**Reading comprehension impairments in autism spectrum disorders**

Lisa M. Henderson1\*, Paula J. Clarke2 and Margaret J. Snowling3

*1 University of York, York, UK*

*2 University of Leeds, Leeds, UK*

*3 University of Oxford, Oxford, UK*

Running Head: Comprehension in Autism

\*Corresponding Author: Dr Lisa Henderson, Department of Psychology, University of York, York YO 10 5DD,United-Kingdom. E-mail: [lisa-marie.henderson@york.ac.uk](mailto:lisa-marie.henderson@york.ac.uk)

**ABSTRACT**

Children with autism spectrum disorder (ASD) often have impairments in reading comprehension alongside relatively spared word reading; however, studies investigating reading profiles in ASD have been small in scale and few have examined whether word reading skills are underpinned by key foundation skills (e.g., phonological decoding) that need to be in place to support the switch to reading for meaning. This study examined reading (word and text reading accuracy, reading comprehension), phonological decoding (nonword reading) and oral language comprehension (receptive vocabulary) in 49 children and adolescents with ASD and 49 typical peers of the same age. Levels of word and text reading accuracy were within age appropriate levels, but reading comprehension and vocabulary were below average; 31% of the sample showed a significant discrepancy between reading comprehension and word reading accuracy (compared to only 10% of a group of typically developing peers). Even when children with ASD were equated with typical peers on word reading they showed significant nonword decoding difficulties. Variance in phonological decoding was also a significant predictor of reading comprehension for the ASD group (but not for the typical peers).These data suggest that apparent strengths in word reading in ASD may mask basic difficulties with phonological decoding, which, together with weaknesses in oral language comprehension, constrain the development of reading comprehension.

1. INTRODUCTION

The ‘simple view of reading’ (Gough & Tunmer, 1986; Hoover & Gough, 1990) proposes that successful reading comprehension depends upon proficient word-level decoding and linguistic comprehension (Catts et al., 2006; Chen & Vellutino, 1997; Cutting & Scarborough, 2006; Harlaar et al., 2010; Keenan et al., 2008; Muter et al., 2004). According to this model, the most obvious cause of reading comprehension difficulty is a word-level reading problem. If a child cannot read words accurately and fluently and decode unfamiliar words, his or her comprehension will be compromised (Perfetti, 1985).

Although word-level decoding and linguistic comprehension are correlated, they build on different language foundations. Evidence shows that whereas phonological skills are critical for the development of decoding and word-level reading (Stuart, 2007) non-phonological oral language skills (vocabulary and grammar) are more closely related to reading comprehension (Nation & Norbury, 2005). It follows that decoding and linguistic comprehension can dissociate (Bishop & Snowling, 2004). Children with dyslexia struggle with word-level aspects of reading, attributable to a difficulty with phonological decoding, but have relatively spared reading comprehension (Vellutino, Fletcher, Snowling & Scanlon, 2004). Poor comprehenders, on the other hand, are defined as having selective difficulties in reading for meaning but can read text fluently and accurately. As a group, poor comprehenders show impairments in oral language comprehension (including vocabulary and grammar) (Cain et al., 2010; Nation & Snowling, 1998; Nation et al., 2004). It is important to emphasise that reading comprehension also depends upon the integration of information during the course of reading, as well as control processes which monitor ongoing comprehension and inhibit irrelevant information (Nation & Angell, 2007). Each of these can also be a source of difficulty for children with poor reading comprehension.

There are no agreed diagnostic criteria for reading comprehension impairment. A recent survey of children’s reading skills conducted during the UK standardization of a reading test (Snowling, Stothard, Clarke,Bowyer-Crane, Harrington, Truelove & Hulme, 2009), defined as a poor comprehender, children with at least average-for-age word reading accuracy (single word reading standard score 90), a comprehension standard score below 90 and a minimum discrepancy greater than 13 standard score points between their decoding and comprehension scores (i.e., greater than 1SD for comprehension standard scores for this sample of children). In this sample, the incidence of the profile was 5.3%; amongst the children so identified, there was a mean discrepancy between single word reading accuracy and reading comprehension of 21.59 standard scores points (*SD* = 7.27, range = 14 - 48).



Similar to poor comprehenders, children with autism spectrum disorder (ASD) appear to have particular difficulty in reading for meaning. The ‘stereotypical’ picture is of a child who decodes print well but fails to understand what they read. Examination of the group means taken from samples of children and adolescents with ASD, shows that whilst word reading skills are closer to (or within) the average range, reading comprehension typically falls below the average range (Norbury & Nation, 2011; Ricketts, 2011). A recent meta-analysis of 36 studies showed that reading comprehension is generally lower than expected based on decoding skill and performance IQ in ASD (Brown et al., 2013). Notwithstanding this, there is considerable variability in the reading profiles of children with ASD, both in their word recognition and decoding skills as well as in reading comprehension and in the extent to which they are discrepant.

An aim of the present study was to investigate the hypothesis that reading profiles are associated with different patterns of oral language skill (as reflected by receptive vocabulary) in a large sample of children and adolescents with ASD ranging in age from 7 – 15 years. In their large scale metaanalysis, Brown et al (2013) reported that both semantic knowledge (measured by standardised measures of receptive vocabulary) and decoding skill (measured by standardised tests of nonword, single word and sentence reading accuracy and/or reading rate) reliably predicted reading comprehension, in line with the simple view of reading. Decoding skill independently explained 57% of variance in reading comprehension scores; semantic knowledge independently predicted 57% of the variance. These regression calculations were run one predictor at a time, and hence correlations were performed to examine the relationships between these variables. The reading comprehension skills of participants with ASD was most strongly associated with decoding (*r* .77, *n* = 1469), followed by semantic knowledge (*r* .59, *n* = 1080), and IQ (*r* .41, *n* = 845).

Similarly, Ricketts, Jones, Happe & Charman (2013) found that after controlling for word recognition (which accounted for 64% of variance), oral language accounted for unique variance in reading comprehension in a group of 100 adolescents with ASD. In this study oral language was measured by receptive and expressive subtests from the Clinical Evaluation of Language Fundamentals 3rd Edition (Semel et al., 2000), as well as the Test for Reception of Grammar (Bishop, 2005). Thus, it is likely that impairments in oral language constrain the development of reading comprehension in ASD, as in poor comprehenders without ASD.

A novel feature of the present study was that we also examined whether intact word recognition skills in ASD are supported by basic proficiency with phonological decoding, since such skills are often used during text reading to decipher unfamiliar words. While small-scale studies have shown that children with ASD who have age-appropriate word reading skills are able to decode simple nonwords (Frith & Snowling, 1983; Minshew, Goldstein & Siegel, 1995), Nation et al. (2006) using a larger, more representative sample, reported that many children had difficulties with nonword reading. Moreover, White et al (2006) found that more than half of a group of children with ASD had word decoding difficulties, poor phonological awareness and problems with rapid naming. Thus, for some children with ASD, word reading may not be underpinned by adequate phonological decoding skills. In line with this hypothesis is the frequently reported speculation that children with ASD rely on visual strategies for reading words, perhaps supported by intact or enhanced associative learning mechanisms (Walenski et al., 2008), that cannot be usefully applied to reading unfamiliar nonwords.

Hence, the switch from learning to read to reading for meaning in ASD may be partly constrained by a lack of proficiency with phonological decoding skills (measured by nonword reading) even though word reading skills are age appropriate. Vellutino, Tunmer, Jaccard and Chen (2007) argue that “[oral] language comprehension processes do not become fully operative in reading until the reader has acquired enough facility in word identification to comprehend, in written language, text that would normally be comprehended in spoken language” (pp. 4). They proposed the Convergent Skills Model in which the relationships between word recognition, phonological skills and reading comprehension were stronger in a group of second and third grade children (*n* 297) than a group of older sixth and seventh grade children (*n* 171). In contrast, there was a stronger relationship between language comprehension and reading comprehension in the older group than in the younger group. This highlights the need to take a developmental perspective when considering the reading skills of children with ASD.

* 1. **The present study**

The present study investigated the patterns and predictors of reading comprehension difficulties in a broad sample of children and adolescents with ASD. It has been argued that in order to improve our understanding of ASD we need to go beyond group comparisons (ASD vs. TD peers), and focus on examining variability within larger groups of individuals (Brock, 2011; Jones et al., 2009; Lord & Jones, 2012; Ricketts et al., 2013). However, when adopting such an approach it is also important to ascertain whether patterns of variability are similar in TD populations. Therefore, we explore individual differences in reading comprehension in ASD and TD samples as well as carrying out analyses of group differences. Three main research questions were examined:

*How discrepant are word reading and reading comprehension in ASD?* We predicted that by virtue of the difficulties children with ASD have in language and communication, as a group, their reading comprehension would fall significantly below the average range. We also predicted a heightened prevalence of the ‘poor comprehender’ profile in children with ASD (Nation et al., 2006).

*Do children with ASD use different word-reading strategies to TD peers?* If word reading is supported by phonological decoding skills in ASD, we predict that nonword reading should be aligned with word reading as in typical development (i.e., there should be no difference between ASD and TD groups in nonword reading when they are matched on word reading skills).

*Are individual differences in reading comprehension predicted by the same skills in ASD as in typical development?* Based on the simple view of reading, we predicted that individual differences in reading comprehension would be associated with variability in reading accuracy for both groups of children and that variability in oral language (measured by receptive vocabulary) would also account for significant unique variance. Given the putative ASD deficit in nonword reading we were also interested in investigating whether the relationships between phonological decoding and word reading with reading comprehension would be similar in ASD and TD groups.

1. EXPERIMENT

**2.1. Method**

**2.1.1. Participants**

Fifty-four children with ASD (51 males) were recruited from special education (*n* 50) and mainstream (*n* 4) schools in Yorkshire and Lincolnshire (aged 7 – 15 years). Prior to the study, initial meetings were set up with the schools to select children identified on the School’s Special Needs Register as having an autism spectrum disorder; children with additional diagnoses such as Fragile X and tuberous sclerosis were excluded. Families were next sent information packs about the study inviting them to take part. All parents provided written confirmation that their child had received a formal diagnosis of ASD through a general practitioner referral. The parents of 20 children returned the Social Communication Questionnaire (SCQ; Berument, Rutter, Lord, Pickels & Bailey, 1999) which provides a dimensional measure of ASD symptomatology (based on the ADI-R; Rutter, Le Couteur, & Lord, 2003). The mean SCQ score was 24.31 (SD = 6.18, range 16 – 36) and all children scored above the recommended cut-off for ASD (i.e., >15).

To explore the literacy profiles in as wide a sample as possible, only two selection criteria were imposed. First, the children with ASD had to be from 7 years to 15 years old. This age range was selected because by 6 years, reading skills are becoming reasonably well established in UK children. Second, language and reading skills had to be sufficient enough to allow the children to participate in the study. Teachers were asked to refer children they considered to have ‘measurable language and reading skills, however minimal’ (as in Nation et al., 2006); the verbal mental ages of the children selected ranged from 4 years 10 months to 17 years (as measured by the British Picture Vocabulary Scales 2nd Edition, Dunn et al., 1997). One child (aged 8.91 years) was completely unable to read despite scoring within the normal range on the measure of oral language (BPVS-II standard score = 88). A further 4 children achieved scores below average on the single word reading test (mean BAS-II standard score = 63, SD = 7.80; range 55 to 74) but failed to read any words when asked to read text. These children also scored below average on the measure of oral language (mean BPVS-II standard score = 62, SD = 20.23; range 39 – 75). All of these children were excluded from further analyses, leaving a sample size of 49 for the ASD group (47 males) aged 7 – 15.50 years (mean age 12.13, SD = 2.21).

A group of 49 TD peers (44 male) were recruited from five mainstream primary and secondary schools in Yorkshire (mean age 11.61, SD = 1.83; range 7.66 – 16.08 years). The ASD and TD groups were group-matched on chronological age (Cohen’s *d* = 0.26) and were also roughly matched on gender (TD 44/49 male; ASD 47/49 male). They had normal or corrected-to-normal vision and hearing, and did not have documented learning difficulties.

**2.1.2. Materials and Procedure**

All children were tested in a quiet room in their schools. The tests were presented in a single session lasting no longer than 45 minutes. Rest periods were allowed as required. It has been argued that computerised tasks reduce the need for experimenter-participant interaction and can improve the behavioural performance of children with ASD (e.g., Ozonoff & Strayer, 2001; Ozonoff, 1995; Pascualvaca, Fantie, Papgeorgiou, & Mirsky, 1998). Therefore, the standardised reading measures were all computerised.

***2.1.2.1. Standardised tests***

Three standardised tests of reading were administered. *Nonword decoding* was measured using the Graded Nonword Reading Test (GNWRT; Snowling et al., 1996). The test was presented on a laptop computer. The nonwords appeared in the centre of the screen in black font (18 point Arial) on a white background. Before each item a picture of a monster was presented on the screen and the examiner told the children that the nonsense word was the monster’s name. This was included to provide a rest period and maintain the children’s motivation. The examiner pressed the space bar to initiate each item. *Single word reading* was assessed using the Word Reading the BAS-II (Elliot et al., 1996). This subtest involves reading words presented in isolation that gradually increase in difficulty. *Text reading accuracy and reading comprehension* were assessed using the Neale Analysis of Reading Ability (Form B; NARA-II; Neale, 1997). This test involves reading story passages and after each one answering 8 comprehension questions that tap a mixture of literal and inferential questions. The children read the stories off a laptop computer screen, each with a picture. In keeping with the standard administration of this test, the picture and the text remained on the computer screen while the experimenter read out the questions and the participants responded orally. In addition to the standardised reading measures, *receptive vocabulary* was measured was measured using the British Picture Vocabulary Scales, 2nd Edition (Dunn et al., 1997).

* 1. **Results**
     1. **How discrepant are word reading and reading comprehension in a broad sample of children with ASD?**

**Patterns of Reading Skill.** Some children in the ASD group performed below the floor of scores on the test of text reading accuracy and comprehension. Following Nation et al. (2006), we took a conservative approach and awarded these children with a score one point below the standardisation floor (for example, the NARA-II standard score floor is 70; children failing to attain this level of performance were awarded a standard score of 69). This was the case for 11 children with ASD for text reading accuracy and 18 children for text comprehension. Hence, the standardised scores for these measures overestimate ability for the ASD group, particularly for reading comprehension. Figure 1 summarises the reading performance of the remaining 49 children with ASD on the standardised tests.

<Insert Figure 1 about here>

As can be seen in Figure 1, the performance of the ASD group was highly variable, compared with that of their TD peers, with performance on all measures ranging from floor to ceiling levels. The mean standard score for the ASD group was 85.02 for word reading (SD=23.66, range 55-144) and 90.18 for text reading (SD=19.73, range 69-126) whilst the TD group mean standard scores were more comfortably in the average range (word reading 107.79, SD=15.24, range 82-145; text reading 104.36, SD=11.96, range 85-129). For text comprehension, the ASD group mean standard score was 79.88 (SD=13.83, range 69-113) in contrast to the TD group of 103.53 (SD=8.92, range 87-127). The groups also differed in receptive vocabulary: for the ASD group the mean was 81.18 (SD=25.49, range 39-160) and the TD, 101.92 ( SD=13.23, range 75-159). Nonword decoding raw scores were particularly variable for the ASD group (mean 11.50 out of 25, SD=8.04, range 0-25) in comparison to the TD group whose scores were towards the ceiling of the test (mean 20.85 out of 25, SD=3.95, range 9-25). TD peers significantly outperformed the children with ASD on all measures (Cohen’s *d*s: word reading, 1.14; text reading 0.87, text comprehension, 2.03; receptive vocabulary, 1.02; nonword decoding 1.59; all *p*s < .05).

* + 1. **Discrepancies between component reading skills.**

We calculated the percentage of children who achieved standard scores of >1 standard deviation (SD) and >2 SDs below the test mean (i.e., of 100) on the measures of word reading, text reading accuracy and text comprehension. Notably, none of the TD children had text reading accuracy or comprehension scores in the below average range and only 2% had word reading scores in the below average range. In contrast, 73% of the ASD group scored below average on the measure of text comprehension, with 45% scoring significantly below age appropriate levels. However, not all of these children can be considered as poor comprehenders since many also showed difficulties with reading accuracy. Indeed, 51% scored > 1SD below the test mean on text reading accuracy (with 20% scoring > 2SDs below) and 57% scored > 1SD below the test mean on word reading (with 31% scoring > 2SDs below).

Many children in the ASD group showed significant discrepancies between reading comprehension and word reading accuracy: 33% of the group obtained a discrepancy of more than 1 SD (mean discrepancy = 22.5 standard scores, SD = 7.24 standard scores); 8% a discrepancy of more than 2 SDs (mean discrepancy = 33.50 standard scores, SD = 3.11 standard scores) and only 1 child (2%) showed the reverse pattern obtaining a comprehension score 1 point in excess of their word reading accuracy score). By way of contrast, the majority of TD peers (90%) achieved a comprehension score within 1 SD of their accuracy score; 10% obtained a comprehension score between 1 – 2 SDs below text reading accuracy (mean discrepancy 16.6 standard scores; SD = 1.14 standard scores) and 37% showed reading comprehension standard scores in advance of reading accuracy.

In the absence of a ‘gold standard’, the following criteria were used to define the ‘poor comprehender’ profile (following Henderson et al., 2013): (i) word reading and text reading accuracy in the average range, (ii) reading comprehension below a standard score of 89, and (iii) at least a 1 SD discrepancy between reading comprehension and word or text reading accuracy1). Among the 49 children in the ASD group, 24.49% could be classified as poor comprehenders. In contrast, only one of the 49 TD controls (i.e., 2.04%) fulfilled these criteria. Together, these observations suggest that delays in reading comprehension relative to reading accuracy are common in children with ASD.

* + 1. **Do children with ASD rely on different word-reading strategies than TD peers?**
       1. ***Discrepancies between word and nonword reading***

Although word and nonword reading were strongly correlated for both groups, low levels of nonword reading were particularly apparent in the ASD group with 8 children failing to read a single nonword. Nevertheless, all of these children achieved scores on the word reading test.

To examine the discrepancy between word reading and nonword reading, 25 children in the ASD group were pair-wise matched to 25 TD children on raw word reading scores (each pair of participants differed by <5 raw scores). Table 1 shows the mean scores on the standardised tests for these two groups. The ASD group obtained significantly lower nonword reading scores than TD peers despite being matched on word reading ability. This suggests that word reading skills are not supported by adequate phonological decoding skills in ASD.

<Insert Table 1 about here>

* + - 1. ***Are individual differences in reading comprehension predicted by the same skills in ASD as in typical development?***

Table 2 shows correlations among raw scores on the standardised tests (partial correlations controlling for age are also presented); correlations which were significantly different in the ASD and TD groups, as reflected by Fishers r-to-z transformations, are shown using subscripts. Reading comprehension was strongly correlated with receptive vocabulary for both groups. Reading comprehension was also strongly correlated with word reading and text reading accuracy for both groups; however, these correlations were stronger for the ASD group than the TD peers. Furthermore, the correlation between nonword reading and text comprehension was significantly stronger for the ASD group than the TD peers. Thus, despite the relative strengths in word reading at a group level and the increased prevalence of the poor comprehender profile, for many children with ASD reading comprehension may be constrained by word-level decoding skills.

<Insert Table 2 about here>

Hierarchical regression analyses were next performed to assess the contributions of age and foundation language and literacy skills (word recognition, phonological decoding and receptive vocabulary) to individual differences in reading comprehension for each group separately (see Table 3). In Model 1 the predictors were age, word reading, nonword reading and receptive vocabulary, entered at each step consecutively. Age accounted for significant variance in reading comprehension for both groups, less so for the ASD group. Word reading accounted for significant variance in reading comprehension for both groups. Nonword reading accounted for unique variance in reading comprehension when word reading was controlled in the TD peers, but it did not account for variance in reading comprehension in the ASD group (likely due to the large amount of variance accounted for by word reading in the ASD group). Indeed, when word reading was omitted as a predictor (Model 2, Table 3), nonword reading accounted for significant unique variance in reading comprehension after receptive vocabulary was controlled for the ASD group but not for the TD group. Finally, receptive vocabulary accounted for significant unique variance in reading comprehension when word reading and nonword reading were controlled for both groups.

<Insert Table 3 about here>

1. DISCUSSION

This study investigated patterns of reading ability in a broad sample of children and adolescents with ASD and compared them to a group of TD children of similar age and gender. Of 54 children with ASD recruited; 91% had measurable reading skills. Consistent with previous research (Brown et al,. 2013; Jones et al., 2009; Mayes & Calhoun, 2008; Nation et al., 2006; Ricketts et al., 2013) there was considerable variability within the ASD group and performance varied from floor to ceiling levels for all measures.

**3.1. How discrepant are word reading and reading comprehension in ASD?**

Consistent with the hypotheses and a large body of research, the mean scores of the ASD group fell within the low average range for word reading accuracy but below this for reading comprehension. Indeed, a large proportion (73%) of children with ASD showed reading comprehension at least 1SD below the test mean, whereas none of the TD peers did. Beyond the description of group means, we investigated the heterogeneity in reading profiles in the groups. In keeping with the literature, there was an increased prevalence of the ‘poor comprehender’ profile in the ASD group with 24% conforming to strict criteria. This estimate is comparable to Nation et al (2006) who reported that 35% of children with ASD showed discrepancies between reading comprehension and word recognition of greater than 1 SD. Thus, approximately 3 out of 10 children and adolescents with ASD have a significant impairment in reading comprehension despite reaching age appropriate levels of word reading. This heightened prevalence is striking considering recent prevalence estimates of around 5% in a representative sample (Snowling et al., 2009).

* 1. **Do children with ASD rely on different mechanisms for word reading?**

Despite relative strengths in word reading and strong correlations between word and nonword reading, some children with ASD in this sample showed significant difficulties with nonword reading (consistent with Nation et al., 2006). Moreover, when children with ASD were pair-wise matched to TD peers based on word reading, they performed significantly worse on the measure of nonword reading. This suggests that word reading is not always aligned to nonword reading in ASD and hence, that some individuals with ASD may rely on different (i.e., non-phonological) strategies for word reading. This finding is the more striking because it is often observed that aspects of word reading (as opposed to nonword reading) is somewhat impaired in poor comprehenders (Nation & Snowling, 1998; Nation et al., 2004). It is plausible that impairments in oral language may be a cause of difficulties with phonological decoding in ASD (Nation et al., 2006; White et al., 2006) but this hypothesis awaits further investigation.

* 1. **Are individual differences in reading comprehension predicted by the same skills in ASD as in typical development?**

Consistent with previous research (e.g., Asberg et al., 2010; Ricketts et al., 2013), individual differences in reading comprehension were strongly correlated with word and text reading accuracy. In line with the simple view of reading, it is therefore likely that poor decoding skill is among the causes of deficits in reading comprehension in ASD. However, since a substantial number of the children with ASD had impairments in language comprehension as measured by a test of receptive vocabulary, this may be a more significant cause in this population.

A novel issue addressed by the present study was whether reading comprehension in ASD is constrained by a lack of basic proficiency with phonological decoding. Not only was nonword reading poorer in the ASD group than in the TD group, but also for them, it was a significant unique predictor of variance in reading comprehension skill whereas it was not for TD controls (see Model 2, Table 3). These findings are intriguing and how to explain them remains unclear. Our speculation is that, unlike typical readers who can use context to decipher unfamiliar words they encounter in text (Nation & Snowling, 1998), readers with ASD do not use context strategically; if this is true then it would follow that their ability to comprehend would be more closely tied to their decoding ability than is the case for typical readers. As we have seen, nonword reading, a measure of pure decoding is often poor, and hence a contributory factor to poor reading comprehension in children with ASD.

Together, these findings are compatible with the view that oral language comprehension cannot exert its influence on reading automatically and efficiently until children have mastered the basic skills involved in word identification, including phonological decoding (Vellutino et al., 2007). When new words are encountered in print, a child with basic word reading skills can attempt to translate its written form (orthography) into its spoken form (phonology) and its meaning can often be inferred using information supplied by the surrounding text (Ricketts, Bishop, Pimperton & Nation, 2011). However, when phonological decoding is slow and effortful, and particularly when the use of context does not bootstrap the process, encountering new words in text will inevitably interfere with comprehension (Perfetti, 1985; Perfetti & Hogaboam, 1975). During the process of learning to read it has long been assumed that children learn to modulate top-down (context based) and bottom-up (decoding based) processes in the service of reading comprehension (LaBerge & Samuels, 1974), partly as a consequence of gaining proficiency over basic processes but also by a drive to monitor comprehension against a standard of coherence (Perfetti et al., 2005). This may not be the case for children and adolescents with ASD who have difficulties in executive control. Consistent with this, it has been shown that while ‘poor comprehenders’ have difficulty activating vocabulary knowledge on-line (Henderson, Snowling & Clarke, 2013), children with ASD are able to activate such knowledge but have difficulties in maintaining activation of relevant information in order to form a coherent understanding of spoken language (Henderson, Clarke & Snowling, 2011).

* 1. **Conclusions, implications, and future directions**

According to Towgood et al (2009), variability is the most prominent feature of ASD. The present study has shown that this also applies to patterns of reading ability and suggests that individuals with ASD with concomitant language impairments, coupled with the difficulties these children experience with executive control (Henderson et al., 2013) are at risk of severe difficulties with reading comprehension. Variance in phonological decoding was also a significant predictor of reading comprehension for the ASD group (but not for the TD peers). Thus, relative strengths in word recognition in ASD may mask difficulties with phonological decoding which can constrain the development of reading comprehension. This finding offers a cautionary note for the assessment of reading in this population: reliance on tests of word recognition may overestimate children’s reading competence in other areas, most notably reading comprehension, but also phonological decoding ability.

A limitation of the study is that it was concurrent and included children widely varying in age and experience. Nonverbal ability was not measured and only one measure of oral language was included; previously documented problems with grammar and syntax (Eigsti, Bennetto, & Dadlani, 2007; Roberts, Mabel, Rice & Tager-Flusberg, 2004) were not investigated. Future research must take a longitudinal approach to investigate the predictors of individual differences in reading development in order to identify the distal and proximal causes of problems these children have in reading for meaning. Such research will be a vital step in developing theoretically motivated interventions.

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**Footnotes**

1 There were two cases where a discrepancy between comprehension and text reading accuracy was used over a discrepancy between reading comprehension and single word reading accuracy; in both cases there was a 14 standard score discrepancy between word reading accuracy and reading comprehension.

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Figure 1. Box plots of standard scores for word reading, text reading and comprehension and receptive vocabulary and raw scores for nonword decoding, for the ASD and TD groups.

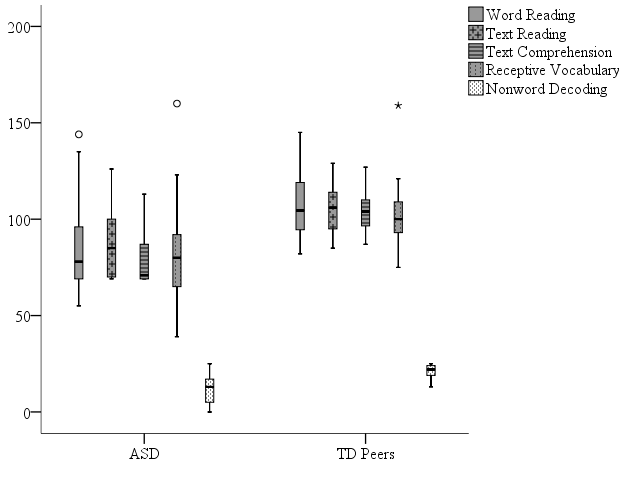


Table 1. Performance on standardised measures of reading and language for the ASD group and Reading Matched TD peers.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | ASD group (*n* = 25) | | Reading Matched TD group (*n* = 25) | |  |  |
|  | Mean (SD) | Range | Mean (SD) | Range | *F* | *d* |
| Age (years) | 12.29 (2.51) | 7 – 15.50 | 11.54 (2.07) | 7.66 – 16.08 | 1.31 | 0.33 |
| Word Reading (raw) | 69.56 (12.58) | 43-86 | 70.60 (11.52) | 44-85 | 0.09 | 0.09 |
| Word Reading (ss) | 99.80 (22.42) | 61-144 | 105.04 (13.95) | 82-133 | 0.98 | 0.28 |
| Nonword Decoding | 14.92 (6.92) | 0 – 25 | 21.0 (3.70) | 13 – 25 | 15.03, *p*=.000 | 1.10 |
| Text Accuracy (raw) | 73.20 (22.41) | 30 – 100 | 70.04 (20.25) | 33 – 98 | 0.27 | 0.15 |
| Text Accuracy (ss) | 104.04 (17.69) | 69 – 126 | 101.83 (11.02) | 85 – 122 | 0.27 | 0.15 |
| Text Comprehension (raw) | 21.36 (10.68) | 5 – 39 | 28.46 (7.09) | 18 – 40 | 7.44, *p*=.009 | 0.78 |
| Text Comprehension (ss) | 87 .72 (14.94) | 69 – 113 | 101.38 (7.60) | 87-117 | 16.05, *p*=.000 | 1.15 |
| Vocabulary (raw) | 99.17 (25.34) | 49 – 138 | 104.24 (15.77) | 76 – 129 | 0.71 | 0.24 |
| Vocabulary (ss) | 90.48 (22.53) | 40 – 123 | 98.72 (11.06) | 75 – 118 | 2.70 | 0.46 |

*Note. Maximum raw scores are 90 and 25 for the word reading and nonword decoding tests, respectively. F values reflect one-way ANOVAs with Group as a between subjects variable and d values reflect Cohen’s d effect sizes. Standard deviations are reported in parentheses*

Table 2. Correlations between standardised test scores for the ASD group (and TD peers in parentheses).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 |
| Word Reading |  | .76 (.67) | .89 (.90) | .80 (.75) | .65 (.67) |
| Nonword Reading | .74 (.62) |  | .71 (.58) | .61 (.32).04 | .42 (.36) |
| Text Accuracy | .89 (.85) | .70 (.51) |  | .89 (.74).02 | .66 (.56) |
| Text Comprehension | .78 (.61).05 | .58 (.17).009 | .89 (.62).001 |  | .77 (.79) |
| Receptive Vocabulary | .61 (.48) | .37 (.20) | .64 (.35).03 | .74 (.66) |  |

Note. Simple correlations are above diagonal, partial correlations controlling for age below the diagonal.

Subscript = correlations between ASD and TD significantly different (p-value)

Table 3. Hierarchical regressions examining predictors of reading comprehension in children with ASD and TD peers.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | ASD | | | | | | TD peers | | | | |
| Model | Step | Variable | R2 | R2 change | F change |  | *β* | *p* | R2 | R2 change | F change | *β* | *p* |
| 1 | 1 | Age | .10 | .10 | 5.18 |  | .32 | <.05 | .45 | .45 | 35.82 | .67 | <.001 |
|  | 2 | Word Reading | .65 | .55 | 69.43 |  | .78 | <.001 | .65 | .20 | 24.93 | .55 | <.001 |
|  | 3 | Nonword Reading | .65 | .00 | .001 |  | -.01 | .97 | .69 | .04 | 5.27 | -.27 | <.05 |
|  | 4 | Receptive Vocabulary | .75 | .10 | 16.82 |  | .43 | <.001 | .77 | .08 | 14.57 | .41 | <.001 |
| 2 | 1 | Age | .10 | .10 | 5.18 |  | .32 | <.05 | .45 | .45 | 37.19 | .67 | <.001 |
|  | 2 | Receptive Vocabulary | .59 | .49 | 51.81 |  | .75 | <.001 | .69 | .23 | 32.66 | .60 | <.001 |
|  | 3 | Nonword Reading | .69 | .10 | 13.74 |  | .35 | <.001 | .69 | .00 | 0.065 | .02 | .80 |

*Note: β, standardised beta coefficients.*