Visual perspective taking impairment in children with autistic spectrum disorder

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Abstract:

Evidence from typical development and neuroimaging studies suggests that level 2 visual perspective taking – the knowledge that different people may see the same thing differently at the same time – is a mentalising task. Thus, we would expect children with autism, who fail typical mentalising tasks like false belief, to perform poorly on level 2 visual perspective taking as well. However, prior data on this issue are inconclusive. We re-examined this question, testing a group of 23 young autistic children, aged around 8 years with a verbal mental age of around 4 years and three groups of typical children (n=60) ranging in age from 4 to 8 years on a level 2 visual perspective task and a closely matched mental rotation task. The results demonstrate that autistic children have difficulty with visual perspective taking compared to a task requiring mental rotation, relative to typical children. Furthermore, performance on the level 2 visual perspective taking task correlated with theory of mind performance. These findings resolve discrepancies in previous studies of visual perspective taking in autism, and demonstrate that level 2 visual perspective taking is a mentalising task.

The ability to appreciate how the world looks to another person is called visual perspective taking (VPT). Studies of VPT in typically developing children have distinguished two levels of ability which develop sequentially. Level 1 VPT (VPT1) refers to the ability to know if another person can see an object or not; i.e. are the observer's eyes open and is his line of sight unobstructed? Tests of VPT1, such as hiding a toy from a 'policeman' doll, are passed by typical two year olds (Lempers, Flavell, & Flavell, 1977). In contrast, level 2 VPT (VPT2) refers to the ability to know that different people experience seeing an object differently. Thus, VPT2 tasks require a child to realise that an object which both people can see at the same time may nevertheless appear different to each person, for example, if the child can see the face of a toy sheep, the adult on the other side of the table may see only the tail. Such tasks are typically not passed until the age of four or five years (Gzesh & Surber, 1985) and seem to require more sophisticated cognitive abilities. In fact, recent data shows that even typical adults may find VPT2 difficult in a naturalistic situation, where they must take into account another person's viewpoint in order to interact with them (Keysar, Lin, & Barr, 2003).

Research on VPT2 in typical individuals has often linked this skill to mentalising, that is, the ability to take account of other people's beliefs and predict their behaviour accordingly. VPT2 performance correlates with performance on a false-belief task which is the standard assessment of mentalising (Flavell, Green, & Flavell, 1986) as well as performance on the appearance-reality task (Flavell et al., 1986). Neuroimaging studies in typical adults have identified a brain region, the temporo-parietal junction (TPJ) which is activated in both mentalising tasks (Fletcher et al., 1995) and VPT2 tasks (Aichhorn, Perner, Kronbichler, Staffen, & Ladurner, 2006).

Over the last 30 years of research into mentalising, two major theoretical accounts have been contrasted. The Theory-Theory account focus on the meta-representational requirements of mentalising tasks, while the simulation theory account argues that these tasks can be achieved by imagining oneself in another person's shoes. This paper does not attempt to distinguish theory-theory from simulation-theory, because we agree with Apperly (2008) that it is time to move beyond this debate. Rather, we are interested in whether VPT2 should be considered a mentalising task, subserved by the same cognitive processes as belief understanding, or whether it should be understood differently. Answering this question will help us understand the type of cognitive processes involved in VPT and mentalising, and lay a foundation for a new approach to understanding the cognitive foundations of the ability to understand other people's perceptions and beliefs.

Past approaches to VPT and mentalising disagree on the link between these abilities. In his theoretical account of the origin of Theory of mind, Leslie has argued that processes such as pretence and representing another person's belief require a decoupling operation to distinguish the alternative state from reality (Frith, Morton, & Leslie, 1991; Leslie, 1987). VPT2, which requires a representation of *how* another person sees a particular scene, should also involve decoupling. Similarly, simulation theory suggests that VPT1 problems, VPT2 problems and mentalising problems can all be solved by 'imaging oneself in the other person's shoes' (Langdon & Coltheart, 2001), and thus performance on all three types of task should be impaired or spared together. These two 'broad' accounts can be contrasted with a more modular account (Baron-Cohen, 1995) where processing of gaze direction and seeing is governed by an Eye Direction Detector (EDD) which is responsible for both VPT1 and VPT2, while an additional Theory of Mind (ToM) module is required for mentalising.

Autism provides a test case for the idea that VPT2 is intimately linked to mentalising. Extensive studies of children with autism over the last twenty years have repeatedly demonstrated that these children have a specific difficulty with understanding other people's beliefs (Baron-Cohen, Leslie, & Frith, 1985; Frith, 2001; Happe, 1995). The decoupling theory predicts that autistic children should find VPT2 difficult, because it requires decoupling, but should find VPT1 relatively easy. Similarly, simulation theory predicts both VPT2 and mentalising should be hard for the autistic child. In contrast, the EDD theory predicts that both VPT1 and VPT2 should be easy because both are governed by an intact EDD module. Thus, answering the question 'is VPT impaired in autism?' should help distinguish between the modular and the broad theories.

Studies of level 1 visual perspective taking in autism are in agreement and demonstrate that this ability is intact (Baron-Cohen, 1989; Hobson, 1984; Leslie & Frith, 1988). However, previous experimental data on VPT2 in autism do not give a clear answer to this question. One study which used a complex VPT2 memory task with teenagers found evidence of impairment in autism (Yirmiya, Sigman, & Zacks, 1994). Correlations have been found between visual perspective taking and other social abilities in autism (Dawson & Fernald, 1987; Perner, Frith, Leslie, & Leekam, 1989). In contrast, two studies using simpler tasks did not find evidence of a VPT2 impairment. (Reed & Peterson, 1990) compared children with autism to typical children on VPT1 and VPT2 tasks as well as false belief tasks, and found the autistic group had no difficulty with the VPT tasks but failed the false belief tasks. Similarly, (Tan & Harris, 1991) found autistic children performed like typical children in a VPT2 task.

These results would seem to be evidence against the decoupling theory, and in favour of the idea that VPT and mentalising are distinct cognitive processes.

However, the studies by Tan & Harris and by Reed and Peterson are limited in two ways. Both tested relatively able children with a mean VMA of 8y7m and 7y1m respectively, and found performance was at ceiling in both controls and autistic children. These ceiling effects may have masked performance differences. Also, neither study included non-social control conditions. All VPT tasks require a level of spatial awareness and spatial memory, which might well differ between typical and autistic populations. Overall, it seems that current evidence on VPT2 in autism is not coherent with either the studies of typical individuals or the decoupling theory, which links VPT2 to mentalising.

Given these contradictions in the existing literature between theory and experimental results, and given the renewed interest in VPT as a mentalising skill in adults, we decided to investigate VPT2 in children with autism. Specifically, we decided to examine both level 2 visual perspective taking and theory of mind in a group of low-functioning children with autism. We did not test VPT1 because there is a clear consensus that VPT1 is intact in autism (Baron-Cohen, 1989; Hobson, 1984; Leslie & Frith, 1988). Our method is based on a sensitive VPT2 task developed for use with typical children (Huttenlocher & Presson, 1973). This task has been used to demonstrate perspective taking problems in adults with schizophrenia, though with a different interpretation of the results (Langdon & Coltheart, 2001).

We adapted the adult task to make it suitable for children with a verbal mental age around 4 years. In the original task, participants saw an array of coloured dots in the middle of a table and were asked to judge the appearance of the array from a different seat at the table. We simplified this task by, first, replacing the arbitrary spatial pattern with a single toy which had a distinct front, back, left and right side, which reduces the spatial memory demands of the task (Huttenlocher & Presson, 1979). Second, we covered the toy before asking the child the test question, to reduce the competing impact of the child's own viewpoint and thus reduce inhibitory demands (Leslie, German, & Polizzi, 2005). Third, we constructed response cards depicting the toy from each possible angle, so that children could respond by pointing to the corresponding picture on the card and strong verbal skills were not necessary. This simplified task requires the child to imagine what a doll can see from a different location, i.e. level 2 visual perspective taking, but minimises all other cognitive demands.

We compared performance on this VPT2 task to performance on a mental rotation (MR) task, where the child must imagine the rotation of the toy on a turntable. This control allows us to equate spatial abilities in the different groups of children. We predicted that if children with ASD have specific difficulties with visual perspective taking, we would see impaired performance by this group on the VPT task, relative to their performance on the control mental rotation task. If successful, this pair of tasks should provide a much needed addition to the repertoire of 'fine cut' techniques (Frith & Happe, 1998) to dissect mentalising problems in autistic spectrum disorder.

Methods

Twenty-three children with a diagnosis of autism or autism spectrum disorder were recruited from schools in the London area. Their mean chronological age was 8 years (range: 4y5m to 12y9m), and 19 were male. The British Picture Vocabulary Scale (BVPS) (Dunn, Dunn, Whetton, & Burley, 1997) was used to establish each child's verbal mental age, and a battery of theory of mind tasks was used to test for understanding of other people's mental states.

For the purposes of comparison, the same tasks were administered to 60 typically developing children (38 male), recruited from nurseries and primary schools in the London area. These children ranged in age from 4y2m to 8y5m and were divided into three subgroups, on the basis of their BPVS raw scores. The 23 typical children with the lowest verbal abilities were classified as the 'typical young group'. This group was matched with the ASD group on BPVS raw score. The next 23 typical children were classified as the 'typical middle group', and were matched with the ASD group on performance on the mental rotation control task described below. The final 14 typical children, with the highest BPVS raw scores, were classified as the 'typical old group' and were closest to the ASD group in chronological age (see Table 1).

All the children their parents and their respective schools gave consent to take part in this study, which was approved by the local ethics committee. Every child was tested individually in a quiet room in his or her own school over two or three sessions, which included the tasks reported here and those described in Hamilton et al. (2007).

Theory of Mind testing

Most children were tested on a battery of Theory of Mind tests, including tests of diverse desires, diverse beliefs, knowledge access, contents false belief and explicit false belief (Wellman & Liu, 2004), the classic Sally-Ann task (Baron-Cohen et al., 1985; Wimmer & Perner, 1983), an interpretive diversity task (cow task, Luckett, Powell, Messer, Thornton, & Schulz, 2002) and a penny hiding task (Devries, 1970). On all each task, the child was given a score of one for demonstrating evidence of theory of mind and zero otherwise, leading to a maximum score of 13 (see Table 1). The theory of mind battery was omitted for 22 older typical children, who would find the tasks too easy.

Visual perspective taking and mental rotation tasks

The two experimental tasks were tested in the same session, and involved the same familiarisation stage. First, a small toy was placed on a square turntable, which had distinct coloured sides (Figure 1A). The child was given a laminated card showing four pictures of the toy taken from the front, back, left and right. With the toy visible on the turntable, the child was asked to point to the picture which resembled the toy, e.g. 'which one looks like the panda?' The turntable was then visibly turned so that the child saw a different side of the toy, and the same question asked. Finally, the toy was covered by an opaque flower pot (but not turned) and the child was asked 'when I lift the pot, which panda will you see?'. Where necessary, training questions were accompanied by a pointing gesture towards the picture card, to make it clear that the child should respond by pointing to a picture. For example, the experimenter indicated the card and asked "Which one? Is it this one? Is it this one?" until the child chose. Gestures were only used in the training trials, and there was no evidence that the children had difficulty understanding the question during either training or test. These three training trials aimed to familiarise the child with the toys, the type of question asked and the use of the picture cards for responding. Errors were corrected in these three training questions and children who made errors completed the training sequence again using a second toy to be sure the child understood.

Both VPT and MR trials began with a new toy placed on the turntable and a new response card given to the child. While the toy was visible, the child was asked to point to the picture of the toy's starting orientation, to be sure that the child attended to this feature (Figure 1A). For MR trials, the toy was then covered, and with the words 'watch carefully', the experimenter turned the turntable through 90^{o} clockwise, 180^{o}, or 90^{o} counter clockwise (Figure 1C). Immediately after turning, the child was asked 'when I lift the pot, which panda will you see?'. For VPT trials, the toy was covered and a small doll, named Susan, with a clearly painted eyes and a neutral expression, was placed on the left, right or far side of the turntable from the child. The experimenter moved the doll up and down to draw attention to it and told the child ‘This is Susan. When I lift the pot, which panda will Susan see?’ with emphasis on the word ‘Susan’ in the question (Figure 1B). For both types of trial, the child responded by pointing to a picture on the card, and praise was given regardless of the child’s answer.

Each child performed six mental rotation trials and six visual perspective taking trials, with block order counterbalanced across participants. The use of similar questions and the same response modality across both types of trial provides a control for children’s comprehension of the task. The starting orientation of the toy and rotation of the turntable or location of the doll were balanced within block. Seven different toys were used (car, jeep, tractor, sheep, panda, rhino and whale) which were all were clearly distinct when viewed from different orientations. Two response cards were generated for each toy, with the pictures of the front, back, left and right sides of each toy in different random locations to avoid any response bias.

Results

As expected, the children with autism performed significantly worse than the typical children on the theory of mind battery (Table 1). An ANCOVA comparing the ASD group with the typical young group revealed a significant main effect of group ($F=13.8$, $df = 1,42$, $p=0.001$) and a main effect of BPVS ($F=10.1$, $df = 1,42$, $p=0.003$). This result confirms that mentalising abilities increase with increasing verbal ability, and that the autistic children have particular difficulties with attributing mental states to other people, even after controlling for verbal skills, as reported previously (Happe, 1995).

The performance of the children with autism and the three groups of typical children on each experimental task is illustrated in Figure 2. The important features of the data are clearly visible on this plot, and were confirmed statistically. First, in the typical children, performance levels on the mental rotation and perspective taking tasks were stable over the different subgroups, with all children showing better performance on the mental rotation task than on the visual perspective taking task. An ANCOVA of task and BPVS score on the data from the 60 typical children revealed a highly significant effect of BPVS ($F=32.8$, $df = 1,58$, $p<0.0001$), a main effect of task ($F = 8.492$, $df = 1,58$, $p=0.005$) and importantly, no task by BPVS interaction ($F = 0.735$, $df = 1,58$, $p=0.40$).

Compared to typical children, the children with autism performed better at the mental rotation task and worse at the visual perspective taking task. An ANCOVA comparing the

ASD group to the typical-young group with BPVS raw score as a covariate revealed a main effect of task ($F = 35.8$, df = 1,43, $p<0.001$) and more importantly, a significant task by group interaction ($F = 7.4$, df = 1,43, $p=0.009$). There were no main effects of group or BPVS or task by BPVS interactions in this analysis (all $p>0.3$). Post-hoc t-tests demonstrated that the task by group interaction was driven by better mental rotation performance from the ASD group ($t=2.46$, df = 44, $p=0.018$).

An equivalent ANCOVA analysis was conducted to compare the ASD group to the typical-mid group, who were matched on mental rotation performance. There was main effect of task ($F=32.9$, df = 1,43, $p<0.001$) and a task by group interaction ($F = 9.42$, df = 1,43, $p=0.004$). As before, there were no main effects of group or BPVS, and no task by BPVS interaction (all $p>0.1$). Post-hoc t-tests demonstrated that the task by group interaction was driven by weaker visual perspective taking in the children with autism ($t=3.4$, df = 44, $p=0.001$).

Regression analyses were used to test which of all the measures obtained best predicted performance on the visual perspective task. Data for the 22 children with autism and 38 typical children who completed the theory of mind testing was entered into a multiple linear regression, to determine which of the factors: diagnosis, chronological age, BPVS score, Theory of Mind score, and mental rotation performance, can predict each child's performance on the visual perspective taking task. The linear regression model had an overall r^2 of 0.22 ($F=3.08$, df = 5,54, $p=0.016$), and revealed that Theory of Mind performance significantly predicted VPT performance ($r^2=0.18$, $t=2.55$, $p=0.014$), but that none of the other variables had a significant effect (all $p>0.1$). Simple regressions between each of the three critical variables (Theory of Mind, VPT score and Mental Rotation score) were conducted to further explore the origins of this effect. This revealed that ToM score correlated with VPT score ($r^2 = 0.76$, $p=0.001$) but not with MR score ($r^2 = 0.001$, $p=0.847$). VPT score correlated modestly with MR score ($r^2 = 0.08$, $p=0.01$), most likely due to the strong influence of BVPS on both of these variables. The correlations confirm that the relationship between ToM score and VPT score could not be mediated by shared variance with mental rotation.

In addition, a regression analysis was performed on the data from only the 38 typical children who completed all tasks. Stepwise regression was used to test the prediction that performance on the VPT2 task was related to MR and ToM but not to BPVS. Each of these three variables was entered into a stepwise regression (in the order – MR, BPVS, ToM). The results revealed that MR made a marginal contribution to explaining the variance in VPT ($t=1.85$, $p=0.073$) while BPVS did not contribute ($t=0.27$, $p=0.789$). These two variables were therefore excluded from the model, leaving ToM which predicted VPT2 (r^2 = 0.117, t=2.18, p=0.036). This analysis demonstrates that, in typically developing children, VPT2 abilities are related to ToM abilities and not to verbal skills. Overall, these results provide further evidence for a link between theory of mind abilities and VPT2, regardless of verbal or spatial abilities, or autism diagnosis.

Discussion

The results of this study, using the technique of 'fine cuts'(Frith & Happe, 1998), provide clear evidence that children with autism have specific difficulties with level 2 visual perspective taking, in comparison to their spatial rotation abilities. Furthermore, VPT2 was significantly related to theory of mind ability. This finding demonstrates that there is a link between the ability to imagine how another person sees an object and the ability to represent another person's beliefs and desires. Our results resolve previous contradictory findings of good VPT in autism, and provide new evidence that VPT2 should be considered as a mentalising task. We now consider how VPT2 relates to other behavioural tasks, in order to gain a deeper understanding of the cognitive processes involved in these tasks

VPT2 and mental rotation

The two novel tasks used in the current study tested level 2 visual perspective taking and mental rotation, with the same stimulus materials and type of response and with minimal language requirements. The contrast between these tasks reveals that children with autism have specific difficulties with VPT2 relative to their mental rotation ability. If, like previous studies (Reed & Peterson, 1990; Tan & Harris, 1991), we had tested only VPT2, we would not have been able to draw these conclusions. Our data resolves the discrepancy in the autism literature between experimental data suggesting good VPT2 performance in autism (Reed & Peterson, 1990; Tan & Harris, 1991) and the theoretical arguments predicting poor VPT2 performance (Frith et al., 1991; Leslie, 1987). Specifically, our results support the decoupling theory (Frith et al., 1991; Leslie, 1987) and suggest that VPT2 should be considered a mentalising task. In contrast, our data is not compatible with the idea that an 'eye direction detector' module is responsible for all processing of where another person looks and what they see (Baron-Cohen, 1995).

The close matching of the MR and VPT tasks allows us to address some possible criticisms of our results. It could be argued that the wording of the question children were asked in our task ("Which panda will you see" / "which panda will Susan see") could adversely affect performance. The structure of the practice trials which taught the children to answer by pointing to the picture card, and which gradually increased the task complexity, meant that children did not have trouble understanding the question. More importantly, because the two test questions for the VPT and MR conditions were so similar, the question wording cannot be responsible for the differences in responding between the MR and VPT conditions, nor for the critical interaction between task and autism diagnosis.

We note here that our current data does not afford strong conclusions about whether the ASD children are better than controls at mental rotation, or worse than controls at VPT2. The ASD children we tested did not perform worse, in absolute terms, than the VMA matched typical control group on the VPT2 task. However, performance differences may have been masked by a floor effect, as both groups were at chance. In the comparison between the ASD children and the typical-mid group who were matched on mental rotation performance, the ASD group performed significantly worse at VPT2. A critical question is – which comparison group is more informative? To address this, we turn to the correlation analysis of performance in the different tasks in the typical group of children. The stepwise regression of VPT2 with MR, BPVS and ToM in the typically developing children shows that VPT2 performance is driven marginally by spatial abilities (MR performance) and strongly by ToM abilities, but not by verbal skills. This means that the extra 'visual perspective taking' component of the VPT task (compared to the MR task) is closely related to ToM abilities and not to verbal abilities. More importantly, this means that is it fair to compare the ASD group to the mid-typical group who show similar MR performance, rather than to the young-typical group who show similar verbal abilities. In this comparison, we found clear evidence for impaired VPT2 in the autistic children.

More generally, our results highlight the fact that VPT2 tasks are difficult, and may even be harder than traditional 'false-belief' tasks. Further evidence for this can be found in studies of typical children, who do not reliably pass more complex VPT2 or appearance-reality tasks until around age 5 or 6 (Flavell et al., 1986). Our typical-mid group who were around 6 years old showed above-chance performance on the VPT2 task but were not yet at ceiling. These data reveal the protracted and incomplete development of visual perspective taking abilities in typical individuals, including even adults (Keysar et al., 2003; Langdon & Coltheart, 2001), and the need for more careful studies to reveal differences between typical and autistic groups on these tasks. The results we present here provide clear evidence that children with autism find VPT2 more difficult than mental rotation compared with three different age groups of typically developing children, but further studies will be needed to clarify the relative difficulty of our VPT2 task, other VPT2 tasks and a whole range of other Theory of Mind tasks.

VPT2 and VPT1

In the present study, we did not test VPT1 skills because of the clear consensus that VPT1 develops early in typical children (Lempers et al., 1977; Sodian, Thoermer, & Metz, 2007; Tomasello & Haberl, 2003) and is intact in children with autism (Baron-Cohen, 1989; Hobson, 1984; Leslie & Frith, 1988). Nevertheless, it is interesting to consider the difference between VPT1 and VPT2 – what makes a task a level 1 problem or a level 2 problem, in general and in our specific study? The original studies VPT (e.g.Masangkay et al., 1974) used a level 1 task where a child must judge that if she can see the cat on one side of the page, a person sitting on the opposite side of the table will see the turtle on the other side of the page. For the level 2 task, the animal picture was placed flat on the table, and the child must realise that, while she can see the turtle on his feet, the person across the table sees the turtle on his back. The latter is considered a level 2 task because it requires decoupling of the viewpoints of the two observers, in order to appreciate that each person sees the same turtle in a different way.

The VPT task we used (based on previous work (Huttenlocher & Presson, 1973; Langdon & Coltheart, 2001)) involved matching a picture to a toy placed in a particular orientation. Either an abstract decoupling of viewpoints or a detailed simulation of the other person's viewpoint would solve this task in a manner similar to false-belief tasks. Are such processes necessary in our VPT task? Conceivably, children might solve the task by a 'level 1' mechanism, for example, asking themselves "Can *I* see the panda's nose?" "Can *she* see the panda's nose?" etc for several body parts, and using the answers to select the appropriate picture. Huttenlocher and Presson (Huttenlocher & Presson, 1979) compared typical children's performance on item questions (Can I see the panda's nose?) and appearance questions (Which picture matches the panda she can see?). They found item questions were easier than appearance questions, suggesting that item questions tap into more basic level 1 abilities. More importantly, the fact that appearance questions were harder indicates that children do not spontaneously use an item strategy to answer questions about the whole appearance of a scene. The picture-matching question we used in our task clearly refers to the whole scene, and we have no reason to believe that children adopted an item / level 1 VPT strategy.

A similar analysis can be applied Keysar et al.s' study (2003), in which typical adults were found to be remarkably bad at considering which elements of a complex scene could be seen by another person. In theory, the participants could have solved the problem using a level 1 line of sight strategy, but it seems that they did not use this simple approach. Further investigation of this issue, with different questions and different stimulus sets, will be necessary to confirm the strategy used, and to gain a better understanding of when people use VPT1 or VPT2 strategies.

VPT2 and mentalising

The results of our study showed that across participants, mentalising ability predicts VPT2 task performance, while other factors such as BPVS score or chronological age do not. This relationship between VPT2 and mentalising supports the idea that VPT2 should be considered a mentalising task. Our data are coherent with the idea that in order to make judgements about someone else's mental state, it is necessary to decouple the representation of that state from reality. Whether such decoupling involves abstract theoretical rules or a simulation mechanism remains unclear. However, it is clear that such decoupling is required for pretense, for false-belief performance and also for level 2 visual perspective taking (Leslie, 1987). An abnormality in this decoupling or mentalising mechanism in autism (Frith et al., 1991) can account for the present data as well as the well-documented false-belief difficulties seen in autism (Baron-Cohen et al., 1985; Happe, 1995).

More importantly, our results contribute to the emerging debate over what mentalising is. Since the seminal studies of false-belief (Baron-Cohen et al., 1985; Wimmer & Perner, 1983), this task has been taken as the key index of mentalising ability. Over the last 30 years the ability to reason about other people's beliefs has been considered central, and relatively little attention has been paid to the question of how we reason about other people's perceptions, desires, intentions or emotions. However, to achieve a full understanding of the cognitive and computational processes involved in mentalising, it is important to look at the variety of types of mentalising, not just at false-belief tasks.

Some recent studies provide steps in this direction. For example, Keysar et al. (2003) showed that typical adults are surprisingly bad at taking another person's visual perspective into account (Keysar et al., 2003). Neuroimaging studies link the temporoparietal junction to both false-belief tasks (Saxe & Kanwisher, 2003) and level 2 visual perspective taking (Aichhorn et al., 2006). Patients with damage to temporoparietal regions have difficulty with both theory of mind tasks (Samson, Apperly, Chiavarino, & Humphreys, 2004) and visual perspective taking (Samson, Apperly, Kathirgamanathan, & Humphreys, 2005). The data we present here adds to the evidence that VPT2 relies on the same cognitive systems as false-belief tasks. This serves as a warning that mentalising should not be equated with belief processing alone. More importantly, it opens up new ways to study mentalising abilities using a wider variety of tasks and thus to obtain a clearer theory of the complex cognitive processes underlying this critical skill.

Conclusion

The data presented here demonstrate that young children with autism have substantial difficulties with visual perspective taking, relative to their performance on a mental rotation control task. This result is compatible with the idea that mentalising and VPT2 both involve the decoupling of mental states from reality, and that this decoupling presents difficulties to individuals with autism (Frith et al., 1991; Leslie, 1987). Our results shed light on the boundaries of mentalising and delineate more precisely the breakdown of mentalising in autism.

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Table 1

	N	Chrono-logical age	Verbal mental age	BPVS raw score	Theory of Mind score
ASD group	23	8;0 ± 0;6 (4;5 – 12;9)	4;4 ± 0;3 (2;4 – 7;5)	43.9 ± 2.97 (15 – 79)	3.61 ± 0.64 (0 – 10)
Typical young group	23	4;2 ± 0;2 (3;4 – 5;4)	4;8 ± 0;3 (3;1 – 6;0)	48.4 ±2.11 (28-61)	7.26 ±0.68 (0 – 11)
Typical mid group	23	5;9 ±0;3 (3;9 – 8;5)	6;10 ± 0;1 (6;0 – 7;10)	69.9 ± 1.15 (61-80)	10.1 ± 0.8 (4-13)
Typical old group	12	7;4 ± 0;2 (6;0 – 8;1)	8;11 ± 0;2 (8;0 – 10;4)	89.8 ± 1.53 (82-100)	

Table 1. Demographics of the participants. All data are given as mean ± standard error (min – max). The theory of mind battery has a maximum of 13 points.

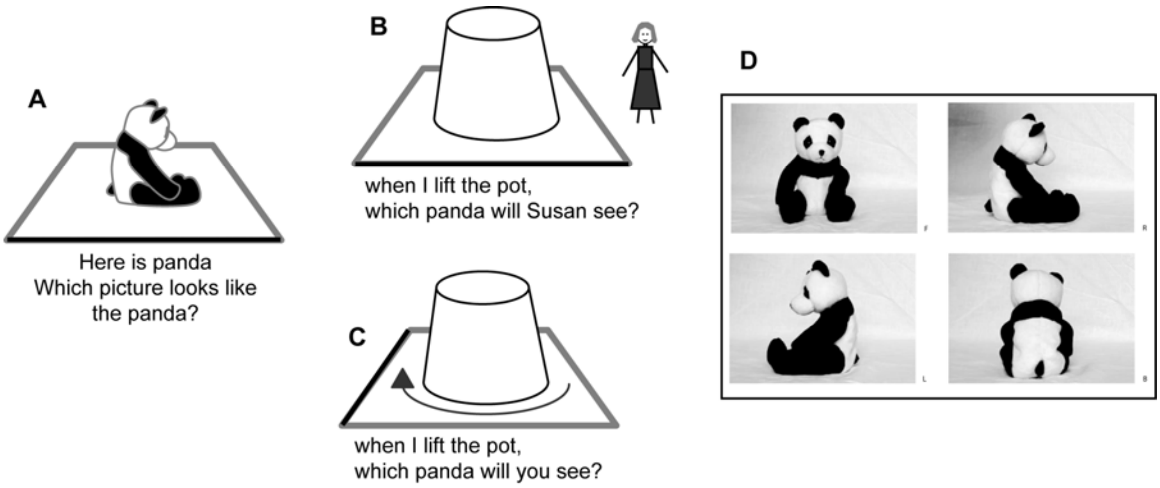

Figure 1. Stimuli and task. A. A square turntable with brightly coloured edges was placed on the table in front of the child, and a toy placed on the turntable. The black edge of the square signifies one coloured side. Each trial began with an orientation question to make the child attend to the orientation of the toy.

B. For Visual Perspective trials, the toy was covered and the doll introduced. The child was required to judge what the doll could see from her viewpoint.

C. For mental rotation tasks, the toy was covered and the turntable rotated. The sides of the turntable were edged with different colours of tape (red, blue, yellow and green), illustrated with a black line in the figure, to clearly signal the rotation. The child was required to judge the orientation of the toy after the rotation.

D. A sample response card. Children responded by pointing to one of the pictures on the card.

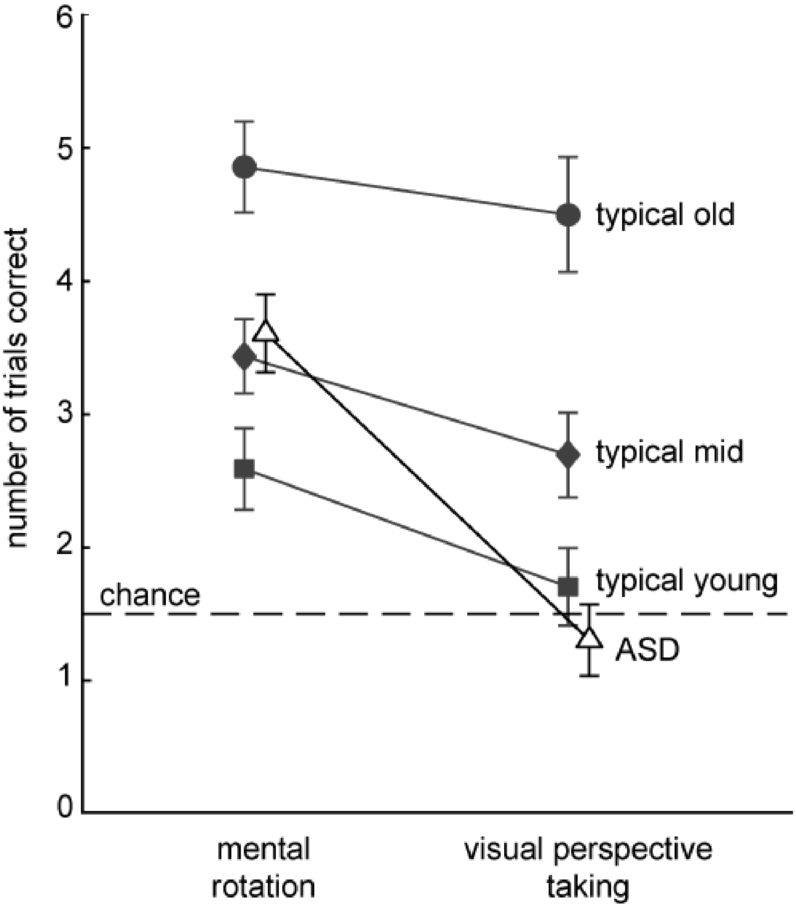

Figure 2. Performance on the experimental tasks. The mean number of trials correct for each group of children (± standard error) is shown. Each child completed 6 trials with four possible choices on each trial, so the maximum score is 6 and chance is 1.5.