autism © 2004
SAGE Publications
and The National
Autistic Society
Vol 8(3) 267–281; 045218
1362-3613(200409)8:3

Weak central coherence: a cross-domain phenomenon specific to autism?

JAMES A. HOY *Blackpool Victoria Hospital, UK*
CHRIS HATTON *Lancaster University, UK*
DOUGAL HARE *Wythenshawe Hospital, Manchester, UK*

ABSTRACT This study investigated whether evidence for the weak central coherence theory could be specifically associated with a group of children with autism compared with normally developing children ($n = 17$ per group). Two tasks were employed, one involving visual illusions and the other verbal homophones. Both were based on tasks used in previous central coherence research. Incorporation of tasks involving the use of different domains (verbal versus visual) also enabled the investigation of claims that weak central coherence is a cross-domain processing style or deficit. The autistic group were found to be no different to the control group in performance on the visual illusions task. The autistic group made more errors than the normally developing group on the rare condition of the homophone task. However, analysis suggests this difference is mediated by verbal ability level and not diagnostic status *per se*. Theoretical implications and alternative explanations are discussed.

KEYWORDS *Asperger syndrome; autism; central coherence theory*

ADDRESS *Correspondence should be addressed to:* DR JAMES A. HOY, *Chartered Clinical Psychologist, Department of Clinical Psychology, Blackpool Victoria Hospital, East Park Drive, Blackpool, Lancashire FY3 8NR, UK. e-mail: jamiehoy@btinternet.com*

Introduction

Cognitive models of autism

In recent years, researchers have developed cognitive models that seek to explain symptoms of autism in terms of underlying cognitive deficits (see Happé, 1994, for a review). One such cognitive model of autism, weak central coherence, seeks to explain some of the features of autism ignored or unexplained by other models (Happé, 1994), including a tendency to focus on parts of objects, extreme sensitivity to small changes in the environment, circumscribed interests, and islets of high functioning or

DOI: 10.1177/1362361304045218

preserved ability on tasks such as the Block Design Task. According to the proponents of this model these features can be explained by a failure or absence of the normal tendency in information processing to draw together stimuli into coherent wholes (Frith, 1989). In autism, the type of processing hypothesized is characterized by seeing stimuli in terms of disparate parts rather than a coherent whole. Research in support of this theory comes from experimental tasks tapping different processing domains (see Table 1). This, proponents of the theory argue, suggests that weak central

Table 1 **A summary of studies investigating weak central coherence**

Task	*Why evidence?*	*For*	*Against*
Interpretation of homographs in context	Poor performance is linked to failure to use context to disambiguate homograph and so is evidence of weak central coherence	Happé (1997): autistic group shows no improvement in performance when rare form of homophone is placed after context	Snowling and Frith (1986): inability to use context to disambiguate homograph is a feature of low ability generally
Judgements about 2D visual illusions	Ability to make accurate judgements about elements of the illusion are linked to not being taken in by inducing context	Happé (1996): autistic group makes fewer errors on judgements about visual illusions than control groups	Ropar and Mitchell (1999): no differences between autistic groups and controls in terms of errors of judgement about illusions
Embedded Figures Task: requires picking out simple component shapes from a larger global shape	Ability to see simple component shapes of global contextually meaningful shapes is enhanced by not coding for the overall shape and instead focusing on local details	Shah and Frith (1983): autistic group was faster and more accurate than controls at picking out simple component shapes from part of larger global meaningful shapes	Brian and Bryson (1996): no differences between clinical group and controls in terms of ability on the Embedded Figures Task
Block Design Task: Requires the copying of a design of coloured bricks	Ability to work out which type of brick segments make up the overall pattern is enhanced by ability to see the pattern to be copied in terms of its components	Shah and Frith (1993): autistic group was faster than controls at completing the block designs	Ozonoff et al. (1991): found no differences between autism and control groups in terms of score on the block design subsection of the WAIS–R or WISC–R
Time taken to count canonically arranged dots (as they would appear on a dice) v. time taken to count randomly arranged dots	Ability to count canonically arranged dots faster than distributed dots indicates an ability to see the overall Gestalt of the arrangement of the dots	Jarrold and Russell (1997): autistic individuals did not show an advantage for counting canonically v. randomly distributed dots relative to normally developing controls who did show an advantage	Jarrold and Russell (1997): this difference between counting speeds for the autism group was equivalent to the difference found for the learning disabled group. This suggests that an inability to benefit from the canonical display could be ability linked and not a feature of autism

coherence is a central form of processing having a cross-domain influence (Frith and Happé, 1994). Two of the core areas implicated in research, disambiguating homographs and visual illusions, are discussed in detail below.

Homograph task

Frith and Snowling (1983) investigated the ability of children with autism, typically developing and dyslexic children to read homographs in a context sentence. They found that children with autism made more errors on this task and tended to read out the more common version of the homophone. These results were interpreted as reflecting the operation of weak central coherence in individuals with autism, as they did not use the sentence context to determine the correct version of the homograph. However, these were small groups (less than 10 in each) and the autism group was heterogeneous in terms of both age (9–17 years old) and ability level (IQ 54–104), making it difficult to argue that the difference was due to diagnostic status alone. In particular the autism group had a much lower IQ level than the others, suggesting that the difference could have been due to cognitive ability.

Happé (1997) replicated this experiment with an extended methodology. Four sentences were used with each homograph, two placing the context after the homograph (e.g. 'There was a big tear in her dress') and two placing it before (e.g. 'In Lucy's dress there was a big tear'). There was one control group of typically developing children matched in terms of chronological age to the youngest participants with autism. The groups did not differ in terms of overall performance on the task. The autistic group performed better on the rare form of the homograph before context condition relative to the control group. The control group performed relatively better on the rare after context condition, compared with their own performance on the rare before context condition. The autism group showed no such improvement. Happé argued this was evidence for weak central coherence since the normal group were showing their ability to use preceding context to disambiguate the homograph. However, these mixed findings are difficult to interpret given there were no overall group differences on the task.

This experiment was recently replicated using adults with autism, Asperger syndrome and no diagnosis, all with IQs in the normal range (Jolliffe and Baron-Cohen, 1999). Findings indicated that the clinical groups made significantly more errors on the rare conditions of the task (collapsed across before and after conditions). This appears to be supportive of weak central coherence theory. However, all participants performed close to ceiling level on all conditions, and critical differences were very small. For example, all groups had a mean score of over four correct items out of five in the rare after context condition, raising concerns over the theoretical significance of this statistical difference.

The findings of all three experiments are contradicted by an earlier study of the homograph task. Snowling and Frith (1986) were the first to use the extended methodology described above, uniquely including a learning disabled control group. The findings indicated that inability to disambiguate the homograph was associated with ability level and not the diagnosis of autism *per se*, and led them to suggest that this inability to use context was a feature of low-ability readers. Like other studies using this methodology, the participants were heterogeneous in terms of both age and ability level. However, the different outcome and interpretation of these results is striking, especially when considering this was the only study of the four directly to investigate the effect of ability level on performance.

Visual illusions

Happé (1996) investigated the degree to which children with autism, children with learning disabilities and normally developing children were fooled by six common 2D visual illusions. These illusions work because the context in which they are presented results in inaccurate perceptions of elements of the display. However, the sample was small; learning disabled and autistic groups were heterogeneous in terms of age and ability, and were significantly older and less able in terms of verbal IQ than the typically developing group. Analysis revealed that the autistic group made more accurate judgements about the 2D illusions than either of the two control groups. This was interpreted as evidence for weak central coherence by virtue of the fact that the autistic group was not integrating elements of the visual illusion into their inducing context. However, the effects of IQ level or chronological age were not investigated.

Ropar and Mitchell (1999) replicated Happé's (1996) study using a more sophisticated methodology. They argued that in requiring a verbal response, as was the case in Happé's study, the results may have been biased and participants may not have responded according to what they actually saw. Using most of the same illusions, participants were required to manipulate the size of elements in the display about which they had to make judgements. This, the authors argued, would be a better indicator of how the participants saw the illusions. The experiment included a group of children with autism, children with Asperger's syndrome, children with learning disabilities and typically developing children who were closer in terms of age and ability level than those used in the Happé study. They found no differences between the groups in terms of the degree to which they were fooled by the visual illusions. The autistic group showed no advantage on the task and this finding was replicated using the same methodology in a further study. Performance on these visual illusions was also shown to be uncorrelated with other visuospatial tasks usually associated with weak central coherence in both autistic and non-autistic participants (Embedded Figures, Block Design and the Rey Test: Ropar and Mitchell, 2001).

The current study

Past findings in relation to weak central coherence are clearly contradictory and few studies have directly investigated the effect of ability on performance. In addition, none of the research to date has explored performance on central coherence tasks in different domains by the same group of individuals with autism. Such a study would provide stronger evidence for the claim that weak central coherence is a centralized cognitive process affecting all processing domains. The current study set out to achieve this goal by comparing the performance of age and ability matched typically developing and autism groups on the visual illusion task as used by Happé (1997) and on a homophone task which is equivalent to the homograph task in terms of its ability to test for weak central coherence.

Specific hypotheses

Central coherence theory predicts that individuals with autism will make more errors on the rare condition of the homophone task and fewer errors of judgement about the visual illusions than typically developing controls. This difference may also be linked to severity of autism as measured by the Child Autism Rating Scale (CARS: Schopler et al., 1993) but not to other factors such as age, language comprehension or performance on false belief tasks.

Method

Participants

All the children were between 4 years and 9 years 11 months, and had a minimum score of 4 years and 7 months on the British Picture Vocabulary Scale 2nd edition (BPVS: Dunn et al., 1997). All groups were also assessed on the CARS by a teacher who knew the child well. Individuals with acquired head injuries, physical disabilities or health problems that might interfere with their ability to comply with the tasks were not included. For the purposes of the descriptive statistics below, BPVS raw scores were converted into age equivalents and means and standard deviations calculated from these.

Autism group A sample of 17 children (16 boys and 1 girl) with autism or Asperger syndrome were recruited to the study through local education authorities, schools and educational psychology services. Each child conformed to DSM-IV criteria for autism (American Psychiatric Association,

1994) according to the independent opinion of an educational psychologist, and attended one of 15 mainstream schools. The group had a mean chronological age of 7 years 9 months (range 6:6 to 9:4, standard deviation 10.48 months), a mean BPVS age equivalent score of 7 years 7 months (range 4:11 to 14:8, standard deviation 30.2 months) and a mean CARS score of 36.9 (range 30.5 to 49.5, standard deviation 5.24). The autism cutoff on the CARS is 30.

Typically developing group Seventeen normally developing children (16 boys and 1 girl) were recruited from three mainstream schools. This group had a mean chronological age of 8 years 1 month (range 6:2 to 9:7, standard deviation 10.65 months), a mean BPVS age equivalent score of 8 years 8 months (range 6:6 to 10:7, standard deviation 15.51 months) and a mean CARS score of 15.5 (range 15.0 to 18.0, standard deviation 0.87).

Three one-way analyses of variance with age, BPVS score and CARS scores as dependent variables indicated no significant differences between the groups in age ($F = 0.712$, d.f. = 1, 32, $p = 0.41$) or BPVS score ($F = 3.9$, d.f. = 1, 32, $p = 0.06$). As expected, there was a difference in the CARS score ($F = 276.96$, d.f. = 1, 32, $p < 0.001$).

Experimental design

This study is a mixed, quasi-experimental design, with between-group and within-group comparisons. The homophone task had two conditions (common homophones versus rare homophones), each with five trials.

Procedure

Ethical consent was sought and obtained from the appropriate ethics committee. Written consent was obtained from parents/guardians of participants who were contacted through educational psychology services or via schools. The children themselves took part on an entirely voluntary basis.

With each child all testing was completed in one session. The BPVS was administered first, to establish receptive verbal ability, followed by the homophone task. The participants were told: 'This part is a bit like the game we just played [BPVS] except that this time you have to listen to a little bit of a story. Then I will ask you to point to a picture that shows a word in the story. The story will help you pick the picture that best shows the word, so listen carefully to the story.' For each version of the homophone the ambiguous sentence was spoken aloud followed by the appropriate disambiguating sentence. The card with the appropriate pictures was then turned over and the test question asked (e.g. 'Can you show me the "reed" in this story?'). If a child correctly selected the appropriate representation, the item was recorded as correct.

The visual illusions task was administered next. Children were told: 'I am going to show you some pictures now and then ask a question about them.' For each, stimuli cards with either a visual illusion or a control stimulus were turned over and then the appropriate question was asked (taken from Happé, 1996).

Results

A summary of the means and standard deviations for the mean number of errors made in the visual illusion task, rare homophones, common homophones, and combined errors on the homophone task are presented in Table 2.

A repeated measures ANOVA (group $\times$ homophone type) was performed on the homophone data. Significantly more errors were made on the rare condition of the homophone task ($F = 89.81$, d.f. =1, 32, $p < 0.001$). The two groups also differed significantly in terms of the numbers of errors made in the task overall ($F = 8.53$, d.f. = 1, 32, $p = 0.006$). There was also a significant interaction between group and homophone type ($F = 9.98$, d.f. = 1, 32, $p = 0.003$). Two separate within-subjects repeated measures ANOVAs were performed for each group to investigate this relationship further. This revealed that significantly more errors were made on the rare condition than on the common condition for both the autism group ($F = 82.38$, d.f. = 1, 16, $p < 0.001$) and the typically developing groups ($F = 19.36$, d.f. = 1, 16, $p < 0.001$). However, the large differences in F-value indicate that this difference was greater for the autistic group than for the typically developing group.

Two one-way ANOVAs, comparing errors made on the rare and common conditions, revealed no significant difference in terms of performance on the common version of the homophone task across the two groups ($F = 0.421$, d.f. = 1, 32, $p = 0.521$). However, the autism group made significantly more errors in the rare condition ($F = 10.59$, d.f. = 1, 32, $p = 0.03$).

Table 2 **Means (standard deviations) for errors made on the homophone and the visual illusion tasks**

	Total errors homophone task (max. 10)	*Common homophone errors (max. 5)*	*Rare homophone errors (max. 5)*	*Visual illusion errors (max. 6)*
Normally developing	1.76 (1.48)	0.24 (0.56)	1.53 (1.23)	3.80 (1.01)
Autism	3.29 (1.57)	0.35 (0.49)	2.94 (1.29)	4.00 (1.11)

In order to determine whether differences in performance on the homophone task were still apparent when factors such as chronological age, BPVS score and CARS score were accounted for, a one-way ANOVA was performed with errors made on the rare condition as the dependent variable, group as the between-subjects variable, and age, BPVS raw score and CARS scores as covariates (see Table 3). This analysis indicated that the effect of group became non-significant when additional factors were accounted for. The only variable that significantly covaried with the number of errors made was BPVS raw score.

In terms of the visual illusion task, examination of the raw data revealed that most participants were able to make correct judgements about the control items and made relatively more errors on the illusions. For all participants a mean of 3.5 errors was made on the control stimuli as opposed to a mean of 22.17 errors for the illusions.

A one-way ANOVA (group × illusion errors) indicated no significant differences between the groups in terms of errors made on the illusions ($F = 0.232$, d.f. = 1, $p = 0.633$).

Table 3 **Results of one-way ANOVA with number of errors in the rare condition as the dependent variable**

	d.f.	*Mean square*	*F*	*Sig.*
Age	1	0.57	0.53	0.47
BPVS	1	11.97	11.12	0.02
CARS	1	0.44	0.41	0.53
Group	1	0	0.03	0.85
Error	29	1.07		

Discussion

Consistent with the earlier findings of Ropar and Mitchell (1999; 2001), the autistic and typically developing groups in this study performed equally well on the visual illusions task. Although the autism group made relatively more errors on the rare condition of the homophone task, these differences were accounted for by variation in BPVS verbal ability score rather than diagnostic status and/or CARS score. If it is assumed that both these experimental tasks are effective measures of weak central coherence then none of the predictions made by the weak central coherence theory of autism is supported.

The findings on the homophone task in the current study are similar to those in Happé (1997), in that an autistic sample was shown to make more errors in identifying rare forms of homophones than a typically developing control group. However, when differences in receptive verbal ability were taken into account, the groups did not differ in terms of performance on the rare condition of the homophone task. If failure on this task is caused by weak central coherence (i.e. inability to extract meaning from context) the findings suggest that performance is associated with levels of language ability not diagnostic status. This conclusion is in keeping with the alternative interpretation of Frith and Snowling's (1983) original finding that lower ability level rather than diagnostic status was associated with inability to disambiguate homographs. It is also consistent with the later Snowling and Frith (1986) homophone task finding that inability to use context was not an autism specific phenomenon but instead reflected a word by word reading strategy amongst low-ability 'hyperlexic' readers. These findings do contrast with those of Jolliffe and Baron-Cohen (1999), who reported differences between clinical and typical adult control groups on a homograph task, despite the fact that the groups were matched for age and ability level. However, as already described, all three groups in that study performed close to ceiling level and critical differences between groups were extremely small. Two other verbal tasks reported to be weak central coherence sensitive were carried out with the same participants. For each of these, performance was correlated with intelligence for the autistic group and there was a trend for a similar correlation in the normal group (Jolliffe and Baron-Cohen, 1999). If we assume these various tasks are in fact a measure of weak central coherence in the verbal domain, the combined research data are suggestive of a link between language ability level and use of context to derive meaning. This is not consistent with the position that weak central coherence is an autism specific trait. However, as considered below, it is also possible that some ability mediated processing style other than weak central coherence could be the cause of differential performance on these tasks.

On the illusions task, both groups were fooled by the illusions relative to control items. However, there was no difference between the groups in terms of their relative performance on the illusions, regardless of diagnostic status or ability level. This finding replicates that of Ropar and Mitchell (1999; 2001) who also found no differences between clinical groups and controls. These combined findings are not supportive of the weak central coherence theory prediction fowarded by Happé (1996) that individuals with autism are better at this task due to an enhanced ability to ignore or not see the inducing context of the illusions.

It could be argued that it is difficult to determine whether the experimental tasks utilized in the current methodology actually tested weak central coherence at all. For example, one could question whether the way in which words were selected for the homophone task could have biased the findings. Words were selected in a pilot study (see Appendices 1 and 2) where homophones were presented in a disambiguating context. Those words for which the children gave correct responses were then used in the main study. It could be thus argued that the words selected made it easier to give the right answer. However, this ignores the fact that the experimental version of the task contained the additional demand of placing an alternative representation of the homophone within the answer set. The presence of a common interpretation of the homophone allows the possibility of a biased local interpretation when another more appropriate context dependent interpretation is required. It is this aspect of the task that has been utilized extensively in other research as the critical test of central coherence (Happé, 1996; Jolliffe and Baron-Cohen, 1999). The fact that the participants with autism in the main study made a mean of nearly 3 out of 5 possible errors on the rare homophone condition compared with a mean of 0.75 out of a possible 22 errors in the pilot study suggests that this additional demand in the main study did make the task more difficult for the autistic group. Additionally it could be argued that some of the rare words utilized were too complex for the participants, and as such the findings reported here are merely a reflection of the more able children understanding these words and giving correct responses. However, this ignores the very basis of word selection, namely that they could be correctly responded to in the pilot (again see the apparent difference in ability to perform the experimental versus pilot task). A further criticism could be that the homophones were not understood and that the disambiguating context provided clues that allowed a correct response. However, if that were the case then this would further undermine the argument that children with autism have specific difficulties in their ability to make use of context.

This debate highlights the difficulty in determining if any of the verbal tasks that purport to be sensitive to weak central coherence are in fact measuring this supposed processing style, or if it actually exists at all. Indeed, children with autism may make mistakes on homophone and homograph tasks for entirely different reasons. It has been suggested that individuals with autism may interpret ambiguous material like homophones and homographs in a common way, then fail to use new material suggesting a less common interpretation because they have been unable to shift mental set from their original interpretation, not because of a local processing bias (Jolliffe and Baron-Cohen, 1999; Ozonoff and Miller, 1996). Another possibility is that the common interpretation is a more prepotent stimulus to which the autism group cannot inhibit their response, rather than an inability to use context to disambiguate the homophone or homograph. Individuals with autism have been shown to have difficulties with executive tasks, involving shifting mental sets and prepotent inhibition (Hughes et al., 1994; Ozonoff et al., 1994) and both of these executive functions are also known to vary with verbal ability level.

It may also be that the visual illusion task is not a measure of weak central coherence. As discussed previously, Ropar and Mitchell (2001) failed to find a correlation between the performance of autistic and non-autistic groups on the visual illusion task or other visuospatial tasks thought to measure weak central coherence (Block Design, Embedded Figures and Rey Complex Figures tasks). However, this still leaves us with the difficulty of knowing what weak central coherence is in the visual domain, whether it exists and how to measure it. The other visuospatial measures used in the Ropar and Mitchell (2001) study, and more generally in weak central coherence research, are rather diffuse non-specific measures of visuospatial ability. Even if a consistent trend was found on these tasks, which is still debatable (see Table 1), this would only really tell us if individuals with autism tend to have better or relatively unimpaired visuospatial skills. This is not compelling evidence to support the notion of weak central coherence as a specific and defining processing deficit/style in autism.

Conclusion

If it is accepted that the tasks used in this experiment do test central coherence at the verbal and visual level, then the current evidence does not support the hypothesis that weak central coherence is a cross-domain tendency specific to autism. An alternative intepretation of these and past research findings is that differences found in homophone and homograph tasks between autistic and typically developing groups are an artefact of verbal ability level. However, as argued above it is very difficult to determine if any of the tasks used in this and related research actually are measures of weak central coherence. This is perhaps a reflection of the general ambiguity and vagueness of the concept itself. This and the equivocal findings in the weak central coherence literature as a whole cast some doubt over the value of weak central coherence as a theory to explain and make predictions about autism.

Acknowledgements

Many thanks to the following people for their support: Sue Sanderson, Mick Connelly and all the children and staff who took part from schools around the north-west. Special thanks to Joanna Scott for her kind help in preparing the many drawings needed for this research.

Appendix 1: tasks

Homophone task

Five pairs of homophones were used in the homophone task. For each of these pairs there was an ambiguous sentence that made sense with either interpretation of the homophone. There were also two associated disambiguating sentences, one of which indicated the common interpretation of the homophone, and another which indicated the rarer interpretation of the homophone. An example is presented below (all other homophone pairs and associated sentences can be found in Appendix 2):

The lady liked a long read/reed (ambiguous sentence).
She had lots of books (common disambiguating sentence).
Especially the tall ones that grew by the river (rare disambiguating sentence).

For each homophone there was a white laminated stimulus card (15 cm by 21 cm) with four pictures, one representing the common interpretation of the homophone, another representing the rare interpretation of the homophone, and two representing incorrect interpretations. Each of these drawings occupied one quadrant of the stimulus card. Homophones were selected on the basis of a pilot to the main experiment, which checked comprehension for 22 homophones in a disambiguating context with four participants with autism with a verbal ability age equivalent of 4:7 years or higher. None of these participants took part in the main experiment. The word pairs then selected were those with the largest difference in terms of frequency according to the Kucera and Francis (1967) word corpus and on which the pilot group as a whole made one error or no errors overall. Results for these 16 homophone pairs can be found in Table 4.

Visual illusions task (Happé, 1997)

The same visual illusions and associated control stimuli were used as in the Happé (1996) study: Tichener circles, Muller–Lyer figures, Ponze illusion, Poggendorf illusion, Kanisza triangle and Hering illusion. These common 2D illusions lead the observer to misperceive an element of the illusion by virtue of an inducing context surrounding these elements. The Muller–Lyer figures and Tichener circles had an associated control image containing the critical element of the illusion, but without the illusion inducing context. These were included to ensure participants had sufficient language to comprehend the test question and were motivated and able to make judgements about length, orientation etc. All illusions and control stimuli were individually printed in black and centred on white laminated cards (15 cm by 21 cm). For each illusion a test question was used (as in Happé, 1996), requiring the participant to make a judgement about the critical illusory element.

Appendix 2: homophone pairs

All 22 homophone pairs with ambiguous sentence and disambiguating sentences for each version of the word are given here. Those used in the main study are shown with an asterisk *.

**sweet/suite*
The boy liked the sweet/suite
It was very tasty
The seats were very comfortable

file/phial
The man used the file/phial at work
It was good for keeping papers in
He could mix chemicals in it

Table 4 **Frequency data for Kucera and Francis word pairs on which the pilot group made one or zero errors: the top five entries represent the words selected for use in the main experiment**

More frequent word of pair	*Numeric frequency*	*Less frequent word of pair*	*Numeric frequency*	*Total difference*	*Total errors made*
Read	173	Reed	5	168	0
Hair	148	Hare	1	148	0
Beach	61	Beech	6	55	1
Sweet	70	Suite	27	43	0
Sale	44	Sail	12	32	1
Shoot	27	Chute	2	25	0
Tied	34	Tide	11	23	0
Flower	23	Flour	8	15	0
Stake	20	Steak	10	10	0
Toad	4	Towed	1	3	0
Ball	110	Bawl	no data	N/A	0
Boy	242	Buoy	no data	N/A	0
Key	88	Quay	no data	N/A	0
Leak	2	Leek	no data	N/A	0
Muscle	42	Mussel	no data	N/A	0
Peak	16	Peek	no data	N/A	1

**read/reed*
The lady liked a long read/reed
She had lots of books
Especially the tall ones that grew by the river

ball/bawl
The child wanted a ball/bawl
Then he could bounce it off the wall
He had just fallen and hurt his leg

**beach/beech*
The boy wanted to go to the beach/beech
He wanted to run along in the sand
He wanted to climb in its branches

chute/shoot
The boy wanted to have a chute/shoot
Then he could slide into the swimming pool
But the soldier said it was too dangerous for him to touch the gun

tide/tied
'It's tide/tied,' shouted the man
The sea approached them faster and faster
He was knotting the rope to the fence

flower/flour
He dropped the flower/flour on the floor
The white powder went everywhere
The petals were all over the floor

key/quay
The man walked over to the key/quay
It was in the lock of his front door
His boat was tied to it

peek/peak
Can we have a peek/peak?', cried the boy
He wanted to look through the keyhole
The family were deciding where to live on the mountain

**sale/sail*
The sale/sail was very big
Everything was half price
It made the ship go very fast

male/mail
'Where is the male/mail?' she shouted
Her girl rabbit was in the cage but the boy rabbit was not
The postman was very late

base/bass
The base/bass was ruined
The bottom of the statue had a big crack in it
The strings were snapped

**hair/hare*
The girl liked to play with her hair/hare
She liked to brush and comb it
She watched it run across the field

boy/buoy
He threw the boy/buoy out
The teacher was very angry with him
It went over the side of the boat and into the sea

naval/navel
'Show me your naval/navel mark,' said the man
He showed him the medal which he earned at sea
He lifted his shirt and showed him his belly button

mousse/moose
The man liked mousse/moose
He had it in his packed lunch every day
He went into the country to see them

hose/hoes
He used the hose/hoes in the garden
It was good for cleaning the car
It was good for weeding the flower bed

steak/stake
The lady handed the man a steak/stake
He was going to cook it for his tea
He was going to hammer it into the ground

leak/leek
She wanted to find the leak/leek
She was going to fix it to stop the water dripping
She was going to cut it up and put it in her soup

toad/towed
It just needed to be toad/towed
Nothing else would do for the witch's cauldron
The car had broken down at the side of the road

muscle/mussel
He had a big muscle/mussel
So he flexed his arm to show it off
He ate it straight from its shell

References

AMERICAN PSYCHIATRIC ASSOCIATION (1994) *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn (DSM-IV). Washington, DC: APA.

BRIAN, J.A. & BRYSON, S.E. (1996) 'Disembedding Performance and Recognition Memory in Autism/PDD', *Journal of Child Psychology and Psychiatry* 37: 865–72.

DUNN, L.M., DUNN, L.M., WHETTON, C. & BURLEY, J. (1997) *British Picture Vocabulary Scale*, 2nd edn. Windsor: NFER-Nelson.

FRITH, U. (1989) *Autism: Explaining the Enigma*. Oxford: Blackwell.

FRITH, U. & HAPPÉ, F. (1994) 'Autism: Beyond "Theory of Mind"', *Cognition* 50: 115–32.

FRITH, U. & SNOWLING, M. (1983) 'Reading for Meaning and Reading for Sound in Autistic and Dyslexic Children', *British Journal of Developmental Psychology* 1: 329–42.

HAPPÉ, F.G.E. (1994) *Autism: An Introduction to Psychological Theory*. London: UCL Press.

HAPPÉ, F.G.E. (1996) 'Studying Weak Central Coherence at Low Levels: Children with Autism Do Not Succumb to Visual Illusions. A Research Note', *Journal of Child Psychology and Psychiatry* 37: 873–7.

HAPPÉ, F.G.E. (1997) 'Central Coherence and Theory of Mind in Autism: Reading Homographs in Context', *British Journal of Developmental Psychology* 15: 1–12.

HUGHES, C., RUSSELL, J. & ROBBINS, T.W. (1994) 'Evidence for Executive Dysfunction in Autism', *Neuropsychologia* 32: 477–92.

JARROLD, C. & RUSSELL, J. (1997) 'Counting Abilities in Autism: Possible Implications for Central Coherence Theory', *Journal of Autism and Developmental Disorders* 27: 25–37.

JOLLIFFE, T. & BARON-COHEN, S. (1999) 'A Test of Central Coherence Theory. Linguistic Processing in High Functioning Adults with Autism or Asperger Syndrome: Is Local Coherence Impaired?', *Cognition* 71: 149–85.

KUCERA, K. & FRANCIS, W.N. (1967) *Computional Analysis of Present-Day American English*. Providence, RI: Brown University Press.

OZONOFF, S. & MILLER, J.N. (1996) 'An Exploration of Right-Hemisphere Contributions to the Pragmatic Impairments of Autism', *Brain and Language* 52: 411–34.

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: 1081–106.

OZONOFF, S., STRAYER, D.L., MCMAHON, W.M. & FILLOUX, F. (1994) 'Executive Function Abilities in Autism and Tourette Syndrome: An Information Processing Approach', *Journal of Child Psychology and Psychiatry* 35: 1015–32.

ROPAR, D. & MITCHELL, P. (1999) 'Are Individuals with Autism and Asperger's Syndrome Susceptible to Visual Illusions?', *Journal of Child Psychology and Psychiatry* 40: 1283–93.

ROPAR, D. & MITCHELL, P. (2001) 'Susceptibility to Illusions and Performance on Visuo-Spatial Tasks in Individuals with Autism', *Journal of Child Psychology and Psychiatry* 42: 539–49.

SCHOPLER, E., REICHER, R.J. & RENNER, B.R. (1993) *The Childhood Autism Rating Scale (CARS) for Diagnostic Screening and Classification of Autism*. New York: Irvington.

SHAH, A. & FRITH, U. (1983) 'An Islet of Ability in Autistic Children: A Research Note', *Journal of Child Psychology and Psychiatry* 24: 613–20.

SHAH, A. & FRITH, U. (1993) 'Why Do Autistic Individuals Show Superior Performance on the Block Design Task?', *Journal of Child Psychology and Psychiatry* 34: 1351–64.

SNOWLING, M. & FRITH, U. (1986) 'Comprehension in "Hyperlexic" Readers', *Journal of' Experimental Child Psychology* 42: 392–415.