Reading for sound and reading for meaning in autism:
Frith and Snowling (1983) revisited

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"Reading skill is acquired quickly, but the children read monotonously and a story or moving picture is experienced in unrelated portions rather than its coherent totality." (Kanner, 1943, p. 250)

In his original description of 11 children with what he termed "autistic disorder", Leo Kanner (1943) noted a marked discrepancy between their fluent (if monotonous) reading and their apparent lack of comprehension of the material they had read. As with many of his observations, subsequent empirical research has been generally supportive of Kanner's views on reading skills in autism. In the 1960s, the term *hyperlexia* was coined to describe advanced decoding skills in the presence of intellectual disability (Huttenlocher & Huttenlocher, 1973; Silberberg & Silberberg, 1967) with researchers noting that many hyperlexics met criteria for autism (Healy, Aram, Horwitz & Kessler, 1982). However, rather than being celebrated as a cognitive strength, or a signal of otherwise unrecognised intelligence, advanced reading skills were widely dismissed as mechanical "barking at print", in much the same way that echolalia, the rote repetition of other people's utterances, was considered to be meaningless and even problematic (see Roberts chapter, this volume).

A turning point came in 1983, with the publication in the Journal of Developmental Psychology of a paper by Uta Frith and Maggie Snowling, who reported a series of seven experiments testing autistic children's reading capabilities. Frith and Snowling concluded that the single word reading skills of autistic children were qualitatively similar to those of younger typically developing children at the same stage of reading acquisition. However, across several experiments, they found evidence for an

inability to extract the broader meaning of connected text, precisely as Kanner had suggested.

Six years later, in *Autism: Explaining the Enigma*, Frith (1989) expanded on these findings, introducing the term 'central coherence' to describe the mechanism that "compels us human beings to give priority to understanding meaning" (p 101). Building on earlier theories put forward by Rimland (1964) and Hermelin and O'Connor (1970), she proposed that *weak* central coherence was the "red thread" running through many of the features of autism including social communication impairments as well as relative strengths on nonverbal tasks that required the meaning or Gestalt of the stimuli to be ignored. Current formulations of the weak central coherence account are somewhat less ambitious in scope (e.g., Happé & Frith, 2006). Nonetheless, it remains one of three dominant cognitive accounts of autism (Rajendran & Mitchell, 2007) and continues to influence theoretical and clinical approaches to the communication impairments associated with the disorder (e.g., Noens & van Berckelaer-Onnes, 2005).

In this chapter, we revisit Frith and Snowling's 1983 study, describing each of the seven experiments and reviewing the studies of reading comprehension in individuals with autism that have been conducted in the intervening three decades that have attempted to replicate and extend their findings. We attempt to reconcile some apparently contradictory findings within this literature and conclude by discussing the relationship between reading comprehension and oral language comprehension more generally.

Participants

Frith and Snowling's autism group comprised of six boys and two girls, aged 9- to 17-years-old, who demonstrated "the classic symptoms of autistic aloneness, cognitive/language deficits, and obsessional phenomena" (p. 331). At the time, there were no standardised autism diagnostic tools, with the authors relying on psychiatric diagnoses. The autistic children were selected to have a reading age of between 8 and 10

years according to the normative data of the British Abilities Scale (BAS) Word

Reading Test (Elliott, Murray & Pearson, 1979), which involved reading aloud single

words. Full scale IQs, measured using the Wechsler Intelligence Scale for Children,

ranged from 54 to 103.

In the majority of experiments, the performance of the autistic children was

contrasted with that of two further groups of children, both matched to the autism group

according to their performance on the BAS Word Reading Test. A typically developing

control group included ten 9- to 10-year-old children (8 boys), described by their

teachers as being of average ability. The dyslexia group were eight 10- to 12-year-old

children (5 boys), who had all been referred to a dyslexia centre by their schools and

were found to have poor reading skills for their age and IQ.

The Neale Analysis of Reading Ability

Frith and Snowling (1983) also reported the performance of autistic and dyslexic

children on the Neale Analysis of Reading Ability (NARA), a popular standardized test

in which children are required to read a short story aloud and then answer questions

about the story (Neale, 1958). The two groups performed at similar levels in terms of

their reading accuracy, consistent with the fact that they were matched on word decoding

skills. However, the autistic children achieved significantly lower scores for reading

comprehension.

These findings are consistent with the results of other studies of autism using the

NARA or NARA II. These have consistently shown reading comprehension to be

significantly poorer than reading accuracy based on age-equivalent or age-standardized

scores (Lockyer & Rutter, 1969; Nation et al., 2006; Rutter & Bartak, 1973. Similar

results have also been reported on other tests of reading comprehension that likewise

involve answering questions about sentences or passages that the participant has just

read (Jones et al., 2009; Minshew, Goldstein, Muenz, & Payton, 1992; Minshew,

Goldstein, & Siegel, 1995; Williams, Goldstein, & Minshew, 2006; see also but see

Asberg, Kopp, Bergkelly, & Gillberg, 2010).

However, while the results are fairly consistent across studies, they may be less consistent across the individuals within those studies. Using the NARA II (Neale, 1997), Nation, Clarke, Wright, and Williams (2006) reported that 10 of 32 autistic children with measurable reading scores had impaired reading comprehension (standard scores <85) despite unimpaired reading accuracy. Only one child showed the opposite pattern, meaning that the overall trend was again for poorer comprehension than decoding. Nonetheless, the majority of children had similar scores for decoding and comprehension. Further correlational analyses showed that reading comprehension was strongly predicted by oral language comprehension skills.

In a more recent study, Norbury and Nation (2011) divided their sample of 27 adolescents with autism (26 male) according to whether or not they had oral language impairment, defined in terms of clinical records and performance below -1.25 SD on the recalling sentences subtest of the Clinical Evaluation of Language Fundamentals (Semel, Wiig, & Secord, 2006). The subgroup with language impairment had significantly lower reading comprehension scores than age-matched typically developing controls. In contrast, those *without* language impairment had age-appropriate reading comprehension.

The link between oral language skills and reading comprehension in autism was further emphasized in another recent study by Huemer and Mann (2010), using the Gray Oral Reading Test-Revised, 4th edition, which follows a similar format to the NARA. Factor analysis of pooled data from children with autism or dyslexia revealed two distinct factors: reading accuracy and rate loaded onto one factor, along with other measures of decoding; while reading comprehension loaded onto a second factor, alongside measures of spoken language comprehension.

This relationship between reading comprehension and oral language skills is an issue we return to at the end of the chapter. For now, it is suffice to say that there is clear and fairly consistent evidence from studies using a wide range of standardized tests to support Frith and Snowling's (1983) view that reading comprehension can dissociate from decoding skills in that individuals with autism tend to have reading comprehension

difficulties that are more severe than can be explained in terms of impaired decoding skills alone. What standardized tests fail to address, however, is the underlying mechanism of this comprehension impairment. IThus, in the seven experiments reviewed below, Frith and Snowling attempted to tease apart different explanations for comprehension difficulty, looking at processing of progressively larger sections of text, from single words through to extended passages of prose.

Experiment 1: Words / Nonwords

The first three experiments in Frith and Snowling's paper involved reading of single words. Frith and Snowling reasoned that, if children with autism were merely "barking at print", then their pattern of reading performance across different classes of lexical material would be different to typically developing children at the same level of reading skill.

Experiment 1 was motivated by Coltheart's *dual route* model of reading (Coltheart, 1978). According to this model, regular words such as "cat" or "house" can be read successfully either by being recognized whole (the lexical route) or being sounded out letter by letter (Grapheme Phoneme Conversion). For irregular words, such as "yacht", the usual letter-to-sound rules don't work, and so reading relies heavily on the lexical route. In contrast, unfamiliar words or nonwords such a "blench" must be sounded out because you can't recognize whole a word you haven't seen before. Contrasting a child's ability to read nonwords with their reading of irregular real words thus provides a metric of the relative strengths of the two different routes.

Figure 1 shows the pattern of performance of the three groups across regular words, irregular words, and nonwords. Compared to typically developing children, those with dyslexia were significantly poorer at reading nonwords. They also showed little difference between regular and irregular words. Within the dual route framework, this pattern of results suggests an inability to sound out words that can't be recognized whole. In contrast, the children with autism showed almost identical patterns of performance to the typically developing children across the different types of word.

Figure 1: Results of Experiments 1, 2, and 3

Experiment 1: Words / Nonwords

Experiment 2: Concrete / Abstract

Experiment 3: Stroop Effect
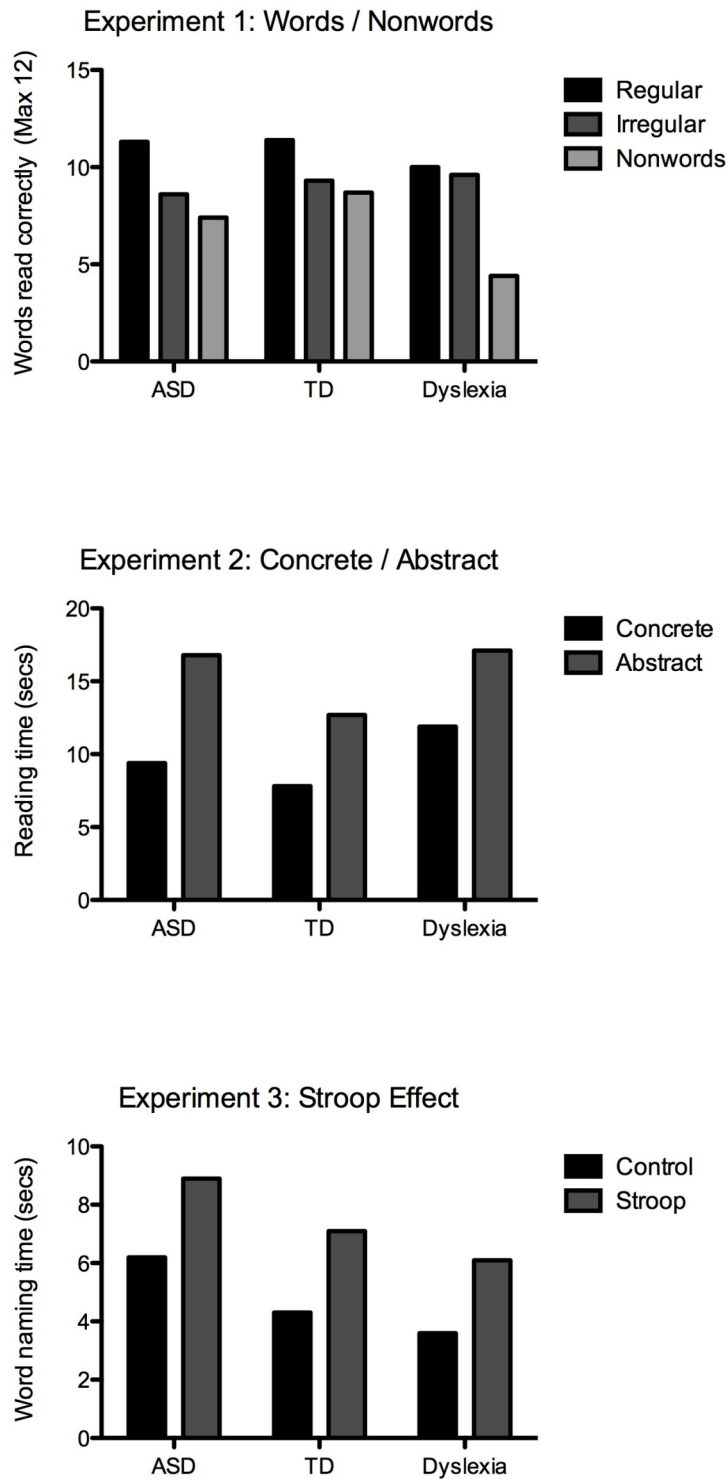
A number of subsequent studies have contrasted word and nonword reading in autistic individuals. Minshew et al (1994) tested high-functioning adolescents and young adults on subtest of the Woodcock Reading Mastery Test – Revised (Woodcock,

1987). Consistent with Frith and Snowling's results, performance was similar for word reading (Word Identification) and nonword reading (Word Attack), with standardized scores slightly above age-appropriate levels.

Other researchers have reported cases of children with very poor nonword reading, in spite of skilled word reading (Aaron, Fantz, & Manges, 1990). For example, Nation et al (2006) identified 5 out of 32 autistic children in their sample who were at floor on nonword reading, despite having a standardized score of at least 95 for word reading. Similarly, Newman et al. (2007) reported considerable variation in nonword reading within autism. In particular, the ability to read nonwords differentiated autistic children with hyperlexia from those who did not meet criteria for hyperlexia.

Surprisingly few studies have investigated the regular / irregular distinction in autistic children. Welsh, Pennington and Rogers (1987) reported that five children with autism and hyperlexia performed better on regular than irregular words. Although the authors claimed that this was evidence for a dysfunctional lexical route, the absence of a control group makes the data difficult to interpret (note that the typically developing children tested by Frith and Snowling also showed this pattern of results). Moreover, the children showed significant effects of word frequency, which according to Coltheart's (1978) model can only be explained in terms of a functioning lexical route.

Experiment 2: Abstract / Concrete words

In their second experiment, Frith and Snowling examined the concreteness effect, whereby concrete or highly imagable words are easier to read than abstract words (Richardson, 1975). Again, the reasoning was that, if children with autism are merely "barking at print" without processing the meaning of the words, then they should not show a concreteness effect.

To test this prediction, children were given lists of 12 concrete and 12 abstract words to read aloud. The word lists were matched for word frequency and length - factors that are known to affect reading accuracy and speed. Any differences in performance could then be attributed to semantic processing. In fact, very few errors

were made by any of the children, but concrete words were read significantly faster than abstract words (see Figure 1). Importantly, this concreteness effect on reading speed did not interact with group membership. If anything, autistic children showed an increased concreteness effect on response times - the opposite to predictions.

There have, to our knowledge, been no attempts to directly replicate Frith and Snowling's Experiment 2. Reduced concreteness effects in autism have been reported in studies of memory for word lists, perhaps reflecting differences in encoding strategy (Toichi & Kamino, 2003). In contrast, other studies have reported typical concreteness effects in tests of vocabulary knowledge (Hobson & Lee, 1989). Perhaps the closest to a replication comes from a study by Eskes, Bryson, & McCormick (1990) investigating the concreteness effect on reading using a Stroop interference paradigm. This study was a response to Frith and Snowling's Experiment 3, which is described next.

Experiment 3: Stroop interference

In the Stroop paradigm (Stroop, 1935), participants are presented with a list of words or character strings typed in different ink colours. Response times for naming the ink colours are considerably slower if the words themselves are incongruous colour words (e.g., the word "GREEN" written in red ink). Given that participants are instructed to ignore the words themselves, this suggests that access to the meanings of the words is automatic and obligatory (Posner & Snyder, 1975) and the Stroop task therefore provides a test of "capture by meaning" (cf. Shah & Frith, 1983). In fact, Frith and Snowling (1983) found that the size of the interference effect was similar across the three groups (see Figure 1).

Similar results have been reported in six replication studies (Bryson, 1983; Christ, Holt, White, & Green, 2007; Eskes, Bryson, McCormick, 1990; Goldberg et al., 2005; Lopez, Lincoln, Ozonoff & Lai, 2005; Ozonoff & Jensen, 1999). A seventh study *did* report a reduced interference effect in children with autism (Adams & Jarrold, 2009), although it is unclear why these results differed from those of other studies.

The most comprehensive investigation was conducted by Eskes et al. (1990). Like

Frith and Snowling, these authors reported that children with autism showed a similar interference effect to typically developing controls when naming the colours of incongruent colour words. They also showed similar interference effects from colour associates (e.g., the word GRASS written in brown). Moreover, as noted above, the autistic children showed increased interference from concrete compared with abstract words (e.g., TABLE vs. LIFE). Again, the magnitude of this concreteness effect was comparable to that shown by control children. These findings indicate that the presence of the Stroop effect extends beyond the effects of colour words and that individuals with autism do process the meanings of the individual words they hear.

Experiment 4: Final 's'

Frith and Snowling's first three studies failed to find any evidence of atypical single word processing. In their fourth and fifth experiments, they moved on to investigate the effect of sentence context on the interpretation of single words. In both experiments, participants were required to read aloud sentences containing ambiguous words that could be pronounced in more than one way. The pronunciation they gave then indicated how they had interpreted the sentence.

In Experiment 4, the critical words were nonwords such as "bippis" that ended in a letter "s" preceded by a vowel. In some sentences (e.g., "All these bippis…"), the participants were expected to infer that the final "s" was a plural marker and so should be pronounced with a voiced /z/ sound (as in "hippos"). In other sentences (e.g., "One yellow bippis…"), the novel word was a singular noun and the "s" was to be pronounced with an unvoiced /s/ (as in "proboscis"). Because the word was a nonword, children had to use the syntactic context of the sentence to determine whether to leave the "s" voiced or unvoiced.

Figure 2: Results of Experiments 4 and 5

Experiment 4: Final -s

Experiment 5: Homograph Reading Task
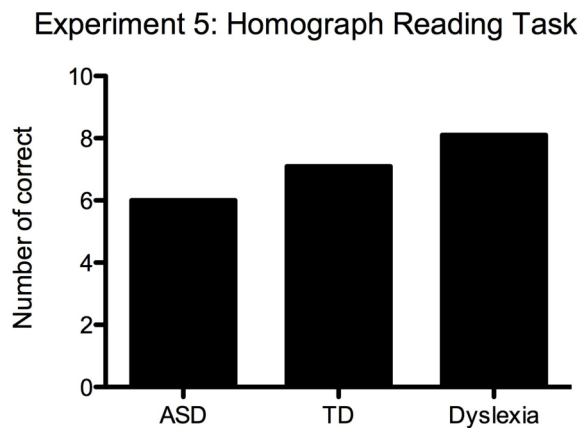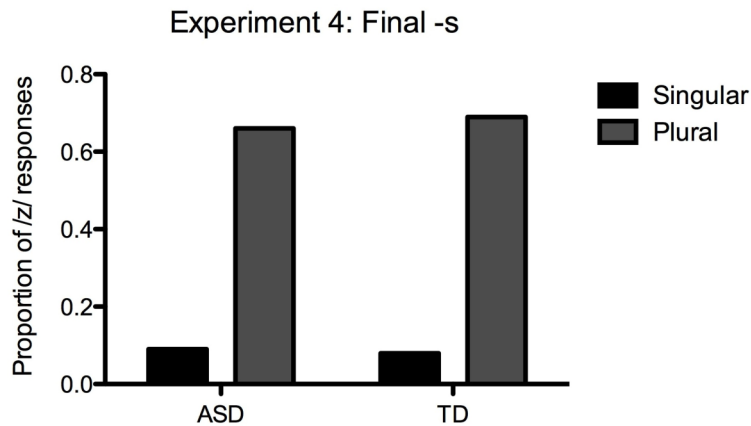
Children with autism were sensitive to this syntactic manipulation, being much more likely to give the voiced /z/ in plural contexts (see Figure 2). Frith and Snowling did not test the typically developing or dyslexic children on this task. However, they noted that, numerically, the performance of the autistic children was very similar to that of typically developing children aged 8- to 10 years (the reading age of the autistic children) in a previous study (Campbell & Besner, 1981). Frith and Snowling concluded, therefore, that "children with autism can be sensitive to syntactic constraints". To our knowledge, no attempts have been made to replicate this experiment.

Experiment 5: Homographs

Undoubtedly the most influential experiment in the series was Experiment 5, in which participants were required to read aloud sentences containing homographs - written words that have multiple meanings associated with the same orthographic form. Crucially, the homographs chosen by Frith and Snowling all had different pronunciations associated with their different meanings. For example, the word *"bow"* is pronounced differently in the sentences.

"Tom was an Indian and pretended to have arrows and a bow."

"Before he began his speech he made a bow."

For four of the five homographs used in the test (bow, row, tear, lead), children with autism consistently gave the most common pronunciation, regardless of contextual cues. Children with dyslexia and typically developing children performed significantly better, although as Figure 2 shows, the difference in terms of actual number of errors was relatively small.

The fifth homograph, "read", was pronounced accurately across both contexts by all of the autistic children. Notably, "read" is a verb, whereas the other homographs were all nouns in both contexts (although they could all be verbs in other syntactic contexts). Perhaps more importantly, the two pronunciations of "read" correspond to different tenses of the same verb stem as opposed to completely unrelated meanings, as was the case for the other homographs. Thus the contextual cues are syntactic rather than semantic and the unimpaired performance on this homograph is entirely consistent with the apparently normal performance on the "bippis" task described above (Experiment 4). Frith and Snowling argued, therefore, that they had identified "a failure to utilize semantic context in the absence of syntactic cues".

In 1986, Snowling and Frith reported a follow-up study, using similar stimuli but adding a second condition in which the homographs came before the disambiguating context (e.g., "He took a bow when everybody clapped"). A further adaptation was that the whole experiment was administered twice, with a training session between the first and second runs, in which participants were alerted to the ambiguous nature of the

words and coached in their alternative meanings. Overall, children with autism performed at a similar level to intellectually disabled control children, with variation in performance linked instead to verbal mental age. As pointed out by Happé (1997), the training session changed the nature of the task, meaning that it was no longer a test of natural reading comprehension. Nonetheless, the 1986 study further highlights the importance of language level in reading comprehension.

A further four studies have been conducted using Snowling and Frith's stimuli, but without the training session. Although none of these studies directly assessed knowledge of the alternative meanings of the homographs, participant groups were matched on verbal IQ (Burnette et al., 2005; Jolliffe & Baron-Cohen 1999; Lopez & Leekam, 2003) or were selected such that those in the autism group had larger receptive vocabularies than control participants (Happé, 1997). Results were broadly in line with Frith and Snowling's original report, with autistic individuals making more pronunciation errors than controls. This was true whether researchers considered only the participants' first responses or allowed them to correct any pronunciation errors. One slight anomaly is that Happé (1997) found evidence for impairment when the context preceded the homograph but not when it came after. The most likely explanation for this finding is that the control children in this study were considerably younger than those with autism and may have been less adept at reading ahead to work out what the correct meaning was.

Another important issue is the extent to which performance varies across individuals. In Frith and Snowling's original study, all 8 children with autism consistently gave the wrong pronunciation for the subordinate meaning. However, given the low levels of performance across all three groups, this impressive consistency may have been a function of floor effects. In other studies, with overall higher levels of performance, the reported standard deviations indicate considerable variability. Indeed, because only four or five trials were administered per condition, it is possible to work out the exact distribution of scores for each condition. Figure 3 shows that, across the three studies conducted by Happé (1997), Jolliffe and Baron-Cohen (1999) and Lopez

and Leekam (2003), 40% of participants with ASD pronounced the subordinate meaning correctly on every single trial. In other words, group differences were driven by a subgroup of individuals with autism who perform poorly, rather than reflecting a 'universal' characteristic of autism (cf. Happé, 1997).

Figure 3: Number of errors made by participants with autism in four studies of homograph reading (context first, rare pronunciation condition). Shaded area shows the combined sample across all four studies.
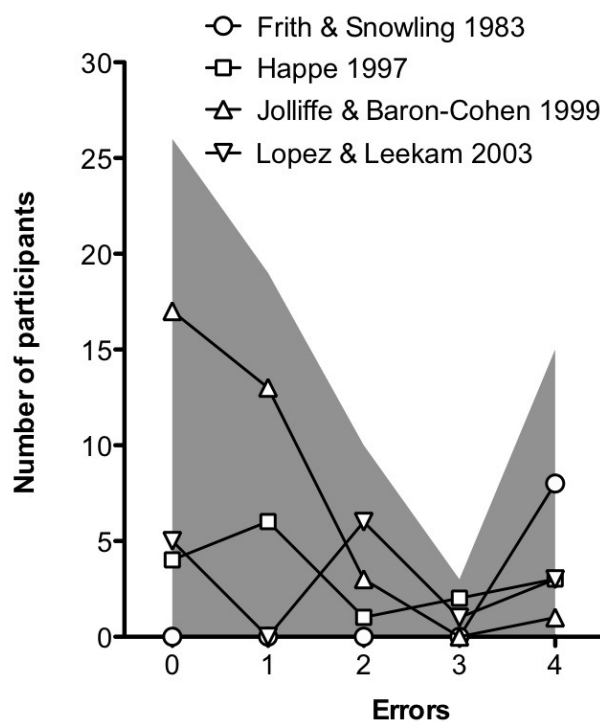
The reason for the small number of trials in the homographs task is that appropriate homographs are relatively rare in English. The majority of homographs are like "bank", having the same pronunciation for both meanings, making it impossible to know which meaning was intended, or they rely on subtle prosodic differences (e.g., "INcense" versus "inCENSE") that may in themselves be challenging for some individuals with autism (see chapter on prosody by Arciuli, this issue). Thus, in a recent and currently unpublished study, we investigated homograph reading in Israeli children with autism whose primary written language was Hebrew - a much richer source of

homographs (Friedmann, Yosef, & Brock, 2012). As in the studies of English-speaking individuals, we found considerable variation in performance, with some children making multiple errors and others performing almost perfectly. Homograph reading accuracy was predicted by children's age and autism severity (according to the Childhood Autism Ratings Scale; Schopler, Reichler, DeVellis, & Daly, 1980), their reading speed, their knowledge of the meanings of written words, and their ability to name pictures. These results provide further evidence for a link between reading comprehension and both decoding skills and oral language abilities.

Experiment 6: Gap test

In Experiment 6, participants completed the Gap test (McLeod, 1970) in which they were required to read a section of text and write in the missing word, as in the example below:

There was a chest of _____ and a cupboard to put things _____.

There was no time limit, children were encouraged to guess, and they were not penalized for spelling errors. Even so, children with autism made many more errors than those in the other two groups. These were predominantly in the same syntactic class (noun, verb, adjective) as the correct word, suggesting that the difficulties were semantic rather than syntactic in nature (see Figure 4).

Similar tests are found in various standardized assessments of reading achievement. Using the Passage Completion subtest of the Woodcock Reading Mastery Test, Minshew and colleagues found that individuals with autism perform worse than age and IQ-matched controls, despite performing at similar levels on measures of reading decoding (Minshew et al 1995; Minshew, Goldstein, & Siegel, 1997; Williams et al., 2006). More recently, Newman et al (2007) administered the Passage Comprehension subtest of the Woodcock-Johnson Tests of Achievement III, which is also similar in format. Once differences in single word reading had been controlled for statistically, children with autism performed significantly worse than typically

developing children, regardless of whether or not they met criteria for hyperlexia.

Figure 4: Results of Experiments 6 and 7

Experiment 6: Gap Test

Experiment 7: Restricted Choice
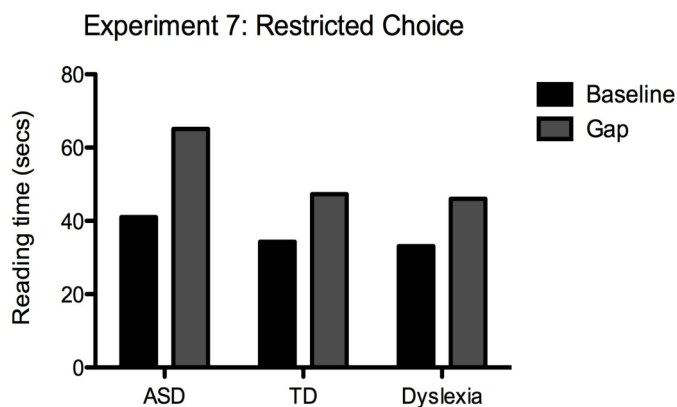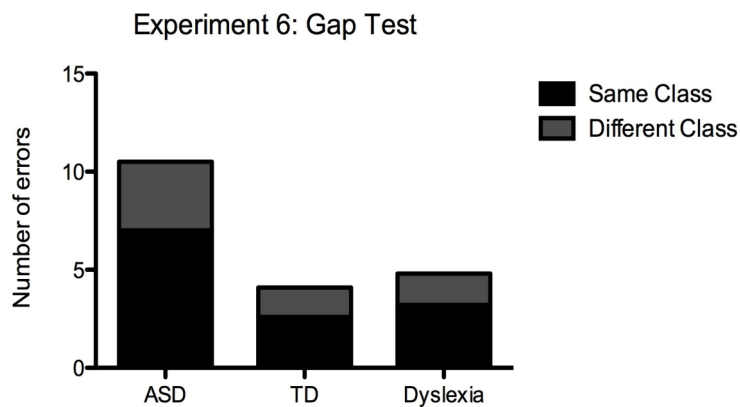
Experiment 7: Restricted choice

Experiment 7 was a development of Experiment 6. Participants were again required to read passages. This time, however, they read aloud and, at various points in the passage, had to choose one from three words. In each case, the three words were all from the same word class (all prepositions, all verbs, or all nouns) so there were no syntactic cues.

Tom could swim/hear/heat something else, nearby. Was it a water rat? He looked in the holes/drawers/books in the riverbank.

As in Experiment 6, children with autism made more errors than dyslexic or typically developing children who were at ceiling. They were also slower to read those sentences containing choices, despite not differing on time overall (see Figure 8).

In their follow-up study, Snowling and Frith (1986) developed a slightly more nuanced version, in which the word choices included the correct word, an entirely implausible word, and a word that was plausible given the sentence context but inconsistent with the broader story context.

In early summer, five tiny babies were born. After only four days, their mother/friends/records led them to the pond for their first swimming lesson.

Children with autism performed at a similar level to intellectually disabled control children of comparable verbal mental age (receptive vocabulary knowledge). However, as for the other tasks conducted by Snowling and Frith, performance varied as a function of verbal mental age.

Somewhat similar results were reported in the recent study by Norbury and Nation (2011) using essentially the same task (although children were also asked comprehension questions throughout the task). Mirroring the results on the NARA, mentioned earlier, autistic children with language impairment performed significantly worse than age-matched typically developing children, whereas those with age-appropriate language were unimpaired. Thus, again, there is clear evidence for variation in reading comprehension linked to oral language skills, this time at the level of paragraph comprehension.

Discussion

The results of Frith and Snowling's 1983 study can be summarized as follows: First, on tests that involved single word reading, autistic children resembled younger typically developing children who were matched on their ability to read single words. Although this sounds somewhat circular, the notion that autistic children merely "barked at print" would have led one to predict *qualitative* differences in single word reading. Instead, the autistic children showed typical pattern of reading performance

across regular, irregular, and novel words (Experiment 1); and across concrete and abstract words (Experiment 2). They also evidenced typical interference from colour words (Experiment 3).

Second, and in contrast to their single-word reading, the autistic children demonstrated clear difficulties when required to process multi-word text. They showed a reduced influence of sentence context on reading homographs (Experiment 5), and had difficulty producing or choosing suitable words that would complete the text (Experiments 6, 7). There was, however, no evidence for difficulties in using sentence context to determine the syntactic class of a word (Experiments 4, 5 and 6). Together, these observations led Frith and Snowling to conclude thus:

> *"So far, we can state only that we traced the deficit to a failure to utilize semantic context in the absence of syntactic cues. Also, we hypothesize that this failure cannot be reduced to a failure of semantic access to individual words."*

As we have seen, Frith and Snowling's results have stood the test of time remarkably well, with similar findings being reported in numerous studies using the same or equivalent tests of reading ability. Basic decoding skills are of course a prerequisite for reading comprehension, but it is clear that many children and adults with autism struggle on tests of reading comprehension despite having relatively strong decoding skills.

In addition to the replication studies reviewed above, Frith and Snowling's conclusions have also been supported by results from other paradigms. For example, evidence for typical processing of word meaning comes from studies using semantic priming paradigms in which the response to a word is facilitated if it is preceded by a semantically related word (Kamio & Toichi, 2000; Lopez & Leekam, 2003; Toichi & Kamio, 2001; but see Kamio et al., 2007). Evidence for reduced context effects at the sentence level comes from studies indicating that the N400 brain response of individuals with autism is insensitive to whether a written word is congruent or incongruent with the preceding sentence context (Braeutigam et al. 2008; Pijnacker et al 2011; Ring, Sharma, Wheelwright, & Barrett, 2007).

Despite the converging evidence at the group level, it has also become evident that not all individuals are affected in this way. As we have seen, some studies with high functioning autistic participants have failed to find evidence of reduced context effects in reading comprehension. Others have found significant impairment only in a subgroup of individuals with autism. Across these studies the most consistent predictor of within-group variability in test performance is the individual's oral language level or, alternatively, their degree of language impairment. This is the case for performance on the NARA (Nation et al., 2006; Norbury & Nation, 2011) and similar tests (Huemer & Mann, 2010); the Restricted Choice test (Snowling & Frith, 1986; Norbury & Nation, 2011); and, indeed, the homograph test (Snowling & Frith, 1986; Brock et al, 2012).

Notably, the same pattern has also been observed in studies of spoken sentence comprehension. Norbury (2005), for example, asked participants to listen to sentences containing homophones – ambiguous *spoken* words - and then decide whether the sentence matched a picture corresponding to one of the meanings of the homophone (e.g., *"John fished from the bank"* followed by a picture of money). Children with autism who had age-appropriate language skills performed at the same level as their typically developing peers (see also Henderson, Clarke, & Snowling, 2011). Autistic children who had language difficulties performed poorly on the test, but so too did non-autistic children with *specific* language impairment. An identical pattern of results was reported by Brock, Norbury, and Einav (2008) using a language-mediated eye-movements paradigm, whereby context effects were indexed by participants' tendency to look at objects on a computer display that were consistent or inconsistent with the context of sentences they were listening to. Again, the magnitude of context effects varied as a function of oral language ability, independent of autism diagnosis.

Thus, we have two apparently conflicting sets of results. On the one hand, there are the many studies reporting evidence for reading comprehension difficulties and reduced sensitivity to context in autism, even when carefully controlling for verbal IQ or verbal mental age. On the other hand, there are a growing number of studies showing that variation in context effects and comprehension performance is primarily a function

of oral language skill, rather than autism diagnosis.

Reconciling these findings is far from straightforward. One possibility is that individuals with autism experience additional comprehension difficulties that cannot be explained in terms of language impairments or poor decoding skills. Exactly what that additional deficit might be, however, remains somewhat mysterious. While the results seem to be fairly consistent across studies using the same task, there is no obvious "fine cut" between the comprehension tasks that reveal group differences and those that do not. Frith and Snowling's original suggestion of a basic deficit in "context processing", as envisaged in the weak central coherence account, runs up against the findings from the eyetracking (Brock et al., 2008) and homophone tasks (Norbury, 2005). Happé's (1994) suggestion that individuals with autism have difficulty "extracting higher level meaning" might allow for intact *local* context effects within sentences in these studies, and is certainly consistent with the evidence reviewed earlier that autistic individuals are unable to make the inferences required to join two sentences into a coherent narrative (e.g., Joliffe et al., 1999; Minshew et al., 1995). However, it is inconsistent with findings from studies using the Restricted Choice task - choosing a word that is coherent with the story context rather than just the sentence context is related to language ability rather than autism diagnosis (Norbury & Nation, 2011; Snowling & Frith, 1986).

There are other factors to consider. Certain reading comprehension tasks might prove difficult for individuals with autism for reasons unrelated to their reading comprehension. For example, a number of studies have reported that individuals with autism have difficulty answering questions that involve inferences about events that are implied but not explicitly stated in the text (Dennis et al. 2001; Jolliffe & Baron-Cohen, 1999; Minshew et al., 1992, 1995; Norbury & Nation, 2011; Williams et al., 2006; see also Ozonoff & Miller, 1996). However, Saldana and Frith (2007) found that, despite performing poorly on a conventional test of reading comprehension, children with autism did appear able to make text-based inferences because they were quicker to read sentences that had been primed by an inference generated earlier in the text. Again, it is

not entirely clear what specific task demands are relevant. Nonetheless, it is important to recognize that scores on many reading comprehension tests may underestimate the true levels of comprehension of autistic children.

A further important consideration may be the nature of the task used for matching. Given the uneven profile of language skills, matching participants on one measure is likely to leave groups unmatched on other linguistic skills that are more directly relevant to reading comprehension (Jarrold & Brock, 2004). Many of the studies reporting significant group differences have matched groups on either receptive vocabulary knowledge or an omnibus measure of verbal IQ. In contrast, studies emphasizing the link between reading comprehension and oral language skills have tended to include measures of sentence-level comprehension or production.

Ultimately, this discussion leads us to question the value of attempts to identify "autism-specific" impairments of reading - or anything else for that matter. A more fruitful approach might be to focus on individual variation, within autism and across diagnostic groups (Brock, 2011). In the case of reading, the aim should be to investigate and identify the factors that contribute towards good reading and reading comprehension, regardless of a child's diagnostic status. As Norbury and Nation (2011) point out, there is also much to be gained by considering reading comprehension in autism in the light of the extensive body of research on individual differences in non-autistic readers, where the link between reading comprehension and general language processes has long been recognised (e.g., Catts, Adlof, & Ellis-Weismer, 2006; Hoover & Gough, 1990). An important goal for future autism research is to determine the precise aspects of oral language that contribute to variation in reading comprehension – and the cognitive mechanisms that mediate this relationship.

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