Article: Impaired performance on see-know tasks amongst children with autism: Evidence of specific difficulties with theory of mind or domain-general task factors?

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This article is published at the Journal of Autism and Developmental Disorders: www.springerlink.com

Full reference: Lind, S. E. & Bowler, D. M. (2009). Impaired performance on see-know tasks amongst children with autism: Evidence of specific difficulties with theory of mind or domain-general task factors? *Journal of Autism and Developmental Disorders. Advance online publication.* doi: 10.1007/s10803-009-0889-y

Abstract

It is widely assumed that children with autism have a diminished understanding of the perception-knowledge relationship, as a specific manifestation of a theory of mind (ToM) impairment. However, such a conclusion may not be justified on the basis of previous studies, which have suffered from significant methodological weaknesses. The current study aimed to avoid such problems by adopting more stringent participant matching methods, using a larger sample, and implementing a new, more rigorous control task in order to ensure that non-ToM task factors were not confounding results. After excluding children who failed the control task, it was found that children with autism were moderately impaired in their understanding of the perception-knowledge relationship, relative to age- and verbal ability-matched comparison children.

Keywords: Autism spectrum disorder; control task; ignorance; knowledge; perception; theory of mind.

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Impaired performance on see-know tasks amongst children with autism: Evidence of specific difficulties with theory of mind or domain-general task factors?

Autism spectrum disorder (ASD) comprises a range of developmental disorders, characterised by impairments in social interaction, communication, and behavioural flexibility (American Psychiatric Association, 2000; World Health Organization, 1993). One of the most influential psychological explanations of the social and communication impairments is that children with ASD have an attenuated theory of mind (ToM) (e.g., Baron-Cohen, 1989; Frith, 1989; Leslie, 1987). ToM refers to the capacity to attribute mental states to self and others to explain and predict behaviour (Premack & Woodruff, 1978). The ability to ascribe false beliefs is considered by many to be the hallmark of a fully-fledged ToM (e.g., Dennett, 1978), and it has been consistently found, using a wide variety of paradigms, that children with ASD show diminished performance on false belief tasks (e.g., Happé, 1995; Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998).

In typical development, an important preceding step to false belief competence is acquiring the ability to attribute knowledge or ignorance of a given piece of information, depending upon whether an individual has had perceptual access to that information (Hogrefe, Wimmer, & Perner, 1986; Wimmer & Gschaider, 2000; Wellman & Liu, 2004). Understanding of the relationship between perception and knowledge is most commonly investigated using “see-know” tasks, which assess children’s understanding that visual access to information is a way of gaining knowledge of that information (Wimmer, Hogrefe, & Perner, 1988). In a typical see-know task, participants are required to ascribe knowledge or ignorance of the contents of an opaque box to individuals who either have or have not looked inside the box. From around 3 years of age, typically developing children correctly attribute knowledge of the box's contents only to individuals who have seen inside the box (e.g., Pratt & Bryant, 1990).

On the basis of such studies, it has been widely assumed that typically developing children below the age of 3 years lack an explicit conceptual understanding of knowledge states (e.g., Perner, 1991). However, innovative new research has called this view into question. For example, Liszkowski, Carpenter, and Tomasello (2008) found that 12-month-old typically developing infants, who observed an adult searching for an object, would communicatively point to the object to help the adult more frequently in conditions where the adult had not seen (and was therefore ignorant of) the location of the object than in conditions where the adult had seen (and therefore knew) the location of the object. Whilst it may be tempting to conclude that such selective pointing demonstrates explicit conceptual understanding of knowledge states, such findings are far from unambiguous (Perner & Ruffman, 2005). An arguably less controversial interpretation of these findings is that such behaviour indexes the (pre-conceptual, possibly implicit) ability to *detect* knowledge states in others, rather than any conceptual *understanding* of mental states (e.g., Bremner & Mareschal, 2004; Hood, 2004). Thus, tests such as those devised by Liszkowski et al. may assess the developmental precursors of conceptual understanding of knowledge states, whilst see-know tests directly assess conceptual understanding of knowledge states.

Given their characteristic limitations in false belief understanding, children with ASD might also be expected to show an impaired understanding of the perception-knowledge relationship. Indeed, two early studies (Leslie & Frith, 1988; Perner, Frith, Leslie, & Leekam, 1989) found that children with ASD performed significantly less well than children with specific language impairment (SLI) on standard see-know tasks. However, in each of these studies, participants with ASD had substantially lower levels of verbal intelligence than comparison participants, with a discrepancy in mean levels of verbal IQ between the groups of over 23 points[1], in each case. As such, the observed deficit amongst participants with ASD on each experimental task may have been merely a consequence of their low levels of verbal intelligence, rather than the consequence of an ASD-specific difficulty with representing the relationship between seeing and knowing (see Burack, Iarocci, Flanagan, & Bowler, 2004).

More recently, Kazak, Collis, and Lewis (1997) assessed understanding of the seeing-knowing relationship using a different kind of task from those used in the studies by Leslie and Frith (1988) and Perner et al. (1989). In this study, participants with ASD, as well as matched comparison participants, observed another person being questioned about the contents of an opaque box. Participants witnessed that sometimes the other person had seen inside the box before being asked about its contents, whereas on other occasions the person had not had such informational access. Under each of these conditions, participants were asked to state whether the other person *knew* what was inside the box, or whether they had merely *guessed* the box's contents when they were asked. Kazak et al. found that, contrary to their predictions, low-functioning children with ASD were no less able than age and verbal ability matched children with Down syndrome, or verbal ability-matched typically developing children, to succeed on this task. However, Kazak et al.'s results should be treated with some caution given that floor effects on the experimental task characterised each of these groups of participants.

Potentially significant group differences in understanding of the relationship between seeing and knowing may, therefore, have been masked by the fact that none of the groups performed at above chance level.

Perhaps the most widely cited evidence for an ASD-specific impairment in understanding of the seeing-knowing relationship emerges from a study by Baron-Cohen and Goodhart (1994). Baron-Cohen and Goodhart compared the performance of 12 adolescents with ASD and 12 age and verbal ability matched comparison adolescents with intellectual disability (ID) on a modified version of a paradigm previously implemented with typically developing children by Pratt and Bryant (1990). The task involved presenting participants with two dolls, named John and Fiona, and a series of five small closed boxes, each containing an object. Each test trial involved one of the dolls lifting a box and the other opening the box and looking inside. Participants were then asked the critical test question, “Who knows what’s in the box? John or Fiona?”, a correct answer being that only the doll who has had the relevant visual access will know what is inside.

Baron-Cohen and Goodhart (1994, p.399) reported that participants with ASD performed significantly less well than participants with ID on this task, with group differences being highly statistically significant (Fisher’s exact probability test, $p < .01$). However, a careful consideration of Baron-Cohen and Goodhart’s results again leads to concerns over the reliability of these findings. There were some inconsistencies in the reporting of the results of the experiment, and a re-analysis of their data indicates that the groups did not, in fact, perform significantly differently from each other.

Baron-Cohen and Goodhart's (1994) Table 2 displays the numbers of individuals within the ASD and ID groups who passed the task (scored 5/5) and failed the task (scored < 5/5). Their Table 3 provides further detail, displaying the numbers of individuals within each group who scored 0, 1, 2, 3, 4 and 5, respectively. However, the results from these tables do not tally. Although both tables suggest that 4/12 participants with ASD passed the task (i.e., scored 5/5 questions correctly), Table 2 suggests that 9/12 participants with ID passed the task, whereas Table 3 suggests that 8/12 participants with ID passed the task. Moreover, a re-analysis of these data reveals that the group difference in the numbers of participants passing/failing the task was only marginally significant, p (one-tailed) = .05 (if the results reported in Table 2 are taken to be correct) or non-significant p (one-tailed) = .11 (if the results reported in Table 3 are taken to be correct). The fact that the group difference did not reach statistical significance is unsurprising, given the very small sample size involved. We calculated the effect size for the group difference and found it to be moderate, $\phi = .33$, or relatively strong, $\phi = .42$ (Rea & Parker, 1997), depending upon which results are taken to be correct. This suggests that if more participants had been tested, the effect may have reached significance.

Despite these issues, one important methodological improvement upon previous studies was that Baron-Cohen and Goodhart (1994) introduced a pre-test control task, designed to ensure that any subsequent failure on the test itself was not due to a general failure to follow the test procedure. However, there are concerns over whether the task adequately served this purpose. The control task involved six trials of the experimenter giving a red counter to John and a blue counter to Fiona, or vice versa, and then asking the child, “Who has the red/blue counter?” All participants were found to pass at least five out of six of these control questions, and it was assumed that all of the participants would, therefore, be able to follow the test procedure. However, the cognitive demands of the control questions differed considerably from those involved in the experimental questions in at least three important respects. The experimental questions, unlike the control questions, involved (a) recalling an action (e.g., Fiona opened the box and looked inside), (b) making an inference based on that action (e.g., Fiona must, therefore, know what is inside the box), whilst (c) reasoning about unobservable variables. These differences raise the possibility that those participants in Baron-Cohen and Goodhart’s study, who failed the task, may have done so because of difficulties with these extraneous factors rather than because of a specific failure to represent the seeing-knowing relationship.

Thus, previous studies of the seeing-knowing relationship in ASD have either found ASD-specific impairments, but failed to include an adequate comparison group, or simply failed to find significant group differences. So, although there are legitimate *theoretical* reasons to predict that children with ASD will show an impaired understanding of the perception-knowledge relationship (given that children with ASD are thought to have difficulties with representing mental states), previous research has not demonstrated this to be the case. The current study, therefore, aimed to assess understanding of the perception-knowledge relationship in ASD with a new, more carefully controlled approach.

We decided to replicate Baron-Cohen and Goodhart’s (1994) version of Pratt and Bryant’s (1990) task with a larger, carefully matched sample, and to design and implement our own, more rigorous control task. Cognitive-experimental tasks, such as Baron-Cohen and Goodhart's task, necessarily invoke multiple cognitive processes – they are rarely "pure" tests of a particular cognitive ability such as ToM. Thus, one of the key aims of the present study was to screen out non-ToM sources of task difficulty, thereby ensuring that any group differences on the experimental task were specifically due to the hypothesised difficulty with understanding the perception-knowledge relationship. Hobson (1991) argues that one of the most powerful methods of determining ASD-specific deficits in a particular cognitive ability is to develop a control task with cognitive demands that closely mirror those of the experimental task except with respect to the key variable of interest. Thus, we aimed to develop a control task that was analogous to the experimental task in as many respects as possible, whilst eliminating any reference to mental states.

A series of six new control questions was created. These questions each required the participant to recall an action and make an inference based on that action. In order to equate the control and experimental questions as closely as possible, the control questions were designed to require inferences about internal, unobservable (but not mental) states, such as feeling sick or cold. This was intended to ensure that difficulties were not arising as a consequence of problems with reasoning about, or representing, unobservable variables. It was predicted that after excluding participants who failed the control task, participants with ASD would perform significantly less well on the test itself than comparison participants.

Methods

Participants

Approval for this study was obtained from City University Senate Research Ethics Committee. Participants were recruited through schools located in South-East England. The parents of all participants gave informed, written consent for their children to take part. The ASD and comparison groups each consisted of 40 participants who were individually matched on chronological age (CA) and verbal mental age (VMA), as assessed with the British Picture Vocabulary Scale (Dunn, Dunn, Whetton, & Burley, 1997). Participant characteristics are presented in Table 1.

[Place Table 1 about here]

All of the participants in the ASD group attended specialist autism schools or units, for which entry required a formal diagnosis of autistic disorder, Asperger's disorder, pervasive developmental disorder not otherwise specified, or atypical autism (American Psychiatric Association, 2000; World Health Organization, 1993). A thorough review of the participants' Statements of Special Educational Needs[2] confirmed that they had all received formal diagnoses from qualified clinicians of autistic disorder or Asperger's disorder, in accordance with internationally accepted criteria (American Psychiatric Association, 2000; World Health Organization, 1993).

The comparison group consisted of children with general intellectual disability (ID; i.e., mental retardation) of unknown origin (*n* = 28; to act as matches for those children with ASD who also had ID) and typically developing children (*n* = 12; to act as matches for those children with ASD who did not have ID). Potential comparison participants were excluded if they had received specific diagnoses, such as dyslexia, Down syndrome or attention deficit hyperactivity disorder (given that such diagnoses are frequently associated with atypical cognitive profiles, thereby making it difficult to draw useful conclusions from any observed group differences on experimental tasks). Any mention of social communication difficulties in any comparison child's Statement of Special Educational Needs resulted in exclusion from the comparison group, as this may have been indicative of ASD-related symptoms or even undiagnosed ASD.

Materials and procedure

The experimenter introduced two "Playmobil" dolls as John and Fiona, and then asked the child to identify each doll by name. For the control procedure, the children were told the following series of one-sentence stories, which were each followed by a question:

1. "Fiona and John go out to play in the park. Fiona falls over and cuts her knees and John gets muddy knees. Who gets sore knees?"

2. "John does some colouring while Fiona goes for a long run. Who gets tired out?"

3. "It's snowing outside. Fiona goes outside to make a snowman while John stays indoors by the fire and reads a book. Who gets cold?"

4. “John and Fiona are very hungry. Fiona has a small glass of water and John has a big roast dinner. Who gets full up?”

5. “John and Fiona go to the beach. John lies down in the sun while Fiona goes swimming. Who gets hot?”

6. “John and Fiona go to a birthday party. John has one plate of food and Fiona eats all the cakes and ice cream. Who starts feeling sick?”

The order of the stories and the position of the key information bearing part of the story (e.g. “falls over and cuts her knees”) were fully counterbalanced across conditions. Participants were randomly assigned to each condition without replacement. For the test phase, the children were shown five boxes, each with a distinct appearance, and each containing a different toy object. They were told, *“Look I’ve got some boxes here. There’s something inside each box. I’m going to show the boxes to John and Fiona.”* They were then given the test questions, which were acted-out by the experimenter and which took the form: *“John lifts up the box and Fiona opens the box and has a look. Who knows what’s in the box?”* The order of characters/looking and lifting was randomly assigned for each of the five questions. Importantly, the participant was not allowed to see inside the boxes until the questioning was completed.

Scoring

In terms of performance on the see-know task, participants who scored 4 or 5 (out of 5) were deemed to have "passed", and participants who scored 0 to 3 were deemed to have "failed". In terms of control task performance, participants who scored 5 or 6 (out of 6) were deemed to have "passed", and participants who scored 0 to 4 were deemed to have "failed". These criteria were selected in order to ensure that participants were (a) not penalised for making a single mistake due (for example) to loss of concentration and (b) unlikely to pass by chance alone. The probability of succeeding on a single trial in either the control task or the see-know task was .50. Therefore, the probabilities of scoring 5 or 6 (out of 6) on the control task were .03 and .02, respectively, and the probabilities of scoring 4 or 5 (out of 5) on the see-know task were .06 and .03, respectively.

Statistical Analyses

Statistical analyses were conducted using SPSS 16.0 for Windows. Chi-square or Fisher's exact tests were used to analyse categorical data and independent *t*-tests were used to analyse continuous data. The effect size measures ϕ (phi) and r were used to accompany chi-square/Fisher's exact tests and *t*-tests, respectively.

Results

Twenty-four (60.0%) participants with ASD and 36 (90.0%) comparison participants passed the see-know task. A chi-square test indicated that this group difference was statistically significant, χ^2 (1, N = 80) = 9.66, p < .01, ϕ = .35. Twenty-nine (72.5%)

participants with ASD and 37 (92.5%) comparison participants passed the control task. Again, this group difference was found to be significant, χ^2 (1, N = 80) = 5.54, p = .04, ϕ = .26. Table 2 shows the numbers of participants in each group who passed/failed the see-know test and control questions.

[Table 2 here]

The fact that the ASD group performed significantly less well on the control task than the comparison group suggests that their poorer performance on the experimental task may not have been specifically due to a difficulty with representing mental states. Thus, in order to ensure that group differences on the test itself were not entirely accounted for by non-ToM factors, further analyses were conducted. Individuals who failed the control task (ASD n = 11; comparison n = 3) were excluded from the sample and the see-know test data were re-analysed. After these participants were excluded, the groups remained equated on CA, VMA, and VIQ – there were no significant group differences on any of these variables and the effect sizes were all negligible to small, indicating close matching (all ts < 1.07, all ps > .29, all rs < .13).

Having excluded participants who failed the control task, it was found that 21/29 (79.4%) participants with ASD and 35/37 (94.6%) comparison participants passed the see-know test. This difference was found to be significant, Fisher's exact test[3], p = .02, ϕ = .31. This effect is considered to be moderately strong (Rea & Parker, 1997).

Discussion

In the current study, children with ASD were found to perform significantly less well than age and verbal ability matched comparison children on a task designed to assess explicit understanding of the relationship between informational access and knowledge. As far as we are aware, this is the first study to *unambiguously* demonstrate a diminished understanding of this relationship amongst children with ASD. Although previous studies have reported ASD-specific deficits in this regard, the results of each was questioned on the basis either that (a) an appropriate comparison group (matched for age and verbal ability) was not included (Leslie & Frith, 1988; Perner, Frith, Leslie, & Leekam, 1989) or (b) results were misreported, and therefore differences between groups were not statistically significant, as originally suggested (Baron-Cohen & Goodhart, 1994).

The results of the current study are contrary to those of Kazak et al. (1997), who found no significant differences between appropriately matched children with and without ASD on a task designed to assess the distinction between knowing and guessing. However, given the floor effects on this task observed amongst participants in Kazak et al.'s study, their results should be treated with some caution. In the current study, there were neither floor nor ceiling effects on the experimental task, making interpretation of results more reliable.

There are further reasons to suppose that the diminution in understanding of the seeing-knowing relationship observed amongst participants with ASD in the current study is genuine. Firstly, the present study utilised a substantially larger sample (N = 80) than previous studies. Indeed, it seems likely that the between-group difference in Baron-Cohen and Goodhart's (1994) experimental task did not reach statistical significance because each group comprised only 12 participants. Secondly, and most importantly, the current study is arguably the only study to include a control task, which is adequate to ensure that any deficits on the experimental task were due to a specific difficulty with representing the seeing-knowing relationship, as opposed to difficulties with other task demands (see Hobson, 1991, for a general discussion of such methodological issues).

Indeed, an important finding was that participants with ASD performed significantly less well than comparison participants on the *control* task as well as the experimental task. This suggests that the failure of some individuals with ASD on the experimental task could well have been due to difficulties with "extraneous" task factors, which may have included (a) recalling an action, (b) making an inference based on that action, (c) reasoning about unobservable variables, or perhaps (d) diminished awareness of physiological states *per se*. This highlights the importance of having included a comprehensive control task. Crucially, it was found that after excluding participants who failed the control task, differences between the (still well matched) groups in see-know task performance remained significant, with a moderate effect size (ϕ = .31). This methodological control, which has not been included in previous studies, confirms our hypothesis that children with ASD have a *specific* deficit in understanding that seeing leads to knowing.

Future research may seek to investigate whether the more basic (possibility pre-cursor) ability to *detect* knowledge states is diminished in ASD in addition to the ability to *infer* knowledge states, as demonstrated by the present study. Future research may also benefit from the inclusion of quantitative diagnostic measures to enable an exploration of whether experimental task performance relates to ASD symptom severity.

References

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders (4th edition - text revision)*. New York: American Psychiatric Association.

Baron-Cohen, S. (1989). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry, 30,* 285-297.

Baron-Cohen, S. & Goodhart, F. (1994). The 'seeing-leads-to-knowing' deficit in autism: The Pratt and Bryant probe. *British Journal of Developmental Psychology, 12,* 397-401.

Bremner, A. J. & Mareschal, D. (2004). Reasoning...what reasoning? *Developmental Science, 7,* 419-421.

Burack, J. A., Iarocci, G., Flanagan, T. D., & Bowler, D. M. (2004). On mosaics and melting pots: Conceptual considerations of comparison and matching strategies. *Journal of Autism and Developmental Disorders*, *34*, 65-73.

Dennett, D. C. (1978). Beliefs about beliefs. *Behavioural and Brain Sciences, 1,* 568-570.

Dunn, L. M., Dunn, L. M., Whetton, C., & Burley, L. (1997). *British Picture Vocabulary Scale (2nd Edition).* Windsor: NFER-Nelson.

Frith, U. (1989). *Autism: Explaining the enigma.* Oxford: Blackwell.

Happé, F. G. E. (1995). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child Development, 66,* 843-855.

Hobson, R. P. (1991). Methodological issues for experiments on autistic individuals perception and understanding of emotion. *Journal of Child Psychology and Psychiatry, 32,* 1135-1158.

Hogrefe, G.-J., Wimmer, H., & Perner, J. (1986). Ignorance versus false belief: A developmental lag in attribution of epistemic states. *Child Development, 57,* 567-582.

Hood, B. (2004). Is looking good enough or does it beggar belief? *Developmental Science,* 415-421.

Kazak, S., Collis, G. M., & Lewis, V. (1997). Can young people with autism refer to knowledge states? Evidence from their understanding of "know" and "guess". *Journal of Child Psychology and Psychiatry, 38,* 1001-1009.

Leslie, A. M. (1987). Pretense and representation: The origins of theory of mind. *Psychological Review, 94,* 412-426.

Leslie, A. M. & Frith, U. (1988). Autistic children's understanding of seeing, knowing and believing. *British Journal of Developmental Psychology, 6,* 315-324.

Liszkowski, U., Carpenter, M., & Tomasello, M. (2008). Twelve-month-olds communicate helpfully and appropriately for knowledgeable and ignorant partners. *Cognition, 108,* 732-739.

Perner, J. (1991). *Understanding the representational mind*. Cambridge, MA: MIT Press.

Perner, J., Frith, U., Leslie, A. M., & Leekam, S. R. (1989). Exploration of the autistic child's theory of mind: Knowledge, belief, and communication. *Child Development, 60,* 689-700.

Perner, J. & Ruffman, T. (2005). Infants' insight into the mind: How deep? *Science, 308,* 214-216.

Povinelli, D. J. & Vonk, J. (2004). We don't need a microscope to explore the chimpanzee's mind. *Mind and Language, 19*, 1-28.

Pratt, C. & Bryant, P. (1990). Young children understand that looking leads to knowing (so long as they are looking into a single barrel). *Child Development, 61*, 973-982.

Premack, D. & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences, 1,* 515-526.

Rea, L. M. & Parker, R. A. (1997). *Designing and Conducting Survey Research: A Comprehensive Guide (2nd Edition)*. San Francisco, CA: Jossey-Bass.

Surian, L. & Leslie, A. M. (1999). Competence and performance in false belief understanding: A comparison of autistic and normal 3-year-old children. *British Journal of Developmental Psychology, 17,* 141-155.

Wellman, H. M. & Liu, D. (2004). Scaling of theory of mind tasks. *Child Development, 75,* 523-541.

Wimmer, H. & Gschaider, A. (2000). Children's understanding of belief: Why it is important to understand what happened. In P. Mitchell & K. J. Riggs (Eds.), *Children's reasoning and the mind* (pp. 253-266). Hove: Psychology Press.

Wimmer, H., Hogrefe, G. J., & Perner, J. (1988). Children’s understanding of informational access as a source of knowledge. *Child Development, 59,* 386-396.

World Health Organization (1993). *International classification of diseases (10th edition).* Geneva: World Health Organization.

Yirmiya, N., Erel, O., Shaked, M., & Solomonica-Levi, D. (1998). Meta-analyses comparing theory of mind abilities of individuals with autism, individuals with mental retardation, and normally developing individuals. *Psychological Bulletin, 124,* 283-307.

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This research was supported by a City University PhD Studentship awarded to the first author. This manuscript was prepared during a Mentor-Based Postdoctoral Fellowship awarded to the authors by Autism Speaks. We would like to thank the following schools for their participation in this research: Bensham Manor, Brent Knoll, Hillingdon Manor, Kilmorie, Linden Bridge, Southmead, Pendragon, St. Winifred's, The Park, and West Wimbledon. Finally, we are extremely grateful to Dr David Williams, Dr Sebastian Gaigg, Professor Chris Jarrold, and the anonymous reviewers of this manuscript for helpful comments on an earlier draft.

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Footnotes

[1] Neither Leslie and Frith (1988) nor Perner et al. (1989) reported verbal IQ scores in their papers. However, we estimated the mean group VIQs from the VMAs and CAs reported in Leslie and Frith's Table 1 and Perner et al.'s Table 2, using the formula: VIQ = (VMA /CA) x 100. These calculations indicated that the autistic and SLI groups had mean VIQs of approximately 52 and 78, respectively, in Leslie and Frith's study, and approximately 54 and 78, respectively, in Perner et al.'s study.

[2]A Statement of Special Education Needs is a document, based on an assessment by the local authority, which provides a detailed description of any special needs (e.g., ASD, intellectual disability, dyslexia, etc.), including diagnostic information and a developmental history.

[3]Given that one of the cells had an expected count of less than 5, a Fisher's exact probability test was used rather than a chi-square test.

Table 1

Participant Characteristics

	ASD (*n* = 40, 10 female)			Comparison (*n* = 40, 11 female)					
Characteristic	*M*	*SD*	Range	*M*	*SD*	Range	*t(78)*	*p*	*r*
CA	10.42	3.55	5.00 - 17.08	10.50	4.04	4.58 - 15.67	0.10	.92	.01
VMA	6.77	2.19	3.00 - 11.33	6.73	2.03	3.25 – 10.83	0.09	.93	.01
VIQ	75.23	16.75	39 - 102	75.00	20.71	39 – 107	0.05	.96	.01

Note: CA = chronological age; VMA = verbal mental age; VIQ = verbal IQ; Ages are in years; VMA and VIQ are based on BPVS scores.

Table 2

Contingency Table Showing Numbers of Participants in Each Group who Passed/Failed the See-Know Test and Control Questions

		Test questions			
		ASD		Comparison	
		Pass	Fail	Pass	Fail
Control questions	Pass	21	8	35	2
	Fail	3	8	1	2