Imagining Real and Unreal Things: Evidence of a Dissociation in Autism

Fiona J. Scott
University of Greenwich

Simon Baron-Cohen
University of Cambridge

Abstract

Current theories of visual imagery hold that the same neural processes govern both the representation of real objects and the representation of imagined (but real) objects. Here we test whether the representation of imagined (real) objects and the representation of imagined (but unreal) objects depend on the same or different neurocognitive processes. A likely clinical group for a dissociation between these two types of imagination are children with autism, since they show deficits in imaginative play, impoverished imagination is part of their diagnosis, but they can search for hidden objects. The present study explored imagination in autism using experimental methods. Experiment 1 investigated if children with autism could introduce changes to their representations of people and houses, using Karmiloff-Smith's (1989) technique of asking children to draw "impossible" people or houses. Results showed that children with autism were significantly worse than matched controls in their ability to introduce "unreal" changes to their representations of people and houses. Instead, they tended to draw real people or objects. Experiment 2 investigated whether the performance in Experiment 1 by children with autism was due to an inability to disengage from "real world" representations, as executive dysfunction theorists would argue. To do this, the experimenter instructed them on what to draw and how to draw it. Results showed that even when executive control passed to the experimenter in this way, the children with autism were still significantly impaired in their ability to draw imaginary but unreal things relative to the matched controls. Experiment 3 investigated whether the results from Experiments 1 and 2 arose because of a generativity deficit in autism, which might be the executive dysfunction theorists' alternative account. To test this, the same subjects were given a test of Verbal Fluency and a test of imagining multiple functions of a brick. Results showed that the children with autism were no worse than clinical controls in their ability to generate ideas about real objects, suggesting that a global generativity deficit cannot explain the previous findings. Rather, these results point to a specific impairment in the ability to imagine unreal objects. This is discussed in terms of its possible neural dissociability from other kinds of imagery, and in terms of its possible relationship to theory of mind.

INTRODUCTION

The debate concerning the nature of the cognitive processes involved in generating visual mental images has been explored in depth over the past decade. Two main hypotheses can be identified: (1) Visual mental images are propositional representations, that is, a kind of mental sentence. Such propositions have to contain a predicate (relation), which ties up with one or more arguments (entities) [e.g., ON (BALL, BOX), describing a scene where the ball is on the box; see Pylyshyn, 1981]. Such propositional representations are purely abstract ways of describing a visual scene. (2) Visual mental images are depictive representations, that is, they are a kind of picture that describes locations of things in a certain space, and the related values and natures of those things. These depictive representations are interpreted by other cognitive processes.

The work of Stephen Kosslyn has been at the forefront of this debate. Using a variety of experiments Kosslyn has arrived at the conclusion that visual mental images are depictive by nature, and that they involve the same cognitive processes as are concerned with actual vision. That is, the same parts of the brain are used for generating and manipulating visual mental images as are used for identifying and exploring direct visual input (see Kosslyn, 1994). Other researchers have also arrived at this conclusion, following studies of normal adults. For example, subjects take longer to rotate a mental image that is oriented further from the perpendicular, thus showing a direct relationship between mental image and perceptual input (Shepard, 1984); second, a strong similarity has been demonstrated between the cognitive functions used to explore mental images and percepts of actual objects in the visual field (Finke & Kurtzman, 1981). Work from studies of patients following brain
damage also supports this conclusion. Thus, a patient whose language and visual areas were disconnected after a stroke was unable to describe both color imagery, or a visually presented color (Beauvois & Saillant, 1985); second, patients with visual object identification impairment and visual localization impairment demonstrate the same impaired and preserved aspects of vision in both their perception of real things and in their imagery (Levine, Warach, & Farah, 1985); third, patients with peripheral noncongenital blindness perform normally on visual imagery tasks (Hollins, 1985; see Farah, 1988, for a full review.)

However, these studies all concern the visual imagery of absent but real things. There is little research into the cognitive processes involved in the generation and manipulation of mental images of absent and unreal things (e.g., the generation of a mental image of a green dog with five legs). Kosslyn (1994, Chapter 9) briefly discusses the fact that imagery can be used to combine objects in novel ways and to visualize novel patterns, but to date there is little experimental evidence on this. It is assumed that Kosslyn's (1994) hypothesis (that the cognitive processes needed for direct perceptual analysis in the visual system are the same processes that are involved in visual mental imagery) also encompasses mental images for unreal things.

The present study was designed to explore if such an assumption is correct, by testing whether representation of imagined but real things, and representation of imagined but unreal things depend on the same, or different, cognitive processes. We propose to use autism to test for a specific dissociation in this, because the criteria for diagnosing autism not only include impairments in social interaction, in verbal and nonverbal communication, but also in imaginative activity ( DSM-IV; 1994; see Frith, 1989 for a review).

Imagination often involves the ability to image nonveridical objects and situations. For example, in pretense one may imagine being pursued by a monster from Mars; and creative imagination may require the mental imaging of previously nonveridical objects, thus allowing the invention of new tools, new artwork, and so on. Much research has been conducted into the social and communication difficulties in autism (see Baron-Cohen, 1988), but there has so far been little exploration of imaginative abilities—that is, the ability to entertain nonveridical representations—in autism per se. Imagination in autism has, however, been examined indirectly. For example, Baron-Cohen (1987) replicated the finding of a deficit in production of pretend play by children with autism. Apart from such studies of pretend play, there has been almost no study of imagination in autism. Perceptual veridical mental imagery has been studied in autism, using Shepard and Meltzer type mental rotation tasks (Shah, 1988). This involves the subject manipulating an existing perceptual image, with the test item visible. This is manipulation of visual imagery of current, real, objects, and children with autism perform normally on this. They can also pass object-permanence tasks, by searching for an object where it was last put, implying that they can utilize visual imagery of absent (but real) objects (Sigma, 1987). In contrast, we suspect that when the subject has to visualize things that are not present and do not even "exist" (except in the subject's mind) this may involve a different cognitive and neural mechanism, and this may be selectively impaired in autism. Imagination at this last level may involve the ability to adapt and/or combine existing concepts to create new and nonempirical ones (Richardson, 1969).

The present study aimed to test this prediction by studying the production of drawings of imaginary entities: real and unreal. Tasks requiring subjects to produce drawings of objects arguably also require the subject to entertain a mental image of that object, and thus drawing tasks have been used to explore mental imagery in patients who have suffered brain damage (e.g., Beyn & Knyazeva, 1962; Levine et al., 1985) as well as in normal development (see e.g., Thomas & Silk, 1990). Drawing in autism has been explored in the past to see if children with autism (including those who do not exhibit a precocious drawing talent) follow the same pattern of development as normal children in their attempts to represent what they see before them. By and large, they do (Charman & Baron-Cohen, 1993), and they also show similar strategies in the production of a variety of different drawings of their choice (Lewis & Boucher, 1991). However, while these earlier studies explored the child's ability to draw empirical, real-world concepts, as far as we know there has been no previous attempt to examine the production of drawings by children with autism of impossible or unreal things.

The present study was based on Annette Karmiloff-Smith's (1989) elegant experiment, where normally developing children (ranging from 4 years to 11 years) were first asked to draw a house and a man, and then asked to draw a house that does not exist, and a man that does not exist. Karmiloff-Smith found that when given the latter task, the younger children (4-6 year olds) changed their representations (by deletion of elements, and changes in size and shape of elements and of the whole), while the older children (8-10 year olds) went even further in introducing changes to their representations (they changed the position and orientation of elements, and added elements from other conceptual categories). For example, the younger children would draw a man with one leg, or a giant. The older children would draw a man with two heads and fifty fingers. The present study was not concerned so much with the types of representational change, but rather with whether children with autism were capable of introducing these changes at all, compared to matched controls. We predicted that the children with autism would be unable to represent "impossible" (unreal) houses and men, compared to matched controls. Subject to the re-
sults of the first experiment, further experiments were planned to test if an executive dysfunction theory (Hughes, Russell, & Robbin, 1994; Ozonoff, Pennington, & Rogers, 1991) could explain the results.

**EXPERIMENT 1: DRAWING IMPOSSIBLE THINGS**

**Subjects**

Three subject groups took part in the study. The first was a group of 15 children with autism, all of whom met the established criteria for autism (Rutter, 1978; American Psychiatric Association, 1987). They were all attending special schools for autism in the London area, and were aged between 8 and 16 years old. The second group consisted of 14 children with moderate to severe mental handicap, attending special schools for mental handicap in Norfolk, and aged between 9 and 16 years old. The diagnoses in this population included children with Down syndrome, and children with mental handicap of unknown etiology. The third subject group included 15 normally developing children, all attending a primary school in Norfolk, and aged between 4 and 5 years old. The two clinical groups were matched on verbal mental age (VMA), calculated using the Test of Reception of Grammar (TROG; Bishop, 1983), which is held to give a clearer estimate of language comprehension than does a simple vocabulary test. The verbal mental ages of both groups were around 4 years to 6 years old. They were also closely matched for chronological age (CA). Subject details are summarized in Table 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Chronological age</th>
<th>Verbal mental age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autism (<em>n</em> = 15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>13:0</td>
<td>4:11</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2:2</td>
<td>1:6</td>
</tr>
<tr>
<td>Range</td>
<td>8:9-16:2</td>
<td>4:0-10:0</td>
</tr>
<tr>
<td>Mental handicap (<em>n</em> = 14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>12:8</td>
<td>4:6</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2:6</td>
<td>0:5</td>
</tr>
<tr>
<td>Range</td>
<td>9:6-16:8</td>
<td>4:0-5:0</td>
</tr>
<tr>
<td>Normal (<em>n</em> = 15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4:10</td>
<td></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0:09</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>4:10-5:0</td>
<td></td>
</tr>
</tbody>
</table>

**Procedure**

**Pretest**

The experimenter presented the subject with some paper and a felt-tip pen, and asked the subject to copy some geometric shapes. (Geometric shapes were chosen because children with autism often show a strong interest in geometric shapes.) Two-dimensional drawings of the shapes were placed in front of the subject for him or her to copy. These comprised a square, a triangle, a circle, and a rhombus. There was no time limit placed upon the subject. This pretest was to ensure that he or she was able to control the pen adequately, and draw at an age-appropriate level.

**Experimental Conditions**

If the pretest was performed successfully, the experimenter then asked the subject if he or she would draw her a picture of a house or man.

**House Condition.** The subject was asked to draw a picture of a house. When the subject had completed the drawing (there was no time restriction) the experimenter said, “Well done. That’s a lovely picture of a house. May I keep this picture?” The picture was put aside for later analysis. The experimenter then asked the subject to draw another picture of a house, but this time to draw a house that “does not exist. An impossible house.” (Other similar phrases were used as appropriate if the subject did not appear to understand the instruction, e.g., “a house that is not real,” although the majority of the subjects responded to the original instructions.) This second picture was also praised, and again the experimenter asked to keep the picture, regardless of whether
the subject had successfully drawn an "impossible" house. The pictures were analyzed at a later date.

**Man Condition.** This was presented on a separate occasion to the House Condition. The subject was asked to draw a picture of a man. When the subject had completed the drawing (with no time restriction) the experimenter said, "Well done. That's a lovely picture of a man. May I keep this picture?" The picture was put aside for later analysis. The experimenter then asked the subject to draw another picture of a man, but this time to draw a man that "does not exist. An impossible man." (Again, further prompts were supplied if the child did not respond to the original instruction.) This picture was also praised, and the experimenter again asked to keep the picture, which was also put aside for later analysis.

**Control Condition**

The Control Condition was presented after the second Experimental Condition, and consisted of a series of five drawings of pairs of items (cows, women, balls, apples, and elephants). Items in each pair were identical except for one of them having an element that made it "impossible" or "real" (see Fig. 1). The subject was asked to point to "the (x) that does not exist. An impossible (x)." The instructions were phrased like this so as to be identical to the task instructions in each of the conditions. The subjects' response to each of the pairs was recorded. This Control Condition was to check if subjects who failed to draw an impossible house or man in the Experimental Conditions did so because they did not understand the meaning of the terms "impossible" or "does not exist," for example. The Control Condition was presented as a post-test, so that the subjects could not use it as an aid to performance in the Experimental Conditions.

**Scoring**

In scoring the Experimental Conditions, analysis of the drawings produced by the subjects employed the same criteria as used by Karmiloff-Smith (1989). That is, in determining whether a drawing was an "impossible" house or man, the following criteria had to be met: (1) changes had to be made to the representation of a house or man that enabled the drawing to retain "houselike" or "manlike" characteristics, while also incorporating ele-
ments that do not normally belong in an accurate representation of a real house or man, or while deleting elements that should be present. (2) These changes could include changing the shape and size of elements, changing the shape of the whole, deletion of elements, insertion of new elements, changing position and/or orientation, insertion of elements from other conceptual categories, and other changes (such as conventionalized forms, like mermaids).

For a subject to draw a "real" house or man, he or she had to produce a drawing that included the essential features and characteristics of househood or manhood (e.g., rectangular in shape, with a door, windows, roof, etc., and for a man, to have a head, two eyes, one mouth, one nose, two arms, two legs, etc.). Two independent judges (blind to the hypotheses being tested and to the diagnosis of each child) rated the children's drawings using the above criteria. Interrater agreement was perfect (100%) for both experimental conditions.

Results

All subjects passed the Pretest by copying the geometric forms. Thus all subjects were included in the Experiment.

Analysis of Drawings of Real Things

Analyses showed that there were no significant differences between the number of children in each group producing a "real" house (3-way $\chi^2 = 0.0039, p > 0.995$). The analysis of drawings of "real" men showed a significant difference between the subjects with autism and the normally developing children (Autism $\times$ Normal, $\chi^2 = 3.34, p < 0.05$), but not between the two clinical groups (Autism $\times$ Mental Handicap, $\chi^2 = 0.17, p > 0.75$), suggesting that the results were due to more of the normally developing children producing drawings of men, and not because the children with autism had any specific problem with representations of real men. In fact, the normally developing children had a 100% success rate in drawing men, whereas the clinical groups were 80% successful (Autism) and 85.7% successful (Mental Handicap). The difference between the subjects with mental handicap and the normally developing children did not reach significance (Mental Handicap $\times$ Normal, $\chi^2 = 2.28, p < 0.1$).

Analysis of Drawings of Impossible (or Unreal) Things

The analyses of the drawings of "impossible" things showed that significantly fewer children with autism produced drawings of an impossible house than either the children with mental handicap (Autism $\times$ Mental Handicap, $\chi^2 = 11.78, p < 0.001$), or the normal controls (Autism $\times$ Normal, $\chi^2 = 22.28, p < 0.001$). The same was true of their attempts at drawing an impossible man (Autism $\times$ Mental Handicap, $\chi^2 = 6.75, p < 0.01$; Autism $\times$ Normal, $\chi^2 = 16.36, p < 0.001$). However, neither of the two control groups differed in their drawings of impossible men (Mental Handicap $\times$ Normal, $\chi^2 = 2.79, p > 0.1$), although significantly fewer children with mental handicap produced drawings of impossible houses than the normal children (Mental Handicap $\times$ Normal, $\chi^2 = 3.69, p < 0.05$). Figure 2 shows the magnitude of the difference in performance between drawing "real" and "impossible" things for the children with autism compared to the two control groups: only 7.7% of the sample with autism successfully drew an impossible house, and 8.3% an impossible man, compared to 75 and 58.3%, respectively, for the group with mental handicap, and 100 and 86.7%, respectively, for the normal children.

Figure 2. Draw a house/man.
Control Condition

The differences that were observed between the subject groups in their attempts to draw impossible houses or men were not due to the subjects with autism failing to understand the meaning of "impossible" or "an x that does not exist," as the results of the Control Condition showed: 93.3% of the subjects with autism passed 4 or 5 of the five control questions, compared to 78.6% of the subjects with mental handicap, and 100% of the normally developing children. There were no significant differences between the subjects with autism and the two control groups (Autism \times Mental Handicap, \chi^2 = 0.35, p > 0.75; Autism \times Normal, \chi^2 = 2.14, p > 0.25), although the difference between the children with mental handicap and the normally developing children just reached significance (Mental Handicap \times Normal, \chi^2 = 3.8, p < 0.05).

A further analysis was conducted to test if the children with autism were at a mental-age (MA) appropriate level in their drawing of men, compared to controls, to investigate if their failure in the Experimental Condition could be due to an inferior ability to draw people. Using the scoring methods employed in the Goodenough-Harris Draw-A-Man Test (Harris, 1963), and basing the analysis on verbal MA, 76.9% of the children with autism were at or above the mean for their MA level, compared to 62.5% of normal children, and 30.77% of the children with mental handicap. Thus, poor performance on the "impossible" conditions of the Experiment by subjects with autism was not due to differences in drawing ability relative to controls.

Discussion

This study set out to test if the representation of absent but real objects depends on a different cognitive system from that used in the representation of absent but unreal objects. The results of this Experiment suggest that there is indeed an abnormality in the ability of children with autism to produce "impossible" or unreal representations. This supported our prediction. The finding thus lends support to the notion that representation of unreal objects may involve different or additional neurocognitive systems, compared to representation of real objects. This is consistent with Leslie's (1987) proposal that in the normal cognitive system there may be two types of representation, and that to pretend or engage in imaginative behavior, a child has to not only be able to create a primary (or veridical) representation of what he or she perceives, but also a decoupled representation that can be manipulated and changed, independent of reality. Leslie suggested that children with autism are intact in their capacity to form primary representations, but cannot spontaneously produce pretend play because of abnormalities in forming decoupled representations.

In Leslie's terms, then, the subjects with autism may have been unable to produce drawings of "impossible" entities because to do so would require an ability to produce decoupled representations, so as to be able to introduce changes in the primary representation without disrupting the original concept (or causing what Leslie (1987) calls "representational abuse"). Since children with autism had no problems in producing drawings of "real" entities, it is clear that they can create primary representations, and this is in line with other studies (e.g., Ungerer & Sigman, 1981; Charman & Baron-Cohen, 1993; Scott, Baron-Cohen, & Leslie, 1995).

However, the present results can also be interpreted as support for the executive dysfunction theory of autism. The executive dysfunction theory suggests that in autism there is a specific deficit in performing functions such as planning, flexible switching between response behaviors, inhibiting inappropriate responses, and spontaneously generating varied outputs, for example. These functions are thought to be mediated by the "central executive," posited to be located primarily in the frontal lobes. It has been suggested by some researchers that children with autism cannot spontaneously inhibit their responses to, or mentally disengage from, the "real" nature of an object (e.g., Ozonoff et al., 1991; Ozonoff, 1993; Russell, Mauthner, Sharpe, & Tidswell, 1991; Hughes, Russell, & Robbins, 1994). It could be argued that the children with autism were unable to produce drawings of unreal things because they were unable to inhibit producing drawings of the real things.

This explanation is markedly different from Leslie's (1987, 1994) hypothesis since the latter suggests that pretense by children with autism cannot be improved because the problem lies in an impaired cognitive mechanism involved in imagination. In contrast, the executive dysfunction hypothesis predicts that performance by children with autism can be improved if the executive demands of the task are reduced. To test these two alternative theories against each other, a second experiment was designed. Experiment 2 assessed both spontaneous and instructed production of drawings, of both real and unreal items. In this way it was possible to test whether children with autism could produce representations of unreal entities under conditions where the experimenter (rather than the child) took executive control, or whether they would still show a deficit in the domain of imagining unreal entities compared to matched controls.

EXPERIMENT 2: SPONTANEOUS VERSUS INSTRUCTED DRAWING

Subjects

Subjects were identical to those that took part in Experiment 1 (see Table 1).
Design and Procedure

Experiment 2 was presented 1 to 2 weeks after Experiment 1. This Experiment involved a further drawing task, with 3 successive conditions.

Condition 1: Spontaneous Drawing

In the first condition, the subject was given paper and a felt-tip pen and asked “Draw me a picture of something frightening. Something really scary!” This condition therefore explored their ability to spontaneously produce a drawing of an exciting subject, to assess if they spontaneously drew something real or something unreal.

Condition 2: Instructed Drawing of Something Real

In the second condition, the subject was instructed by the experimenter to draw something real, which was frightening (such as a spider or a snake). The experimenter checked that the subject agreed the chosen example was indeed frightening, and then told the subject what to draw, and specifically how to draw it. Thus, for example, the experimenter would say, “Can you draw a spider?” and would prompt, e.g., “Draw a round body. O.K. Now draw eight legs on the body—one, two, . . . eight.” This condition was therefore a further check that the subject could follow the experimenter’s instructions for drawing a real object.

Condition 3: Instructed Drawing of Something Unreal

In the third condition, the subject was instructed by the experimenter to draw something unreal or impossible, which was frightening (e.g., a two-headed monster). Again the experimenter told the subject what to draw, and specifically how to draw it. For example, the experimenter would say, “Can you draw a monster with two heads?” and would prompt, e.g., “Now draw some big teeth,” “Now draw another monster head on the body,” “Now draw two horns,” and so on. This condition therefore assessed the subjects’ abilities to produce drawings of unreal things under specific instruction. This was to test if a lack of such drawings in Condition 1 (above), and in Experiment 1, was due to a problem in executive control, or in processing representations of unreal things.

All pictures produced by the subjects were kept for later analysis. Each subject received all three conditions during a single session, in the fixed order above. The order was necessarily fixed so as to avoid the instructed condition (2) influencing the spontaneous condition (1), or the instructed imaginary condition (3) influencing the instructed real condition (2).

Scoring

Two independent judges (again, blind to hypotheses and diagnoses) categorized the children’s drawings, following the methods outlined below. Drawings in Condition 1 were rated as “real” if they depicted a factual, real-world object (such as a rollercoaster, or a crocodile), and “unreal” if they depicted something that does not exist (such as a ghost, or a monster). The subjects were asked for verbal clarification of what they had drawn, to ensure that no drawings were misclassified. Drawings in Conditions 2 and 3 were scored as a “Pass” if the subject successfully drew the object that the experimenter had instructed, and scored as a “Fail” if the subject drew nothing at all, or drew something other than the item instructed. As before, the subjects were asked to clarify what they had drawn, so that in cases where a subject may have been attempting to do as instructed but there was some ambiguity in the drawing (e.g., only one horn on the monster’s head, when asked to draw two) the experimenter was able to note whether the drawing was a genuine attempt to follow the instruction. However, if a subject attempted to draw what had been requested, but drew a real-world object (e.g., drew a “real” man when asked to draw a two-headed hairy monster), the drawing was scored as a “Fail.” Interjudge agreement was again very high: 100% for Conditions 1 and 2, and 94% for Condition 3.

Results

In Condition 1, where the subjects were simply asked to draw something they thought was frightening, 60% of the normally developing subjects and 46.2% of the children with mental handicap spontaneously drew something imaginary (e.g., a monster), whereas only 13.3% of the children with autism did so. Among the children with autism 73.3% spontaneously drew something real (e.g., a snake). This difference was significant (Autism × Mental Handicap, χ² = 3.17, p < 0.05; Autism × Normal, χ² = 7.04, p < 0.005). In Condition 2, where the subjects were instructed to draw a particular “real” scary thing (e.g., a spider), and told how to draw it, there were no significant differences between the three groups: 76.9% of the subjects with autism, 85.7% of the children with mental handicap, and 100% of the normally developing children were able to draw the requested object under instruction (Autism × Mental Handicap × Normal, 3-way χ² = 1.76, p > 0.75).

However, in Condition 3, where subjects were instructed to draw an imaginary or impossible thing (e.g., a hairy two-headed monster), again being told what to draw and how to draw it, the children with autism were significantly worse than both control groups: 100% of the normally developing controls drew an imaginary/impossible thing under instruction, and 85.7% of the
children with mental handicap also did, whereas only 7.7% of the subjects with autism did (Autism × Mental Handicap, $\chi^2 = 10.07, p < 0.001$; Autism × Normal, $\chi^2 = 15.03, p < 0.001$; see Fig. 3).

It was noted that in Condition 3, seven children with autism drew nothing in response to the instruction, while six drew a normal person (confirmed by experimenter questioning) while apparently attempting to draw a two-headed monster (for example, three of these subjects drew a second head, and then drew a second complete body with it—resulting in a drawing of two real people), or drew an unrelated but real object. Six of these subjects spontaneously stated that they could not draw what the experimenter had requested.

Discussion

The results of Experiment 2 suggest that even when executive control passes from the child to the experimenter, children with autism cannot produce drawings of unreal entities. The subjects with autism were able to follow the experimenter's instructions as well as those in the two control groups (as demonstrated in Condition 2), so the poor performance in Condition 3 could not have been due to an inability to act under instruction. Following the earlier argument that drawing tasks require imagery (e.g., Beyn & Knyazeva, 1962), this leaves as a more likely explanation the possibility that children with autism had a deficit in the processing of images of unreal objects. Since both the spontaneous (Condition 1) and the instructed (Condition 2) responses of the subjects with autism were reality-based, it may be that this is the only way in which these subjects are capable of thinking. Children with autism may have a deficit in the ability to represent concepts in anything other than "factual" format. They appear unable to manipulate concepts to create nonveridical or imaginary/impossible ideas.

However, the executive dysfunction theorist has a further possible repost: perhaps children with autism performed poorly in both Experiments 1 and 2 because of a generativity deficit: that is, in the spontaneous generation of varied ideas or behaviors. Generativity is what the central executive is held to allow (Shallice, 1988). Jarrold, Boucher, & Smith (1996) suggest that children with autism can engage in instructed pretense, but that they are impaired in producing spontaneous pretense because of generativity problems. In the same way, it could be suggested that the children with autism in the present studies were unable to represent unreal objects because they have a deficit in the ability to generate novel ideas. The generativity hypothesis seems plausible because a number of previous studies suggest there may be impairments in this domain (Rumsey & Hamburger, 1987; Boucher, 1988; Hughes et al., 1994), although the finding that children with autism could not produce unreal drawings, even when instructed, questions such a claim. Nevertheless, to test this idea further Experiment 3 was conducted to assess if children with autism are impaired, relative to controls, in their ability to generate novel ideas, even when the ideas are of real objects. The standard measures of these are the Verbal Fluency Task (Benton & Hamsher, 1976; Milner, 1964; Perret, 1974) and the Functions of a Brick Task (see Lezak, 1983). The Verbal Fluency Task employed in Experiment 3 tested phonemic (or graphemic) Verbal Fluency, rather than semantic Verbal Fluency (Boucher, 1988). Phonemic Verbal Fluency is impaired in patients with damage to the left frontal cortex (Milner, 1964; Benton, 1968; Perret, 1974), while semantic Verbal Fluency is impaired in patients with severe memory disorders (Talland, 1965) and pa-

Figure 3. Spontaneous and instructed drawings.

Percent of Ss successfully passing each condition

- Autism
- Mental Handicap
- Normal

Spont. real | Instructed real | Spont. imag. | Instructed imag.
patients with various left hemisphere lesions (Newcombe, 1969).

EXPERIMENT 3: ASSESSING GENERATIVITY

Subjects
The subjects involved in Experiment 3 were again the same subjects as those involved in Experiments 1 and 2 (see Table 1).

Design and Procedure
This experiment had two conditions—Functions of a Brick and Verbal Fluency. The two conditions were presented in counterbalanced order across subjects and were presented on separate occasions, with at least two days between each condition.

Functions of a Brick Condition
The subject was presented with a toy “brick” and asked “What can you do with this brick? What could you use it for?” Their responses were tape-recorded for later analysis, and a time limit of 2 min was allowed. During the 2-min period, the experimenter encouraged and prompted the subject saying, “That’s a good idea. Now, what else could you use the brick for? Tell me as many things as you can that you could do with the brick.”

Verbal Fluency Condition
The experimenter asked the subject, “Tell me as many different words as you can think of that begin with an F sound (A sound, S sound). What starts with an F?” The letters were spoken phonemically so that the task would be easy enough for children who did not know their alphabet or who were poor readers. Again 2 min were allowed for each letter, and the experimenter encouraged and prompted the subjects saying, “That’s a good word. What else starts with an F (A, S)?” All responses were praised, though if the words chosen did not actually start with the required letter these were not counted and the experimenter reminded the subject that the word should start with the relevant sound. Once again, the subject’s responses were tape-recorded for later analysis.

Results
Both the Functions of a Brick and the Verbal Fluency Conditions produced a low level of output from all three groups, a maximum number of 6 items being generated in either condition. Table 2 shows the mean number of items produced by each group in each condition. This may have been due to the relatively low verbal mental ages of the subjects.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Verbal fluency</th>
<th>Brick task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autism</td>
<td>1.2</td>
<td>2.47</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Range</td>
<td>0-5</td>
<td>0-5</td>
</tr>
<tr>
<td>Mental handicap</td>
<td>1.36</td>
<td>2.57</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Range</td>
<td>0-4</td>
<td>1-5</td>
</tr>
<tr>
<td>Normal</td>
<td>2.79</td>
<td>3.73</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.19</td>
<td>0.01</td>
</tr>
<tr>
<td>Range</td>
<td>0-6</td>
<td>1-6</td>
</tr>
</tbody>
</table>

Brick
For the Functions of a Brick condition, a one-way ANOVA showed a significant difference between the groups \((F(2,41) = 3.68, p < 0.05)\). A post hoc Scheffe comparison showed that this was because the subjects with autism generated significantly fewer ideas than the normally developing controls (Autism \(\times\) Normal, \(p < 0.01\)), but not than the subjects with mental handicap (Autism \(\times\) Mental Handicap, \(p > 0.05\)). On average, both clinical groups generated less than three ideas in the allotted time, 80% of the children with autism generating 0-3 ideas (\(x = 2.47\)) and 78.6% of the children with mental handicap generating 0-3 ideas (\(x = 2.57\)). The normally developing children, on the other hand, generated on average more than three ideas, with only 33.3% of that group generating 0–3. (The mean for the normal group was 3.73 ideas.)

When the kinds of ideas that the subjects generated were examined, it was found that 71.4% of the children with mental handicap, and 66.7% of the normal 4–5 year olds, generated at least 1 abstract or pretend idea as to what the brick could be used for. For example, after giving such examples as “building a house,” or “Put it in a wall,” one child suggested “Pretend it’s a bed for dolly,” and “Use it to stand (cassette) tapes on—a tape stand.” Considering that most children with mental handicap only generated 2–3 ideas in total, such pretend ideas constitute a high proportion of their answers. In contrast, 86.7% of the subjects with autism did not generate any abstract or pretend ideas at all. This difference was highly significant (Autism \(\times\) Mental Handicap, \(\chi^2 = 8.48, p < 0.005\); Autism \(\times\) Normal, \(\chi^2 = 8.9, p < 0.005\)). Thus, although the total number of new and varied ideas generated by the subjects with autism did not differ

| Table 2. Mean Number of Items Produced by Each Group in Each Condition |
|-----------------|----------------|----------------|
| Subjects        | Verbal fluency | Brick task     |
| Autism          | 1.2            | 2.47           |
| Standard deviation | 0.01      | 0.01           |
| Range           | 0-5            | 0-5            |
| Mental handicap | 1.36           | 2.57           |
| Standard deviation | 0.01      | 0.01           |
| Range           | 0-4            | 1-5            |
| Normal          | 2.79           | 3.73           |
| Standard deviation | 0.19      | 0.01           |
| Range           | 0-6            | 1-6            |
from the clinical control group, the content of those ideas did.

**Verbal Fluency**

For the Verbal Fluency condition there was a significant difference between the three groups [one-way ANOVA, \( F(2, 40) = 5.24, p < 0.01 \)]. A post-hoc Scheffe test showed that the children with autism did not differ in the number of items generated from the children with mental handicap (Autism \( \times \) Mental Handicap, \( p > 0.05 \)). The children with autism generated a mean of 1.2 words, and the children with mental handicap generated a mean of 1.36 words. The normally developing children performed significantly better than both clinical groups (Normal \( \times \) Mental Handicap, \( p < 0.01 \); Normal \( \times \) Autism, \( p < 0.01 \)), with these children generating a mean of 2.79 correct words.

**Discussion**

Experiment 3 showed that on both the Verbal Fluency task and the Function of a Brick task, children with autism performed at an equivalent level to children with mental handicap. This suggests that children with autism do not have a specific deficit in generativity compared to matched clinical controls. The low number of items produced by the clinical groups in both the Brick condition and the Verbal Fluency condition may reflect their mental handicap, and it is possible that a greater difference would have emerged if the subjects had been of a higher general ability. However, as it stands there is no evidence to suggest that the subjects with autism have any more difficulty generating varied ideas than the children with mental handicap. The poor performance by the subjects with autism in representing unreal objects in Experiments 1 and 2 cannot therefore have been due to deficits in generativity.

Although generativity in autism may be poor compared to normal children, it does not appear from these results to be an autism-specific deficit. Previous studies of generativity in autism have reported a deficit compared to normal subjects. For example, Rumsey and Hamburger (1987) found that high-functioning adults with autism performed significantly less well than matched normal controls in a variety of frontal tasks, including Word Fluency. Boucher (1988) also found a deficit in performance with high-functioning autistic children, compared to matched normal controls, in their ability to generate miscellaneous words without semantic category cues. However, both of these studies compared the subjects with autism to only MA-matched normal subjects. Critically, there were no clinical subjects used as controls. Thus, one possible explanation for the present results is that this aspect of executive function is a product of mental handicap, exhibited in a number of clinical syndromes, and is independent of autism.

The results of Experiment 3 also lend further support to the argument that children with autism have a specific deficit in processing representations of unreal objects and concepts, since they generated significantly fewer abstract/pretend ideas than the two control groups, while still performing equally as well in the overall number of varied ideas generated, compared to the children with severe learning difficulties.

**GENERAL DISCUSSION**

The three experiments reported here suggest that children with autism have a deficit in the representation of unreal objects: (1) Experiment 1 found that children with autism showed a deficit in performance, compared to both clinical and normal control groups, in their ability to draw "impossible" houses and men. (2) Experiment 2 found that this deficit in performance was not likely to be due to an executive dysfunction, since they were unable to produce drawings of "impossible" things even when executive control had passed to the experimenter. Finally, (3) Experiment 3 found that the deficit in performance was not due to a generativity deficit, since they were no different to controls in the ability to generate words or ideas of real objects. Note also that the deficit in Experiment 1 could not have been simply due to perseveration (or a failure of inhibition), since when asked to draw different real objects, they were capable of changing their drawings from one trial to the next (see Experiment 2).

The evidence from these three experiments thus points to an abnormality in the ability to transform veridical representations into nonveridical ones, both spontaneously and under instruction. This may explain not only the lack of imaginative drawings, but also the lack of spontaneous pretense, produced by children with autism: In order to pretend one has to be able to override one's knowledge of reality, to create an unreal idea, by ascribing to an object or agent properties that are not present in "reality."

Jarrold et al. (1996) suggested that children with autism can produce pretend if they are instructed to do so, and this has also been found by others (Jarrold, Boucher, & Smith, 1993; Charman & Baron-Cohen, in press). For example, Jarrold et al. found that under instruction children with autism will use an item such as a length of dowel appropriately as a "pretend" toothbrush. However, in this example, it is not clear if they are doing this because they are representing an unreal object, or simply because they have been requested to perform a certain action and the length of dowel is the only item available that resembles a toothbrush. Baron-Cohen (1989) called this "intelligent guessing." To mimic a well-known routine does not necessarily require representing an unreal object or necessarily require an understanding.
of pretense; it simply shows that the subject is able to use a real object, or the nearest available substitute. The existence of instructed pretend play in autism is therefore not incompatible with the findings from the present study in which subjects with autism were unable to represent unreal things.

We now wish to return to the issue with which we opened this paper: might representation of real and unreal objects involve different neurocognitive mechanisms? The results from the three experiments reported here strongly suggest that in autism these two kinds of representation dissociate from one another, and in this sense they lend support to Leslie’s (1987) contention that children with autism can produce primary (veridical) representations, but cannot produce representations of unreal (nonveridical) things. Why might such a deficit arise?

One possibility is that representing an unreal object involves “bolting together” or fusing two representations of real objects. For example, in producing the representation of a flying pig one needs to represent a real pig (without wings) and a real bird (with wings), fuse aspects of these, to create the novel nonveridical representation. If the deficit in autism was simply an inability to fuse two primary representations together, then they should be unable to perform Finke, Pinker, and Farah’s (1989) task of imagining what is created when one joins a J with a D on its side (Answer: an umbrella). We are currently exploring this possibility.

An alternative account relates the deficit in representing unreal objects to the deficits in employing a theory of mind (Baron-Cohen, Leslie, & Frith, 1985; see Baron-Cohen, Tager-Flusberg, & Cohen, 1993; or Baron-Cohen, 1995, for reviews). On this account, representing an unreal object necessarily requires pretending, or representing that you (the agent) are holding a pretend attitude (or mental state) towards an object. Leslie’s (1991, 1994) suggestion is that representing attitudes is the function of ToMM (or the Theory of Mind Mechanism), and it is this that is impaired in autism. Testing between these two accounts is a priority for further research in this area.

In closing, we concur with Kosslyn’s (1994) claim that vision and imagery of real (but absent) objects may involve the same neural processes, but argue that the evidence from autism forces neuroscientists to search for additional mechanisms governing the representation of unreal objects. These additional mechanisms may relate to the “decoupler” proposed by Leslie (1987), and involve the adaptation and/or combination of veridical images to form nonveridical images.

Acknowledgments

F. J. S. was supported by an MRC Studentship during this work. This work was submitted in part fulfilment of a Ph.D. in Psychology, Institute of Psychiatry, University of London, by her.

A version of this paper was presented at the SRCD Biannual conference, Indianapolis, IN, 1995. We would like to thank Leda Cosmides, Steve Kosslyn, Steve Pinker, Annette Karmiloff-Smith, Greg Curric, Paul Harris, and Alan Leslie for their useful comments and suggestions following earlier drafts of this paper.

Reprint requests should be sent to Dr. Fiona Scott, Department of Psychology, University of Greenwich, Southwood Site, Avery Hill Road, Eltham, London, SE9 2HB, U.K.; or Dr. Simon Baron-Cohen, Departments of Experimental Psychology and Psychiatry, University of Cambridge, Downing Street, Cambridge CB2 3EB, U.K.

Note

1. Note that changing size alone did not constitute “impossible” or “unreal.” Size had to be changed in conjunction with the shape, although the shape could be changed without the size being altered.

REFERENCES


