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Comprehension in "Hyperlexic" Readers

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Mentally retarded children who can read aloud written words better than one would expect from their Mental Age are often called hyperlexic. The reading comprehension thought to be impaired in such children was investigated in four experiments. Mentally retarded advanced decoders, including autistic and nonautistic children, were compared with younger nonretarded children matched for Mental Age and Reading Age. Experiment 1 established that mildly mentally retarded readers could match sentences to pictures as well as could be expected from their verbal ability. This was the same whether they read the sentences or heard them. Experiment 2 demonstrated that only the more able retarded subjects, but not the less able ones, used sentence context in a normal way in order to pronounce homographs. Experiments 3 and 4 showed that these same more able children could extract meaning at both sentence and story level, and their performance was indistinguishable from that of normal controls. Hence, it is doubtful whether these advanced decoders should be called hyperlexic. In contrast, the readers of relatively low verbal ability performed much worse than their normal controls. Although they could be induced under certain conditions to read sentence-by-sentence rather than word-by-word, they did not do so spontaneously. Furthermore, they did not make use of already existing general knowledge in order to answer questions about the stories they had read. The ability to comprehend in terms of large units of meaning seems to be specifically impaired in these low verbal ability fluent readers. We suggest that it is this impairment that marks true hyperlexia. Since there were no differences between autistic and nonautistic

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readers on any of our tasks, we conclude that hyperlexia is not an autism-specific phenomenon.

If a mentally retarded child can read aloud fluently, this comes as a surprise, as most mentally retarded children never learn to read at all. It is even more astonishing if one compares such unexpected reading fluency with the marked dysfluency of otherwise bright dyslexic children. In the light of the contrast to the dyslexic child, with poor decoding skills, the mentally retarded child, with good decoding skills, is likely to be called "hyperlexic." While definition and terminology are still confused, the phenomenon of fluent word decoding in retarded children has now been well documented. But are such exceptional children "just" word callers, or do they decode words in the same way as bright normal readers?

From the studies of Mehegan and Dreyfuss (1972), Cobrinik (1974, 1982), Huttenlocher and Huttenlocher (1973), Elliot and Needleman (1976), Richman and Kitchell (1981), Healy (1982), Healy, Aram, Horowitz and Kessler (1982), Goldberg and Rothermel (1984), Siegel (1984), and Whitehouse and Harris (1984), there is evidence that the processing of printed words in hyperlexic readers is just like that in normal readers, and very different from that of dyslexic readers. We found (Frith & Snowling, 1983) that *hyperlexic*, in contrast to *dyslexic* children, were able to recognize words using visual/orthographic and phonological strategies equally well, and were able to decode nonwords proficiently. Also, they were susceptible to the usual effects of word frequency and word imageability, that is, more frequent words are read more quickly, and so are more imageable words. The normality of decoding processes in these "hyperlexics" was attested also by the results of an e-cancellation task that we carried out subsequently. Just like normal readers they missed a high proportion of E's in the word THE (ranging from 26 to 50%), but missed very few E's in other words (less than 10%). This effect, which is well established for normal skilled readers, is due to the word THE being treated as a single unit (Healy, 1976). From all this evidence we have to conclude that the typical "hyperlexic" reader is certainly not just barking at print.

Beyond the single word level, however, "hyperlexics" seem to show considerable problems. While Huttenlocher and Huttenlocher's (1973) three cases could respond to simple written commands, and the Healy et al. (1982) subjects could comprehend short literal sentences, comprehension of larger units of text was very poor. Similarly, Goldberg and Rothermel (1984) have reported severe difficulties with the comprehension of paragraphs. Few investigators, however, have systematically studied the nature of the comprehension deficit thought to be associated with hyperlexia. A more serious criticism is that studies have seldom reported normative data or included appropriate control groups for comparison.

Hence, a confusing picture of efficient decoding but deficient comprehension skill, against a background of impaired language ability, has emerged (Graziani, Brodsky, Mason, & Zager, 1983). For this reason a satisfactory definition of hyperlexia does not as yet exist. To date, it is not clear what is meant by poor comprehension of written materials in these readers, and whether poor comprehension is a specific deficit or simply part and parcel of poor linguistic or intellectual abilities.

In a previous study we examined the comprehension failure of eight "hyperlexic" readers, who besides being mentally retarded were also autistic (Frith & Snowling, 1983). We compared their performance with that of nonretarded clinically normal school children of the same Reading Age as assessed in terms of word decoding skill. As a group, our autistic subjects had difficulty with the comprehension of sentences and longer text. First, they found it difficult to disambiguate the pronunciations of homographs (e.g., *row*, *lead*) which were presented in sentence contexts (e.g., the boy had to *row* across the river). They mispronounced the homographs more often than the control subjects and, moreover, seemed unperturbed by their own mispronunciations. The "hyperlexic" autistic readers also had more difficulty than Reading Age matched normal readers when they were asked to select one of three words of the same syntactic class in order to complete sentences within a short story (e.g., "Tom could SWIM/HEAR/HEAT something nearby. Perhaps it was a water rat?"). Although the "hyperlexic" autistic children as a group scored above chance, they had significantly more difficulty than would have been predicted from their Reading Age. It is still open to question whether this difficulty was more than would have been predicted from their Mental Age.

The main aim of the present paper was to replicate and extend these studies and to establish the specificity of the phenomenon. As noted by Whitehouse and Harris (1984) all studies of "hyperlexic" children in the literature include cases of children who have also been diagnosed as autistic. It is therefore important to ascertain whether any of the reported aspects of "hyperlexic" reading are features of the concomitant autism. In many cognitive tasks, autistic children perform as though unaware of the structure and meaning inherent both in linguistic and perceptual stimulus arrays (Hermelin & O'Connor, 1970; Frith, 1970; Shah & Frith, 1983). It is possible then that "hyperlexic" reading behavior is a special example of their failure to take account of context during cognitive processing. In order to address this question, in all the following experiments, we compared and contrasted autistic with mentally retarded children, who were of similar chronological age, Mental Age, and Reading Age, but had none of the profound communication failure typical of autism.

EXPERIMENT 1: SENTENCE AND PICTURE

The studies of Healy et. al. (1982), Frith and Snowling (1983), and Goldberg and Rothermel (1984) rule out difficulties at the single word level as a primary source of comprehension failure in "hyperlexic" readers. We therefore focused on comprehension in terms of larger units of meaning. Our earlier studies also suggested that comprehension failure could not be attributed to specific syntactic deficits. However, a more direct test of this hypothesis was desirable. An ideal tool for these purposes was Bishop's (1982b) Test for the Reception of Grammar, a multiple choice sentence picture matching test designed to assess the understanding of a wide range of grammatical contrasts. Finally, the possibility that only reading, but not listening, comprehension is specifically impaired needed examining. Therefore, understanding of grammatical constructs through visual (print) and auditory (speech) modalities was tested.

Method

Subjects. Eight autistic children diagnosed according to established criteria (Rutter, 1978), and attending a special school were chosen to participate in this experiment. They were selected on the basis of their Reading Ages which ranged between 8 and 10 years on the word recognition test of the British Ability Scales (mean Reading Age = 9 years 5 months, *SD* = 9 months). They were aged between 11 and 19 years (mean C.A. = 15 years 3 months, *SD* = 25 months), and their I.Q.s, as measured by the Performance Scale of the WISC-R, with a mean of 78 (*SD* = 16), identified them as a relatively able group.

Eight children attending a school for mildly educationally retarded children, not exhibiting any autistic features, were chosen as controls, and were matched with the autistic children in terms of Reading Age, and as closely as possible for I.Q. They were aged between 9 and 16 years, and had a British Ability Scales Reading Age of between 7 and 14 years (mean = 9 years 6 months, *SD* = 25 months). Performance I.Q.s showed a mean of 75 (*SD* = 11).

Procedure. Each subject was administered two parallel versions of Bishop's (1982b) Test for the Reception of Grammar. Sentences were presented in order of increasing difficulty, including negatives, comparative adjectives, pronouns (masculine and feminine, agent and object), plurals, reversible actives, and passives. For each item, subjects were required to select one of four pictures to match the test sentence which was presented in either spoken or written form. For example, for the test sentence "He is sitting in the tree," one distractor would depict "She is sitting in the tree," another, "He is sitting on the wall," and the third "He is swinging in the tree." For the most difficult items all distractors depict subtle grammatical contrasts and represent a situation in which the same content words as in the test sentence are used, in a different order, or with different function words.

The session began with a vocabulary pretest designed to ensure that each child was familiar with the individual words used in the test. All of the children passed to pretest without difficulty. They were then told that they were going to read (hear) some sentences and to see some pictures. Each time, they had to point to the picture that "went with" the sentence. The 80 test items then followed, two written items being alternated with two spoken items throughout. After 40 items there was a short break before continuing.

Results and Discussion

The mean number of correct responses made was almost the same to the written (24 out of 40) as to the spoken sentences (23 out of 40). Moreover, autistic and nonautistic retarded subjects performed as well as each other (23.3 vs. 22.9), $F(1, 14) = 0.237$. They passed between 4 and 12 blocks on Bishop's test representing an understanding of grammatical contrasts at a level of between 4 and $5\frac{3}{4}$ years, and both groups made similar errors over the test. Furthermore, our subjects' errors were typical of those made by young normal children. Therefore, we can assume for the group as as whole that they exhibit general language delay, rather than any specific deviance.

The comparable performance of our mildly retarded autistic and nonautistic children suggests that the two groups were equally competent in their ability to understand sentences of a wide range of grammatical contrasts. This ability was in no way impaired when the sentences had to be read rather than listened to. Thus we conclude that our subjects could process meaning no worse by eye than by ear—a conclusion similar to that drawn by Huttenlocher and Huttenlocher (1973) and Silberberg and Silberberg (1967). It must be stressed, however, that there was a considerable discrepancy between the subjects' ability to understand (5-year level, on average) and their ability to decode printed words to sound (9-year level, on average).

The language delay relative to both chronological and Reading Age revealed on this test might at least partially explain any comprehension impairment in reading. Indeed, the results raise the possibility that comprehension will simply be as good as verbal ability allows it to be. The question now arises whether this is the sole limiting factor, or whether there are additional problems which might reduce reading comprehension for these children. One area where such an additional problem is likely to be found, as suggested from our previous results, is use of sentence context in understanding ambiguous words.

EXPERIMENT 2: SENTENCE AND AMBIGUOUS WORD

In our previous studies we found that autistic readers were less inclined than normal and dyslexic readers to modify their pronunciations of homographs to fit in with the context of sentences they were reading. Characteristically, the autistic readers would respond with the most frequent pronunciation for a homograph, without regard to the integrity of the sentence. The present experiment attempted to replicate this finding, using an improved set of experimental materials, and comparing autistic and nonautistic children of varying levels of verbal ability as well as younger normal controls of similar Mental Age and Reading Age.

Method

Subjects. 20 subjects of relatively high verbal ability were compared with 20 subjects of low verbal ability, some of which had participated in Experiment 1. Verbal ability was assessed by the British Picture Vocabulary Scales and all "high ability" scores were above a Mental Age of 7:10. None of the "low ability" scores was lower than 4:7. Among children of high ability there were 5 autistic, 4 nonautistic mildly retarded, and 11 young clinically normal school children. Among low ability subjects, there were 11 autistic, 5 nonautistic mildly retarded, and 4 young children from a normal primary school. All subjects were of comparable Reading Age. Subject details are given in Table 1. The autistic subjects came from two National Autistic Society schools and the nonautistic retarded subjects came from a special school for the moderately educationally retarded. The normal subjects came from an Inner City school with a high proportion of socially disadvantaged children. These subjects participated in all the remaining experiments.

TABLE 1
SUBJECT DETAILS

Group	*n*		Chronological age (years:months)	Reading age[a] (years:months)	Verbal Mental age[b] (years:months)
High ability					
Normal	11	Mean	10:06	9:06	10:04
		Range	8:00–10:06	8:00–9:06	7:10–17:06
Autistic	5	Mean	18:03	11:02	10:00
		Range	15:00–21:00	8:11–14:05	7:10–12:05
Non-autistic retarded	4	Mean	14:07	9:07	9:00
		Range	12:10–16:00	8:06–13:09	8:05–10:03
Low ability					
Normal	4	Mean	9:07	8:03	6:07
		Range	8:09–10:02	8:00–8:04	4:07–7:08
Autistic	11	Mean	16:05	9:06	6:06
		Range	12:01–21:07	8:11–10:10	5:00–7:00
Non-autistic retarded	5	Mean	15:01	8:03	5:02
		Range	13:00–16:01	7:00–9:07	4:07–6:05

[a] Based on British Ability Scales word recognition subtest.
[b] Based on British Picture Vocabulary Scales.

Procedure. An experimental pretest consisted of a list of words, embedded in which were the homographs *read, tear, row, bow, lead.* These words were presented for reading aloud in order to check whether the Ss' pronunciations of the homographs corresponded to their more frequent pronunciation in English. This was confirmed in almost all cases.

Four sentences were compiled for each homograph, two in which the homograph was to be pronounced in its *more frequent* way, two in which its *less frequent* usage was primed. For each pronunciation, the homograph was presented, once toward the *beginning* of the sentence, before the disambiguating context, and once toward the *end*, after the disambiguating context. Thus, there were 20 sentences altogether (see Appendix 1). These were presented twice, on separate days, for reading aloud on 20 cards with order of presentation randomized. On the second occasion there was a pretraining session during which the subjects were told that each word had two possible meanings and pronunciations. In most cases, the children gave clear evidence of knowing the two different meanings. In cases where there was any doubt, the alternative meanings were "taught" with the aid of synonyms and embedding contexts. For example, LEAD was described as a heavy metal, the inside of a pencil, etc. The alternative pronunciation was defined as a dog's *lead*, to be first, to take the *lead* part in a play, and so forth. The need for this further explanation and demonstration did not differentiate children in autistic or nonautistic groups. All sessions were tape recorded.

Results

The scores used were the number of correct pronunciations in each condition over all the homographs. There were significant effects on correct pronunciation of *verbal ability*, $F(1, 32) = 8.49$, $p < .001$; *session*, $F(4, 32) = 35.13$, $p < .001$; *word frequency*, $F(1, 32) = 58.49$, $p < .001$; and *position in sentence*, $F(1, 32) = 21.67$, $p < .001$. As expected, all subjects improved from the first to the second session, and there was a *session* × *frequency* interaction, $F(1, 32) = 10.08$, $p < .01$. That is, the less frequent pronunciations were more likely to be used correctly in the second session. There was an important interaction of *frequency* × *ability* × *group*, $F(2, 32) = 8.58$, $p < .001$, as shown in Fig. 1. The three high verbal ability groups performed identically, $F(2, 17) = 0.11$, n.s. All were subject to a frequency effect, $F(1, 17) = 9.02$, $p < .01$. Among low ability groups, the retarded and the autistic children showed a strong frequency effect which was absent for the normal subjects, $F(2, 15) = 27.23$, $p < .001$. Overall, the performance of the low ability normal and handicapped groups did not differ, $F(2, 15) = 1.32$.

Discussion

To some extent these results replicate our previous findings, from which we concluded that "hyperlexic" autistic children make little use

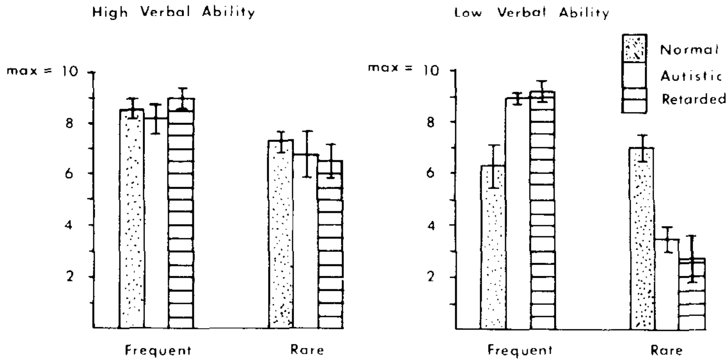

FIG. 1. Number of correct homograph pronunciations according to frequency.

of context to disambiguate homographs. However, the present results indicate that this is not an autism-specific phenomenon. Moreover, the results establish that not all "hyperlexic" readers are particularly impaired when reading homographs relative to young normal readers. Thus, the handicapped children whose Mental Age was above 7 years *were* able to disambiguate meanings by using sentence context. They performed as well as their normal controls. The results from the children whose verbal Mental Age was between 5 and 7 years showed a different picture. These handicapped children responded with the most frequent pronunciation, most of the time, resulting, by accident, in high performance in the frequent condition. Interestingly, the young normal readers did not show a frequency effect. This could have been due to greater awareness of the two possible pronunciations, or due to uncertainty of the alternative meanings for each homograph. Thus, they often gave the rare pronunciation when the more frequent one would have been correct. In terms of accuracy, their performance was worse than that of the high ability groups, and similar to that of the low ability handicapped groups. In terms of errors, their performance, however, was very different from the latter. These low ability retarded children read the ambiguous words in the sentence in the same way as they read them in the list. This suggests that they might always adopt a word-by-word reading strategy, rather than integrating words into larger units of meaning.

EXPERIMENT 3: SENTENCE AND STORY

In order to investigate this question further, we compared comprehension of units of text differing in size. For this we used a reading task with a modified cloze procedure similar to one we had used previously: at intervals throughout a lengthy text subjects had to choose one out of three given words to complete a "gap." The three words were always of the same grammatical class (noun, verb, adjective, or preposition) but their *appropriateness* was manipulated systematically. As far possible, each time, one alternative was STORY APPROPRIATE (in both the sentence and the story context), one alternative was SENTENCE APPROPRIATE (it fitted ONLY the narrow context of the sentence, but was not appropriate given the story context). The third choice was INAPPROPRIATE in both ways: it fitted neither the sentence nor the story context. For instance: "Their *mother/friends/room* led the young beavers to the pond." The choice between the first two words depends entirely on the story, in this case *mother* happened to be correct, i.e., STORY APPROPRIATE, while *friends* would only have been SENTENCE APPROPRIATE. The word *room* is incorrect in both sentence and story context. A significant preference for STORY-APPROPRIATE items would indicate efficient text processing, over and above sentence level. If INAPPROPRIATE items were not systematically rejected, then this would suggest poor comprehension of even small units of meaning within sentences.

With an *on-line* comprehension task of this type, the reader's attention is continuously focused on the exact selection of words and is given explicit alternatives. This is equivalent to imposing a "monitor," and hence may well simulate a metalinguistic process. If so, this could artifically enhance text processing. Therefore, a second, slightly different reading task was also used. Here subjects were asked simply to read a story, and at the same time to detect more or less anomalous target words surreptitiously embedded in the text. Here, attention was not continuously focused on word choice, and alternatives were not provided; the anomalous words were either inappropriate in both sentence and story context (we labeled this IMPLAUSIBLE), or PLAUSIBLE, that is, acceptable in the immediate context of the sentence, but not in the context of the story. Examples are: "The hedgehog could smell the scent of the ELECTRIC (implausible substitution for SPRING) flowers. . . . The hedgehog felt weak and very hungry. She poked around in the grass and found a slug and a STONE (plausible substitution for WORM)."

Method

The texts used in these experiments were adapted from children's nature stories as shown in Appendix 2. They were judged suitable for children with a Reading Age of 7 to 8 years, and none of the subjects had any difficulty in reading (decoding) them. The first text (Beaver story) consisted of 70 sentences. At intervals throughout the text, subjects had to select one of three alternative words (as described above) to fit the context of the story. Altogether 88 choices had to be made, 22 of each of four grammatical categories: nouns, verbs, adjectives, and prepositions.

The second text (Hedgehog story) consisted of 59 sentences. At intervals throughout the text the actual wording was changed. On 15 occasions one of the original words was replaced by an IMPLAUSIBLE alternative, on 15 occasions by a PLAUSIBLE alternative. The substitutions were confined to nouns, verbs, and adjectives.

Subjects were the same as in the previous experiment, except that one did not read the Hedgehog story because of absence.

All subjects completed the Beaver and the Hedgehog stories in separate sessions, the Beaver story in which alternative choices had to be made being presented first. The children were told that they were going to read a story in which, from time to time, words had been left out. It was explained that whenever they came across a missing word, three possible words would be provided and they would have to pick the one which "fitted the gap" and "made sense." Practice was given using isolated sentences and continued as necessary for task understanding. Some informal discussion about animals followed, and if a child did not know what a beaver was, a brief verbal and pictorial description was provided.

The children then read the text aloud, selecting alternatives as instructed. Their responses were recorded verbatim, and the session was also tape recorded for later transcription. Halfway through the story, the children were asked questions about what they had read (see Experiment 4) and a short break was allowed. The story then continued, with further questions at the end.

In the next session, children were told that this time they were going to read a story about a hedgehog. All children were familiar with these animals. From time to time they would see that a "funny" or "silly" word had been put in the story by mistake. These words did not "make sense." They had to cross out any silly word which they saw. Again, practice was given using substituted, more or less anomalous words in sentences, and comprehension questions were asked half way through the text, as well as at the end.

Results

Beaver story. In order to see whether the subjects had understood the task at all, and were comprehending the text at least in small units of meaning, the number of IMPLAUSIBLE choices was examined. If subjects were performing at chance, one-third of all choices would be IMPLAUSIBLE. This was clearly not the case. Table 2 shows that the tendency for subjects to select IMPLAUSIBLE completions was extremely low, although prepositions created more difficulty than the other three word classes, contributing to a significant effect of *word type*, $F(3, 102) = 13.06$, $p < .001$.

In order to see whether the subjects were comprehending units larger than a sentence, we looked for a preference for STORY-APPROPRIATE choices. A subset of sentences had been vetted by 10 independent raters

TABLE 2
BEAVER STORY[a]

		Nouns		Verbs		Adjectives		Prepositions	
Group	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
High ability									
Normal	11	1.1	1.1	0.6	0.7	0.6	0.8	1.0	1.8
Autistic	5	0.4	0.5	1.4	1.1	0.8	0.8	3.8	1.6
Non-autistic retarded	4	0.3	0.5	0	0	0	0	0.5	0.6
Low ability									
Normal	4	2.5	2.5	1.0	0.8	0.3	0.5	1.8	1.5
Autistic	11	1.9	1.4	3.3	1.9	2.6	2.0	4.6	0.9
Non-autistic retarded	5	1.4	0.6	2.6	1.1	2.8	1.9	5.6	2.4

[a] Number of errors made in text gaps with multiple choice by normal, autistic, and non-autistic retarded subjects according to word type (maximum = 22 in each category).

allowing a strict test of this question. This was done in the following way. Each target sentence was written out separately, with one of the three possible choices. These sentences were randomly presented for rating as *acceptable* or *unacceptable*. Only those sentences, where both STORY-APPROPRIATE and SENTENCE-APPROPRIATE choices were rated as equally acceptable, by at least 8 out of 10 raters, or where the SENTENCE-APPROPRIATE one was actually preferred, were chosen for the present analysis. We argued that, if it was impossible on a single sentence basis to reject the SENTENCE-APPROPRIATE word, then a systematic tendency for choosing the STORY-APPROPRIATE word could only be attributed to story comprehension. Provided that implausible choices have been avoided, STORY-APPROPRIATE choices could be made on 50% of occasions by chance. Hence, a simple measure of story comprehension is given by the probability of selecting the STORY- APPROPRIATE alternative, given that the choice was between itself and the SENTENCE-APPROPRIATE alternative (i.e., number of STORY-APPROPRIATE choices divided by the sum of STORY-APPROPRIATE and SENTENCE-APPROPRIATE choices).

The probability of making a STORY-APPROPRIATE choice, given that the implausible alternatives were rejected, is shown for each group in Fig. 2. There were significant effects of *group*, $F(2, 32) = 3.26$, $p < .05$, and *ability*, $F(1, 32) = 9.31$, $p < .01$, and an important interaction of *group* × *ability*, $F(2, 32) = 5.64$; $p < .01$. There was no significant difference between the performance of the autistic, nonautistic retarded, and younger normal readers of high ability ($q = 14.63$, n.s.). But, among low ability children, younger normal subjects performed significantly

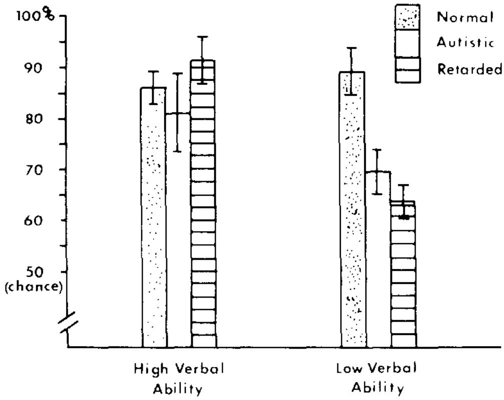

FIG. 2. Choice of STORY-APPROPRIATE over SENTENCE-ONLY-APPROPRIATE alternative.

better than nonautistic ($p < .05$) and autistic handicapped groups ($p < .05$), who did not differ from each other. The performance of the low ability handicapped children was close to chance (50%). It turned out that, using the whole set of data from 66 gaps (including all nouns, verbs, and adjectives), without using the stringent vetting procedure, exactly the same results were obtained.

Hedgehog story. Table 3 shows the mean number of PLAUSIBLE and IMPLAUSIBLE target words detected together with the mean number of false-alarm responses made. It is evident from these data that autistic and nonautistic handicapped children of low verbal ability were unable

TABLE 3
HEDGEHOG STORY[a]

Group	n	Plausible (Max = 15) M	Plausible (Max = 15) SD	Implausible (Max = 15) M	Implausible (Max = 15) SD	False alarm M	False alarm SD
High ability							
Normal	11	3.0	2.4	12.5	2.5	2.2	1.7
Autistic	5	1.4	1.5	10.6	1.9	2.4	2.3
Non-autistic retarded	4	1.3	1.3	13.3	0.5	2.5	2.3
Low ability							
Normal	4	1.5	1.3	5.5	4.9	3.3	4.0
Autistic	10	3.4	3.4	8.0	2.7	10.1	7.1
Non-autistic retarded	5	2.3	2.5	6.7	2.9	10.7	10.6

[a] Detection of embedded target anomalous words during reading.

to carry out the task successfully. Their false alarms (i.e., crossing out perfectly acceptable words) were relatively frequent compared to their rate of target word detection. It was therefore not appropriate to analyze data from the low ability groups further. However, the data from the young, low ability normal group was more reliable, as their false-alarm rate was low, that is, in the same range as that of the high verbal ability groups. Their target detection was nevertheless poorer than that of the latter, $t\ (13) = 3.373, p < .01$.

The performance of high ability subjects of all three diagnostic groups was close to ceiling for the detection of IMPLAUSIBLE words. IMPLAUSIBLE targets were detected more easily than PLAUSIBLE targets, $F(1, 17) = 10.5, p < .01$, which were indistinguishable from false alarms for all three groups. There was no significant difference between *groups*, $F(2, 17) = 1.19$, and no *group* × *word type* interaction, $F(2, 17) = 0.08$.

Discussion

When required to select words to complete texts they were reading, handicapped children of low verbal ability, whether autistic or nonautistic, did not distinguish systematically between STORY-APPROPRIATE and SENTENCE-APPROPRIATE words. Their "chance" performance indicates that they were not comprehending the story. However, they were able to reject words that were inappropriate in the immediately surrounding context. Nevertheless, it is important to note that getting meaning from a sentence, as indicated by the rejection of IMPLAUSIBLE words, was not automatic for these subjects. They only succeeded when some type of "monitoring" was enforced (*Beaver story*). That is, they avoided the IMPLAUSIBLE alternatives by considering which word to choose and which to avoid. In contrast, in the *Hedgehog story*, where alternative meanings were not provided, they crossed out indiscriminately, PLAUSIBLE, IMPLAUSIBLE, and perfectly correct words. From their errors, as well as their intonation, it can only be inferred that they read in this situation in a word-by-word fashion.

On the other hand, low verbal ability *normal* children, though less able to detect surreptiously embedded targets, were closely similar to the high ability groups. They all avoided IMPLAUSIBLE choices when monitoring was enforced (*Beaver story*), and also to a large extent when it was not (*Hedgehog story*). They could extract meaning at a level beyond the single sentence; i.e., they showed evidence of text comprehension. This was indicated by the fact that they preferred STORY-APPROPRIATE over SENTENCE-APPROPRIATE choices. This was true equally for autistic and nonautistic *retarded* children of high verbal ability, as well as for all the *normal* readers.

However, for these groups too, imposed "monitoring" had a beneficial effect. Target words, which were *PLAUSIBLE at sentence level*, and were of course of exactly the same type which they had rejected when alternatives were explicitly provided, were not very well detected. Yet, some bright young readers of our acquaintance readily noticed even these subtle anomalies. To notice such text variation presumably requires a degree of metalinguistic skill beyond the level reached by the readers in our present sample.

EXPERIMENT 4: SENTENCE AND GENERAL KNOWLEDGE

Comprehension of text may be enhanced by the way the reader integrates "old" information already in his or her mind, with the new information the text provides. A simple test of what a child has gleaned from text, i.e., how new information has been integrated with previous knowledge, can be made by asking two types of questions after the text has been read: one requiring the subject to remember factual detail provided by specific sentences in the text, the other inviting general knowledge to be brought to bear. For example, to the question *"For how long had the hedgehog been in her underground nest?"* a correct answer was only possible if the text had been read and remembered. The answer could be *days*, *weeks*, or *months*. In contrast, consider the answer to the question *"What makes hedgehogs wake up from their winter sleep?"* This could also be correctly answered if the text had been read and remembered but, in addition, or instead, the child might already know that hibernating animals wake up in spring. Therefore questions of this type should have a better chance of being answered correctly. It might be expected that retarded children would have poor world knowledge, and hence, they might answer both types of questions equally well—or rather, equally poorly. Another possibility is that these children will not apply world knowledge, because their ability to comprehend large units of meaning is specifically impaired. Only if one has this ability can one recognize existing knowledge as relevant to the question at hand. We therefore predicted that even those normal readers with very low verbal skills, and with limited "world knowledge," due to their young age, would differentially respond to fact and general knowledge type questions. We would also expect this to be true for those handicapped "hyperlexic" children who had previously demonstrated an ability to comprehend text beyond the sentence level.

Method

Initially a total of 32 comprehension questions were devised, 16 concerned with the *Beaver story*, and 16 concerned with the *Hedgehog story*. Half of the sentences tested the children's memory for particular information in the story that they had read (Story Fact questions). The remaining questions were devised on an a priori basis to tap the children's ability to give reasoned answers on the basis of what they had read with the possibility of using general knowledge if they wished. All the answers were scored as correct or incorrect in terms of the stories by three raters.

To ensure that comprehension questions truly tapped either story facts, or else, could be answered by recourse to general knowledge, they were given to a new group of young normal readers who had not read the texts. These new subjects were matched with our existing normal groups in terms of chronological age, Reading Age, and Verbal Mental Age. They were, on average, 8 years old, and ranged in Reading Age from 7 to 8 years, with a mean of 7 years 6 months. Their Vocabulary Age ranged from 4 years to 9 years 9 months, with a mean of 7 years 5 months. Any of the questions which they could answer successfully, without exposure to the text, could truly be deemed "General Knowledge questions." Those which could not be answered were most certainly "Story Fact questions."

A target set of 10 Fact and 10 General Knowledge questions was selected following this procedure (see Appendix 3). Each Fact question was answered correctly (presumably by chance, or by following the drift of the story through the sequence of questions) by fewer than 3 out of 10 subjects who had not read the text. Each General Knowledge question was, in contrast, answered correctly by a minimum of 6 out of 10 subjects.

The data for Experiment 4 were collected at the same time as for Experiment 3, using the same subjects. The questions were posed after each half of each story (without the text being present), and responses were tape recorded for later scoring. In the final analysis, only answers to the "target" questions (10 Fact and 10 General Knowledge), for both stories combined, were analyzed.

Results

The average number of questions correctly answered by autistic, retarded and normal readers, grouped according to verbal ability is shown in Fig. 3. There was a highly significant effect of verbal *ability* on overall per-

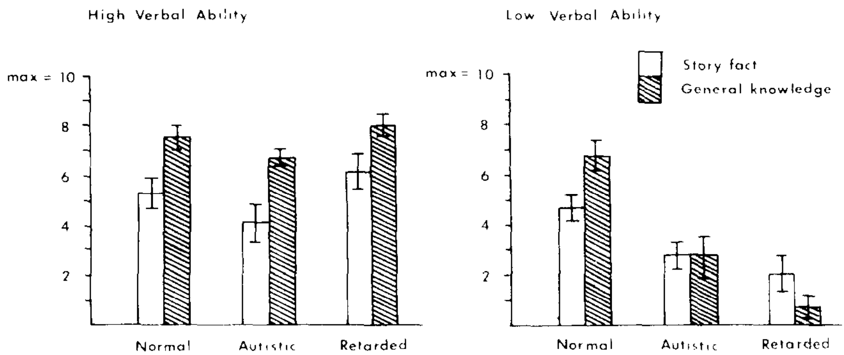

FIG. 3. Number of correct answers to questions of Story Fact and General Knowledge.

formance, $F(1, 32) = 31.85$, $p < .001$. There was also evidence that the three diagnostic *groups* differed from each other, $F(2, 32) = 5.76$, $p < .01$, but in addition, there was a significant *ability* × *group* interaction, $F(2, 32) = 6.5$, $p < .01$. This interaction indicated that, while verbal ability significantly affected the performance of autistic and nonautistic retarded subjects, it did not affect the performance of normal readers.

A significant effect of *question type*, $F(1, 32) = 12.36$, $p < .001$ confirmed that Fact and General Knowledge questions were different in nature. However, there was also a significant *question type* × *ability interaction*, $F(1, 32) = 7.79$, $p < .01$. As predicted, in high ability groups, General Knowledge questions were answered better than Fact questions. In low ability groups this trend was absent although inspection of Fig. 3 suggests that this was only clearly the case for the handicapped subjects.

Discussion

As in the previous experiments the autistic and nonautistic retarded subjects of relatively high verbal ability performed identical to each other, and as well as normal controls. For all these subjects general questions were easier than factual questions. Thus, all these groups could use general knowledge to supplement their memory for, or understanding of, a text. Moreover, Fig. 3 points toward the possibility that the performance of normal readers of low verbal ability was once again relatively close to that of high ability groups. Although the 3-way interaction, group × ability × question type, failed to reach significance, it is tempting to consider separately the low ability groups, in order to confirm our impression that the normal and handicapped groups differ in their use of general knowledge. Nonparametic tests on the low ability groups indeed indicated that the General Knowledge questions were answered better than Fact questions by normal readers, $z(2) = 1.73$, $p < .05$, but not by autistic, $z(2) = 1.26$, $p = .1$ or nonautistic readers, $z(2) = 1.41$, $p = .08$. This resulted in a significant group difference between handicapped and normal readers, $z(2) = 3.08$, $p < .001$. Moreover, there was no significant difference between the performance of normal readers of high and low verbal ability on Fact ($z(2) = 0.86$, $p < .5$) or on General Knowledge questions ($z(2) = 1.14$, $p < .1$).

While the evidence remains tentative, this finding is consistent with our hypothesis that verbal ability alone, at least as far as this is reflected in the vocabulary test scores, cannot account for text comprehension. We would suggest that even young normal readers have available specific strategies for the comprehension of units of meaning larger than the sentence which they can utilize even in the absence of sophisticated vocabulary knowledge, and with a very limited amount of world knowledge.

This potential is well illustrated by the children's answers to the following questions: "*Are beavers lazy animals?*" and "*Are beavers brave animals?*" Reasoned answers to the first question included "*No, because they cut down trees and hardly sleep*" and to the second question "*Yes, because they can fight their own battles and don't need anyone else.*" Thirteen out of 15 normal subjects regardless of verbal ability gave reasoned answers to both these questions, while only 9 out of the 23 retarded subjects did so. Similarly, when asked "*Why do baby hedgehogs gradually stay farther away from their mother?*"—a question which is answered in the text itself but may well require some world knowledge in order to be fully understood—8 out of 15 normal subjects gave a reasoned reply compared with only 3 out of 23 of the subjects in the retarded groups.

Our findings for autistic and retarded children within the low verbal ability range strongly suggested that they did no better on General Knowledge than on Fact questions (which were also answered poorly). Since it is difficult to know whether this was due to lack of world knowledge, or to not applying any such knowledge, we compared these low ability handicapped children with very much younger children. For this we choose some normal preschoolers, again from the same Inner City school, none of whom could read, and for this reason, but also for reasons of age and environment, had limited knowledge of the type that might be relevant to our nature stories.

We examined 10 four- to five-year-old children, all pre-readers, ranging in Vocabulary Age from 3 years 6 months to 4 years 5 months according to the norms of the British Picture Vocabulary Test. These children listened in small groups to the *Beaver* and *Hedgehog* stories and then were asked the same questions as the experimental subjects had been given. On average, the children answered 4.4 Fact questions and 4 General Knowledge questions correctly. Examination of Fig. 3 shows clearly that their performance was better than that of the low ability retarded groups. Thus, it is unlikely that the comprehension failure of these groups can be accounted for entirely by restricted general knowledge: preschoolers with extremely limited relevant knowledge did better when they were questioned about the content of our stories which were not even aimed at such a young group. We suggest that our low ability autistic and retarded groups processed the texts superficially, and remembered only occasional isolated details. Although we have only tested their comprehension of printed material, we presume, on the basis of Experiment 1, that they would have similar difficulty when listening. We would argue that low ability handicapped children are unable to integrate different sources of information simultaneously. Preexisting knowledge, if any, is not accessed during reading. Therefore new facts are not well represented, and the story is not understood.

GENERAL DISCUSSION

The present series of experiments explored comprehension of sentences and units of meaning larger than the sentence in low and high verbal ability groups of autistic, moderately retarded, and normal children who all achieved a similar performance level on a standard word recognition test.

The results of Experiment 1 indicated that subjects in the two handicapped groups we studied were equal at understanding grammatical constructions to a level commensurate with their vocabulary knowledge. Furthermore, it did not matter whether the sentences were heard or read.

In Experiments 2 and 3, we investigated how well subjects could read sentences with homographs or with anomalous words. Subjects of relatively high verbal ability, regardless of diagnostic group, completed these tasks satisfactorily; i.e., they pronounced the homographs according to sentence context, and detected the anomalous words. This indicated automatic use of sentence context to guide reading. In contrast, low ability autistic or nonautistic children gave little evidence of using context, and were unperturbed if they pronounced a homograph incorrectly, or read out an anomalous word.

In Experiments 3 and 4, we attempted to distinguish between comprehension of sentence and story units. Verbal ability was once more an excellent predictor of performance among handicapped but not normal groups. Autistic and nonautistic retarded readers of "high" verbal ability did remarkably well—their processing of both sentence and story units being indistinguishable from that of matched normal readers. This was not the case for the low ability handicapped children who at best seemed to read sentence by sentence, but never connected the whole story together. A very similar pattern of results emerged when subjects were questioned about the stories they had read. The responses of all the high verbal ability handicapped subjects were as good as those of the normal readers, and they did significantly better on questions in which general knowledge could be used to supplement information provided by the texts. However, as Fig. 3 indicates, this was not true of autistic and nonautistic groups of low verbal ability. A comparison of their performance with that of younger normal children suggested that they remembered rather less of the information presented in the stories, and did no better on questions which could be answered by recourse to general knowledge. They performed worse even compared to 5-year-olds with no reading experience and very little general knowledge.

What do these results—based as they are on very small numbers—add to our understanding of hyperlexia? First, none of the experiments revealed deficits specific to autistic children. In all cases the performance of autistic readers was indistinguishable from that of their mildly retarded nonautistic peers. Because of this consistency we would like to make the strong claim that hyperlexia is not a syndrome-specific phenomenon. Second, although all of the handicapped children showed excellent decoding skills, they clearly do not equally merit the label "hyperlexia." Autistic and mildly retarded readers of verbal Mental Age of around 10 years comprehended the printed materials we used to the same extent as normal readers aged 10. Their decoding skill was often above this level, but their comprehension was just as might be expected from their verbal ability. In contrast, the reading comprehension of low verbal ability handicapped children was *worse* than that of younger nonhandicapped children of equal decoding ability. They did not use context spontaneously to monitor their reading and they had poor understanding of what they had read aloud when answering questions. These children we suggest can be described as *truly hyperlexic*. If so, it appears that *true hyperlexia* is manifested in terms of both (surprising) decoding success *and* (surprising) comprehension failure (the surprise being in relation to verbal ability). This double discrepancy does not, however, constitute a satisfactory definition. Apart from the fact that it is unclear by what criterion the extent of discrepancy should be evaluated, a statistical, e.g., regression-based, definition does not provide any explanation.

The question of why the *true* hyperlexic children's reading comprehension is so poor remains to be answered. However, there was some evidence of the potential ability of these hyperlexic readers to integrate word meanings into larger units, when they were directed to chose between explicit alternatives to complete a sentence. These results suggest that hyperlexic children may possess some of the skills required for adequate sentence processing, but fail to apply them spontaneously. Thus, in tasks where they were not constantly engaged in an effort to understand, i.e., when they were required to detect surreptitiously embedded anomalous words or homographs, the *true* hyperlexics remained focussed on small units of meaning.

The existence of hyperlexia demonstrates that, in principle, a functional decoding system can be set up in the absence of the usual links with the semantic and or general knowledge systems. This is of great theoretical interest. We have shown that those handicapped adolescents, whose verbal Mental Age was above 7, were able to achieve comprehension skills that were at least commensurate with their verbal skills. There is no reason then to label these readers hyperlexic. This was not the case for those whose verbal Mental Age was below 7.

We suggest that these subjects were *true* hyperlexics, and are clearly different from the higher verbal ability superior decoders. We have shown that hyperlexia implies a particular failure to comprehend in terms of large units of meaning, not accounted for by poor general language skills, or poor word knowledge. How to operationalize this deficit in order to provide a useful diagnostic remains to be seen. On the one hand, the specific comprehension failure we demonstrated is a serious handicap, on the other hand, hyperlexic children's ability to comprehend is actually often better than has previously been believed. Furthermore, this ability can apparently be increased by the provision of explicit cues.

APPENDIX 1
Experiment 2

Sentences containing the homographs READ, BOW, ROW, TEAR, LEAD arranged according to frequency of pronunciation (1,3 = frequent; 2,4 = rare) and according to position in sentence (1,2 = before disambiguation; 3,4 = after disambiguation).

READ
(1) I read a story now, and then I do some Math.
(2) I always read a lot when I was younger.
(3) First I tidy up and then I read a story.
(4) Yesterday I read a new story.

BOW
(1) He took a bow from his violin case.
(2) He took a bow when everybody clapped.
(3) The boys played cowboys and Indians. Paul was a cowboy and pretended to have a gun. Tom was an Indian and pretended to have arrows and a bow.
(4) Puss-in-Boots went to the castle to speak to the king. Before he began his speech he made a bow.

ROW
(1) The man had a second row seat in the cinema.
(2) The man had a second row with his wife the day after.
(3) *Everybody who wanted to see the new film had to stand in a row.*
(4) The brothers started shouting. Dick left because he didn't want to be involved in a row.

TEAR
(1) There was a big tear in her eye.
(2) There was a big tear in her dress.
(3) Molly was very happy, but in Lily's eye there was a big tear.
(4) The girls were climbing over the hedge. Mary's dress remained spotless, but in Lucy's dress there was a big tear.

LEAD
(1) It was the lead guitarist that sang at the concert.
(2) It was the lead in the box that made it so heavy.
(3) The dog knew he was going to be taken for a walk: he saw his master take the lead.
(4) The scrap metal man first took the copper and iron and then he took the lead.

APPENDIX 2a
Experiment 3: The Beaver Story

(Italicized words were choice points at which 3 words of the same syntactic class were provided. For the experiment these were typed on top of each other, randomized for position. Examples are shown only for those sentences which were used for the analysis of STORY-APPROPRIATE vs. SENTENCE-ONLY-APPROPRIATE choices.)

The beaver was now two years old. She was one of a large *family* of beavers who lived together in a lodge made of mud and *sticks*. Her brothers of the same age had left the lodge to *live* on their own. Now it was her turn to *go*. It was a *warm* evening in early summer. The beaver *sniffed*/loved/heated/ the air and cut a *small* branch from a tree that had been left *lying* on the bank. As she chewed its *soft*/heavy/silly/ bark, she looked back *across* the pond. On the other side, her father and the *older*/fatter/greener/ children were hard at work. The beaver *watched* them for a while. But she did not join *in* their work. Instead, she *turned* and walked away *into* the forest. The forest was *darker* than the river bank and strange noises came from the rustling *trees*. The frightened *beaver*/cat/room/ could see almost nothing at first. Then she *saw* a light *glinting* ahead of her. It was the fierce *golden* eyes of a tiger glowing *in* the darkness. The beaver froze. She was too far *from* the water to dive for *safety*. She could only *wait* for the cat to pass by. It came closer but it could neither smell her nor *see* her dark shape. It yawned, *licked* itself, then padded away on its huge *furry* paws. As soon as the beast had gone, the beaver hurried back *to* the river *bank*/boat/hill/. From then on she stayed *within* safe distance of the water. Night after night the *young* beaver wandered along *by* the stream. She slept by day in any safe hollow she could *find*/mate/boil/. After a while, she noticed a new scent. It was a good smell. Suddenly, she *saw*/made/mended/ a movement and heard a *splash*. She waddled down *to* the water and looked about. There, surfacing in the *dim* light, was a young male *beaver*/horse/telephone/. He climbed out of the *water*/hole/wheather/ and came *towards* her. She nuzzled up *to* his fur. She had been on her own for too long. It was time for her to *have* a mate. Soon the two were kissing and *cuddling* and combing each other's fur. When morning came, the beaver took her *new* mate back to the hollow *beneath* the tree. They snuggled up together and went to *sleep*/swim/shop.

One evening they started to dam the stream. The female cut a notch *in* a tree with her *sharp* teeth. Then she chiselled and gnawed all round the *trunk*. She tore out the wood chips *with* her teeth. At last, she heard the tree *crack*. She made a dash *for* the water as the *tall*/new/hot/ tree crashed to the ground, its branches tearing *through* other trees. Her mate only just managed to get out of the *way*. The female cut the *larger*/blacker/faster/ branches from the tree and then cut these into *shorter* lengths. Then she pulled the pieces down *to* the water. The beavers started dam building by pushing the larger branches into the *muddy* bed of the stream. Next they wove *smaller*/*heavier*/*friendlier*/ logs, branches and *twigs*. They stuffed the *gaps*/roof/pram/ with mud and stones to make the dam watertight. One midwinter morning the beavers were woken *by* a snuffling noise and the sound of claws *scraping* their roof. The lodge was filled *with* the smell of hot *fishy*/steamy/grateful/ breath. The beavers could see a patch of rough *black*/healthy/tasty/ hair. It belonged to a bear who was scratching *at* the walls of their home. Luckily the walls were frozen solid. Throughout the winter other *animals*/birds/hospitals/ also tried to invade the lodge, but it was too strong *for* them. 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. A few weeks later they had their first hard *food*/skin/milk. Their mother taught them how to rip leaves and *bark* from twigs and showed them where to find *tasty*/horrible/noisy/ water lilies. One night, two of the *babies*/rabbits/candles/ went to a distant clump of trees and started to gnaw at them. Suddenly came the howl of a wolf. One was *quick*/happy/strict/ enough to get away. The other stood *facing* the wolf. The *terrified* beaver hissed and bared his teeth as the great animal sprang. The wolf missed him and *howled*/laughed/boiled/. Just then there was another noise and the wolf *disappeared*/appeared/threaded/. A hare had bounded before its path and it could not resist the *chase*. The young beaver was *safe*/joyful/closed/. As these beavers grew up, their mother had more *babies*. There was no longer room *for* them in the *lodge*/cottage/bread/. One by one they left to find mates for themselves. Their babies would do the same in their turn: dam streams, build lodges and bring up *families* of their own.

APPENDIX 2b
Experiment 3: The Hedgehog Story

(The italicized words indicate anomalous words to be detected, with the original words in brackets.)

For three months the hedgehog had been warm and snug in her underground nest. Now the weather was *fatter* (warmer), she woke from her long sleep and saw that winter had really gone. The hedgehog could smell the scent of the *electric* (spring) flowers. She knew that among them there would be worms, snails, insects and other good things to *see* (eat). As soon as it was dark she would go out and *burn* (find) some food. After such a long sleep, the hedgehog felt weak and very hungry. She poked around in the grass and found a slug and a *stone* (worm). Then, after a while, she found a newt. Quickly she pressed her spines into it and bit into its *metal* (tasty) flesh. All the time, while looking for food, she had to take care that no foxes or badgers crept up on her. By morning, she was very *sick* (tired). So she found a pile of dead leaves under a hollybush and settled down to *play* (sleep). One night, as the hedgehog was tramping off to the steam, she heard a scuffling noise behind her. She found that there was another *tractor* (hedgehog) following her. It was a male and he wanted to *stay* (mate) with her. When they had mated the hedgehogs parted and the male went off to look for food. Just as the sun was coming up, he found a nest full of *noises* (eggs). In seconds, all the thin shells were broken and the hedgehog was sucking up the creamy yolks. There was nothing the mother bird could do.

The bird was not the only animal that saw the hedgehog's *head* (attack). A fox saw it too. And the fox was always hungry. The hedgehog caught the scent of the fox and began to *smoke* (run). But the fox ran too, and the hedgehog knew that he could not *lose* (escape). Quickly the terrified hedgehog rolled up into a ball. The fox would find it hard to eat him now. But the fox did not give up. He *loved* (pushed) the hedgehog with his paw. The prickly ball began to move. The fox hit it again and this time it started to *bounce* (roll), tumbling downhill towards the stream. Suddenly, the hedgehog was in the *school* (water). He quickly swam to safety—but then the fox *whistled* (pounced). His fangs sank into the hedgehog's belly. No spines could save him now. The female never knew what happened to her *handbag* (mate). She continued to hunt for food each night and sleep during the day. All the time, a litter of *old* (young) hedgehogs were growing inside her. So, the hedgehog looked for a place where she could bring up her *children* (young). She found a hole by the bottom of a *happy* (stone) wall and filled it with a soft bed of leaves. Safely inside, she waited for the babies to be born. At first the babies were blind, deaf and helpless, and the white spines on their *toes* (backs) were quite soft. Soon, a second set of harder spines grew between the soft ones. The mother hedgehog fed the babies on milk from her body. All the time they were growing *cleverer* (stronger). When they were a month old, they had grown hundreds of fine new spines and a set of *games* (teeth). As soon as they could roll up to protect themselves, their mother took them out to find their own food. One night, the whole family had a *smiling* (fine) feast. The young hogs ate insects and worms. But their mother found a snake. She rushed round it as it lashed out and tried to strike her. Then she charged at the *short* (long) creature and it struck back at her. But instead of *loving* (killing) the hedgehog, the snake got caught up in her spines. The young hedgehogs had grown so fast that they would not need to stay in the nest much longer. They would be *quieter* (safer) once they had left the nest. So, the hedgehogs strayed farther from their mother. Soon only one of them came back to the nest in the *woods* (wall). And after a few days, the mother drove him away. Like the others he must learn to look after himself.

APPENDIX 3

Experiment 4

Story Fact Questions

How old was the beaver when she left her parents' lodge?
What time of year was it?
What animal tried to get into their home?
How many babies did the mother beaver have?
What animal did the young beaver meet?
For how long had the hedgehog been in her underground nest?
What could the hedgehog smell when she woke up?
Who saw the hedgehog break the eggs?
How did the fox kill the hedgehog?
Where did the hedgehog make her nest?

General Knowledge Questions

How many beavers live in a lodge?
What did the beavers use to build the dam?
How do beavers manage to cut trees?
What is important for beavers to learn when they are young?
What makes animals like hedgehogs wake up from their winter sleep?
Why was it important for the hedgehog to find some insects to eat?
Why do you think some small creatures are afraid of hedgehogs?
Why was the hedgehog unable to escape the fox?
How do hedgehogs protect themselves from other animals?
Why do baby hedgehogs have to be cared for by their mother?

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