

*This paper appeared in
Journal of Child Psychology and Psychiatry, 1997, 38, 527-534*

**Are people with autism and Asperger
Syndrome faster than normal on the Embedded
Figures Test?**

Therese Jolliffe and Simon Baron-Cohen

Departments of Experimental Psychology and Psychiatry,
University of Cambridge, Downing St,
Cambridge, CB2 3EB, UK.

Abstract

Previous work suggests children with autism show superior performance (in relation to their general mental age) on the Embedded Figures Task (EFT). Frith interprets this as showing that they have “weak central coherence”. In Experiment 1, using an adult level version of this task, we aimed to replicate and extend this finding, first, by collecting response time (RT) data; secondly, by testing adults with autism who were normally intelligent; and thirdly, by testing a group of normally intelligent adults with Asperger Syndrome (AS), in order to test for differences between autism and AS. Both clinical groups were significantly faster on the EFT. In Experiment 2, we investigated if this difference was due to a preference for local over global processing, using a novel drawing task, based on the classical Rey Figure. The clinical groups did not differ significantly on this test, but there was a trend towards such a difference. Alternative explanations for the EFT superiority in autism and AS are considered.

More than a decade ago, a small Research Note was published in this Journal (Shah & Frith, 1983). In it, an interesting finding was reported. Children with autism, when tested on the Embedded Figures Test (EFT), functioned at a level above that of their general mental age (MA). On the EFT, the subject is shown a complex design, and then is asked to find a target (simple) shape within the complex design. Children with autism were reported to be more accurate on this test.

This was important for several reasons. First, cognitive abnormalities in autism are usually thought of in terms of *deficits* rather than superior skills (e.g., Baron-Cohen, Leslie & Frith, 1985, regarding ‘theory of mind’ deficits; or Tager-Flusberg, 1989, 1993, regarding ‘pragmatics’ deficits). Their superior performance (in relation to their general mental age) on the EFT therefore suggests we should not in all respects conceptualize autism as a disability but in some respects consider it as a different type of information-processing system. Secondly, the EFT superiority was found even in a group of mentally handicapped children with autism, when matched with a non-autistic mentally handicapped control group. Thus it is unlikely that the effect could be a function of IQ as generally construed. Thirdly, it suggests that autism might be due to abnormalities in processing information in the *non-social* domain (see Courchesne et al, 1994; Dawson, 1989; Hermelin & O’Connor, 1970; Bryson, Wainwright-Sharp & Smith 1990), despite the fact that a core symptom in autism is social abnormality (Rutter, 1983; Wing, 1976; Baron-Cohen, 1988; Kanner, 1943).

All the more surprising was that this finding, despite its potential importance, failed to receive the attention due to it. In part this was probably because much psychological research during the rest of the 1980’s involved studies of *social* cognition (see Baron-Cohen, 1995). But in retrospect, the importance of the Shah and Frith finding on the EFT should have been picked up with far greater haste, since it had relevance to a feature of autism that had long been recognized but poorly understood: “islets of ability” (Kanner, 1943). Right through the 1960’s and 70’s a range of studies

(Hermelin & O'Connor, 1970; Bartak, Rutter & Cox, 1975) had demonstrated that children with autism show characteristic peaks and troughs in their scores on IQ subtests, with well-preserved and often superior functioning on certain visuospatial tests such as the Block Design, alongside relative impairments on more verbal tests such as Comprehension. The peak performance on Block Design has been repeatedly demonstrated since then (Allen, Lincoln & Kaufman, 1991; Happé, 1994; Lincoln, Courchesne, Kilman, Elmasian & Allen, 1988; Ohta, 1987; Shah & Frith, 1993; Szatmari, Tuff, Finlayson & Bartolucci, 1990).

In addition, the association between autism and the phenomenon of “idiot savant” had been frequently described (Selfe, 1977; Hermelin & O'Connor, 1970) - and the “savant” abilities were often (though not exclusively) in visuospatial domains (e.g.: drawing). The EFT result might have been a potentially important clue to why such an uneven cognitive profile, and savant abilities, are significantly associated with autism. Frith and her colleagues (Frith, 1989; Frith & Happé, 1994) were among the few to recognise the potential significance of the EFT result.

A further reason that the EFT result should have been taken seriously is that independent studies in normal samples had pointed to an unexpected connection between performance on the EFT and social behaviour. Thus Paul (1975) found that normal children who exhibited less separation anxiety were better at disembedding. Witkin, Oltman, Raskin and Karp (1971) and Kagan and Kogan (1970) found low sensitivity to social cues was associated with high performance on the EFT and vice-versa. Also, Eagle, Goldberger and Breitman (1969), and Fitzgibbons, Goldberger and Eagle (1965) found that good performers on the EFT tended to show lower incidental learning for social material than poorer performers, but did not differ when the material was nonsocial.

Finally, Witkin and Goodenough (1977) found that poor performers on the EFT pay more attention than good performers to social cues: “they favour situations that bring them into contact with others over solitary situations; they prefer educational-vocational domains that are social in content and require working with people; they seek physical closeness to people in their social interactions; they are more open in their feelings” (*ibid*, p.43); and they show characteristics such as warmth, affection, tact and accommodation. These contrast with the characteristics reported for good performers on the EFT, such as being cold and distant. This line of research suggests that autism might be at one end (the good performers end) of the normal continuum of EFT scorers.

Brian and Bryson (in press) and Ozonoff, Pennington and Rogers (1991) both attempted to replicate the Shah and Frith (1983) finding of autistic superiority on the EFT, but found no differences to matched controls. Because these results are at odds with the Shah and Frith study, we set out to investigate EFT performance further in autism and Asperger’s Syndrome, in order to elucidate possible reasons for the discrepant results.

In Experiment 1, reported below, we aimed to test the EFT finding, by attempting to replicate Shah and Frith’s study. We also aimed to extend their earlier study in four ways. First, we aimed to collect response time (RT) data, since the original study had omitted to do this - yet there was the real possibility that people with autism might actually be *faster* as well as more accurate on the EFT. Secondly we included subjects of normal intelligence, so as to study what might be considered “pure autism” - unconfounded by mental handicap. Such a design might conceivably highlight the EFT superiority even more clearly. Thirdly, we included subjects with Asperger Syndrome (AS), so as to test if the EFT superiority was restricted to autism, or was a feature of this related condition. In part, this would reveal if language played any part in the effect, since the key difference between autism and AS is that in the former there is a history of language delay, whilst in the latter there is not. (Language

delay tends to be defined quite narrowly: not using single words by 2 years old, and not using phrase speech by three. Pragmatics is not included). We predicted that the EFT superiority would be found in both autism and AS, if this is a core cognitive feature of the continuum (Wing, 1976) on which both conditions lie. Finally, we tested *adults* with both autism and AS, whereas the original study had only tested children. This was because it afforded us the opportunity of using the more challenging adult version of the EFT (Witkin et al , 1971). If superiority was still found on this much more taxing test, this would underscore the difference in cognitive style.

Experiment 1: The Embedded Figures Test

Subjects

51 adults participated in the study. These comprised 17 normal adult controls (henceforth the Normal Group), 17 individuals with high-functioning autism (HFA), and 17 with Asperger Syndrome (AS). The sex ratio in all 3 groups was 15:2 (m:f), reflecting the sex ratio found in these clinical groups in other studies (Wing, 1981). The groups were also closely matched on handedness. The HFA Group all showed a history of ‘classical’ autism (i.e. autism accompanied by language delay) and fulfilled established diagnostic criteria (DSM-IV, American Psychiatric Association 1994). Note that because they were high-functioning adults, they would be considered “residual” cases. The AS Group all met the same criteria for autism, but without any clinically significant language delay. They thus met criteria for AS as defined in ICD-10 (World Health Organisation, 1994). Such clinical subjects, being of normal intelligence, are relatively rare and were therefore recruited via a wide range of clinicians. The 17 normal controls were drawn from the city centre of Cambridge (excluding students of the University) and were all free of any psychiatric symptoms.

All subjects were selected for being of at least normal intelligence (i.e., scoring ≥ 85) on the WAIS-R (full scale, performance, and verbal IQ). Table 1 gives the subject characteristics in terms of chronological age (CA), verbal IQ (VIQ), performance IQ (PIQ) and full-scale IQ (FSIQ). ANOVAs revealed no significant differences between groups on any of these variables: CA: $F(2, 48) = 0.59$, $p = .56$; VIQ: $F(2, 48) = 0.54$, $p = .59$; PIQ: $F(2, 48) = 0.6$, $p = .55$ and FSIQ: $F(2,48) = 0.15$, $p = .87$.

insert table 1 about here

Materials

The standard adult Embedded Figures Test (EFT) (Witkin et al, 1971) was used. This has two alternative versions (Form A and B) which do not differ in terms of number of stimuli, or difficulty. Form A was therefore chosen. This consists of a set of 12 test cards, each depicting a different complex design. For each complex design there is a simple shape hidden somewhere within it. In fact, there are just 8 different simple shapes, because some of these are common to several complex designs.

Procedure

All subjects were tested either in their homes, or in a quiet room in the University. Each design, with its simple shape, was placed back to back and laminated. In accordance with the instruction manual, the designs were presented in a fixed order, beginning with a practice item. This fixed order guards against demotivating

subjects, since the items become progressively more difficult. A stylus pen was provided to enable the subject to trace the outline of the simple shape in each design. A stopwatch was used to measure response time.

The practice item

The experimenter introduced the test by saying: "I am going to show you some coloured designs, like this one. Each time I show you one, I want you to describe it in any way you like. I will then show you a simple shape which is contained within the coloured design. You will then be given the larger design again, and your job is to locate the simple shape in it. Let's have a try before we start the task."

The experimenter showed the subject the practice complex design for 15 seconds. She then turned the design over to reveal the simple shape on the back. After 10 seconds the experimenter said: "Now look at the design again. See if you can find the simple shape. Tell me as soon as you find it and then start tracing the lines of the simple shape with this pen."

The experimenter then re-exposed the design by turning over the card, and immediately started recording response time. As soon as the subject said s/he had found the simple shape, the experimenter noted the time. If the subject had traced the shape correctly, this speed was recorded as the response time for the practice item. No subject had any difficulty in finding the simple shape in the practice design.

The test items

After the practice item, the experimenter said: "OK, that's how we are going to do all the designs. Some of the shapes might be a little bit difficult to find but they will always be there. Also they are always in an upright position - the same way you see it,

so you don't have to tilt the card in order to find it. Some of the designs contain several examples of the shape you need to find, but you only need to trace one of them. Work as quickly as you can, because I will be timing you, but you need to be accurate as well. The shape you find should be exactly the same as the original one you saw on the back of the card - the same size and proportions. Tell me as soon as you have found the shape and start tracing it out. If you forget what the shape looks like, tell me and you can look at it again - as often as you like. Do you have any questions?"

In accordance with the instructions in the EFT manual, the experimenter then presented each design for 15 seconds, asking subjects to describe it in any way they wish, in order to assist encoding the design; then turning it over to reveal the simple shape for 10 seconds; then turning back the card to reveal the complex design whilst simultaneously starting the stopwatch. Subjects were encouraged with positive comments.

Timing procedure

The timing procedure was based on the instructions in the EFT manual: The stopwatch was started as soon as the complex design was exposed. As soon as the subject reported seeing the simple shape, the experimenter recorded the time, but did not stop the watch. If the subject's tracing was incomplete or inaccurate, the experimenter said to the subject: "No, that's not it," and carried on timing. When the subject again reported they had found the simple shape, the experimenter only recorded the time if and when the tracing was also correct. Subjects were given an upper limit of three minutes (180 secs) to trace out the embedded figure. Failure to find the simple shape within this allotted time resulted in the attempt being scored as a failure. The response time in such cases was recorded as 180 s (F).

If a subject wanted to re-examine the simple shape, the stopwatch was stopped and the simple shape was again exposed. Subjects were given a further 10 seconds to re-examine the shape. After this, the complex design was reexposed and the stopwatch restarted. The subject was shown the simple shape as often as they liked, so as to minimize effects being due to memory problems. All response times were scored in whole seconds.

Scoring

Two scores were recorded:

(i) the response time (the time taken to correctly locate/trace out the embedded figure); (ii) the accuracy score (the number of correct solutions within the time allowed).

Results

The mean accuracy score and mean response time for each of the three groups is shown in Table 2.

insert table 2 about here

The data were approximately normally distributed for each group and there were no obvious outliers, so two one-way ANOVA's were performed, one on each performance measure. The groups did not differ in terms of accuracy $F(2, 48) = 1.046, p = .36$. However, they did differ in terms of response time: $F(2,48) = 3.66, p = .03$. Post-hoc comparisons showed the clinical groups to be significantly faster than the normal control group ($p < .05$), but the clinical groups did not themselves differ significantly (Newman-Keuls test).

Discussion

As predicted, both groups of clinical subjects were significantly faster on the EFT than age and IQ matched normal controls. This replicates the finding of superior performance reported by Shah and Frith (1983), and extends it by demonstrating this in terms of speed, on a more challenging adult-level test, and finding it in adults of normal intelligence who have either autism or Asperger Syndrome (AS). There were no significant group differences in terms of accuracy on the EFT, and this replicates the study by Ozonoff, Pennington and Rogers (1991), whilst underscoring the importance of collecting response time (RT) data, rather than simply accuracy data. We do not have any explanation of why accuracy data produced different findings in Shah & Frith's study compared to ours.

Of interest, many studies have found normal males to be faster than normal females on this task (e.g. Witkin et al, 1971). The mean RT scores from the clinical subjects in this study were even faster than those of normal males - compared to published norms. Elsewhere (Baron-Cohen & Hammer, in press) we have suggested that in this respect, autism and AS may represent an extreme of the 'male cognitive style', or the 'male brain' (defined as spatial skills being greater than social skills). In a more recent study (Baron-Cohen & Hammer, 1996) we have also found this EFT superiority among the *parents* of children with AS, suggesting that since autism and AS have a strong genetic component (Bolton & Rutter, 1990; Gillberg, 1991), EFT superiority may be an important part of the cognitive phenotype of autism/AS.

However, by itself, it is not clear what is causing this EFT superiority in autism and AS. Frith (1989) suggests it arises from "weak central coherence", but this is in need of greater specification. Is it due, for example, to a lack of the normal precedence of global over local processing? Global precedence is defined as attending more to

global than to local details. To test this hypothesis, we carried out a second experiment, reported next.

Experiment 2: The Modified Rey Figure Task

In Experiment 2 we used a modified version of the classical Rey Complex Figure Test (Osterrieth, 1944). In the classical form, the subject is shown a drawing of an unfamiliar, abstract nature, and is asked either to copy it or to draw it from memory. Typically it is used by neuropsychologists to assess visuospatial memory (Lezak, 1983). We considered that it might also enable us to examine if drawings by our subjects with autism or AS reflect a lack of the normal global precedence. Normal subjects would be expected to use a global strategy (drawing the outline first, and filling in the details later), if they have “strong central coherence”, whilst subjects with autism or AS might be expected to use a local strategy (drawing the details first, and completing the outline later), if as Frith suggests they have “weak central coherence”. However, the original Rey Figure does not have an ‘outline’ which constitutes an easily identifiable shape. In order to facilitate scoring drawing style, we produced a modified version of the Rey Figure (see Figure 1).

insert Figure 1 about here

The advantage of the modified Rey Figure is thus two-fold: First, the outline is easily defined, whilst it nevertheless contains local detail. This makes for ease of scoring. Secondly, it is made up of purely straight lines, which can be formed in smaller (local) or larger (global) units. Using a videocamera, it is therefore possible to record (a) if the subject draws the outline first, or later; and (b) how many lines the subject draws to complete the drawing.

Subjects

These were the same as those who took part in Experiment 1.

Materials

A large black rectangle, split into nine equal sized smaller rectangles, was shown (see Figure 1). The smaller rectangles each contain *either* a diagonal line going upwards from left to right, or two diagonal lines which cross to form an X. The whole figure was presented on white card measuring 15 x 21 cm. Blank sheets of paper and a black felt pen for drawing the figure were provided. A video camera was used to record how the subject drew the figure.

Procedure

Subjects were told they would see a pattern, and that they would have one minute to look at it, after which they would be asked to draw it from memory. They were shown the video camera and told that only their hand - not their face - would be filmed. The figure was then placed face down on the table directly in front of the subject. It was then exposed, and after 60 seconds the figure was again turned face down on the table. The subject was handed a sheet of paper, along with the black pen and asked to start drawing the design. The experimenter sat next to the subject, on the side of their non-dominant hand so that she could videorecord the subjects drawing approach.

Scoring

Each subject was scored on (a) the number of lines used to complete the figure, and (b) whether the global outline was drawn first (before the details) or later (after the details).

Results

Only subjects who drew a complete and correct representation of the figure were included in the analysis. Incorrect representations (with missing or additional lines not portrayed in the original figure) were therefore excluded. This resulted in the exclusion of one adult in the HFA group, three in the AS group, and three normal control subjects. (Although it was possible to include those who drew incomplete or incorrect representations in the analysis of the global outline of the figure - we chose not to include these subjects for the purpose of consistency with our analysis of the mean number of lines used to complete the figure). The mean number of lines used to complete the figure for each of the three groups is shown in Table 3. The number of subjects in each group who drew the global outline first is shown in Table 4.

insert tables 3 and 4 about here

Since the data for all groups was positively skewed, and contained at least one outlier in each clinical group, a Mann-Whitney test was used to look for group differences in the mean number of lines used to complete the figure. A line was defined as any single line drawn in a single smooth gesture and without a change in angle. The Mann-Whitney comparisons showed no differences between the clinical groups (Autism x Asperger, $U = 74.5$, $p = .47$) and nor were there differences between the clinical groups and the normal group (Autism x Normal, $U = 37.5$, $p = .42$; Asperger x Normal, $U = 69.5$, $p = .45$). Equally, the groups did not differ in terms of

how many drew the global outline first (Fisher Exact Probability Test: Autism x Normal, $p = .1$; Autism x Asperger, $p = .27$; and Asperger x Normal, $p = .248$).

Discussion and General Conclusions

The results of Experiment 2 show that neither adults with autism or AS differ from normal controls in terms of the number of lines they use to reproduce a complex drawing, and nor do they differ in terms of their strategy: they are as likely to begin their drawing by creating the global outline as normal controls are. Inspection of Table 4 however does reveal that there was a trend for the group with autism to draw the global outline later in more cases than was seen in the normal group. Similarly, inspection of Table 3 reveals that there was a trend for the group with autism to draw in a more fragmented way - using more lines to complete the figure.

Like Shah and Frith (1983; 1993) we found an autistic superiority in disembedding, whilst Brian and Bryson (in press) did not. It is useful to explore the different findings between the studies.

Brian and Bryson explored whether Shah and Frith's (1983; 1993) findings of superior disembedding performance in autism reflected 'less capture by meaning'. They contrasted the meaningful designs used by Shah and Frith (1983) with that of abstract designs (similar to ours) and that of fragmented designs without any real global outline. They also tested recognition memory for these designs. They failed to find any differences between their clinical and their two matched control groups on any of their measures; accuracy, response time, or the strategy used to locate the

figure (i.e. whether the shape was found immediately, or whether subjects used a visual search strategy, or used a more concrete strategy of using a cut-out shape).

It is nevertheless useful to compare Brian and Bryson's study with our own, since both we and they employed a high-functioning group with autism. There are number of methodological differences between our study and that of Brian and Bryson which could account for the difference in findings. Firstly, the inclusion of a PDD group must make any direct comparison with our study quite difficult, since we only included individuals with a firm diagnoses of either autism or Asperger's syndrome.

Secondly, their use of a Bonferroni type adjustment for multiple comparisons (where the alpha level was divided by three) resulted in their level for significance being set at $p=.016$, which would have made it more difficult to detect group differences. We made fewer comparisons and so did not need to adopt such stringent measures. Had we done so, it is likely that we would too might have failed to detect a difference between our groups.

Thirdly, the adult version requires subjects to describe the complex design for 15 seconds prior to even seeing the simple shape which had to be found, whereas the children's version appears to have no such requirement. The normal adults in our study not only had more to say about the abstract designs but frequently made them meaningful by describing them as a kite, a fan, a staircase, a rug, a window, etc., whereas the clinical groups rarely did this instead referring to designs as being a number of triangles and squares, etc. As Brian and Bryson noted in their study, disembedding from meaningful contexts was slower, so there is a strong possibility that in our study the normal control subjects may have been slower to disembed due to their tendency to look for meaning. Our normal individuals' mean response time

was similar to that of published norms (47.7 - 55.6 seconds for males, and 63.6 - 84.2 seconds for females).

It is also likely that there are sub-groups within the autistic spectrum, since like Shah and Frith (1983) we found that some of our clinical subjects predominate pattern of responding was to find the shape immediately, whereas only one subject with autism showed this type of pattern in Brian and Bryson's study.

Finally, Brian and Bryson also tested incidental memory for the shape of the meaningful and abstract designs. The meaningful shapes were better remembered by both clinical and control subjects. We did not look at recognition of our shapes, since Navon (1977) argues that global perception precedes local perception. There is no reason to believe that individuals with autism are less likely to recognise objects that they have seen - indeed if they did, their biological survival would be seriously compromised. Brian and Bryson's decision to test recognition memory may in part stem from the common confusion between global advantage (the ability to see and process a gestalt) and global precedence (the relative significance of the gestalt or outline in relation to its local details).

Regarding the lack of differences in the memory recognition task, Brian and Bryson manipulated the internal details for a quarter of the stimuli. Subjects, quite rightly, were unaware that their memory was going to be tested, but they were also not warned in the recognition test that internal details could differ. Given that subjects only had five seconds, which is probably insufficient to encourage the analysis of details, and given that processing frequently stops at the global level for recognition (Navon 1977), it is not surprising to us that there was no group difference at the level of recognition of internal details in their study.

In the final part of this paper we turn to consider what might be causing the autistic/AS superiority on the EFT in our study. We float three hypotheses, which future research will need to test. The first of these we call the superior segmentation hypothesis. Under this hypothesis, people with autism/AS may simply be faster at analysis of complex information into constituent components. The finding that they are quicker at the Block Design subtest of the WISC/WAIS is consistent with this hypothesis (Shah & Frith, 1993).

The second hypothesis we call the superior spatial hypothesis. Under this hypothesis, people with autism/AS may simply be superior at all spatial tasks, the EFT being just one of these. The Block Design result in Shah and Frith's (1993) study suggests their advantage is not spatial in nature, although this needs further testing. We are currently testing this using the Mental Rotation task (Shepherd & Metzler, 1971).

The third hypothesis we call the global precedence hypothesis. Under this hypothesis, people with autism and AS lack global precedence, even though they show the normal global advantage. The term 'global precedence' means attending more to global details than local details. The term 'global advantage' means attending to the outline of an object first/faster (Navon, 1977). Experiment 2 suggests they show normal global advantage, and it is no surprise that that this is intact since their biological survival would be seriously compromised without it. But it remains an open question as to whether people with autism or AS show global precedence, and there are seeds of evidence from other studies that they may not.

First, Mottron and Belleville (1993) found in a single case study that, using the Navon task (Navon, 1977), a man with autism (E.C.) showed a lack of global precedence in the presence of intact global advantage. In the Navon task the subject is shown a large letter H made of little H's ('compatible' global and local features), or made of little

S's ('incompatible' global and local features). Subjects are asked to name the big and little letters. Ozonoff, Strayer, McMahon, and Filloux (1994) failed to replicate Mottron and Belleville's finding, but this was probably because they used an exposure time that was far too long to bring out this subtle effect. (In the Mottron and Belleville study the deficit only appeared at an exposure time of 10-25 milliseconds, whereas in the Ozonoff study the exposure time was 1000 milliseconds. Hence their latencies were long: 550 ms for the global level, and 650 ms for the local level). Mottron and Belleville also asked subjects to report both levels (eg: "a large letter O made up of small letter C's"), whereas Ozonoff et al only asked subjects to respond at one level. This may have led to a response bias.

Secondly, previous studies that have used the classical Rey Figure Test (Prior & Hoffman, 1990; Steel, Gorman & Flexman, 1984) suggest that subjects with autism may indeed focus more on detail than is normally seen. It may have been that as a result of simplifying the figure to be drawn in Experiment 2 (above), we created conditions in which the subjects did not need to focus on details to the same degree. Certainly, the global precedence hypothesis is consistent with the drawing characteristics of "savant" artists who exhibit the idiosyncratic tendency to begin a figure by a peripheral detail (Hermelin & O'Connor, 1990; O'Connor & Hermelin, 1987; O'Connor & Hermelin, 1990; Selfe, 1977, 1983). Identifying which of these hypotheses, if any, can explain the EFT superiority, is a necessary next step in the neuropsychology of autism and AS.

References

- Allen, M., Lincoln, A. & Kaufman, A. (1991). Sequential and simultaneous processing abilities of high-functioning autistic children and language impaired children. Journal of Autism and Developmental Disorders, **21**, 483-502.
- American Psychiatric Association. (1994). Diagnostic and Statistical Manual of Mental Disorders. Fourth Edition. Washington DC: American Psychiatric Association.
- Asarnow, R. F., Tanguay, P. E., Bott, L. & Freeman, B. J. (1987). Patterns of I.Q. in nonretarded autistic and schizophrenic children. Journal of Child Psychology and Psychiatry, **28**, 273-280.
- Asperger, H. (1944). Die "Autistischen Psychopathen" im Kindesalter. Archiv fur Psychiatrie und Nervenkrankheiten, **117**, 76-136. Reprinted in U. Frith. (1991). Autism and Asperger's Syndrome. Cambridge University Press.
- Baron-Cohen, S. (1988a). Social and pragmatic deficits in autism: cognitive or affective? Journal of Autism and Developmental Disorders, **18**, 379-402.
- Baron-Cohen, S. (1995). Mindblindness: an essay on autism and theory of mind. MIT Press/Bradford Books.
- Baron-Cohen, S. & Hammer (in press). Is autism an extreme form of the male brain? In Infant Behaviour and Development, **11**.
- Baron-Cohen, S. & Hammer, J. (1996). Parents of children with Asperger Syndrome:

What is the cognitive phenotype? Unpublished ms, University of Cambridge.

- Baron-Cohen, S; Leslie, A.M. & Frith, U. (1985). Does the autistic child have a “theory of mind”? Cognition, **21**, 37-46.
- Bartak, L., Rutter, M & Cox, A. (1975). A comparative study of infantile autism and specific developmental receptive language disorder: 1. The children. British Journal of Psychiatry, **126**, 127-145.
- Bolton, P. & Rutter, M. (1990). Genetic influences in autism. International Review of Psychiatry, **2**, 67-80.
- Brian, J. A. & Bryson, S. E. (in press). Disembedding Performance and Recognition Memory in Autism/PDD. Journal of Child Psychology and Psychiatry.
- Bryson, S.E., Wainwright-Sharp, J.A. & Smith, I. (1990). Autism: A developmental spatial neglect syndrome? In J. T. Enns (Ed.), The development of attention: Research and theory (pp. 405-427). North-Holland: Elsevier.
- Courchesne, E., Townsend, J. P., Akshoomoff, N. A., Yeung-Courchesne, R., Press, G. A. & Murakami, J. W. (1994). A new finding: Impairment in shifting attention in autistic and cerebellar patients. In S. H. Broman & J. Grafman (Eds.), Atypical cognitive deficits in developmental disorders: Implications for brain development (pp. 101-137). Hillsdale, NJ: Erlbaum.
- Eagle, M., Goldberger, L. & Eagle, M. (1969). Field dependence and memory for social vs neutral and relevant vs irrelevant incidental stimuli. Perceptual and Motor Skills, **29**, 903-910.

- Fitzgibbons, D., Goldberger, L & Eagle, M. (1965). Field dependence and memory for incidental material. Perceptual and Motor Skills, **21**, 743-749.
- Frith, U. (1989). Autism: explaining the enigma (pp. 95-102). Oxford: Basil Blackwell.
- Frith, U. & Happe, F. (1994). Autism: beyond "theory of mind". Cognition, **50**, 115-132.
- Gillberg, C. (1991). Clinical and neurobiological aspects of Asperger Syndrome in six family studies. In U. Frith. (Ed.), Autism and Asperger's syndrome (pp. 122-146). Cambridge: Cambridge University Press.
- Happé, F. (1994). Autism (pp. 22-48). London: UCL Press.
- Happé, F. (1994). Wechsler IQ Profile and Theory of Mind in Autism: A Research Note. Journal of Child Psychology and Psychiatry, **35**, 1461-1471.
- Hermelin, B. & O'Connor, N. (1970). Psychological experiments with autistic children. Oxford: Pergamon Press.
- Hermelin, B. & O'Connor, N. (1990). Art and accuracy: the drawing ability of idiots-savants. Journal of Child Psychology and Psychiatry, **31**, 217-228.
- Kagan, J. & Kogan, N. (1970). Individuality and cognitive performance. New York: John Wiley.
- Kanner, L. (1943). Autistic disturbance of affective contact. Nervous Child, **2**, 217-250. Reprinted in L. Kanner. (1973). Childhood Psychosis: Initial Studies and New Insights. New York: John Wiley and Sons.

- Lezak, M. (1983). Neuropsychological assessment (pp. 395 - 402). Oxford: Oxford University Press.
- Lincoln, A., Courchesne, E., Kilman, B., Elmasian, R. & Allen, M. (1988). A study of intellectual abilities of high-functioning people with autism. Journal of Autism and Developmental Disorders, **18**, 505-523.
- Mottron, L & Belleville, S. (1993). A study of perceptual analysis in a high-level autistic subject with exceptional graphic abilities. Brain and Cognition, **23**, 279-309.
- Navon, D. (1977). Forest before trees: the precedence of global features in visual perception. Cognitive Psychology, **9**, 353-383.
- O'Connor, N. & Hermelin, B. (1987). Visual and graphic abilities of the idiot savant artist. Psychological Medicine, **17**, 79-90.
- O'Connor, N. & Hermelin, B. (1990). The recognition failure and graphic success of idiots-savant artists. Journal of Child Psychology and Psychiatry, **31**, 203-215.
- Ohta, M. (1987). Cognitive disorders of infantile autism: a study employing the WISC, spatial relationship conceptualization, and gesture imitation. Journal of Autism and Developmental Disorders, **17**, 45-62.
- Osterrieth, P. (1944). Le test de copie d'une figure complexe. Archives de Psychologie, **30**, 206-356.

- Ozonoff, S., Pennington, B & Rogers, S. (1991). Executive function deficits in high-functioning autistic children: relationship to theory of mind. Journal of Child Psychology and Psychiatry, **32**, 1081-1106.
- Ozonoff, S., Strayer, D., McMahon, W. & Filloux, F. (1994). Executive function abilities in autism and Tourette Syndrome: an information processing approach. Journal of Child Psychology and Psychiatry, **35**, 1015-1032.
- Paul, E. (1975). A study of the relationship between separation and field-dependency in a group of 3 year old nursery children. Unpublished Master's thesis, Bank St College of Education.
- Prior, M. & Hoffman, W. (1990). Neuropsychological testing of autistic children through exploration with frontal lobe tests. Journal of Autism and Developmental Disorders, **20**, 581-590.
- Rumsey, J. M., Creasey, H., Stepanek, J. S., Dowart, R., Patronas, N., Hamburger, S. D. & Duara, R. (1988). Hemispheric Asymmetries, Fourth Ventricular Size, and Cerebellar Morphology in Autism. Journal of Autism and Developmental Disorders, **18**, 127-137.
- Rumsey, J. M. & Hamburger, S. D. (1990). Neuropsychological Divergence of High-Level Autism and Severe Dyslexia. Journal of Autism and Developmental Disorders, **20**, 155-168.
- Rutter, M. (1978). Diagnosis and definition. In M. Rutter & E. Schopler. (Eds.), Autism: a reappraisal of concepts and treatment. (pp 1-25)New York: Plenum Press.

- Rutter, M. (1983). Cognitive deficits in the pathogenesis of autism. Journal of Child Psychology and Psychiatry, **24**, 513-531.
- Selfe, L. (1977). Nadia: a case of extraordinary drawing ability in an autistic child. London: Academic Press.
- Selfe, L. (1983). Normal and Anomalous Representational Drawing Ability in Children. London: Academic Press.
- Shah, A. & Frith, U. (1983). An islet of ability in autism: a research note. Journal of Child Psychology and Psychiatry, **24**, 613-620.
- Shah, A. & Frith, U. (1993). Why do autistic individuals show superior performance on the block design test? Journal of Child Psychology and Psychiatry, **34**, 1351-1364.
- Shepard, R. & Metzler, J. (1971). Mental rotation of 3-dimensional objects. Science, **171**, 701-703.
- Steel, J., Gorman, R. & Flexman, J. (1984). Neuropsychiatric testing in an autistic idiot-savant: evidence for non-verbal abstract capacity. Journal of the American Academy of Child and Adolescent Psychiatry, **23**, 704-707.
- Szatmari, P., Tuff, L., Finlayson, M & Bartolucci, G. (1990). Asperger Syndrome and autism: neurocognitive aspects. Journal of the American Academy of Child and Adolescent Psychiatry, **29**, 130-136.
- Tager-Flusberg, H. (1989). A psycholinguistic perspective on language development in

the autistic child. in G. Dawson. (Ed.), Autism: nature, diagnosis, and treatment (pp. 92-115). New York: Guilford Press.

Tager-Flusberg, H. (1993). What language reveals about the understanding of minds in

children with autism. In S. Baron-Cohen., H. Tager-Flusberg & D. J. Cohen. (Eds.), Understanding other minds: perspectives from autism (pp. 138-157). Oxford: Oxford University Press.

Tymchuk, A. J., Simmons, J. Q. & Neafsey, S. (1977). Intellectual characteristics of adolescent childhood psychotics with high verbal ability. Journal of mental deficiency research, **21**, 133-138.

Wing, L. (1976). Early Childhood Autism. Pergamon Press.

Wing, L. (1981). Asperger Syndrome: a clinical account. Psychological Medicine, **11**, 115-130.

Witkin, H. & Goodenough, D. (1977). Field dependence and interpersonal behaviour. Psychological Bulletin, **84**, 661-689.

Witkin, H. & Goodenough, D. (1981). Cognitive styles: essence and origins (pp. 43). New York: International University Press.

Witkin, H., Oltman, P., Raskin, E. & Karp, S. (1971). A manual for the Embedded Figures Test. Consulting Psychologists Press, Inc.

World Health Organisation. (1994). International Classification of Diseases. Tenth Edition. Geneva's World Health Organisation.

Acknowledgements: We are grateful to a large number of people for helping us recruit subjects: Lorna Wing, Wendy Phillips, the National Autistic Society, Pat Howlin, Clive Robinson, Ben Sacks, Mike Rutter, and Pam Yates. The first author was supported by an MRC Studentship during the period of this work. The Harold Hyam Wingate Foundation also provided her with valuable financial support. Both studies reported here were submitted in part fulfilment of her PhD Degree at the University of Cambridge.

Keywords: Autism, Asperger's Syndrome, Embedded Figures Test, Central Coherence

Table 1: Subject characteristics

Age/IQ		CA	VIQ	PIQ	FSIQ
Group					
AUTISM n=17	mean	30.71	107.18	101.53	104.59
	sd	7.84	14.64	12.84	13.50
	range	(19.0-46.0)	(88.0-135.0)	(86.0-132.0)	(90.0-133.0)
NORMAL n=17	mean	30.0	106.35	105.24	106.18
	sd	9.12	10.89	14.0	12.58
	range	(18.0-49.0)	(87.0-127.0)	(85.0-134.0)	(88.0-132.0)
ASPERGER n=17	mean	27.77	110.77	100.3	107.06
	sd	7.81	13.76	14.23	14.58
	range	(18.0-49.0)	(89.0-130.0)	(85.0-133.0)	(86.0-132.0)

Table 2: Results from Experiment 1 (means, with standard deviations in brackets)

GROUP	RESPONSE TIME IN SECONDS	ACCURACY SCORE OUT OF 12
AUTISM	29.28 (21.6)	11.41 (0.9)
NORMAL	52.63 (32.6)	10.76 (2.0)
ASPERGER	32.21 (27.0)	11.29 (1.1)

Table 3: Number of lines used to complete the figure

		NUMBER OF LINES USED
Group		
AUTISM	mean	21.19
	sd	6.86
	range	14.0 - 36.0
NORMAL	mean	15.43
	sd	2.17
	range	14.0 - 20.0
ASPERGER	mean	18.57
	sd	6.37
	range	14.0 - 36.0

Table 4: Number of subjects drawing the global outline first

	Global outline drawn:	
Group	FIRST	LATER
AUTISM	11	5
NORMAL	13	1
ASPERGER	11	3

Figure legend

Fig. 1: The Modified Rey Figure