By Professor Simon Baron-Cohen (e1995), Fellow in Experimental Psychology and Director, Cambridge Autism Research Centre

Autism and Invention

Is there a link between autism and the capacity for invention? I hope to lay out the evidence that shows some links. But first, when did invention begin?

It is clear that our hominid ancestors could use simple stone tools. For example, *Homo habilis* and *Homo erectus*, who both lived 2 million years ago, used stone axes and hammers. And so could the *Neanderthals* who lived as recently as 40,000 years ago. But despite small changes in the design of their tools, for millions of years there was little evidence for *generative* invention – the ability to invent in multiple ways, not just as a one-off. And if we look at non-human species alive today, a lot of animals can use simple stone tools. Chimpanzees, for example, can use a rock as a hammer to crack a nut (Figure 2), and crows can drop a stone to raise the water level to be able to reach a worm. Both the behaviour of other animals and our hominid ancestors can be parsimoniously explained as the result of associative learning, forming an association between two items, A and B, with little sign of generative invention (Figure 1).

But then, 70 to 100,000 years ago, when *Homo sapiens* was on the scene, the rate of inventions suddenly took off and it's been unstoppable ever since. Suddenly we see the capacity for generative invention, not just inventing once, but inventing non-stop. A cognitive revolution had occurred in the human brain.

So what was this cognitive revolution? There were two new circuits in the human brain and the first of these was the Systemizing Mechanism. This allowed humans to look for special patterns in the world, that I call *if-and-then* patterns. These are the basis of any system. *If* I take something, *and* I do something to it, *then* I get an outcome. The Systemizing Mechanism allowed us to analyse the world to find such patterns and confirm that they hold true. To do this we repeat our observations over and over again. And once confirmed, we then can vary it by experimenting with the *if* or the *and*. If we produce a new pattern, that is an invention. I borrow this terminology from the 19th century logician George Boole (Figure 3), who analysed the structure of thought.

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Figure 2: Many non-human animals can use simple tools.

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Tool made by *H. habilis*
2.1m to 1.5 yrs

Tool made by *H. erectus*
2.1m to 250K yrs

Tool made by *H. Neanderthalis*
300k to 40K yrs

Figure 1: Simple stone tools made by our hominid ancestors, ranging from 2.1m to 40K years ago.

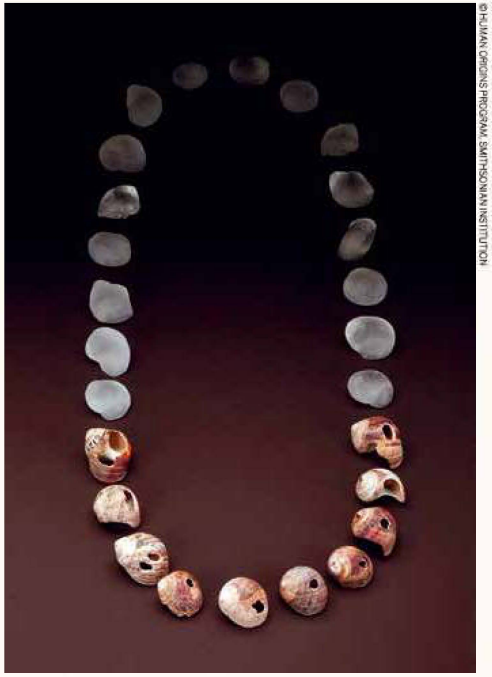

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Figure 4: The earliest jewellery, 75,000 years old.

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Figure 5: The earliest musical instrument, 40,000 years old.

And 40,000 years ago, we see the earliest musical instrument that has ever been found: a flute made from a hollow bone (Figure 5). *If* I blow down the hollow bone, *and* cover one hole, *then* I make a specific sound. But *if* I blow down the hollow bone, *and* cover two holes, *then* I make a different sound. Our ancestor had invented a new complex tool, a musical instrument, and a system of sounds we call music.

And 40,000 years ago we see the cave paintings, and by 25,000 years ago we see sculptures. By 12,000 years ago we see the invention of agriculture. *If* I take a tomato seed, *and* I plant it in moist soil, *then* I get a tomato plant. The invention of agriculture transformed our diet, our health, and our lifestyles. And we are still inventing unstoppably today, a recent example being the invention of a vaccine. *If* I take the genes for Covid's spike protein, *and* put them into a harmless virus, *then* I have a vaccine against Covid.

But let's go back to the first jewellery 75,000 years ago because the Systemizing Mechanism explains how we could make the jewellery, but the empathy circuit explains why we made it. We wear jewellery because we can imagine what someone else might think or feel – that they might think we are beautiful or of high status, or we make jewellery to give as a gift, because we can think that someone might feel happy. The evolution of empathy enabled a whole raft of complex social interactions, including deception and referential communication.

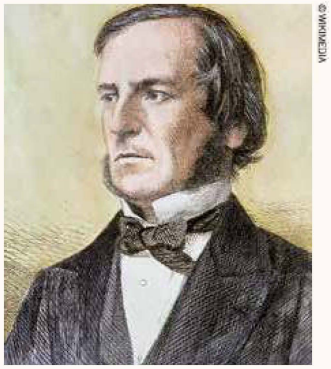

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Figure 3: George Boole.

Let's go back to our big question: is there a link between autism and invention? Anecdotally, many inventors show a high level of autistic traits. Thomas Edison, who famously invented the first electric lightbulb, invented non-stop. As a teenager he was obsessed with Morse code, a system of patterns, and he even named his children Dot and Dash. His wife moved a mattress into his workshop so that he could carry on inventing and experiment day and night. Anecdotally, many autistic people have a talent at pattern recognition and systemizing. And Max Park is autistic, and despite his social difficulties is the world champion in the Rubik's Cube, a system of visual patterns.

But anecdotes are not evidence. We looked at 600,000 people in the general population and measured their autistic traits using the AQ, the Autism Spectrum Quotient. We found those who work in STEM (science, technology, engineering and mathematics) on average have more autistic traits than those who do not. This shows a clear link between aptitude in understanding systems, and higher levels of autistic traits. Those 600,000 people also took the Empathy Quotient and the Systemizing Quotient. We found you can divide people into 5 brain types based on whether they lean more towards empathy or systemizing. Those who lean more towards empathy are Type E. Those who lean more towards systemizing are Type S. And those who are extreme Type S systemize non-stop, seeing patterns everywhere, but who struggle to understand other people's thoughts and feelings. We found more women are Type E, more men are type S, and the majority of autistic people are Type S or extreme Type S. So more evidence of a link between autism and hyper-systemizing.

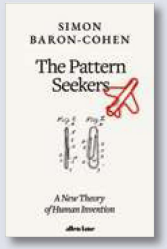
But is the link between autism and pattern-seeking genetic? We had the opportunity to work with the personal genomics company 23andMe, and found that the genetic variants associated with high systemizing overlap with the genetic variants associated with autism. So some of the genes that cause autism also cause talent in pattern recognition. This leads to a prediction: that autism might be more common in places like Silicon Valley. We went to the Dutch city of Eindhoven, where one third of jobs are in IT and which is home to the Institute of Technology, much like MIT, and where the Philips Factory has been for over 100 years. We found autism rates were twice as high in Eindhoven compared to two other Dutch cities, Utrecht and Haarlem, matched for demographics. This is again consistent with a genetic link between autism in the child, and a talent in pattern seeking among their parents.

So, we have evidence that the genes for autism have driven human invention. And yet, how are we as a society treating autistic people? The majority of autistic adults are unemployed and have high levels of poor mental health, likely the result of a lack of support and being excluded from education and work. We owe autistic people a huge debt of gratitude for the role their genes have played in human progress, and we have a moral responsibility to ensure no group of individuals are deprived of their human rights to education, employment and participation in society. It's time for a change. We can learn from the Israeli army that has a special unit who only recruit autistic adults because of their aptitude to look at thousands of aerial photographs to look for unexpected patterns that might be a sign of terrorist activity. They are making sure autistic people are included and are playing their part in society.

It's time to embrace the concept of neurodiversity – the idea that brains come in many varieties – and none is better or worse than another; they are just different.

What's your brain type

We recently built an online tool to enable people to take surveys at home, so that they can contribute to our research. We will be able to use this data to explore a range of significant questions: do the five brain types vary by culture, age, gender, neurology, occupation, biology and experience? And what advantages does each brain type confer? To join in our research, please go to **yourbraintype.com**



Professor Baron-Cohen's book *The Pattern Seekers* is out now with Allen Lane.

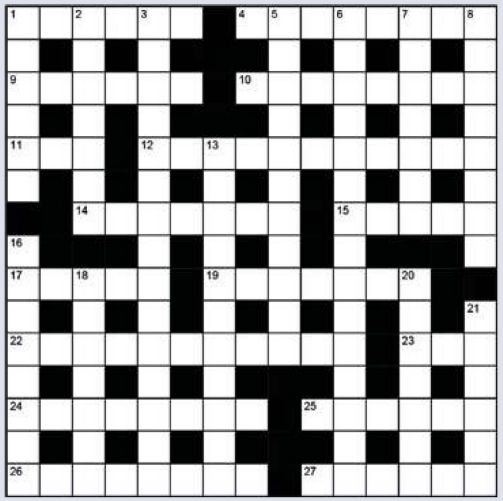
@sbaroncohen

www.autismresearch centre.com

Trinity Cryptic Crossword No.7

Trinity Summer 2021 by *Encota*

Visit *The Fountain* web page for a word version of the crossword: **www.trin.cam.ac.uk/alumni/publications/the-fountain**



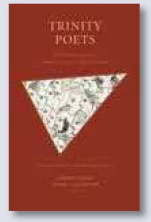
ACROSS

1 Primarily blinking your eyes and blocking your ears for so long (3-3)
4 Green light / lamp protects damaged bus (6,2)
9 This acid test combined with neat mixture could yield last-minute result (6)
10 It's sparkling in Italian province making unlimited pastis? (8)
11 Respect for Ministry of Defence research facility (3)
12 Sides of syringe having more than nine applications (11)
14 Finally inventive reason for arousing intense feeling (7)
15 *Citizen Kane* director informally begins with obituary: Rosebud's spoken one night (5)
17 Meeting James Clerk Maxwell? (5)
19 Simon's initially hesitating when speaking and doing calculations (7)
22 Richard's capital's in ten lakes specially engineered for this family of American natives (11)
23 Worried that everyone's bottled it! (3)
24 One that outlives virus reflected ahead of alternative vaccine when initially injected (8)
25 Show international-level batting skills here? (6)
26 Trinity PM's cuppa (4,4)
27 21's apple tree is apparently in one grand forest (6)

DOWN

1 Song coming from 'May' College celebration nowadays? (6)
2 Desperate old flame meets Trinity's top servicemen (7)
3 It encourages active young to the hills (5,10)
5 It's very chilly when at first he's at back of library, parking books on Lysander's love (11)
6 I can represent this in one time format after rotation (6,2,7)
7 Busy aboard ship in reservoirs (7)
8 Charming bumpkin describing the far side of Angel (8)
13 The spoilers mistakenly reveal this secret room (7,4)
16 Describing 20 here engaged in the French game (8)
18 Three queens maybe joined one from the kitchens? (7)
20 Indian state governor's 4 (2-5)
21 English mathematician and physicist's modern? Not in retrospect (6)

Please email your entry to **alumni-comms@trin.cam.ac.uk** or send it to us: The Editor, Alumni Relations & Development Office, Trinity College, Cambridge CB2 1TQ
Entries are due by 30 September 2021.



The first correct entry drawn will win a copy of *Trinity Poets*, and the winner will be included in the next issue of *The Fountain*.

For the solution to Cryptic Crossword No.6 visit *The Fountain* web page listed above, or email us at **alumni-comms@trin.cam.ac.uk**

WINNING ENTRIES:

Alumni competition

Congratulations to **Dr Trevor Hawkes (1957),** who successfully completed Trinity Cryptic Crossword No.6, winning a copy of *Trinity Poets*.

Student competition

Congratulations to **Bethany Austin (2018),** winner of the third student crossword competition in memory of avid crossword fan John Grenfell-Shaw (2011). The prize of a generous Trinity catering credit is kindly supported by John's parents, Jenny and Mark.

Tim King (1980) is the Ipswich-based professional crossword compiler *Encota*. Tim also sets personalised puzzles as unique and thoughtful gifts. If you'd like to know more, contact him at: **specialisedcrosswords@gmail.com** and visit his website: **www.specialisedcrosswords.co.uk**