This paper appeared in British Journal of Psychiatry, 175, 484-490, (1999)

'Obsessions' in children with autism or Asperger Syndrome: a content analysis in terms of core domains of cognition

Simon Baron-Cohen and Sally Wheelwright

Departments of Experimental Psychology and Psychiatry,

University of Cambridge, Downing St,

Cambridge, CB2 3EB, UK

Acknowledgements: We are grateful to Vicky Scahill for suggestions on the first draft of the questionnaire.

Abbreviations: OCD (Obsessive Compulsive Disorder); ADHD (Attention Deficit and Hyperactivity Disorder); TS (Tourette Syndrome); AS (Asperger Syndrome).

Abstract

Background

We report a survey of the content of obsessions in children with autism spectrum conditions. We use the term 'obsessions' narrowly, to indicate strong, repetitive intersts, even if this is not accompanied by anxiety. We predicted that obsessions would not cluster randomly, but rather would occur significantly more often in the domain of 'folk physics' (an interest in how things work), and significantly less often in the domain of 'folk psychology' (an interest in how people work). These predictions were tested relative to a control group of 33 children with Tourette Syndrome. In the control group we predicted a different pattern, namely, an increase in the domain of sensori-motor obsessions.

Aims

To examine the content of autistic obsessions; and to test the theory that these reflect an evolved cognitive style of good folk physics alongside impaired folk psychology.

Method

Ninety-two parents returned a questionnaire designed to determine the subject of their child's obsessional intersts. The results of these were analysed in terms of core domains of cognition.

Results

All three predictions were confirmed.

Conclusions

These results are consistent with the notion that impaired folk psychology and superior folk physics are part of the cognitive phenotype of autism, and suggest that a content-free theory of obsessions, e.g., in terms of executive dysfunction, is inadequate.

Declaration of interest

SBC and SW were supported by the MRC during the period of this work.

Obsessional interests are a major diagnostic feature of autism spectrum conditions (APA, 1994). They have received relatively little research attention directly, in comparison to the other major diagnostic features of social, communicative, and imaginative impairments. Note that there is no evidence that in autism the obsession is distressing or unwanted egodystonic (Baron-Cohen, 1989). In the study reported here we ask parents to report on the content of their child's obsessions, towards establishing a *taxonomy* of obsessions in autism spectrum conditions.

The evolutionary framework: core domains of cognition

We use the *evolutionary framework* to constrain this study. According to this framework, the human mind should be considered in terms of its evolved adaptedness to the environment (Pinker, 1997). Two broad challenges to human survival would have been predicting object motion in the physical and the social environment. The specialized *core cognitive domains* of folk physics and folk psychology can be seen as the brain's adaptations to each of these challenges. Folk physics refers to our basic knowledge of how the physical world of objects works (e.g., that inanimate objects only move when

touched, fall if unsupported, can have mechanical properties, etc.,). Folk psychology refers to our basic knowledge of how the social world works (e.g., that animate objects are capable of self-propulsion, goal-directedness, emotional expression, and perception). Folk psychology appears to be present from at least 12 months of age in humans (Rochat, Morgan & Carpenter, 1997). Folk physics is present even earlier in human ontogeny (Leslie & Keeble, 1987). There is considerable evidence that there are impairments in folk psychology in children with autism (Baron-Cohen, 1995).

Folk physics in contrast appears to be intact, and it may even be *superior* in autism, relative to normally developing children (Baron-Cohen, Leslie & Frith, 1986; Leekam & Perner, 1991). For example, whilst there are reports of extremely high-achieving individuals[1] with Asperger Syndrome in the fields of maths, physics, and computer science, there are few if any equivalents from the humanities (Baron-Cohen, Wheelwright, Stone & Rutherford, in press).

Such cognitive domains are considered 'core' because the basic knowledge appears to be acquired rapidy, early, universally, and therefore may be partly innate (Hatano & Inagaki, 1994). What makes them 'domains' is that they may be independent of each other, though revealing this may only be apparent via dissocations following neural insult. They are said to be 'folk' theories of how the world works because the knowledge is not the result of explicit teaching, but rather comprises the intuitions all folk possess. Other core cognitive domains, beyond folk psychology and folk physics, may also exist

[1] These include one individual who won the equivalent of the Nobel Prize in Mathematics.

(Wellman, 1990). The principal others are folk mathematics (counting) and folk biology (classification of the animate world into species, predators, prey, etc.). It remains to be convincingly demonstrated that these are independent domains, since it is plausible that folk mathematics is simply part of folk physics, for example.

The above studies lead to the prediction that if obsessions in autism reflect what the child is interested in and what they may be good at, such obsessions should not be random with respect to content, but instead should cluster in certain core cognitive domains rather than others. Specifically, we predicted that obsessions would cluster in the domains of folk physics, and be under-represented in the domain of folk psychology. We made no prediction for the domain of folk mathematics, as this has been studied so little in autism.

Method

The Cambridge University Obsessions Questionnaire (shown in the Appendix) was posted to parents who had a child with autism or Asperger Syndrome, who were members of the National Autistic Society (UK). This asks parents if their child has an obsession in any one of 19 categories, chosen to cover the full range of objects and activities. A 20th category, Other, was to ensure that any omission among the 19 categories could be recorded somewhere. We did not design the questionnaire around the core domains, since the questionnaire was intended to ensure obsessions in any area of life could be recorded. Thus, data collection was as broad and as neutral as possible. We left it until after data collection before attempting to code the responses in terms of core

domains. Note also that there was no attempt to define 'obsession' for the parents, since this is notoriously difficult. It was however expected that parents would have their own notion of what this was.

Coding

Following receipt of the completed questionnaires, the two authors (blind to case-control status) independently re-coded the results into the following 15 categories, guided by the evolutionary framework discussed earlier:

6 core cognitive domains:

(1) folk physics (including machines, vehicles, spinning objects, physical systems, computers, astronomy, other sciences, building (e.g., lego), and lights);

(2) folk mathematics (including numerical information, dates, time-tables, diaries, maths, measuring, calenders, time, and counting);

(3) folk biology (including plants, animals, life, death, illness, reproduction, biology, geography, and nature);

(4) folk psychology (including imagination, relationships, gossip, desires, beliefs, intentions, emotions, and pretending);

(5) language (including echoing, collecting words, phrases, and learning languages); and

(6) taxonomy (including sorting, categorizing, lists, taxonomy, and collecting).

These latter two categories were included because of claims that language might be modular (Pinker, 1997) and thus to some extent independent of the other core domains; and because taxonomizing is also seen universally, and whilst a number of theorists see this as part of folk biology (stemming from our evolved drive to categorize things into edible/inedible, or living/not-living, or predator/prey, etc.,) it is clear that much categorizing is unrelated to biological entitiies.

8 other areas of everyday life: These were included so as to code obsessions that did not fit into one of the above core domains, in order to test for group differences (unpredicted) beyond the core domains. These comprised:

(1) attachments (to a specific object);
(2) crafts (including painting, drawing, play-doh, knitting, and models);
(3) everyday life (including routines and tidiness);
(4) facts (including non-fiction books, and memorizing facts);
(5) food (including dietary habits, types of food, restaurants, menus, etc.,)
(6) people (i.e., being obsessed with a particular person);
(7) sports or games (including playing or watching); and
(8) TV/audio (including films, videos, cartoons, listening to tapes, etc.,)

1 other clinically relevant domain: sensory phenomena (including touching, smelling, sights, and sounds).

These 15 categories, operationally defined as above, were used by 2 coders. Inter-rater agreement on this coding was 100%, presumably reflecting how clear-cut these categories are. Inter-rater agreement was checked by each response on the Cambridge University Obsessions Questionnaire on half of the questionnaires, selected at random. From the previous work summarized earlier, we predicted that in autism, more children would show obsessions in folk physics, and less in folk psychology, relative to controls. We predicted that the groups may not differ in the 8 other areas of everyday life. Finally, we predicted that the control group (children with Tourette Syndrome) might show more obsessions relating to sensory phenomena, because tic disorder includes involuntary touching and vocalisations. Regarding scoring, we made no attempt to count how many obsessions a child had in any given category: if they had ever had an obsession in that category, then they scored one point in that category.

Sample

Group 1 comprised 92 parents of children with autism (n = 50), Asperger Syndrome (n = 32), or Autism Spectrum (n = 10). As diagnosis was simply reported by parents, this was re-checked using the Autism Spectrum Questionnaire (ASQ) (Kazak Berument, Rutter, Lord, Pickles & Bailey, in press). All subjects scored above the suggested cut-off (≥13) on this. Since there was no independent assessment of age of language onset beyond parental report, no attempt was made to distinguish between these 3 subtypes in later analyses. The mean age in years of the children was 11.2 (sd = 2.1), and the sex ratio was 76:16 (or 19:4), male to female.

Group 2 comprised 33 parents of children with Tourette Syndrome (TS), 7 of whom had comorbid Attention Deficit with Hyperactivity Disorder (ADHD) and 9 of whom had obsessional behaviour. The mean age in years of the children was 12.8 (sd = 2.4), and the sex ratio was 30:3 (or 10:1) male to female. This control group was chosen because it controls for several different factors: (a) Both TS and autism are neuropsychiatric conditions, (b) affecting boys more often than girls, (c) with a genetic aetiology, (d) with a childhood onset, (e) involving obsessionality, (f) and with a degree of comorbid ADHD, (g) and often disrupting normal schooling. All had been diagnosed by a leading expert psychiatrist at the Institute of Neurology, London.

We did not include a group of non-psychiatric controls simply because asking parents about obsessions in children who do not have them raises the difficulty of how to define 'obsession'. In psychiatric samples one can assume that parents will have a good idea of what this word entails. Furthermore, in a random sample, one would have to ask simply about 'patterns of interests' rather than obsessions, and these may not be comparable.

Results

Of 120 questionnaires sent out to the Autism Group, and 45 sent out to the TS group, we received back 92 (76.7%) and 33 (73.3%) respectively. These return rates are reasonably high for postal questionnaire research. Since the main question tested here was in terms

of the core domains of cognition, Table 1 shows the raw number of children scoring in each of the 15 recoded categories, from each group.

insert Table 1 here

In order to avoid artefacts arising from multiple statistical testing, we carried out Pearson Chi Square tests only on the 3 domains in which a difference was predicted, in a hypothesis-driven approach to testing significance, setting our significance level at $p = 0.05$. The 3 domains were folk physics, folk psychology, and sensory phenomena.

As predicted, group differences were found in each of these, in the expected direction. Thus (1) more children with autism spectrum conditions had obsessions which fell in the domain of folk physics ($Chi = 7.45$, $p = 0.006$); (2) fewer had obsessions in the domain of folk psychology ($Chi = 4.92$, $p = 0.027$); and (3) more children with TS had obsessions relating to sensory phenomena ($Chi = 9.05$, $p = 0.0003$). Finally, for completeness, we tested all other categories, but this time setting the significance level at $p = 0.01$. No other categories differed significantly at this level except for TV/audio, in which more children with autism spectrum conditions were obsessed ($Chi = 15.54$, $p = 0.00008$). Attachment to specific objects differed at the $p = 0.05$ level ($Chi = 3.38$, $p = 0.05$), being more common in the autism spectrum group, but this is not discussed further since it did not meet our more stringent test of significance controlling for multiple comparisons.

Discussion

This study reports a survey of obsessions by children with autism spectrum conditions, in terms of their content. This was guided by the evolutionary theory of core cognitive domains (Pinker, 1997). We predicted that obsessions would not be random in children with autism spectrum conditions, with respect to content, but would cluster in the domain of folk physics, and be significantly reduced in the domain of folk psychology. These predictions were confirmed[2]. In addition, we expected that in the TS control group a different pattern would be seen, namely obsessions relating to action and sensory phenomena (involuntary touching and vocalising) being more common. This was also confirmed. Below, we consider how such results relate to clinical accounts and family studies.

Clinical accounts

The finding that children with autism and AS show significantly more obsessional interests in the area of folk physics fits with clinical reports. There is no shortage of clinical descriptions of children with autism being fascinated by machines (the paragon of non-intentional systems). One of the earliest clinical accounts was by Bettelheim (Bettelheim, 1968) who describes the case of "Joey, the mechanical boy". This child with autism was obsessed with drawing pictures of machines (both real and fictitious),

[2] An additional but unpredicted difference was that more children with autism spectrum conditions were also more obsessed with television. This latter finding probably relates to the predictability of TV programmes, and the repeatability of videos, which would be attractive to such children. Indeed, parents often noted that their child watched the same video over and over again.

and with explaining his own behavior and that of others in purely mechanical terms. On the face of it, this would suggest he had a well-developed folk-physics.

The clinical literature reveals many cases of children similarly obsessed by machines. Parents' accounts (Hart, 1989) are a rich source of such descriptions. Indeed, it is hard to find a clinical account of autism that does *not* involve the child being obsessed by some machine or another. Typical examples include extreme fascinations with electricity pylons, burglar alarms, vacuum cleaners, washing machines, video players, trains, planes, and clocks. Sometimes the machine that is the object of the child's obsession is quite simple (e.g. the workings of drain-pipes, or the designs of windows, etc.).

Of course a fascination with machines need not necessarily imply that the child *understands* the machine, but in fact most of these clinical reports also reveal that children with autism have a precocious understanding too. The child (with enough language, such as is seen in children with Asperger Syndrome (AS)) may be described as holding forth, like a "little professor", on their favourite subject or area of expertise, often failing to detect that their listener may have long since become bored of hearing more on the subject. The apparently precocious mechanical understanding, whilst being relatively oblivious to their listener's level of interest, is consistent with the idea that their folk physics is outstripping their folk psychology in development.

Family studies

Autism and AS appear to have a strong heritable component (Bailey et al., 1995). Parents of children with Asperger Syndrome [AS] also show mild but significant deficits on an adult folk psychology task, mirroring the deficit in folk psychology seen in patients with autism or AS (Baron-Cohen & Hammer, 1997). Parents of children with autism or AS are also over-represented in occupations in which possession of superior folk physics is an advantage, whilst a deficit in folk psychology does not necessarily lead to any disadvantage. The paradigm occupation for such a cognitive profile is engineering. A recent study of 1000 families found that fathers and grandfathers (patri- and matrilineal) of children with autism or AS were more than twice as likely to work in the field of engineering, compared to control groups (Baron-Cohen, Wheelwright, Stott, Bolton & Goodyer, 1997). Indeed, 28.4% of children with autism or AS had at least one relative (father and/or grandfather) who was an engineer. This may reflect that the genes shared by both parents and their child with an autism spectrum condition shape the brain towards interests in folk physics, and away from folk psychology.

Related evidence comes from a family study of psychiatric conditions including autism. Students at Cambridge University, studying either sciences (physics, engineering, or maths) or humanities (English or French literature) were surveyed about family history of a range of psychiatric conditions (schizophrenia, anorexia, autism, Down's Syndrome, or manic depression). The students in the science group showed a six-fold increase in the rate of autism in their families, relative to the humanities students, and this was specific to autism (Baron-Cohen et al., 1998). This may also be because the genes involved in autism cluster with the genes involved in good folk physics.

Alternative accounts

Early accounts tended to assume obsessions were a form of repetitive behaviour functioning to control high arousal (Hutt & Hutt, 1968). However, the concept of arousal itself has been hard to define. More recently, researchers have considered obsessions in terms of how they might be secondary to a specific cognitive deficit. For example, Russell suggested that obsessions and other repetitive behaviours seen in autism are the result of an executive dysfunction, probably mediated by frontal lobe damage (Russell, 1997). Executive function is the umbrella term to cover those processes involved in attention switching, flexible responding, and planful behaviour (Luria, 1969). Patients with frontal lobe damage show executive dysfunction (Shallice, 1988), and so do patients with autism (Hughes, Russell & Robbins, 1994). Patients with obsessive-compulsive disorder (OCD) also show executive dysfunction (Christensen, Kim, Dysken & Hoover, 1992) so the notion that obsessionality in autism may be caused by executive dysfunction has some face validity.

However, executive dysfunction does not account for why the obsessional interests in autism are wholly different to the neurotic obsessionality seen in patients with OCD. For example, a child with autism may have an obsessional collection of names of type of lizard, or an obsessional collection of meteorites. In contrast, a patient with OCD may have checking obsessions (e.g., a need to check the gas taps repeatedly) or washing obsessions (an excessive need to get rid of germs on their hands or clothes). Thus,

whereas the patient with OCD has obsessions that typically involve fears of danger and harm, and unwanted thoughts that are egodystonic, intrusive, and which the patient tries to get rid of through performing compulsions (Rachman & Hodgson, 1980), people with autism spectrum conditions typically follow their interests or hobbies to an extreme and narrow degree, so that they become experts in their chosen field (Wing, 1988). In sum, the executive dysfunction theory ignores the *content* of the obsession, and so would not have predicted the present results. A further problem for the executive dysfunction theory is that neither patients with frontal lobe damage (Owen, Roberts, Polkey, Sahakian & Robbins, 1991), nor schizophrenia (Elliot & Sahakian, 1995), or attention deficit with hyperactivity disorder (ADHD) (Chelune, Ferguson, Koon & Dickey, 1986) necessarily develop obsessions, despite also showing executive dysfunction.

One other cognitive account of obsessions in autism spectrum conditions suggests that these are the child's attempt to impose order or control in a world where social behaviour appeared unpredictable and confusing (Baron-Cohen, 1989). This account stems from the theory of mind hypothesis of autism. In brief, the child's deficit in making rapid sense of people's actions and intentions (Baron-Cohen, 1995) is held to trigger high levels of anxiety, which the child seeks to control by retreating into the predictable world of things and systems. However, it is yet to be demonstrated that social anxiety is always the cause of the child's obsessionality, though this may be true for a sub-group. The child may just be fascinated by the particular topic.

The present study shows the value of a *content analysis* of obsessions: children with autism spectrum conditions show more obsessional interests in mechanical systems (such as light switches or water faucets) or other systems that can be understood in physical-causal or other lawful terms. Rather than these being a sign of executive dysfunction, it is suggested that these reflect the child's intact or even superior folk physics. The child's "need for sameness" or attempt to hold the environment constant might therefore in fact be a sign of the child as a superior folk-physicist: conducting mini-experiments in his or her surroundings, in an attempt to identify laws governing events. The present study suggests that obsessions in autism spectrum conditions are not random with respect to content; rather, that obsessions cluster positively in the domain of folk physics, and negatively in the domain of folk psychology. This may provide clues to the cognitive phenotype of this spectrum of conditions (Baron-Cohen, in press).

Clinical Implications

- Obsessions in autism may reflect cognitive strengths.
- Obsessions in autism may not simply exist as signs of executive dysfunction.
- As obsessions topics are pursued with strong spontaneous motivation, their potential use in education in autism should be explored.

Limitations of the study

- This data derives from parental report alone.
- It remains unclear if obsessional interests and stereotypies in autism have a shared cause.
- The relationship between autistic obsessions and their 'weak central coherence' (Frith, 1989) or remains unknown.

Table 1: Percentage of children in each group showing an obsession in each of the 15 coding categories.

Category	Autism Spectrum Group	Tourette Syndrome Group
Biology	35 (38.0%)	10 (30.3%)
Language	22 (23.9%)	4 (12.1%)
Maths	32 (34.8%)	9 (27.3%)
Physics	77 (83.7%)	20 (60.6%)[a]
Taxonomy	67 (72.8%)	21 (63.6%)
Psychology	5 (5.4%)	6 (18.2%)[b]
Attachment	49 (53.3%)	11 (33.3%)
Crafts	17 (18.5%)	9 (27.3%)
Facts	17 (18.5%)	5 (15.2%)
Sensory	58 (63.3%)	30 (90.9%)[c]
Sports/games	23 (25.0%)	9 (27.3%)
TV/audio	59 (64.1%)	8 (24.2%)
People	13 (14.1%)	5 (15.2%)
Food	58 (63.0%)	15 (45.5%)
Everyday life	14 (15.2%)	10 (20.3%)
Total	92 (100%)	33 (100%)

[a] Pearson Chi = 7.45, p = 0.006

[b] Pearson Chi = 4.92, p = 0.027

[c] Pearson Chi = 9.05, p = 0.003

CAMBRIDGE UNIVERSITY OBSESSIONS QUESTIONNAIRE

We are interested to collect basic information on obsessional interests and behaviours in people with autism or Asperger Syndrome. We would be grateful if you would answer the following questions.

Your child's name: ..... Sex: .....

Date of birth: ..... Diagnosis: .....

For each category of obsession, please **tick whether your child has ever had an obsession** in that category. If "YES", please specify the exact obsession(s).

1. MACHINES (how things work) e.g. computers, radios, TVs, washing machines, clocks, burglar alarms, etc.,

YES☐ NO☐

If YES, please specify .....

.....

2. SYSTEMS e.g. toilet flushing, drains, light switches, etc.,

YES☐ NO☐

If YES, please specify .....

.....

3. SORTING/CATEGORISING e.g. lining objects up, arranging objects in alphabetical order or by size, shape, colour, etc.,

YES☐ NO☐

If YES, please specify .....

.....

4. BELIEF SYSTEMS e.g. religion, politics, etc.,

YES☐ NO☐

If YES, please specify .....

.....

5. NUMERICAL INFORMATION e.g. timetables, number plates, calculators, charts or tables of information, calculations, prime numbers, calendars, etc.,

YES ☐ NO ☐

If YES, please specify .....

.....

6. SPORTS/GAMES e.g. football, tennis, walking, mountain climbing, swimming, cycling, ice skating, snooker, playing cards, board games, etc.,

YES ☐ NO ☐

If YES, please specify .....

.....

7. STRONGLY ATTACHED TO A PARTICULAR ITEM e.g. an article of clothing, a rag, a bottle top, etc.,

YES ☐ NO ☐

If YES, please specify .....

.....

8. SENSORY EXPERIENCES e.g. touching things, hearing specific sounds, lights, smells, tearing paper, etc.,

YES ☐ NO ☐

If YES, please specify .....

.....

9. CRAFTS e.g. model making, knitting, sewing, cooking, carpentry, etc.,

YES ☐ NO ☐

If YES, please specify .....

.....

10. FACTUAL INFORMATION e.g. writing, reading or memorising lists of things, writing letters, reading encyclopaedias, newspapers, etc.,

YES ☐ NO ☐

If YES, please specify .....
.....

11. THE CREATIVE ARTS/FICTION e.g. theatre, cinema, art work, opera, watching drama on TV/videos, playing an instrument, listening to music, writing/reading fiction, etc.,

YES ☐ NO ☐

If YES, please specify .....
.....

12. THE SCIENCES e.g. astronomy, chemistry, geography, physics, engineering, biology, geology, etc. ,

YES☐ NO☐

If YES, please specify .....

.....

13. ANIMALS e.g. pets, wild or farm animals, dinosaurs, insects, fish, birds, etc.,

YES☐ NO☐

If YES, please specify .....

.....

14. COLLECTING THINGS e.g. bottles, matchboxes, stamps, catalogues, etc.,

YES☐ NO☐

If YES, please specify .....

.....

15. PEOPLE e.g. talking to people, a specific person, etc.,

YES☐ NO☐

If YES, please specify .....

.....

16. VEHICLES e.g. trains, buses, planes, boats, model railways, etc.,

YES☐ NO☐

If YES, please specify .....

.....

17. SPINNING OBJECTS e.g. tops, wheels, plates, frisbees, coins, etc.,

YES☐ NO☐

If YES, please specify .....

.....

18. FOOD AND DRINK e.g. consuming particular food and drink, etc.,

YES☐ NO☐

If YES, please specify .....

.....

19. PLANTS e.g. gardening, house plants, woodland plants, seaweed, etc.,

YES ☐ NO ☐

If YES, please specify .....

.....

20. OTHER: Please list any other obsessions which you do not feel are covered by the other categories .....

.....

References

APA. (1994). DSM-IV Diagnostic and Statistical Manual of Mental Disorders, 4th Edition. Washington DC: American Psychiatric Association.

Bailey, T., Le Couteur, A., Gottesman, I., Bolton, P., Simonoff, E., Yuzda, E., & Rutter, M. (1995). Autism as a strongly genetic disorder: evidence from a British twin study. Psychological Medicine, 25, 63-77.

Baron-Cohen, S. (1989). Do autistic children have obsessions and compulsions? British Journal of Clinical Psychology, 28, 193-200.

Baron-Cohen, S. (1995). Mindblindness: an essay on autism and theory of mind.: MIT Press/Bradford Books.

Baron-Cohen, S. (in press). Autism: deficits in folk psychology exist alongside superiority in folk physics. In S. Baron-Cohen, H. Tager Flusberg, & D. Cohen (Eds.), Understanding Other Minds, (Vol. 2,): Oxford University Press.

Baron-Cohen, S., Bolton, P., Wheelwright, S., Short, L., Mead, G., Smith, A., & Scahill, V. (1998). Autism occurs more often in families of physicists, engineers, and mathematicians. Autism, 2, 296-301.

Baron-Cohen, S., & Hammer, J. (1997). Parents of children with Asperger Syndrome: what is the cognitive phenotype? Journal of Cognitive Neuroscience, 9, 548-554.

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

Baron-Cohen, S., Wheelwright, S., Stone, V., & Rutherford, M. (in press). A mathematician, a physicist, and a computer scientist with Asperger Syndrome: performance on folk psychology and folk physics test. Neurocase.

Baron-Cohen, S., Wheelwright, S., Stott, C., Bolton, P., & Goodyer, I. (1997). Is there a link between engineering and autism? Autism: An International Journal of Research and Practice, 1, 153-163.

Bettelheim, B. (1968). The empty fortress. Chicago: The Free Press.

Chelune, G., Ferguson, W., Koon, R., & Dickey, T. (1986). Frontal lobe disinhibition in attention deficit disorder. Child Psychiatry and Human Development, 16, 221-234.

Christensen, K., Kim, S., Dysken, M., & Hoover, K. (1992). Neuropsychological performance in obsessive compulsive disorder. Biological Psychiatry, 31, 4-18.

Elliot, R., & Sahakian, B. J. (1995). The neuropsychology of schizophrenia: relations with clinical and neurobiological dimensions. Psychological Medicine, 25, 581-594.

Frith, U. (1989). Autism: explaining the enigma. Oxford: Basil Blackwell.

Hart, C. (1989). Without reason. New York: Harper & Row, Inc.

Hatano, G., & Inagaki, K. (1994). Young children's naive theory of biology. Cognition, 50, 171-188.

Hughes, C., Russell, J., & Robbins, T. (1994). Specific planning deficit in autism: evidence of a central executive dysfunction. Neuropsychologia, 32(4), 477-492.

Hutt, S. J., & Hutt, C. (1968). Stereotypy, arousal and autism. Human Development, 11, 277-286.

Kazak Berument, S., Rutter, M., Lord, C., Pickles, A., & Bailey, A. (in press). Autism screening questionnaire: Diagnostic validity. British Journal of Psychiatry.

Leekam, S., & Perner, J. (1991). Does the autistic child have a metarepresentational deficit? Cognition, 40, 203-218.

Leslie, A., & Keeble, S. (1987). Do six-month old infants perceive causality? Cognition, 25, 265-288.

Luria, A. (1969). Frontal lobe syndromes. In P. Vinken & G. Bruyn (Eds.), Handbook of clinical neurology, (Vol. 2, pp. 725-757). Amsterdam: North Holland.

Owen, A., Roberts, A., Polkey, C., Sahakian, B., & Robbins, T. (1991). Extradimensional versus intradimensional set shifting performance following frontal lobe excisions, temporal lobe excisions, or amygdalo-hippocampectomy in man. Neuropsychologia, 10, 99-106.

Pinker, S. (1997). How the Mind Works.

Rachman, S., & Hodgson, R. (1980). Obsessions and Compulsions. Englewood Cliffs, NJ: Academic Press.

Rochat, P., Morgan, R., & Carpenter, M. (1997). Young infants' sensitivity to movement information specifying social causality. Cognitive Development, 12, 537-561.

Russell, J. (Ed.). (1997). Autism as an executive disorder. Oxford: Oxford University Press.

Shallice, T. (1988). From neuropsychology to mental structure. Cambridge: Cambridge University Press.

Wellman, H. (1990). Children's theories of mind. Bradford: MIT Press.

Wing, L. (1988). The Autistic Continuum. In L. Wing (Ed.), Aspects of Autism: biological research, . London: Gaskell/Royal College of Psychiatrists.