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Reading for meaning and reading for sound in autistic and dyslexic children

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Autistic, dyslexic and normal readers matched for reading age (RA) were compared on a large range of oral reading tasks. In terms of single word reading autistic children demonstrated intact processing strategies, entirely in keeping with their RA level, while dyslexic children failed on phonological, but not on lexical or semantic processing. With connected prose, the autistic children showed failure in reading for meaning. This failure was traced to a difficulty in using semantic context in the absence of syntactic cues. Dyslexic children showed superior ability in using semantic context relative to their RA level. The reading problems in the two groups can thus be seen as complementary.

Many autistic children learn to read despite their various cognitive and social handicaps (Lockyer & Rutter, 1969; Rutter & Bartak, 1973; Cobrinik, 1974; Bartak & Rutter, 1975). In a London school for autistic children with about 40 children ranging in age from 7 to 18 years and ranging in intellectual ability from severely retarded to normal, 14 children were found to have reading ages of over 7 years. Four had reading ages of more than 12 years 6 months which is commonly recognized as an adult level of competence. This is surprising since all these children were unequivocally autistic, and cognitive and language dysfunction are part of the diagnostic criteria (Ritvo & Freeman, 1978; Rutter, 1978, 1979; Wing, 1978, 1979; Schopler *et al.*, 1980).

This observation challenges a comparison with dyslexic children. Dyslexic reading failure is often attributed to some cognitive or language dysfunction although this is still a controversial issue (Vernon, 1977, 1979). Vellutino (1979) reviewed the evidence for an underlying visual–perceptual impairment and dismissed this hypothesis in favour of an auditory–verbal impairment. Other authors have come to the same conclusion (Tallal, 1980; Bradley & Bryant, 1981; Ellis & Miles, 1981; Godfrey *et al.*, 1981). Those authors who have considered subgroups of dyslexia nearly always describe a major subgroup that is said to suffer from some auditory–verbal impairment (Naidoo, 1972; Boder, 1973; Nelson & Warrington, 1974; Mattis *et al.*, 1975). A current theory of developmental dyslexia attempts to explain this impairment by a specific phonological difficulty (Snowling, 1980; Bradley & Bryant, 1981; Frith, 1981; Done, 1982; Russell, 1982). This theory takes seriously the often reported delay in speech acquisition in children who later appear dyslexic (Ingram, 1970; Rutter *et al.*, 1970). By certain probing methods it can be revealed that there is more than a delay since there are subtle but persistent speech problems in dyslexic children (Snowling, 1981; Done, 1982). Mild articulation problems are often reported in adolescent dyslexics (Miles, 1974, 1983), and there are also problems in articulatory awareness (Montgomery, 1981).

If we can think that such subtle language problems might cause reading failure, then we should certainly expect that the serious language problems of autistic children would do so. It is strange therefore that we find a surprising amount of reading success in this group. However, this reading success is usually denigrated as a merely mechanical skill, as 'barking at print', or 'word calling'. Advanced ability to recognize and pronounce written words within the context of a developmental disorder has been termed hyperlexia (Silberberg & Silberberg, 1967; Huttenlocher & Huttenlocher, 1972; Mehegan & Dreifuss, 1972). It has further been suggested that hyperlexia should be seen as a form of dyslexia (de Hirsch, 1971; Benton & Pearl, 1978). This makes sense if at the same time there is a failure in other aspects of reading. On the other hand, Elliott & Needleman (1976) have

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pointed out that accelerated ability to recognize written words need not necessarily be accompanied by lack of comprehension, and may not always indicate a pathological condition.

Healy *et al.* (1982) and Healy (1982) have recently reviewed studies of hyperlexic children and in their own investigations of such children have confirmed the view that hyperlexia is a syndrome of developmental language disorder. Many of their hyperlexic children could be considered autistic and showed profound impairment on a variety of cognitive and linguistic tasks. These authors suggest that a general cognitive deficit is the underlying factor. However, even people with severe mental retardation, with IQs between 30 and 50, can be taught word and sentence recognition skills that are in line with comprehension, as was shown by O'Connor & Hermelin (1963). Therefore, a general cognitive deficit does not appear to be a sufficient explanation of hyperlexia. The possibility also exists that the apparent discrepancy between reading success and language failure in autistic children points to some hidden linguistic capacity. An analytic study of their reading would provide an unusual opportunity to see if they indeed possess some special linguistic skills that are not normally revealed.

The work of Hermelin & O'Connor which is summarized in their monograph (1970) has shown that autistic children suffer from a specific central processing dysfunction rather than from more peripheral input or output problems. This dysfunction was revealed by a comparison of memory for sentences and random word strings. It was also observed with visual or auditory binary sequences (Frith, 1970*a*, *b*). In these experiments, autistic children, relative to their MA matched controls, were better at remembering random sequences and worse at structured ones. The hypothesis of a failure to make use of redundancy could explain these findings as well as many of the handicaps of autistic children (Aurnhammer-Frith, 1969; Hermelin & Frith, 1971).

The notion of use of redundancy relates closely to notions of use of context in perception and especially reading (Neisser, 1967). We would therefore expect to find evidence of this peculiar cognitive dysfunction in autistic children also in their reading behaviour. In particular, we would predict that they show reading failure only when it is necessary to take meaningful context into account, that is when sentences have to be read for meaning, but not when reading single words. The 'barking at print' hypothesis, in contrast, would predict lack of access to the semantic features of single words let alone sentences. With dyslexic children we would expect difficulties only when single words have to be read for sound, because of problems in input or output phonology, but not when sentences have to be read for meaning. With autistic children who read we have no reason to expect phonological impairment. It is true that, in autism, language and speech tend to be severely delayed, even to the extent that some children never develop speech at all, and verbal behaviour is often abnormal (Waterhouse & Fein, 1982). This area has received much attention as testified by the reviews of Baltaxe & Simmons (1975), Fay & Schuler (1980) and Tager-Flusberg (1981*a*). In view of the different levels of language, each of which can show abnormalities in different developmental disorders (Cromer, 1981), it is important to note that in autism articulation and phonology have frequently been reported as normal (Goldfarb *et al.*, 1956; Bartak & Rutter, 1975; Bartolucci *et al.*, 1976; Boucher, 1976). The intactness of phonology is especially evident in the phenomenon of echolalia.

Our attention therefore was first drawn towards an investigation of single word reading in dyslexic and autistic children. Recent theories in cognitive psychology have made it possible to analyse the processes underlying single word reading (see Coltheart *et al.*, 1980; Henderson, 1982, for reviews and developments of these theories). One particularly fruitful assumption is that there are two strategies that readers use. Briefly, a lexical strategy is used for reading familiar words (look-and-say) and a phonological strategy, based on

grapheme-to-phoneme conversion, is used for unfamiliar words (phonics). Bradley & Bryant (1979) and Snowling & Frith (1981) have shown that both strategies are available even to children who are just beginning to read. On the basis of our theory of a phonological deficit in dyslexia we would predict problems only in the use of the phonological but not the lexical strategy for the dyslexics. Given that there is no evidence for a phonological deficit in autism, we would predict unimpaired performance in this group. On the other hand, if it were true that autistic children merely barked at print, then there should be no semantic effects in their single word reading. For the investigation of single word reading we used a number of tests that have proved useful in analysing strategies and processes that underly this deceptively simple skill.

Autistic and dyslexic children of the same reading age were compared with each other and with children reading at a normal level for their age. This equation of subjects on quantitative level of achievement is a method propagated by O'Connor & Hermelin and has been discussed for instance in their 1970 monograph. It has proved an essential tool in the discovery of truly qualitative differences in the achievement of handicapped children. To show that some children perform better than others on specific reading tasks can be a meaningless exercise if it is the case that the better performers also have more reading expertise and experience. This leads to the unsurprising conclusion that more experienced readers do better than less experienced ones, or, that dyslexic children are poor readers. Our matching procedure ensures that any differences in experiments would not be of such a trivial nature.

It is also worth noting here that our material for most of the experiments, be it word lists, or connected text, consisted of two parallel sets. The two sets were administered to alternate children. This was done in order to avoid artifacts due to specific words included, and to lend a greater degree of generalizability to our results.

Method

Subjects

Table 1 shows details of the three groups of subjects. Eight *autistic* children attending a special school in London were selected on the basis of their reading ability. Each subject was given several different standard reading tests and all tests showed high agreement. We chose the range of reading age to fall between 8 and 10 years using the British Ability Scales (BAS) Word Reading Test, a test of single word naming. This restriction was imposed so that a given range of tasks was appropriate for the range of ability, while avoiding ceiling and floor effects.

All children had been diagnosed by psychiatric experts on autism and showed the classic symptoms of autistic aloneness, cognitive/language deficits and obsessional phenomena. Their Full Scale WISC IQs showed a very wide range. The performance IQs of four of the children were within the normal range of intelligence. Since the performance of these four children on the reading tasks throughout the present investigation never differed appreciably from that of the other four children whose IQs would designate them mentally retarded, we did not include another control group of mentally retarded readers, although such a comparison would be of interest in future studies.

Table 1. Subject data

	n	Boys	Girls	CA range (years)	RA range (BAS)	IQ range (WISC)
Autistic	8	6	2	9–17	8:1–10·2	54–103
Normal	10	8	2	9–10	8:6–10·2	—
Dyslexic	8	5	3	10–12	8:4–10·9	100–133

Thus, we used a control group of *young normal* children to match the autistic children in terms of BAS reading age. The children came from several classes of two London schools and had been selected by their teachers to be of average ability for their age. A subsample of these children who were matched by sex and RA as closely as possible participated in the experiment.

A group of eight *dyslexic* children of the same level of reading ability as the other groups was also tested. They had all been referred by their schools to a dyslexia centre for assessment and were found to be specifically retarded in both reading and spelling relative to their expected level. Thus, they were not just poor readers, reading below their age peers, but more pertinently they were reading below their IQ peers. These children all exhibited a typical dyslexic profile in IQ tests, showed short-term memory difficulties and specific speech/language problems. All had a history of delayed speech acquisition in early childhood.

Experiment 1 (Words/non-words)

This experiment was designed to see if autistic and dyslexic readers showed differences in their use of the two reading strategies, lexical and phonological. The children were asked to read lists of real words and lists of nonsense words. While real words, especially regular ones, can be read using either strategy, it is usually assumed that a phonological strategy is necessary for non-word reading (Coltheart, 1978, 1980). Furthermore, the frequently obtained regularity effect, i.e. an advantage of reading regular over irregular words, is attributed to the use of a phonological strategy. Lists of 12 regular words (e.g. coffee, spade) all pronounceable according to frequent grapheme–phoneme rules and 12 irregular (e.g. laugh, biscuit) words, all exceptions to these rules, matched for number of letters and frequency, were presented for reading aloud; also, lists of 12 two-syllable non-words containing consonant clusters (e.g. molsmit, slosbon). These have been found to be difficult for dyslexic children (Snowling, 1981) as they draw heavily upon phonological processes. Unlike single-syllable non-words (e.g. wut, blem), these more complex ones are not readily treated by a lexical strategy, as if they were familiar words, since they have no near neighbours in the lexicon (Henderson, 1982). As already mentioned we used the method of two parallel sets. Figure 1 shows the number of words collapsed over regular and irregular lists and the number of non-words read correctly. The interaction of group and word type was significant ($F=4{\cdot}82$, d.f. $=2,23$, $P<0{\cdot}02$). There was no significant difference between the groups on reading real words which confirms and validates our matching procedure. However, the dyslexic children were significantly worse on reading non-words than either autistic or normal children ($q=5{\cdot}07$, d.f. $=2,23$, $P<0{\cdot}01$), who did not differ from each other.

Table 2 shows means and SDs for regular, irregular and nonsense words read correctly. The difference between regular and irregular words deserves some mention even though a group interaction failed to reach significance especially as it was recently replicated with a now significant result ($F=6{\cdot}5$, d.f. $=1,34$, $P<0{\cdot}02$). In this replication the dyslexic sample was increased by 18 new subjects. Of the regular words they read 9·6 and of the irregular ones 9·2 words on average. While normal and autistic children showed an expected superiority of regular words, dyslexic children did not. They read regular words no more accurately than irregular ones. This is compatible with a lexical but not with a phonological reading strategy. The same group difference was also reflected in the time scores—while normal and autistic children took less time to read regular then irregular words, dyslexic children did not show a time advantage for regular words.

Taken together, the absence of the regularity effect and the significant aggravation of the word–non-word effect in dyslexic children, in clear contrast to the other groups, suggests that they tend to use a lexical rather than phonological strategy. This finding is in line with our earlier work (Frith, 1981; Snowling, 1981) and strengthens the view that there is an underlying phonological disability in developmental dyslexia. Turning to the autistic children, this experiment clearly showed that as expected they have no problem with the phonological aspects of reading. Their use of a phonological strategy was appropriate for their reading age, and so was their use of lexical strategy. This must be assumed since they were able to pronounce correctly irregular words such as 'cough', 'move' and 'build'. They certainly could not derive the correct pronunciation of such words using a purely phonological strategy.

It seems plausible that the meaning of the word becomes directly available once it is recognized. However, we cannot assume that autistic children access semantic representation as do normal children. Indeed, we have grounds to believe that they show semantic impairment (Hermelin & O'Connor, 1967; Ricks & Wing, 1976; Tager-Flusberg, 1981*b*), although it remains to be seen whether this applies even to single words. For instance, on vocabulary tests, which are a quite

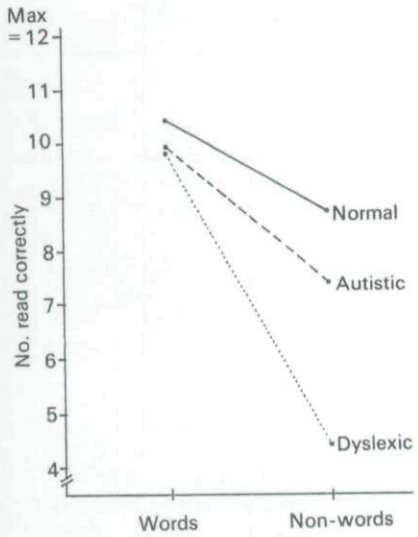

Figure 1. Experiment 1: Words and non-words read correctly.

Table 2. Single word lists

	Regular words		Irregular words		Non-words	
	Mean	SD	Mean	SD	Mean	SD
Accuracy (max = 12)						
Autistic	11·3	*0·7*	8·6	*1·7*	7·4	*2·8*
Normal	11·4	*0·8*	9·3	*1·8*	8·7	*2·0*
Dyslexic	10·0	*2·0*	9·6	*2·7*	4·4	*3·0*
Time taken (s)						
Autistic	13·3	*6·0*	16·1	*6·0*	39·4	*22·1*
Normal	10·6	*4·0*	15·8	*6·2*	42·3	*18·6*
Dyslexic	16·3	*12·2*	15·9	*11·8*	51·6	*27·2*

stringent test of single word comprehension, autistic children are not always poorer than controls (Wurst, 1976; Tymchuk *et al.*, 1977; Waterhouse & Fein, 1982; but see also Bartak *et al.*, 1975). Oral reading can give evidence that is relevant to this question. Thus, normal readers as well as dyslexics are usually subject to a word class effect, such that they find concrete or highly imageable words such as 'ambulance', 'gift', easier to read than abstract ones, such as 'idea', 'peace' (Richardson, 1975; Jorm, 1977; Baddeley *et al.*, 1982). This possibility was investigated in Expt 2. If it were true that autistic children 'bark at print' then they should not differentiate between concrete and abstract words, while normal and dyslexic readers should be sensitive to this distinction.

Experiment 2 (Abstract/concrete words)

Parallel lists of 12 concrete and 12 abstract words were compiled from lists matched for word frequency and word length made available by Linda Pring. Again, the children were asked to read the words aloud and errors as well as the time to read each list were recorded. The results are shown in Table 3. The three groups had almost identical performance and all showed the expected effect of concrete words being easier to read ($F = 25{\cdot}8$, d.f. $= 1,22$, $P < 0{\cdot}001$). The time scores showed the same picture. There were no significant group differences. This result would suggest that autistic children differentiate abstract and concrete words as classes of semantic representation just as normal and dyslexic children do. This of course does not tell us if they actually access the meaning of individual words. This immediate access to the meaning of particular words makes normal readers subject to Stroop interference (Stroop, 1935; Martin, 1978; Naish, 1980). If autistic children did not show Stroop interference, or a reduced effect, then one might argue that they lack immediate access to the meaning of individual colour words. Experiment 3 explored this possibility in a preliminary way.

Experiment 3 (Stroop interference)

For the interference condition, six 'lists' of six colour names (two red, two blue, two green) in random order were prepared. Each colour name was written in ink of a conflicting colour, e.g. RED was printed in blue ink, and placed in a circle of the same colour. For the control condition, six similar 'lists' were prepared where the letters making up the words were replaced by Xs (e.g. XXX for RED). For a complete investigation of the Stroop phenomenon it is necessary to include other conditions and this is currently in progress.

Table 3. Concrete and abstract word lists

	Concrete		Abstract	
	Mean	SD	Mean	SD
Accuracy (max = 12)				
Autistic	11·9	*0·4*	10·0	*1·6*
Normal	11·8	*0·4*	10·8	*1·1*
Dyslexic	11·3	*1·4*	9·8	*1·8*
Time taken (s)				
Autistic	9·4	*4·1*	16·8	*7·7*
Normal	7·8	*1·8*	12·7	*6·4*
Dyslexic	11·9	*11·8*	17·1	*12·0*

Each subject was instructed to name aloud the colour of the circles on each list as quickly as possible. They were told to ignore the words inside the circle and were given practice to ensure that they understood the task demands. There was also a check that they were able to name all of the colours correctly.

The times taken to name the colours in both conditions are shown in Table 4. There was a significant effect of conditions ($F = 51·4$, d.f. = 1,21, $P < 0·001$) but not of groups ($F = 2·2$, d.f. = 2,21, $P < 0·14$). Clearly, there was no interaction. All three groups showed the classic Stroop effect to the same degree. When word meaning was incongruent with the ink colour, performance was slowed down. It is not possible at this stage to be sure whether this degree of interference was produced in the autistic group by the same mechanism as in the normal control group or in the dyslexic group. We tentatively conclude that autistic children can access the meaning of individual printed words and may do this as automatically as would be predicted from their reading age.

Table 4. Stroop effect: Time taken (s) to name six colours

		XXX condition		Colour word interference	
	n	Mean	SD	Mean	SD
Autistic	8	6·2	*2·9*	8·9	*4·2*
Normal	10	4·3	*1·6*	7·1	*3·2*
Dyslexic	6	3·6	*0·8*	6·1	*1·9*

Preliminary discussion

All three experiments attest to the normality of autistic children's strategies in single-word reading. They are able to use both a phonological and a lexical strategy efficiently. Furthermore, their access to lexical semantics appears normal in terms of speed and implied differentiation of concrete/abstract word classes, as well as the presence of Stroop interference.

This evidence suffices to dismiss the view that autistic children merely 'bark at print'. Moreover, it leads us to take seriously the notion that autistic children show sophisticated mastery on several linguistic levels. This is intriguing since at the same time these children are known to have difficulty in understanding 'meaning'. It seems that, unlike in dyslexic children, the foundations of literacy are intact, i.e. efficient decoding skills are available. However, as indicated earlier we would expect a deficit in the comprehension of sentences. This is certainly the case in spoken language (Tager-Flusberg, 1981*b*). Especially relevant

here is a finding by Prior & Hall (1979). In their experiment autistic subjects were retarded in their comprehension of phrases, but not in their comprehension of single words. In the same way, although we find that reading of lists of single unconnected words is efficient, some reading failure might be expected at a level where words are connected.

Some suggestion that this might be the case comes from disparity between comprehension and accuracy scores of the Neale Analysis of Reading Ability. This is shown in Table 5. The performance of the autistic children in terms of comprehension of the stories they read was worse than their performance in terms of accuracy of reading aloud individual words. The opposite was found to be the case for dyslexic children. Amongst autistic children, six out of eight had lower comprehension than accuracy scores, while no dyslexic child showed this pattern. In the Neale test, comprehension is assessed by asking the child questions on the content of the story that he has just read. Hence, failure could be due to many factors, not all of them germane to reading, such as understanding the questions, or holding the story in memory. The same problems were encountered by Lockyer & Rutter (1969), and Rutter & Bartak (1973) who also found that Neale accuracy scores were higher than comprehension scores. The following experiments on prose comprehension were designed with these problems in mind. Thus we aimed at assessing comprehension concurrently with oral reading, not afterwards, in as unobtrusive a way as possible.

Table 5. Reading accuracy and comprehension on the Neale Analysis of Reading

	Neale accuracy		Neale comprehension	
	Mean	SD	Mean	SD
Autistic	9:3	*0:5*	8:9	*0:11*
Dyslexic	9:5	*1:1*	10:11	*1:6*

The first question we wanted to ask was whether reading comprehension could be deficient in autistic children because of syntactic processing demands. Clearly, experiments showing poor performance with meaningful sentences relative to single words confound meaning and syntax (Schwartz, 1981). With certain oral reading tests, however, a means of separating these two factors is provided. This we pursued in the following studies.

Experiment 4 (Final 'S')

In English, certain syntactic distinctions are marked phonologically. For example, final 'S' preceded by a vowel is pronounced in unvoiced form /s/, when the noun is singular (thesis, bus) but in voiced form /z/ when the noun is plural (theses, buses). Therefore the pronunciation of nonsense words with final 'S' presented in context so as to make them singular or plural can reveal the ability to make this particular syntactic distinction. A similar principle has been utilized with adult readers by Campbell & Besner (1981).

In the present experiment the autistic children were asked to read sentences containing a nonsense word ending in a vowel + final 'S'. These were provided by Ruth Campbell. In half of the cases the nonsense word was marked as singular, e.g. 'One yellow bippis is enough for me', 'I like to fly in a gakis', in half the cases the nonsense word was marked as plural, e.g. 'All these bippis are fresh today', 'Twenty gakis lived in a box'.

The children's pronunciation was recorded and transcribed. The probability of pronouncing final 'S' in unvoiced form, /s/, was calculated when the non-word was singular (0·91) and when it was

plural (0·34). This was compared with data collected by Campbell on 19 normal children aged 8–10 years (which is the range of RA of the present subjects). The probability of pronouncing unvoiced /s/, for singular was (0·92) and for plural (0·31). Thus there was remarkable similarity between both groups. For both groups the difference between the singular and plural pronunciation is highly significant ($F=30·94$, d.f. $=1,27$, $P<0·001$). This experiment shows that autistic children can be sensitive to syntactic constraints. They are clearly able to use phonology to mark the distinction between singular and plural forms. Thus, the present result points to another hidden linguistic asset in autistic children. This finding is consistent with the view that phonological and syntactic development are not deviant, but merely delayed (Pierce & Bartolucci, 1977; Tager-Flusberg, 1981*a*; Waterhouse & Fein, 1982).

Experiment 5 (Homographs)

A more complex task which taxes both semantic and syntactic competence is the pronunciation of homographs in context. For example, 'He had a pink BOW' and 'He made a deep BOW'. This provides a very unobtrusive test of sentence comprehension. Five homographs (READ, ROW, BOW, MINUTE, LEAD) were used in 10 sentences comprising a short story (I like to read. Once I read a story about a boy and his dog. Etc.). Children read this story aloud and their pronunciation was transcribed.

Figure 2 shows the number of homographs read correctly. The three groups differed significantly from each other ($F=9·37$, d.f. $=2,23$, $P<0·001$) such that autistic children were worse than normal children and normal children were worse than dyslexic ones. This result supports the data from the Neale Comprehension Test where autistic children showed a significant failure over children with the same level of word recognition ability, including dyslexic children. The pattern of errors indicates a failure of the autistic children to use semantic/syntactic context in pronouncing the homographs. In fact, they all performed correctly on the READ pair, but with the other pairs they always chose the more frequent pronunciation regardless of context. Thus, if one considered accuracy in terms of single-word reading they were correct. In terms of connected prose, however, accuracy was poor. We also observed that during reading they never showed any signs of being aware of errors. These signs, hesitation, substitution of a similar word, for instance, miniature for MINUTE (=small), or starting the sentence again, were very common in normal and dyslexic readers when they made errors. The few pronunciation errors of the dyslexic children were almost entirely accounted for by the most difficult homograph, namely MINUTE (=small). In all these cases there were corrections. Their performance was superior even compared to normal children, who were of course some two to three years younger and might therefore have a somewhat less extensive vocabulary. Thus, despite their severe difficulties with decoding single words, dyslexic children are able to use the syntactic/semantic information provided by context. This could be the way they manage to compensate to some extent for their specific decoding problem.

The failure of the autistic children in this task is unlikely to be due to lack of direct access to a lexical entry. Our previous experiments have shown the proficiency that one would have expected

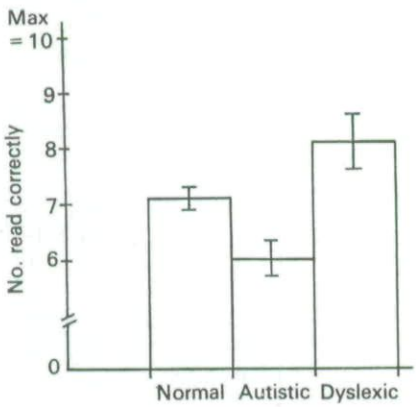

Figure 2. Experiment 5: Homographs in context read correctly.

from their level of reading skill. It must be concluded that they were unable to utilize the syntactic/semantic cues provided to disambiguate the pronunciation of the homographs.

To see if this interpretation is correct—homographs could be a special case—children were asked to read short passages containing gaps where they were required to insert plausible words.

Experiment 6 (Gap test)

The first five passages of the parallel forms of the Gap test (McLeod, 1970) of reading comprehension were given to the three groups to read silently and to write in the missing words. For example: 'There was a chest of . . . and a cupboard to put things . . .' (spaces do not give clues to the length of the word). Spelling errors were ignored and the children were encouraged to guess when in doubt. No time limit was imposed.

The completions made by the subjects were scored as correct or incorrect. Furthermore, errors were analysed as to whether or not they belonged to the same syntactic class as the target word, e.g. for the sentence 'it seems to . . . disappeared', the response 'have' was correct, 'be' was an error but one that preserved the correct syntactic class; 'a' was an error of the incorrect syntactic class.

The results are shown in Table 6. While the autistic children made a significantly greater number of errors than controls in this task ($t=4{\cdot}82$, d.f.$=23$, $P<0{\cdot}001$) the errors which they made were within the correct syntactic class approximately twice as often as they were within the incorrect syntactic class. This was also true for normal and dyslexic readers. The effect occurred in every child except one who was in fact a normal reader. It therefore can be assumed that autistic children were sensitive to the syntactic constraints of the sentences. This syntactic competence is consistent with the result of Expt 4 (Final S). Thus the failure to pronounce homographs correctly is more probably due to an inability to utilize semantic rather than syntactic information in reading. This possibility was further explored by Expt 7.

Table 6. Gap test errors

	n	RA range	Syntactic class of error			
			Same class		Different class	
			Mean	SD	Mean	SD
Autistic	8	8:1–12:10	7·0	*2·2*	3·5	*2·3*
Normal	12	8:0–12:0	2·6	*1·9*	1·5	*1·0*
Dyslexic	5	8:8–11:5	3·2	*1·8*	1·6	*1·1*

Experiment 7 (Restricted choice)

Here subjects were required to read a short story in which, at intervals, a choice of one out of three words had to be made. These words all came from the same syntactic class but only one of the words was semantically appropriate. Thus no clue to the correct choice could be gained from purely syntactic considerations. Thus, if autistic children have difficulty in utilizing semantic in the absence of syntactic information, then they should find the task of selecting the most appropriate word very hard. Four prose passages of 150 words each at a reading age level of about seven years, all well within the capability of all the children, were to be read aloud.

The four passages made up a story and two of them (using the method of parallel versions) contained three 'gaps' where either a preposition, a verb, or a noun were missing. In this gap were printed on top of each other three words, all of the appropriate word class. The children were instructed to read aloud only one of these, after having considered which was the most appropriate. A practice sentence was used to explain this. For example:

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

Figure 3 shows the number of correct choices. The normal and dyslexic groups performed at ceiling—as expected, given their reading age and the text difficulty. A significant group difference ($F=13{\cdot}27$, d.f. $=2,23$, $P<0{\cdot}001$) was attributable to the poor performance of the autistic children. This poor performance was not due to lack of task understanding, since the autistic children performed above chance (this would be 2). Also, the autistic children's effort in solving the problem was further proved by the time it took them to complete the passages containing gaps. For all subjects, passages containing gaps were read more slowly than passages without gaps ($F=34{\cdot}00$, d.f. $=1,23$, $P<0{\cdot}001$) as shown in Table 7. The average time difference was 16 s. Although the groups did not differ significantly in the time taken overall, the relative increment in time to read the passages containing gaps with word choices was greater for the autistic children. For seven out of eight of these subjects the increment was greater than the average 16 s. This was true for only four out of 10 normal and three out of eight dyslexic subjects. The contrast between the autistic and the other two groups was significant ($z=2{\cdot}25$, $P=0{\cdot}01$; Meddis, 1980). Both error and time data therefore suggest that autistic children found this task more difficult than would be expected from their RA.

This experiment is therefore the clearest indicator of a specific inability of the autistic children with reading comprehension. This inability is at a stage beyond lexical access. This second stage is concerned with access of meaning from sentences.

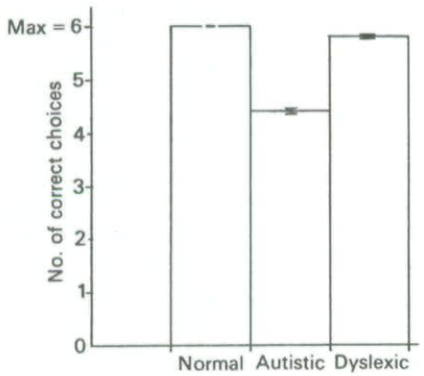

Figure 3. Experiment 7: Words in gaps chosen correctly.

Table 7. Gaps with restricted choices: Time taken to read 60-word passage (s)

	Base-line (no gaps)		Passage containing 3 gaps with choices	
	Mean	SD	Mean	SD
Autistic	41·0	*11·9*	65·1	*29·1*
Normal	34·3	*10·1*	47·3	*14·2*
Dyslexic	33·1	*11·1*	46·0	*16·0*

General discussion

Our results lead us to refute the widely held belief that the reading of autistic children is merely 'barking at print'. Instead, their performance on various reading tasks revealed considerable and surprising linguistic competence. Their ability to read aloud nonsense words and to mark singular and plural 'S' phonologically was found to be RA appropriate, as was their sensitivity to syntactic cues of sentences. While these particular phonological and syntactic aspects of performance were intact, this was also true of some semantic aspects. For instance, the autistic children were subject to the normal abstract/concrete word class effect and to the Stroop effect. These findings rule out the simple hypothesis that autistic children are unable to associate speech sounds with meaning as was suggested by Huttenlocher & Huttenlocher (1973) in their study of hyperlexic reading.

The comparison with dyslexic readers shows plainly that the various reading skills of the autistic children should not be discounted as 'mechanical' and by implication worthless. The dyslexic readers despite being intellectually and verbally more advanced than the autistic children exhibited some glaring problems in single-word reading tasks not shown

by autistic readers. These problems were entirely as predicted from the phonological deficit theory of dyslexia, namely a specific difficulty in reading nonsense words and an absence of the normal superiority of regular over irregular words. Both these findings can be explained by a subtle phonological impairment. It is noteworthy that at none of the other reading tasks employed did the dyslexic children show an impairment. On the contrary, when comprehension of sentences was required they even performed at a level superior to their RA controls. This is evidence for an occasionally voiced but hitherto speculative notion that dyslexic children have *intact* comprehension despite word decoding problems and, furthermore, can use this ability to compensate to some extent for the decoding problems.

As perceptively pointed out by Hinshelwood (1917) in one of the first studies on developmental reading failure, it is helpful to distinguish letter blindness, word blindness, and sentence blindness. If word blindness is descriptive of our dyslexic children, then sentence blindness might well be descriptive of our hyperlexic autistic children. In this sense one could indeed consider hyperlexia as a form of dyslexia. Dyslexics have a decoding problem that is not present in autistic children of the same level of word recognition competence. Autistic children have a comprehension problem that is not present in dyslexic children. Thus, we see two complementary deficits in reading for sound on the one hand and reading for meaning on the other. A very similar finding was obtained by Bartak & Rutter (1975) and Bartak *et al.* (1975) in their comparison of able autistic and aphasic children. Frith (1975) pointed out that in this study the reading tests gave the clearest separation of two hypothesized complementary deficits in the two groups as reflected in a large number of language and communication tests.

Although we are prepared to be quite precise about the particular deficit in reading for sound in dyslexic children, we are as yet unable to be very precise about the deficit in reading for meaning in autistic children. 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. It certainly cannot be due to a syntactic failure.

Further investigation might show why autistic children fail to utilize contextual semantic cues when reading. The tendency to ignore context (to be field independent) has been noted in other cognitive tasks (Shah & Frith, 1983). It is therefore conceivable that this is a general characteristic of their behaviour evident in this particular form in reading. The failure in reading for meaning could be seen as related to their failure in making use of redundancy (Hermelin & O'Connor, 1970; Hermelin & Frith, 1971) as discussed earlier.

Nevertheless, the present results point to very specific rather than general effects of this hypothesized dysfunction. For instance, there seems to be no problem in making use of context for processing syntax. We could speculate that this is because purely linguistic ability is intact and problems arise only at the level where extralinguistic factors are concerned. In particular, it may be difficult for autistic children to integrate semantic information derived from single words with their knowledge of the world, derived from previous experience. They need to do this if they are to make sense of written material. The same applies of course to spoken material. Tager-Flusberg (1981*b*) was able to demonstrate convincingly that the comprehension of spoken sentences was deficient in a very specific way. She concluded that it was *use* of semantic knowledge, not semantic knowledge itself, that was underlying the comprehension failure. No clear distinction can however be made as yet, between a semantic and a cognitive system failure.

The present evidence strengthens the view that it is inaccurate to think of either autism or dyslexia as global and primary language disorders. The dyslexic children were seen to be subject to a very specific decoding disability, when reading for sound. This is

presumably rooted in a subtle phonological but not syntactic or semantic impairment. Similarly, reading for meaning was only selectively impaired in the autistic children while there was no evidence for any problems in reading for sound.

It would be interesting to explore the interaction between cognitive and semantic processing in autistic children and reading age as well as mental age matched controls. At present, we can only guess that their particular problem in comprehension lies not within the 'inner lexicon', but within the 'inner encyclopaedia'.

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