

so can reach vast dimensions — as in the blue whale.

This narrative is neatly done, but the fascination exerted by human bone on human minds lies at the book's heart. With Switek, we visit Neolithic tombs and medieval ossuaries, consider skull cults and muse on the bony personification of Death. The book makes extended explorations of how nineteenth-century anthropologists such as Samuel Morton in Philadelphia, Pennsylvania, used skull measurements to claim the existence of racial differences, a malign legacy that, although long discredited in science, lingers today in apologies for racism. Switek also describes the protracted tug-of-war between scientists and the Native American community around the Columbia River in Washington state over who owns the 9,000-year-old skeleton of the Ancient One, also known as Kennewick Man (D. H. Thomas *Nature* 531, 302–303; 2016). This is terrain most palaeontologists never navigate; Switek picks through it well.

In the book's coda, the narrative gets up close and personal. Switek considers his own skeleton, and how it might follow those of the dinosaurs into geological immortality. Switek's deep-time focus comes through a little too strongly, I think, in his assertion that it is mainly our skeletons that will be left to tell of our passing.

“Bone’s potential for physical immortality reminds us all too vividly of our personal mortality.”

Of the detritus that each of us casually scatters — thousands of ballpoint pens, polyester socks, aluminium cans and so on — much is a good deal more decay-resistant than the average cranium or femur. Our bones might be only a small part of our ultimate legacy.

Nevertheless, as this book shows, the skeletal side of life grips us now, and might enthrall whoever excavates our remains in the far future. As Switek ponders the sediments in which his own bones might be fossilized, he needs to think of larger geological processes. The sea floor off the shore of New Orleans, Louisiana, might provide a good start: there are stagnant muds, and local tectonic subsidence will allow the fossil to be securely entombed. In the meantime, we should enjoy Switek's talent for spinning compelling tales of old bones. ■

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NEUROSCIENCE

Bad science and the unisex brain

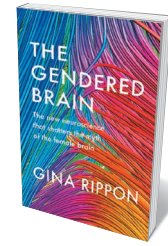
The hunt for differences between men's and women's brains is full of poor research practice, writes **Lise Eliot**.

Early in *The Gendered Brain*, cognitive neuroscientist Gina Rippon describes one of the myriad brain studies heralded as ‘finally’ explaining the difference between men and women. It was a magnetic resonance imaging (MRI) analysis of 21 men and 27 women by researchers at the University of California, Irvine (R. J. Haier *et al. NeuroImage* 25, 320–327; 2005). Tiny by today's standards, this brief communication nonetheless went on quite a publicity tour, from newspapers and blogs to television, books and, eventually, teacher education and corporate leadership conferences.

I woke one morning in 2010 to see an especially bad extrapolation of this study on the *Early Show*, a programme on US television network CBS. The presenter, Harry Smith, gushed as medical correspondent Jennifer Ashton declared that men have “six-and-a-half times more grey matter” than women, whereas women have “ten times as much white matter” as men. Next came the obvious quips about men's talent at mathematics and women's uncanny ability to multitask. Never mind that these differences would demand that women's heads were about 50% larger, or that the Irvine team didn't even compare brain volumes, but investigated a correlation between IQ and measures of grey or white matter.

NEUROSEXISM

The history of sex-difference research is rife with innumeracy, misinterpretation, publication bias, weak statistical power, inadequate controls and worse. Rippon, a leading voice against the bad neuroscience of sex differences, uncovers so many examples in this ambitious book that she uses a whack-a-mole metaphor to evoke the eternal cycle. A brain study purports to discover a difference between men and women; it is publicized as, ‘At last, the truth!’, taunting political correctness; other researchers expose some hyped extrapolation or fatal design flaw; and, with luck, the faulty claim fades away — until the next post hoc analysis produces another ‘Aha!’ moment and the cycle repeats. As Rippon



The Gendered Brain: The New Neuroscience That Shatters The Myth Of The Female Brain
GINA RIPPON
The Bodley Head
(2019)

shows, this hunt for brain differences “has been vigorously pursued down the ages with all the techniques that science could muster”. And it has exploded in the past three decades, since MRI research joined the fray.

Yet, as *The Gendered Brain* reveals, conclusive findings about sex-linked brain differences have failed to materialize. Beyond the “missing five ounces”

of female brain — gloated about since the nineteenth century — modern neuroscientists have identified no decisive, category-defining differences between the brains of men and women. In women's brains, language-processing is not spread any more evenly across the hemispheres than it is in men's, as a small 1995 *Nature* study proclaimed but a large 2008 meta-analysis disproved (B. A. Shaywitz *et al. Nature* 373, 607–609 (1995) and I. E. Sommer *et al. Brain Res.* 1206, 76–88; 2008). Brain size increases with body size, and certain features, such as the ratio of grey to white matter or the cross-sectional area of a nerve tract called the corpus callosum, scale slightly non-linearly with brain size. But these are differences in degree, not kind. As Rippon notes, they are not seen when we compare small-headed men to large-headed women, and have no relationship to differences in hobbies or take-home pay.

HISTORY OF BIAS

Rippon's central message is that “a gendered world will produce a gendered brain”. Her book stands with Angela Saini's 2017 *Inferior* and Cordelia Fine's 2010 *Delusions of Gender* in rooting out the “neurosexism” that has pervaded attempts to understand difference at the brain level. It's a juicy history that would make for

super-fun reading, if it were all truly in the past. Sadly, the moles keep surfacing. Rippon begins with an 1895 quote from social psychologist Gustave Le Bon, who used his portable cephalometer to declare that women “represent the most inferior forms of human evolution”. She ends in 2017, with Google engineer James Damore blogging to co-workers about “biological causes” for the dearth of women in tech and leadership roles.

As Rippon shows, the hunt for proof of women’s inferiority has more recently elided into the hunt for proof of male–female ‘complementarity’. So, this line goes, women are not really less intelligent than men, just ‘different’ in a way that happens to coincide with biblical teachings and the status quo of gender roles. Thus, women’s brains are said to be wired for empathy and intuition, whereas male brains are supposed to be optimized for reason and action.

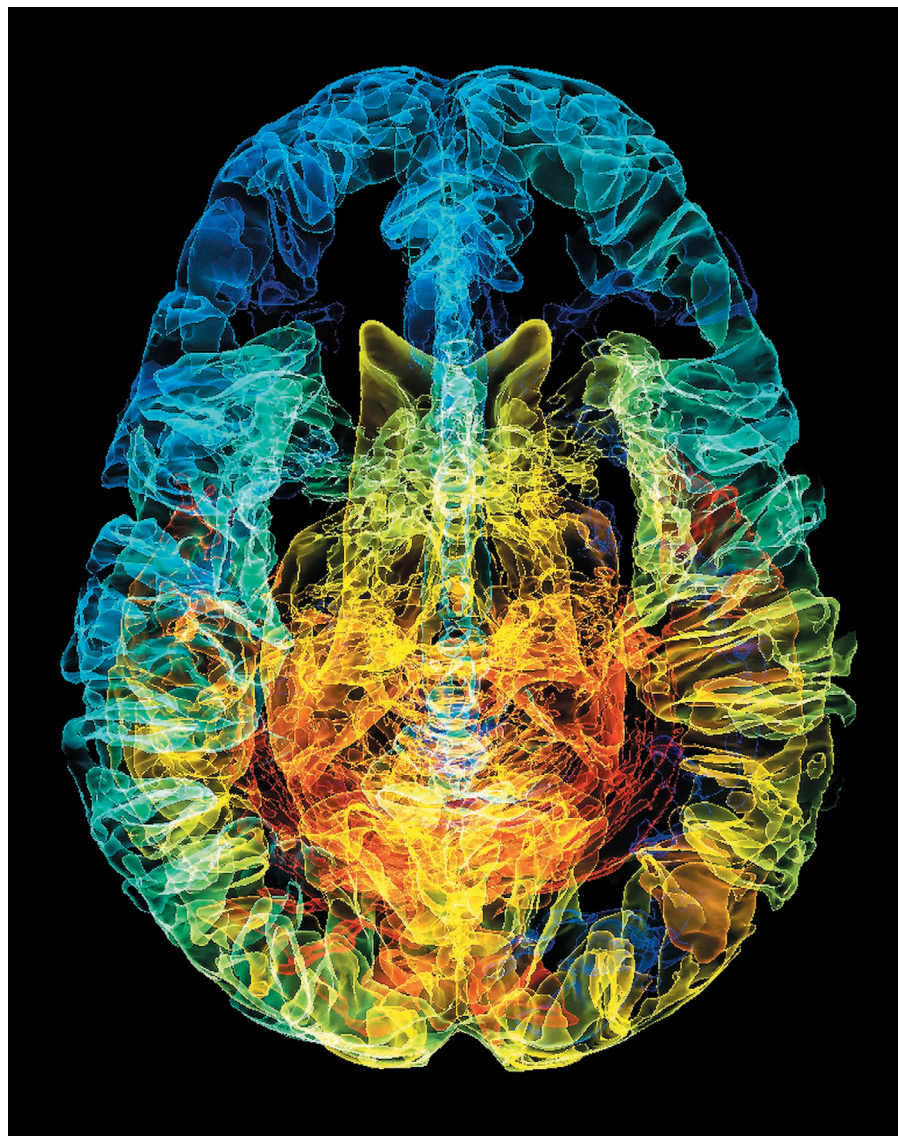
This was how researchers at the University of Pennsylvania in Philadelphia framed a highly touted 2014 MRI study that seared into the public imagination a picture of men’s and women’s brains as diametrically opposed subway maps: the connections in women are mostly between hemispheres, and those in men within them (M. Ingahlakar *et al. Proc. Natl Acad. Sci. USA* **111**, 823–828; 2014). However, the map omits the vast majority of connections that did not differ between the study’s adolescent participants; nor did it control for puberty-related maturation or, once again, for brain size, all of which reduces apparent male–female difference.

CULTURAL PATHS

So if it’s not brain hard-wiring, how do we explain the often stark differences in behaviour and interests between men and women? Here is where we get to Rippon’s thesis on the impact of a gendered world on the human brain. She builds her case in four loosely defined parts, from the sordid history of sex-difference research through modern brain-imaging methods, the emergence of social cognitive neuroscience and the surprisingly weak evidence for brain sex differences in newborns. Rippon shows how children’s “cerebral sponges” probably differentiate thanks to the starkly pink-versus-blue cultures in which they are soaked from the moment of prenatal sex reveal.

Part 4 brings us into the twenty-first century, although not to any happy ending. It focuses on women in science and technology, and how the gendered world — including the professionalization of

“The brain is no more gendered than the liver or kidneys or heart.”



An artificially coloured 3D magnetic resonance imaging scan of a human brain.

science and a masculine stereotype of “brilliance” — has impeded their entry into, and advancement across, this high-status realm. Talented women are regarded as “workhorses”, men as “feral geniuses”, a distinction that children internalize by the age of six, according to research by Lin Bian, Sarah-Jane Leslie and Andrei Cimpian (L. Bian *et al. Am. Psychol.* **73**, 1139–1153; 2018). And all of this factors into the brain-building cycle of differential expectations, self-confidence and risk-taking that drives boys and girls down different trajectories of career and success.

CHANGING MINDS

This final focus explains the book’s subtitle, ‘The New Neuroscience that Shatters the Myth of the Female Brain’. For a volume about debunking brain difference, why narrow it to women? At first, I thought it was a stab at Louann Brizendine’s 2006 *The Female Brain*, skewered in these very pages (see R. M. Young and E. Balaban *Nature*

443, 634; 2006). Or perhaps it’s to underscore how ‘the female brain’ has been sized up as a strange variant of the real thing, much as we refer to a ‘female physicist’ or ‘female surgeon’.

Whatever the subtitle, the book accomplishes its goal of debunking the concept of a gendered brain. The brain is no more gendered than the liver or kidneys or heart. Towards the end, Rippon flirts with the implications of this finding for the growing number of people transitioning or living between current binary gender categories. But for now, she concludes, most of us remain strapped in the “biosocial straitjackets” that divert a basically unisex brain down one culturally gendered pathway or another. ■

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CORRECTION

The article 'Bad science and the unisex brain' (*Nature* **566**, 453–454; 2019) included incorrect wording on the effects of brain size: in fact, differences are not seen between small-headed men and large-headed women.