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The link between autism and skills such as engineering, maths, physics, and computing: A reply to Jarrold and Routh

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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, Wheelwright, Stott, Bolton & Goodyer, 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 father of children with autism, even taking into account the professional bias.

In the first edition of this journal, we published a paper 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 than 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 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; Baron-Cohen, 2000a; Baron-Cohen, Wheelwright, Scahill, Lawson & Spong, in press; Baron-Cohen, Wheelwright, Stone & Rutherford, 1999). 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 & 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 grandfathers of children with autism (on both sides of the family). Specifically, 12.5% of fathers of children with autism spectrum conditions were engineers, compared with about 5% in the other groups. A similar result was found for the grandfathers. Data for mothers and grandmothers were not analysed because may of them were not working outside the home. In the original paper, 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 to carry out a more thorough examination of the data (Jarrold & Routh, 1998). 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 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 rest of the results.

(1) The results from accountancy and science are *additional support for the folk psychology/folk physics theory*. Like engineering, accountancy and science also depend on well-developed folk physics abilities (broadly defined), and any weakness in folk psychology would not be prohibitory. Jarrold and Routh criticise 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 is *post hoc*. We had a clear hypothesis that relatives of children with autism would be more likely to work in occupations where the need for a good ability in folk physics was more important than was an ability in folk psychology. The reason that we tested this hypothesis in relation to engineering specifically was that it epitomised 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.

(2) The alternative explanation that Jarrold and Routh propose to explain the results of their two analyses is that there may be *sampling biases among the groups*: specifically, that 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 both are as plausible as each other. However, they do not consider a third possibility:

(3) 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 classified as professional. Table 1 presents the number and percent (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, Chi^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.

Insert table 1 here

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. 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; Baron-Cohen et al., 1999). We suspect that the features this family of fields share include being factual, exact, 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, 2000b; Happe, 1999).

Table 1: Number and percent of fathers in each of the "professional" occupation categories

	Fathers of children with autism n = 473	**Control group fathers** n = 208
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%)

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