

Autism: beyond “theory of mind”

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Abstract

The theory of mind account of autism has been remarkably successful in making specific predictions about the impairments in socialization, imagination and communication shown by people with autism. It cannot, however, explain either the non-triad features of autism, or earlier experimental findings of abnormal assets and deficits on non-social tasks. These unexplained aspects of autism, and the existence of autistic individuals who consistently pass false belief tasks, suggest that it may be necessary to postulate an additional cognitive abnormality. One possible abnormality – weak central coherence – is discussed, and preliminary evidence for this theory is presented.

The theory of mind account of autism

In 1985 *Cognition* published an article by Baron-Cohen, Leslie, and Frith, entitled: Does the autistic child have a “theory of mind”? The perceptive reader would have recognized this as a reference to Premack and Woodruff’s (1978) question: Does the chimpanzee have a theory of mind? The connection between these two was, however, an indirect one – the immediate precursor of the paper was Wimmer and Perner’s (1983) article on the understanding of false beliefs by normally developing pre-school children. Each of these three papers has, in its way, triggered an explosion of research interest; in the social impairments of autism, the mind-reading capacities of non-human primates, and the development of social understanding in normal children. The connections which existed between the three papers have been mirrored in continuing connections between these three fields of research – developmental psychology (Astington, Harris, & Olson, 1989; Perner, 1991; Russell, 1992; Wellman, 1990), cognitive ethology

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(Byrne & Whiten, 1988; Cheney & Seyfarth, 1990), and developmental psychopathology (Cicchetti & Cohen, in press; Rutter, 1987). There can be little doubt that these contacts have enriched work in each area.

Perceptive readers would also have noticed the inverted commas surrounding the phrase “theory of mind” in the 1985 paper. Baron-Cohen, Leslie, and Frith followed Premack and Woodruff’s definition of this “sexy” but misleading phrase: to have a theory of mind is to be able to attribute independent mental states to self and others in order to explain and predict behaviour. As might befit a “theory” ascribable to chimpanzees, this was not a conscious theory but an innately given cognitive mechanism allowing a special sort of representation – the representation of mental states. Leslie (1987, 1988) delivered the critical connection between social understanding and understanding of pretence, via this postulated mechanism; metarepresentation is necessary, in Leslie’s theory, for representing pretence, belief and other mental states. From this connection, between the social world and the world of imaginative play, sprung the link to autistic children, who are markedly deficient in both areas.

The idea that people with autism could be characterized as suffering from a type of “mind-blindness”, or lack of theory of mind, has been useful to the study of child development – not because it was correct (that is still debatable) but because it was a causal account which was both specific and falsifiable. The clearest expression of this causal account is given in Frith, Morton, and Leslie (1991). What is to be explained? Autism is currently defined at the behavioural level, on the basis of impairments in socialization, communication and imagination, with stereotyped repetitive interests taking the place of creative play (DSM-III-R, American Psychological Association, 1987). A causal account must link these behavioural symptoms to the presumed biological origins (Gillberg & Coleman, 1992; Schopler & Mesibov, 1987) of this disorder.

Specificity is particularly important in any causal account of autism because autistic people themselves show a highly specific pattern of deficits and skills. The IQ profile alone serves to demonstrate this; autistic people in general show an unusually “spiky” profile across Wechsler subtests (Lockyer & Rutter, 1970; Tymchuk, Simmons, & Neafsey, 1977), excelling on Block Design (constructing a pattern with cubes), and failing on Picture Arrangement (ordering pictures in a cartoon strip). This puzzling discrepancy of functioning has caused many previous psychological theories of autism to fail. For example, high arousal, lack of motivation, language impairment, or perceptual problems are all too global to allow for both the assets and deficits of autism.

Fine cuts along a hidden seam

What are the specific predictions made by the hypothesis that people with autism lack a “theory of mind”? The hypothesis does not address the question of

the spiky IQ profile – it is silent on functioning in non-social areas – but it focuses on the critical triad of impairments (Wing & Gould, 1979). Not only does it make sense of this triad, but it also makes “fine cuts” *within* the triad of autistic impairments. Social and communicative behaviour is not all of one piece, when viewed from the cognitive level. Some, but not all, such behaviour requires the ability to “mentalize” (represent mental states). So, for example, social approach need not be built upon an understanding of others’ thoughts – indeed Hermelin and O’Connor (1970) demonstrated to many people’s initial surprise that autistic children prefer to be with other people, just like non-autistic children of the same mental age. However, sharing attention with someone else does require mentalizing – and is consistently reported by parents to be missing in the development of even able autistic children (Newson, Dawson, & Everard, 1984).

The mentalizing-deficit account has allowed a systematic approach to the impaired and unimpaired social and communicative behaviour of people with autism. Table 1 shows some of the work exploring predictions from the hypothesis that autistic people lack mentalizing ability. The power of this hypothesis is to make fine cuts in the smooth continuum of behaviours, and in this it has been remarkably useful. It has sparked an enormous amount of research, both supporting and attacking the theory (reviewed by Baron-Cohen, Tager-Flusberg, & Cohen, 1993; Happé, 1994a; Happé & Frith, in press).

The fine cuts method, as used in the laboratory, has also informed research

Table 1. *Autistic assets and deficits as predicted by the “fine cuts” technique, between tasks which require mentalizing and those which do not*

Assets	Deficits
Ordering behavioural pictures	Ordering mentalistic pictures (Baron-Cohen et al., 1986)
Understanding see	Understanding know (Perner et al., 1989)
Protoimperative pointing	Protodeclarative pointing (Baron-Cohen, 1989b)
Sabotage	Deception (Sodian & Frith, 1992)
False photographs	False beliefs (Leslie & Thaiss, 1992; Leekam & Perner, 1991)
Recognizing happiness and sadness	Recognizing surprise (Baron-Cohen et al., 1993)
Object occlusion	Information occlusion (Baron-Cohen, 1992)
Literal expression	Metaphorical expression (Happé, 1993)

References refer to Assets and Deficits.

Table 2. *Autistic assets and deficits observed in real life*

Assets	Deficits
Elicited structured play	Spontaneous pretend play (Wetherby & Prutting, 1984)
Instrumental gestures	Expressive gestures (Attwood, Frith, & Hermelin, 1988)
Talking about desires and emotions	Talking about beliefs and ideas (Tager-Flusberg, 1993)
Using person as tool	Using person as receiver of information (Phillips, 1993)
Showing “active” sociability	Showing “interactive” sociability (Frith et al., in press)

References refer to Assets and Deficits.

into the pattern of abilities and deficits in real life (Table 2), although this enterprise has still some way to go. This technique, which aims to pit two behaviours against each other which differ only in the demands they make upon the ability to mentalize, pre-empts many potential criticisms. It is also peculiarly suitable for use in brain-imaging studies. By looking at performance across tasks which are equivalent in every other way, except for the critical cognitive component, intellectual energy has been saved for the really interesting theoretical debates.

Another key benefit of the specificity of this approach is the relevance it has for normal development. The fine cuts approach suits the current climate of increased interest in the modular nature of mental capacities (e.g., Cosmides, 1989; Fodor, 1983). It has allowed us to think about social and communicative behaviour in a new way. For this reason, autism has come to be a test case for many theories of normal development (e.g., Happé, 1993; Sperber & Wilson's 1986 Relevance theory).

Limitations of the theory of mind account

The hijacking of autism by those primarily interested in normal development has added greatly to the intellectual richness of autism research. But just how well does the theory of mind account explain autism? By the stringent standard, that explanatory theories must give a *full* account of a disorder (Morton & Frith, in press), not that well. The mentalizing account has helped us to understand the nature of the autistic child's impairments in play, social interaction and verbal and non-verbal communication. But there is more to autism than the classic triad of impairments.

Non-triad features

Clinical impressions, originating with Kanner (1943) and Asperger (1944; translated in Frith, 1991), and withstanding the test of time, include the following:

- Restricted repertoire of interests (necessary for diagnosis in DSM-III-R, American Psychological Association, 1987).
- Obsessive desire for sameness (one of two cardinal features for Kanner & Eisenberg, 1956).
- Islets of ability (an essential criterion in Kanner, 1943).
- Idiot savant abilities (striking in 1 in 10 autistic children, Rimland & Hill, 1984).
- Excellent rote memory (emphasized by Kanner, 1943).
- Preoccupation with parts of objects (a diagnostic feature in DSM-IV, forthcoming).

All of these non-triad aspects of autism are vividly documented in the many parental accounts of the development of autistic children (Hart, 1989; McDonnell, 1993; Park, 1967). None of these aspects can be well explained by a lack of mentalizing.

Of course, clinically striking features shown by people with autism need not be specific features of the disorder. However, there is also a substantial body of experimental work, much of it predating the mentalizing theory, which demonstrates non-social abnormalities that are specific to autism. Hermelin and O'Connor were the first to introduce what was in effect a different “fine cuts” method (summarized in their 1970 monograph) – namely the comparison of closely matched groups of autistic and non-autistic handicapped children of the same mental age. Table 3 summarizes some of the relevant findings.

The talented minority

The mentalizing deficit theory of autism, then, cannot explain all features of autism. It also cannot explain all people with autism. Even in the first test of the hypothesis (reported in the 1985 *Cognition* paper), some 20% of autistic children passed the Sally-Ann task. Most of these successful children also passed another test of mentalizing – ordering picture stories involving mental states (Baron-Cohen, Leslie, & Frith, 1986) – suggesting some real underlying competence in representing mental states. Baron-Cohen (1989a) tackled this apparent dis-

Table 3. *Experimental findings not accounted for by mind-blindness. Surprising advantages and disadvantages on cognitive tasks, shown by autistic subjects relative to normally expected asymmetries*

Unusual strength	Unusual weakness
Memory for word strings	Memory for sentences (e.g., Hermelin & O'Connor, 1967)
Memory for unrelated items	Memory for related items (e.g., Tager-Flusberg, 1991)
Echoing nonsense	Echoing with repair (e.g., Aurnhammer-Frith, 1969)
Pattern imposition	Pattern detection (e.g., Frith, 1970 a,b)
Jigsaw by shape	Jigsaw by picture (e.g., Frith & Hermelin, 1969)
Sorting faces by accessories	Sorting faces by person (e.g., Weeks & Hobson, 1987)
Recognizing faces upside-down	Recognizing faces right-way-up (e.g., Langdell, 1978)

References refer to Unusual strength and Unusual weakness.

confirmation of the theory, by showing that these talented children still did not pass a harder (second-order) theory of mind task (Perner & Wimmer, 1985). However, results from other studies focusing on high-functioning autistic subjects (Bowler, 1992; Ozonoff, Rogers, & Pennington, 1991) have shown that some autistic people can pass theory of mind tasks consistently, applying these skills across domains (Happé, 1993) and showing evidence of insightful social behaviour in everyday life (Frith, Happé, & Siddons, in press). One possible way of explaining the persisting autism of these successful subjects is to postulate an additional and continuing cognitive impairment. What could this impairment be?

The recent interest in *executive function deficits* in autism (Hughes & Russell, 1993; Ozonoff, Pennington, & Rogers, 1991) can be seen as springing from some of the limitations of the theory of mind view discussed above. Ozonoff, Rogers, & Pennington (1991) found that while not all subjects with autism and/or Asperger's syndrome showed a theory of mind deficit, all were impaired on the Wisconsin Card Sorting Test and Tower of Hanoi (two typical tests of executive function). On the basis of this finding they suggest that executive function impairments are a primary causal factor in autism. However, the specificity, and hence the power of this theory as a causal account, has yet to be established by systematic comparison with other non-autistic groups who show impairments in executive functions (Bishop, 1993). While an additional impairment in executive functions may be able to explain certain (perhaps non-specific) features of autism (e.g., stereotypies, failure to plan, impulsiveness), it is not clear how it could explain the specific deficits and skills summarized in Table 3.

The central coherence theory

Motivated by the strong belief that both the assets and the deficits of autism spring from a single cause at the cognitive level, Frith (1989) proposed that autism is characterized by a specific imbalance in integration of information at different levels. A characteristic of normal information processing appears to be the tendency to draw together diverse information to construct higher-level meaning in context; “central coherence” in Frith’s words. For example, the gist of a story is easily recalled, while the actual surface form is quickly lost, and is effortful to retain. Bartlett (1932), summarizing his famous series of experiments on remembering images and stories, concluded: “an individual does not normally take [such] a situation detail by detail . . . In all ordinary instances he has an overmastering tendency simply to get a general impression of the whole; and, on the basis of this, he constructs the probable detail” (p. 206). Another instance of central coherence is the ease with which we recognize the contextually appropriate sense of the many ambiguous words used in everyday speech (son–sun, meet–meat, sew–so, pear–pair). A similar tendency to process information in context for global meaning is also seen with non-verbal material – for example, our everyday 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 may characterize even mentally handicapped (non-autistic) individuals – who appear to be sensitive to the advantage of recalling organized versus jumbled material (e.g., Hermelin & O’Connor, 1967).

Frith suggested that this universal feature of human information processing was disturbed in autism, and that a lack of central coherence could explain very parsimoniously the assets and deficits shown in Table 3. On the basis of this theory, she predicted that autistic subjects would be relatively good at tasks where attention to local information – relatively piecemeal processing – is advantageous, but poor at tasks requiring the recognition of global meaning.

Empirical evidence: assets

A first striking signpost towards the theory appeared quite unexpectedly, when Amitta Shah set off to look at autistic children’s putative perceptual impairments on the *Embedded Figures Test*. The children were almost better than the experimenter! Twenty autistic subjects with an average age of 13, and non-verbal mental age of 9.6, were compared with 20 learning disabled children of the same age and mental age, and 20 normal 9-year-olds. These children were given the Children’s Embedded Figures Test (CEFT; Witkin, Oltman, Raskin, & Karp, 1971), with a slightly modified procedure including some pretraining with cut-out shapes. The test involved spotting a hidden figure (triangle or house shape)

among a larger meaningful drawing (e.g., a clock). During testing children were allowed to indicate the hidden figure either by pointing or by using a cut-out shape of the hidden figure. Out of a maximum score of 25, autistic children got a mean of 21 items correct, while the two control groups (which did not differ significantly in their scores) achieved 15 or less. Gottschaldt (1926) ascribed the difficulty of finding embedded figures to the overwhelming “predominance of the whole”. The ease and speed with which autistic subjects picked out the hidden figure in Shah and Frith’s (1983) study was reminiscent of their rapid style of locating tiny objects (e.g. thread on a patterned carpet) and their immediate discovery of minute changes in familiar lay-outs (e.g., arrangement of cleaning materials on bathroom shelf), as often described anecdotally.

The study of embedded figures was introduced into experimental psychology by the Gestalt psychologists, who believed that an effort was needed to resist the tendency to see the forcefully created gestalt, at the expense of the constituent parts (Koffka, 1935). Perhaps this struggle to resist overall gestalt forces does not occur for autistic subjects. If people with autism, due to weak central coherence, have privileged access to the parts and details normally securely embedded in whole figures, then novel predictions could be made about the nature of their islets of ability.

The *Block Design* subtest of the Wechsler Intelligence Scales (Wechsler, 1974, 1981) is consistently found to be a test on which autistic people show superior performance relative to other subtests, and often relative to other people of the same age. This test, first introduced by Kohs (1923), requires the breaking up of line drawings into logical units, so that individual blocks can be used to reconstruct the original design from separate parts. The designs are notable for their strong gestalt qualities, and the difficulty which most people experience with this task appears to relate to problems in breaking up the whole design into the constituent blocks. While many authors have recognized this subtest as an islet of ability in autism, this fact has generally been explained as due to intact or superior general spatial skills (Lockyer & Rutter, 1970; Prior, 1979). Shah and Frith (1993) suggested, on the basis of the central coherence theory, that the advantage shown by autistic subjects is due specifically to their ability to see parts over wholes. They predicted that normal, but not autistic, subjects would benefit from pre-segmentation of the designs.

Twenty autistic, 33 normal and 12 learning disabled subjects took part in an experiment, where 40 different block designs had to be constructed from either whole or pre-segmented drawn models (Fig. 1). Autistic subjects with normal or near-normal non-verbal IQ were matched with normal children of 16 years. Autistic subjects with non-verbal IQ below 85 (and not lower than 57) were compared with learning disabled children of comparable IQ and chronological age (18 years), and normal children aged 10. The results showed that the autistic subjects’ skill on this task resulted from a greater ability to segment the design. Autistic subjects showed superior performance compared to controls in one

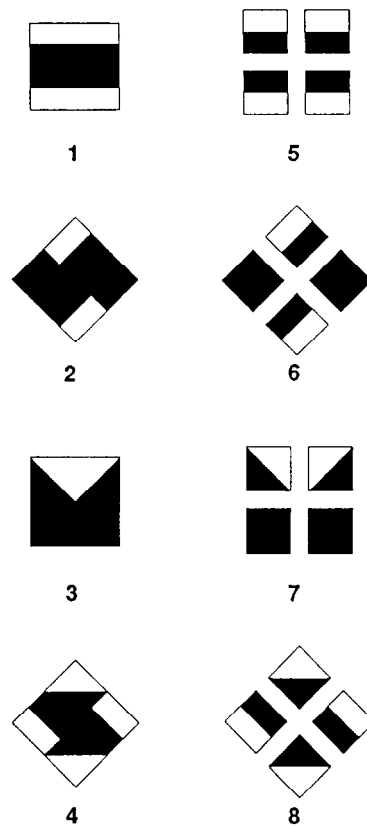


Fig. 1. Examples of all types of design: "whole" versus "segmented" (1, 2, 3, 4 vs. 5, 6, 7, 8) "oblique" versus "non-oblique" (3, 4, 7, 8 vs. 1, 2, 5, 6) "unrotated" versus "rotated" (1, 3, 5, 7 vs. 2, 4, 6, 8).

condition only – when working from whole designs. The great advantage which the control subjects gained from using pre-segmented designs was significantly diminished in the autistic subjects, regardless of their IQ level. On the other hand, other conditions which contrasted presence and absence of obliques, and rotated versus unrotated presentation, affected all groups equally. From these latter findings it can be concluded that general visuo-spatial factors show perfectly normal effects in autistic subjects, and that superior general spatial skill may not account for Block design superiority.

Empirical evidence: deficits

While weak central coherence confers significant advantages in tasks where preferential processing of parts over wholes is useful, it would be expected to confer marked disadvantages in tasks which involve interpretation of individual

stimuli in terms of overall context and meaning. An interesting example is the processing of faces, which seems to involve both featural and configural processing (Tanka & Farah, 1993). Of these two types of information, it appears to be configural processing which is disrupted by the inverted presentation of faces (Bartlett & Searcy, 1993; Rhodes, Brake, & Atkinson, 1993). This may explain the previously puzzling finding that autistic subjects show a diminished disadvantage in processing inverted faces (Hobson, Ouston, & Lee, 1988; Langdell, 1978).

One case in which the meaning of individual stimuli is changed by their context is in the disambiguation of homographs. In order to choose the correct (context-appropriate) pronunciation in the following sentences, one must process the final word as part of the whole sentence meaning: “He had a pink *bow*”; “He made a deep *bow*”. Frith and Snowling (1983) predicted that this sort of contextual disambiguation would be problematic for people with autism. They tested 8 children with autism who had reading ages of 8–10 years, and compared them with 6 dyslexic children and 10 normal children of the same reading age. The number of words read with the contextually appropriate pronunciation ranged from 5 to 7 out of 10 for the autistic children, who tended to give the more frequent pronunciation regardless of sentence context. By contrast, the normal and dyslexic children read between 7 and 9 of the 10 homographs in a contextually determined manner. This finding suggested that autistic children, although excellent at decoding single words, were impaired when contextual cues had to be used. This was also demonstrated in their relative inability to answer comprehension questions and to fill in gaps in a story text. This work fits well with previous findings (Table 3) concerning failure to use meaning and redundancy in memory tasks.

The abnormality of excellence

The hypothesis that people with autism show weak central coherence aims to explain both the glaring impairments and the outstanding skills of autism as resulting from a single characteristic of information processing. One characteristic of this theory is that it claims that the islets of ability and savant skills are achieved through relatively abnormal processing, and predicts that this may be revealed in abnormal error patterns. One example might be the type of error made in the Block Design test. The central coherence theory suggests that, where errors are made at all on Block Design, these will be errors which violate the overall pattern, rather than the details. Kramer, Kaplan, Blusewicz, and Preston (1991) found that in normal adult subjects there was a strong relation between the number of such configuration-breaking errors made on the Block Design test and the number of local (vs. global) choices made in a similarity-judgement task

(Kimchi & Palmer, 1982). Preliminary data from subjects with autism (Happé, in preparation) suggest that, in contrast to normal children, errors violating configuration are far more common than errors violating pattern details in autistic Block Design performance.

A second example concerns idiot savant drawing ability. Excellent drawing ability may be characterized by a relatively piece-meal drawing style. Mottron and Belleville (1993) found in a case study of one autistic man with exceptional artistic ability that performance on three different types of tasks suggested an anomaly in the hierarchical organization of the local and global parts of figures. The authors observed that the subject “began his drawing by a secondary detail and then progressed by adding contiguous elements”, and concluded that his drawings showed “no privileged status of the global form . . . but rather a construction by local progression”. In contrast, a professional draughtsman who acted as a control started by constructing outlines and then proceeded to parts. It remains to be seen whether other savant abilities can be explained in terms of a similarly local and detail-observant processing style.

Central coherence and mentalizing

Central coherence, then, may be helpful in explaining some of the real-life features that have so far resisted explanation, as well as making sense of a body of experimental work not well accounted for by the mentalizing deficit theory. Can it also shed light on the continuing handicaps of those talented autistic subjects who show consistent evidence of some mentalizing ability? Happé (1991), in a first exploration of the links between central coherence and theory of mind, used Snowling and Frith’s (1986) homograph reading task with a group of able autistic subjects. Autistic subjects were tested on a battery of theory of mind tasks at two levels of difficulty (first- and second-order theory of mind), and grouped according to their performance (Happé, 1993). Five subjects who failed all the theory of mind tasks, 5 subjects who passed all and only first-order tasks, and 6 subjects who passed both first- and second-order theory of mind tasks were compared with 14 7–8-year-olds. The autistic subjects were of mean age 18 years, and had a mean IQ of around 80. The three autistic groups and the control group obtained the same score for total number of words correctly read. As predicted, however, the young normal subjects, but not the autistic subjects, were sensitive to the relative position of target homograph and disambiguating context: “There was a big tear in her eye”, versus “In her dress there was a big tear”. The normal controls showed a significant advantage when sentence context occurred before (rare pronunciation) target words (scoring 5 out of 5, vs. 2 out of 5 where target came first), while the autistic subjects (as in Frith and Snowling, 1983) tended to give the more frequent pronunciation regardless (3 out of 5 appropriate pronun-

ciations in each case). The important point of this study was that this was true of all three autistic groups, irrespective of level of theory of mind performance. Even those subjects who consistently passed all the theory of mind tasks (mean VIQ 90) failed to use sentence context to disambiguate homograph pronunciation. It is possible, therefore, to think of weak central coherence as characteristic of even those autistic subjects who possess some mentalizing ability.

Happé (submitted) explored this idea further by looking at WISC-R and WAIS subtest profiles. Twenty-seven children who failed standard first-order false belief tasks were compared with 21 subjects who passed. In both groups Block Design was a peak of non-verbal performance for the majority of subjects: 18/21 passers, and 23/27 failers. In contrast, performance on the Comprehension subtest (commonly thought of as requiring pragmatic and social skill) was a low point in verbal performance for 13/17 “failers” but only 6/20 “passers”. It seems, then, that while social reasoning difficulties (as shown by Wechsler tests) are striking only in those subjects who fail theory of mind tasks, skill on non-verbal tasks benefiting from weak central coherence is characteristic of both passers and failers.

There is, then, preliminary evidence to suggest that the central coherence hypothesis is a good candidate for explaining the persisting handicaps of the talented minority. So, for example, when theory of mind tasks were embedded in slightly more naturalistic tasks, involving extracting information from a story context, even autistic subjects who passed standard second-order false belief tasks showed characteristic and striking errors of mental state attribution (Happé, 1994b). It may be that a theory of mind mechanism which is not fed by rich and integrated contextual information is of little use in everyday life.

The finding that weak central coherence may characterize autistic people at all levels of theory of mind ability goes against Frith’s (1989) original suggestion that a weakness in central coherence could by itself account for theory of mind impairment. At present, all the evidence suggests that we should retain the idea of a modular and specific mentalizing deficit in our causal explanation of the triad of impairments in autism. It is still our belief that nothing captures the essence of autism so precisely as the idea of “mind-blindness”. Nevertheless, for a full understanding of autism in all its forms, this explanation alone will not suffice. Therefore, our present conception is that there may be two rather different cognitive characteristics that underlie autism. Following Leslie (1987, 1988) we hold that the mentalizing deficit can be usefully conceptualized as the impairment of a single modular system. This system has a neurological basis – which may be damaged, leaving other functions intact (e.g., normal IQ). The ability to mentalize would appear to be of such evolutionary value (Byrne & Whiten, 1988; Whiten, 1991) that only insult to the brain can produce deficits in this area. By contrast, the processing characteristic of weak central coherence, as illustrated above, gives both advantages and disadvantages, as would strong central coherence. It is possible, then, to think of this balance (between preference for parts

vs. wholes) as akin to a cognitive style, which may vary in the normal population. No doubt, this style would be subject to environmental influences, but, in addition, it may have a genetic component. It may be interesting, then, to focus on the strengths and weaknesses of autistic children's processing, in terms of weak central coherence, in looking for the extended phenotype of autism. Some initial evidence for this may be found in the report by Landa, Folstein, and Isaacs (1991) that the parents of children with autism tell rather less coherent spontaneous narratives than do controls.

Central coherence and executive function

With the speculative link to cognitive style rather than straightforward deficit, the central coherence hypothesis differs radically not only from the theory of mind account, but also from other recent theories of autism. In fact, every other current psychological theory claims that some significant and objectively harmful deficit is primary in autism. Perhaps the most influential of such general theories is the idea that autistic people have executive function deficits, which in turn cause social and non-social abnormalities. The umbrella term "executive functions" covers a multitude of higher cognitive functions, and so is likely to overlap to some degree with conceptions of both central coherence and theory of mind. However, the hypothesis that autistic people have relatively weak central coherence makes specific and distinct predictions even within the area of executive function. For example, the "inhibition of pre-potent but incorrect responses" may contain two separable elements: inhibition and recognition of context-appropriate response. One factor which can make a pre-potent response incorrect is a change of context. If a stimulus is treated in the same way regardless of context, this may look like a failure of inhibition. However, autistic people may have no problem in inhibiting action where context is irrelevant. Of course it may be that some people with autism do have an additional impairment in inhibitory control, just as some have peripheral perceptual handicaps or specific language problems.

Future prospects

The central coherence account of autism is clearly still tentative and suffers from a certain degree of over-extension. It is not clear where the limits of this theory should be drawn – it is perhaps in danger of trying to take on the whole problem of meaning! One of the areas for future definition will be the *level* at which coherence is weak in autism. While Block Design and Embedded Figures tests appear to tap processing characteristics at a fairly low or perceptual level,

work on memory and verbal comprehension suggests higher-level coherence deficits. Coherence can be seen at many levels in normal subjects, from the global precedence effect in perception of hierarchical figures (Navon, 1977) to the synthesis of large amounts of information and extraction of inferences in narrative processing (e.g., Trabasso & Suh, 1993, in a special issue of *Discourse Processes* on inference generation during text comprehension). One interesting way forward may be to contrast local coherence within modular systems, and global coherence across these systems in central processing. So, for example, the calendrical calculating skills of some people with autism clearly show that information within a restricted domain can be integrated and processed together (O'Connor & Hermelin, 1984; Hermelin & O'Connor, 1986), but the failure of many such savants to apply their numerical skills more widely (some cannot multiply two given numbers) suggests a modular system specialized for a very narrow cognitive task. Similarly, Norris (1990) found that building a connectionist model of an "idiot savant date calculator" only succeeded when forced to take a modular approach.

Level of coherence may be relative. So, for example, within text there is the word-to-word effect of local association, the effect of sentence context, and the larger effect of story structure. These three levels may be dissociable, and it may be that people with autism process the most local of the levels available in open-ended tasks. The importance of testing central coherence with open-ended tasks is suggested by a number of findings. For example, Snowling and Frith (1986) demonstrated that it was possible to train subjects with autism to give the context appropriate (but less frequent) pronunciation of ambiguous homographs. Weeks and Hobson (1987) found that autistic subjects sorted photographs of faces by type of hat when given a free choice, but, when asked again, were able to sort by facial expression. It seems likely, then, that autistic weak central coherence is most clearly shown in (non-conscious) processing preference, which may reflect the relative cost of two types of processing (relatively global and meaningful vs. relatively local and piece-meal).

Just as the idea of a deficit in theory of mind has taken several years and considerable (and continuing) work to be empirically established, so the idea of a weakness in central coherence will require a systematic programme of research. Like the theory of mind account, it is to be hoped that, whether right or wrong, the central coherence theory will form a useful framework for thinking about autism in the future.

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