

The link between autism and skills such as engineering, maths, physics and computing

A reply to Jarrold and Routh, *Autism*, 1998, 2 (3): 281–9

SALLY WHEELWRIGHT University of Cambridge, UK

SIMON BARON-COHEN University of Cambridge, UK

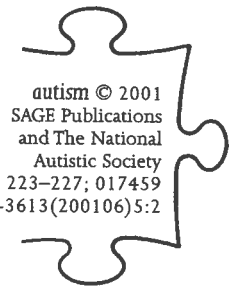
ABSTRACT In the first edition of this journal, we published a paper reporting that fathers and grandfathers of children with autism were over-represented in the field of engineering (Baron-Cohen et al., 1997). This result was interpreted as providing supporting evidence for the folk-psychology/folk-physics theory of autism. After carrying out further analyses on the same data, Jarrold and Routh (1998) found that fathers of children with autism were also over-represented in accountancy and science. They suggested that these results could either provide additional support for the folk-psychology/folk-physics theory or be accounted for by an over-representation of professionals amongst the fathers of children with autism. Here we present evidence that engineers are still over-represented among fathers of children with autism, even taking into account the professional bias.

ADDRESS Correspondence should be addressed to: DR SALLY WHEELWRIGHT, Autism Research Centre, Departments of Experimental Psychology and Psychiatry, University of Cambridge, Downing Street, Cambridge CB2 3EB, UK

In the first issue of this journal, we published an article reporting a link between engineering and autism (Baron-Cohen et al., 1997). We compared the occupations of parents and grandparents of children with autism with the occupations of the parents and grandparents of children with Tourette syndrome, and the parents of children with language delay, Down's syndrome and normally developing children. We used a hypothesis-driven approach to examine the data. Our hypothesis was that relatives of children with autism would be more likely to be engineers, compared with the relatives in the other groups.

This prediction was based on a cognitive theory of autism (referred to as the *folk-psychology/folk-physics theory*). This theory holds that relative to their

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mental age, children and adults with autism spectrum conditions have normal or even superior folk physics abilities, whilst their folk psychology skills are impaired (Baron-Cohen, 1997; 2000; Baron-Cohen et al., 1999; in press). Folk physics refers to our understanding of the physical world whilst folk psychology refers to our understanding of the social world. These abilities are termed 'folk' since they are not formally taught but nevertheless develop in the majority of people, irrespective of culture.

From family and twin studies, autism appears to have a genetic basis (Folstein and Rutter, 1988). We predicted that if the parents of children with autism spectrum conditions shared the cognitive phenotype of their affected child (superior folk physics with relatively impaired folk psychology), albeit to a lesser degree, then parents and grandparents of children with autism might be over-represented in engineering. This is because engineering is a clear example of a field which might attract an individual who had a talent for folk physics but whose folk psychology was less well developed. This prediction was confirmed for both the fathers and the grandfathers of children with autism (on both sides of the family). Specifically, 12.5 percent of fathers of children with autism spectrum conditions were engineers, compared with about 5 percent in the other groups. A similar result was found for the grandfathers. Data for mothers and grandmothers were not analysed because many of them were not working outside the home. In the original article, we were careful to stress that the majority of parents of children with autism spectrum conditions have no connection with engineering, and similarly the vast majority of engineers have no connection with autism. Nevertheless, there was a small but statistically significant link between autism and engineering.

This result has generated considerable interest and led Jarrold and Routh (1998) to carry out a more thorough examination of the data. Both correspondence analysis and analysis of adjusted residual scores confirmed the association between fathers of children with autism and engineering. In addition, correspondence analysis found that this association extended to accountancy and science, whilst there was a negative association between fathers of children with autism and skilled manual work. Similarly, the analysis of adjusted residual scores indicated that fathers of children with autism were over-represented not only in engineering, but also in medicine, science and, to a lesser degree, accountancy. There were fewer fathers of children with autism in the skilled and unskilled manual categories.

Jarrold and Routh accept that the over-representation in medicine (according to the adjusted residual scores analysis) may simply reflect that doctors are more aware of the signs of autism and are better equipped to access a diagnosis. We agree that this is a parsimonious explanation of the link with medical occupations and so do not consider this further. They

suggest that there are two possible interpretations to explain the remainder of the results.

The first is that the results from accountancy and science are *additional support for the folk-psychology/folk-physics theory*. Like engineering, accountancy and sciences also depend on well-developed folk physics abilities, and any weakness in folk psychology would not be prohibitory. Jarrold and Routh criticize this interpretation on the basis that it is *post hoc*. In particular, they argue that the folk-physics/folk-psychology approach would predict that computer specialists should also be over-represented amongst the fathers of children with autism, since this is another profession where an ability in folk physics is more important than an ability in folk psychology.

We agree that computing specialists should have been over-represented in the occupations of fathers of children with autism, since this type of occupation would also match the cognitive profile we have linked with autism. One reason that computing might not have been over-represented might be that computers are now an important part of many jobs, and people who spend most of their time working with computers may not refer to themselves as computer specialists.

We would disagree that the folk-psychology/folk-physics explanation of the data was *post hoc*. We had a clear hypothesis that relatives of children with autism would be more likely to have occupations where the need for a good ability in folk physics was more important than an ability in folk psychology. The reason that we tested this hypothesis in relation to engineering specifically was that it epitomized an occupation where this cognitive profile would not be an impediment to success. In addition, engineering is a relatively common occupation so that comparison between groups would involve larger numbers.

The alternative explanation that Jarrold and Routh propose to explain the results of their two analyses is that there may be *sampling biases amongst the groups*: specifically, the fathers of children with autism may be more professionally qualified or have a higher level of education than the other groups. They accept that this could also be a *post hoc* argument but highlight that they found a correlation between 'professional' occupations and the fathers of children with autism. In addition, there were significantly fewer fathers of children with autism in the skilled manual and unskilled manual occupation categories than the combined control groups.

Jarrold and Routh do not favour either of the two explanations above, claiming that each is as plausible as the other. However, they do not consider a third possibility. This is that there may be a professional bias in the fathers of children with autism, but even taking this into consideration, engineers are still over-represented in this group. The way to test this hypothesis is to consider only those fathers who are in occupations

Table 1 Number and percentage of fathers in each of the 'professional' occupation categories

	<i>Fathers of children with autism (n = 473)</i>		<i>Control group fathers (n = 208)</i>	
	No.	%	No.	%
Engineers	115	24.3	36	17.3
Social	24	5.1	14	6.7
Surveyors	20	4.2	10	4.8
Law	14	3.0	9	4.3
Medical	50	10.6	17	8.2
Teachers	65	13.7	40	19.2
Arts/media	27	5.7	12	5.8
Clergy	8	1.7	3	1.4
Science	50	10.6	17	8.2
Computing	43	9.1	26	12.5
Accountants	57	12.1	24	11.5

classified as professional. Table 1 presents the number and percentage (of those in professional occupations only) of fathers of children with autism and the combined control group (i.e. fathers of children with Tourette syndrome, children with language delay, children with Down's syndrome and normally developing children). By inspection, the only significant differences between the two groups appear to be for engineering (with the fathers of children with autism over-represented) and teaching (with the fathers of children with autism under-represented). In fact, χ^2 tests indicate that the only significant difference is actually for engineering ($\chi^2 = 4.1$, d.f. = 1, $p = 0.05$). (For teaching, $\chi^2 = 3.3$, d.f. = 1, $p = 0.07$.) Fathers of children with autism are therefore over-represented in engineering, even when considering professional occupations alone.

Summary

Jarrold and Routh proposed that differences between the fathers of children with autism and control fathers in terms of occupation could be explained in terms of a professional sampling bias. However, this does not hold, since the link between engineering and autism remains statistically significant even controlling for professional status. It is worth noting that conclusions about the link between autism and engineering are necessarily limited as we were unable to include female relatives in the analysis. In addition, the small size of the grandparent control group means that we are unable to examine whether the grandfathers of children with autism continue to be

over-represented in engineering when looking at those in professional occupations only. All that can be concluded from the further analysis reported above is that, considering just professional occupations alone, fathers of children with autism are over-represented in engineering compared with fathers of other children.

We do not however think that there is anything special about the link between autism and the field of engineering, since this is just one clear case of a field requiring good folk physics. Our more recent studies suggest the link is with a family of such fields: physics, engineering, computer science and mathematics (Baron-Cohen et al., 1998; 1999). We suspect that the features shared by this family of fields include being factual and highly rule-governed. Unpacking the concept of 'folk physics' down to its fundamental basis remains a challenge for the future. But such studies reinforce an old yet often lost idea: that the genes underlying autism are not always only associated with (social) disability but may also be associated with talent in non-social fields (Baron-Cohen, 2000; Happé, 1999).

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