British Journal of Developmental Psychology (1991), **9**, 417–430 *Printed in Great Britain*

Semantic processing in the free recall of autistic children: Further evidence for a cognitive deficit

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Two memory experiments were conducted with groups of autistic, mentally retarded and normal children, matched on verbal mental age and digit span. In the first experiment free recall of semantically related and semantically unrelated word lists was investigated. Autistic children were found to be comparable to the control groups in recalling the unrelated list; however, they were significantly poorer in recalling words from the related list. The second experiment utilized a cued recall paradigm, comparing the subjects' ability to use semantic and rhyme cues to retrieve unrecalled words from memory. This time the autistic children were no different from the retarded and normal children in using semantic cues. These findings extend earlier work on cognitive deficits specific to autism, suggesting that autistic children cannot make use of linguistic knowledge to facilitate retrieval of stored information. It is speculated that this failure to use memory strategies is related to autistic children's hypothesized deficit in developing a 'theory of mind'.

During the past 25 years considerable progress has been made in the study of infantile autism (Cohen & Donnellan, 1987; Dawson, 1989). Much of the work focusing on the psychological deficits associated with this disorder has been influenced by the seminal research conducted by Hermelin, O'Connor and their associates (Hermelin & O'Connor, 1970). Among the most important aspects of their work were the experiments aimed at elucidating the cognitive deficit that is specific to autistic children. Their experimental studies comparing autistic children with matched control groups of normal and retarded children led Hermelin & O'Connor to conclude that autism involves a basic cognitive deficit in the ability to 'encode stimuli meaningfully' (Hermelin & O'Connor, 1970, p. 129).

This hypothesis about the nature of the cognitive deficit in autism is based largely on the findings from a series of experiments in which autistic and control subjects' recall of different types of material was investigated (Hermelin & O'Connor, 1967; O'Connor & Hermelin, 1967). In one experiment (Hermelin & O'Connor, 1967), 20 autistic children were matched to a group of 20 mentally retarded children on verbal mental age, as assessed by the Peabody Picture Vocabulary Test (PPVT) and digit span. Subjects were asked to recall two kinds of verbal material: sentences and

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random word strings. The main findings were that, while mentally retarded children recalled significantly more from the sentences than from the random word strings, for the autistic children the difference between sentences and random words was not significant. In a second experiment the same children were presented with semantically related word sequences in which the words came from a number of categories, and random semantically unrelated word strings. The results showed that in recall the mentally retarded children reorganized and clustered words from the same categories significantly more often than the autistic children did.

These experiments demonstrate that autistic children do not make use of syntactic or semantic relationships to facilitate recall of meaningful material. There have been a number of attempts to replicate these findings using similar stimuli. Schwartz (1981) reviewed the results of several studies (Frith, 1969; Fyffe & Prior, 1978; Wolff & Barlow, 1979) and concluded that every replication demonstrated that autistic children did not show in their recall as great a difference between meaningful and non-meaningful stimuli as did the control subjects, although the data did not reach statistical significance in every study. Schwartz suggests that, contrary to Prior's (1979) claim, a meta-analysis of this set of experiments supports Hermelin & O'Connor's (1970) conclusion that at least some autistic children suffer a specific cognitive deficit in processing linguistic material.

There is, however, some doubt about the precise nature of this deficit. Schwartz (1981) points out that thus far research has not distinguished whether autistic children fail to encode linguistic input (as proposed by Hermelin & O'Connor, 1970); fail to retrieve what has been encoded (as proposed by Boucher & Warrington, 1976); or fail to acquire the requisite linguistic knowledge (as proposed by Menyuk, 1978).

There is also some question about the specificity of the deficit: does the deficit in linguistic coding entail both syntactic and semantic aspects of language or is it restricted to a deficit in processing syntax? Ramondo & Milech (1984) argue that autistic children suffer a more limited syntactic deficit. With the exception of one of the original experiments by Hermelin & O'Connor (1967), all the studies have compared recall of sentences (in which syntax and semantics are confounded) with non-sentences. Ramondo & Milech rightly point out that, even in Hermelin & O'Connor's experiment in which the recall of semantically related words and random word strings was compared, their use of clustering differences as the main support for a semantic processing deficit is questionable.

Ramondo & Milech (1984) attempted to separate syntactic and semantic components in their study by including two examples for each of four types of word sequences, all 12 words long: grammatical/meaningful sentences; grammatical but semantically anomalous sentences; semantically related word strings; and semantically anomalous jumbled sentences. Their subjects included 12 autistic children range-matched on age, digit span and PPVT to mentally retarded children, and to normal children on PPVT and digit span.

As in previous research, Ramondo & Milech found that the autistic children did not show a significant difference in their recall of random word strings and sentences, supporting previous work demonstrating a deficit in processing syntactic information. The difference between the autistic and mentally retarded subjects did

not reach statistical significance, leaving open the possibility that this deficit may not be specific to autism. On the other hand, Ramondo & Milech did not find any interaction between subject group and semantics: that is, all three groups were very similar in their recall of the semantically related word strings. This finding is paradoxical as it conflicts with the emphasis in the literature on the special difficulties autistic children have with linguistic meaning, and their superior functioning in the domain of syntax (e.g. Baltaxe & Simmons, 1975; Caparulo & Cohen, 1977; Kanner, 1946; Menyuk & Quill, 1985; Paul, 1987; Tager-Flusberg, 1981, 1989). Ramondo & Milech raise the possibility that their data are an artifact based on the stimuli they used and, indeed, a number of problems can be identified. Specifically, three kinds of word sequences (meaningful, semantically anomalous and jumbled sentences) involved a mixture of content and function words, many of which were repeated in several of the lists, whereas only the semantically related word strings, which were the critical ones for testing the semantic deficit hypothesis, contained all nouns of which only one or two appeared on any of the other lists. It is very possible that function words are easier to recall as they are accessed faster and form a restricted set (cf. Bradley, 1978). Furthermore, the effect of including the same words on several lists may have contributed to a facilitative learning effect, particularly since all the testing was completed in a single session. Because of these problems, Ramondo & Milech's findings cannot be taken as evidence against a semantic deficit hypothesis, although there is a clear need for more data on how autistic children process semantic information.

This article presents two studies that were designed to test the semantic processing deficit as proposed by Hermelin & O'Connor (1970). In the first experiment autistic children's free recall of semantically related and unrelated word lists was tested including only nouns on both lists so as to avoid some of the difficulties Ramondo & Milech encountered. The second experiment uses a cued recall paradigm in an attempt to clarify the nature of the processing deficit, by distinguishing between problems in encoding or retrieval (cf. Boucher, 1981 *a*; Boucher & Warrington, 1976).

Experiment 1

The purpose of this experiment was to replicate, using different stimuli, Hermelin & O'Connor's original experiment on the free recall of semantically related and unrelated word lists in order to clarify the nature of the linguistic processing deficit in children with autism. In this experiment children's recall of two word lists was compared: one list was composed of 12 nouns each drawn from a different semantic category, while the second list was composed of 12 nouns all drawn from the same semantic category. The dependent variable was the number of words recalled, rather than degree of clustering (cf. Ramondo & Milech, 1984).

Method

Subjects. Three subject groups participated in this experiment: autistic, mentally retarded and normal children. The autistic children were located through the schools they attended. Autism was diagnosed

according to DSM-III criteria and current proposals for defining the syndrome (Cohen, Paul & Volkmar, 1987; Denckla, 1986), based on medical history, information in the subjects' files and a behaviour checklist completed during observations prior to testing. The children classified as autistic were identified by the presence or definite history of all the following characteristics: onset prior to 30 months, gross and sustained impairments in socialization and social relationships; delays and deficits in language development; and repetitive or stereotyped activities. Children with incomplete or ambiguous case histories were not considered. All the autistic subjects in the final sample had always attended special day school programmes and were living at home with their families. Only relatively high functioning autistic children were selected for this study, following Prior (1979) and Rutter (1983). In this way differences in performance on the memory tasks can be more confidently attributed to autism-specific deficits, and not to general influences of developmental delay.

The mentally retarded children had educational, socio-economic and family backgrounds similar to the autistic subjects. Their retardation was linked to a variety of aetiologies (for many unknown), but none of the subjects in this group met DSM-III criteria for autism, nor had any of them ever received a medical diagnosis of autism. The control group of normal children came from a preschool day-care centre.

A summary of the main characteristics and test scores for the groups is presented in Table 1. The autistic and mentally retarded groups were matched on chronological age (t (28) = 0.47). Verbal mental age and IQ were assessed using the Peabody Picture Vocabulary Test, Revised form (PPVT–R), and non-verbal mental age and IQ were assessed using the Raven's Coloured Progressive Matrices – Board Form. Although the autistic and mentally retarded children were not matched on non-verbal intelligence (t (28) = 3.67, $p < .01$), all three groups were matched on verbal mental age (F (2, 42) = 0.31), and the verbal IQ scores of the autistic and mentally retarded children were also very similar (t (28) = 0.11). The higher non-verbal IQ levels of the autistic subjects reflect the typical profile for this population (De Myer, 1976).

Table 1. Subject characteristics

	Autistic	Mentally retarded	Normal
Number	15	15	15
Male/female	11/4	10/5	8/7
Chronological age	11:2 (3:3)[a]	10:8 (3:0)	4:7 (0:10)
Verbal mental age	5:2 (1:4)	5:0 (1:8)	4:9 (1:3)
Verbal IQ	46 (14)	47 (9)	104 (12)
Non-verbal mental age	9:6 (3:0)	6:0 (2:0)	—
Non-verbal IQ	85 (13)	56 (10)	—
Forward digit span (raw score)	3.8 (3–5)[b]	3.7 (3–6)	3.7 (3–6)

[a] Standard deviation.
[b] Range.

Subjects were also given the forward digit span subtest of the Wechsler Intelligence Scale for Children (revised version). The children in each group were individually matched within one digit and there were no significant group differences on digit span (F (2, 42) = 0.0). These represent relatively low digit spans, and in this respect our subjects were somewhat different from the high span subjects studied by Ramondo & Milech (1984).

Stimuli. The stimuli for this experiment consisted of two word lists, each 12 words long. The words were all concrete nouns. One list contained 12 nouns drawn from different categories (*airplane, apple, brown, cabin, drum, elephant, lamp, onion, pencil, pot, shirt, thumb*). The second list contained 12 words from a

single category, namely all animals (*bear, cow, giraffe, horse, lion, monkey, mouse, pig, rabbit, racoon, sheep, turtle*). The words on both lists were approximately matched for frequency of use.

Procedure. Each child's free recall was tested in two sessions, scheduled about one week apart. The child and two experimenters sat together at a table in a quiet room in the school attended by the child. In order to familiarize the child with the memory task, a practice set of four simple words was given (*pin, cat, tea, wall*). The child was told: 'I will say some words, and when I'm done, you say the same words as I did.' After these instructions the experimenter presented the practice words in a monotone voice. Then the experimenter asked: 'Can you say the words I said?' The child was prompted to recall until it was clear that no more words could be remembered. All the children were successful at learning the task requirements.

Once the practice set was completed, the child was presented with a test list. The order of presenting the two word lists was counterbalanced across the children in each group. The test lists were presented in the same way, using the same instructions as for the practice set. The 12 words on the test lists were presented in random order at a rate of one word every two seconds. The second experimenter recorded the order in which the words were presented, and the words were recalled by the child. All the child's attempts at recall were encouraged and praised. The second session, in which the second word list was presented, was the same as the first.

Results and discussion

The number of words correctly recalled from both lists was totalled for each child. The group data are presented in Table 2. The data were analysed using a two-way mixed design ANOVA with group (autistic, mentally retarded, normal) as the between-subjects variable and list (semantically related, unrelated) as the within-subject variable. Both main effects were significant: for group (F (2, 42) = 3.43, $p < .05$) and for list (F (1, 42) = 29.2, $p < .001$). The group × list interaction was also significant (F (2, 42) = 6.14, $p < .005$).

Table 2. Mean number of words correctly recalled by autistic, mentally retarded and normal children in Expt 1

	Autistic		Mentally retarded		Normal	
	M	SD	*M*	SD	*M*	SD
Unrelated word list	3.0[a]	(1.6)	2.9	(1.8)	3.1	(1.3)
Related word list	3.2	(2.3)	5.7	(1.6)	5.1	(1.4)

[a] Maximum = 12.

Post hoc analyses of the means were carried out using the Scheffé test at the .05 level. These analyses indicated that, for both the mentally retarded and normal children, recall was significantly better on the semantically related list, and that both these groups performed better on the related word list than did the autistic group. There were no significant differences between any of the groups on the unrelated word list, and for the autistic groups there was not a significant difference between the two word lists.

These results confirm Hermelin & O'Connor's (1967) findings that autistic children are impaired in using semantic relatedness to facilitate free recall, and contradict Ramondo & Milech's (1984) finding of no group x list interaction on the semantic lists, probably because of differences in stimuli and methodology. Taken together, the results of this experiment and previous studies cited above provide support for the hypothesis that autistic children are impaired in using syntactic and semantic information free recall.

One weakness with the present study is that it relies on only a single list of semantically related words drawn from the category of animals. One might argue that the findings are related to specific problems that autistic children may have with animal names. This seems unlikely since Hermelin & O'Connor (1967) used different semantic categories, namely colours and numbers. We also know from other research on these same autistic subjects' representation of concepts and word meanings that they have no specific problems with the category of animals (Tager-Flusberg, 1985 *a*, *b*, 1986).

To what extent is this linguistic processing impairment the result of a failure to encode the requisite linguistic information, as suggested by Hermelin & O'Connor (1970)? There is some indirect evidence in the recall patterns obtained in this experiment that the autistic children had encoded the appropriate semantic information in the related word list. In addition to recalling a certain number of words from each list, about two-thirds of the children in each group incorrectly recalled words that had not been on the test lists. These recall errors were mixed in with correctly recalled words. There were two main types of recall errors: words that were not from the same semantic categories as the words on the target lists (including associations to target words, words for things present in the testing room and completely irrelevant words), and words from the same semantic categories. Because the two lists were presented on separate days, there were no discernible intrusions from one list to the other.

Table 3 shows the number of words incorrectly recalled for both lists. For the semantically related word list these are divided into semantically similar (i.e. other animals) and dissimilar words. Because the unrelated word list included 12 different categories it was difficult to classify errors in recall as similar or different as almost all the errors could be related in some ways to the test categories. The data for incorrect recall are remarkably similar for the mentally retarded and normal children. The autistic children produced nearly three times more incorrect words than either of the other groups. The high totals for the autistic group are mainly due to four children who continued producing incorrect words until stopped by the experimenter. It is difficult to understand why these children interpreted the task in this way; however, it may have been because all attempts at recall were praised and encouraged and these children have been trained to comply with such reinforcement. Of particular interest are the recall errors produced by all the groups for the semantically related list. More than half of the incorrect words from each group were animal names, providing evidence that the children producing these errors had processed the meanings of the words on this test list and encoded correctly the animal category from which they were drawn. Proportionately fewer of the autistic children's errors were semantically similar (54 per cent of the total number of errors on this list) compared to the

Table 3. Total number of words incorrectly recalled by autistic, mentally retarded and normal children in Expt 1

	Autistic	Mentally retarded	Normal
Unrelated word list	79 (9)[a]	22 (8)	33 (12)
Related word list	81 (10)	34 (10)	25 (11)
Semantically related words	44 (9)	23 (8)	16 (10)
Unrelated words	37 (6)	11 (5)	9 (4)

[a] Number of children contributing to total shown in parentheses.

mentally retarded (68 per cent) and normal (64 per cent) groups. However, a chi-square test revealed no significant group differences (χ^2 (2) = 4.41).

These error data show indirectly that the children from all three groups had to some degree encoded the meanings of the to-be-recalled words. Nevertheless, clearer evidence that autistic children do semantically encode verbally presented material is needed in order to clarify the precise nature of the cognitive deficit demonstrated in their linguistic processing and recall patterns. This was accomplished in the second experiment in which semantic encoding was assessed using cued recall (cf. Tulving & Pearlstone, 1966).

Experiment 2

This experiment was designed to test the hypothesis that autistic children encode the meaning of words presented for recall to the same extent as mentally retarded and normal children, using a cued-recall paradigm. Matched groups of autistic, mentally retarded and normal children were compared in the ability to use semantic and phonemic cues to retrieve unrecalled words. This paradigm has been used in one study by Boucher & Warrington (1976) in which the semantic cue was a functional description of the to-be-recalled items, and the phonemic cue was the first letters of the word. They found that autistic children were comparable to control subjects in the use of such cues, although in other respects autistic children showed retrieval deficits that paralleled those found in amnesic adults (Boucher, 1981 *a*). This experiment is a replication of Boucher & Warrington's, using different stimuli and cues.

Method

Subjects. As in Expt 1, there were three groups of subjects: autistic, mentally retarded and normal children. Because a small number of the children who had completed the first experiment were no longer available, the exact composition of the groups was slightly different. For this experiment there were 14 subjects in each group, 13 of whom had participated in the first experiment. Again, all three groups were well matched on verbal mental age and forward digit span.

Stimuli. Two comparable lists of 12 unrelated nouns were drawn up, approximately matched for frequency. The words on each list were associated with specific cues. For one list the cues were words that rhymed with the target word (e.g. target—*fox*; cue—*box*). For the second list the cue was semantic, that is the superordinate category label of the target word (e.g. target—*cherry*; cue—*fruit*).

Procedure. Each child's cued recall was tested in a quiet room in the school that the child attended, in separate sessions, scheduled about a week apart. As in the previous experiment, each session began with a short practice list to familiarize the child with the task. The same instructions were used, asking the child to repeat the words spoken by one of the experimenters.

After the practice list the child was presented with one of the test lists. The order of presentation for the test lists was counterbalanced across subjects within each group. The 12 words on the test line were presented in random order by one experimenter, at a rate of one word every two seconds, using the same instructions as for the practice list. The child's recall of the words was recorded by the second experimenter. When no more words could be recalled the first experimenter offered cues. For the rhyme cue the experimenter said: 'I will say a word that rhymes with, that is it sounds like, one of the words I said before; so I said a word that sounds like ____. What was that word?' For the semantic cue the experimenter said: 'I will say a word that tells you what kind of thing the word I said before was; so I said a word that was a kind of ____. What was that word?' Thus for each word that had not been spontaneously recalled a cue was given, and the second experimenter recorded the child's response to each cue. The two test sessions were conducted in the same way.

Results and discussion

The number of words correctly recalled from both lists before and after the cues were presented was totalled for each subject. The group data are presented in Table 4. The data were analysed using ANOVA. For the subjects' pre-cued recall, group was the between-subjects factor, and list was a repeated measures factor. Neither group (F (2, 39) = 0.11) nor list (F (1, 39) = 0.18) were significant, nor was their interaction (F (2, 39) = 0.18).

Table 4. Mean number of words recalled before and after semantic and rhyme cues in Expt 2

	Autistic		Mentally retarded		Normal	
	M	SD	*M*	SD	*M*	SD
Semantic cue list						
Before cue	3.3	(2.1)	3.5	(1.6)	3.7	(1.5)
After cue	1.9	(1.7)	1.6	(1.6)	1.9	(1.4)
Total	5.2		5.1		5.6	
Rhyme cue list						
Before cue	3.5	(2.2)	3.6	(1.5)	3.6	(1.1)
After cue	1.7	(1.8)	0.5	(0.9)	2.2	(2.1)
Total	5.2		4.1		5.8	

Because post-cued recall is not independent of pre-cued recall, separate one-way ANOVAs were carried out on the post-rhyme cued and post-semantic cued recall. For the post-rhyme cued recall, group was significant (F (2, 39) = 3.91, $p < .05$). The Scheffé test at the 5 per cent significance level yielded a critical difference between means of 1.6, indicating that the mentally retarded group was significantly worse than the normal group in using a rhyme cue. There were no significant differences

between the autistic and control groups. For the post-semantic cued recall, there were no significant group differences (F (2, 39) = 0.2).

These data demonstrate that autistic children can use semantic cues as well as matched mentally retarded and normal children, thus replicating Boucher & Warrington's (1976) findings. The ability to use semantic cues to facilitate the retrieval of unrecalled words suggests that the children had encoded the meanings of the words when they were presented, however, it may also be that the cues work by non-specific prompting of the target words. Care was taken to select target words that were not highly prototypical for the category cue, nevertheless a breakdown of the error data in response to both types of cues showed that children frequently guessed at words that fitted the cue provided. The percentages of different error types made by the subjects are presented in Table 5. The relatively high proportion of errors that either rhymed with or were semantically related to the cues suggests that some correct post-cue reponses might have been the result of non-specific prompting. Since chi-square tests revealed no significant group differences either on correct responses or errors on the semantic list, the main conclusion, that autistic children are equivalent to matched control groups in semantic cued recall, is still supported.

Table 5. Percentage of different types of responses to semantic and rhyme cues presented in Expt 2

	Autistic	Mentally retarded	Normal
Semantic cue			
Correct response	21.8	20.8	19.7
Related semantic words	55.5	55.6	48.7
Repeats cue	0.0	8.1	3.4
Association response	3.4	6.4	1.7
Unrelated word	5.9	3.6	8.5
Don't know/no response	13.4	5.5	17.9
Rhyme cue			
Correct response	22.9	6.5	22.1
Related rhyming words	30.9	14.0	23.9
Repeats cue	9.5	10.3	7.4
Same first letter as cue	2.9	9.3	0.0
Association response	6.7	12.1	12.3
Unrelated word	1.9	19.6	15.4
Don't know/no response	25.7	28.1	18.9

The only significant difference found in this experiment was the relatively poor performance by the mentally retarded children on rhyme-cued recall. During testing it was clear that several subjects did not know what a rhyme was, despite the instructions that explained rhymes as words 'sounding like' the target words. Those children who never guessed words that rhymed with the cue probably did not understand the concept itself (see Table 4). In the normal group, four out of 14

children did not know what a rhyme was, six autistic children did not and 10 mentally retarded children did not.

Research has demonstrated that the concept of a rhyme, or phonological awareness, emerges in the preschool years (Read, 1971, 1978; Smith & Tager-Flusberg, 1982), but it may well be delayed in some mentally retarded children, especially those with low IQ levels. Because the mentally retarded group had significantly lower non-verbal IQs than the autistic and normal groups, the relationship between non-verbal IQ and the ability to use a rhyme cue was examined. Among the mentally retarded and autistic children, all those children who understood the concept of a rhyme had IQs above 60. However, the relationship between non-verbal IQ and use of rhyming cues was not so clear cut, and there were several mentally retarded children whose IQs were above 60 but who did not have the concept of a rhyme.

General discussion

The results of this study confirm and extend previous work on cognitive deficits in autistic children. The first experiment supports Hermelin & O'Connor's (1967) original finding that autistic children have specific difficulties processing semantic as well as syntactic and other structured verbal information (Frith, 1970 *a*). On the other hand, these results contradict Ramondo & Milech's (1984) negative findings on a semantic processing deficit. Differences between the studies are probably due to methodological problems in the experiment by Ramondo & Milech that were identified earlier.

The second experiment was conducted to clarify the form of the processing deficit in autism. Schwartz (1981) proposed three alternatives: a failure to encode linguistic information; a failure to retrieve encoded information; or a failure to acquire the linquistic knowledge necessary for encoding and retrieval. Because the cued-recall experiment showed that autistic children were comparable to matched controls in their ability to use a semantic cue, this suggests that they had understood the meanings of the words, and had encoded them appropriately; the deficit, therefore, is the result of failing to use effectively linguistic information to facilitate the retrieval of stored information.

This interpretation is supported by other research indicating that autism does not involve a primary deficit in acquiring linguistic knowledge, either semantic (Tager-Flusberg 1985 *b*, 1986) or syntactic (Paul, 1987; Swisher & Demetras, 1985; Tager-Flusberg, 1981, 1989). There are also other studies that found cued recall unimpaired in autistic children (Boucher & Lewis, 1989; Boucher & Warrington, 1976), thus providing additional evidence against an encoding deficit. The specific cognitive deficit thus appears to be related to retrieval, as Boucher and her colleagues have argued (Boucher, 1981 *a*,*b*; Boucher & Lewis, 1989; Boucher & Warrington, 1976). Work by Frith (1970 *b*) using visual stimuli, specifically colour sequences, suggests that the deficit is not limited to verbal material: autistic children are impaired in their ability to use knowledge spontaneously in a strategic way to facilitate cognitive processing.

In the last few years, research on psychological deficits in autism has turned in a

different direction. Experimental work by Baron-Cohen, Leslie and Frith (Baron-Cohen, 1989 *a,b*; Baron-Cohen, Leslie & Frith, 1985, 1986; Leslie & Frith, 1988; Perner, Frith, Leslie & Leekam, 1989) has led to the development of a new hypothesis about the core deficit underlying the syndrome of autism. According to these researchers, autistic children are impaired in the acquisition of a 'theory of mind'; that is, they have particular difficulty understanding mental states in themselves and other people. This hypothesis is especially important in that it explains the relationship between different aspects of the cognitive, social and linguistic deficits that are identified with autism (Baron-Cohen, 1988; Frith, 1989). How can we link these new ideas about the nature of the underlying deficit in autism to the older work on deficits in cognitive processing and memory, represented in the present study? In other words, could there be a relationship between problems in the acquisition of a theory of mind and the problem of using structured or semantic knowledge to facilitate memory retrieval?

In an interesting recent paper Perner (in press) provides the theoretical means for relating memory to theory of mind. Perner speculates that there is an important developmental connection between *experiential awareness* and *episodic memory*. Experiential awareness refers to 'being aware of one's experience', which is exemplified by an understanding of the relationship between informational (sensory) access and knowledge formation. Normal children develop this awareness at about the age of four, at the same time as they are developing other aspects of a theory of mind. Episodic memory is the term introduced by Tulving (1983, 1985) to refer to the memory system that 'mediates the remembering of personally experienced events' or, as Perner redefines it, 'mediates the remembering of *personal experiences of events*' (italics added). Episodic memory captures the conscious experience a person has of *remembering* something, in contrast to the experience of *knowing* something, which, according to Tulving, is mediated by the semantic memory system. Within an experimental paradigm, Tulving claims that free recall relies on episodic memory traces, whereas cued recall depends only on semantic memory. This distinction between semantic and episodic memory is still somewhat controversial and speculative in nature. Nevertheless, Perner hypothesizes that there is a developmental relationship between experiential awareness and episodic memory, suggesting that children's free recall should improve at the point when they develop experiential awareness (as well as other aspects of a theory of mind). Perner (in press) presents some supporting data from an experiment which found a significant correlation between free-recall ability and experiential awareness, as measured by the ability to distinguish 'know' and 'guess'.

Perner's claim, clearly speculative at this point, is that, as children develop a theory of mind — which includes an understanding of where knowledge comes from — and a conscious experience of knowing that one knows something, they begin to develop episodic memory. With the advent of episodic memory, free recall improves significantly, as does memory for personally experienced events. Without episodic memory, free recall will be relatively limited and lack the quality of 'remembering' with a high degree of certainty that is only possible with episodic memory.

Although neither Tulving nor Perner discuss how memory strategies or metamemory capacities might be related to episodic memory, it follows from their

descriptions that enhancing memory by the use of strategies entails conscious awareness of the need to remember; in other words the use of episodic memory. Following Perner's argument, therefore, the ability to use strategies to facilitate recall, which depends on episodic memory, is closely connected with the development of experiential awareness, one key component of a theory of mind. To put it another way, retrieval from long-term memory in free-recall tasks requires conscious or deliberate processing of stored information.

Autistic children have been shown to be significantly impaired in their acquisition of numerous aspects of a theory of mind. From this, we might speculate that they lack experiential awareness, and are impaired in their acquisition of episodic memory. Following Perner's hypothesis, children with deficits in episodic memory should be impaired on free-recall tasks, especially those requiring strategies to enhance recall, and in remembering personally experienced events, but should be unimpaired on cued-recall tasks which rely exclusively on semantic memory. These predictions were supported in the experiments reported here and fit well with the findings of Boucher and her colleagues (Boucher, 1981 *a*,*b*; Boucher & Lewis, 1989; Boucher & Warrington, 1976), all of which suggest a deficit in episodic memory, using Tulving's definition.

These speculations suggest that there may be a potential relationship between earlier work on cognitive deficits in autism, and current research that focuses on deficits in theory of mind. There is, however, an obvious need for more research on experiential awareness in autistic children, related aspects of cognitive functioning, memory ability and other aspects of a theory of mind, before we can move from conjecture towards the development of specific theories about the underlying nature of the cognitive deficit in autism.

Acknowledgements

This research was supported by grants from the National Institute of Mental Health (5RO1 MH-37074) and a Social and Behavioral Sciences Research Grant (no. 12–181) from the March of Dimes Research Foundation.

I am grateful to the teachers and students at the following schools in Massachusetts for their help and participation in this study: the League School, Newton; St Colletta's Day School, Braintree; the Osgood School, Cohasset; South Shore Educational Collaborative, Hingham; University of Massachusetts–Boston Child Care Center. I am also indebted to Helene Chaika Fausold for her help in preparing the stimuli, data collection and coding.

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Received 4 August 1989; revised version received 9 August 1990