Understanding assets and deficits in autism

Why success is more interesting than failure

FRANCESCA HAPPÉ *gave the Spearman Medal Lecture at the Society's London Conference in December 1998. She argued that we can discover more about autism through examples of task success than of failure — and that it involves a distinct cognitive style, rather than deficit.*

AUTISM is a devastating developmental disorder, affecting at least one in a thousand children and adults. Although biologically based, with a strong genetic component, diagnosis of autism is still based on behavioural criteria: qualitative impairments in social and communicative development, with restricted and repetitive activities and interests.

The manifestations of autism cover a wide spectrum. These range from the child with severe impairments who may be silent, aloof, of low IQ and locked into rocking and hand flapping, to the high-functioning individual with pedantic and verbose communication, an active but odd social approach, and rarefied special interests (e.g. registration numbers on lamp posts).

It is not hard to identify things that people with autism find problematic — indeed, most people with autism also have general learning difficulties and low IQ. However, I would like to argue that progress in understanding this disorder, and its implications for normal development, has come chiefly through exploration of what people with autism are *good* at.

Much progress has been made in the last 15 years in understanding the nature of the social and communicative handicaps in autism. Primary in this has been the notion that people with autism fail to represent the mental states of others (and possibly themselves) — a deficit in what has been called 'theory of mind'(see Box 1). This account explains well why children with autism have such difficulty with simple and early-emerging behaviours such as joint attention, pretend play and even telling lies.

However, these deficits, and failure on key tasks such as false belief tests, are only interesting against a background of task success. Clearly, (behavioural) task failure is ambiguous with regard to underlying (cognitive) deficits; a child may fail a test for any number of uninteresting reasons such as lack of motivation, attention or task comprehension. To pinpoint the reason for task failure and to rule out these alternative explanations, closely matched control tasks have been used.

So, for example, the autistic failure to understand deception (manipulating beliefs) is interesting only when contrasted with success on control tasks involving sabotage (manipulating behaviour). Thus, children with autism understand that they can lock a box to defeat a competitor and keep a prize for themselves, but do not understand that telling a lie (saying the box is locked) can do the same job.

This work, showing preserved as well as deficient social skills, has clarified the nature of the social impairment in autism. Autism is not rightly characterised as a lack of sociability, rather it is a disorder of social *ability* of a specific sort — 'mindreading'.

The theory of mind deficit account of autism (see Baron-Cohen *et al*., 1993) has been of enormous theoretical and practical benefit in understanding, recognising and addressing the social and communicative difficulties in autism. This account clearly allows for areas of preserved skill — it predicts deficits in only those tasks that require 'mindreading'.

However, the theory of mind account, as indeed any deficit account of autism (e.g. executive dysfunction — deficits in frontal lobe processing), fails to explain why people with autism show not only preserved but also superior skills in certain areas.

Take, for example, the young man with autism who draws like a master although he is unable to fasten his coat or add five and five. Or the girl with autism who has absolute pitch and can play any tune by ear after only one hearing. Or the boy with autism who can tell you, within seconds, on what day of the week any past or future date falls.

Or, less spectacularly but more commonly, the child who can construct jigsaw puzzles at lightning speed, even picture side down; and the adult who, despite generally low ability, recalls the exact date and time of your last meeting 20 years ago.

How can we explain these abilities, which sometimes exceed the performance of ordinary individuals of the same chronological age?

BOX 1 Theory of mind

'Theory of mind' refers to the everyday ability to infer what others are thinking (believing, desiring) in order to explain and predict their behaviour. The ability to represent thoughts has been tested, classically, with 'false belief' tests. When Sally leaves her ball in the basket and goes out, Ann moves it to her own box. Now Sally returns and wants her ball — where will she look for it?

The correct answer — in the basket — requires a representation of Sally's mistaken belief; that's where she *thinks* it is. Most normally developing 4-year-olds pass such tests, but most people with autism — even quite bright teenagers with this diagnosis — answer that Sally will look in the box, where the ball really is. This failure to represent Sally's belief has been taken as evidence of impaired theory of mind (see Baron-Cohen *et al*., 1993).

Superior performance

Savant skills, in recognised areas such as music, art, calculation and memory, occur in approximately one in 10 people with autism. This makes them a great deal more common in this group than in others with learning disabilities (Rimland & Hill, 1984). If skills outside these areas are counted, such as doing jigsaw puzzles remarkably well, then the great majority of people with autism would be counted as showing some specific talent — most people with autism have at some time surprised their carers by a skill out of line with their general ability.

How can we account for these assets that deficits in theory of mind, executive function, and so forth appear unable to explain?

In principle, I think there are at least two possible sorts of explanation. First, we might conclude that the child with apparently severe autism, who nonetheless makes rapid calculations in the manner of a very intelligent adult, is in fact highly intelligent — that is, their talent signifies what it signifies in the non-autistic individual. Alternatively, we might conclude that their talent does not have the usual significance with relation to general ability, because they are going about the task in a different way from normal.

Assets and deficits

One current account of autism proposes a different rather than merely deficient mind at the core of autism. Uta Frith, prompted by a strong belief that assets and deficits in autism might have one and the same origin, proposed in her seminal book that autism is characterised by weak 'central coherence'(Frith, 1989).

FIGURE 1: Parts and wholes

Central coherence is the term Frith coined for the everyday tendency to process incoming information in context for gist — pulling information together for higher level meaning, often at the expense of memory for details. For example, as Bartlett's classic work showed (Bartlett, 1932), the gist of a story is easily recalled, while the actual surface form is quickly lost, and is difficult to retain.

Central coherence is also demonstrated in the ease with which we recognise the contextually appropriate sense of the many ambiguous words heard in everyday speech (e.g. son/sun, meet/meat, sew/so, pear/pair). The tendency to process information in context for global meaning is seen, too, with non-verbal material — for example, the tendency to misinterpret details in a jigsaw piece according to the expected position in the whole picture.

It is likely that this preference for higher levels of meaning also characterises young children and adults with (non-autistic) learning disability — who appear, for example, to find material easier to recall when it is meaningful (e.g. Hermelin & O'Connor, 1967). Global processing predominates in some aspects of perception (e.g. Kimchi, 1992), and may do so from the first months of life (Freedland & Dannemiller, 1996).

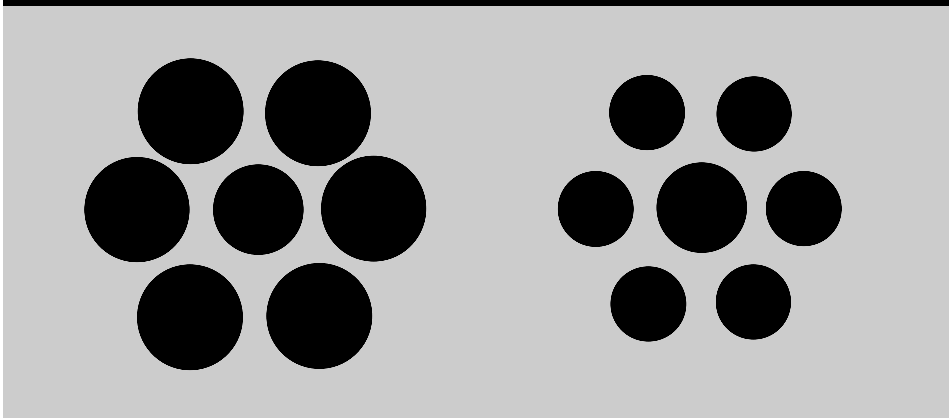
Frith suggested that this aspect of human information processing is disturbed in autism. She argued that people with autism show detail-focused processing, in which features are noticed and retained at the expense of global configuration and contextualised meaning. At the level of clinical presentation, children and adults with autism often show a preoccupation with details and parts (indeed this is one diagnostic criterion in DSM-IV), while failing to extract gist or notice context.

Kanner (1943), who named the disorder, also comments on the tendency for fragmentary processing in autism, and its role in the children's characteristic resistance to change: '… a situation, a performance, a sentence is not regarded as complete if it is not made up of exactly the same elements that were present at the time the child was first confronted with it' (pp.37–38).

Indeed, Kanner saw as a universal feature of autism the 'inability to experience wholes without full attention to the constituent parts'(p.38), a description akin to Frith's notion of weak central coherence.

The idea of weak central coherence allows us to explain patterns of excellent

FIGURE 2 Titchener circles — the presence of the surrounding circles affects the ability to judge whether the inner circles are really the same size



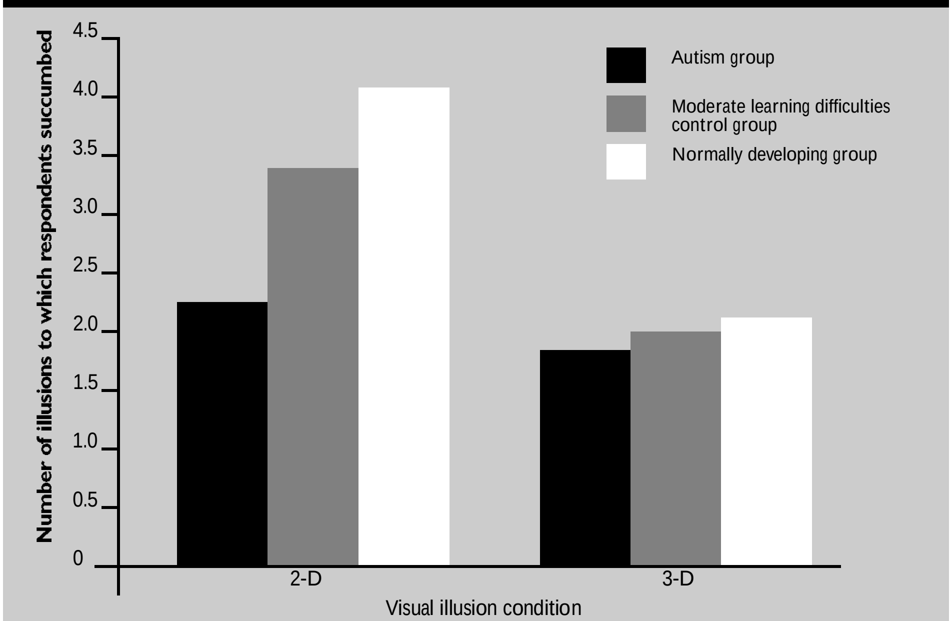
and poor performance with a single cognitive postulate. Thus, individuals with autism are predicted to be relatively good at tasks where attention to local information (i.e. relatively piecemeal processing) is advantageous, but poor at tasks requiring the recognition of global meaning or integration of stimuli in context. It was this aspect of the account that first enthralled me, and was brought home to me by the anecdote illustrated in Figure 1.

A clinician testing a boy with autism asked him to name the various toy objects in front of him, and he obligingly named the bed, blanket and so forth. The clinician then pointed to the toy pillow, asking what that was, to which the young man replied, ‘It’s a piece of ravioli’.

What is so nice about this example is that the clinician remarked that the pillow did indeed look like a piece of ravioli, but that she would never have noticed the resemblance *in that context*. In an important sense, then, the boy was not misperceiving, or even mislabelling — his perception was accurate, perhaps all the more so for being entirely context-independent.

The central coherence account of autism attempts to predict and explain such skills, as well as impairments. As such, it can best be characterised in terms of cognitive style, rather than as a deficit account.

FIGURE 3 People with autism, who may perceive visual illusions such as Titchener circles (Figure 2) in a less unified way, are better able to resist the ‘inducing context’ and so succumb less to the illusion (based on Happé,1996)



Three levels of processing

In the last few years, the notion that children with autism show weak central coherence — a tendency to focus on parts and details at the expense of processing wholes and meaning — has received empirical support from a growing number of studies. Detail-focused processing has been demonstrated at a number of levels, and here I would like to mention just a few examples spanning these different levels (see Happé, in press, for a review).

Perceptual processing Let’s start with the lowest level of information processing (although this alone spans a vast range of complexities and levels). On the face of it, the theory of weak coherence would, in its strongest form, predict radical anomalies of perception. Could it really be that children with autism see a fragmented world?

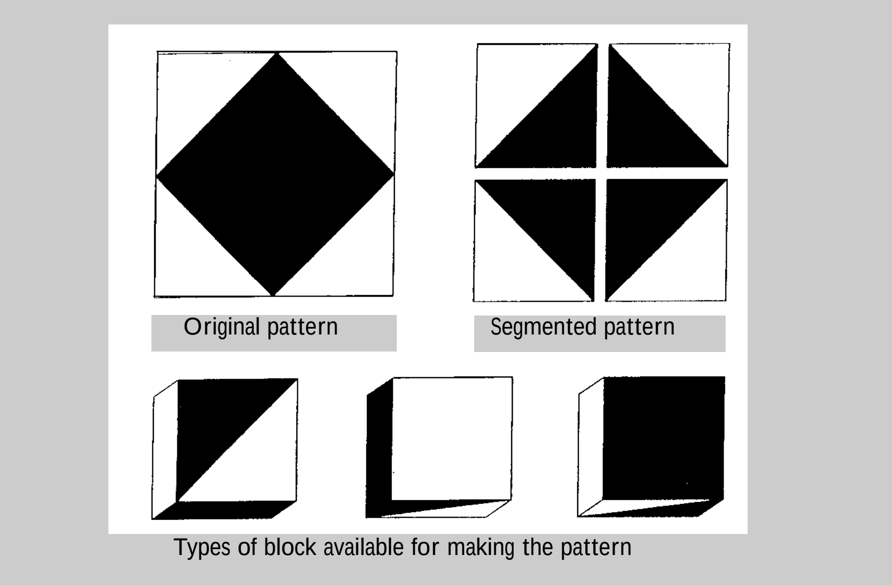
To explore coherence at a perceptual level, I asked individuals with autism (who ranged in age from 8 to 16, and in IQ from 40 to 92) to make simple judgements about standard textbook visual illusions. The logic behind the choice of materials was that at least some illusions can be analysed into a ‘to-be-judged’ figure and an inducing context or ground. In the Titchener circles illusion, for example, it is the presence of the surrounding small or big circles that induces the misperception that the inner circles are of different sizes (Figure 2).

If people with autism have a tendency towards fragmented perception, and focus on the to-be-judged parts without integrating them with the surrounding illusion-inducing context, one might expect them to succumb less to the typical misperceptions. And this was exactly what happened — the people with autism were better able than controls with or without learning disabilities to make accurate judgements of the illusions (2-D condition in Figure 3) (Happé, 1996).

This superior ability seemed to be related to disembedding skill, since when the figures were artificially disembedded by highlighting the to-be-judged parts with raised coloured lines (3-D condition in Figure 3), control groups performed as accurately as the autism group. The autism group, however, was not much helped by this artificial disembedding — like the little boy with the ‘ravioli pillow’, they did not fall prey to context.

Although it may seem hard to believe that people with autism might see the world in a radically different way, some first-person accounts do suggest fragmented and disorganised perception.

FIGURE 4 In the Wechsler block design task, the respondent must copy the design using cubes with differently patterned faces



Parents, too, report intriguing and unexpected difficulties — for example, that their children have problems walking down stairs unless light and shadow provide depth cues.

Weak coherence appears at present to be independent from — though it interacts with — deficits in theory of mind (Happé, 1994*a*, 1997). However, detail-focused processing at a perceptual level may play a part in certain social impairments.

Children with autism are thought to process faces in terms of individual features, not their overall configuration. They suffer less decrement in face recognition tests when the faces are inverted (Hobson *et al.*, 1988); inverting faces is thought to affect primarily configural (as opposed to featural) processing (Bartlett & Searcy, 1993). The problem is that certain emotions appear to be recognised predominantly from configural information (McKelvie, 1995). The autistic featural processing style, then, may hamper emotion recognition.

Visuospatial constructional coherence An elegant demonstration of weak coherence was given by Shah and Frith (1993). They showed that people with autism were unusually good at the standard block design subtest of the Wechsler scales (see Figure 4) and that this facility has specifically to do with segmentation abilities.

On a modified task using pre-segmented designs, controls performed as well as the autism group. A sizeable advantage gained from pre-segmentation was shown by controls with (and without) learning disabilities, but not by people with autism — suggesting that the latter group already saw the design in terms of its constituent parts (Figure 5).

So while the block design task may be hard for the rest of us because we cannot overcome the gestalt of the whole design (for example, we see the design in Figure 4 as a black diamond, rather than the four triangles of which it is composed) — people with autism have no such difficulty. They do not succumb to the gestalt, and instead see the design in terms of its constituent blocks. A similar skill is often seen on the embedded figures test (see Figure 6), in which a small shape must be found within a larger design (Shah & Frith, 1983).

Verbal-semantic coherence Hermelin and O'Connor's (1967) groundbreaking work on cognition in autism showed that people with autism did not derive the usual benefit from meaning in memory tasks. While control groups recalled sentences far better than unconnected word strings, this advantage from meaning was greatly diminished in the autism group.

This work, subsequently replicated by a number of authors, suggested that people with autism did not make use of either semantic relations (e.g. words from the same category versus assorted words) or grammatical relations (e.g. sentences versus word lists) in memory.

Weak coherence is also demonstrated by people with autism in their good verbatim but poor gist memory for story material (Scheuffgen, 1998), and poor inference, disambiguation and construction of narrative (Jolliffe, 1998). Children with autism show a local bias too in a sentence completion test. Given stems such as 'The sea tastes of salt and …', or 'You can go hunting with a knife and …', they tend to answer with local completions such as 'pepper' and 'fork'(Happé, in preparation).

Frith and Snowling (1983) used homographs (words with one spelling, two meanings and two pronunciations) to check whether children with autism would use preceding sentence context to derive meaning and determine pronunciation — for example, 'In her eye there was a big tear', 'In her dress there was a big tear'.

If people with autism have weak central coherence at this level, then reading a sentence may, for them, be akin to reading a list of unconnected words — and sentence context will not be built up to allow meaning-driven disambiguation. In the original studies (Frith & Snowling, 1983; Snowling & Frith, 1986), and a subsequent study with higher-functioning children and adults (Happé, 1997), individuals with autism failed to use

FIGURE 5 Shah and Frith's (1993) block design results

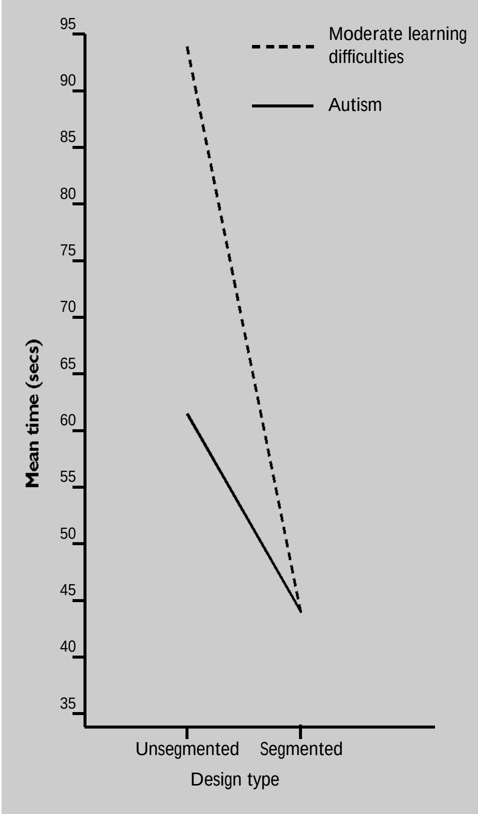
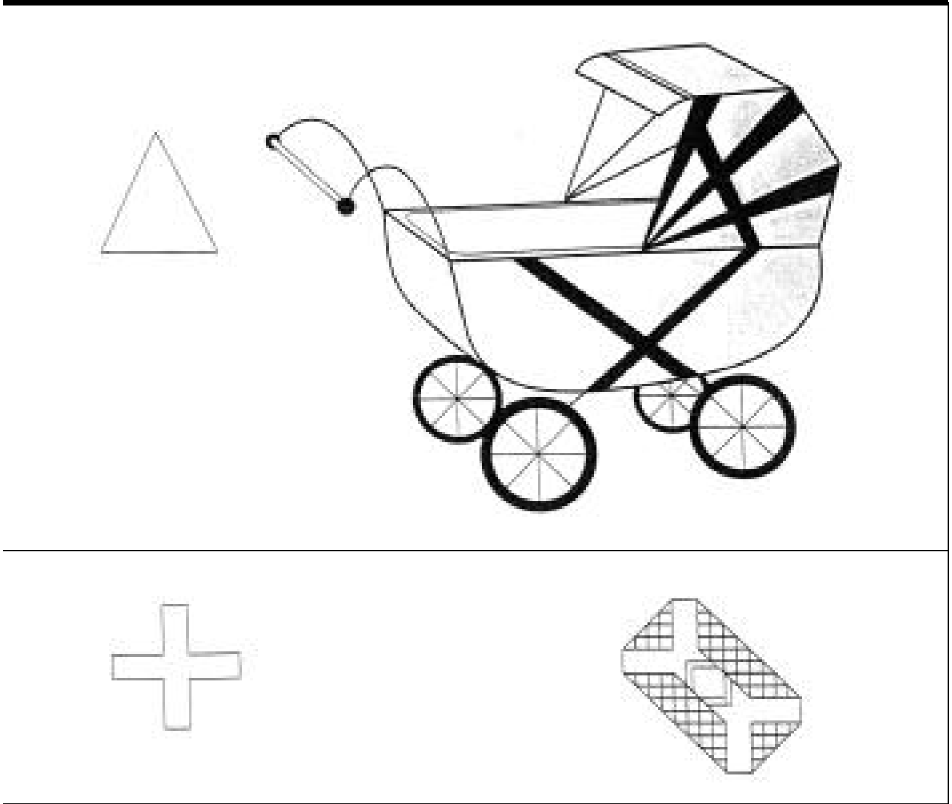


FIGURE 6 Embedded figures test



preceding sentence context to determine the pronunciation of homographs.

These findings bring to mind Kanner's (1943) description of his original cases: '… the children read monotonously, and a story … is experienced in unrelated portions rather than in its coherent totality'(p.42).

However, people with autism (at these levels of intelligence) are able to read sentences for meaning when they are explicitly required to do so. For example, when instructed in reading for meaning (Snowling & Frith, 1986), group differences on the homograph task disappeared.

It seems, then, that weak central coherence characterises the spontaneous approach or processing preference of people with autism, best captured in open-ended tasks, and thus deserves the term 'style' rather than 'deficit'.

In general, then, published findings to date suggest that people with autism are distinguished from age- and ability-matched comparison groups in showing relative attention to parts and relative inattention to wholes. The notion of coherence is currently being debated and refined, however, and the boundaries of the local bias are being delineated (see e.g. Plaisted *et al.,* 1998; Mottron *et al.,* 1998).

It is worth noting, for example, that people with autism do appear to integrate the properties of a single object (e.g. colour and form in a visual search task: Plaisted *et al.,* 1998), and to process the meaning of individual words (in Stroop tasks: Frith & Snowling, 1983) and objects (in memory tasks: Pring & Hermelin, 1993). It seems to be in connecting words or objects that coherence is weak.

Coherence and savant skills

Weak central coherence, then, may be a cognitive style capable of explaining assets as well as deficits on tests. Can it help us to understand the puzzling clinical features of autism, such as the high rate of savant skills? Perhaps — as can be illustrated from suggestive data in two domains.
In the area of musical talent, Heaton *et al.* (1998) have shown that absolute pitch is unusually common among even musically naive children with autism. How might absolute pitch relate to weak coherence?

Takeuchi and Hulse (1993) conclude from a review of research that absolute pitch can be learnt by most children before about age six, after which 'a general developmental shift from perceiving individual features [notes] to perceiving relations among features [melody] makes [absolute pitch] difficult or impossible to acquire' (p.345). If people with autism show a pervasive and persistent local processing bias, this would explain the high frequency of absolute pitch and the superior ability to learn note-name mappings at later ages.

In the domain of graphic talent, it also appears that the superior performance of some individuals with autism may reflect a detail-focused processing style. Studies (Mottron & Belleville, 1993; Mottron *et al.,* in press) have shown that savant artists with autism tend to draw from one contiguous detail to the next, rather than sketching an outline first as is done ordinarily. Other evidence of featural processing includes the unusual ease with which they copy globally incoherent (impossible) figures.

Pring *et al.* (1995) tested part–whole processing in children with autism and normally developing children using modified block design tasks. They conclude that there is 'a facility in autism for seeing wholes in terms of their parts, rather than as unified gestalts' (p.1073) — and that this ability may also be characteristic of individuals with an aptitude for drawing, whether or not they have autism.

Central coherence and the broader phenotype

Since weak central coherence gives both advantages and disadvantages, it is possible to think of this balance (between preference for parts versus wholes) as akin to a cognitive style — a style which may vary in the normal population. We might think of a normal distribution of cognitive style, from 'weak'central coherence (preferential processing of parts, e.g. good proofreading), to 'strong'coherence (preferential processing of wholes, e.g. good gist memory).

There is existing but disparate evidence of normal individual differences in local–global processing, from infancy (e.g. Colombo *et al.,* 1995), through childhood (e.g. Chynn *et al.,* 1991), and into adulthood (e.g. Marendaz, 1985). Sex differences have also been reported on tasks thought to tap local–global processing (e.g. Kramer *et al.,* 1996), although studies have typically confounded type of processing (local/global) and domain (visuospatial/verbal).

The possibility of sex differences in coherence is intriguing in relation to autism, which shows a very high male to female ratio, especially at the high-ability end of the autism spectrum. We might speculate that the normal distribution of coherence in males is shifted slightly towards weak coherence and local/featural processing.

Lastly, we might superimpose at the extreme weak end of the normal distribution a putative area of risk for autism. We could hypothesise that individuals who fall at this extreme end of the continuum of cognitive style are predisposed to develop autism if unlucky enough to suffer the additional social deficits (impaired theory of mind) characteristic of this disorder.

As a cognitive style, rather than a deficit, weak central coherence is an interesting contender for the aspect of autism that may be transmitted genetically and which may characterise the relatives of individuals with autism. In work under way, Uta Frith, Jackie Briskman and I have investigated cognitive style in parents and siblings of children with autism, and in comparison families in which a son had dyslexia or no developmental disorder.

To date, our results suggest that parents, and especially fathers, of children with autism show significantly superior performance on tasks favouring featural, detail-focused processing. So fathers of boys with autism are especially good at the embedded figures test, at block design (and are little aided by pre-segmentation), and at accurately judging visual illusion figures.

They are also more likely than other fathers to give local sentence completions, while being rather good at verbal tasks requiring segmentation skills (e.g. Spoonerisms). In all these respects they resemble individuals with autism but, importantly, for these fathers their detail-focused cognitive style is an asset not a deficit.

These findings again argue for the pertinence of task success. Many studies of the broader phenotype of autism suggest mild social or communicative deficits in parents and siblings — deficits which may be, in large part, the *result* of living with a child with autism. The superior skills we are finding in fathers of children with autism are less ambiguous, we believe, in terms of causal direction.

Future directions

Many challenges remain to the central coherence account, not least to specify the mechanism for coherence. Should we think of a central mechanism taking information from several modules and systems and integrating these for higher-level meaning? Or should central coherence be thought of as a property of each subsystem, in which one might think of a setting for the relative precedence of global versus local processing?

This latter question might be resolved through explorations of individuals' central coherence across and within a number of domains. Does degree of coherence in a verbal task predict degree of coherence in a visuospatial task, or are these somewhat independent?

Functional imaging work may help to shed light on the unitary or distributed neuro-anatomic substrate(s) for coherence. Neuropsychological studies also give clues; research on the effects of brain damage suggests a special role for the right hemisphere in integrative processing of both visual and verbal information (Robertson & Lamb, 1991; Benowitz *et al.,* 1990).

It is unlikely, however, that autism will prove to be the result of damage confined to one brain region — and the very notion of weak central coherence conjures up images of diffuse differences in brain organisation. One intriguing finding, in this respect, is that some people with autism have larger or heavier brains than do comparison groups, with increased cell density in several areas (Piven *et al.,* 1995).

It is possible that this increased cell density reflects an abnormal increase in number of neurons, perhaps due to failure of pruning in brain development. In turn, processing with excess neurons may result in a failure to process information for gist. If the brain has the capacity to encode each separate example (event, individual) it encounters, perhaps there is no need for the cognitive economy derived from processing for gist.

FROM: *CITIES* (1989), DENT & SONS, LONDON

'Canary Wharf' drawn by Stephen Wiltshire, a young man with autism and extraordinary artistic skill

Cohen (1994) has presented a computational model of autism, in which lack of generalisation results from an increase in units — an intriguing example of how computational analyses may interact with neuroanatomical data and psychological theory to help solve the puzzle of autism.

It is possible, then, that autism may result from an 'embarrassment of riches' at the neural level. This translates into a cognitive system only too well able to distinguish featural differences at the expense of 'the big picture'.

Requests for reprints of this article should be addressed to:
Dr Francesca Happé
Social, Genetic and Developmental Psychiatry Research Centre
Institute of Psychiatry
De Crespigny Park
Denmark Hill
London SE5 8AF
Tel: 0171 740 5121
E-mail: spjwfgh@iop.kcl.ac.uk

References

Baron-Cohen, S., Tager-Flusberg, H. & Cohen, D.J. (Eds) (1993). *Understanding Other Minds: Perspectives from Autism.* Oxford: Oxford University Press.

Bartlett, J.C. (1932). *Remembering: A Study in Experimental and Social Psychology.* Cambridge: Cambridge University Press.

Bartlett, J.C. & Searcy, J. (1993). Inversion and configuration of faces. *Cognitive Psychology,* 25, 281–316.

Benowitz, L.I., Moya, K.L. & Levine, D.N. (1990). Impaired verbal reasoning and constructional apraxia in subjects with right hemisphere damage. *Neuropsychologia,* 23, 231–241.

Chynn, E.W., Garrod, A., Demick, J. & DeVos, E. (1991). Correlations among field dependence–independence, sex, sex-role stereotype, and age of preschoolers. *Perceptual and Motor Skills*, 73, 747–756.
Cohen, I.L. (1994). An artificial neural network analogue of learning in autism. *Biological Psychiatry*, 36, 5–20.
Colombo, J., Freeseman, L.J., Coldren, J.T. & Frick, J.E. (1995). Individual differences in infant fixation duration: Dominance of global versus local stimulus properties. *Cognitive Development*, 10, 271–285.
Freedland, R.L. & Dannemiller, J.L. (1996). Nonlinear pattern vision processes in early infancy. *Infant Behavior and Development*, 19, 21–32.
Frith, U. (1989). *Autism: Explaining the Enigma*. Oxford: Blackwell.
Frith, U. & Snowling, M. (1983). Reading for meaning and reading for sound in autistic and dyslexic children. *Journal of Developmental Psychology*, 1, 329–342.
Happé, F.G.E. (1994*a*). Wechsler IQ profile and theory of mind in autism: A research note. *Journal of Child Psychology and Psychiatry*, 35, 1461–1471.
Happé, F.G.E. (1994*b*). *Autism: An Introduction to Psychological Theory*. London: UCL Press.
Happé, F.G.E. (1996). Studying weak central coherence at low levels: Children with autism do not succumb to visual illusions: A research note. *Journal of Child Psychology and Psychiatry*, 37, 873–877.
Happé, F.G.E. (1997). Central coherence and theory of mind in autism: Reading homographs in context. *British Journal of Developmental Psychology*, 15, 1–12.
Happé, F.G.E. (in press). Autism: Cognitive deficit or cognitive style? *Trends in Cognitive Sciences*.
Happé, F.G.E. (in preparation). Weak coherence in a sentence completion task.
Heaton, P., Hermelin, B. & Pring, L. (1998). Autism and pitch processing: A precursor for savant musical ability. *Music Perception*, 15, 291–305.
Hermelin, B. & O'Connor, N. (1967). Remembering of words by psychotic and subnormal children. *British Journal of Psychology*, 58, 213–218.
Hobson, R.P., Ouston, J. & Lee, T. (1988). What's in a face? The case of autism. *British Journal of Psychology*, 79, 441–453.
Jolliffe, T. (1998). Unpublished PhD thesis, University of Cambridge.
Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child*, 2, 217–250. Reprinted in L. Kanner (1973), *Childhood Psychosis: Initial Studies and New Insights*. Washington, DC: Wiley.
Kimchi, R. (1992). Primacy of wholistic processing and the global/local paradigm: A critical review. *Psychological Bulletin*, 112, 24–38.
Kramer, J.H., Ellenberg, L., Leonard, J. & Share, L.J. (1996). Developmental sex differences in global–local perceptual bias. *Neuropsychology*, 10, 402–407.
McKelvie, S.J. (1995). Emotional expression in upside-down faces: Evidence for configurational and componential processing. *British Journal of Social Psychology*, 34, 325–334.
Marendaz, C. (1985). Global precedence and field dependence: Visual routines? *Cahiers de Psychologie Cognitive*, 5, 727–745.
Mottron, L. & Belleville, S. (1993). A study of perceptual analysis in a high-level autistic subject with exceptional graphic abilities. *Brain and Cognition*, 23, 279–309.
Mottron, L., Burack, J.A., Stauder, J.E.A. & Robaey, P. (1998). Perceptual processing and autism. *Journal of Child Psychology and Psychiatry*, 40, 203–211.
Mottron, L., Belleville, S. & Ménard, A. (in press). Local bias in autistic subjects as evidenced by graphic tasks: Perceptual hierarchization or working memory deficit? *Journal of Child Psychology and Psychiatry*.
Piven, J., Arndt, S., Bailey, J., Havercamp, S., Andreasen, N.C. & Palmer, P. (1995). An MRI study of brain size in autism. *American Journal of Psychiatry*, 152, 1145–1149.
Plaisted, K., O'Riordan, M. & Baron-Cohen, S. (1998). Enhanced visual search for a conjunctive target in autism: A research note. *Journal of Child Psychology and Psychiatry*, 39, 777–783.
Pring, L. & Hermelin, B. (1993). Bottle, tulip and wineglass: Semantic and structural picture processing by savant artists. *Journal of Child Psychology and Psychiatry*, 34, 1365–1385.
Pring, L., Hermelin, B. & Heavey, L. (1995). Savants, segments, art and autism. *Journal of Child Psychology and Psychiatry*, 36, 1065–1076.
Rimland, B. & Hill, A.L. (1984). Idiot savants. In J. Wortis (Ed.), *Mental Retardation and Developmental Disabilities*, vol. 13. New York: Plenum Press.
Robertson, L.C. & Lamb, M.R. (1991). Neuropsychological contribution to theories of part/whole organization. *Cognitive Psychology*, 23, 299–330.
Scheuffgen, K. (1998). Unpublished PhD thesis, University of London.
Shah, A. & Frith, U. (1983). An islet of ability in autistic children: A research note. *Journal of Child Psychology and Psychiatry*, 24, 613–620.
Shah, A. & Frith, U. (1993). Why do autistic individuals show superior performance on the block design task? *Journal of Child Psychology and Psychiatry*, 34, 1351–1364.
Snowling, M. & Frith, U. (1986). Comprehension in 'hyperlexic' readers. *Journal of Experimental Child Psychology*, 42, 392–415.
Takeuchi, A.H. & Hulse, S.H. (1993). Absolute pitch. *Psychological Bulletin*, 113, 345–361.