

# Disentangling weak coherence and executive dysfunction: planning drawing in autism and attention-deficit/hyperactivity disorder

**Rhonda Booth, Rebecca Charlton, Claire Hughes and Francesca Happé\***

*Social, Genetic and Developmental Psychiatry Research Centre, Institute of Psychiatry, King's College London, DeCrespigny Park, Denmark Hill, London SE5 8AF, UK*

A tendency to focus on details at the expense of configural information, 'weak coherence', has been proposed as a cognitive style in autism. In the present study we tested whether weak coherence might be the result of executive dysfunction, by testing clinical groups known to show deficits on tests of executive control. Boys with autism spectrum disorders (ASD) were compared with age- and intelligence quotient (IQ)-matched boys with attention-deficit/hyperactivity disorder (ADHD), and typically developing (TD) boys, on a drawing task requiring planning for the inclusion of a new element. Weak coherence was measured through analysis of drawing style. In line with the predictions made, the ASD group was more detail-focused in their drawings than were either ADHD or TD boys. The ASD and ADHD groups both showed planning impairments, which were more severe in the former group. Poor planning did not, however, predict detail-focus, and scores on the two aspects of the task were unrelated in the clinical groups. These findings indicate that weak coherence may indeed be a cognitive style specific to autism and unrelated to cognitive deficits in frontal functions.

**Keywords:** autism; coherence; executive function; cognitive style; drawing; planning

## 1. INTRODUCTION

Autism has attracted a number of psychological theories and accounts that focus on the deficits in social and communicative development and the inflexibility of behaviour and interests. Prominent among these accounts are the 'theory of mind' deficit account and the executive dysfunction theory. The former posits a failure of an innate system for attending to and representing the mental states of others, and explains well some of the social and communication difficulties (Baron-Cohen *et al.* 2000). The latter attempts to explain the non-social difficulties in autism, such as repetitive behaviour and poorly controlled novel goal-directed action, in terms of deficits in frontal functions such as planning, inhibition and set-shifting, covered by the umbrella term 'executive functions' (Russell 1997).

These accounts explain well some of the deficits in autism, but cannot, on the face of it, explain the areas of preserved or even superior skill seen in people with ASDs. These include the high rate of savant skills (in, for example, music, mathematics and art), the 'islets of ability' (in, for example, rote memory and visuo-spatial puzzles) and the perception of small details (often leading to distress at small changes in the familiar environment). One psychological account that does attempt to explain these assets, along with certain areas of difficulty in autism, is the 'central coherence' account. This term was

first introduced by Frith (1989) to refer to the normal tendency for global, configural processing, which integrates information in context to give meaning. People with autism, by contrast, appear to show a processing bias for parts versus wholes, surface form versus gist, and are able to process information in a relatively context-independent fashion (see Happé (1999) for a review of this account and recent evidence). This bias for 'weak coherence' is hypothesized to be a cognitive style rather than a deficit, because it leads to assets on tasks that benefit from detail focus (e.g. the embedded figures test; Shah & Frith 1983) and because people with autism appear to be capable of processing information globally when directed to do so.

The relationship between the postulated cognitive style of weak coherence and the deficits seen in theory of mind and executive function has been little explored (but see Jarrold *et al.* (2000) for work on coherence and theory of mind). In particular, it seems possible that executive dysfunction and weak coherence may be overlapping or even redundant notions. In particular, it might be argued that the processing of information in context for global meaning is an executive skill and that the findings currently attributed to weak coherence might be explained by executive dysfunction. Even savant skills have recently been suggested to result from 'disinhibition', or release from top-down frontal control (e.g. Snyder & Thomas 1997). Failure to process information globally might be argued to follow from problems in shifting between local and global processing, if local processing is considered to be the default. Limitations of working memory might bias perform-

\*Author for correspondence (f.happe@iop.kcl.ac.uk).

One contribution of 14 to a Theme Issue 'Autism: mind and brain'.

ance towards smaller fragments of information. Similarly, poor planning might result in piecemeal approaches to novel tasks. Harris & Leavers (2000), for example, have argued that inability to draw imaginary objects might be due to planning problems in autism.

The present study aimed to disentangle coherence and executive dysfunction by comparing two clinical groups. Executive problems are by no means specific to autism, and can be found in several other developmental disorders, most notably ADHD (see Sergeant *et al.* (2002) for a review). We hypothesized that, while children with ASD and those with ADHD might share some executive impairments, only the former group would show a detail-focused processing bias, that is 'weak coherence'. Thus we hypothesized that poor executive functions would not necessarily lead to or accompany weak coherence, and that individuals with ADHD would show normal global processing despite their executive impairments. To this end, we developed a task with both executive and coherence components, to examine the effect of one aspect of executive dysfunction (poor planning) on local-global processing. Our planning drawing task was inspired by an original test by Henderson & Thomas (1990), and required children to copy a drawing (e.g. a snowman), and then to make a new drawing including an additional feature (e.g. teeth). Addition of the new feature required planning in advance, to allow space and adjust the size of the relevant elements (e.g. the head). Thus the second drawings could be compared with the first to assess the degree of planning (an executive function). In addition, the drawing style was analysed for global or local processing bias. We attempted to make the task as naturalistic and open-ended as possible, because it appears to be in such non-directive tasks that the bias for local processing is most clearly seen in ASD (e.g. Plaisted *et al.* 1999). Our prediction was that (i) the ASD group, but not the ADHD or control groups, would show a tendency for detail-focused drawing; (ii) both the ASD and ADHD groups would show poor planning compared with the control group; and (iii) detailed drawing style would not be related to poor planning.

## 2. METHODS

### (a) *Subjects*

The ASD group comprised 30 boys with a formal diagnosis of either high-functioning autism ( $n = 5$ ) or Asperger syndrome ( $n = 25$ ) who were recruited through specialist units and parent group contacts. In each case, it was confirmed that a psychiatrist or paediatrician had made the diagnosis according to established criteria. Children were excluded if they had co-morbid ADHD, ADD, hyperkinetic disorder or Tourette syndrome.

The ADHD group comprised 30 boys with a formal diagnosis of either ADHD (DSM-IV (American Psychiatric Association 1994);  $n = 20$ ) or hyperkinetic disorder (ICD-10 (World Health Organization 1992);  $n = 10$ ) who were recruited through specialist referral centres. Children were excluded if they had additional disorders such as PDD, Tourette syndrome or obsessive compulsive disorder. Furthermore, children with a diagnosis of ADD without the hyperactivity component were not included. The majority of boys ( $n = 27$ ) had been prescribed medication for the management of their ADHD. All were required not to take medication for at least 24 h prior to the administration of

the experimental tasks. One exception occurred where a boy could only be taken off medication 17 h prior to assessment owing to family constraints. Data from this child were included, after analysis of group data excluding this participant showed no resulting change in the pattern or significance of the results. Following clinical advice, IQ assessments were conducted with children on medication, as this is considered to result in a more fair assessment of intellectual level.

A TD comparison group was included, comprising 31 boys recruited through schools, family friends of participants in the clinical groups and personal contacts. Boys were excluded from this group if they had any clinically significant impairment or diagnosis, or family history of social- or attention-related problems (i.e. ADHD or PDD).

Across all groups, no child was excluded on the basis of comorbid epilepsy, reading (five ADHD, one ASD, one TD), conduct (five ADHD) or anxiety disorder (one ADHD, two ASD). All participants were aged between 8 and 16 years and had a minimum FIQ of 69 or above as assessed by the WISC-III (Wechsler 1992). Owing to time constraints, 15 boys in the control group were administered a shortened version of the WISC-III (based on four subtests: information, vocabulary, picture completion and block design). The IQ estimate calculated from this short form of the test is reported to have high reliability (Sattler 1992). Participant characteristics for each group are presented in table 1. Statistical comparisons showed that groups did not differ significantly in age, FIQ or PIQ, although the ADHD group had lower VIQ than the TD group ( $F_{(2,88)} = 3.31$ ,  $p = 0.04$ ; Tukey's HSD:  $p = 0.04$ ) perhaps reflecting the literacy difficulties commonly found to accompany this disorder.

### (b) *Materials*

For the planning drawing task, seven picture stimuli were created and piloted with a group of 63 children aged from 8 to 16 years. Four of these pictures were then selected as appropriate for the present age and ability range. The drawings were as shown in figure 1: a snowman (add teeth), a clock (add numbers), a house (add four windows) and a ship (add people at the portholes). The drawings were chosen to have clear local and global elements, as well as necessitating planning ahead to increase the size of key parts (snowman's head, clock's face, house, portholes) in order to incorporate the additional detail. Participants were provided with a crayon and blank sheets of A4 paper. A crayon was used after piloting suggested that fine pens allowed children to fit in the additional detail without needing to plan ahead, and to make drawing parts bigger.

### (c) *Procedure*

Testing took place within the context of a larger study that consisted of two sessions of *ca.* 2 h. Because the data from the four drawings were combined, a set order of presentation was used; the house, the snowman, then after *ca.* 60 min, the clock and then the ship. In each case, the children were shown a picture and told: 'this is a picture of a (house) that I drew earlier. I want you to draw a picture of a (house) like mine'. The picture was left in view while the children used it as a model for their own drawing. When it was clear that the drawing was complete, both the original and copy were removed from view. A further blank sheet of paper was provided and the experimenter told the participant: 'now I want you to draw another picture of a (house), but this time draw it with (four windows)'. Each picture was presented in the same manner with the instructions to add a feature as appropriate to the picture. The drawing process was

Table 1. Participant characteristics: means (s.d.).

group	<i>n</i>	age (yr)	FIQ	VIQ	PIQ
ASD	30	10.7 (2.2)	100.0 (19.3)	102.8 (18.6)	96.8 (18.3)
ADHD	30	11.7 (1.7)	99.1 (17.7)	99.7 (18.6)	97.7 (14.7)
TD	31	11.3 (2.0)	107.1 (13.5)	110.3 (11.9)	101.7 (18.5)

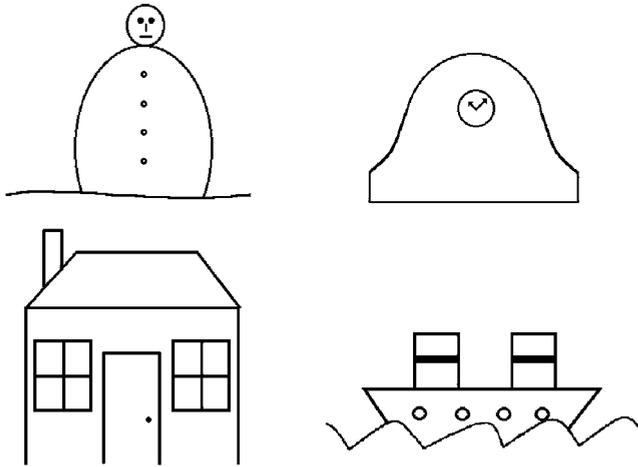


Figure 1. Drawing stimuli.

videotaped for later analysis, and the experimenter noted the order in which features were drawn.

#### (d) Scoring

##### (i) For central coherence

Three aspects of the drawings were rated for detail-focused style. First, the *initial features* drawn were noted: were the first two elements that were drawn local elements or details, rather than global aspects such as the outline? This was scored on a three-point scale, with two points being given where local features were drawn first, one point where local features were the second thing to be drawn, or where undefined features (e.g. the roof on the house) were drawn first, and zero points where global aspects were drawn first. Because for the second drawing in each pair the child was explicitly directed to add an extra detail, initial feature was rated from the first drawing only, where the child's natural approach could be fairly judged.

The second dimension rated for central coherence scoring was *fragmentation*; did the drawing proceed in a piecemeal fashion? This too was rated on a three-point scale from highly fragmented (two points) to not at all fragmented (zero points). Fragmentation was defined by the degree of disjointed appearance, separation of parts or drawing style that was not sequential in the usual manner (e.g. breaking off from incomplete lines in order to move to another part of the drawing; drawing four individual window panes rather than drawing two lines dissecting the square that represented the window).

The third and last dimension rated was the degree of *configural violation*; did the drawing include parts that were placed wrongly in relation to other parts, with distorted or omitted outline, or abnormal in overall shape? This rating related to the finished drawing only and was scored on a three-point scale according to the degree of change in the overall configuration of the object to be copied.

Fragmentation and configural violation were scored for all (first and second) drawings. The three aspects rated for coher-

ence were, in principle, independent of one another, that is, a child could start a drawing with a detail but draw in a cohesive fashion without fragmentation and produce a fully 'coherent' drawing at the end. Similarly, a child could begin with the house outline, for example, then draw the windows piece by piece (i.e. pane by pane: an example of fragmentation), and still produce a coherent finished drawing. Lastly, a child could start with the outline, draw each part as a whole, yet violate the configuration by drawing a fractured outline.

##### (ii) For planning

An *allowance score* was given based on the degree of advance planning evident in the changes that were made to accommodate the new feature. This was judged by comparing the first and second pictures in a pair, for example to assess how much larger the head of the second snowman had been made in order to fit in the mouth with teeth.

An enlarged picture did not necessarily indicate good allowance, but there must be evidence that a modification was made to take into account the additional feature (e.g. drawing the windows of the house smaller in order to fit in four windows, in preference to increasing the size of the house). Two points were given when a clear and effective allowance was made, one point for some allowance but not enough to prevent the drawing from seeming squashed, and zero points for no allowance.

##### (iii) Reliability

Thirty per cent of the pictures, taken equally from the three participant groups, were scored by a second rater blind to diagnosis. Inter-rater agreement was good, with Kappa values in every case above 0.75, ranging from 0.77 to 0.95 across the different types of score. Disagreements were resolved between the two coders.

## 3. RESULTS

Mean scores for each of the coherence variables were low, and so a summed score was created combining the independent ratings for initial feature, fragmentation and configuration violation. Higher scores indicated weaker coherence. The mean score for this measure showed a significant effect of group: mean = 0.9 (s.d. = 0.88) for ASD; 0.47 (0.78) for ADHD; and 0.26 (0.44) in the TD group ( $F_{(2,88)} = 6.22, p = 0.003$ ). This group difference was due to higher scores in the ASD group (versus TD:  $p = 0.002$ ; versus ADHD:  $p = 0.058$ ; Tukey's HSD). However, analysis in terms of frequencies appeared more appropriate in view of the small absolute number of instances of fragmentation and so forth, and the possibility that means reflected high scores by a small proportion of the participants.

Table 2 shows the numbers (and percentages) of children in each group who showed weak coherence as measured by the initial feature, fragmentation and configuration violation scores. Figure 2 shows examples of

Table 2. Frequency data for coherence scores.

group	number (%) ever scoring two for initial feature	number (%) ever scoring one or two for fragmentation	number ever scoring two for configural violation
ASD ( $n = 30$ )	8 <sup>a</sup> (26.7)	8 (26.7)	10 <sup>a</sup> (33.3)
ADHD ( $n = 30$ )	2 (6.67)	5 (16.7)	4 (13.3)
TD ( $n = 31$ )	2 (6.45)	2 (6.45)	3 (9.67)

<sup>a</sup> ASD > ADHD, TD,  $p < 0.05$ .

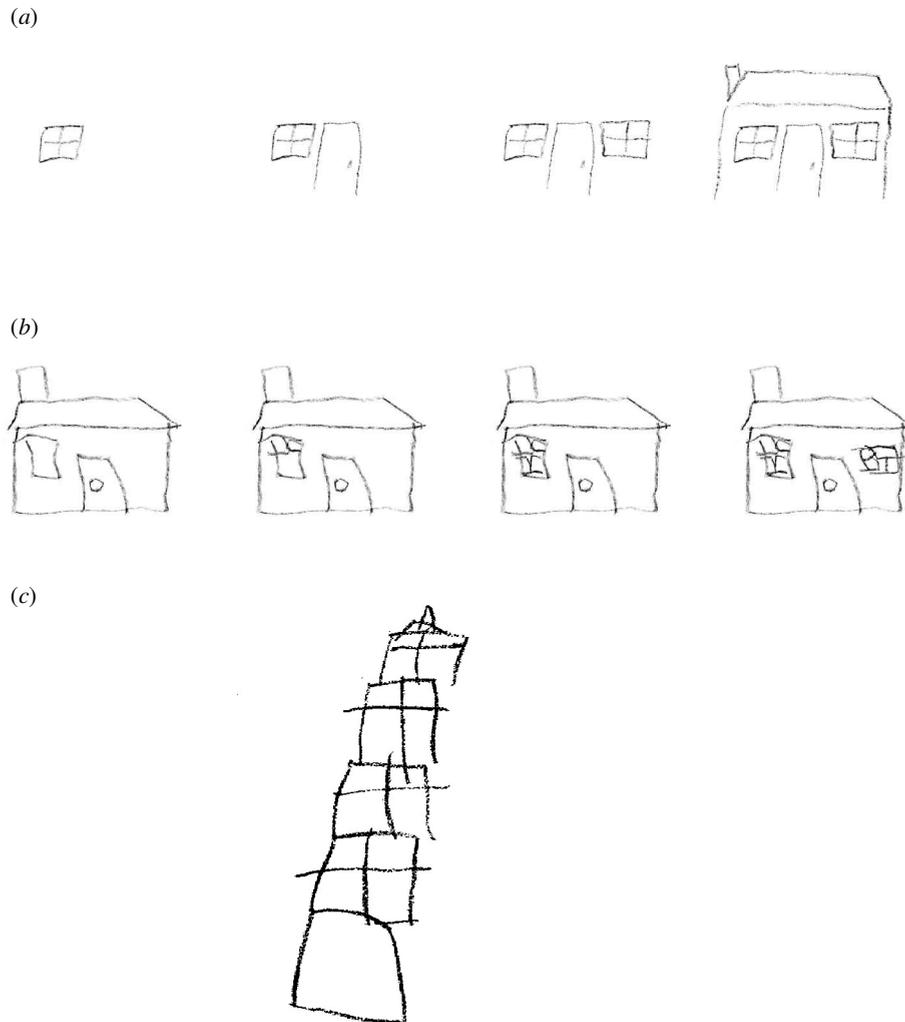


Figure 2. Examples of drawings scoring two for each of the weak coherence ratings: (a) initial feature, (b) fragmentation, and (c) configural violation.

drawings scoring two points for each of these variables. Significantly more of the ASD participants started at least one of their (first) drawings with a detail, compared with the ADHD and TD groups ( $\chi^2 = 7.10$ , d.f. = 2,  $p = 0.03$ ). More of the ASD group drew at least one of their drawings in a fragmented style ( $\chi^2 = 4.53$ , d.f. = 2,  $p = 0.10$ ), and this reached significance for the comparison with the TD group ( $\chi^2 = 4.55$ , d.f. = 1,  $p = 0.03$ ). Significantly more of the ASD children broke configuration (scoring two on configuration violation) on at least one drawing, compared with the ADHD and TD groups ( $\chi^2 = 6.18$ , d.f. = 2,  $p = 0.04$ ). Across these three types of rating, 60% of the ASD group showed weak coherence (scoring one or two for one or more drawings) on at least one of these ratings,

versus 33% of the ADHD and 26% of the TD group ( $\chi^2 = 8.18$ , d.f. = 2,  $p = 0.02$  for ASD, versus ADHD:  $\chi^2 = 4.29$ , d.f. = 1,  $p = 0.04$ ). The boys in the ASD and ADHD groups who showed weak coherence on this task did not differ from the other boys in their diagnostic group in either age or IQ (all  $p > 0.2$ ). However, among the TD boys, the eight who showed some degree of weak coherence were significantly lower than the rest of the group in FIQ (mean 99 versus 110;  $F_{(1,29)} = 4.14$ ,  $p = 0.05$ ) and PIQ (89 versus 106;  $F_{(1,29)} = 6.27$ ,  $p = 0.02$ ).

Figure 3 shows an example of good planning. A frequency analysis of the planning measure was carried out, looking at the numbers of children who ever scored zero on the allowance measure (showing no planning). Eighty

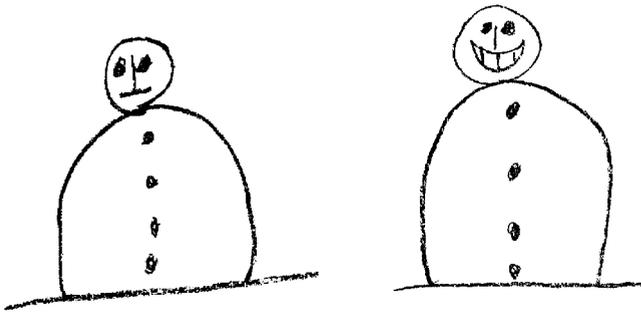


Figure 3. Example of good planning.

per cent of the ASD group showed some lack of planning by this standard, as did 70% of the ADHD group and 52% of the TD group. A chi square test showed a marginally significant difference between the three groups ( $\chi^2 = 5.74$ , d.f. = 2,  $p = 0.057$ ), but the two clinical groups did not differ from one another. The 'poor planners' by this criterion did not differ from the remainder of their groups in age or IQ (all  $p > 0.1$ ).

A key question for the present study was whether weak coherence might be a result of executive dysfunction, so the relationship between planning and detail-focused drawing style was examined. The correlation between the total allowance score and the summed coherence score was 0.15 in the ASD group and 0.16 in the ADHD group ( $p > 0.4$ ). By contrast, the correlation in the TD group was significant ( $r = 0.36$ ,  $p = 0.04$ ). Bearing in mind the relationship between weak coherence and PIQ in this group, the correlation was repeated partialling out PIQ, resulting in a correlation of 0.34, which fell below significance ( $p = 0.07$ ). It should be noted that the positive correlations show that children in the TD group who obtained high allowance scores scored more highly on the weak coherence composite also: that is, good planners showed *more* detail focus. This is also seen when the planning and coherence measures are compared in terms of frequencies of children showing good versus poor planning, and weak versus normal coherence of drawing style (using the divisions described above). Chi square analysis showed a significant relationship between these categorizations in the TD group only ( $\chi^2 = 6.61$ , d.f. = 1,  $p = 0.01$ ). The TD children classed as 'good planners' ( $n = 15$ ) divided equally into those showing weak coherence ( $n = 7$ ) and those not doing so ( $n = 8$ ), while the 'poor planners' ( $n = 16$ ) were predominantly classed as *not* showing weak coherence ( $n = 15$ ). There was a trend towards a very similar distribution in the ADHD group, but the relationship between the two measures did not reach significance in this group ( $p = 0.09$ ). In the ASD group, by contrast, there appeared to be no relationship between the two measures ( $p = 0.58$ ).

#### 4. DISCUSSION

This study explored the relationship between weak coherence and executive dysfunction through comparison of contrasting clinical groups performing a specially designed drawing task. The results largely confirmed the predictions that (i) boys with ASD but not those with ADHD tended to show a detail-focused drawing style; (ii) boys from both clinical groups showed planning deficits,

but these were particularly noticeable in the ASD group; and (iii) measures of detail focus were not related to poor planning. These findings indicate that weak coherence is independent of executive dysfunction and is not common to other groups with difficulties of executive control. Below we briefly discuss each of these findings, and their relevance for our understanding of autism.

The ASD group in this study was more likely to begin drawing with a detail, to draw in a piecemeal fashion and to create a drawing in which configuration was violated than were TD boys and those with ADHD. This fits with previous findings in the literature. Fein *et al.* (1990) also explored fragmentation in drawing, as well as overlap of drawn parts. They found more evidence of these signs of failure to integrate the whole in a group of 5- to 17-year-olds with autism compared with developmental-level-matched TD children when asked to draw a child. Mottron and colleagues have studied drawing style in a savant artist with Asperger syndrome (Mottron & Belleville 1993) and a group of adolescents and adults with autism (Mottron *et al.* 1999). In both studies, the ASD participants tended to begin drawing with a local feature.

While the ASD group as a whole was significantly different from the ADHD and TD groups in drawing style, it is important to note that not every child with ASD in this study showed detail focus on our task. Forty per cent of the ASD group did not show evidence of preference for featural processing, at least as measured by this task and scoring system. These boys did not appear to be different in age or IQ from the boys showing detail focus, but it remains to be seen whether they differ in other respects (such as clinical features) or whether they might show weak coherence on other types of tasks. We are currently exploring the nature of weak coherence in TD and ASD groups to attempt to establish whether detail focus in the visual domain is related to detail focus in, for example, auditory tasks. It is also worth mentioning that our scoring system for the drawings deliberately distinguished between focus on detail and inability to capture the configuration. While many of the classic tests of coherence cannot measure separately the ability to process parts and the (in)ability to process wholes, it seems important to distinguish these processes. It may well be that children with autism are not poor at configural processing but rather excel at featural processing, or it is possible that different subgroups within the autism spectrum have a facility for details or a difficulty with configurations.

The second prediction supported by this study was that both the ASD and ADHD groups would show planning deficits. The most commonly used tests of planning in the literature are probably the Tower of Hanoi and Tower of London, which require participants to plan ahead a sequence of moves. These are considerably more challenging, and also more directed, than the task employed in the present study. In their useful review of recent work on executive functions, Sergeant *et al.* (2002) summarize findings from 12 studies using the Towers tasks with ADHD and/or ASD groups. Three of the five studies with ADHD participants found significant impairment compared with control participants, as did all five of the studies comparing ASD with control groups. Two studies directly comparing the two clinical groups found significantly worse performance in the ASD group than the

ADHD and control groups (Ozonoff *et al.* 1991; Ozonoff & Jensen 1999). The present finding using a much simpler and more naturalistic test of planning ability also indicates that planning is more severely impaired in children with ASD than in those with ADHD.

The third finding was that impairments of planning did not account for the tendency for detail focus in the drawing task; allowance scores did not correlate significantly with coherence scores in the clinical groups, and in the TD group it appeared that poor planners were, if anything, *less* likely to be detail focused. This, along with the lack of detail focus in the ADHD group—a disorder strongly associated with deficits in at least some executive functions—argues against an executive dysfunction explanation of weak coherence in autism. This is important because it might well have been that children with autism start their drawings with details, draw in a piecemeal fashion and create less coherent drawings because they do not plan ahead and fail to use ‘top-down’ strategies such as sketching in outline before filling in details. Instead, the present results indicate that detail focus is a characteristic of autism unrelated to impairments in executive skills such as planning, and also unrelated to age or IQ. Further work is needed to clarify the nature and mechanism of weak coherence, but findings from this drawing task support the characterization of weak coherence as a cognitive *style* rather than deficit.

This work was funded by a Wellcome Trust project grant to F.H. Our sincere thanks go to the boys who participated in this research, as well as to their families and schools. We are extremely grateful to the following for their generous help with recruitment: Eric Taylor, Jodie Warner-Rogers and the ADHD team at the Institute of Psychiatry; Mima Simic; Gillian Baird; Marilyn Hammill; Janet Poole; St Anthony’s RC Primary School; Ernest Bevin College; Stewart Flemming Primary School; Fircroft Primary School; Langley Park School for Boys; and Alderbrook Primary School. John Rogers gave invaluable help with coding.

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## GLOSSARY

- ADD: attention deficit disorder  
 ADHD: attention-deficit/hyperactivity disorder  
 ASD: autism spectrum disorders  
 FIQ: full-scale IQ  
 HSD: honestly significant difference test  
 IQ: intelligence quotient  
 PDD: pervasive developmental disorder  
 PIQ: performance IQ  
 TD: typically developing  
 VIQ: verbal IQ  
 WISC: Wechsler intelligence scale for children