



When geeks meet

Psychologist Simon Baron-Cohen thinks scientists and engineers could be more likely to have a child with autism. Some researchers say the proof isn't there.

In the opening scene of *The Social Network*, Jesse Eisenberg portrays a cold Mark Zuckerberg getting dumped by his girlfriend, who is exasperated by the future Facebook founder's socially oblivious and obsessive personality. Eisenberg's Zuckerberg is the stereotypical Silicon Valley geek — brilliant with technology, pathologically bereft of social graces. Or, in the parlance of the Valley: 'on the spectrum'.

Few scientists think that the leaders of the tech world actually have an autism spectrum disorder (ASD), which can range from the profound social, language and behavioural problems that are characteristic of autistic disorder, to the milder Asperger's syndrome. But according to an idea that is creeping into the popular psyche, they and many others in professions such as science and engineering may display some of the characteristics of autism, and have an increased risk of having children with the full-blown disorder.

The roots of this idea can largely be traced

BY LIZZIE BUCHEN

to psychologist Simon Baron-Cohen at the University of Cambridge, UK. According to a theory he has been building over the past 15 years, the parents of autistic children, and the children themselves, have an aptitude for understanding and analysing predictable, rule-based systems — think machines, mathematics or computer programs. And the genes that endow parents with minds suited to technical tasks, he hypothesizes, could lead to autism when passed on to their children, especially when combined with a dose of similar genes from a like-minded mate¹.

The notion has an intuitive plausibility. In the public mind, it meshes with the stereotype of the scientist or computer geek as smart but socially awkward.



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(Baron-Cohen has speculated that luminaries such as Albert Einstein and Isaac Newton had Asperger's syndrome.) And in scientific circles, many accept that certain autistic traits — social difficulties, narrow interests, problems with communication — form a continuum across the general population, with autism at one extreme. As most experts believe that genes have an important role in autism, it's also plausible that two parents with milder, 'autistic-like' traits could be more likely to have a child with autism.

It also fits at least some clinicians' experiences. "I see deep geeks of all sorts," says Bryna Siegel, a clinical psychologist who runs the autism clinic at the University of California, San Francisco, referring to the parents of children with autism. "They don't make great eye contact, all their clothing is from the Intel shop, they don't have a lot of social understanding. I do think that when these geeks marry each other, that's bad news for the offspring." But

critics of Baron-Cohen's theories aren't hard to find. Autism researchers say that his work has focused primarily on a subset of people with 'high-functioning' autism — such as Asperger's syndrome — who have good language capabilities and at-least average intelligence. They say that the data are insufficient to support his theories and that many experiments cry out for independent replication.

"They're some really good hypotheses to think about, but they need to be tested," says John Constantino, a psychiatrist at Washington University in St Louis. "There's not a lot of data." Some critics are also rankled by Baron-Cohen's history of headline-grabbing theories — particularly one that autism is an 'extreme male' brain state. They worry that his theory about technically minded parents may be giving the public wrong ideas, including the impression that autism is linked to being a 'geek'.

Baron-Cohen acknowledges that "there is a problem that there are too few attempts at replication" of his studies, and says that he remains "open minded about these hypotheses until there are sufficient data to evaluate them". But he says he doesn't see a problem with introducing theories before definitive evidence has been collected. "I would see it as a positive contribution rather than a concern that scientists move from preliminary evidence to formulate the more general theory, especially when the theory is highly testable, since this is how science advances," he says.

BUCKING THE SYSTEM

In the 1990s, while most research on autism focused on problems with social interaction, Baron-Cohen became fascinated by the obsessive, narrow interests and repetitive behaviours that also characterize the condition. He noticed that children with autism were drawn to things such as machines, numbers, calendars and spinning objects². One child might memorize the technical specifications of gadgets; another would flip light switches on and off incessantly.

"The old view was that [such behaviours] were lacking in purpose, they just did it," says Baron-Cohen. But he started seeing these eccentricities from a new perspective. "They're figuring out how the family DVD player works, or understanding the electrical circuitry of the house. The child is doing it to understand the system." In autism, he theorizes, the brain has an average or superior ability to understand predictable systems, or 'hypersystemize', coupled with an inability to empathize, or understand other people's intentions and feelings.

Baron-Cohen cites several lines of evidence in support of his theory. In a 2003 study³, for example, he found that people with autism scored highly on the 'systemizing quotient', a questionnaire he designed. In a survey of undergraduates at the University of Cambridge, he found that those studying mathematics were more likely to have been



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diagnosed with autism than were students majoring in medicine, law or social science⁴. And, using another questionnaire called the autism quotient, he found that students in science and maths had higher scores on measures of autistic traits than did students in the humanities and social sciences⁵. Baron-Cohen says that although these surveys do not measure systemizing ability directly, they demonstrate that systemizing is a trait of autism, and also part of the 'broader autistic phenotype' that includes some of the wider population.

Baron-Cohen's critics, however, are sceptical of these surveys, in which subjects answer questions about themselves such as: 'I notice patterns in things all the time' and 'I would rather go to a library than to a party'. "Whether those self-perceptions, as with any of our self-perceptions, are accurate is questionable," says Francesca Happé, a cognitive neuroscientist at King's College London.

It would be more objective, say Happé and others, to test children with and without autism on their abilities to understand systems, and then compare the scores. "Rigorous studies are still missing," says Uta Frith, a developmental psychologist at University College London. "At the moment, he has people saying, 'yes, I'm a person interested in details', as opposed to actually observing them on tasks."

Baron-Cohen says that his lab is doing such follow-up work. He says that questionnaires can be advantageous because data can be collected quickly, and that even though biases can creep in, "you do find consistent patterns". He also points to a 2001 study⁶ in which he

showed that children with Asperger's syndrome can outperform typical children at figuring out how simple mechanical systems work. But critics counter that the children with Asperger's were selected on the basis of having average or above average IQs, whereas the typical children were selected at random. Similarly, critics point out that the Cambridge students with autism are highly unusual because they function well enough to attend one of the top universities in the world.

This is a common complaint about Baron-Cohen's work. "He's tended to focus on very bright individuals with ASD," says Catherine Lord, a clinical psychologist and autism researcher at Weill Cornell Medical College in New York. "A lot of the things he might say in describing those individuals are pretty irrelevant for most people with ASD."

Baron-Cohen acknowledges that "some of the psychological research is focused on high-functioning children with autism", because, he says, they have the language capabilities to perform the tests. "But my thought is that it could apply across the system," he says of the systemizing theory, to all children who have some form of the disorder.

Earlier this year, Liz Pellicano, a developmental psychologist at the Institute of Education in London, tested how a group of children with a wider range of ASD compare with a control group in figuring out a system. Her team designed a small room in which the floor was arrayed with 16 identical green lights. The children were asked to find the one light that, when pressed, would turn from green to red.

The target light was on the same side of the room 80% of the time. Children with autism, including Asperger's syndrome, were much worse at figuring out this system than the children in the control group⁷. "They weren't systematic," says Pellicano. "When they were searching, they were unbelievably haphazard." In her view, she says, studies such as this show that Baron-Cohen's theory "isn't standing up to empirical tests".

Baron-Cohen says he is not sure that Pellicano's paradigm was testing the same sort of systemizing he describes. But, he says, he's "glad that at least people are starting to look at systemizing". So far, most work on the subject has come out of his lab. "I think our published studies are rigorous, but there are still too few studies into systemizing," he says. "It is still way too early to be able to look across dozens or hundreds of studies to evaluate that theory."

LIKE FATHER, LIKE SON?

Baron-Cohen proposes that systemizing ability can be inherited — and that in information-technology (IT) enclaves such as Silicon Valley, where hypersystemizers are more likely to meet, pair off and have children, the result is a higher incidence of autism.

Back in 1997, for example, he concluded that fathers of children with autism were more than twice as likely to be engineers as were fathers of non-autistic children⁸. But autism researchers Christopher Jarrold and David Routh at the University of Bristol, UK, pointed out that Baron-Cohen reported the analysis of data only for engineers, not for the other occupations surveyed. After analysing the same data⁹, they found that fathers of children with autism were more likely to work in medicine, science and accountancy, as well as engineering, and less likely to have manual occupations. They suggested that these fathers were simply more likely to have reached a higher level of education.

similar size¹⁰ — evidence that he takes as support for the idea that parents who are strong systemizers could be more likely to have a child with autism. But, he says, he chose to study Eindhoven after parents contacted him about an autism epidemic there, rather than, as some researchers may prefer, comparing the prevalence of autism in randomly selected IT regions with that of non-IT regions with similar demographics. And the Eindhoven school records did not disclose parental age or level of education — both of which are positively correlated with autism diagnoses — or whether the parents worked in the IT industry.

Indeed, researchers say that several other factors could explain the seeming correlation between autism and science or engineering. A 2010 analysis of autism diagnoses in California¹¹ did not find that autism clustered preferentially around areas rich in IT industry. Instead, it found that clusters tended to occur in areas where parents were older and educated to a higher level than were parents in surrounding areas. "Virtually all of these clusters were also clusters of higher education," says lead author Irva Hertz-Picciotto, an epidemiologist at the University of California, Davis.

People who have progressed further in education tend to have children later in life, and at least some evidence suggests that older parents are at higher risk of having children with autism. Parents who are more educated are also more likely to be aware of the symptoms of autism and to seek a diagnosis, which can open the door to support and education services. One Silicon Valley school for children with learning disabilities costs US\$30,000 per student per year, but if a child has been diagnosed with autism, the school district may pick up the tab.

In response to criticisms of his Eindhoven study, Baron-Cohen says he plans to follow up by looking at the age, occupation and other details of the parents, and that he'd also like

Despite the criticisms of Baron-Cohen's experiments, most of his colleagues commend him for putting his theories forward, and many are open to the possibility that parts of them could prove correct. "He does try to address big questions that many of us would be too wimpy to take on," says Lord.

Constantino is testing related ideas. He has developed the 'social responsiveness scale' — a questionnaire to measure autistic-like traits in the general population. He found hints that parents with more autistic-like traits tend to partner with each other, and that when they do, their children have even more of those traits than their parents¹². Those children, however, are not more likely to be diagnosed with autism¹³. What is needed now, Constantino says, is a large study that determines whether having two parents with autistic-like traits is more common among people with autism than in the general population. "Those are the kind of data one needs," he says, "rather than to infer, from an epidemiological cluster in a place where people tend to be a little nerdier, that that's why you've got more autism there."

For now, the idea that technical brilliance requires a dash of autism seems to have taken root, at least in some tech and science hubs. It's a trend that, for Happé, provokes mixed feelings. "On the one hand, I'm glad that 'geek chic' has some kudos in our current society, because a lot of people with AS or ASD have a jolly tough and unpleasant life, and if people can recognize their talents a little more, I'm glad for that."

On the other hand, she says, "a large number of children with autism have significant intellectual disabilities and no speech. For their parents to be surrounded by people spotting all these famous people and saying they have autism, it must be absolutely infuriating." ■

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Baron-Cohen says that when he reanalysed the data and controlled for education level, he found that fathers of children with autism were still more likely to be engineers, although the difference was smaller.

One of Baron-Cohen's most recent studies comes from the town of Eindhoven, a technology hub in the Netherlands. By examining school records, he found that children living in the town were 2–4 times more likely to be diagnosed with autism than were children living in two other Dutch towns of

to examine autism rates in other IT centres, such as Silicon Valley. He's putting together a large online survey (go.nature.com/umyv61) to gather detailed information about the general population — including age, education, occupation and hobbies — to explore whether these factors correlate with having a child with autism. He says that Hertz-Picciotto's study didn't support his hypothesis because it "was not designed to look at autism in IT-rich regions. What I'm doing is coming at it in a different way," he says.

1. Baron-Cohen, S. *Prog. Neuro-Psychopharmacol. Biol. Psychiatry* **30**, 865–872 (2006).
2. Baron-Cohen, S. & Wheelwright, S. *Br. J. Psychiatry* **175**, 484–490 (1999).
3. Baron-Cohen, S., Richler, J., Bisarya, D., Guranathan, N. & Wheelwright, S. *Phil. Trans. R. Soc. Lond. B* **358**, 361–374 (2003).
4. Baron-Cohen, S., Wheelwright, S., Burtenshaw, A. & Hobson, E. *Hum. Nature* **18**, 125–131 (2007).
5. Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J. & Clubley, E. *J. Autism Dev. Disord.* **31**, 5–17 (2001).
6. Baron-Cohen, S., Wheelwright, S., Spong, A., Scahill, V. & Lawson, J. *J. Dev. Learn. Disord.* **5**, 47–78 (2001).
7. Pellicano, E. *et al. Proc. Natl Acad. Sci. USA* **108**, 421–426 (2011).
8. Baron-Cohen, S., Wheelwright, S., Stott, C., Bolton, P. & Goodyer, I. *Autism* **1**, 153–163 (1997).
9. Jarrold, C. & Routh, D. *Autism* **2**, 281–289 (1998).
10. Roelfsema, M. T. *et al. J. Autism Dev. Disord.* <http://dx.doi.org/10.1007/s10803-011-1302-1> (2011).
11. Van Meter, K. C. *et al. Autism Res.* **3**, 19–29 (2010).
12. Constantino, J. N. & Todd, R. D. *Biol. Psychiatry* **57**, 655–660 (2005).
13. Virkud, Y. V., Todd, R. D., Abbacchi, A. M., Zhang, Y. & Constantino, J. N. *Am. J. Med. Genet. B* **150B**, 328–334 (2009).