cauraugh, 2010; LeBarton & Inverson 2013). Although issues with motor development are not considered primary diagnostic criteria for autism spectrum disorder, various researchers have highlighted differences in motor development for school-aged children with ASD (Provost, Lopez & Heimerl, 2006). Issues with fine-motor development at 18 months have even been suggested as a predictive factor for ASD (Brian et al., 2008).

Many studies have made use of eye gaze tracking to seek insight into reading behaviour and cognitive functioning (Bax, 2013; Mani & Huettig, 2014). For example, Ann-Evans and Saint-Aubin (2005) were interested in the reading behaviours of young children, particularly with regards to how much attention they give to printed text as opposed to illustrations while being read to. The researchers employed the use of eye-tracking equipment to track the eye gaze movements of a group pre-school children as they were looking at pages from storybooks on a computer screen while being read to. Researchers were able to determine that these young children paid more attention to illustrations than printed words during these activities, regardless of illustration type or presentation style.

Yanva, Temnikova, and Mitkov (2015) used an eye gaze tracking facility to consider attention paid to illustrations by adults with autism. From their results, they produced a set of guidelines for improving text accessibility for readers who have autism. Pazzaglia et al. (2012) used eye gaze tracking in a single case study of an adult with autism and a hyperlexic pattern of reading ability. They recommended the use of eye gaze tracking facility as a non-invasive method in research and diagnostic contexts.

Further examples of the use of eye gaze tracking in research are

Hutzler and Wimmer (2004) who made use of eye gaze technology in their study into dyslexia, Norbury, Brock, Cragg, Einav, Griffiths, & Nation (2009) used eye gaze tracking facility to investigate weak central coherence theory and Brady, Anderson, Hahn, Obermeier, and Kapa (2014) used eye gaze technology to measure speech comprehension in young boys with autism. In all these studies, researchers propose that information was gained from eye gaze tracking which would not have been available without the use of technology.

With regards to the use of eye gaze tracking in schools, this is still a relatively new technology, and eye gaze equipment in an ALN setting would be more likely seen in a provision for those with profound multiple learning difficulties rather than autism spectrum disorder. However, the use of eye gaze as a possible additional method was explored in this study in the interests of inclusive practice.

In summary, the aims of the current study were based on our prediction that the NSRT would be inaccessible for non-verbal participants with ASD, who once the requirement for verbalisation was removed, may display abilities in word recognition skills. To explore this, we developed a modified version of the test utilising a multiple-choice method delivered using touch-screen technology and eye gaze tracking facility. Results from all three groups of participants (verbal ASD, non-ASD, non-verbal ASD) were compared for all three test formats.

## 3.3 Method

### 3.3.1 Participants

Initial contact was made with 22 schools from a list of special schools that appeared in the directory of schools featured on the schoolswebdirectory.co.uk website (schoolswebdirectory.co.uk). Schools in the South Wales area were selected on the basis that they appeared in the 'special' school section of the list and were within a reasonable distance for the researcher to travel. Special school attendance is deemed appropriate by a Local Authority on the basis that the nature of additional

learning needs is so severe or complex as to disallow the possibility of suitable educational progress being made in a mainstream setting.

Over a period of 4 weeks, the researcher spoke with members of senior or middle leadership teams of all 22 schools and briefly explained that the study aimed to explore the reading abilities of children with autism who were non-verbal and that we were looking to recruit participants who would fit into one of three groups i.e. children with autism who are non-verbal, children with autism who were verbal, and children with general special education needs that did not include the presence of autism. At this point, it was also suggested that if the school leader felt that the study was of interest, they could provide the researcher with a contact at the school that could be emailed further information and could act as a 'point of contact' for the researcher. All 22 leaders provided a contact who was sent further information via email, and 9 of those schools became involved in the study. A further two schools that were involved in the study were a primary school with a special resource base, who made contact with the researcher having heard about the study from another school and the school in which the researcher was based. Participants recruited from the school in which the researcher was employed as a middle leader were not pupils taught by the researcher, however, some would likely be familiar with the researcher through other forms of contact at the school.

Of the 11 schools that took part, 10 were special schools and 1 was a primary school with a special educational needs resource base. Only 1 of the special schools had an age range limited to primary age children and the population of this school was from age 4 to age 11. The primary school age range was 3 to 11, with full-time attendance beginning at age 4. The age range for 9 of the special schools was pupils age 3 to 19. An age range of 3 to 19 is common for special schools in the UK, this includes the full spectrum of key stages from foundation phase to key stage 5. Although it is usual for pupils to begin to follow 'vocational pathways' from key stage 4, the core subjects of literacy, numeracy, and ICT continue to form an essential part of the curriculum for these pupils until they leave school at 19. This being the case it was felt essential that where possible the age range of participants for this study should be just as diverse. Although the New Salford Reading Test

states that it ‘gives reading ages up to 11 years 3 months with the provision of standardised scores for less able readers to age 13 for reading and 14 for comprehension, it is common practice (known to the researcher as a special school practitioner) for the test to be used across all age ranges in a special school setting. The reason being, in an additional learning needs setting, the cognitive age of pupils is usually much lower than their chronological age.

From the 11 schools in the South Wales area, a total of 103 participants (90 males and 13 females) were recruited. The participants with autism had been diagnosed by a paediatrician, independent from this study, using DSM-IV criteria. Participation in the study was based on availability. The schools involved were given the remit of identifying pupils who could possibly be readers or emerging readers. This was based on the class teachers opinion informed by formative classroom assessment and/or summative assessment procedures employed by the school. Participants were allocated to one of three groups, depending on the information provided by the school. Schools were asked to state for each participant information they had regarding the diagnosis for each participant and whether the participant was considered to be verbal or non-verbal. It was important that schools provide this information as in practice it would be the school’s definition that influences the educational provision for the child. Participants were then assigned to one of the three groups: non-verbal ASD (NVASD), verbal ASD (VASD), or non-ASD (NASD). All participants in the non-ASD group were verbal. All participants experienced the same conditions, however, with each group, the participants were divided as equally as possible in terms of whether they would do the traditional paper-based test (NSRT) format or one of the modified versions first. Assignment to these groups was random. Participants were also divided as equally as possible in terms of which reading test forms would be completed. Assignment to these groups was random.

Table 3.1 provides an overview of all groups, including chronological age range, overall IQ, verbal IQ and nonverbal IQ (Wechsler’s Abbreviated Scale of Intelligence, WASI; Wechsler, 2011), diagnosis as provided by the school and Autism Behavior Checklist (ABC) scores (Krug, Arick, & Almond, 2008).

**Table 3.1**

*An Overview of all Participants Included in the Study*

| Group Name | Verbal ASD | Nonverbal ASD | Non ASD |
|---|---|---|---|
| Group Total | 31 | 40 | 32 |
| Males | 29 | 35 | 26 |
| Females | 2 | 5 | 6 |
| Mean Chronological Age | 147 months (12yrs 3 mts. ) SD ± 36.05; range = 90 - 225 | 140 months (11yrs 8 mts.) SD ± 42.22; range 72 – 217 | 128 months (10 yrs 8 mts.) SD ± 34.15; range 66 - 196 |
| Diagnosis | ASD | ASD | Down Syndrome (5) Moderate Learning Difficulties (24) Severe Learning Difficulties (3) |
| Median IQ (overall) | 62 (SD ± 13.95) | 49 (SD ± 9.09) | 58 (SD ± 9.74) |
| Median Verbal IQ | 57 (SD ± 19.22) | 45 (SD ± 5.15) | 59 (SD ± 9.39) |
| Median Nonverbal IQ | 67 (SD ± 12.63) | 53 (SD ± 12.32) | 59 (SD ± 12.56) |
| Median ABC | 98 (SD ±17) | 102 (SD ± 20.75) | 62 (SD ± 7.50) |

**Table 3.2**

*Results from Kruskal-Wallis Performed for Verbal IQ, Nonverbal IQ, and ABC Scores for all Three Groups of Participants.*

| | Verbal IQ | Nonverbal IQ | ABC |
|---|---|---|---|
| KWT | $X^2(2) = 36.86$, $p < .001$ | $X^2(2) = 18$, $p < .001$ | $X^2(2) = 49.3$, $p < .001$ |
| Post hoc | NVASD p<.005 | VASD p<.005 | NASD p<.005 |

### 3.3.2 Materials

***Wechsler Abbreviated Scale of Intelligence*** (WASI; Wechsler, 2011) was used to determine IQ scores through administering four subtests: vocabulary and similarities which make up the verbal element of the test and block design and matrix reasoning, which make up the nonverbal element**.**

For the block design, the examinee was shown constructed models from the stimulus book provided and the requirement was to re-create the design within specified time limits. For the matrix reasoning element of the test, the examinee was shown an incomplete matrix or series from the stimulus book provided and asked to select the response option that would complete the matrix or series. For both these elements of the test, no verbal response was required.

The vocabulary subtest consisted of 31 items, including 3 picture items and 28 verbal items. For the picture items, the requirement was for the examinee to name the pictures displayed from the stimulus book provided with the test. Considering that the definition for non-verbal participants used in the study i.e. 'a population of children who are of or above school age but have little, or no, expressive spoken language abilities used spontaneously for the purpose of communication, (Plesa Skwerer et.al. 2015) did not rule out the possibility that some non-verbal participants may have some words. It was assumed likely that some of these participants would also be able to engage with this naming element of the test. However, for the 28 verbal items that followed, the examinee would be expected to provide definitions for words read to them by the examiner. Therefore, this section of the test would not be accessible to the non-verbal participants. For the similarities element of the test, the examinee was presented with pictures or two words that represent common objects or concepts and asked to describe how they are similar. This section of the test would therefore not be accessible to the non-verbal participants.

In recognition that the verbal IQ element of the test would require verbal responses beyond those of which our non-verbal participants would be capable of providing, additional care would be needed in interpreting any verbal IQ result comparisons. Therefore, verbal IQ and nonverbal IQ were controlled for separately when comparing reading test results.

For the WASI IQ test, verbal and nonverbal results are combined to give a score for overall cognitive ability. The mean of the overall scores was 56.57 (12.64 SD). In terms of reliability, the alpha of the revised scale was recorded at .81 (Wechsler, 2011).

***Autism Behavior Checklist*** (Krug, Arick & Almond, 2008) was completed by teachers of the participants. Four items on the ABC relating to behaviours that teachers would be unlikely to have knowledge of were discounted, and this was reflected in the calculations of the score. These related to behaviours which may have been in evidence prior to the child starting school and would not be appropriate (due to the now age of the student) for the teacher to test:

Does not (or did not as a baby) extend arms to an adult who has reached out to pick him/her up

Is (or was as a baby) stiff and hard to hold

Doesn't cling to an adult when held

Has or had difficulties in learning to use the toilet

Further, as the main focus of the study was the inclusion of participants who are non-verbal, items also discounted were those where the statement could only be true if the participant had speech. Again, calculations were adjusted accordingly. There were five of these items:

Reverses pronouns (e.g., uses "you" for "I")

Speech has a flat tone, little rhythm, and unusual rate

Repeats phrases over and over again

Repeats sounds or words over and over again

Echoes (repeats questions or statement made by others

Therefore, the calculations were adjusted from 47 possible to 38 counted. In terms of reliability, the alpha of the revised scale was .80. (Krug et al., 2008). Items used in the test can be seen in appendix I.

***New Salford Reading Test*** (NSRT; McCarty & Lallaway, 2012) consists of three forms, each made up of 17 sentences (appendix B). The forms are equally graded in terms of word reading difficulty. The words increase in difficulty as the student reads through the test. On the sixth error, the test is stopped, and the reading

age determined by cross-referencing the 6th incorrectly read word on the scoring form with the reading age cited below it. Included in the sentences are words that are 'not counted'. Words that are not counted, are words that are not used to determine a reading age but have been inserted into the test to provide the sentence with structure. There are a total of 114 counted words in the test. The New Salford Reading Test is designed for use in schools that would likely deliver the test year on year to the same students. Therefore, the forms are alternated when delivered to avoid practise effects. Therefore, three forms in total are available, labelled as 'a', 'b', and 'c'. Only one form, therefore, was needed to be delivered to each participant. The forms are equally graded. In terms of reliability, the alpha of the revised scale was .97 for this sample.

***Modified Word Recognition Test***. The NSRT was modified (appendix B & D) by the researcher for the purposes of this study. The counted words were taken from the test as a context-free word recognition items presented as a multiple-choice test. The words were presented on PowerPoint slides, for use with either a desktop computer, iPad, or tablet. Multiple-choice was a necessary adjustment to facilitate non-verbal responses. On each slide, there was an equal number of incorrect answers available as there were correct. As an example, if the sentence in the NSRT contained 4 counted words, the slide would contain those four counted words with four incorrect words, so a total of 8 words on the slide. Appendix D shows the multiple-choice alternatives for each sentence. To ensure that the incorrect answers had the same grade of difficulty as the correct answers, these words were also taken from the NSRT. Each slide represented one sentence of the test, therefore there were 17 slides in total. There is a total of 114 counted words in the test. To score the test, the same NSRT score sheet which was used for the paper version of the test was used for the modified version. Therefore, on the sixth error, the test was stopped, and the reading age determined by cross-referencing the 6th incorrectly read word on the scoring form with the reading age cited below it. In terms of reliability, the alpha of the revised scale was .96 for this sample.

***Modified word recognition test with eye gaze facility*.** The test materials used for the eye gaze word recognition test were the same as those used for the modified test (appendix B). However, as opposed to touch screen facility, a Tobii

Eye Tracker (4C) was connected via USB port to a school laptop computer. This enables the Eye Tracker software provided with the device to track the gaze of the eyes i.e. any eye movements will move the cursor on the screen, tracking head and eye simultaneously. The Tobii Eye Tracker (4C) is provided with 'track status' software which is used to determine the optimum distance and angle for the user and a brief calibration test to ensure the eye gaze is being tracked accurately. In terms of reliability, the alpha of the revised scale was .98 for this sample.

***Listening comprehension test.*** A modified version of the NSRT reading comprehension test was produced by the researcher for the purposes of this study. Information relating to this test is provided in the materials section of chapter 4 of this thesis.

### 3.3.3 Procedure

All assessments were conducted within the school environment as part of the pupils' routine programme of study, by the researcher who, as a qualified teacher, has many years of experience teaching children with ASD. Assessments were carried out over a period of three days, sometimes two, if the participant was particularly able with the tests. Usually, these days were consecutive, however, where this was not possible (due to attendance for example), all tests were carried out within a two-week window. Before the start date of testing, teachers of participants were asked to complete the ABC checklist and the scores were calculated. In the first test sitting with each pupil, IQ scores were obtained by the researcher who is experienced in administering the WASI.

The reading tests were then administered, also by the researcher, in a second and third sitting over the course of two days. All participants experienced the same conditions, however, with each group, the participants were divided as equally as possible in terms of whether they would do the traditional paper-based test (NSRT) format or one of the modified versions first. Therefore approximately one-third of participants received the tests in the order of NSRT (S), modified test (m) and modified test with eye gaze (e), one third received the tests in order of modified, eye

gaze and NSRT and one third in order of eye gaze, modified and NSRT. Assignment to these groups was random.

**Table 3.3**

*An Overview of the Order in which the Tests were Delivered*

| | Test Order | | |
|---|---|---|---|
| Group | sme | mes | esm |
| NASD | 11 | 11 | 10 |
| NVASD | 13 | 13 | 14 |
| VASD | 11 | 10 | 10 |

Participants were also divided as equally as possible in terms of which reading test forms (a, b, or c) would be completed. Assignment to these groups was random. Table 3.4. provides an overview of the forms that were allocated to each group.

**Table 3.4**

*An Overview of Test Form Allocation for Each Group*

| | Form Order | | |
|---|---|---|---|
| Group | abc | bca | cab |
| NASD | 11 | 10 | 11 |
| NVASD | 13 | 14 | 13 |
| VASD | 11 | 10 | 10 |

All tests were administered in the same environment each time. In the interests of promoting 'good practice,' there was nothing in either test to communicate to the participant whether their answers were correct or incorrect.

For the NSRT version of the test, the participants were presented with any of the forms from the available selection of forms a, b and c and asked to read the sentences aloud. Whenever the participant misread a word, a note was made on the form, and once the 6th error was made the test was terminated. In line with procedures for the NSRT, if a participant was unable to read the first word for which

a reading age was shown on the record sheet, a score of 0 was recorded (McCarty & Lallaway, 2012, 2012, p.9). If a participant read a word incorrectly but spontaneously corrected the mistake, this was not counted as an error. However, if a participant was unable to produce a word after 6 seconds, the researcher would supply the correct word and record this as an error.

The modified version of the test was carried out with the multiple-choice options being shown on the screen and the NSRT recording sheet being completed in the same way as it had been for the NSRT version; the rules for determining errors were also the same. Individual scores for all participants are shown in Appendix G. The counted words were presented as context-free word recognition items using PowerPoint slides. Depending on the space available in each school, the test was usually delivered using a desktop or laptop computer with a touch screen facility, or an iPad or tablet no smaller than an iPad 2 model (1024x768).

Starting at the first sentence on the form, the researcher would give the instruction "show me [word from the sentence]. For example, from form a, the first instruction would be "show me my" as 'my' is the first counted word in the first sentence. The second would be "show me pen" and so on and so forth, working through each counted word and each sentence in the form. The participant was expected to then point to what they believed to be the corresponding words on the screen. If the participant gave no response, the researcher would change the instruction to "point to" or "where is" to ensure the participant understood the instruction. When the participant touched a word on the screen, there was no response elicited from the screen to indicate whether or not the response was correct or incorrect. In line with the guidance from the NSRT manual, if a participant identified a word incorrectly but spontaneously corrected the mistake, this was not counted as an error. If a participant was unable to identify a word after 6 seconds, the researcher pointed to the correct word and moved on with the test. Once the participant made their $6^{th}$ error the test was stopped. The errors were marked on the NSRT scoring sheet which determined the 'reading age' of the participant. In line with procedures for the NSRT, if a participant was unable to read the first word for which a reading age was shown on the record sheet, a score of 0 was recorded (NSRT; (McCarty & Lallaway, 2012). As the aim of the current study was to

explore context-free word recognition, scores were recorded as word recognition scores (WRS) and not reading ages.

For the modified version of the test with eye gaze facility, the tracking status box was open on the screen, and participants' seating adjusted to ensure that they were sat at the correct angle and distance from the screen. The calibration test was then run to ensure that the participant's gaze was being accurately tracked. Following this, the PowerPoint with the multiple-choice options were presented on the screen and the NSRT recording sheet was completed in the same way as it would be for the NSRT version; the rules for determining errors were also the same. The participant was instructed to 'only look' at the word on the screen that they believed to be the words on the screen which corresponded with those being read out by the researcher. If the participant gave no response, the researcher would change the instruction to "where is" to ensure the participant understood the instruction. The words were selected using a 'dwell time' with the duration set using the eye tracker settings facilities to 800 milliseconds. This meant that after the participant rested their gaze on a word a circle would begin to appear and then be drawn on the tile (see appendix B for screenshot). The tab would then enlarge slightly and then revert to size and a small sound 'click' sound was emitted from the laptop, indicating that the word had been selected. These effects were achieved using basic PowerPoint animation effects. The sound emitted was the same whether the answer was correct or not. A correct mark was allocated when participants correctly selected the target word. However, if a participant was unable to detect a target word, or fixated on the incorrect word, this was counted as an error. In line with the NSRT procedures, the test was stopped after the participant made a sixth error. No feedback was given regarding the accuracy of the response in both parts of the study, but all participants were praised and thanked for their participation.

Procedures and results for the listening comprehension test can be found in chapter 4 of this thesis.

## 3.4 Results

### *Results for word recognition (calculated using NSRT) materials*

To test for possible impact that order of test delivery may have on performance for the modified test, we performed a one-way ANOVA with test delivery order as the independent variable and test result as the dependent variable. There was no significant effect for the modified test, $F(2,102) = .82$, $p=.443$, $\eta^2_p = .016$.

To test for possible impact that order of test delivery may have on performance for the eye-gaze test, we performed a one-way ANOVA with test delivery order as the independent variable and test result as the dependent variable. There was no significant effect for the test modified for use with eye-gaze facility, $F(2,102) = .29$, $p=.75$, $\eta^2_p =.006$.

To test for the possible impact that form allocation may have on performance for the modified test, we performed a one-way ANOVA with form allocation as the independent variable and test result as the dependent variable. There was no significant effect for the modified test, $F(2,102) = .86$, $p=.4$, $\eta^2_p =.017$.

To test for the possible impact that form allocation may have on performance for the eye-gaze test, we performed a one-way ANOVA with form allocation as the independent variable and test result as the dependent variable. There was no significant effect for the test modified for use with eye-gaze facility, $F(2,102) = .51$, $p=.6$, $\eta^2_p =.010$.

Therefore, as far as can be interpretated from the data above, there was no impact of test order delivery or form allocation on results.

***Figure 3.1***

*Mean Word Recognition Scores for all Three Groups for all Three Conditions of Word Recognition Test. Error bars = standard error.*

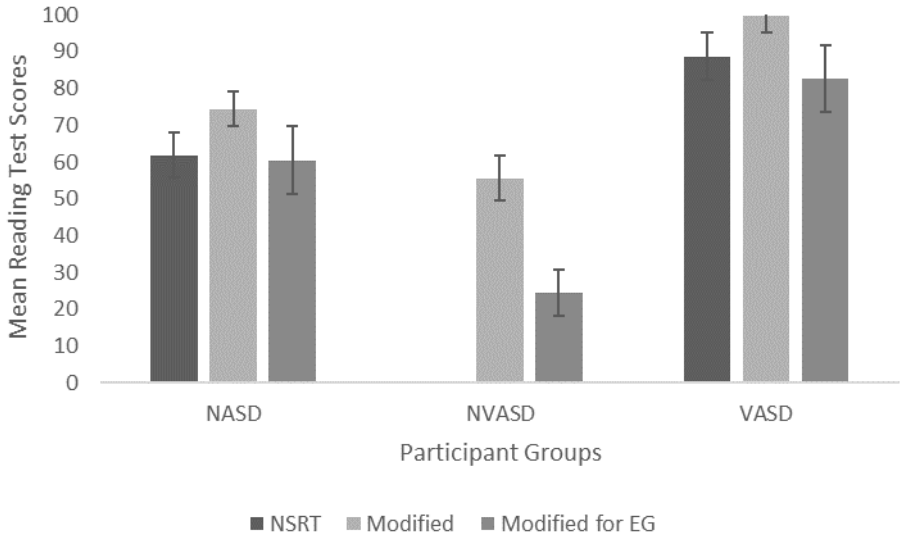



Figure 3.1 shows the raw mean WRS's for all three groups in the NSRT condition, the modified test condition, and the modified test delivered with the eye gaze condition of the test. When compared to the NSRT version of the test, all three groups showed improvement when using the modified test format presented on touchscreen. However, this improvement was most pronounced for the non-verbal ASD group, who did not score on the paper-based version of the test. The results for the eye- gaze tracking version of the test when compared to the paper-based version, were improved for the non-verbal ASD group. However, the verbal ASD group, and the non-ASD group, demonstrated a decrease in score when accessing this format of the test. The scores for the modified test, when compared to the eye gaze tracking version of the test, were again improved for all three groups. However, this was most pronounced for the non-verbal ASD group.

To compare the performance of the verbal groups for all three test formats a 2 (Participant Group: verbal ASD, non-ASD) x 3 (Test Format: NSRT, Modified, Eye-Gaze) ANCOVA was conducted, controlling for verbal IQ, nonverbal IQ, and chronological age of participants. There was no significant main effect of group $F(1,58) = 3.67$, $p = .06$, $\eta^2_p = .060$. There was no significant main effect of test $F(1,58) = 1.96$, $p = .167$, $\eta^2_p = .033$, and no significant interaction $F(1,58) = 1.06$, $p = .307$, $\eta^2_p = .018$.

A 3 (Participant Group: verbal ASD, non-ASD, non-verbal ASD) x 1 (Test Format: modified), controlling for verbal IQ, nonverbal IQ and chronological age of participants revealed a significant main effect on the groups $F(2,102) = 11.69$, $p<.001$, $\eta^2_p = .194$. Tukey's Honestly Significant Difference (HSD) test revealed that there were no reliable pairwise differences between the groups.

The introduction of the data for the performance of the non-verbal ASD group on the modified test had a significant effect, and due to the large difference in the means for the groups, this was an expected result. However, in order to provide an explanation for result from the Tukey's post hoc test, which would not have been predicted, further analysis was required. To test the possibility that the inclusion of verbal IQ may be skewing the data, as the majority of those in the non-verbal ASD group were at floor level for this test, the analysis was performed again with this covariate removed. There was a significant main effect of test on the groups, $F(2,102) = 10.9$, $p <.001$, $\eta^2_p = .182$. Tukey's HSD revealed no significant difference between the non-ASD group and the verbal ASD group, but a significant difference between the non-verbal ASD group and each of the other two groups, $p < .001$.

A 3 (Participant Group: verbal ASD, non-ASD, non-verbal ASD) x 1 (Test Format: Eye-Gaze), controlling for verbal IQ, nonverbal IQ, and chronological age of participants was conducted. There was a significant main effect of test on the groups, $F(2,102) = 6.03$, $p = .003$, $\eta^2_p = .111$. Tukey's HSD revealed no significant difference between the non-ASD group and the verbal ASD group, but a significant difference between the non-verbal ASD group and each of the other two groups, $p < .005$.

**Table 3.5**

*Pearson Correlation Performed for All Three Test Formats (NSRT, Modified, Eye-Gaze)*

| | NSRT | Eye-Gaze | Modified |
|---|---|---|---|
| NSRT | 1 | .762 | .765 |
| Eye-Gaze | .762 | 1 | .847 |
| Modified | .765 | .847 | 1 |

As shown in table 3.5 correlations between the traditional paper-based test (NSRT) and the modified tests (modified, eye-gaze) were large and positive.

**Table 3.6**

*Numbers of Individual Participants who Met Criteria for Clinically Significant and Reliable Change when Comparing their Performance for the Paper-Based Test and the Modified Format*

| **Group** | **Threshold** | | **Clinically Sig. Change** | **Reliable Change (pos.)** | **Reliable Change (neg.)** |
|---|---|---|---|---|---|
| | **CS** | **RC** | | | |
| **Non-ASD N=32** | 88.42 | 41.68 | 7/32 | 6/32 | 1/32 |
| **Verbal ASD N=31** | 96.68 | 43.96 | 14/31 | 3/31 | 0/31 |
| **Non-verbal ASD N=40** | 6.25 | 1.21 | 30/40 | 30/40 | 0/40 |

Analysis was carried out on the data to determine the extent of clinically significant and reliable change for each individual participant. First introduced by Jacobson, Follette, and Revenstorf (1984), for use with patients undergoing psychotherapy, this method offers a way to summarise changes in the level of the individual in the context of the observed changes for the whole sample. Reliable Change (RC) is about whether performance changed sufficiently that the change is unlikely to be due to simple measurement unreliability. We determined who had changed reliably (i.e. more than the unreliability of the measure would suggest might happen for 95% of subjects) by seeing if the difference between the modified test

scores and initial NSRT scores were more than a certain level. That level was a function of the initial standard deviation of the measure and its reliability. For reliable change, the mean and standard deviation for each group were taken and the level of reliable change calculated using an online calculator (Evans, 1998; https://www.psyctc.org/stats/rcsc.htm). We then looked at the scores for each individual participant for the modified version of the test to ascertain if the change observed met the criteria for reliable change in either a positive or negative direction.

Clinically significant change is a change that has taken the person from a score typical of a 'problematic' user group to a score typical of the 'normal' population. Jacobson, Follette & Ravenstorf (1984) offer three different methods of working this out. Details of the three individual methods proposed can be found on the website:
http://www.psyctc.org/stats/rcsc.htm. For clinically significant change, we used the calculator on this website, and following the procedure for criterion 'c' (has the participant moved to the 'normal' side of the point halfway between the 'problem group' and the 'normal group'?) we took the mean and standard deviation for the paper version of the test and the scores of '100' and '15' to represent a normative sample. We then looked at each individual participant's score for the digital version of the test to ascertain if the change observed met the criteria for clinically significant change.

Table 3.6 shows the numbers of individual participants meeting criterion for clinically significant change, and for reliable change. With regard to clinically significant change, 75% of the non-verbal ASD group met the criterion. This figure was 45% for the verbal ASD group, and 22% for the non-ASD group. This data was analysed using a chi-square, which demonstrated a significant difference between the three groups $X^2(2) = 39.92$, $p < .001$. With regard to reliable change, 75% of the NVASD group met the criteria for reliable change in the positive direction. This figure was 10% for the VASD group and 19% for the NASD group with 1 participant (3%) meeting criteria for reliable change in the negative direction in this group. This data was analysed using a chi-square, which was significant $X^2(2) = 59.63$, $p < .001$.

***Results using percentages of words correct (PWC)***

Before carrying out analysis using percentages of words identified correctly, all participant's scores were corrected for guessing. The formula used in order to correct for guessing (Espinosa & Gardeazabal, 2010) was corrected = #correct – (#wrong/#options -1).

To replicate the procedure for the traditional paper-based version of the test as closely as possible, when designing the modified multiple-choice version of the test, each slide on the PowerPoint represented 1 sentence from the forms on the test. Each sentence of the traditional test has a number of "counted words" (NSRT; McCarty & Lallaway, 2012) with additional words that provide context so that words can be read as sentences. For the modified version of the test, we were measuring context-free word recognition, therefore only the counted words were included in the test. For each word correct, an incorrect answer was provided**.** There are a total of 17 sentences in the NSRT, each with a different number of counted words. The further the participant gets into the test, the more difficult the words become, and generally, the longer the sentences get. Table 3.7 shows the number of counted words and incorrect words for each slide of the modified reading test.

**Table 3.7**

Numbers of Counted Words and Incorrect Words for Each Slide of the Modified Test

| Slide Number | Total of counted words | Total of incorrect word choices | Total number of words on each slide | | Counted words in corresponding NSRT sentence |
|---|---|---|---|---|---|
| 1 | Shows instructions for the examiner | | | | |
| | | | Slide total | Running total | |
| 2 | 4 | 4 | 8 | 8 | 4 |
| 3 | 4 | 4 | 8 | 16 | 4 |
| 4 | 5 | 5 | 10 | 26 | 5 |
| 5 | 4 | 4 | 8 | 34 | 4 |
| 6 | 6 | 6 | 12 | 46 | 6 |
| 7 | 7 | 7 | 14 | 60 | 7 |
| 8 | 8 | 7 | 14 | 74 | 7 |
| 9 | 9 | 9 | 18 | 92 | 9 |
| 10 | 8 | 8 | 16 | 108 | 8 |
| 11 | 8 | 8 | 16 | 124 | 8 |
| 12 | 8 | 8 | 16 | 140 | 8 |
| 13 | 8 | 7 | 14 | 154 | 7 |
| 14 | 8 | 8 | 16 | 170 | 8 |
| 15 | 8 | 7 | 14 | 184 | 7 |
| 16 | 8 | 7 | 14 | 198 | 7 |
| 17 | 8 | 8 | 16 | 214 | 8 |
| 18 | 7 | 7 | 14 | 228 | 7 |
| Totals | 114 | 114 | 228 | 228 | 114 |

From this table and bearing in mind that the test is stopped on the 6$^{th}$ error the participant makes, we can see that probability of a participant being able to guess the correct word is dependent on how far they get through the test. Therefore, when making corrections for guessing, each participant's corrected score was calculated and adjusted individually. To do this, rather than a 'reading age' calculation aligned with the scoring system in the traditional paper-based version of the NSRT, we calculated percentage scores based on the number of words chosen correctly for each participant. This amount was then adjusted using the correction for guessing formula, based on the average of words per slide to the point in the test was that reached.

To test for possible impact that order of test delivery may have on performance for the modified test, we performed a one-way ANOVA with test delivery order as the independent variable and test result as the dependent variable. There was no significant effect for the modified test, $F(2,102) = .75$, $p=.47$, $\eta^2_p = .015$

To test for possible impact that order of test delivery may have on performance for the eye-gaze test, we performed a one-way ANOVA with test delivery order as the independent variable and test result as the dependent variable. There was no significant effect for the test modified for eye-gaze, $F(2,102) = .65$, $p = .52$, $\eta^2_p = .013$

To test for possible impact that form allocation may have on performance for the modified test, we performed a one-way ANOVAs with form allocation as the independent variable and test result as the dependent variable. There was no significant effect for the modified test, $F(2,102) = .83$, $p=.44$, $\eta^2_p = .016$

To test for possible impact that form allocation may have on performance for the eye-gaze test, we performed a one-way ANOVA with form allocation as the independent variable and test result as the independent variable. There was no significant effect for the test modified for eye-gaze, $F(2,102) = .84$, $p=.44$, $\eta^2_p = .016$.

Therefore, as far as can be interpretated from the data above, there was no impact of test order delivery or form allocation on results.

***Figure 3.2***

*Mean Percentages of Words Correctly Identified for all Three Groups for all Three Conditions of Word Recognition Test. Error bars = standard error.*

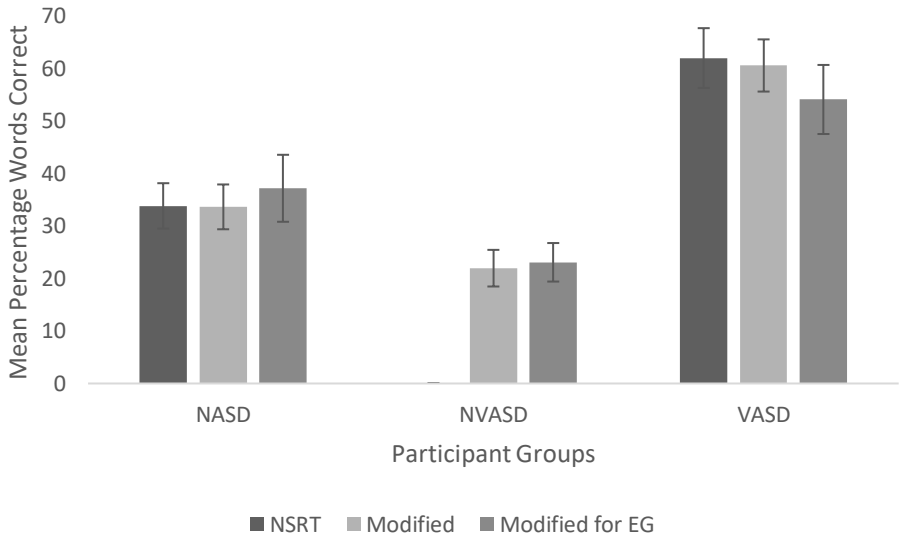



Figure 3.2 shows the raw mean PWC's for all three groups in the NSRT condition, the modified test condition, and the modified test delivered with the eye gaze condition of the test. When compared to the NSRT version of the test, all three groups showed improvement when using the modified test format presented on touchscreen. However, this improvement was most pronounced for the non-verbal ASD group, who did not score on the paper-based version of the test. For the non-verbal group and the non-ASD group, there was improvement when accessing the eye gaze tracking version of the test. However, for the verbal ASD group, there was a decrease in score.

A 3 (Participant Group: verbal ASD, non-ASD, non-verbal ASD) x 3 (Test Format: NSRT, modified, eye-gaze) ANCOVA was conducted on these data, controlling for verbal IQ, nonverbal IQ, and chronological age of participants. There was a significant main effect of group, $F(2,97) = 17.03$, $p < .001$, $\eta^2_p = .260$, no

significant main effect of test, $F(1,97) = 1.33$, $p = .251$, $\eta^2_p = .014$, and a significant effect, $F(2,97) = 8.94$, $p < .001$, $\eta^2_p = .148$.

Simple effects analysis showed that there was no difference in the word recognition performance as measured by the three tests for the non-ASD group, $F(1,32) = .19$, $p = .666$, $\eta^2_p = .030$, or for the verbal ASD group, $F(1,30) = 1$, $p = .325$, $\eta^2_p = .099$. However, there was a significant difference between the tests for the non-verbal ASD group, $F(1,39) = 4.44$, $p < .05$, $\eta^2_p = .290$.

The simple effect of group for the NSRT was significant and large-sized, $F(2,102) = 35.51$, $p < .001$, $\eta^2_p = .581$. Tukey's Honestly Significant Difference (HSD) test revealed a significant difference between all pairwise comparisons of the groups, $p < .001$. The simple effect of group for the modified test was significant, but smaller sized, $F(2,102) = 12.27$, $p < .001$, $\eta^2_p = .282$. Tukey's HSD test revealed that there was no significant difference for the non-ASD and non-verbal ASD groups, but a significant difference between the verbal ASD group and the other two groups, $p < .001$. The simple effect for the group using the modified test with eye gaze was also significant, but smaller sized, $F(2,102) = 14.54$, $p < .001$, $\eta^2_p = .216$. Tukey's HSD revealed no significant difference between the non-ASD group and the non-verbal ASD group, but a significant difference between the verbal ASD group and each of the other two groups, $p < .05$.

**Table 3.8**

*Pearson Correlation Performed for All Three Test Formats (NSRT, Modified, Eye-Gaze)*

| | NSRT | Modified | Eye-Gaze |
|---|---|---|---|
| NSRT | 1 | .800 | .762 |
| Modified | .800 | 1 | .806 |
| Eye-Gaze | .762 | .806 | 1 |

As shown in table 3.8 correlations between the traditional paper-based test (NSRT) and the modified tests (modified, eye-gaze) were large and positive.

**Table 3.9**

*Numbers of Individual Participants who Met Criteria for Clinically Significant and Reliable Change when Comparing Percentages of Words Correct for Paper-Based Test and the Modified Test Format*

| Group | Threshold | | Clinically Sig. Change | Reliable Change (pos.) | Reliable Change (neg.) |
|---|---|---|---|---|---|
| | CS | RC | | | |
| **Non-ASD N=32** | 76.68 | 30 | 1/32 | 0/32 | 0/32 |
| **Verbal ASD N=31** | 87.90 | 39.80 | 7/31 | 0/31 | 0/31 |
| **Non-verbal ASD N=40** | 6.25 | 1.21 | 36/40 | 40/40 | 0/40 |

Table 3.9 shows the numbers of individual participants meeting criterion for clinically significant change, and for reliable change. Regarding clinically significant change, 90% of the non-verbal ASD group met the criterion. This figure was 22% for the verbal ASD group, and 3% for the non-ASD group. This data was analysed using a chi-square, which demonstrated a significant difference between the three groups $X^2(2) = 169$, $p < .001$. With regard to reliable change, 90% of the NVASD group met the criteria for reliable change in the positive direction. Participants in the verbal ASD group and the non-ASD group did not meet criteria for reliable change. This data was analysed using a chi square, which was significant $X^2(2) = 208$, $p < .001$.

## 3.5 Discussion

The aim of the current study was to compare the context-free word recognition performance of children with ASD who are non-verbal, to those of children with ASD who are verbal and children without ASD who are verbal, using the traditional paper-based New Salford Reading Test and a modified multiple-choice version of the test, which eliminated the requirement to verbalise words being recognised. In the interests of accessibility, the modified version of the test was presented using touchscreen and eye gaze tracking facility.

Verbal and nonverbal intelligence quota (IQ) scores and age were included as covariates in all analyses. Analysis to detect the possible impact of order of test delivery or reading test form used showed no test form or order effects in any of the test conditions for any of the participant groups.

When word recognition results for the verbal ASD group and the non-ASD group were analysed, no significant differences were found between performances using the traditional paper-based NSRT and the modified tests. However, once scores were introduced for the non-verbal group, who were unable to score at all on the paper-based version of the test, results became significant.

Analysis of percentages of words correct for all three groups offered further support for these results. Further, floor effects for the paper-based version of the test for the non-verbal group were then eradicated. This is because we were able to include the total of words correctly identified in this analysis. Whereas, when we calculated scores using the NSRT materials, which calculates scores below 4 years 5 as non-readers, a score of zero was entered for those who recognised some words but did achieve a ‘reading age’ equal to or above 4 years 5 months.

Results for clinically significant and reliable change offered further support for the view that once we remove the requirement for verbalisation, the non-verbal ASD group were able to demonstrate word recognition skills.

When analysing results using ‘reading ages’ as calculated by the NSRT only the non-verbal ASD group showed improvement when compared to the traditional paper- based test for the modified test with eye gaze tracking facility. However, the

other two groups demonstrated a decrease in score. When looking at the percentage of words correct for the test, only the verbal ASD group score decreased, while the other two groups showed improvement.

This could be attributed to a limitation in a design of the study, as we didn't factor in the possible effect that lack of familiarity with the eye gaze tracking facility could have. Some participants found it difficult to understand that the researcher was able to know their answer when they were making no other movements than with their eyes. As a result, some participants attempted to point to the answers or touch the screen and appeared to find it off-putting when it was pointed out that this wasn't necessary. Some participants who are verbal, pointed out that they found this version of the test 'hard on the eyes' as they seemed to interpret the instruction to 'only look' and 'not point', as requiring increased concentration to complete the test. A disadvantage which has been identified with eye gaze tracking, is data loss (Plesa-Skwerer et al, 2016). This can occur when the eye tracking device fails to report the eye gaze position. This can be a calibration issue, which is usually easy to fix by recalibrating the device, or it can occur when a participant is looking outside the tracking area, usually a computer screen. This is more likely to occur when a participant has difficulty in understanding that the responses on the screen are being performed through their eye gaze. Therefore, a practise test to help acclimate participants to the eye gaze facility could be a valuable inclusion for future studies. A follow up study to examine the impact of acclimatisation with the eye gaze tracking facility could also provide further useful information with regards to how this should be carried out.

The correlations between the paper-based and modified tests indicated that there was concurrent validity between the modified and paper-based test. These results would imply that when considering the abilities of children with ASD who are non-verbal, we cannot rule out word recognition ability, even if these children are considered to be 'low functioning'.

While we may not deem the word recognition ability demonstrated by this group with ASD who are non-verbal 'reading', as there was no measure of understanding, it is nevertheless of import. Gough and Tumner (1986) argue that

word recognition as part of decoding ability is a necessary element of the reading process. There would therefore be implications here for classroom practice.

Findings have suggested that reading profiles for children with ASD will differ from their peers who are typically developing in a variety of ways. Nation et al. (2006) for example concluded that there were children with ASD in their study whose difficulties with reading comprehension could not be attributed to deficits in word or text level reading accuracy. Smith and Gabig (2010) found that children with ASD performed in a similar way to age-matched peers who are typically developing for sight word identification and decoding of nonwords, but below average scores for phonological awareness. Phonological awareness did not correlate with word identification ability for the ASD group in the study in the way it did for the non-ASD group. Hyperlexia, a term used to describe a condition where decoding ability is often far in advance of chronological age and reading comprehension ability (Snowling & Frith, 1986) is often associated with ASD.

However, as research has focused on the verbal and often 'high functioning' (in terms of language skills) ASD population, it is difficult to find results which are comparable with this current study. This means that while great progress may be being made in terms of the design of classroom reading interventions which are appropriate for children on the autism spectrum, this will not necessarily hold true for those who are also non-verbal.

To make this study accessible to non-verbal participants, it was necessary to convert the test into a multiple-choice format. A more detailed discussion concerning the use of an on screen presentation employing multiple-choice format can be found in the next chapter (chapter 4) of this thesis. To account for the possibility of guessing we adjusted scores using the 'optimal correction for guessing for formula' (Espinosa & Gardeazabal, 2010) when analysing the percentages of words correct. Results all sets of analysis highlight than once we remove the requirement for verbalisation, results are most improved for the non-verbal ASD group.

The implications of the study are clear then, in that not every young person with ASD who is non-verbal will lack an ability to recognise printed words. This means that many children who are non-verbal and on the autism spectrum, may have

the beginnings of a reading skill which is currently undetected. Verbalisation is a common element of reading tests being used in ALN settings, by removing this element, the modified multiple-choice format of assessment used in this study promotes a form of assessment that not only measures the reading ages of children who are non-verbal, but also allows for comparison with their cohorts who are verbal. This is important for the field of special education, as without this, children, and young people with ASD who are non-verbal, will continue to be excluded from interventions which could improve their chances being successful readers in the future.

# CHAPTER 4

## Listening Comprehension Abilities of Children with Autism who are Non-verbal: Extending the analysis of a modified test format

### 4.1 Abstract

Reading without meaning can be a futile and frustrating task, therefore, the ultimate goal of reading is reading comprehension. Listening comprehension skills are a crucial element of reading comprehension but particularly difficult to assess in children who are non-verbal. Children with autism are said to be a high-risk group for reading comprehension deficits, however very little research has been carried out with children who are non-verbal as participants. Most reading tests require verbalisation, which may under-estimate reading ability in this group. To determine listening comprehension abilities of children with ASD who are non-verbal (age range: 5yrs. to 18 yrs.), a modified multiple-choice form of listening comprehension assessment, comparable to the widely used 'New Salford Reading Test' was created to produce a multiple-choice listening comprehension tool. Three groups were tested: verbal ASD ($n$=31) non-verbal ASD ($n$=40); and verbal non-ASD with a statement of special educational needs ($n$=32). For all three groups using the traditional paper-based version of the test, a modified multiple- choice version was presented on touch screen and performance for all three groups compared for both versions of the assessment. The non-verbal group were unable to score using the paper-based version of the test, however, some listening comprehension skills were detected with the modified version. These results suggest that the use of the modified test may offer a good assessment of the listening comprehension abilities of children with ASD who are non-verbal.

## 4.2 Rationale

Reading without meaning can be a futile and frustrating task; therefore, the ultimate goal of reading is comprehension. The reading comprehension abilities of children with autism are far from homogenous (Nation, Clarke, Williams & Wright, 2006). However, there are some recurring themes, which suggest that children with autism spectrum disorders (ASD) will experience barriers to reading comprehension. These barriers can differ, not only from their peers who are typically developing, but also atypically developing peers, who are not on the autism spectrum (Brown, Oram-Cardy & Johnson 2013; Nally, Holloway & Lydon, 2018; Nation, et. al. 2006; O'connor & Klien, 2004; Snowling and Frith 1986; Zuccarello, et al. 2015).

While some children with autism may display reading skills which are aligned to their typically developing peers, others experience difficulties with reading (Cronin 2014; Nation et al., 2006). The nature of these difficulties vary and, for some children with autism, reading is a goal that may never be achieved (Vacca, 2007). Others, however, demonstrate exceptional skills in this area (Grigorenko 2003; Turkeltaub 2004) . Between these two extremes are those that may achieve reading later than their typically developing peers, and children who may acquire some elements of reading, word recognition for example, while experiencing issues with other components, such as comprehension (Nation et al., 2006).

There is much empirical evidence to support the view of reading as an interaction between word decoding and oral comprehension. Lervag, Hulme and Lervag (2018) suggest that without adequate decoding skills, oral language skills and listening comprehension cannot sufficiently be engaged to achieve reading comprehension. Therefore, for good decoders, listening comprehension becomes more predictive of how well they will understand written text. For poor decoders, improvement of decoding skills will lead to a better understanding of text. In their meta-analysis of the relationship between decoding and reading comprehension, Garcia & Cain (2014) found a strong concurrent relationship between decoding and reading comprehension which became weaker in older age groups, when the correlation between listening comprehension and reading becomes stronger.

Poor oral language skills experienced by children with autism, therefore, put them at high risk of encountering difficulties with reading (Bishop & Snowling, 2004; Catts & Kamhi, 2005) . Clarke, Snowling, Truelove and Hulme (2010) suggest that reading comprehension deficits for this population may be improved through the employment of teaching interventions which address underlying oral language weaknesses. High incidents of hyperlexia, a good and even precocious word recognition ability that is accompanied by poor reading comprehension ( Silberberg & Silberberg, 1968) are also found in the autistic population (Grigerenko et al., 2003).

In their study, which included children with autism with and without hyperlexia, Newman (2007) found that children with ASD decoded words by relying on the same phonological processes as typical readers. However, unlike typical readers, the comprehension abilities of children with hyperlexia were not well aligned to their single word recognition skills. However, in their study, Smith and Gabig (2010) found that children with ASD demonstrated below average skills in phonological awareness when compared to age-matched participants who were typically developing. From this study we might assume that since phonemic awareness supports decoding and good decoding supports reading comprehension, poor reading comprehension skills in the ASD population might be connected to their poor phonemic awareness skills.

However, when Nation et al. (2006) compared skilled reading comprehenders with less-skilled, they found similar performance in word recognition (context-free) tasks and nonword recognition tasks which draw on phonological skills. They concluded that, for these children with ASD, reading comprehension deficits could not be attributed to deficits in word or text level reading accuracy but were more aligned to vocabulary skills and language comprehension. When we also consider that, for the children with ASD in the Smith and Gabig (2010) study, phonological awareness did not correlate with word identification ability in the same way it did for the children who were typically developing there could be the suggestion that some children with autism develop the skills necessary to

comprehend words they recognise, without having developed the ability to phonetically decode them (O'Connor & Klein, 2004).

The unique cognitive processing style often seen in children with autism may help to explain the difficulties they experience with listening comprehension and therefore reading comprehension (Carnahan, Williamson & Christman, 2011; El Zein, Solis, Vaughn, McCulley, 2013; Nguyen, Leytham, Schaefer Whitby, & Gelfer, 2015). The three most influential theories in the literature which seek to highlight the unique experiences of the ASD population are: weak central coherence theory (Frith, 1987), the Theory of Mind (ToM) hypothesis (Baron-Cohen, 1995) and Executive Dysfunction Theory (Pennington, 1997).

Weak central coherence is characterised by attention to details rather than the whole which present as difficulties experienced with making the links between details of information and the bigger picture that they relate to (Happé & Frith, 2006). Carnahan, Williamson and Christman (2011) provide the following example of how weak central coherence may impact on reading comprehension for some students with autism:

> "During a reading workshop session, Connor sat listening to a peer read … the story of a young boy, Henry, who visits his aunts … Henry's aunts take him on an adventurous road trip full of stress and learning. However, Connor loses sight of the meaning of the text. He continually wonders aloud 'Where will they go next? I wonder which highway the aunts will choose. What is the average speed limit?' … When his classmates talk about the frustration Henry felt, Connor talks about directions to each location in the story and the number of miles the family travelled".

There is a range of empirical evidence to suggest that, when reading, children with autism may struggle to integrate information in order to draw meaningful inferences from text (Carnahan et al., 2011; Nuske & Bavin, 2015). It is believed that, among other processes such as those which relate to syntactic understanding (knowledge of grammatical structure) semantics (meaning of text) (Cronin 2014; National & Snowling 2004) and effective use anaphoric cueing

strategies (El Zein et al., 2014), inference and Theory of Mind (ToM) are reliable predictors of good listening comprehension skills (Kim, 2016).

Theory of Mind (ToM) has two components: the ability to understand and recognise that people have different feelings and thoughts and the ability to understand that individual thoughts and feelings influence actions (Baron-Cohen, 1999). ToM deficit can lead to difficulties with understanding the motivations of characters, predicting characters' actions (Carnahan et al., 2011) and displaying only a literal understanding of text, where there is a demand on inferential skills (Norbury, 2005).

There is also evidence that executive dysfunction disrupts literacy skills (Shaul & Schwartz, 2014). Organising, planning and self-monitoring all relate to executive function (Attwood, 2008) and these skills assist us in identifying the purpose of reading and appropriate responses to the salient features of texts. Deficit in executive function has been linked to deficit in reading comprehension (Locascio, Mahone, Eason & Cutting, 2010). Whether the role is direct or indirect is not entirely clear, however research suggests that working memory (which comes under the umbrella of executive function) may predict listening comprehension skills (Kim 2004; Swanson 1999). A further consequence is that without effective self-monitoring strategies, a reader is likely to read without 'checking' their understanding of the text (Carnahan et al., 2011). This becomes evident in the reading behaviours of children who continue to read a text even when their thoughts about the text don't make sense to them. For example, it would be usual for skilled readers to be alerted to errors they make when reading when the mis-read word causes the string of text to no longer make sense. In this situation, good self-monitoring leads to self-correction. However, a child without these skills is likely to continue reading regardless, resulting in poor understanding of the text.

In our previous study (chapter 3 of this thesis) consideration of the word recognition abilities of children with autism focused on children who are non-verbal. There has been a tendency for research to focus on the verbal, and often 'high functioning' (in terms of language skills), ASD population. Very little is known about the reading profiles of children on the autism spectrum who are non-verbal,

due in no small part to the challenges faced carrying out assessments with this cohort (Tager-Flusberg et al., 2017). Approximately 30% of those with Autism Spectrum Disorder (ASD) have little or no spoken language when they reach school age (Plesa Skwerer, Jordan, Brukilacchio, and Tager-Flusberg, 2016). In 2011, the Interagency Autism Coordinating Committee published its strategic plan (US Dept. of HHS & IACC, 2011), in which it was concluded that more research was needed into interventions for the population of people with ASD who are non-verbal. In the light of this report, Tager-Flusberg and Kasari (2013) highlighted the paucity of research relating to this population, specifically referring to minimally verbal children with ASD as the 'neglected end of the spectrum'. In 2016, the Interagency Autism Coordinating Committee recommended the development of more 'teacher-implemented' testing and interventions in school settings (US Dept. of HHS & IACC, 2016).

The results from the previous study (chapter 3) showed that once the requirement for verbalisation was removed from a standardised reading test (NSRT; McCarty & Lallaway, 2012) children with autism who were non-verbal demonstrated context-free word recognition skills. The modified multiple-choice version of the test, created for the purpose of the study, could, therefore, be a reliable way of assessing the word recognition abilities for this cohort.

The aim of the current study seeks to build those results, to determine if a multiple-choice test format, which removes the requirement of verbalisation, can detect listening comprehension skills for children with autism who are non-verbal. Therefore, the groups of participants for this study remained the same as in the previous study. Since multiple-choice format was employed to eliminate the requirement of verbalisation, both the traditional paper-based NSRT and the modified version of the test were presented as listening comprehension tests and were not a test of reading comprehension. As with the previous study, a variety of measures were employed to analyse the results. Results were converted into comprehension scores, as determined by the NSRT materials and adjusted in line with corrections for guessing (Espinosa & Gardeazabal, 2010), then percentages of correct answers were compared. Results were also analysed by measuring clinically significant and reliable change (Jacobson, Follette, and Revenstorf, 1984).

## 4.3 Method

### 4.3.1 Participants

The participants employed in this study were those featured in chapter 3 of this thesis.

### 4.3.2 Materials

*Wechsler Abbreviated Scale of Intelligence* (WASI; Wechsler, 2011) was used to determine IQ scores. Information relating to how this test was used can be found in chapter 3.

***Autism Behavior Checklist* (Krug, Arick & Almond, 2008)** was completed by teachers of the participants. Information regarding how this test was used can be found in chapter 3.

***New Salford Reading Comprehension Test* (NSRT; (McCarty & Lallaway, 2012).** For every sentence successfully read by the examinee in the NSRT (see chapter 3) the publishers have provided two comprehension questions: a literal question and an inferential question. Answers are marked as correct or incorrect on the record form provided and a conversion table provided in the manual which allows the examiner to cross-reference the number of correct answers (regardless of literal or inferential) to receive a calculated "reading comprehension age". The number of questions asked is determined by how many sentences the examinee can successfully read. This means that once the reading test is stopped, the comprehension questions will cease also. Comprehension questions are also not asked for any sentence in which the examinee has made two or more errors when reading.

***Listening comprehension test.*** A modified multiple-choice version of the New Salford Reading Comprehension Test (NSRT; McCarty & Lallaway, 2012) reading comprehension test was produced by the researcher for the purposes of this study (appendix C & E). There are 17 sentences for each form provided in the NSRT and therefore 34 questions. To facilitate a non-verbal response to questions, for each sentence a PowerPoint slide was produced which showed the correct response and an incorrect response for each question. In the interest of limiting

ambiguity when marking responses, the incorrect answer was so incorrect as to be completely implausible in the context of the sentence that had been read and the question asked regarding it. In terms of reliability, the alpha of the revised scale was .96 for this sample.

### 4.3.3 Procedure

Ordinarily, when carrying out the NSRT, the examinee would read each sentence aloud and this sentence would be followed by the two comprehension questions provided for that sentence. These questions would be read out by the examiner and answers marked correct or incorrect. However, for this to be a multiple-choice listening comprehension test that could accommodate non-verbal responses, the comprehension element of the test was not completed until after the reading test element ceased i.e. on the 6$^{th}$ error. At this point, the examiner read through each sentence that had already been successfully read by the examinee and followed this reading by asking the questions provided. The participant was expected to provide the answer to the question using a verbal response. This was the procedure for the traditional paper-based NSRT and as the non-verbal ASD group were not able to access the paper version of the test, only the verbal ASD and non-ASD groups had scores recorded.

For the modified version of the listening comprehension test, the results from the modified multiple-choice word identification test were used. The researcher read each sentence from which the counted words had been taken and successfully identified by the participant. This was followed by the two comprehension questions provided by the NSRT publishers, a correct and incorrect answer to which was displayed on the touch screen. The researcher read aloud each choice and pointed to it. The participant was expected to use the touch screen to select the answer which he/she believed was correct. The modified version of the test was delivered to all three groups of participants.

All tests were administered in the same environment each time. In the interests of promoting 'good practice,' there was nothing in either test to communicate to the participant whether their answers were correct or incorrect.

## 4.4 Results

***Results calculated using NSRT materials***

To test for the possible impact that order of test delivery may have on performance for the modified test, we performed a one-way ANOVA with test order delivery as the independent variable and test result as the dependent variable. There was no significant effect for the modified test**,** $F(272,102) = 1.15$, $p=.32$, $\eta^2_p = .023$.

To test for the possible impact that form allocation may have on performance for the modified test, we performed a one-way ANOVA with form allocation as the independent variable and test result as the dependent variable. There was no significant effect for the modified test, $F(2,102) = .93$, $p=.4$, $\eta^2_p = .018$.

Therefore, as far as can be interpretated from the data above, there was no impact of test order delivery or form allocation on results.

***Figure 4.1***

***Mean Scores for All Three Groups for Both Paper and Modified Tests. Error bars = standard error.***

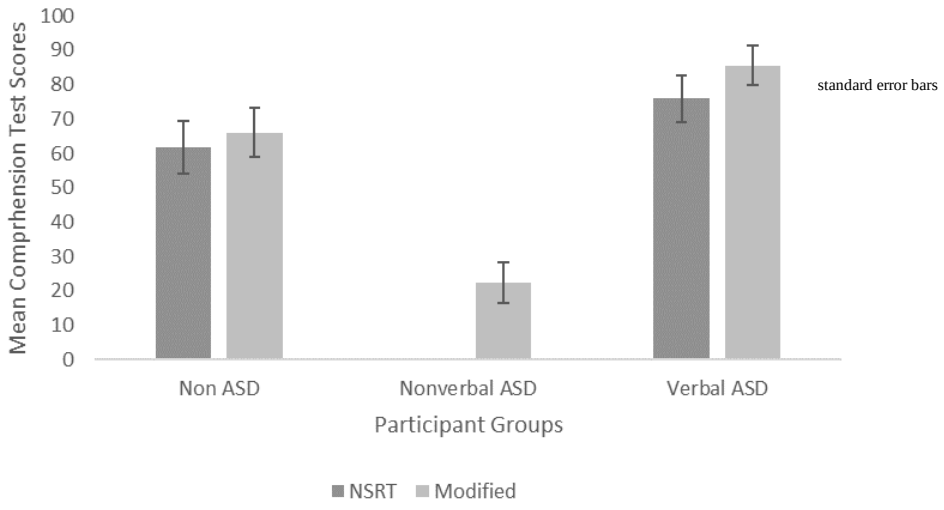


Figure 4.1 shows the raw mean listening comprehension scores for all three groups in both paper and modified conditions of the listening comprehension test. As 'reading comprehension age' scores calculated in the NSRT material are dependent on 'reading age' scores, the scores of the 10 non-verbal who did not demonstrate a 'reading age' in any of the tests were not included in these analyses.

There was a higher score for the non-ASD group, the non-verbal ASD group, and the verbal ASD group when using the modified version of the test compared to the paper-based test. This difference was most pronounced for the non-verbal ASD group. The pattern of results for the listening comprehension test were similar to those of the word recognition (chapter 3) test, though the impact was smaller. There was a higher score for all three groups when using the modified version of the test compared to the standard paper-based test. The difference in means scores for the non-ASD group for the paper and modified versions of the test was 4.3, for the verbal ASD group the difference was 9.8. However, for the non-verbal ASD group who were unable to score using the standard verbal version of the test, the improvement was most pronounced with a difference of 22.4.

A 3 (Participant Group: verbal ASD, non-ASD, non-verbal ASD) x 2 (Test Format: NSRT, modified) ANCOVA was conducted on these data, controlling for performance IQ, verbal IQ, and chronological age of participants. There was a significant effect of group $F(1,87) = 21.24$, $p < .001$, $\eta^2_p = .718$, no significant effect of test, $F(1,87) = <.001$, $p = .99$, $\eta^2_p = <.001$, but a significant effect, $F(2,87) = 3.33$, $p = .04$, $\eta^2_p = .071$.

Simple effect analysis showed that there was no difference in the comprehension performance as measured by the two tests for the non-ASD group, $F(1,30) = 0.25$, $p = .62$, $\eta^2_p = .718$, or for the verbal ASD group, $F(1,29) = 1.27$, $p = .27$, $\eta^2_p = .149$. However, there was a significantly better reading performance when measured by the non-verbal modified test for the non-verbal ASD group, $F(1,28) = 6.47$, $p = .02$, $\eta^2_p = .329$.

The simple effect of group for the paper test was significant, $F(2,93) = 42.54$, $p < .001$, $\eta^2_p = .491$. Tukey's Honestly Significant Difference (HSD) test revealed that there was a significant difference for all three groups for the paper version of the test, all *p*s <.001.

The simple effect for group using the modified test was significant, $F(2,98) = 27.38$ $p < .001$, $\eta^2_p = .370$. Tukey's HSD test revealed that the verbal and non-verbal ASD groups did not differ from one another, but both were lower than the non-ASD group, both *p*s = .06. Due to the obvious 'naked-eye' differences in the means, this was unpredicted post-hoc result. To test the possibility that the inclusion of verbal IQ may be skewing the data, as the majority of those in the non-verbal ASD group were at floor level for this test, the analysis was performed again with this covariate removed. The simple effect for group using the modified test was significant, $F(2,98= 45.66$, $p.<.001$, $\eta^2_p$ .482. Tukey's Honestly Significant Difference (HSD) test revealed a significant difference between the non-verbal ASD group and the other two groups, $p < .001$.

The correlations between the comprehension scores for the paper and modified versions of the assessment were calculated for each group. For the non-ASD group (NASD), there was a positive correlation between paper and modified versions of the test, $r = .919$, $p < .001$, as there was for the VASD group, $r = .788$, $p < .001$. Given the lack of variation in performance for the verbal reading test for the non-verbal ASD group, this correlation was not calculated.

**Table 4.1**

Numbers of Individual Participants who Met Criteria for Clinically Significant and Reliable Change when Comparing Paper-Based Test and Modified Test Format

| Group | Threshold | | Clinically Sig. Change | Reliable Change (pos.) | Reliable Change (neg.) |
|---|---|---|---|---|---|
| | CS | RC | | | |
| **Non-ASD N=32** | 90.12 | 53.20 | 7/32 | 1/32 | 0/32 |
| **Verbal ASD N=31** | 93.23 | 46.50 | 12/31 | 3/31 | 0/31 |
| **Non-verbal ASD N=40** | 6.25 | 1.24 | 10/30 | 10/30 | 0/30 |

Analysis was carried out on the data to determine the extent of clinically significant change and reliable change for each individual participant.

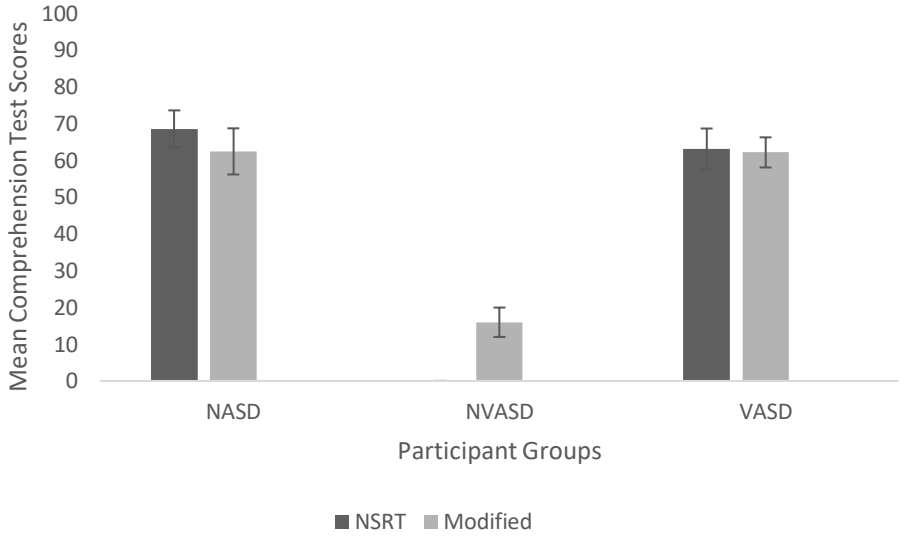
Table 4.3 shows the numbers of individual participants meeting criterion for clinically significant change, and also for reliable change. With regard to clinically significant change, 33% of the NVASD group met the criterion. This figure was 39% for the VASD group, and 22% for the NASD group. This data was analysed using a chi-square, which demonstrated no significant difference, $X^2(2) = 2.17$, $p = .34$. With regard to reliable change, 33% of the NVASD group met the criteria for reliable change in the positive direction. This figure was 10% for the VASD group and 3% for the NASD group with no participants meeting criteria for reliable change in the negative direction in any of the groups. These data were analysed using a chi-square, which did demonstrate a significant difference between the groups, $X^2(2) = .36$, $p < .05$.

***Results for percentages of correct answers (PCA)***

Before carrying out analyses using percentages of correct answers (PCA) all participant's scores were corrected for guessing. The formula used to correct for guessing (Espinosa & Gardeazabal, 2010) was corrected = #correct – (#wrong/#options -1). The number of opportunities to answer comprehension questions for both the NSRT and the modified version of the test was dependent on how many sentences each participant read successfully in the reading test or how many slides they completed in the modified word recognition test (see chapter 3). This was taken into account when calculating corrections for guessing for each individual participant.

***Figure 4.2***

*Mean Scores for All Three Groups for Both Paper-Based and Modified Test Format. Error bars = standard error.*




A three-factor mixed-model analysis of covariance (ANCOVA) was conducted on the data for the non-verbal ASD group, ASD and non-ASD groups with test as within-subject factor and group as between-subject factor, controlling for verbal IQ, nonverbal IQ and chronological age of participants. There was a significant main effect of group $F(2.97) = 59.82$, $p = .<.001$, $\eta^2_p = .552$. There was no significant main effect of test $F(1,97) = .108$, $p = .743$, $\eta^2_p = .001$, and a significant interaction $F(2,97) = 4.716$, $p = .011$, $\eta^2_p = .089$.

Simple effects analysis showed that there was no difference in the PCA performance as measured by the three tests for the non-ASD group, $F(1,31) = .92$, $p = .345$, $\eta^2_p = .047$. However, there was a significant difference between the tests for the verbal ASD group, $F(1,30) = 48.68$, $p = <.001$, $\eta^2_p = .879$ and for the non-verbal ASD group, $F(1,39) = 7.75$, $p$ . 008=, $\eta^2_p = .284$.

The simple effect of group for the NSRT was significant and large-sized, $F(2,102) = 381.20$, $p < .001$, $\eta^2_p = .667$. Tukey's Honestly Significant Difference (HSD) test revealed a significant difference between the non-verbal ASD group and the other two groups, $p < .001$. The simple effect of group for the modified test was

significant, but smaller sized, , $F(2,102) = 35.89$, $p < .001$, $\eta^2_p = .395$. Tukey's Honestly Significant Difference (HSD) test revealed a significant difference between the non-verbal ASD group and the other two groups, $p < .001$.

**Table 4.2**

Numbers of Individual Participants who Met Criteria for Clinically Significant Change and Reliable Change when Comparing Percentages of Answers Correct for the Paper-Based Test and the Modified Test Format

| Group | Threshold | | Clinically Sig. Change | Reliable Change (pos.) | Reliable Change (neg.) |
|---|---|---|---|---|---|
| | CS | RC | | | |
| **Non-ASD N=32** | 89.16 | 35.08 | 9/32 | 2/32 | 6/32 |
| **Verbal ASD N=31** | 87.91 | 38.18 | 4/31 | 3/31 | 3/31 |
| **Non-verbal ASD N=40** | 6.25 | 1.24 | 16/40 | 16/40 | 0/40 |

Table 4.2 shows the numbers of individual participants meeting criterion for clinically significant change, and for reliable change. With regard to clinically significant change, 40% of the non-verbal ASD group met the criterion. This figure was 13% for the verbal ASD group, and 28% for the non-ASD group. This data was analysed using a chi-square, which demonstrated a significant difference between the three groups $X^2(2) = 8.638$, $p = .013$. With regard to reliable change, 40% of the NVASD group met criteria for reliable change in the positive direction. This figure was 10% for the verbal ASD group and 6% for the non-ASD group. In the non-ASD group 19% met the criteria for reliable change in the negative direction, this figure was 10% for the verbal ASD group. This data was analysed using a chi-square, which was significant $X^2(2) = 20.787$, $p < .001$.

## 4.5 Discussion

The current study aimed to compare the listening comprehension performance of children with ASD who are non-verbal, to those of verbal ASD, and verbal non-ASD, using the traditional paper-based New Salford Reading Test (NSRT; McCarty & Lallaway, 2012) and a modified multiple-choice version of the test, which eliminated the requirement to verbalise answers to questions. Results were calculated in three ways. Firstly, we used the materials provided in the NSRT to calculate scores. Ordinarily, schools using the test would refer to these as 'reading comprehension ages'. However, as we modified the test to create a multiple-choice format, during which sentences were read to participants, this was a test of listening comprehension rather than reading comprehension. For clarity, we shall refer to those scores as LC scores. Results for LC scores were compared using group analysis methods and at an individual level through the calculation of reliable and clinically significant change (Jacobson, Follette and Revenstorf, 1984). Where there was a comparison of LC as measured by the NSRT, data for participants who did not score in any of the conditions were excluded from further analysis. This is a similar approach to that used by Nation et al. (2006). As the questions asked in the comprehension element of the NSRT depend on achievement in the word recognition test, children who were unable to score, would not access this part of the test.

It was acknowledged that due to the wide age range of participants; 5 yrs. 5 mts. to 18 yrs. 9 mts., there would be a difference in the number of reading instruction participants had received prior to the study and quite possibly a variation in exposure to reading tests. Therefore, to ensure that results reflected the impact of alterations made to the assessment and not to age as a confounding factor, chronological age was also included as a covariate. Verbal and nonverbal intelligence quota (IQ) scores and age were also included as covariates in all analyses. Analysis to detect the possible impact of order of test delivery or reading test form used showed no test form or order effects in any of the test conditions for any of the participant groups.

Comparisons for all three groups demonstrated a higher score when accessing the modified version of the test, however, this was most pronounced for the group with ASD who are non-verbal. No participants in the group with ASD who are non-verbal were able to score using the paper-based version of the test. In contrast, 10 participants in this group demonstrated a listening comprehension score, as calculated using NSRT materials, when accessing the modified version of the test. Scores ranged from age 5 years to 6 years 8 months. Of these 10, 5 participants demonstrated a score within 12 months of their word recognition score as measured by the modified version of the test.

Observations related to clinically significant change lend further support to the positive impact of the test for the group with ASD who are non-verbal, but also for the group with ASD who are verbal. However, when we consider results purely from an accessibility standpoint, the most noticeable difference is for the group with ASD who are non-verbal. This group demonstrates the most dramatic difference in terms of an increased ability to demonstrate a score when using the modified test as opposed to the paper-based version tests when compared to the other two groups.

Further analysis focused on the percentage of questions correctly answered (PCA). For this analysis, we were able to include scores for all participants as the use of this method was able to tell us which percentage of those words that participants successfully identified were being accurately comprehended. Evidence from this data lends further support that only the non-verbal group were significantly impacted by the change in test from the paper-based traditional test to the modified multiple-choice version of the test. When we used critical and reliable change methods for these results, as we did with the LC scores, the number of participants in the non-verbal group who demonstrated listening comprehension skills went from 10 (LC score) to 16 (PCA). This was the figure for critically significant change and reliable change in a positive direction.

As has already been stated, the method employed to facilitate non-verbal responses to the test was multiple-choice. It could be argued that this would have made the modified test easier, particularly as for this test there were only two options for each question. Ways in which we tried to counteract this was to ensure that the

incorrect answer was so implausible as it to be obvious to the researcher if the participant was consistently guessing, no participant displayed this kind of behaviour, as participants in the non-ASD group were more likely to say, “I don’t know” and those in the verbal ASD group and non-verbal ASD group would usually just not answer at all if they didn’t know the answer. A further countermeasure was to correct scores to account for the possibility of guessing for all participants when we calculated the results for the modified test.

Further, we might consider that the multiple-choice format did not offer advantages for listening comprehension per se but was a reasonable adjustment to offer assistance with word retrieval issues that can be experienced by people with ASD due to executive function deficit (Attwood, 2003, cited by Paxton & Estay, 2007; Attwood, 2007). Children with autism are often identified as visual learners and teaching methods that utilise multiple-choice visual presentations of information have been noted to benefit the learning styles of children with autism (Mesibov, Shea & Schopler 2005; Simpson 2008). Multiple-choice methods, as opposed to open-ended questions are, therefore, one recommendation for good practice to help mitigate word retrieval problems when communicating with members of the autistic population (Paxton & Estay, 2007).

The other main difference with the modified test from the traditional paper-based test was the digital screen presentation. The decision to present the test digitally was informed by a desire for accessibility and portability for the researcher, and so that if participating schools wished to continue to use the test (which some opted to do) this could be easily facilitated. The screen was used as a non-interactive display i.e. there was no auditory or visual response which would reward either correct or incorrect answers. Therefore, it is unlikely that the use of digital equipment would have greatly impacted on performance. However, for the children with autism, it could have been a motivating factor to take part in the test as children with autism tend to have an affinity with digital technologies (Constantin et al., 2017) and digital equipment often forms part of class-based reward systems for children with ASD.

Further, it can be noted that as the multiple-choice version of the test required the tester to verbalise the words to the participants, an auditory element of the test was created, which since difficulties with auditory processing and ASD are commonly associated (O'Connor, 2012), could be considered a disadvantage. This is a highly speculative comment however, as evidence is limited. There is some evidence to suggest that auditory impairment in ASD is more severe for speech than non-speech stimuli (O'Connor, 2012). However, this is associated with atypical perception of perceptual features of speech such as pitch and prosody (rhythm). Sharma, Purdy, and Kelly (2009) found some overlap of auditory processing disorder and reading disorder when they looked for possible comorbidity of auditory processing disorder, language disorder and reading disorder. However, to draw any conclusive links would require improved diagnostic tools for auditory processing, language impairment and reading tests that are sure to discriminate between auditory language impairment and reading dysfunction.

Understandably, there are going to be a number of barriers to overcome when including children who are non-verbal in research studies (Kasari et al. (2013). Taking an individualised approach to methods of assessment that utilises technology such as eye gaze tracking or touch screen methods has been suggested as one possible way forward for improving our understanding of this cohort (Plesa Skwerer et al., 2015; Tager-Flusberg et al., 2017). If we do not attempt to negotiate the obstacles presented, we are unlikely to develop the level of understanding needed to improve literacy provision and eradicate the disadvantages and discrimination associated with being non-verbal, that may be experienced by many children in this population (IACC 2013; 2016, Kasari et al., 2013; Tager-Flusberg & Kasari, 2013).

Findings have suggested that reading profiles for children with ASD will differ from their peers who are typically developing in a variety of ways (Snowling and Frith, 1986; Smith Gabig, 2010; Nation et al., 2006). As research has focused on the verbal and often 'high functioning' (in terms of language skills) ASD population, it is difficult to find results that are comparable with this current study. Mucchetti (2013) looked at the impact of shared reading activities with a small group of minimally verbal children. Materials were adapted to facilitate participants' non-verbal responses to story comprehension questions asked which included picture

symbols and tactile objects. All four children demonstrated increased task engagement following the adapted shared reading activities. They also demonstrated increased story comprehension abilities as was measured by their ability to answer questions by pointing to/touching symbols.

When Zuccarello et al. (2015) compared the decoding abilities of children with ASD with and without impaired cognitive function, their results suggested that those participants with ASD exhibited a hyperlexic reading profile irrespective of cognitive impairment, suggesting a direct link between ASD and reading comprehension ability as opposed to reading comprehension deficits being primarily a result of cognitive impairment comorbidities. Although there is no mention of participants who are non-verbal, the study is of interest as it implies that children with ASD who are non-verbal, who are often associated with the 'low functioning' end of the spectrum, may have a reading profile more in common with their verbal ASD counterparts than non-ASD children with learning disabilities. Inclusion of IQ as a covariate in the analysis demonstrated IQ not to be a contributing factor for the current study also.

Although generally there is a lack of research relating to the ASD population who are non-verbal, it is not known whether this cohort is very likely to fall into the 'low functioning' category of ASD. However, 'low functioning' is a common term for those children on the ASD spectrum who are identified as having poor language and cognitive abilities (O'Connor & Klein, 2004). In the UK, children with ASD who fit into this broad category of 'low functioning' are likely to be educated in settings which form part of schools providing additional learning needs (ALN) education (Reed & Osbourne, 2014).

Picture Exchange Communication Systems (Frost & Bondy, 2002) along with other forms of alternative augmentative communication are commonly used in ALN settings to support the communication skills of non-verbal and minimally verbal students. The results of the current study, therefore, have implications for such settings, as they would imply that there could be children who can read and comprehend to at least a single word level, who are being supported by the use of picture and/or symbol-based systems for the purpose of communication. This is not to say that the use of PECS would be wholly inappropriate, but that the use of

pictures only for the purpose of communication, could be limiting rather than exploiting the potential for more advanced forms of communication to develop for this particular group.

Further implications of the study are also clear in that not every child or young person with ASD who is non-verbal will lack the ability to recognise printed words and/or understand their meaning. This means that many children who are on the autism spectrum who are non-verbal may have the beginnings of a reading skill which is currently undetected. Verbalisation is a common element of reading tests being used in ALN settings (Arnold & Reed, 2016), by removing this element, the modified format of assessment used in this study promotes a form of assessment that allows us to detect word recognition ability and listening comprehension skills for children who are non-verbal. What schools choose to measure can be a reflection of what they choose to value. Assessment data forms part of school self-evaluation which informs the plans for school improvement. The school improvement plan will set out how resources are allocated, and which interventions are employed. Therefore, students with ASD who are non-verbal, who are not represented in the data, will also be prone to exclusion from more advanced forms of reading instruction and communication intervention.

This is a crucial matter for the field of special education, as unless reasonable adjustments are made, children and young people with ASD who are non-verbal will continue to be excluded from interventions that could improve their chances of being successful readers and communicators in future. In which case they are likely to remain, as Tager-Flusberg and Kasari (2013) argue ‘the neglected end of the spectrum’.

# CHAPTER 5

## Evaluating Eye Gaze Tracking Practise to Facilitate the Usefulness of a Modified Non-verbal Test of Reading Abilities of Children, with and without Autism Spectrum Disorder.

### 5.1 Abstract

Approximately 30% of individuals with Autism Spectrum Disorder (ASD) are non-verbal (i.e. individuals of school age with little or no spontaneous spoken language). Little is known about the reading abilities of this cohort due to the challenges presented for assessment. There has been growing interest in the use of eye gaze tracking as an observation tool, however, there can be issues with data loss which can occur when participants are unfamiliar with the use of an eye gaze tracking facility. The aim, therefore, was to evaluate the use of eye gaze tracking as a suitable method of assessment for non-verbal children. Word recognition scores for two groups of participants with a diagnosis of additional learning needs were compared; a group that took part in 'primer activities', designed to encourage familiarity with eye gaze tracking, and a group who received no such intervention. The prediction was that familiarity with eye gaze would improve word recognition scores. The study highlights the importance of experimentation with methods of assessment if we are to be able to support the reading abilities of non-verbal children in special education through inclusive practices.

## 5.2 Rationale

It can be difficult to gain an accurate picture of the literacy abilities of children with Autism Spectrum Disorder (ASD) who are non-verbal, or minimally verbal. (Tager-Flusberg, et al., 2017). To facilitate the assessment of reading abilities of children who were both verbal and non-verbal with ASD, Arnold, and Reed (2019) employed the use of a digitized version of the New Salford Reading Test, which utilised a touch screen facility. Once the requirement for verbalisation was eradicated, word recognition scores and listening comprehension scores of non-verbal children with ASD were improved, and the conclusion was that this was an effective form of assessment for non-verbal children who were able to use pointing as a form of response. However, whether due to physical limitation, or comorbidity of their ASD, some children struggled to develop pointing skills (see also Paquet, Olliac, Golse, & Vaivre-Douret, 2016; Shetreat-Klein, Shinnar, & Rapin, 2014; Charman, et al., 1997; Dawson, et al., 2004).

Eye gaze tracking has the benefit of requiring neither verbal response nor pointing ability, and so it has been suggested that the use of eye-tracking facility as a tool could form part of a solution for gathering assessment data with this population (Plesa-Skwerer et al, 2016; Tager- Flusberg & Kasari 2013). A disadvantage of eye gaze tracking, however, can be data loss. This is when the eye tracking device fails to report the eye gaze position. This can be a calibration issue, which is usually easy to fix by recalibrating the device, or it can occur when a participant is looking outside the tracking area, usually a computer screen. This is more likely to occur when a participant has difficulty in understanding that the responses on the screen are being performed through their eye gaze. Arnold and Reed (2019) modified the digitized version of the New Salford Reading Test and noted some success with the eye gaze tracking for non-verbal participants, in that word recognition and listening comprehension scores were better than those for the traditional paper-based version of the test. However, scores were most improved with access to a touch screen device. One possible reason that was considered for this. was a lack of familiarity on the part of participants with the eye gaze facility which could cause data loss to occur.

The aim of the current study, therefore, was to evaluate the use of eye gaze tracking as a suitable method of word recognition assessment for non-verbal children. All of the children in the study had been identified as having additional learning needs of enough complexity to warrant education in special needs school setting, 75% of the children also had a diagnosis of ASD, and 40% were non-verbal. Word recognition scores for two groups of participants were compared; a group that took part in 'primer activities', designed to encourage familiarity with eye gaze tracking, and a group that received no such intervention. The thought behind this was if, through familiarity with the equipment, participants gained the understanding that their gaze was the required response, data loss would be less likely to occur, and word recognition scores for the primer group would, therefore, improve from the baseline score.

## 5.3 Method

### 5.3.1 Participants

33 participants (29 males and 4 females) were recruited from those attending special needs schools. Special school attendance is deemed appropriate by a Local Authority on the basis that the nature of additional learning needs are so severe or complex as to disallow the possibility of suitable educational progress being made in a mainstream setting. Of the participants, 25 had an additional diagnosis of ASD, made by a paediatrician, independent from this study, using DSM-IV criteria, and clinical judgment. 20 participants were verbal and 13 non-verbal. Participation in the study was based on availability. The schools involved were given the remit of identifying pupils who, in the opinion of their teachers and based on ongoing classroom performance and assessment procedures employed by the school, could possibly be readers or emerging readers.

**Table 5.1**

An Overview of Participant Subgroups and Verbal IQ Means

| | ASD | | Non-ASD | |
|---|---|---|---|---|
| | non-verbal | Verbal | non-verbal | verbal |
| Total No. Participants | 13 | 12 | 0 | 8 |
| Mean and Standard Deviations for Verbal IQ | 48 (SD 3.58) | 93.17 (SD 16.35) | 0 | 80.15 (SD 8.7) |

**Table 5.2**

An Overview of Groups Relating to their Autism Behavioural Checklist (ABC) Scores, Verbal Comprehension, and Perceptual Reasoning.

| | **ABC** | | | **Verbal Comprehension** | | | **Perceptual Reasoning** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range |
| **Primer N=16** | 81 | 18.75 | 59-106 | 71.06 | 24 | 45-106 | 73.06 | 18.83 | 45-119 |
| **Non-Primer N=17** | 84.41 | 21.5 | 59-122 | 72.87 | 22.55 | 45-108 | 80.65 | 23.37 | 45-100 |

Participants were randomly assigned to either a 'primer group' or a 'non-primer group'. Table 6.1 shows the Autism Behavioural Checklist (ABC) scores (Krug, Arick and Almond, 2008), the verbal comprehension IQ, and perceptual reasoning IQ (Wechsler Intelligence Scale for Children IV; Wechsler, 2003) scores of all participants. There were 17 participants in the non-primer group, with a mean chronological age of 141 months (11 yrs. 9 mts.) (SD $\pm$ 40.86; range = 59-186). In the primer group, there were 16 participants, with a mean chronological age of 143 months (11 yrs. 11 mts.) ($\pm$ 34.94; range 80-181).

An independent t-test was performed on these data with the primer group and non-primer group assigned as grouping variables and verbal IQ, perceptual reasoning IQ, and ABC scores as test variables. For ABC scores there was no significant difference between scores, t <1, $d$ = 0.19. For verbal IQ, there was no significant difference in the scores t<1, $d$ = 0.15. There was also no significant difference in scores for perceptual reasoning IQ, t(1,31) = 1.04, p=.304, $d$ = 0.32.

Ethical permission for the research was gained from the University Psychology Department Ethics Committee.

### 5.3.2 Materials

**Wechsler Intelligence Scale for Children (IV).** (WISC IV; Wechsler, 2003) was used to determine verbal IQ scores and perceptual reasoning IQ scores. Verbal comprehension consisted of 3 subtests: similarities, vocabulary, and comprehension. Perceptual reasoning consists of 3 subtests: block design, picture concepts, and matrix reasoning. In terms of reliability, the alpha of the revised scale was .92. (Wechsler, 2003).

**Autism Behavior Checklist.** (Krug et al., 2008) was completed by teachers of the participants. ABC is a 47-item questionnaire which requires the examiner to place a checkmark beside each item that most precisely describes the child. Four items on the ABC relating to behaviors that teachers would be unlikely to have knowledge of were removed. Thus, the calculations included 43 items out of 47 possible. ABC yields standard scores which range from 5 to 141, a score of above 68 suggests a high probability of ASD. The reliability of the revised scale was .80.

**The British Picture Vocabulary Scale** (BPVS3; Dunn & Dunn, 2009) was used to determine pupils' receptive vocabulary. During the test, the examiner says a word, and the subject is asked to point to a picture from four options that best describes the meaning of the word. The items get progressively harder until the child's limit is reached. BPVS does not require reading, speaking, or writing skills. BPVS provides norms for individuals aged 3-16, with a mean of 100. The reliability of BPVS was recorded at .91 (Dunn et al., 2009).

**Modified Word Recognition Test.** The modified test was based on the New Salford Reading Test (NSRT; McCarty & Lallaway, 2012) which consists of three forms, each made up of 17 sentences of 114 'counted' words. The forms are equally graded in terms of word reading difficulty. The words increase in difficulty as the student reads through the test. On the sixth error, the test is stopped, and the reading age determined. Included in the sentences are words that are 'not counted'. Words that are not counted are words that have been inserted into the test to provide sentence structures. There are three forms in total, which are labelled as 'a', 'b', and 'c', but only one form is delivered to each participant. The forms are equally graded. The New Salford Reading test is designed for use in schools that would likely deliver the test year on year to the same students. Therefore, the forms are alternated when delivered to avoid practice effects. The modified version of the test, created by Arnold and Reed (2019) was a multiple-choice version of the test with the same words as those used in the NSRT (Appendix B & D). These were presented on a screen in the form of multiple-choice. There was an equal number of incorrect answers available as there were correct. To ensure that the incorrect answers had the same grade of difficulty as the correct answers, these words were also taken from the SRT. In the interests of mobility and accessibility, the test was designed in PowerPoint, which has the advantage of requiring a very commonly used software that can be accessed through a wide range of devices. Each slide represented one sentence of the test, therefore there were 17 slides in total with 114 'counted' words. In terms of reliability, the alpha of the revised scale was .96 for this sample.

**Apparatus.** A touch screen facility, a Tobii Eye Tracker (4C), was connected via USB port to a school laptop computer with specifications that met with the requirements for the Tobii Eye Tracker (4C). This enables the Eye Tracker software provided with the device to track the gaze of the eye, i.e. any eye movements will move the cursor on the screen, tracking head and eye simultaneously.

**Eye gaze games**. On-screen games (Appendix F) were presented to the primer group prior to the word recognition test. There were two eye gaze games, which required participants to use their eye movement to move, target, or select,

objects in the game. There were two online games: ‘Colourful Caterpillar’ and ‘Catch Me’. The first criterion for choosing the games was that they were designed specifically for use with the Tobii Eye Tracker. This was done to lessen the possibility of any ‘off-putting glitches’ or problems when we came to use them with participants. Therefore, we chose the game from tobiidynavox.com [last accessed 07.08.19]. The second criterion was simplicity. As it was likely that the range of cognitive abilities for our participants was going to vary, we chose games which were simple cause and effect. Thirdly, the games needed to be colourful and/or appealing to the eye with an element of fun. Both games are in the ‘screen engagement’ section of games on the site which have been designed to encourage familiarity and engagement with the use of an eye-tracking facility. For the options, both games were set on ‘classic’ and ‘easy’ mode.

‘Colourful Caterpillar’ http://www.tobiidynavox-webgames.com/sensory-game/sensory-game.html#settings [last accessed 07.08.19] displays colourful circles on the screen, linked together to give the impression of a caterpillar. Once the eye-tracker equipment is attached to the screen, the caterpillar can be moved around it with eye gaze.

‘Catch Me’ http://www.tobiidynavox-webgames.com/catchme/catchme.html#1[last accessed 07.08.19] involves a cartoon character which ‘hides in the dark’ of the screen until it is found by the eye gaze of the player.

As the word recognition task involved the ability to dwell on a particular area of the screen, we created a PowerPoint to replicate this task. The aim was to prepare participants for the task and for the researcher to get some idea of a participant’s ability to use eye gaze as opposed to pointing. On the screen where a series of colourful balloons which can be ‘popped’ if the eye gaze rested on it for 0.8 seconds, which was the same amount of time used for the word recognition test to determine if a participant was ‘selecting’ a particular word.

### 5.3.3 Procedure

The study involved participation in four activities. Before the first activity, participants were split in line with their diagnosis, into either ASD or a non-ASD group and then individuals in each group were randomly assigned to either a 'primer group' or a 'non-primer group' and teachers of participants were asked to complete the ABC checklist. The procedure for the first, second, and fourth activity was the same for both groups; only the third activity was different.

For the first activity, assessments were carried out over a period of three days, sometimes two, if the participant was particularly able with the tests. Usually, these days were consecutive; however, where this was not possible (due to attendance for example), all tests were carried out within a two-week window. The first activity for each participant involved the administration of the IQ tests by the researcher who is experienced in administering the WISC IV.

For the second activity, the eye tracker calibration was conducted and the word recognition test (baseline) was administered to all participants. Pupils were seated approximately 50cm away from the computer screen. Participants were told that they were about to hear a target word, and they were instructed to identify the target word presented on the computer screen using their eyes. They were asked to 'only look' at the word they believed matched the word they had heard and were told that there was no need to point to the word on the screen. The word box highlighted in blue if participants looked at it for 800ms. A correct mark was allocated when participants correctly selected the target word by looking at it for 800ms. However, if a participant was unable to detect a target word, or fixated on the incorrect word, this was counted as an error. In line with the NSRT procedures, the test was stopped after the participant made a sixth error. No feedback was given regarding the accuracy of the response in both parts of the study, but all participants were praised and thanked for their participation.

The third activity was carried out within a week of the first sitting to avoid participant fatigue. This activity involved two different procedures, one for the primer group and a different procedure for the non-primer group. The primer group took part in the digital eye gaze games. They played the two online games, presented in 10-minute slots. However, if a participant appeared to be particularly adept at moving

the caterpillar around the screen or revealing the spider using their gaze, the game could be stopped early to prevent boredom. Participants were then asked to complete a PowerPoint activity which required them to pop the balloons by resting their eyes on the image. If a participant was unable to pop the balloons, two online games were repeated to reinforce the concept of using eye gaze as a cause and effect tool. The time in which each participant demonstrated an awareness of this concept i.e. by being able to rest their gaze on the image long enough to pop the balloon, varied from 6 min to 12 min, with an average of 8 min.

To control for the time spent with the researcher for the primer group, the non-primer group spent time playing action games on an iPad for approximately 8 min. During these activities, the researcher was seated next to the participants to observe progress and engagement.

The fourth activity involved both the primer and non-primer group as all participated in the word recognition test again. The procedure was the same as when they originally participated, however, to avoid practise effects, the form administered was different. So, for example, if a participant has been administered ‘form a’ in the first sitting, then they would be asked to identify words from form ‘b’ or ‘c’ in the subsequent sitting. Again, no feedback was given regarding the accuracy of the response in both parts of the study, but all participants were praised and thanked for their participation.

## 5.4 Results

***Figure 5.1***

*Mean  Scores for the Primer and Non-Primer Group for the Baseline Condition and Post-Primer Condition of the Test. Error bars = standard error.*

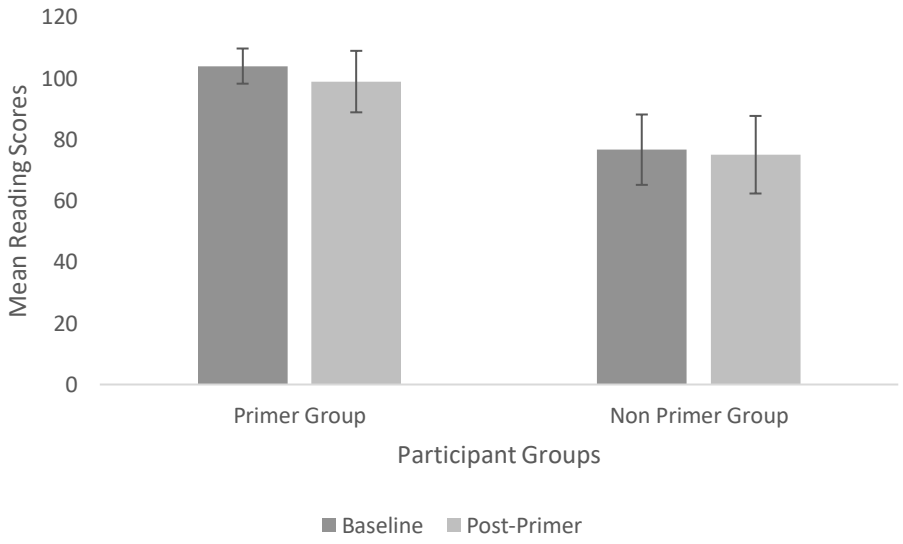
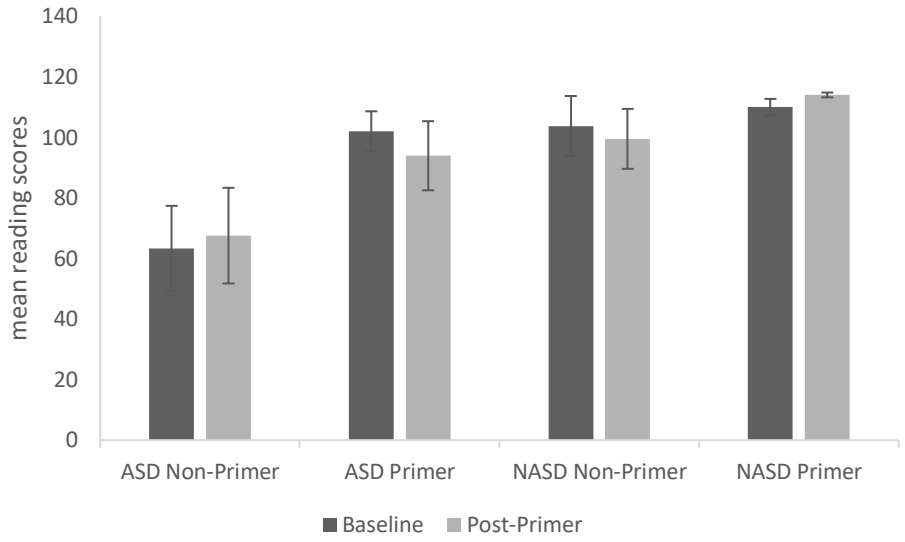



Figure 5.1 shows the mean word recognition scores (WRS) for both groups for the baseline and the post primer reading test conditions.  The means for the post primer condition were marginally lower than those of the first, for both groups.

A two-factor mixed -model analysis of variance (ANOVA) was conducted on these data, with test as within-subject factor, and group as between-subject factor. There was no significant effect of test, $F(1,31) = .9$, $p = .35$, $\eta^2_p = .028$, no significant effect of group, $F(1,31) = 3.2$, $p = .08$, $\eta^2_p = .094$, and no significant interaction, $F(1,31) = .23$ $p = .63$, $\eta^2_p = .007$.

***Figure 5.2*** *Mean Scores for the Baseline and Post-Primer Conditions of the Test for Both the Primer Group and the Non-Primer Group Separated by Diagnosis. Error bars = standard error.*

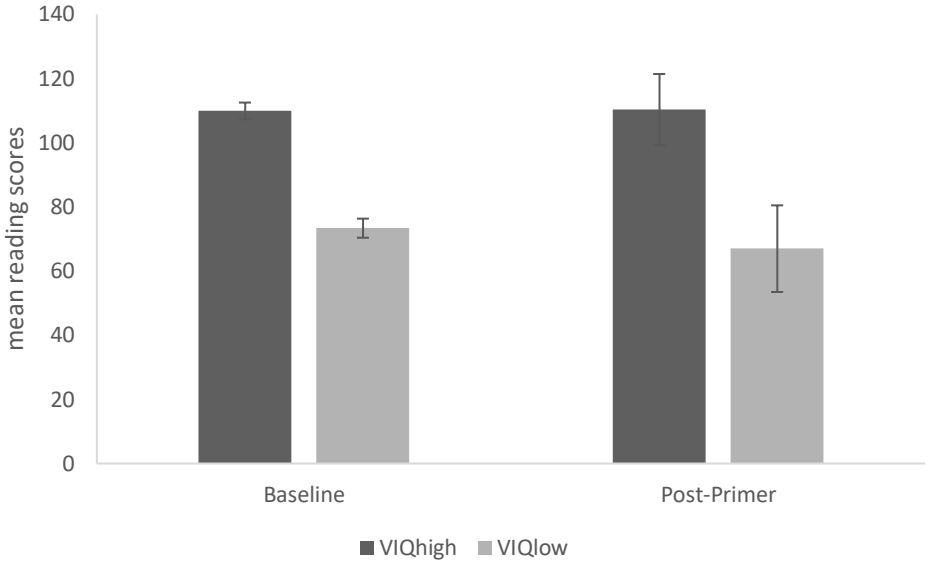



Data were also analysed for the participants with and without ASD, separately. Figure 5.2 shows the mean baseline WRS and post primer for the primer group and the non-primer group separated by diagnosis. For those with a diagnosis of ASD WRS improved marginally for the group who didn't have the primer but receded for the primer group. For those without a diagnosis, the scores were marginally lower without the primer but improved slightly for the group who experienced the primer. Therefore, for those with an ASD diagnosis, the impact of the primer appeared to be the reverse of what was predicted.

A two-factor mixed -model analysis of variance (ANOVA) was conducted on these data, with test as within-subject factor, and group as between-subject factor. There was no significant effect of test, $F(1,29) = .3$, $p = .59$, $\eta^2_p = .010$, a significant effect of group, $F(3,29 = 1.9$, $p < .001$, $\eta^2_p = .819$, but no significant interaction, $F(3,29) = .45$ $p = .72$, $\eta^2_p = .044$.

***Figure 5.3***

*Mean Scores for the Baseline and Post-Primer Conditions of the Test for the Higher Verbal IQ (VIQ) Group and the Lower Verbal IQ (VIQ) Group. Error bars = standard error.*




The possible effect of verbal IQ and perceptual reasoning IQ were also examined. Figure 5.3 shows the mean verbal IQ score for the primer and non-primer group in both the baseline condition and the post primer condition of the test. The verbal IQ scores for the sample ranged from 45 to 108 with a median of 71. The sample, irrespective of groups, was split at the median to create a lower verbal IQ group ($N$=18, mean verbal IQ = 53.6 $\pm$ 10.1), and a higher verbal IQ group ($N$= 15, mean 93.93 $\pm$ 11.46).

The group with the higher verbal IQ had higher WRS in the baseline condition than the group with the lower verbal IQ range . A mixed-model ANOVA (group x test) conducted on these data revealed no significant main effects of test, $F(1,31) = .73$, $p = .4$, $\eta^2_p = .227$, a significant effect of group $F(1,31) = 9.08$, $p = .005$, $\eta^2_p = .092$, but no significant interaction between these factors, $F(1,31) = .93$, $p = .34$, $\eta^2_p = .029$.

***Figure 5.4***

*Mean WRS Scores for the Baseline and Post-Primer Conditions of the Test for the Higher Perceptual Reasoning (PRIQ) group and the Lower Perceptual Reasoning (PRIQ) group. Error bars = standard error.*

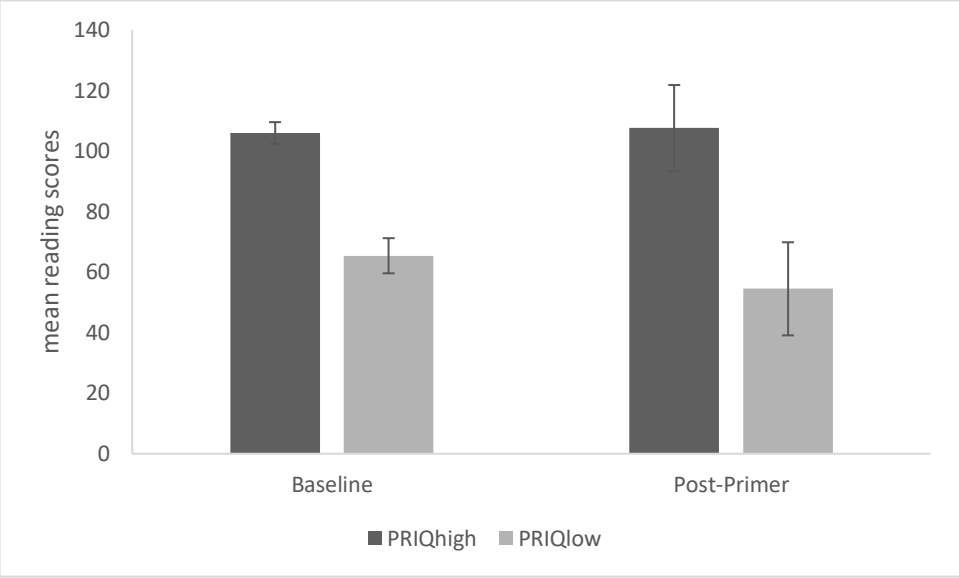



Figure 5.4 shows the mean perceptual reasoning IQ score for the primer and non-primer group in both the baseline condition and the post primer condition of the test. The perceptual reasoning IQ scores for the sample ranged from 45 to 119 with a median of 82. The sample, irrespective of groups, was split at the median to create a lower perceptual reasoning IQ group ($N$=13, mean perceptual reasoning IQ = 53.77 $\pm$ 7.19) and a higher perceptual reasoning IQ group ($N$= 20, mean perceptual reasoning IQ = 91.7 $\pm$ 11.22). The group with the higher perceptual reasoning IQ had higher WRS than the group with the lower perceptual reasoning IQ range in the baseline condition of the test. A mixed-model ANOVA (group x test) conducted on these data revealed no significant main effects of test, $F(1,31) = 1.8$, $p = .19$, $\eta^2_p = .055$, a significant effect of group $F(1,31) = 13.27$ , $p < .001$, $\eta^2_p = .300$, but no significant interaction between these factors, $F(1,31) = 3.32$, $p = .08$, $\eta^2_p = .097$.

***Figure 5.5***

*Mean Scores for the Baseline and Post-Primer Conditions of the Test for the Lower and the Higher BPVS Group. Error bars = standard error.*

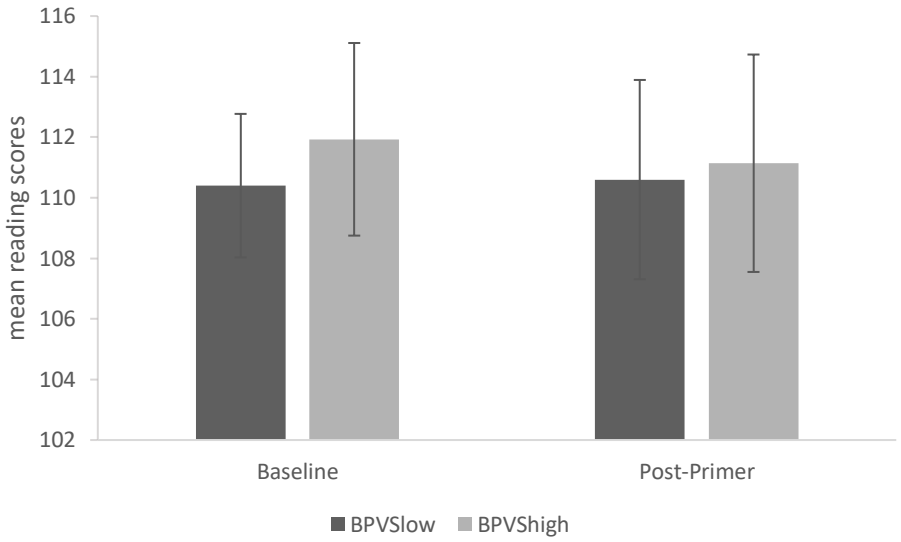
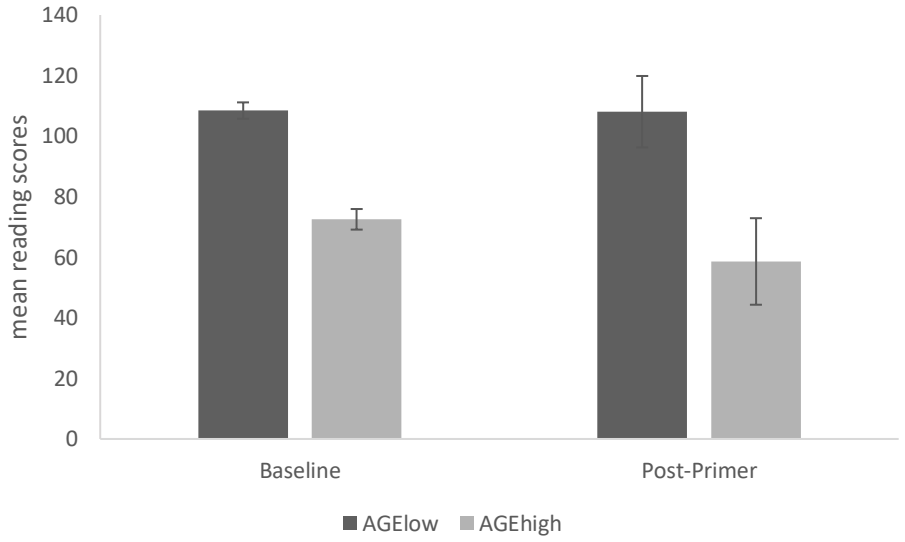



Figure 5.5 shows the mean BPVS scores for the primer and non-primer group in both conditions of the test. The BPVS scores for the sample ranged from <45 to 112 months with a median of 62. 5 months. The sample, irrespective of groups, was split at the median to create a lower BPVS group ($N$=14, mean BPVS = 23.28 $\pm$ 28.12) and a higher perceptual BPVA group ($N$= 14, mean BPVS = 88.5 $\pm$ 18.05). There was very little difference between the WRS for the two groups in the baseline condition of the test. A mixed-model ANOVA (group x test) conducted on these data revealed no significant main effects of test, $F(1,30) = .41$, $p = .527$, $\eta^2_p = .013$, a significant effect of group $F(2,30) = 10.45$ , $p < .001$, $\eta^2_p = .411$, but no significant interaction between these factors, $F(2,30) = .42$, $p = .66$, $\eta^2_p = .027$.

**Figure 5.6**

*Mean Scores for the Baseline and Post-Primer Conditions of the Test for the Lower and the Higher Age Group. Error bars = standard error.*




We also looked at the possible impact of age on participant's scores. The ages for the sample ranged from 59 months **(4 yrs. 11 mts.)** to 186 months **(15 yrs. 6 mts.)** with a median of 157 months **(13 yrs. 1 mt.).** The sample, irrespective of groups, was split at the median to create a lower age group ($N$=17, mean age = 114.18 $\pm$ 32,25) and a higher age group ($N$= 16, mean age = 172.19$\pm$ 6.66). The higher age group had a higher word recognition mean than the lower in the baseline condition of the test. A mixed-model ANOVA (group x test) conducted on these data revealed no significant main effects of test, $F(1,31) = .83$, $p = .37$, $\eta^2_p = .026$, a significant effect of group $F(1,31) = 8.4$, $p = .007$, $\eta^2_p = .215$, but no significant interaction between these factors, $F(1,31) = .65$, $p = .42$, $\eta^2_p = .021$.

## 5.5 Discussion

The study aimed to evaluate the use of eye gaze tracking as a suitable method of assessment for children with additional learning needs, by comparing the scores of participants before and after the delivery of a primer activity, designed to familiarise participants with the use of eye gaze tracking equipment. Familiarity, it was predicted, may help to decrease the possibility of data loss, and therefore improve word recognition scores.

Results demonstrated that there were no significant differences between the scores of those who participated in the primer activities to those who didn't. When data for those participants with a diagnosis of ASD was analysed separately, the mean scores appeared to show that the primer activity had the reverse effect of what has been predicted, as their scores actually decreased in the post primer condition. However, statistical analysis showed no significant difference, therefore we couldn't rule out the possibility of these effects having occurred by chance. Further analysis of the data showed no impact of verbal IQ, perceptual reasoning IQ, or receptive vocabulary ability as measured by the British Picture Vocabulary Scale.

The suggestion of the Arnold and Reed study (2019), which compared results from a traditional paper-based version of the test with a modified touch screen format and a modified version with eye-tracking facility was that the use of a modified touch screen version was the more effective test format of the three. However, there was a consideration that a lack of familiarity with eye gaze equipment could in part account for the results. The current study, however, would suggest that the modified touch screen version of the test created by Arnold and Reed continues to be the most effective format for children with additional learning needs as long as they have the ability to utilise pointing as a form of response. Where a participant is able to use pointing as a form of response, it is easier for the assessor to know if the participant has not provided a response (as in their finger hasn't made contact with the screen) or has provided a wrong answer, by touching an area of the screen that represents an incorrect answer.

This said, a limitation of the current study was possibly the amount of time given for participants to familiarise themselves with the use of eye gaze and it may

well be that a more longitudinal approach would yield better results. Although the participants engaged well with the games, it could also have been the case that these particular games were not reinforcing the hoped-for understanding, that eye gaze was the cause of the on-screen effects. Alternatively, it could be that participants developed that understanding when playing the games but were unable to transfer this understanding when carrying out the word recognition assessment.

If we are to improve the prospects of children who are non-verbal, it is important that we experiment with methods of assessment which could lead to more successful interventions. This could be particularly important for younger children or those who may, as a result of motor deficits, not have developed pointing skills. As well as children who have a physical disability, motor deficits are also commonly associated with children who have autism (Paquet, Olliac, Golse, & Vaivre-Douret, 2016; Shetreat-Klein, M., Shinnar, S., & Rapin, I., 2014). Another comorbid issue for children on the autism spectrum can be deficits in joint attention (Charman, et al., 1997; Dawson, et al., 2004). This means that although some children will appear to be very capable with the use of touch screens, manipulating an iPad or tablet, for example, they won't necessarily have developed the ability to use pointing to make requests or as a form of response.

For non-verbal children to achieve their true potential therefore, there has to be a desire to develop forms of assessment that can account for such barriers. This can only be achieved through a willingness to experiment with methods of observation that have the potential to be truly inclusive. Only then will educational settings be making the kind of reasonable adjustments that all non-verbal children should be entitled to.

# CHAPTER 6

# Measuring the Reading-Related Skills of Children with Autism who are Non-verbal

## 6.1. Overview of Aims and Findings

### 6.1.1. Findings

The thesis aimed to begin to fill the research gap relating to children with autism who are non-verbal (US Department of Health and Human Services; IACC, 2011 & 2016), with a focus on patterns of word recognition and listening comprehension ability in this population.

Autism Spectrum Disorder (ASD) is a developmental disorder, which has varying degrees of severity, and is classified by marked delays and challenges in social communication, social interaction, and restricted, repetitive patterns of thought and behaviour (refs). Sensory sensitivities and sensory integration issues are also a factor (DSM 5; American Psychiatric Association, 2013, cited by Fletcher-Watson & Happé, 2019, p.30 - 32).

The challenges that children with autism face when learning to read have been shown to differ from those of children who are typically developing. These differences have been identified in elements of decoding and oral language skills, which are both important to achieve the ultimate goal of reading that is reading comprehension (Lervag et al., 2018), and may begin to occur in the earliest stages of learning to read (Whitehurst & Lonigan, 1998). Research has attempted to explain these differences through consideration of how the unique cognitive processing styles of children with autism interact with the cognitive processes that may be employed in reading (Carnahan, Williamson & Christman, 2011; El Zein, Solis, Vaughn, McCulley, 2013; Nguyen, Leytham, Schaefer Whitby, & Gelfer, 2015). Children with autism can experience difficulties with print concept knowledge (Dynia et al., 2016) and phonological awareness (Westerveld et al., 2017, Smith

Gabib, 2010). Further challenges have been linked to the prevalence of poor oral language skills in this population (Bishop & Snowling 2004, Catts & Kahmi, 2005) and social deficit (Ricketts et al., 2013).

The autistic community is a highly diverse population and there is far too much variation in reading patterns to be able to predict the reading style of a child with autism (Nally et al., 2018; Nation et al., 2006). However, what we can say, is that links identified between reading and language put children with autism, who are likely to have some form of language deficit, at high risk of reading difficulties (Bishop & Snowling 2004; Catts & Kamhi, 2005). We also know that while some children with autism can have word identification and reading comprehension skills which are well aligned, word reading ability does not guarantee effective reading comprehension skills for many of this population (Nation et al., 2006: O'Connor & Klein, 2004).

The focus of the current thesis has been on the group of children with autism who are non-verbal. Very little is known about these children, who on reaching school age, have not developed the ability to use words spontaneously in any meaningful way. There is no agreed definition for these children, however, they are usually identified as having a small (if any) repertoire of words (Kasari, Brady, Lord & Tager-Flusberg, 2013) or they may be considered echolalic (Charlop, 1983; Prizant & Rydell, 1984), which means their speech output mostly echoes the words or phrases of others. Research relating to this population is limited and there is nothing currently in the literature to explain why some children who appear to be non-verbal when they reach school age go on to develop speech later on, often much later than for their peers who are typically developing. Yet again, some of these children will continue to be non-verbal into and throughout their adult lives. (Bondy & Frost, 2001; Distefano et al., 2016; Kasari, Brady, Lord & Tager-Flusberg, 2013; Tager-Flusberg & Kasari, 2013). The underlying factors which could explain why some children are non-verbal are therefore not known and could very well differ from child to child. Some causational factors which have been suggested are apraxia of speech and issues with fine oral-motor movements which have been linked to general fine motor issues (Amato & Slavin 1998; Buekelman & Mirenda 1998;

Gernsbacher 2008) and there is some limited evidence in support of selective mutism as a possible explanation for some, but certainly not all cases (American Psychological Association, 1994; 2013, cited by Steffenburg, Steffenburg, Gillberg & Billstedt, 2017; Gillberg & Billstedt, 2000; Steffenburg et al., 2017).

A term which has been often associated with children with autism who are non-verbal is 'low functioning' (Prizant, 2012). This is a particularly unhelpful term which may encourage the under-estimation of abilities and potential of a cohort who are under-researched and often excluded from studies which involve their verbal peers. Examples of these studies were given in chapter 1 and included Nally et al., (2018) who described their sample as a "nationally representative sample of 110 children with ASD". However, explicit in the participant recruitment criteria, was a requirement to be able to "vocally echo a minimum of two words". Fourteen prospective participants were excluded from the study, as they could not meet the criteria. For Smith Gabig's (2010) study, which looked at phonological awareness, amongst participation criteria were "functional verbal ability at the phrase or sentence level". Nation et al., stipulated in their participation criteria, "language skills sufficient enough to allow them to participate in our study". While not always explicit in participation criteria, exclusion can also be implicit in the materials studies have employed to assess reading ability, which carries a requirement of being able to verbalise responses (Ricketts, et.al., 2013; Zuccarello et.al., 2015). A general lack of homogeneity in assessments used across reading studies can also make it difficult to generalise results.

A perhaps obvious explanation, for the exclusion of children who are non-verbal from reading studies, would be that there aren't assessments available that are able to measure performance in reading for this cohort, as reading tests require the ability to verbalise. However, lack of research which would explore the issue of measuring the reading abilities of children who are non-verbal, implies also a possibility that the association between children who are non-verbal and the term 'low functioning', may serve to lower academic expectations for these children.

The aim of the studies in this thesis, therefore, was, in chapter 2, to establish the provision for children with autism who are non-verbal in terms of the kinds of

reading assessment that are currently employed in additional learning needs settings. A further aim was to explore the views of educational practitioners concerning the usefulness of these assessments for children with ASD who are non-verbal. In chapter 3, the aim was to discover what we might expect from a child who has autism and is non-verbal with regards to word recognition abilities, once the requirement for verbalisation was removed from a standardised reading test (NRST; McCarty & Lallaway, 2012). In the following chapter (chapter 4) we extended the analysis to find out if, again, we removed the requirement for verbalisation from the traditional paper-based test, would we be able to detect listening comprehension abilities for children with autism who are non-verbal? In chapter 5 we attempted to resolve the issues experienced when using eye gaze tracking equipment to detect word recognition abilities, specifically the possibility that under-familiarisation with the equipment on the part of the participants had adversely impacted on the eye gaze tracking results in chapter 3. Familiarity, it was predicted, may help to decrease the possibility of data loss, and therefore improve word recognition scores.

This final study (chapter 5), therefore, evaluated the use of eye-tracking as a method of assessment for children with additional learning needs. Scores for prior to and post-delivery of a primer activity, designed to familiarise participants with eye gaze tracking equipment, were compared. The results demonstrated that there were no significant differences between the scores of those who participated in the primer activities, to those who participated in alternative activities which would not familiarise them with eye gaze tracking equipment. When data for those participants with a diagnosis of ASD were analysed separately, the mean scores appeared to show that the primer activity had the reverse effect of what has been predicted, as their scores decreased in the post primer condition. However, statistical analysis showed no significant difference, therefore we couldn't rule out the possibility of these effects having occurred by chance. Further analysis of the data showed no impact of verbal IQ, perceptual reasoning IQ, or receptive vocabulary ability as measured by the British Picture Vocabulary Scale.

### 6.1.2 Limitations

Samples throughout the thesis were based on the availability of participants and schools willing to take part. In terms of the sizes of the three groups i.e. verbal ASD, non-verbal ASD and non-ASD, groups were generally well balanced. It is difficult to say how representative of the ASD population samples was, as this is such a diverse population. However, all participants were recruited from special schools and there is confidence of a good representation from this sector. A limitation that was noted with regards to the online survey (chapter 2) was that due to the way in which the survey was distributed, via e-mailing the link to the Headteacher, there was an assumption that all those who participated were practitioners working with ASD students in educational settings. If this process were to be repeated, it would be useful to clarify the exact nature of the role and level of responsibility of each participant, to ensure they had adequate knowledge of all systems employed by their setting.

A limitation of the survey was the relatively low response rate. Only 70 schools out of 1050 that were invited, responded to the invitation to complete the survey. For the purpose of generalisation, there is a need to interpret the results of the current study with caution. This said since all school practitioners reported a percentage of ASD students, students with severe communication difficulties and those to be considered 'high functioning', in the researcher's opinion the sample was a good representation of SEN schools in the UK. Further evidence that the reading tests identified by respondents represent a true reflection of methods employed, is the evidence from the reading studies cited in chapter 1 which used similar materials

There were some limitations in the research which could be addressed in future practice. We attempted to counteract any advantages to performance that may be gained through the use of multiple-choice test format by using corrections for guessing formula. For the listening comprehension study, we also made the incorrect answers so implausible as for it to be obvious to the researcher if a participant was guessing. However, there were only two options for each question in the listening comprehension test and it might be interesting to see the results if more options were provided. However, in the interests of inclusion, multiple-choice could

be considered reasonable adjustment for members of the autistic population ((Paxton & Estay, 2007) to help mitigate issues with word retrieval which some may experience (Attwood, 2007).

Limitations involving data loss for the eye gaze tracking facility have been discussed above. This relatively new technology continues to be developed and the limitations we experienced do not rule out the possible potential of further exploration of its use in assessing the abilities of children who are non-verbal.

The researcher who carried out these studies was aware of the diagnosis of the participants; this could have resulted in some confounding experimenter effects. Experimenter effects occur when errors in the research process, or interpretation of results, can be attributed to the something in the researcher's "behaviour, preconceived beliefs, expectancies, or desires" (VandenBos, 2007). Commonly identified unconscious behaviours are nonverbal behaviours such as head, facial or body movements, vocal tone, and eye gaze (Scherer, Harrigan, & Rosenthall, 2005). The extent to which each participant may be affected by nonverbal cues is not the same for everyone, as individual differences in interpersonal sensitivity have been identified (Scherer et. al., 2005). As deficits in nonverbal communicative behaviours, for example in understanding nonverbal communication, forms part of the autism diagnosis (DSM-V), the extent to which nonverbal behaviours might impact on participants with this diagnosis (which made up approximately two-thirds of the participant pool for the current study) are likely to be highly variable.

An example of how unconscious experimenter behaviour could impact on results in a study such as the current one, might be that a participant reaches to select a word but then alters their selection in response to the researcher's facial expression or body language. This would mean the data would not be as reliable as the researcher assumed. Without knowing the level of interpersonal sensitivity for each participant it would be difficult to know the extent of the impact or which groups (if any) were most affected. As mitigation, it may be advisable for the person carrying out the assessments in any future studies to be unaware of participants' diagnosis. However, even with these measures, someone with experience of children with autism may be able to identify participants who exhibit repetitive or stereotypical

behaviours which relate to autism; for example hand-flapping (Turner, 1999), eye-rolling, or finger wiggling/waving in front of the face (Schopler 1995, cited by Gal, Dyck & Passmore, 2010).

**A main benefit of creating the tests in a digital format, is accessibility and portability. Therefore, it could be possible, and even advisable, for the test to be converted into a self-scoring application that could be delivered online. This way, the researcher would only be familiar with the results and not the participants.** The implications this might have for engagement would be difficult to predict, however, as evidence in support of technology-based interventions for children with learning disabilities and autism can vary (Fletcher-Watson et. al., 2002; Knight, McKissick & Saunders, 2013; Valencia, Rusu, Quiñones, & Jamet, 2019;Williams, Wright, Callaghan & Coughlan, 2002) and be inconclusive (Stetter & Tejero Hughes, 2013).

Further, some possible benefits that may have been present due to the researcher's knowledge of autism diagnosis and experience of working with children with autism would also be lost. For example, we know that children with autism, particularly children who are non-verbal (Tager-Flusberg et. al., 2016) often exhibit a range of challenging behaviours. The skills of the researcher in this instance, therefore, may have improved the outcome for some participants just because the supportive way in which the tests were delivered enabled them to stay on task.

In terms of practical application, if the test were to be delivered by a teacher in a school setting, schools will likely face a similar conundrum. If results for a pupil are better when the test is delivered by a teacher who has experience of working with that pupil, do we accept that result? Alternatively, would we want to record only results that we know will be consistent independent of delivery? The advice of this author would be that the answer to that question depends very much on the purpose for carrying out the test. If the purpose of the test is purely a summative data exercise, then no doubt the latter would suffice. However, if the aim is to have the truest and most accurate picture of a child's abilities that we can get, under what can be very difficult testing circumstances, with a view to improving provision for the learner, then this author would advocate the former.

A further consideration in terms of the use of a self-scoring test, with no interactions between the researcher and the participant, relates to the possibility that variability in participant's ICT skills could introduce a new confounding variable. In the current research, there was no requirement on any participants to navigate the test on the screen. Therefore, the individual ICT abilities of participants had no bearing on test participation or results.

Going forward, it may be advisable to establish a protocol which has the capacity to balance some of these possible effects. For example, a self-scoring test with participants supported by a researcher with knowledge of diagnosis. The test could then be performed more than once, with different but equally graded forms being used to avoid over-familiarity, and the second test being delivered by a second researcher. There would be ethical matters to consider if the second researcher, however, had no knowledge of diagnosis as this could create a less supportive environment for the participant, leading to distress. Whatever the knowledge of the second researcher however, having two results to compare for each condition would likely improve validity. In a practical setting this could be achieved by results produced by one teacher being verified by those obtained by a second teacher.

## 6.2 Implications for Practice

### 6.2.1 Educational Practice

Currently, we know very little about the abilities of children with autism who are non-verbal. This is evident in academic research and the teaching profession. At the time of writing this chapter of the thesis, the author has twenty years of practice as a school-based educational practitioner working with children who have autism and who are non-verbal. The original catalyst for this research was having the experience as a teacher, of suspecting a child who is non-verbal to be a reader but having no access to a test suitable for detecting any potential reading skills. The

survey of special schools reported in chapter 2, demonstrates that this is not a unique experience for special school practitioners. The two most used reading assessments employed in additional learning needs settings require a child to be able to verbalise. The alternative to this appeared to be no reading test at all. While it could be argued that some teachers may develop their own ad-hoc methods for assessing reading skills (as has the author), these methods don't provide information for children who are non-verbal which is comparable to the information gained by assessing their verbal peers. Assessment data forms part of school self-evaluation which informs the plans for school improvement. The school improvement plan will set out how resources are allocated, and which interventions are employed. Therefore, students with ASD who are non-verbal, who are not represented in the data, will also be prone to exclusion from more advanced forms of reading instruction and communication intervention that the school provides.

There are two issues proposed as a way of explanation for this practice Firstly, there is the absence of a reading test that is suitable for this cohort. Consideration of the reading research carried out with the autistic population cited in chapter 1 of this thesis, provides evidence for this assumption. For example, measures of reading accuracy in Nation et al. (2006) were The Graded Nonword Reading Test (Snowling, Stothard & McLean, 1996), Neale's Analysis of Reading Ability II (NARA II; Neale, 1997) and the British Ability Scales reading subtest (Elliot, Smith & McCulloch, 1996). All of which requires the ability to read aloud. Nally et al. (2018) also made use of the NARA II and Zuccarello et al. (2015) employed reading tests standardised for Italian children, which require verbalisation. As was highlighted in chapter 1, such methods have led to the exclusion of children with autism who are non-verbal from reading studies.

The second proposed explanation relates to the first when we begin to ask why it is the case, that rather than developing methods that can accommodate the child who is non-verbal, they are excluded from reading studies? Researchers who have considered the literacy provision for children with autism who have been labelled as 'low functioning', have cited findings of low expectations which lead to a lack of appropriate literacy provision for these pupils in the classroom setting

(Erickson & Koppenhaver, 95; Mirenda, 2003). In looking at perspectives on supporting children with autism with literacy development, Mirenda (2003), voiced the opinion that the 'reading readiness model', which has helped shape the way literacy instruction is delivered in the classroom, has negatively impacted on expectations and provision for children with autism.

Reading readiness is a model that proposes a hierarchy of pre-requisites to reading which once achieved are indicators that a child is ready for more formal literacy instruction i.e. beginning reading (Mason, 1977). These skills are emergent reading skills (discussed in chapter 1), which include letter knowledge, phonological awareness, and print concept knowledge. Concept of print refers to the knowledge of what books and print are and how they function and includes the understanding that print conveys meaning. Mirenda (2003) proposes that as children with autism often don't demonstrate these skills, they are not then provided with literacy instruction alongside their peers, which then limits their opportunities for reading. As discussed in chapter 1, studies have shown that children with autism often underperform on tasks relating to print concept knowledge and phonological awareness when compared to children who are typically developing (Dynia et al., 2016). However, the links between prerequisites to reading, phonological awareness for example (Smith Gabig, 2010) and word reading are not always evident for this cohort. Therefore, it would be a mistake to assume that just because the child with autism does not display these skills, they should not be included in reading instruction. Mirenda (2003, p. 272) also notes, "students without functional speech who require augmentative and alternative communication (AAC) are at especially high risk for failure in readiness-based literacy programs…".

Studies carried out by Bishop and Adams (1980), Catts (1993), and Ferreira et al. (2007) have shown that articulation is not a necessary prerequisite for reading. However, despite a large-scale study of pre-school children (Munson 2008) which discovered that not all children who are non-verbal have a low nonverbal IQ, there is often an assumption that children who are non-verbal are likely to be 'low functioning' (Mirenda 2003, Tager-Flusberg & Kassari, 2013). Further, while some children who are non-verbal have low receptive and expressive language abilities,

others with minimal expressive language skills have good receptive language abilities (Rapin, Dunn, Allen, Stevens, & Fein, 2009). Good receptive language has been identified as a predictor of good outcomes in reading skills (Gough & Tumner, 1986; Sticht & James, 1984, cited by Perfetti, Landi & Oakhill, 2005).

It can, therefore, be argued that it is not a lack of speech alone which informs opinions of the abilities of children with autism who are non-verbal, but this idea that children with autism who are non-verbal are likely to be 'low functioning'. A possible consequence of this is that teachers do not provide adequate instruction; based on the notion that children who are non-verbal are also likely to be too 'low functioning' to be ready to read. What we have then, is a high chance of self-fulfilling prophesy, as these children will receive a lack of instruction which then limits their chances of learning to read. Reading assessment which can accommodate this cohort and provide teachers with an accurate, rather than an assumed level of reading ability, would discourage this kind of practice.

Research carried out as part of this thesis lends further support to the possibility that children with autism who are non-verbal may have some potential for developing reading skills. Overall, results suggest that although children with autism who are non-verbal are often labelled 'low functioning', their reading patterns may well be more in line with their verbal ASD counterparts than children without ASD who have learning difficulties. For example, Nation et al. (2006) considered the reading patterns of verbal children with autism and found that, of 20 readers who achieved word reading levels within or above age-related norms, half demonstrated poor reading comprehension skills. A profile of good or even precocious word recognition ability, accompanied by poor reading comprehension skills is commonly associated with ASD (O'Connor & Klein, 2004). In the literature, this is usually referred to as a 'hyperlexic reading style' or 'hyperlexia'. In their sample of verbal children with ASD, Zuccarello, et al. (2015), also identified a pattern of reading consistent with hyperlexia, or a 'hyperlexic' reading style.

However, the results from the online survey (Chapter 2) suggest a strong chance that in the population of children with ASD who are non-verbal, reading skills will go undetected. The likely result being that children with autism who are

non-verbal will not be appropriately supported in the classroom to further develop or apply such skills.

In support of this statement, the author can provide one of several examples available from her classroom practice, to demonstrate the positive difference acknowledgment of reading skill can make to the quality of life for a child with autism who is non-verbal. The name used is not the real name of the child involved.

> "Paul is our least able pupil in the class. He is very disruptive, he breaks everything, he rips everything up. If you are getting ready for a lesson don't put anything out beforehand, he'll just wreck it."
>
> After working as a teaching assistant with children with autism for a number of years, this was to be my first class as a qualified teacher, and this was the information I was given about Paul by the teacher who was due to leave. Paul was six years old and he had been in the school since he was four.
>
> "What about PECS?" I asked this question because I knew that Paul was completely non-verbal. He had no words at all, although he did vocalize if he was upset or angry. Picture Exchange Communication Systems (PECS; Frost & Bondy 2002), along with other forms of symbol-based forms of alternative augmentative communication (AAC), are commonly used to support the communication skills of students who are non-verbal.
>
> "He used to use it. He could exchange a symbol for some stuff like food and drinks, but he stopped. Now he just chews the symbols in his book."
>
> I soon discovered that the teacher was right about how much mess Paul liked to make! His favourite pastime was tipping out equipment from any box in which it was stored. To try to distract Paul from this activity, while still giving him something he liked to do, I provided a box of old books which he was encouraged to 'tip and then tidy' whenever he felt the urge. Before long, I noticed that rather than just put the books straight back in the box Paul liked to examine the books. I started to make a point of sitting with Paul during

these ‘tip and tidy’ sessions and he would grab my finger and point it to words, his face lighting up with joy every time I read it aloud.

Other behaviours, such as being able to find the file names of favourite videos and pictures (without visual images displayed) and pointing to words on poster displays around the school, made me suspect that Paul may be able to read. It was after around eight months that I had been working with Paul when the member of staff responsible for coordinating literacy at the school began handing out summative reading tests for pupils to complete. The reading test was the New Salford Reading Test, as the current thesis has demonstrated, this is quite common for special school assessment practices. I pointed out to the coordinator that Paul wouldn’t be able to read the words aloud and asked for advice. The advice was that Paul wouldn’t be able to take the test.

Paul was one of the participants in the research studies contained in this thesis. He demonstrated both word recognition and listening comprehension skills. As a result, the school purchased an iPod for Paul so that rather than just use symbols he could be taught to type words. As Paul’s frustrations eased, his behaviour improved, and we were able to put things out before lessons without them being destroyed. The following year, all of Paul’s other assessment scores demonstrated dramatic improvement. These were in literacy but also in maths and other foundation areas of learning such as knowledge and understanding of the world and personal social and emotional development. Paul continues to communicate his wants, needs, and thoughts by typing words on to a digital screen which then reads the words aloud for others to hear. He sometimes uses symbols on the screen as ‘shortcuts’ and he doesn’t seem to mind this as long as the device says the whole sentence and not just the word for the symbol. For example, if Paul uses the symbol for ‘toilet’ he likes the device to say, “can I go to the toilet please?” and not just the word ‘toilet’. Staff working with Paul felt that once Paul’s reading skills had been acknowledged and his communication provision improved to align, Paul was able to understand the value of communication again. The

> school uses the modified version of the NSRT annually to test the word recognition skills of all pupils who are non-verbal. Paul now accesses books in a way far beyond tipping them out of a box and putting them back in again!

Eleven schools participated in the research for this thesis. We know of three (and a follow-up study could reveal more) that continue to use the modified test to improve their provision for children who are non-verbal.

The development of literacy skills is one of the foremost aims of education, as a life skill and because it provides access to all other curriculum areas (Department for Education, 2014; Welsh Government, 2019). In the case of children with autism who are non-verbal, a crucial area is communication. Therefore, when carrying out reading assessments, one might argue that we should not only avoid excluding children with ASD who are non-verbal but that this population should be a priority for reading assessment and instruction.

Overall, results in this thesis have consistently shown that once the requirement for verbalisation is removed from a reading test, children with autism who are non-verbal can demonstrate skills in both the area of word identification and listening comprehension. Therefore, it is proposed that the use of the modified test with a touch screen facility may offer a good assessment of some elements of reading skills for children with ASD who are non-verbal.

### 6.2.2 Broader implications

Academic achievement for young people with autism is variable across the autistic spectrum (Keen, Webster & Ridley, 2016) which, when we consider the diverse academic profiles exhibited by children with autism, is perhaps to be expected. However, variability in long-term outcomes with regards to overall quality of life, are far less acceptable (Howlin & Moss 2012; Levy & Perry 2011). Research regarding long-term outcomes for adults with autism is limited and often contradictory (Howlin & Magiati, 2017), and measuring quality of life of adults with autism is an under-researched area (McConachie et al., 2018). However, in a recent

review of the literature Howlin and Magiati (2017, p.3) stated that prospects for those people with autism who have low IQ *or* who fail to develop functional speech are "particularly poor". A recurring theme in the literature relating to the quality of life is prospects gained from the educational provision, which as we have seen concerning literacy is not a priority for teaching with this cohort. (Erickson, 1995; Mirenda 2003).

Shattuck et al. (2012) used information from the US department of education to inform their study of postsecondary education and employment among the autistic population. This population had the lowest rates of participation in employment compared with youth in other disability categories and had the highest risk of being completely disengaged from any kind of postsecondary education or employment. Impairments in functional skills (English, Maths, ICT skills required for work and personal life) were associated consistently with worse outcomes. Education levels were also one predicting factor of employment identified by Chaing, Cheung, and Tsai (2013) when they looked at factors associated with participation in employment for high school leavers with autism.

Henninger and Taylor (2014) considered family perspectives on a successful transition to adulthood for individuals with disabilities using an internet survey. In answer to a question relating to how they would define successful transition to adulthood for their children, the most frequent responses were those that fell into the category of 'having an occupation or functional role in society'. This was defined as not only paid employment but any productive occupation fitting the needs and abilities of the individual as well as general feelings of productivity and contributing to the community. These goals were echoed by the autistic participants in the Sosnowy, Silverman, and Shattuck survey (2017) who cited 'getting a job' or 'further education' amongst their aspirations. Research that has focused on factors that contribute to quality of life and 'successful adulthood' (Levy 2011) has identified adequacy of educational provision and access to education that is appropriate, as a major factor affecting social outcomes and economic independence in adulthood for the autistic population. Therefore, an appropriate assessment that leads to the provision of informed and relevant education provision has the potential

to improve the long-term outlook for the ASD population. If we are to improve the overall prospects for the autistic population and increase the possibilities for 'successful adulthood', it is essential that we can identify realistic aims for each autistic individual. The use of appropriate and inclusive forms of assessment could assist with this endeavour.

## 6.3 Final Conclusions

The thesis aimed to begin to fill the research gap relating to children with autism who are non-verbal (US Department of Health and Human Services; IACC, 2011 & 2016), with a focus on patterns of reading ability in this population. The challenges that children with autism face when learning to read are unique to this population. An additional challenge for children with autism who are non-verbal is that reading tests require verbalisation, this requirement acts as a barrier to the discovery of the potential reading skills of this cohort.

The initial study, which was in the form of an online survey revealed that practitioners are using reading tests in their special needs schools which they believe are not fit for purpose for children with autism who are non-verbal. Evidence from this study, combined with evidence gained from looking at the methodology in a range of reading studies showed that as a result, children with autism who are non-verbal tend to be excluded from reading assessment. This is in both educational and academic circles.

Two explanations were offered for this situation. Firstly, and perhaps the most obvious is that there isn't a reading test which is suitable for this cohort. Secondly, the association between children who are non-verbal, and the lower functioning end of the autism spectrum has served to lower expectations of the reading abilities for non-verbal members of the ASD population.

To address these issues, a novel modified multiple-choice test format was developed which was aligned to the NSRT. The requirement for verbalisation was not part of the modified format, which was presented using touch screen and later, eye gaze tracking facility. Three studies were carried out which looked specifically at the reading performance of participants with ASD who were non-verbal when compared to their verbal and non-ASD counterparts. In all three studies, when accessing the modified test format, participants who were non-verbal demonstrated detectable reading scores. This was as opposed to the score of zero which all participants received when accessing the traditional paper-based version of the test. Further, some participants with ASD who were non-verbal were also able to demonstrate detectable reading comprehension scores when accessing the modified format of the test. Improvements when using the modified test format was only significant for this group. The test which demonstrated the most improved performance was the touch screen version of the test. The final study (chapter 6) considered the possibility that data loss was the reason for participants poorer performance when accessing the eye gaze tracking version of the test when compared to touch screen. However, results from this study were not significant.

Overall, results have consistently shown that once the requirement for verbalisation is removed from a reading test, children with autism who are non-verbal can demonstrate skills in both the area of reading and reading comprehension. Therefore, it is proposed that the use of the novel modified reading test with touch screen facility may offer a good assessment of **some elements of reading skills** for children with ASD who are non-verbal.

This has implications for both academic studies and educational provision. Not every child or young person with ASD who is non-verbal will lack the ability to read. This means that many children on the autistic spectrum who are non-verbal may have reading skills which are currently undetected. Verbalisation is a common element of reading tests being used in special school settings, by removing this element, the modified format of assessment used in this thesis promotes a form of assessment that not only measures reading skills for children who are non-verbal, but does so in a way that allows for comparison with their verbal counterparts. This is

important for the field of special education, as, without this, children who are non-verbal will continue to be excluded from literacy provision, which could improve their chances of being successful readers and future ‘successful adults’.

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# Appendix A

## Reading Assessments for ASD Students Survey

| Question Number | Instruction | Available Answers |
|---|---|---|
| 1 | Please tick the statement which best describes your school. | Additional Needs/SEN |
| | | Mainstream |
| | | AN/Mainstream Combined |
| 2 | Are you classed as a school with Welsh as a first language? | yes |
| | | no |
| 3 | Please tick the statement which best describes your setting | Local Authority |
| | | Free School |
| | | Academy |
| | | Other – please specify |
| 4 | Please tick the statement which best describes your setting | 50 pupils or less |
| | | 51-100 pupils |
| | | 101-150 pupils |
| | | 151-200 pupils |
| | | 201-250 pupils |
| | | 251-300 pupils |
| | | 301-350 pupils |
| | | 351-400 pupils |
| | | 401-450 pupils |
| | | 451-500 pupils |
| | | If over 500 please specify |

| Question Number | Instruction |
|---|---|
| 5 | Approximately how many (%) of these pupils have additional needs/special educational needs? |
| 6 | Approximately how many (%) of your AN/SEN pupils have communication difficulties? |
| 7 | Approximately how many (%) of your pupils have a diagnosis of ASD? |
| 8 | How many (%) of your students with ASD can be described as mostly non-verbal? |
| 9 | How many (%) of your students with ASD can be described as having very limited communication? |
| 10 | How many (%) of your students with ASD are considered to be high functioning/Asperger's? |
| 11 | Do you have students with other forms of communication difficulty? If so, please comment. |

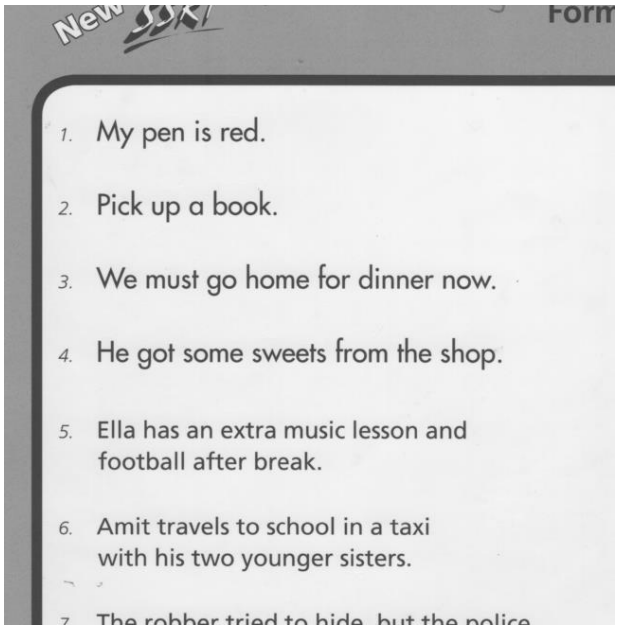
| Instruction | Answers Available |
|---|---|
| Please select the reading assessments which you are currently using to measure reading ability (whole school). | Neale's Analysis of Reading Ability (NARA) |
| | Salford Reading Test (SRT) |
| | National Foundation for Educational Research (NFER) |
| | Progress in Reading Assessment (PiRA) |
| | Wechsler Individual Achievement Test (WIAT) |
| | Suffolk Reading Scale (SRS) |
| | Non word reading test |
| | National Reading Test Wales |

## Appendix B

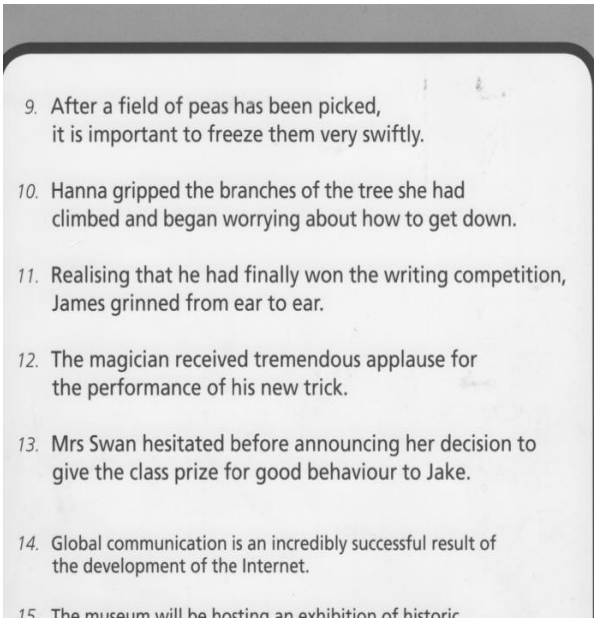
**Example of materials used for delivering and scoring of both paper and modified versions of the word recognition test (including eye gaze condition).**

*New Salford Reading Test: Form A, traditional paper version, sides 1 and 2: 17 sentences in total.*

Side 1



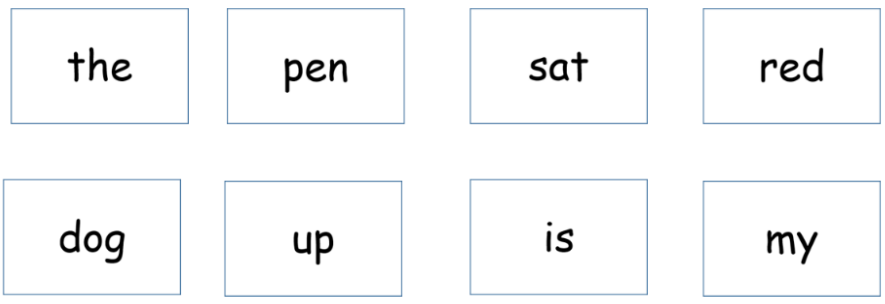

Side 2



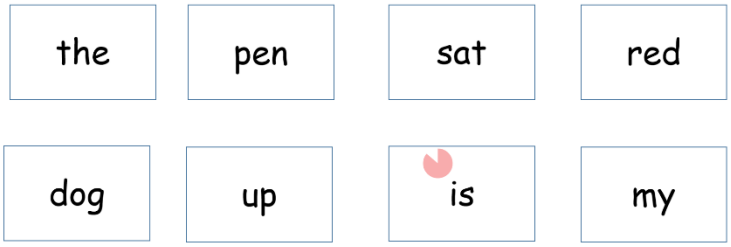

**Note:** Only some of the 17 sentences are visible due to copyright restrictions.

*Modified version of New Salford Reading Test (screenshots), designed for purposes of the study.*

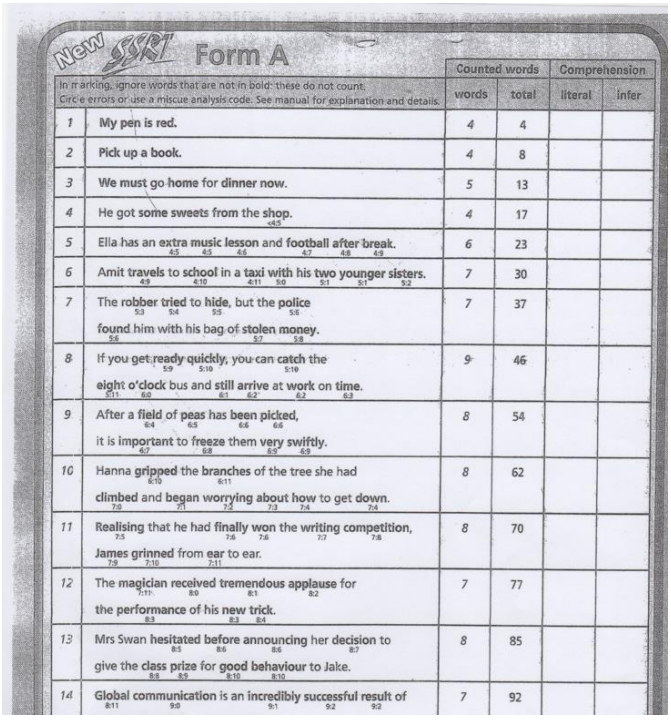
*Form A, slide 1 represents sentence 1 of form A paper version and contains 4 'counted words' and 4 incorrect alternatives (taken from Forms B and C to ensure words are equally graded). 17 slides in total to represent 17 sentences in the test.*



*Screenshot to demonstrate eye gaze tracking being used to make a word selection*




*New Salford Reading Test scoring sheet for Form A (used for both paper and modified versions of the word recognition test).*



New SERT Form A

| | In marking, ignore words that are not in bold: these do not count. Circle errors or use a miscue analysis code. See manual for explanation and details. | Counted words: words | Counted words: total | Comprehension: literal | Comprehension: infer |
|---|---|---|---|---|---|
| 1 | My pen is red. | 4 | 4 | | |
| 2 | Pick up a book. | 4 | 8 | | |
| 3 | We must go home for dinner now. | 5 | 13 | | |
| 4 | He got some sweets from the shop. | 4 | 17 | | |
| 5 | Ella has an extra music lesson and football after break. | 6 | 23 | | |
| 6 | Amit travels to school in a taxi with his two younger sisters. | 7 | 30 | | |
| 7 | The robber tried to hide, but the police found him with his bag of stolen money. | 7 | 37 | | |
| 8 | If you get ready quickly, you can catch the eight o'clock bus and still arrive at work on time. | 9 | 46 | | |
| 9 | After a field of peas has been picked, it is important to freeze them very swiftly. | 8 | 54 | | |
| 10 | Hanna gripped the branches of the tree she had climbed and began worrying about how to get down. | 8 | 62 | | |
| 11 | Realising that he had finally won the writing competition, James grinned from ear to ear. | 8 | 70 | | |
| 12 | The magician received tremendous applause for the performance of his new trick. | 7 | 77 | | |
| 13 | Mrs Swan hesitated before announcing her decision to give the class prize for good behaviour to Jake. | 8 | 85 | | |
| 14 | Global communication is an incredibly successful result of | 7 | 92 | | |

**Note:** Only some of the 17 sentences are visible, due to copyright restrictions.

# Appendix C

## Example of materials used for delivering and scoring of both paper and modified versions of the listening comprehension test

*New Salford Reading Comprehension Test: form A, traditional paper version, sides 1 and 2: 17 sentences in total.*

Side 1

New SSRT Comprehension Test Form A

| | | |
|---|---|---|
| 1 | What colour is the pen? | red |
| | *What would you use the pen for?* | *drawing or writing or colouring* |
| 2 | What will you pick up? | a book |
| | *What do you think you will see in the book?* | *words or pictures, etc* |
| 3 | What must they do? | go home or to have dinner |
| | *Why do you think they must go home?* | *it's dinner time or Mum says, they are hungry, etc* |
| 4 | What did he get? | sweets |
| | *What do you think he did with them?* | *ate them or shared them* |
| 5 | What does Ella do after break? | plays music and football (*both* required – prompt by saying 'and...' if only one given) |
| | *Which do you think is better for her, and why?* | *either, with a reason (eg more fun, or for fitness or for pleasure)* |
| 6 | How many children are in the taxi? | three (prompt by saying 'are you sure?' if not correct first time) |
| | *What do you think they might talk about?* | *school or home or anything reasonable* |
| 7 | What was the robber trying to do | trying to hide or hide the money |

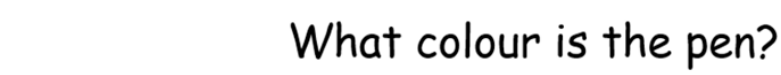
Side 2

| | | |
|---|---|---|
| 9 | What has been picked? | peas |
| | *What do you think happens to the peas after they are frozen?* | *put in bags or fridge, sent to shop or cooked (if 'eaten' given, say 'When frozen?')* |
| 10 | Where is Hanna? | up a tree or on a branch |
| | *What do you think happens next?* | *finds way down or falls, calls for help or is rescued, etc (do not accept 'stuck')* |
| 11 | What did James win? | writing competition (prompt with 'what sort?' if only 'competition' said). If 'prize' given, ask 'What for?' |
| | *How do you think James felt?* | *happy, pleased or proud, etc* |
| 12 | What has the magician just done? | a new trick (accept magic or trick) |
| | *Do you think the magician was pleased by his performance ... and why?* | *yes, because of the applause or the trick worked well* |
| 13 | What did Mrs Swan announce? | her decision or Jake had won or 'the prize' |
| | *Why do you think Mrs Swan hesitated?* | *a close competition or Jake doesn't usually win, etc* |
| 14 | What does it say is a success of the Internet? | (global) communication |
| | *What sorts of things get communicated on the Internet?* | *pictures, documents, emails or messages, etc (accept 'texts' or 'Google')* |

**Note:** Only some of the 17 sentences are visible due to copyright restrictions.

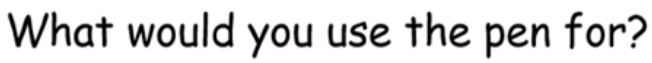
*Modified version of New Salford Reading Comprehension Test (screenshots), designed for the purposes of this study:*

*slide showing the literal comprehension question for sentence 1 of the reading test:*

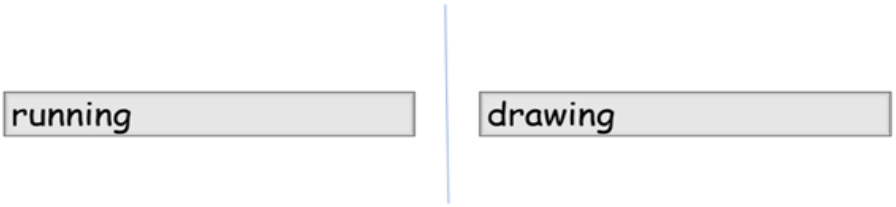



*the next slide shows the choices for response:*

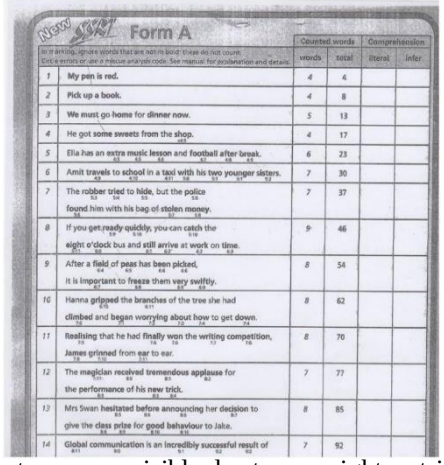

*slide showing the inferential comprhension question for sentence 1 of the reading test:*




*the next slide shows the choices for response:*




*New Salford Reading Test scoring sheet for Form A (used for both paper and modified versions of the test*



New Salford Test — Form A

In marking, ignore words that are not in bold; these do not count.
Circle errors or use a miscue analysis code. See manual for pronunciation and details.

| | | Counted words | | Comprehension | |
|---|---|---|---|---|---|
| | | words | total | literal | infer |
| 1 | My pen is red. | 4 | 4 | | |
| 2 | Pick up a book. | 4 | 8 | | |
| 3 | We must go home for dinner now. | 5 | 13 | | |
| 4 | He got some sweets from the shop. | 4 | 17 | | |
| 5 | Ella has an extra music lesson and football after break. | 6 | 23 | | |
| 6 | Amit travels to school in a taxi with his two younger sisters. | 7 | 30 | | |
| 7 | The robber tried to hide, but the police found him with his bag of stolen money. | 7 | 37 | | |
| 8 | If you get ready quickly, you can catch the eight o'clock bus and still arrive at work on time. | 9 | 46 | | |
| 9 | After a field of peas has been picked, it is important to freeze them very swiftly. | 8 | 54 | | |
| 10 | Hanna gripped the branches of the tree she had climbed and began worrying about how to get down. | 8 | 62 | | |
| 11 | Realising that he had finally won the writing competition, James grinned from ear to ear. | 8 | 70 | | |
| 12 | The magician received tremendous applause for the performance of his new trick. | 7 | 77 | | |
| 13 | Mrs Swan hesitated before announcing her decision to give the class prize for good behaviour to Jake. | 8 | 85 | | |
| 14 | Global communication is an incredibly successful result of | 7 | 92 | | |

**Note:** Only some of the 17 sentences are visible due to copyright restrictions.

# Appendix D

**Modified Word Recognition Test** ©Sharon Arnold 2015

| **Counted Words NSRT** | **Word Choices Available** |
|---|---|
| **Form A slides– slide 1 contains instructions for test** | |
| my pen is red | the pen sat red dog up is my |
| pick up a book | up come book pick ball a play and |
| we must home dinner now | home across now dinner bike loves she we park must |
| some sweets from shop | shop sweets like some make from things school |
| extra music lesson football after break | music world land animal break football lesson after elephant largest extra an |
| travels school taxi with two younger sisters | than always buses travels stopping two school sisters younger train taxi goes faster with |
| robber tried hide policy found stolen money | robber money climbed still hide police stolen fireman could tree tried ladder found reach |
| ready quickly catch eight o'clock still arrive work time | quickly window kitchen still catch pouring smoke o'clock noticed eight time work when out talking arrive brother ready |
| field peas been picked important freeze very swiftly | serious field gets fishing freeze very trouble boat nets important been swiftly picked peas trapped dolphin |
| gripped branches climbed began worrying about how down | while chasing down worrying ankle where began about how injured gripped branches attempting escape climbed who |
| realising finally won writing competition James grinned ear | have grinned ear regularly train writing won runners international finally level dedicated realising competition compete James |
| magician received tremendous applause performance new trick | mountain place tremendous although applause rescuers received exhausted trick refused magician new accompany performance |
| hesitated before announcing decision class prize good behaviour | please before good earthquake money requested behaviour announcing prize decision survivors clothing donate class assistance hesitated |
| global communication incredibly successful result development internet | development impact incredibly exploring result climate studies global communication internet scientific continually change successful |
| museum hosting exhibition historic contemporary paintings January | used hypnotism museum exhibition medical historic paintings hosting history contemporary January ages purposes throughout |

| | |
|---|---|
| fund-raising events government grants enabled purchase expand grounds | fund-raising immense enabled cause purchase atmosphere events grounds eruption high ejected volcanoes expand government grants columns |
| prestigious orchestra require expert musicians conductor rehearse | orchestra emerging gradually periscope shore conductor rehearse submarine prestigious prepared surface expert require musicians |
| **Form B slides – slide 1 contains instruction for test** | |
| the dog sat up | up the park sat run to dog my |
| come and play ball | come and got ball cat our wet play |
| she loves bike across park | she sing they loves happy bike park songs across like |
| like make things school | make school ride like things lake we boat |
| an elephant largest land animal world | land largest lovely elephant world growing herbs an flowers animal some garden |
| train goes faster than buses always stopping | goes there foxes buses than faster more shopping towns living always train ever before |
| fireman climbed ladder still could reach tree | kicked fireman Robert climbed ladder still could reach tree door glass broke mean break |
| talking brother when noticed smoke pouring out kitchen window | smoke watches window traffic out brother busy talking speeding pouring kitchen house when road hopes built noticed soon |
| dolphin gets trapped nets fishing boat serious trouble | fishing visitor trapped room serious trouble gets fell class silent boat entered nets whole dolphin suddenly |
| injured ankle while attempting escape who were chasing | fatal accident later described police exactly how happened chasing were who escape injured ankle while attempting |
| dedicated runners have train regularly compete international level | dedicated compete tourists paris train have huge population runners attractive international often regularly visited city level |
| although exhausted refused accompany rescuers place mountain | although intelligence accompany children's exhausted developed rescuers world refused place experiences around mountain learning |
| assistance requested survivors earthquake please donate money clothing | doctor arranged quickly transferred hospital stomach assistance survivors pains requested investigated please money earthquake clothing donate |
| scientific studies continually exploring impact change climate | pollution scientific industrial impact studies cities climate continually problem exploring increasing planet countries change |
| throughout ages hypnotism used medical purposes entertainment | hypnotism medical poisoning used food outstanding ages restaurant's entertainment ruined reputation purposes outbreak throughout |

| | |
|---|---|
| eruption volcanoes cause immense columns ejected high atmosphere | crisis eruption volcanoes cause immense financial columns ejected high atmosphere months performance engineering company reaching state |
| emerging gradually periscope shore prepared submarine surface | amphibians lizards regenerate limbs seriously damaged amputated emerging gradually periscope shore prepared submarine surface |
| **Form C slides – side 1 contains instructions for test** | |
| run to the park | my run to is red pen park the |
| our cat got wet | pick book a our got up cat wet |
| they like sing happy songs | they must like songs we sing dinner now happy home |
| we boat ride lake | we boat some ride lake sweets from shop |
| growing some lovely flowers herbs garden | lovely extra herbs garden football after some break flowers lesson growing music |
| there more foxes living towns ever before | more travels town taxi foxes living school there sisters younger ever before with two |
| Robert kicked door broke glass mean break | many police broke hide door break robber found kicked mean stolen Robert glass tried |
| watches busy traffic speeding house hopes road built soon | watches busy speeding ready arrive quickly traffic robber still build catch o'clock work soon time house road hopes |
| visitor entered room whole class suddenly fell silent | entered peas whole field picked visitor suddenly freeze room swiftly important silent been very fell class |
| fatal accident later described police exactly how happened | police down accident climbed how began branches happened later described fata about worrying down exactly gripped |
| paris attractive city huge population often visited tourists | huge grinned realising paris often finally competition visited won city ear writing attractive population tourists James |
| children's intelligence developed learning experiences word around | learning applause intelligence around trick received developed new performance world magician experiences tremendous children's |
| doctor arranged quickly transferred hospital stomach pains investigated | transferred pains prize good stomach behaviour hesitated doctor decision before announcing investigated quickly class hospital arranged |
| pollution industrial cities increasing problem countries planet | countries communication cities incredibly successful industrial global result planet development pollution internet problem increasing |
| restaurant's outstanding reputation ruined outbreak food poisoning | paintings restaurant's outbreak museum poisoning food exhibition contemporary ruined January historic outstanding hosting reputation |

| | |
|---|---|
| months performance engineering company reading state financial crisis | months company crisis grants grounds performance reaching fund-raising enabled engineering state events purchase financial government expand |
| amphibians lizard regenerate limbs seriously damaged amputated | prestigious expert amphibians seriously orchestra musicians lizards damaged required conductor regenerate amputated rehearse limbs |

# Appendix E

**Modified Listening Comprehension Test** ©Sharon Arnold 2015

| NSRT comprehension questions | Answers available |
|---|---|
| **Form A slides– slide 1 contains instructions for test** | |
| What colour is the pen? | blue |
| | red |
| What would you use the pen for? | running |
| | drawing |
| What will you pick up? | book |
| | car |
| What do you think you will see in the book? | words and pictures |
| | cinemas and shops |
| What must they do? | go swimming |
| | go home for dinner |
| Why do you think they must go home? | it is dinner time |
| | to have a bath |
| What did he get? | carrots |
| | sweets |
| What do you think he did with the sweets? | he painted a picture |
| | he ate them |
| What does Ella do after break? | plays music and football |
| | plays with trains and cars |
| Which do you think is better for her and why? | playing football is good for her fitness |
| | going to see a movie is fun |
| How many children are in the taxi? | fifteen |
| | three |
| What do you think they might talk about? | school, teachers and friends |
| | whales usually live in the sea |
| What was the robber trying to do when he was caught? | running away |
| | trying to hide |
| What do you think will happen? | he will be taught to swim |
| | he will be taken to the police station |
| What time does the bus go? | eight o'clock |
| | twelve o'clock |
| What will happen if you are slow getting ready? | I will miss the bus |
| | I will learn violin |
| What has been picked? | peas |
| | flowers |
| What do you think happens to the peas after they are frozen? | put in bags and sent to the shops |
| | they are taught to swim |
| Where is Hanna? | in the house |
| | up a tree |
| What do you think happens next? | she will watch a movie about sharks |
| | she might fall out of the tree |
| What did James win? | a chocolate bar |
| | a writing competition |
| How do you think James felt? | James felt happy |
| | James felt angry |
| What has the magician just done? | a fast run |

| | |
|---|---|
| | a new trick |
| Do you think the magician was pleased with his performance and why? | yes, because they all ran away |
| | yes, because everyone clapped |
| What did Mrs Swan announce? | that Jake had won the prize |
| | that it was home time |
| Why did Mrs. Swan hesitate? | Jake doesn't usually win |
| | Jake is a very good singer |
| What does it say is a success of the internet? | buying things |
| | global communication |
| What sort of things get communicated on the internet? | emails, facebook, messages |
| | eating chocolate, reading |
| What is on show at the museum? | paintings |
| | dogs |
| Do you think you will only find old paintings? | no, because bicycles can also be ridden there |
| | no, because modern paintings are also on show |
| What did the club do to raise money? | fund-raising |
| | singing |
| Why do you think the government grants money to sports clubs? | to encourage people to play sports |
| | to help people improve their singing |
| Who play in prestigious orchestras? | anyone |
| | prestigious musicians |
| What do you think might happen if the conductor of this orchestra was no good? | the conductor would get the sack |
| | the conductor would buy a new yacht |
| **Form B slides – slide 1 contains instructions** | |
| What did the dog do? | sat up |
| | ran away |
| Why do you think the dog did this? | the dog saw the cat |
| | the dog was sleepy |
| What will you play with? | doll |
| | ball |
| Where do you think you will play with the ball? | in the garden |
| | on the roof |
| What does she love to do? | ride a bike |
| | eat chocolate |
| What do you think she sees when she rides in the park? | cinemas and dog kennels |
| | swings, slides and trees |
| Where do they make things? | school |
| | home |
| What do you think they will do with the things they make? | sit on them |
| | take them home |
| What is the largest land animal? | cat |
| | elephant |
| Do you think there are larger animals in the water? | yes, zebras |
| | yes, whales |
| Which is faster? | train |
| | bus |
| Why do you think buses stop? | to win the race |
| | to let people off |
| Who could not reach the cat? | the policeman |
| | the fireman |
| | the top |

| | |
|---|---|
| Where do you think the fireman got to on the ladder? | the bottom |
| Where was the smoke coming from? | the bus |
| | the kitchen window |
| What should they do? | call the fire service |
| | call a vet |
| What is trapped in the nets? | dolphins |
| | fish |
| What might happen to the dolphin? | it could die |
| | it could go for a walk |
| Who was chasing Ben? | boys |
| | dogs |
| What do you think happened next? | Ben stops for a pizza |
| | Ben runs home |
| How often do these sports people train? | regularly |
| | never |
| Why do you think they do lots of training? | to get better at it |
| | to put on weight |
| How did Sara feel? | happy |
| | exhausted |
| Why do you think Sara refused to go with the rescuers? | she didn't want to leave the others who were also stuck |
| | she wanted to finish watching the movie |
| What do the survivors need? | money and clothing |
| | toys and DVDs |
| Why do you think money is asked for? | to pay the restaurant bill |
| | to buy food and clothes |
| What are these studies exploring? | earthquakes |
| | climate change |
| Why do you think that scientists are studying climate change? | to see if we are being affected by global warning |
| | to see if anyone would like to go ice-skating |
| What is a helpful use of hypnotism? | intelligence and growing plants |
| | medical purposes and entertainment |
| Do think entertainment by hypnotists is a modern thing? | no, because they can train people to do all sorts of things nowadays |
| | no, because it has been known throughout the ages |
| What does it say is thrown into the atmosphere? | ash |
| | rain |
| What else might happen because of the ash? | the air will get polluted and it will be dark |
| | lots of people will go on holiday |
| Where had the submarine been? | under the water |
| | in the sky |
| What do you think might happen after it surfaces? | the crew will get off |
| | the people will go dancing |
| **Form C slides – slide 1 contains instructions** | |
| Where will you run to? | the shop |
| | the park |
| What do you think you might find there? | swings slides and flowers |
| | dog grooming, schools and cinemas |
| What happened to the cat? | ran away |

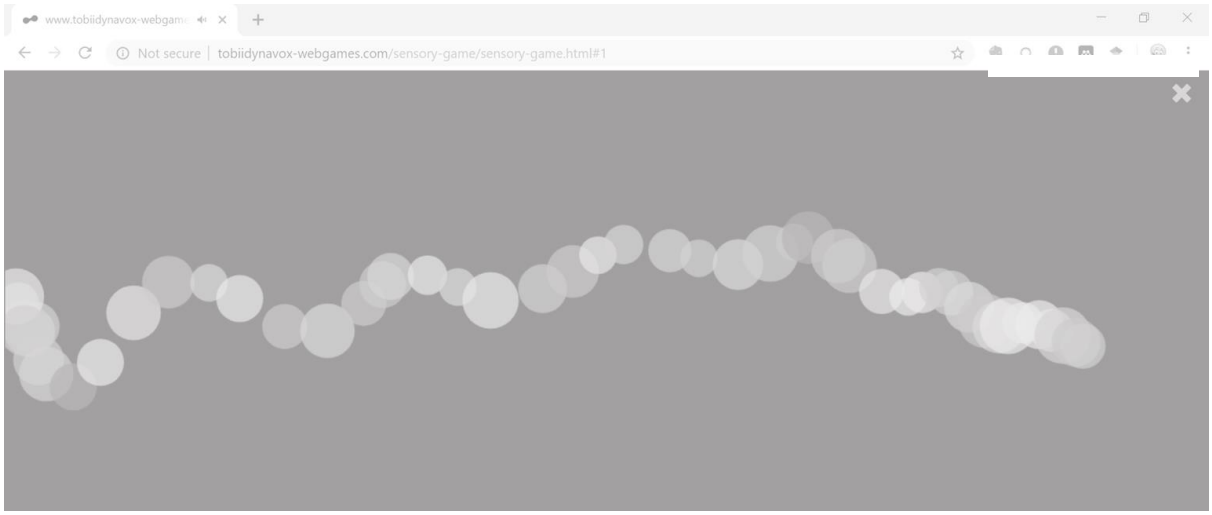
| | |
|---|---|
| | got wet |
| Do you think the cat is happy? | no, it was chased by a dog |
| | no, it got wet |
| What do they like? | to sing |
| | to eat |
| Why do you think they sing? | they like singing |
| | they are hungry |
| Where is the boat? | at school |
| | on the lake |
| What do you think they do on the boat? | shopping |
| | row or paddle |
| What two things does Anna grow? | leeks and potatoes |
| | flowers and herbs |
| Do you think Anna likes her garden? | yes, she likes growing things |
| | yes, she likes eating pizza |
| Where are more foxes now living? | towns |
| | cities |
| Why do you think the foxes are now living there? | there is more food |
| | there are more swimming pools |
| What did Robert do? | stole the money |
| | kicked the door |
| How do you think Robert felt after he broke the glass? | sorry, scared |
| | hungry, happy |
| What does Mrs Patel hope for? | a new road |
| | a new car |
| Where do you think Mrs Patel was? | at the cinema |
| | in her house |
| Who entered the room? | a visitor |
| | a child |
| Why do you think the class became silent? | they didn't know the visitor |
| | they wanted ice cream |
| What has happened? | an accident |
| | a robbery |
| What do you think Sam said? | would you like some peas? |
| | there has been an accident |
| Who are we told visits Paris? | tourists |
| | teachers |
| Why do you think they visit Paris? | it's an attractive city |
| | it has lots of cats |
| What does it say is developed in a child? | music ability |
| | intelligence |
| What do you think shows a child is intelligent? | good at skipping and sings nicely |
| | does good work and passes tests |
| Where was Nick hurting? | stomach |
| | leg |
| Who do you think the doctor contacted? | the school or the local library |
| | the hospital or ambulance service |
| What does it say is polluted? | the internet |
| | air and water |
| Do you think industrial cities are the only cause of pollution? | no, birds are also a problem for pollution |
| | no, cars are also a problem for pollution |
| What ruined the restaurant's reputation? | food poisoning |

| | |
|---|---|
| | prices |
| Would you like to eat at that restaurant? | no, it's not close to where I live |
| | no, I could be ill |
| What was the cause of the crisis? | illness |
| | poor sales |
| What do think might happen to the people who work at the company? | lose their jobs |
| | run a marathon |
| What happens if a lizard loses a limb? | it flies |
| | it regenerates |
| How do you think regenerating a limb helps amphibians to survive? | they can go shopping |
| | they can run better so they can escape |
| | |

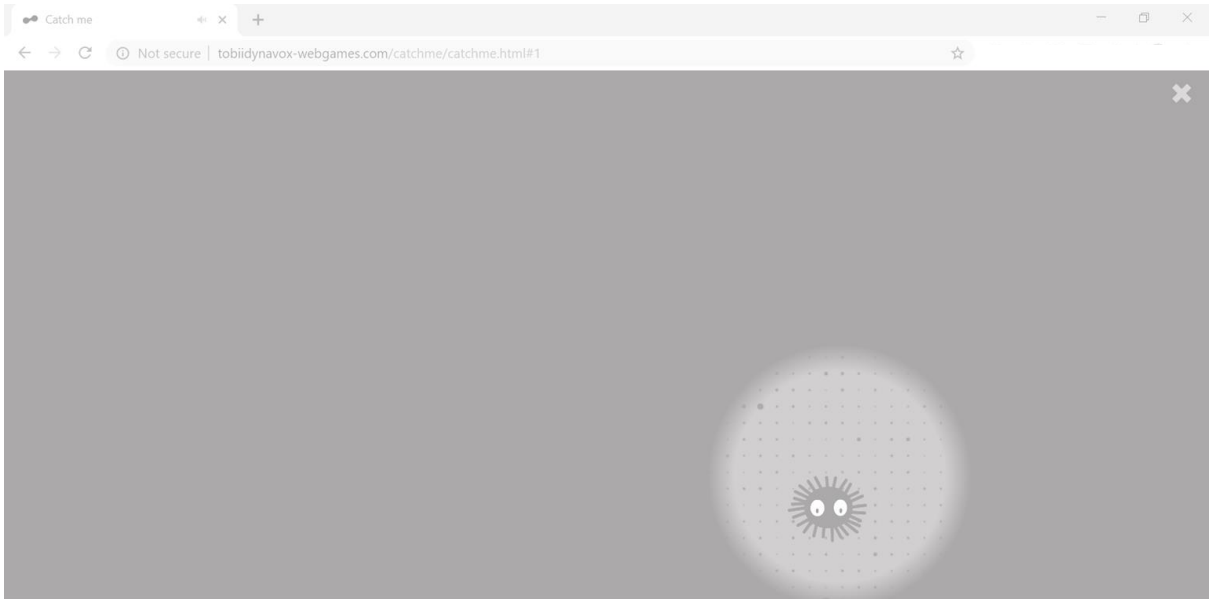
# Appendix F

## Example of eye gaze activities

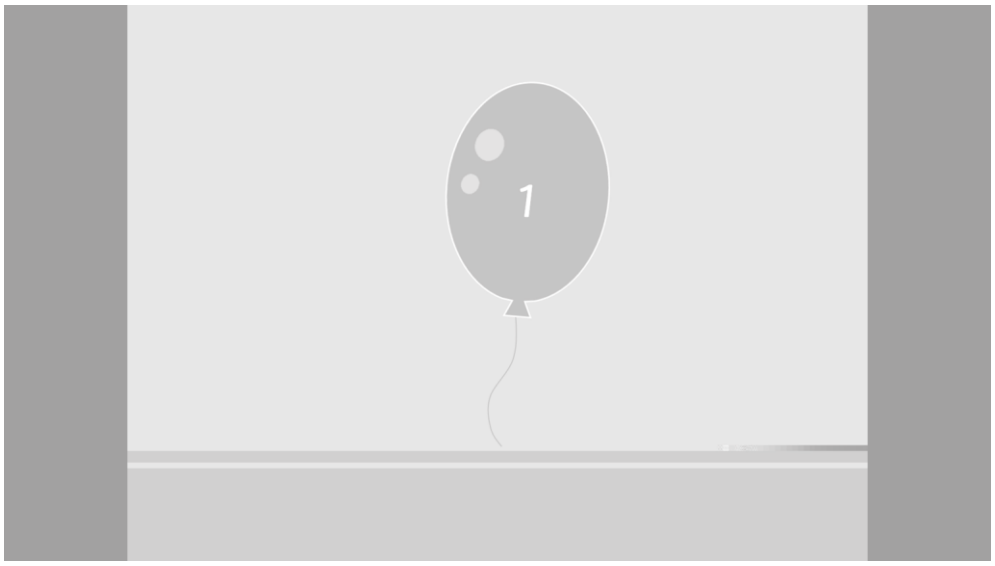
*'Colourful Caterpillar'* http://www.tobiidynavox-webgames.com/sensory-game/sensory-game.html#settings [last accessed 07.08.19]




*'Catch Me'* http://www.tobiidynavox-webgames.com/catchme/catchme.html#1[last accessed 07.08.19]



*PowerPoint 'balloon popping' activity: slide 1*



# Appendix G

| Individual Word Recognition Scores All Participants | | | | | |
|---|---|---|---|---|---|
| NSRT | Modified Word Recognition | Modified Word Recognition Eye gaze | NSRT PWC | Modified PWC | Modified PWC Eye gaze |
| .00 | 56.00 | .00 | 10.00 | 11.64 | 9.58 |
| 67.00 | 65.00 | .00 | 27.00 | 21.22 | 6.26 |
| 82.00 | 82.00 | 130.00 | 47.00 | 40.75 | 94.31 |
| 73.00 | 75.00 | 63.00 | 35.00 | 32.83 | 21.34 |
| 54.00 | 53.00 | .00 | 12.00 | 9.89 | 6.33 |
| 57.00 | 73.00 | .00 | 18.00 | 30.17 | 8.95 |
| 100.00 | 110.00 | 130.00 | 70.00 | 72.31 | 94.31 |
| .00 | 53.00 | .00 | 8.00 | 9.89 | 4.84 |
| .00 | 61.00 | .00 | 11.00 | 17.83 | 8.07 |
| 62.00 | 62.00 | 59.00 | 22.00 | 18.71 | 16.96 |
| 69.00 | 67.00 | 69.00 | 30.00 | 23.96 | 27.53 |
| 82.00 | 82.00 | 130.00 | 47.00 | 40.75 | 94.32 |
| 100.00 | 110.00 | 130.00 | 70.00 | 72.38 | 94.32 |
| 89.00 | 109.00 | 124.00 | 54.00 | 70.62 | 88.18 |
| 60.00 | 59.00 | 57.00 | 19.00 | 15.20 | 15.15 |
| 58.00 | 62.00 | 58.00 | 17.00 | 18.71 | 16.03 |
| 57.00 | 73.00 | .00 | 16.00 | 30.20 | 5.46 |
| .00 | 53.00 | .00 | 11.00 | 9.89 | 8.95 |
| 115.00 | 127.00 | 115.00 | 89.00 | 89.05 | 77.64 |
| 82.00 | 82.00 | 130.00 | 47.00 | 40.75 | 94.32 |
| 89.00 | 109.00 | 124.00 | 55.00 | 70.62 | 88.18 |
| .00 | 53.00 | .00 | 7.00 | 9.89 | 8.02 |
| 53.00 | .00 | .00 | 12.00 | 7.20 | 2.75 |
| 56.00 | 66.00 | 59.00 | 14.00 | 23.14 | 16.96 |
| 69.00 | 72.00 | 57.00 | 30.00 | 29.34 | 15.15 |
| 69.00 | 64.00 | 60.00 | 30.00 | 20.46 | 17.83 |
| 84.00 | 88.00 | 88.00 | 50.00 | 46.92 | 48.66 |
| 115.00 | 127.00 | 115.00 | 89.00 | 72.58 | 77.64 |
| 61.00 | 57.00 | 57.00 | 21.00 | 13.39 | 15.15 |
| 73.00 | 73.00 | 69.00 | 35.00 | 30.20 | 27.53 |
| .00 | 53.00 | .00 | 9.00 | 9.89 | 8.89 |
| 101.00 | 105.00 | 108.00 | 71.00 | 66.45 | 70.62 |
| .00 | 53.00 | 53.00 | .00 | 9.89 | 11.64 |
| .00 | .00 | .00 | .00 | 7.19 | 1.00 |
| .00 | 74.00 | 60.00 | .00 | 31.96 | 17.83 |
| .00 | .00 | .00 | .00 | 5.46 | .12 |
| .00 | 110.00 | 89.00 | .00 | 71.50 | 49.54 |

| | | | | | |
|---|---|---|---|---|---|
| .00 | 121.00 | 122.00 | .00 | 84.67 | 85.54 |
| .00 | 86.00 | 88.00 | .00 | 45.15 | 47.78 |
| .00 | 88.00 | .00 | .00 | 46.90 | 1.00 |
| .00 | 76.00 | .00 | .00 | 33.71 | 7.21 |
| .00 | .00 | .00 | .00 | 3.63 | .19 |
| .00 | .00 | .00 | .00 | 5.38 | 3.70 |
| .00 | 75.00 | 53.00 | .00 | 32.83 | 11.60 |
| .00 | 65.00 | .00 | .00 | 21.38 | 5.46 |
| .00 | 88.00 | .00 | .00 | 47.78 | 5.46 |
| .00 | 84.00 | .00 | .00 | 43.48 | 2.75 |
| .00 | .00 | .00 | .00 | 7.02 | -.75 |
| .00 | 54.00 | .00 | .00 | 9.89 | 1.88 |
| .00 | 67.00 | .00 | .00 | 24.01 | 9.58 |
| .00 | .00 | .00 | .00 | 3.60 | 1.07 |
| .00 | 95.00 | .00 | .00 | 54.81 | 8.70 |
| .00 | 60.00 | .00 | .00 | 16.08 | 7.82 |
| .00 | 61.00 | 57.00 | .00 | 16.96 | 15.15 |
| .00 | 55.00 | 53.00 | .00 | 9.00 | 11.64 |
| .00 | 56.00 | .00 | .00 | 70.62 | 29.28 |
| .00 | 65.00 | .00 | .00 | 21.38 | 9.58 |
| .00 | 54.00 | .00 | .00 | 9.88 | 4.58 |
| .00 | 59.00 | .00 | .00 | 15.20 | 6.33 |
| .00 | 56.00 | 54.00 | .00 | 11.64 | 11.64 |
| .00 | 135.00 | 135.00 | .00 | 11.85 | 99.58 |
| .00 | 59.00 | .00 | .00 | 15.20 | 1.00 |
| .00 | 56.00 | 57.00 | .00 | 11.64 | 15.15 |
| .00 | 108.00 | 103.00 | .00 | 69.74 | 65.36 |
| .00 | 57.00 | .00 | .00 | 13.39 | 9.58 |
| .00 | .00 | .00 | .00 | 6.31 | 1.00 |
| .00 | .00 | .00 | .00 | 4.58 | -.75 |
| .00 | 85.00 | .00 | .00 | 44.27 | 5.46 |
| .00 | .00 | .00 | .00 | 7.19 | -.75 |
| .00 | 58.00 | 56.00 | .00 | 14.27 | 14.27 |
| .00 | .00 | .00 | .00 | 7.21 | -.75 |
| .00 | 63.00 | .00 | .00 | 19.59 | 7.21 |
| 98.00 | 96.00 | 98.00 | 67.00 | 56.57 | 60.08 |
| .00 | 64.00 | 54.00 | 11.00 | 20.46 | 11.64 |
| 105.00 | 97.00 | .00 | 76.00 | 57.45 | 8.70 |
| 79.00 | 81.00 | .00 | 43.00 | 39.00 | -.75 |
| 116.00 | 95.00 | 115.00 | 91.00 | 54.81 | 78.52 |
| 61.00 | 64.00 | .00 | 21.00 | 20.46 | 2.75 |
| 89.00 | 119.00 | 125.00 | 55.00 | 82.91 | 89.05 |
| 85.00 | 91.00 | .00 | 51.00 | 51.30 | -.75 |
| 102.00 | 103.00 | 134.00 | 72.00 | 64.48 | 98.70 |
| 109.00 | 110.00 | 92.00 | 81.00 | 71.50 | 53.06 |
| 89.00 | 95.00 | 89.00 | 55.00 | 54.81 | 49.54 |

| | | | | | |
|---|---|---|---|---|---|
| 80.00 | 87.00 | 103.00 | 44.00 | 46.03 | 65.36 |
| 68.00 | 74.00 | 62.00 | 29.00 | 31.96 | 20.46 |
| 88.00 | 96.00 | .00 | 55.00 | 56.57 | 1.00 |
| 120.00 | 130.00 | 135.00 | 96.00 | 97.81 | 99.57 |
| 67.00 | 89.00 | 84.00 | 28.00 | 48.67 | 44.27 |
| 86.00 | 94.00 | 88.00 | 52.00 | 53.94 | 48.66 |
| 86.00 | 85.00 | 85.00 | 52.00 | 44.28 | 45.15 |
| 134.00 | 135.00 | 135.00 | 113.00 | 99.58 | 99.58 |
| 78.00 | 95.00 | 90.00 | 42.00 | 54.81 | 51.31 |
| 135.00 | 135.00 | 135.00 | 114.00 | 99.57 | 99.58 |
| 124.00 | 121.00 | 121.00 | 101.00 | 84.67 | 84.67 |
| 60.00 | 60.00 | .00 | 19.00 | 16.08 | 7.14 |
| .00 | 55.00 | .00 | 10.00 | 9.00 | 1.88 |
| 122.00 | 120.00 | 120.00 | 98.00 | 83.79 | 83.79 |
| 131.00 | 135.00 | 135.00 | 110.00 | 99.58 | 99.58 |
| 94.00 | 125.00 | 125.00 | 62.00 | 89.05 | 89.05 |
| .00 | 61.00 | 70.00 | 11.00 | 16.96 | 29.32 |
| 125.00 | 129.00 | 129.00 | 102.00 | 93.44 | 93.44 |
| 99.00 | 130.00 | 127.00 | 68.00 | 94.31 | 91.68 |
| 118.00 | 121.00 | 109.00 | 93.00 | 84.67 | 71.51 |

# Appendix H

| Individual Listening Comprehension Scores All Participants | | | |
|---|---|---|---|
| NSRT | Modified LC Scores | NSRT PCA | Modified PCA |
| .00 | .00 | 50.00 | .00 |
| 61.00 | 62.00 | 50.00 | 45.50 |
| 84.00 | 87.00 | 93.75 | 88.28 |
| 64.00 | 60.00 | 66.67 | 20.00 |
| .00 | .00 | 25.00 | 28.75 |
| 60.00 | 65.00 | 50.00 | 72.75 |
| 109.00 | 105.00 | 100.00 | 99.23 |
| 66.00 | 75.00 | 100.00 | 100.00 |
| .00 | .00 | 20.00 | .00 |
| 64.00 | 63.00 | 80.00 | 85.75 |
| 63.00 | 64.00 | 70.00 | 77.80 |
| 84.00 | 87.00 | 93.75 | 88.28 |
| 109.00 | 105.00 | 91.67 | 99.23 |
| 116.00 | 112.00 | 90.91 | 99.83 |
| 62.00 | 60.00 | 75.00 | 33.30 |
| 62.00 | 60.00 | 75.00 | 27.33 |
| 60.00 | 65.00 | 40.00 | 72.75 |
| .00 | .00 | 75.00 | .00 |
| 148.00 | 144.00 | 92.86 | 100.00 |
| 84.00 | 87.00 | 93.75 | 99.39 |
| 116.00 | 112.00 | 85.71 | 81.50 |
| 66.00 | 75.00 | 100.00 | 100.00 |
| 61.00 | 61.00 | 62.50 | 100.00 |
| .00 | .00 | .00 | 22.00 |
| .00 | 62.00 | 33.33 | 45.50 |
| .00 | 61.00 | .00 | 30.79 |
| 75.00 | 75.00 | 75.00 | 73.31 |
| 148.00 | 144.00 | 92.86 | 93.94 |
| 61.00 | 64.00 | 83.33 | 77.80 |
| 65.00 | 66.00 | 75.00 | 60.00 |
| .00 | .00 | 75.00 | .00 |
| 87.00 | 91.00 | 80.00 | 76.18 |
| .00 | .00 | .00 | 32.50 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | 15.36 |
| .00 | .00 | .00 | .00 |
| .00 | 74.00 | .00 | 47.92 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | 13.31 |

| | | | |
|---|---|---|---|
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .50 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | 8.00 |
| .00 | 60.00 | .00 | 33.00 |
| .00 | .00 | .00 | .00 |
| .00 | 77.00 | .00 | 80.00 |
| .00 | 77.00 | .00 | 80.00 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | 61.00 | .00 | 21.00 |
| .00 | .00 | .00 | .00 |
| .00 | 61.00 | .00 | 57.50 |
| .00 | .00 | .00 | 1.63 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | 60.00 | .00 | 33.30 |
| .00 | 60.00 | .00 | 33.30 |
| .00 | .00 | .00 | 6.18 |
| .00 | .00 | .00 | .00 |
| .00 | 80.00 | .00 | 100.00 |
| .00 | .00 | .00 | 9.55 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | 62.00 | .00 | 33.13 |
| .00 | .00 | .00 | 32.50 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| .00 | .00 | .00 | .00 |
| 64.00 | 64.00 | 36.36 | 37.00 |
| 60.00 | 60.00 | 100.00 | 33.00 |
| 70.00 | 77.00 | 45.83 | 63.00 |
| 70.00 | 77.00 | 68.75 | 80.00 |
| 95.00 | 95.00 | 69.23 | 89.00 |
| 61.00 | 64.00 | 62.50 | 78.00 |
| .00 | 105.00 | .00 | 73.93 |
| 75.00 | 75.00 | 75.00 | 64.44 |
| 109.00 | 144.00 | 91.67 | 91.25 |
| 98.00 | 105.00 | 95.00 | 86.96 |
| 63.00 | 64.00 | 38.89 | 41.11 |
| .00 | .00 | 25.00 | 11.67 |
| 70.00 | 70.00 | 91.67 | 77.14 |

| | | | |
|---|---|---|---|
| 116.00 | 116.00 | 95.00 | 85.00 |
| 142.00 | 142.00 | 91.18 | 90.88 |
| 60.00 | 70.00 | 50.00 | 52.50 |
| 80.00 | 80.00 | 87.50 | 86.88 |
| 85.00 | 70.00 | 83.33 | 52.50 |
| 134.00 | 134.00 | 85.29 | 84.85 |
| 63.00 | 62.00 | 43.75 | 23.82 |
| 102.00 | 100.00 | 58.82 | 57.65 |
| 102.00 | 100.00 | 71.43 | 65.67 |
| .00 | 58.00 | 10.00 | 42.88 |
| .00 | 58.00 | .00 | 60.00 |
| 132.00 | 138.00 | 96.67 | 87.94 |
| 75.00 | 88.00 | 35.29 | 45.59 |
| 75.00 | 88.00 | 66.67 | 48.44 |
| 62.00 | 60.00 | 100.00 | 55.00 |
| 134.00 | 130.00 | 85.29 | 87.19 |
| 95.00 | 98.00 | 81.82 | 54.41 |
| 60.00 | 63.00 | 15.38 | 20.67 |

# Appendix I

## Items Included from Autism Behavioural Checklist (ABC; Krug & Almond, 2008)

| |
|---|
| Whirls self for long periods of time |
| Learns a simple task but quickly forgets it |
| Frequently does not attend to social cues from others or activities taking place nearby |
| Does not follow simple commands given once (e.g., "Sit down," "Come here," "Stand up") |
| Does not play with toys appropriately (e.g., spins tires, lines up toys in same manner again and again) |
| Demonstrates poor visual discrimination skills when learning; fixates on one characteristic such as position, color, or size |
| Does not smile at others |
| Insists on keeping specific objects with him or her (e.g., plastic toys or other objects) |
| At times seems not to hear so that hearing loss is suspected |
| Rocks self for long periods of time |
| Has strong reactions to changes in routine or environment |
| Does not respond to his or her own name when it is called out among two other names (e.g., Joe, Bill, Mary) |
| Darts around room quickly and erratically, toe walks, spins self, flaps hands, etc. |
| Does not respond to other people's facial expressions or feelings |
| Does not follow simple commands involving prepositions (e.g., "Put the ball on the box" or "Put the ball in the box") |
| Sometimes is not startled in response to a loud noise (reacts as if deaf) |
| Flaps hands |
| Has severe temper tantrums and/or frequent minor tantrums |
| Actively avoids eye contact |
| Resists being touched or held |
| Sometimes does not respond to pain, such as bruises, cuts, or injections |
| Walks on toes |
| Hurts others by biting, hitting, kicking, etc. |
| Does not imitate other children who are playing nearby |
| Often does not blink when a bright light is shined in eyes |
| Hurts self (e.g., bangs head, bites hand, etc.) |
| Becomes upset if needs are not met immediately |
| Has not developed friendships with other people |
| Covers ears in response to many sounds |
| Often twirls, spins, and bangs objects |
| Appears to "look through" people |
| Frequently unaware of surroundings or dangerous situations |
| Prefers to play with objects and manipulate their parts |
| Feels, smells, and/or tastes certain objects in environment |
| Usually does not react to the presence of a "new" person |
| Gets involved in complicated "rituals" such as lining things up |
| Is very destructive (e.g., breaks toys and household items) |
| Stares into space for long periods of time |