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Drawing development in autism: The intellectual to visual realism shift

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Normal children above 5 years old or so show a shift in their drawing development from intellectual to visual realism (the I–VR shift). Some cases of individuals with autism have been reported who appear to have a mental age (MA) of considerably *less* than 5 years old but who are capable of visual realism. This raises the possibility that in autism, the I–VR shift is independent of MA—that children with autism as a group might show precocious visual realism, independent of technical competence. This hypothesis was tested by giving three different drawing tasks to a group of subjects with autism who were *not* selected for drawing competence. On these tasks they did not differ from either normal children or subjects with mental handicap (of an equivalent MA)—they showed the I–VR shift at approximately the same MA level (above 5:5 years). This refutes the hypothesis that this shift is independent of MA in autism. The existence of intellectual realism as a normal phase in the drawing development of subjects with autism is discussed in relation to Leslie's meta-representation theory.

The investigation of drawing development has been dominated by the idea that children develop through a series of distinct stages. Luquet (1913, 1927) proposed a three-stage theory of development through which children's drawings develop: (i) *failed realism*—where elements within the drawings are unrelated to each other (e.g. a mug and its handle may be drawn unconnected); *(ii) intellectual realism*—in which children draw what they know about an object (e.g. drawing a mug with a handle connected to it, even when the handle is occluded); and *(iii) visual realism*—in which the child draws what is actually seen (e.g. omitting to draw the mug's handle, because it is occluded). Luquet's stage theory was taken up enthusiastically by Piaget & Inhelder (1956, 1971) and the notion that young children 'draw what they know rather than what they see' came to be widely accepted.

The Luquet/Piagetian model of drawing development has been criticized for being uneccessarily rigid in its application of these stages (Freeman, 1980), and a range of

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task characteristics have been shown to influence the level of drawings children produce (e.g. Barrett & Bridson, 1983; Bremner & Moore, 1984; Light & McEwan, 1987; Moore, 1987). An excellent example of the importance of task characteristics determining the level of drawing production was reported by Cox (1981). She showed that 6-year-olds who were unable partially to occlude a ball placed behind a toy wall were nevertheless able to produce a partially occluded drawing of a toy policeman 'hiding' behind the wall. Similarly, 7-year-old children switched to a partial occlusion response when balls in an array were given faces and when one character hid behind the other (Littleton & Cox, 1989). Despite these effects, normal children below the age of 5 years old rarely produce visually real drawings. Instead their drawings, if they are representational and connected at all, show intellectual realism. Exactly what intellectual realism implies about the processes involved in drawing is still contentious, but there remains little doubt today that the normal development of drawing does indeed involve a shift from intellectual to visual realism.

Drawing and autism

It is well known that a small proportion of people with autism have unusual drawing ability that is out of keeping with their general intelligence (O'Connor & Hermelin, 1988; Sacks, 1985; Selfe, 1977, 1983). For example, Sacks (1985) reports a case of a 21-year-old man with autism and a mental handicap who had no language but who produced drawings of flowers that were of a standard of which most professional illustrators would be proud. Selfe (1977) reported the now famous case of Nadia who, at 6 years old, produced pictures of horses which included all the features of visual realism (appropriate occlusion, size-scaling, and perspective). This was despite her mental age (as measured by the Merrill-Palmer) being just 3 years 3 months. And Steven Wiltshire, a boy with autism, has recently published three books of his remarkable drawings which focus on his interest in drawing buildings (Wiltshire, 1987, 1989, 1991). Some examples of their work are shown in Figs 1a and b.

Selfe (1977, 1983) argued that such artistically gifted children with autism proceed through the same developmental stages in drawing ability as normal children, but at a different rate: they appear to produce visually realistic drawings at a much earlier age. Accounting for this anomalous developmental pathway is of considerable interest (O'Connor & Hermelin, 1987, 1990).

In contrast to this focus on exceptionally talented children with autism, there have been relatively few studies looking at drawing by children with autism who have no special ability. This is despite the fact that unusual drawing ability is quite rare in autism. Of the few studies that have looked at an unselected group of children with autism (e.g. Fein, Lucci & Waterhouse, 1990; Lewis & Boucher, 1991), none have specifically examined if drawing develops in line with their mental age (MA). If the talented minority share some common cognitive characteristics with the untalented majority of children with autism, then it may be that (irrespective of technical competence) an unselected group of children with autism might also show precocious visual realism. The experiment reported below set out to investigate this.

We were interested in this question for several reasons. First, we wanted to find

Figure 1a. Drawing by Nadia.

out whether in the wider group of children with autism, visual realism is tied to MA (and if so, more to non-verbal than verbal MA, as one would predict with a spatial skill such as drawing). A second reason for studying the intellectual to visual realism (I–VR) shift in autism was to investigate if drawing ability in autism is enhanced by the social context of drawings, as Cox (1981) has shown for normal children. We predicted that because of their social difficulties, and in particular because of their impairments in developing a *theory of mind* (Baron-Cohen, 1990; Baron-Cohen, Leslie & Frith, 1985, 1986; Perner, Frith, Leslie & Leekam, 1989), reference to implicitly mental activities (such as *hiding*) would not affect drawing level in children with autism, unlike controls.

A final reason for looking at this topic is that demonstration of a capacity for intellectual realism could have implications for the metarepresentation explanation of autism (Leslie, 1987). Leslie proposed that the theory of mind deficit in autism was due to a specific inability to represent *mental* representations. Recent tests of a general metarepresentation deficit, involving tests of the ability to represent *non-mental*

St Paul's Cathedral

Figure 1b. Drawing by Stephen Wiltshire. St Paul's Cathedral.

representations such as photographs (Leekam & Perner, 1991; Leslie & Thaiss, 1992) and drawings (Charman & Baron-Cohen, 1992) confirm the deficit is indeed specific to representing mental representations. There are reasons (discussed later) for arguing that if a child manifests intellectual realism, this can also be taken as evidence of an ability to represent non-mental representations.

We used three drawing tasks, derived from methods used to examine the development of drawing ability in normal populations (Cox, 1981; Freeman & Janikoun, 1972; Moore, 1986). These, we felt, represented the best tests of the I–VR shift in being relatively non-verbal, simple to administer and score, and likely to reveal a child's potential in an experimental setting that a free-drawing task might conceal.

Method

Subjects

There were 17 subjects with autism, all of whom had been diagnosed according to established criteria

(American Psychiatric Association: DSM III-R, 1987; Rutter, 1978) and who were attending a special school for autism. In addition, there were 15 subjects with mental handicap but without autism, in order to control for MA and chronological age (CA), and 16 children attending a normal school, in order to obtain normative data. The sex ratio in the normal group and in the group with mental handicap was approximately 1:1, whilst in the group with autism it was approximately 2:1 (m:f), reflecting the predominance of males who have this condition. Details of the subjects are summarized in Table 1.

Table 1. Subject variables: Chronological age (CA) and mental age (MA)

Diagnostic groups	*N*	CA	Non-verbal MA*	Verbal MA†
Autism	17	Mean 13:6	7:9	5:3
		SD 3:9	2:0	2:0
		Range 6:1–18:0	4:5–11:2	2:9–9:4
Mental handicap	15	Mean 14:7	4:9	4:2
		SD 3:0	0:5	1:1
		Range 10:0–18:1	4:0–5:5	2:9–5:7
Normal	16	Mean 5:4	—	—
		SD 1:1		
		Range 3:3–7:2		

* Raven's matrices; †BPVS.

Non-verbal MA was assessed using the Raven's Coloured Progressive Matrices (Raven, 1956). Two subjects with autism and two from the mentally handicapped group refused to be tested on the Raven's. Verbal MA was assessed using the British Picture Vocabulary Scale (Dunn, Dunn, Whetton & Pintillie, 1982). For the normal group we assumed that MA would roughly correspond to CA. Non-verbal MA was higher than verbal MA for the subjects with autism, reflecting typical discrepancies in the IQ profile (De Meyer, 1976). The subjects with autism had a higher verbal MA ($t(30) = 2.06$, $p = .05$) and non-verbal MA ($t(26) = 5.21$, $p < .001$) than the subjects with mental handicap. Table 1 shows the minimum verbal MA was 2:9 years, although in fact only two subjects scored this low (one with autism, one with mental handicap). The rest all had verbal MAs above 3 years.

Procedure

Each drawing task was standardized using specific instructions, and by asking the subject to name the objects prior to drawing them. These precautions were taken as such factors have been found to affect the kind of drawings children produce (Barrett, Beaumont & Jennett, 1985; Bremner & Moore, 1984; Cox, 1986; Lewis & Russell, 1989). The mug, cube and wall tasks were administered in random order.

The mug task. This task was derived from Freeman & Janikoun (1972). Each child sat at a table and was handed a mug, asked to examine it and name it. The mug was then placed onto the table in front of the subject so that its handle was occluded. The experimenter then said: 'Draw exactly what you can see. Draw how it looks to you.'

The wall task. This task was derived from Cox (1981). Still sitting at the table, each subject was shown a ball and a toy wall. The ball was placed so that it was partially occluded by the wall. The experimenter then said: 'Draw exactly what you can see. Draw how it looks to you'. In a second trial of the wall task,

the ball was removed and each child was then shown the doll. Following this, the doll was placed behind the wall, in a similar position to where the ball had been, so that only the doll's head and shoulders were visible. The subject was told that 'the little girl is hiding from her mummy'. The experimenter then again said: 'Draw exactly what you can see. Draw how it looks to you.'

These two trials of the wall task were intended to be formally identical in visual terms, and allowed a test of whether 'social' objects (and the instructions encouraged the child to think of the doll in an intrinsically social context, *hiding*) would affect drawing ability. These two trials had a fixed order of presentation (ball first, then doll).

The cube task. This test was derived from Moore (1986). A cube, with each face painted a different colour, was shown to each subject. They were asked to name it, and name the colours on its faces. The cube was then placed on the table so that only the top, left and right sides were visible. Each subject was given a black felt-tip pen. The experimenter said: 'Make a drawing of this cube (brick, etc.). Draw exactly what you can see from where you're sitting'.

After the subject had finished, the experimenter then removed the subject's pen and handed her/him 10 coloured felt-tip pens (among which were included all six colours of the faces of the cube) and said: 'I've got some colours here. Colour in your drawing. Use the right ones to make it look exactly how you see it from where you're sitting'.

This colouring condition was used because Moore (1986) had found that sometimes children drew in outline more than three faces of the cube (resulting in an intellectual realism rating), but then coloured only three of these faces when given coloured pens (resulting in a visual realism rating). The colouring condition therefore provided a second opportunity to establish if a child could produce a visually real drawing, independently of their ability to draw the outline of the cube (an object which is particularly difficult, Cox, 1986).

Scoring criteria and reliability. Although there is some debate as to whether intellectual and visual realism are distinct developmental stages, it is nevertheless possible to categorize drawings as either intellectually, or visually, real.

Drawings were rated as showing IR (intellectual realism) if the subject included any hidden, or occluded, features. Drawings were rated as showing VR (visual realism) if they included only those features visible to the subject. Thus, the mug drawing was scored as IR if a handle was clearly shown in the drawing. The ball drawing was scored as IR if either (*a*) a whole ball was drawn, or (*b*) there was superimposition of the ball onto the wall. The doll drawing was scored as IR if either (*a*) the whole body of the doll was included, or (*b*) there was superimposition of the doll onto the wall. For the cube, two judgements were made: first, the outline drawing was scored as IR if more than three faces were represented; second, the coloured-in drawing was scored as IR if any of the colours not visible to the subjects were used in colouring in their outline. These two cube scores were analysed separately.

Drawings in which the objects were clearly depicted but where these critical (intellectually real) features were occluded were scored as VR. If what was represented on any drawing was not clear, the drawing was scored as unintelligible and the drawing was then excluded from further analysis. The scoring criteria and examples of the drawings produced are shown in Appendix 1. (In fact, only two out of 85 of the drawings produced by the autistic group, and 13 out of 75 of those produced by the mental handicap group, and seven out of 80 of those produced by the normal group, were rated as unintelligible.)

All of the drawings produced were rated independently by two judges, using the criteria summarized in Appendix 1. The results of this reliability test are also shown in this Appendix. Agreement between the two raters was high. Across the three categories (IR/VR/unscorable), agreement measured by Cohen's kappa (Cohen, 1960) ranged from .74 to .95. Artistic and graphic drawing ability was not considered, as this was not relevant to the main aim of the study.

Results

All subjects were able to name the objects used in the drawing trials. The percentage of each group producing VR drawings on each condition is shown in Table 2. As this

Table 2. Percentage of subjects in each group producing VR drawings[a]

Task	Groups		
	Autism ($N=17$)	Mental handicap ($N=15$)	Normal ($N=16$)
Mug	25	31	53
Ball/wall	47	0	20
Doll/wall	53	43	60
Cube (outline)	77	82	94
Cube (colour)	62	78	47
% increase ball→doll[b]	6	43	40
Predominantly VR (>4)	41	0	31

* $p<.03$.

[a] Percentages are given as the number of subjects varied from one condition to another, as a result of excluding some subjects who produced drawings rated as unintelligible.

[b] Percentage increase between doll and ball conditions on the wall task.

shows, there were no significant differences between the groups on either the mug, doll, cube (outline only) or cube (colouring) tests (all comparisons, using Fisher's exact probability test, $p>.05$). However, on the ball task the subjects with mental handicap produced significantly fewer visually real drawings than the subjects with autism (Fisher's $p<.003$), though they did not differ from the normal subjects on this. The increase in visually real drawings found by Cox (1981) when the ball was replaced by the doll in the wall tasks was shown by both the normal and mentally handicapped groups, but not by the subjects with autism (both Fisher's $p<.03$). This is also shown in Table 2. Finally, a total 'visual realism' score (VR) was calculated for each subject, with 1 point being given for a visually real drawing on each task (maximum = 5 points). As mentioned earlier, drawings rated as unintelligible received no score. Subjects were considered to produce visually real drawings *consistently* (i.e. to be predominantly visual realists) if their overall VR score was 4 or above. The number of subjects classified as predominantly VR in each group is shown at the foot of Table 2. On this basis there were significantly fewer subjects with mental handicap who were consistent visual realists than there were in the other two groups (both Fisher's exact tests, $p<.03$).

The role of CA and MA

Analysis of the role of CA and MA in drawing performance using t tests showed that, in the group with autism, the subjects who produced visually real drawings (on the mug and wall tasks and as defined by their overall VR score) tended to have a higher CA and MA (both verbal and non-verbal) than those who did not. For none of these comparisons did this pattern reach statistical significance. In part, this may have been because only one subject with autism had a non-verbal MA less than 5 years old—the

mental age by which normal children begin to show visual realism consistently. A sample of children with autism which included more children with lower non-verbal mental ages (e.g. in the range of 3–4 years) might have led to clearer differences between subjects with a consistent overall VR score and those without.

Similarly, in the group with mental handicap there were no significant differences between those subjects producing visually real drawings and those who did not. We suspect that no clear MA differences emerged within this group because of the small non-verbal MA distribution (4:0–5:5 years). Subjects with mental handicap at this level may be able to produce some visually real drawings, but not be able to produce them consistently. A sample of subjects with mental handicap with a wider range of non-verbal MA (e.g. 4–8 years) might have led to clear differences between subjects with a consistent overall VR score and those without.

In the normal group, statistically significant differences did appear. Those subjects who produced VR drawings had a higher CA than those who did not on the ball task ($t(13) = 2.39$), the doll task ($t(13) = 2.41$) and the cube (colour) task ($t(11) = 2.81$, all these tests, $p < .04$), as well as on their overall VR rating ($t(14) = 4.70$, $p < .001$). On the mug task no difference emerged, and on the cube-outline task 14 out of 15 subjects received a VR rating, making it meaningless to compare those with a VR or IR rating.

Despite the lack of significant CA or MA differences in the clinical groups between those scored as producing VR or IR drawings, the following pattern in all the groups could be clearly identified: in the normal group, all subjects who were rated as producing VR drawings overall (VR score 4 or 5) had a CA of 6 years or above. In the group with autism all subjects who were rated as producing VR drawings overall had a non-verbal MA of 5:5 years or above. In the mentally handicapped group, no subjects had an overall VR rating, but all had a non-verbal MA of 5:5 years or less. The non-verbal MAs of each subject with autism or mental handicap, and the CAs of each normal subject, are shown in Appendix 2, grouped according to their overall IR or VR score. (Non-verbal MA is presented in Appendix 2 on the grounds that this would be expected to have some relationship to a visuospatial skill such as drawing.)

Discussion

This experiment set out to discover if an unselected group of children with autism would show the same pattern of development in drawing ability (a shift from intellectual to visual realism), at a comparable mental age to normal and non-autistic subjects, or whether, like the few *autistic savants* who have been studied (Sacks, 1985; Selfe, 1983) they would show precocious visual realism, even in the absence of developed skill or talent. The results of our experiment showed no significant difference in the production of intellectually or visually real drawings produced by subjects with autism, compared to other subjects of an equivalent mental age.

The subjects with autism who consistently produced visually real drawings were not significantly older than subjects with autism who did not, but all had a non-verbal mental age of 5:5 years or above. This developmental shift mirrors that found in the normal group, in which all subjects who consistently produced visually real drawings were 6 years old or over. None of the subjects with mental handicap had

non-verbal mental ages as high as this, and none consistently produced visually real drawings.

A non-verbal mental age of at least this level therefore appears to be a necessary but insufficient condition for the consistent production of visually real drawings. It seems insufficient because some subjects had higher non-verbal mental ages but even so did not produce visually real drawings (see Appendix 2). Accounting for this pattern requires further research. In general, though, the development of drawing ability in autism appears to follow the normal developmental pattern, being related to non-verbal mental age—as would be expected for such a visuospatial skill. There is no evidence for a general trend towards precocious visual realism.

These results replicate those of previous studies which show that the production of visually real drawings increases with mental age (Cox, 1981, 1985; Freeman, 1980). They also support evidence that normal children can produce visually real drawings from as young as 5 or 6 years old (Cox, 1985; Littleton & Cox, 1989). Finally, the experiment confirms that among a randomly selected population of subjects with autism, exceptional drawing ability is rare. Most had no special drawing ability.

For the normal subjects and those with mental handicap, introducing a social context to the visual display increased the proportion of subjects who produced visually real drawings, replicating other studies (Cox, 1981, 1985; Light & McEwan, 1987; Littleton & Cox, 1989). This did not, however, help our subjects with autism. We speculate that their inability to respond to the social cues in the doll task, where the girl is described as 'hiding behind the wall', might relate to their poor social understanding, and particularly their relative 'blindness' to the importance of mental states (Baron-Cohen, 1990). However, in the wall tasks, the introduction of a different object (replacing a ball by a doll) was confounded with the introduction of a mentalistic term ('hiding'). It would be interesting to separate the influence of these two factors in future experiments.

Before leaving the interpretation of the current experiment, it is worth noting that we did not include a task investigating how children with autism draw in the absence of a model, or how they perform when task instructions or context are varied. Such comparisons would be a useful addition to future studies of this group.

Some unusual cases in our sample

Despite showing the normal shift overall, some qualitative abnormalities did arise in the group with autism. One subject, for example, showed a typical obsessive interest in an unusual topic, albinos (both human and animal), and insisted on drawing these on one of his sheets. Another teenager with autism drew in a very detailed (and visually real) manner, attempting to draw the intricate pattern on the dress of the doll. His drawing speed was, however, commensurately slow. A third teenager with autism (with a verbal MA of 2:9 years) produced consistently visually real drawings—her verbal mental age being considerably lower than that for other subjects who showed the same level of drawing development. However, her non-verbal MA was 9:5 years, a level at which visually real drawing would be expected, emphasizing the importance of measuring both verbal and non-verbal mental age.

Finally, it is worth noting that six subjects with autism had a non-verbal MA above

5:5 years, and yet did not attain a rating of VR overall. As discussed earlier, this underlines the conclusion that in autism non-verbal MA is necessary but not sufficient to account for the emergence of consistent visual realism. It remains for future studies to identify which additional factors must also contribute to this skill.

Drawing development and metarepresentation

As mentioned earlier, Leslie (1987) put forward the metarepresentation theory to explain the autism-specific deficits in the development of a theory of mind (Baron-Cohen, Leslie & Frith, 1985, 1986). He suggested that there might be damage to the specific cognitive mechanism underlying a theory of mind, called the *metarepresentation capacity*. He defined this as the ability to represent an agent's mental attitude or 'informational relation' (belief, thought, knowledge, etc.) towards a proposition. In effect, this is equivalent to an inability to represent mental representations.

It is safe to assume that, when children produce intellectually real drawings, they must be using an internal representation of the object to guide them. The production of intellectually real features in a drawing can therefore be taken as evidence of a capacity to represent representations. Since the experiments reported here show that subjects with autism can produce intellectually real drawings this suggests that they are able to represent non-mental representations. This is consistent with Leslie's specific claim for deficits in the capacity to represent mental representations. Other recent experiments, employing a 'false drawing' task (Charman & Baron-Cohen, 1992) and 'false photographs' tasks (Leekam & Perner, in press; Leslie & Thaiss, 1992), to contrast with a 'false belief' task, have similarly found that subjects with autism have an intact understanding of non-mental representations.

We conclude that in autism the development of drawing generally follows the same developmental pattern as that seen in other groups, at approximately equivalent levels of non-verbal mental age, and that this is in line with predictions from Leslie's metarepresentational theory.

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References

American Psychiatric Association (1987). DSM III R: *Diagnostic and Statistical Manual of Mental Disorders*, 3rd rev. ed. Washington, DC: APA.

Baron-Cohen, S. (1990). Autism: A specific cognitive disorder of 'mind-blindness'. *International Review of Psychiatry*, **2**, 81–90.

Baron-Cohen, S., Leslie, A. M. & Frith, U. (1985). Does the autistic child have a 'theory of mind'? *Cognition*, **21**, 37–46.

Baron-Cohen, S., Leslie, A. M. & Frith, U. (1986). Mechanical, behavioural and Intentional understanding of picture stories in autistic children. *British Journal of Developmental Psychology*, **4**, 113–125.

Barrett, M. D. & Bridson, A. (1983). The effect of instructions upon children's drawings. *British Journal of Developmental Psychology*, **1**, 175–178.

Barrett, M. D., Beaumont, A. V. & Jennett, M. S. (1985). Some children do sometimes do what they have been told to do: Task demands and verbal instructions in children's drawings. In N. H. Freeman & M. V. Cox (Eds), *Visual Order: The Nature and Development of Pictorial Representation*. Cambridge: Cambridge University Press.

Brenner, J. G. & Moore, S. (1984). Prior visual inspection and object naming: Two factors that enhance feature inclusion in young children's drawings. *British Journal of Developmental Psychology*, **2**, 371–376.

Charman, T. & Baron-Cohen, S. (1992). Understanding drawings and beliefs: A further test of the meta-representation theory of autism. *Journal of Child Psychology and Psychiatry*, **33**, 1105–1112.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, **20**, 37–46.

Cox, M. V. (1981). One thing behind another: Problems of representation in children's drawings. *Educational Psychology*, **1** (4), 275–287.

Cox, M. V. (1985). One object behind another: Young children's use of array-specific or view-specific representations. In N. H. Freeman & M. V. Cox (Eds), *Visual Order: The Nature and Development of Pictorial Representation*. Cambridge: Cambridge University Press.

Cox, M. V. (1986). Cubes are difficult things to draw. *British Journal of Developmental Psychology*, **4**, 341–345.

De Meyer, M. K. (1976). Motor, perceptual-motor and intellectual disabilities of autistic children. In L. Wing (Ed.), *Early Childhood Autism*. Oxford: Pergamon Press.

Dunn, L. M., Dunn, L. M., Whetton, C. & Pintillie, D. (1982). *British Picture Vocabulary Scale*. London: NFER-NELSON.

Fein, D., Lucci, D. & Waterhouse, L. (1990). Brief report: Fragmented drawings in 'autistic children'. *Journal of Autism and Developmental Disorders*, **20**, 263–269.

Freeman, N. H. (1980). *Strategies of Representation in Young Children: Analysis of Spatial Skills and Drawing Processes*. London: Academic Press.

Freeman, N. H. & Janikoun, R. (1972). Intellectual realism in children's drawings of a familiar object with distinctive features. *Child Development*, **43**, 1116–1121.

Leekam, S. & Perner, J. (in press). Does the autistic child have a meta-representational deficit? *Cognition*.

Leslie, A. M. (1987). Pretence and representation: The origin of theory of mind. *Psychological Review*, **94**, 412–426.

Leslie, A. M. & Thaiss, L. (1992). Domain specificity in conceptual development: Neuropsychological evidence from autism. *Cognition*, **43**, 225–251.

Lewis, V. & Boucher, J. (1991). Skill, content and generative strategies in autistic children's drawings. *British Journal of Developmental Psychology*, **9**, 393–416.

Lewis, V. & Russell, C. (1989). When is a mug not a mug? A factorial analysis of the influence of content, object naming and instruction type upon children's drawings. Poster at the BPS Developmental Section Annual Conference.

Light, P. & McEwan, F. (1987). Drawings as messages: The effects of a communication game upon production of view-specific drawings. *British Journal of Developmental Psychology*, **5**, 53–60.

Littleton, K. S. & Cox, M. V. (1989). If balls have faces, children will partially-occlude them. Poster at BPS Developmental Section Annual Conference.

Luquet, G. (1913). *Les Dessins d'un Enfant*. Paris: Alcan.

Luquet, G. (1927). Le réalisme intellectuel dans l'art primitif. 1. Figuration de l'invisible. *Journal de Psychologie*, **24**, 765–797.

Moore, V. (1986). The use of a colouring task to elucidate children's drawings of a solid cube. *British Journal of Developmental Psychology*, **4**, 335–340.

Moore, V. (1987). The influence of experience on children's drawings of a familiar and unfamiliar object. *British Journal of Developmental Psychology*, **5**, 221–229.

O'Connor, N. & Hermelin, B. (1987). Visual and graphic abilities of the idiot-savant. *Psychological Medicine*, **17**, 79–90.

O'Connor, N. & Hermelin, B. (1988). Low intelligence and special abilities. *Journal of Child Psychology and Psychiatry*, **39**, 391–396.

O'Connor, N. & Hermelin, B. (1990). The recognition failure and graphic success of idiot-savant artists. *Journal of Child Psychology and Psychiatry*, **31**, 203–215.

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

Piaget, J. & Inhelder, B. (1956). *The Child's Conception of Space*. London: Routledge & Kegan Paul.

Piaget, J. & Inhelder, B. (1971). *Mental Imagery in the Child*. London: Routledge & Kegan Paul.

Raven, J. (1956). *The Coloured Progressive Matrices*. London: H. K. Lewis.

Rutter, M. (1978). Diagnosis and definition. In M. Rutter & E. Schopler (Eds), *Autism: A Reappraisal of Concepts and Treatments*. New York: Plenum.

Sacks, O. (1985). *The Man who Mistook his Wife For a Hat*. London: Picador.

Selfe, L. (1977). *Nadia: A Case of Extraordinary Drawing Ability in an Autistic Child*. London: Academic Press.

Selfe, L. (1983). *Normal and Anomalous Representational Drawing Ability in Children*. London: Academic Press.

Wiltshire, S. (1987). *Drawings*. London: Dent.

Wiltshire, S. (1989). *Cities*. London: Dent.

Wiltshire, S. (1991). *Floating Cities*. London: Dent.

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Appendix 1: Scoring criteria for the drawing production tasks

	Intellectually real	*Visually real*	*Unclear*	Cohen's kappa
Mug	Handle shown	No handle shown	Unclear if whole ball shown	.80
Ball/wall	Whole ball shown and/or superimposition	Cut off ball and no superimposition	Unclear if whole ball shown	.95
Doll/wall	Whole body shown and/or superimposition	Head and shoulders only shown and no superimposition	Unclear if whole body shown	.81
Cube (outline only)	>3 faces	<3 faces	Unclear if marks are faces	.74
Cube (including colour)	Any combination including green, red and brown	Any combination including blue, yellow and white	Colours other than the 6 on the cube used	.80

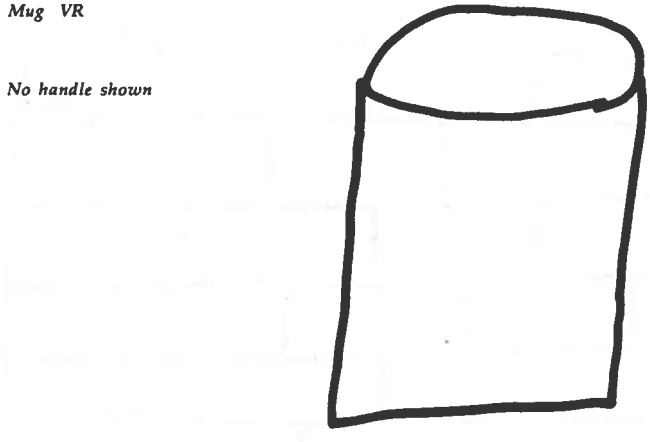
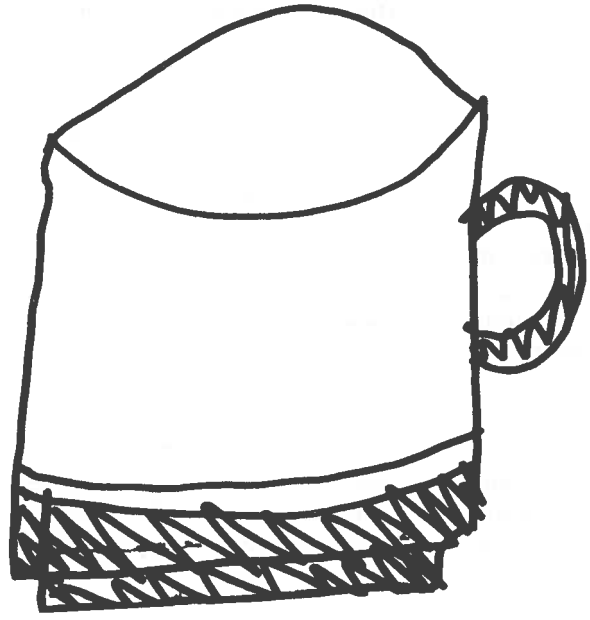


Figure 2. Examples of the mug and the ball-and-wall and the ratings they received (IR or VR).

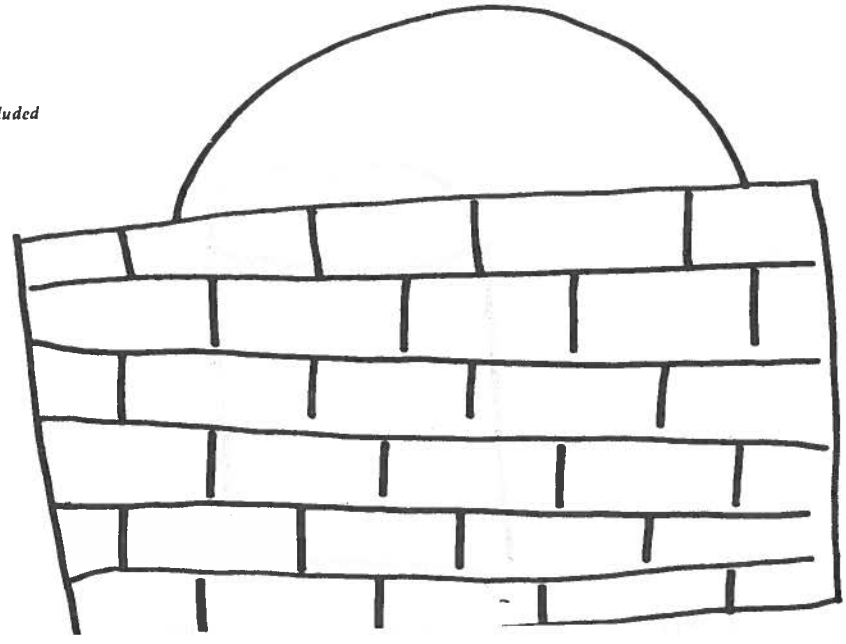
Mug IR

Handle shown



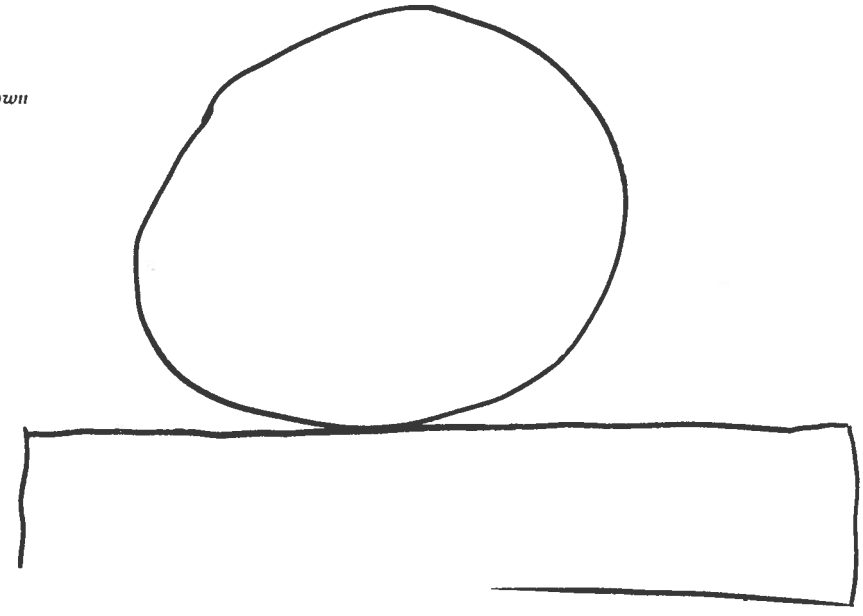
Ball/Wall VR

Ball partially-occluded



Ball/Wall IR

Whole ball shown



Appendix 2: Non-verbal MA of each subject rated predominantly IR or VR

Autism[a]		*Mental handicap*		*Normal*[b]	
IR	VR	IR	VR	IR	VR
4:5	5:5	4:0		3:3	6:2
5:5	7:5	4:0		3:9	6:4
7:0	8:0	4:5		4:2	6:4
7:2	8:0	4:5		4:4	7:0
7:5	9:5	4:7		4:7	7:2
7:5	11:0	5:0		4:8	
8:0	11:2	5:0		4:8	
10:5		5:0		5:2	
		5:4		5:5	
		5:5		5:5	
		5:5		6:3	
		5:5			
		5:5			

[a] Non-verbal MA was not measured for two subjects with autism.
[b] CA was used as an index of non-verbal MA for the normal subjects.