Think you're clever, do you?

The baffling science of intelligence

What makes the human brain special or unique? There are numerous possible answers, but the most likely is that it provides us with superior intelligence. Many creatures are capable of all the basic functions our brain is responsible for, but thus far no other known creature has created its own philosophy, or vehicles, or clothing, or energy sources, or religion, or a *single* type of pasta, let alone over three hundred varieties. Despite the fact that this book is largely about the things the human brain does inefficiently or bizarrely, it's important not to overlook the fact that it's clearly doing something right if it's enabled humans to have such a rich, multifaceted and varied internal existence, and achieve as much as they have.

There's a famous quote that says, 'If the human brain were so simple that we could understand it, we would be so simple that we couldn't.' If you look into the science of the brain and how it relates to intelligence, there's a strong element of truth in this aphorism. Our brains make us intelligent enough to recognise that we *are* intelligent, observant enough to realise this isn't typical in the world, and curious enough to wonder why this is the case. But we don't yet seem to be intelligent enough to grasp easily where our intelligence comes from and how it works. So we have to fall back on studies of the brain and psychology to get any idea of how the whole process comes about. Science itself exists thanks to our intelligence, and now we use science to figure out how our intelligence works? This is either very efficient or circular reasoning, I'm not smart enough to tell.

Confusing, messy, often contradictory, and hard to get your head round; this is as good a description of intelligence itself as any you're likely to find. It's difficult to measure and even define reliably but I'm going to go through how we use intelligence and its strange properties in this chapter.

My IQ is 270 … or some other big number

(Why measuring intelligence is harder than you think)

Are you intelligent?

Asking yourself that means the answer is definitely yes. It demonstrates you are capable of many cognitive processes that automatically qualify you for the title of 'most intelligent species on earth'. You are able to grasp and retain a concept such as intelligence, something that has no set definition and no physical presence in the real world. You are aware of yourself as an individual entity, something with a limited existence in the world. You are able to consider your own properties and abilities and measure them against some ideal but currently-not-existing goal or deduce that they may be limited in comparison to those of others. No other creature on earth is capable of this level of mental complexity. Not bad for what is basically a low-level neurosis.

So humans are, by some margin, the most intelligent species on earth. What does that *mean*, though? Intelligence, like irony or daylight-saving time, is something most people have a basic grasp of but struggle to explain in detail.

This obviously presents a problem for science. There are many different definitions of intelligence, provided by many scientists over the decades. French scientists Binet and Simon, inventors of one of the first rigorous IQ tests, defined intelligence as: 'To judge well, to comprehend well, to reason well; these are the essential activities of intelligence.' David Weschler, an American psychologist who devised numerous theories and measurements of intelligence, which are still used today via tests such as the Weschler Adult Intelligence Scale, described intelligence as 'the aggregate of the global capacity to act purposefully, to deal effectively with the environment'. Philip E. Vernon, another leading name in the field, referred to intelligence as 'the effective all-round cognitive abilities to comprehend, to grasp relations and reason'.

But don't go thinking it's all pointless speculation; there are many aspects of intelligence that are generally agreed on: it reflects the brain's ability to do … stuff. More precisely, the brain's ability to handle and exploit information. Terms such as reasoning, abstract thought, deducing patterns, comprehension; things like this are regularly cited as examples of superior intelligence. This makes a certain logical sense. All of these typically involve assessing and manipulating information on an entirely intangible basis. Simply put, humans are intelligent enough to work things out without having to interact with them directly.

For example, if a typical human approaches a gate held shut with large padlocks, they'll quickly think, 'Well, that's locked', and go find another entrance. This may seem trivial, but it's a clear sign of intelligence; the person observes a situation, deduces what it means, and responds accordingly. There is no physical attempt to open the gate, at which point they'd discover, 'Yep, that's locked'; they don't *have* to. Logic, reasoning, comprehension, planning; these have all been utilised to dictate actions. This is intelligence. But that doesn't clarify how we study and measure intelligence. Manipulating information in complex ways inside the brain is all well and good, but it's not something that can be observed directly (even the most advanced brain scanners just show us blurs of differing colour at present, which isn't especially useful) so measuring it can be done only indirectly by observing behaviour and performance on specially designed tests.

At this point, you might think that something major has been missed here, because we *do* have a way of measuring intelligence: IQ tests. Everyone knows about IQ, meaning Intelligence Quotient; it's a measurement of how smart you are. Your mass is provided by measuring your weight; your height is determined by measuring how tall you are; your intoxication level is calculated by breathing into one of those gadgets the police make you breathe into; and your intelligence is measured by IQ tests. Simple, right?

Not exactly. IQ is a measurement that takes the slippery, unspecified nature of intelligence into account, but most people assume it's far more definitive than it is. Here's the important fact you need to remember: the average IQ of a population is 100. *Without exception*. If someone says, 'The average IQ of [country x] is only 85', then this is wrong. It's basically the same as saying, 'The length of a metre in [country x] is only 85 cm'; this is logically impossible, and the same is true for IQ.

Legitimate IQ tests tell you where you fall within the typical distribution of intellect in your population, according to a proposed 'normal' distribution. This normal distribution dictates that the 'mean' IQ is 100. An IQ between 90 and 110 is classed as average, between 110 and 119 is 'high average', between 120 and 129 is 'superior', and anything over 130 is 'very superior'.

Conversely, an IQ between 80 and 89 is 'low average', 70 to 79 is 'borderline', and anything below 69 is considered 'extremely low'.

Using this system, over 80 per cent of the population will fall in the average zones, with IQs ranging from 80 to 110. The further out you go, the fewer people you'll find with these IQs; less than 5 per cent of the population will be have a very superior or extremely low IQ. A typical IQ test doesn't directly measure your raw intelligence, but reveals how intelligent you are compared to the rest of the population.

This can have some confusing consequences. Say a potent but bizarrely specific virus wiped out everyone in the world with an IQ of over 100. The people left behind would*still have an average IQ of 100*. Those with IQs of 99 before the plague hit would now suddenly have IQs of 130+ and be classed as the *crème de la crème* of the intellectual elite. Think of it in terms of currency. In Britain the value of the pound fluctuates in accordance with what happens in the economy, but there are always 100 pennies to the pound, so the pound has values that are both flexible and fixed. IQ is basically the same: the average IQ is always 100, but what an IQ of 100 is actually worth in terms of intelligence is variable.

This normalisation and adhering to population averages means that IQ measurement can be a bit restrictive. People such as Albert Einstein and Stephen Hawking reportedlyhave IQs in the region of 160, which is still very superior but doesn't sound so impressive when you consider the population average is 100. So if you meet someone who does claim to have an IQ of 270 or some such, they're probably wrong. They've been using some alternative type of test that isn't considered scientifically valid, or they've seriously misread their results, which does undermine their claim to be a super genius.

This isn't to say that such IQs don't exist at all; some of the most intelligent people on record supposedly had IQs of over 250, according to the *Guinness Book of Records*, although the category of Highest IQ was retired in 1990 due to the uncertainty and ambiguity of the tests at this level.

The IQ tests used by scientists and researchers are meticulously designed; they're used as actual tools, like microscopes and mass spectrometers. They cost a lot of money (so aren't given away online for free). The tests are designed to assess normal, average intelligences in the widest possible range of people. As a result, the further to the extremes you go, the less useful they tend to be. You can demonstrate many concepts of physics in the school classroom with everyday items (for instance, using weights of different sizes to show the constant force of gravity, or a spring to show elasticity) but, if you delve into complex physics, you need particle accelerators or nuclear reactors and frighteningly complex mathematics.

So it is when you have someone of extremely high intelligence; it just becomes much harder to measure. These scientific IQ tests measure things such as spatial awareness with pattern completion tests, comprehension speeds with dedicated questions, verbal fluency by getting the subject to list words from certain categories, and stuff like that; all reasonable things to look into but not something that is likely to tax a super genius to the extent where it would be possible to spot the very limits of his or her intelligence. It's a bit like using bathroom scales to weigh elephants; they can be useful for a standard range of weights, but at this level they'll give no useful data, just a load of broken plastic and springs.

Another concern is that intelligence tests claim to measure intelligence, and we know what intelligence is because intelligence tests tell us. You can see why some of the more cynical

scientist types wouldn't be happy with this situation. In truth, the more common tests have been revised repeatedly and assessed for reliability often, but some still feel that this is just ignoring the underlying problem.

Many like to point out that performance on intelligence tests is actually more indicative of social upbringing, general health, aptitude to testing, education level, and so on. Things that aren't intelligence, in other words. So the tests may be useful, but not for what they're intended.

It's not all doom and gloom. Scientists aren't ignorant of these criticisms and are a resourceful bunch. Today, intelligence tests are more useful – they provide a wide range of assessments (spatial awareness, arithmetic etc.), rather than one general assessment, and this gives us a more robust and thorough demonstration of ability. Studies have shown that performance on intelligence tests also seems to remain fairly stable over a person's lifetime despite all the changes or learning they experience, so they must be detecting some inherent quality rather than just random circumstance.[1]

So, now you know what we know, or what we think we know. One of the generally accepted signs of intelligence is an awareness and acceptance of what you don't know. Good job.

Where are your trousers, professor?

(How intelligent people end up doing stupid things)

The stereotype of an academic is a white-haired white-coated chap (it's almost always a man) in late middle age, talking quickly and often about his field of study while being utterly clueless about the world around him, effortlessly describing the fruit fly genome while absent-mindedly buttering his tie. Social norms and day-to-day tasks are completely alien and baffling to him; he knows everything there is to know about his subject, but little to nothing beyond that.

Being intelligent isn't like being strong; a strong person is strong in every context. However, someone brilliant in one context can seem like a shuddering dunce in another.

This is because intelligence, unlike physical strength, is a product of the never uncomplicated brain. So what are the brain processes that underpin intelligence, and why is it so variable? Firstly, there is ongoing debate in psychology about whether or not humans use a single intelligence, or several different types. Current data suggests it is probably a combination of things.

A dominant view is that there is a single property that underpins our intelligence, which can be expressed in varying ways. This is often known as 'Spearman's g', or just *g*. Named after Charles Spearmen, a scientist who did a great service for intelligence research and science in general in the 1920s by developing factor analysis. The previous section revealed how IQ tests are commonly used despite certain reservations; factor analysis is something that makes them (and other tests) useful.

Factor analysis is a mathematically dense process but what you need to know is that it is a form of statistical decomposition. This is where you take large volumes of data (for example, those produced by IQ tests) and mathematically break them down in various ways and look for factors connecting or influencing the results. These factors aren't known beforehand, but factor analysis can flush them out. If students at a school got middling marks overall in their exams, the headmaster might want to see exactly how the marks were achieved in more detail. Factor analysis could be used to assess the information from all the exam scores and take a closer look. It could reveal that maths questions were generally answered well, but history questions were answered poorly. The

headmaster can then feel justified about yelling at the history teachers for wasting time and money (although he probably isn't justified, given the many possible explanations for poor results).

Spearman used a process similar to this to assess IQ tests and discovered that there was seemingly one underlying factor that underpinned test performance. This was labelled the single general factor, *g*, and if there's anything in science that represents what your everyday person would think of as intelligence, it's *g*.

It would be wrong to say that *g* = all possible intelligence, as intelligence can manifest in so many ways. It's more a general 'core' of intellectual ability. It's viewed as something like the foundations and frame of a house. You can add extensions and furniture, but if the underlying structure isn't strong enough it'll be futile. Similarly, you can learn all the big words and memory tricks you like, but if your *g* isn't up to scratch you won't be able to do much with them.

Research suggests there might be a part of the brain that is responsible for *g*. Chapter 2 discussed short-term memory in detail and alluded to the term 'working memory'. This refers to the actual processing and manipulation, the 'using' of the information in short-term memory. In the early 2000s, Professor Klaus Oberauer and his colleagues ran a series of tests and found that a subject's performance on working-memory tests corresponded strongly with tests to determine his or her *g*, indicating that a person's working-memory capacity is a major factor in overall intelligence.[2] Ultimately, if you score highly on a working-memory task, you're very likely to score highly on a range of IQ tests. It makes logical sense; intelligence involves obtaining, retaining and using information as efficiently as possible, and IQ tests are designed to measure this. But such processes are basically what the working memory is for.

Scanning studies and investigations of people with brain injuries provide compelling evidence for a pivotal role of the prefrontal cortex in processing both *g* and working memory, with those afflicted with frontal-lobe injury demonstrating a wide range of unusual memory problems, typically traced back to a deficit in working memory, thus further implying a large overlap between the two things. This prefrontal cortex is the right behind the forehead, the beginning of the frontal lobe that is regularly implicated in higher 'executive' functions such as thinking, attention and consciousness.

But working memory and *g* are not the whole story. Working-memory processes mostly work with verbal information, supported by words and terms we could speak aloud, like an internal monologue. Intelligence, on the other hand, is applicable to all types of information (visual, spatial, numerical …), prompting researchers to look beyond *g* when trying to define and explain intelligence.

Raymond Cattell (a former student of Charles Spearman) and his student John Horn devised newer methods of factor analysis and identified two types of intelligence in studies spanning the 1940s to 1960s; fluid intelligence and crystallised intelligence.

Fluid intelligence is the ability to *use* information, work with it, apply it, and so on. Solving a Rubik's cube requires fluid intelligence, as does working out why your partner isn't talking to you when you have no memory of doing anything wrong. In each case, the information you have is new and you have to work out what to do with it in order to arrive at an outcome that benefits you.

Crystallised intelligence is the information you have stored in memory and can utilise to help you get the better of situations. Knowing the lead actor in an obscure 1950s film for a pub quiz requires crystallised intelligence. Knowing all the capital cities of the northern hemisphere is

crystallised intelligence. Learning a second (or third or fourth) language utilises crystallised intelligence. Crystallised intelligence is the knowledge you have accumulated, where fluid intelligence is how well you can use it or deal with unfamiliar things that need working out.

It's fair to say that fluid intelligence is another variation of *g* and working memory; the manipulation and processing of information. But crystallised intelligence is increasingly viewed as a separate system, and the workings of the brain back this up. One quite telling fact is that fluid intelligence declines as we age; someone aged eighty will perform worse on a fluid intelligence test than he or she did aged thirty, or fifty. Neuroanatomical studies (and numerous autopsies) revealed the prefrontal cortex, believed responsible for fluid intelligence, atrophies more with age than most other brain regions.

Contrastingly, crystallised intelligence remains stable over a lifetime. Someone who learns French at eighteen will still be able to speak it at eighty-five, unless they stopped using it and forgot it at nineteen. Crystallised intelligence is supported by long-term memories, which are distributed widely throughout the brain and tend to be resilient enough to withstand the ravages of time. The prefrontal cortex is a demanding energetic region that needs to engage in constant active processing to support fluid intelligence, actions that are quite dynamic and thus more likely to result in gradual wear and tear (intense neuronal activity tends to give off a lot of waste products such as free radicals, energetic particles that are harmful to cells).

Both types of intelligence are interdependent; there's no point in being able to manipulate information if you can't access any of it, and vice versa. It's tricky to separate them clearly for study. Luckily, intelligence tests can be designed to focus mostly on either fluid or crystallised intelligence. Tests that require individuals to analyse unfamiliar patterns and identify odd ones out or work out how they are interconnected are thought to assess fluid intelligence; all the information is novel and needs to be processed, so crystallised-intelligence use is minimal. Similarly, tests of recall and knowledge such as word-list memory, or the aforementioned pub quizzes, focus on crystallised intelligence.

It's never quite *that* simple of course. Tasks where you have to sort unfamiliar patterns still rely on an awareness of images, colours, even the means by which you complete the test (if it's rearranging a series of cards, you'll be using your knowledge of what cards are and how to arrange them). This is another thing that makes brain-scanning studies tricky; even doing a simple task involves multiple brain regions. But, in general, tasks for fluid intelligence tend to show greater activity in the prefrontal cortex and associated regions, and crystallised intelligence tasks suggest a role of the wider cortex, often the parietal-lobe (the upper-middle bit of the brain) regions, such as the supramarginal gyrus and Broca's area. The former is often thought of as being necessary for storage and processing of information concerning emotion and some sensory data, while the latter is a key part of our language-processing system. Both are interconnected, and suggest functions requiring access to long-term memory data. While it's still not clear cut, there's mounting evidence to support this fluid/crystallised distinction of general intelligence.

Miles Kingston captures the theory brilliantly: 'Knowledge is knowing that a tomato is a fruit; wisdom is not putting it in a fruit salad.' It requires crystallised intelligence to know how a tomato is classed, and fluid intelligence to apply this information when making a fruit salad. You might now think that fluid intelligence sounds a lot like common sense. Yes, that would be another example. But, for some scientists, two distinct types of intelligence are still not enough. They want

more.

The logic is that a single general intelligence is insufficient for explaining the wide variety of intellectual abilities humans can demonstrate. Consider footballers – they often didn't thrive academically, but being able to play a complicated sport like football at professional level requires a great deal of intellectual ability such as precise control, calculating force and angles, spatial awareness of a wide area, and so on. Concentrating on your job while filtering out the rantings of the obsessive fans takes considerable mental fortitude. The common concept of 'intelligence' is clearly a bit restrictive.

Perhaps the starkest examples are 'savants', individuals with some form of neurological disorder, who show an extreme affinity or ability for complex tasks involving maths, music, memory, etc. In the film *Rain Man*, Dustin Hoffman plays Raymond Babbit, an autistic but mathematically gifted psychiatric patient. The character was inspired by a real individual called Kim Peek who was dubbed a 'mega-savant' for his ability to memorise, to the word, up to twelve thousand books.

These examples and more lead to the development of multiple intelligence theories, because how can someone be both unintelligent in one sphere and a gifted in another if there's only one type of intelligence? The earliest theory of this nature is probably that put forward by Louis Leon Thurstone in 1938, who proposed that human intelligence was made up of seven Primary Mental Abilities:

Verbal comprehension (understanding words: 'Hey, I know what that means!')
Verbal fluency (using language: 'Come here and say that, you acephalous buffoon!')
Memory ('Wait, I remember you, you're the cage-fighting world champion!')
Arithmetic ability ('The odds of me winning this fight are about 82523 to 1.')
Perceptual speed (spotting and linking details: 'Is he wearing a necklace made of human teeth?')
Inductive reasoning (deriving ideas and rules from situations: 'Any attempt to placate this beast is only going to anger him further.')
Spatial visualisation (mentally visualising/manipulating a 3D environment: 'If I tip this table it'll slow him down and I can dive out that window.')

Thurstone derived his Primary Mental Abilities after devising his own methods of factor analysis and applying them to IQ test results of thousands of college students.[3] However, reanalysis of his results using more traditional factor analysis showed there was a single ability influencing all the tests, rather than several different ones. Basically, he'd discovered *g* again. This and other criticisms (for instance that he studied only college students, hardly the most representative group when it comes to general human intelligence) meant the Primary Mental Abilities weren't that widely accepted.

Multiple intelligences returned in the 1980s via Howard Gardner, a prominent researcher who proposed that there were several modalities (types) of intelligence, and his aptly titled *Theory of Multiple Intelligences*, following research into brain-damaged patients who still retained certain types of intellectual abilities.[4] His proposed intelligences were similar to Thurstone's in some ways, but also included musical intelligence, and personal intelligences (ability to interact well

with people, and ability to judge your own internal state).

The multiple-intelligence theory has its adherents though. Multiple intelligences are popular largely because it means everyone can potentially be intelligent, just not in the 'normal' brainy boffin way. This generalisability is also something it's criticised for. If everyone is intelligent, the concept itself becomes meaningless in the scientific sense. It's like giving everyone a medal for showing up at a school sports day; it's nice that everyone gets to feel good, but it does defeat the point of 'sport'.

So far, the evidence for the multiple-intelligence theory remains debatable. The data available is widely regarded as being yet more evidence for *g* or something like it, combined with personal differences and preferences. What this means is that two people who excel, one at music and one at maths, aren't actually demonstrating two different types of intelligence, but the same general intelligence applied to different types of tasks. Similarly, professional swimmers and tennis players use the same muscle groups to practise their sports; the human body doesn't have dedicated tennis muscles. Nonetheless, a champion swimmer can't automatically play top-level tennis. Intelligence is believed to work in similar ways.

Many argue that it is perfectly plausible to have a high *g* but prefer to utilise and apply it in specific ways, which would manifest as different 'types' of intelligence if you look at it in a certain way. Others argue that these supposed different types of intelligence are more suggestive of personal inclinations based on background, tendencies, influences, and so on.

Current neurological evidence still favours the existence of *g* and the fluid/crystallised set-up. Intelligence in the brain is believed to be due to the way the brain is arranged to organise and coordinate the various types of information, rather than a separate system for each one. This will be covered in more detail later in this chapter.

We all direct our intelligence in certain ways and directions, whether due to preference, upbringing, environment or some underlying bias imparted by subtle neurological properties. This is why you get supposedly very smart people doing things we'd consider daft; it's not that they aren't clever enough to know better, it's that they're too focused elsewhere to care. On the plus side, this probably means it's OK to laugh at them, as they'll be too distracted to notice.

Empty vessels make the most noise

(Why intelligent people can often lose arguments)

One of the most infuriating experiences possible is arguing with someone who's convinced they're right when you know full well that they're wrong, and can prove they're wrong with facts and logic, but still they won't budge. I once witnessed a blazing row between two people, one of whom was adamant that this is the twentieth century, not the twenty-first, because, 'It's *twenty* fifteen? Duh!' That was their actual argument.

Contrast this with the psychological phenomenon known as 'impostor syndrome'. High achievers in many fields persistently underestimate their abilities and achievements despite having *actual evidence* of these things. There are many social elements to this. For instance, it's particularly common in women who achieve success in a traditionally male-dominated environment (aka most of them) so they are likely to be influenced by stereotyping, prejudice, cultural norms and so on. But it's not limited to women, and one of the more interesting aspects is that it predominately affects high achievers – those people with a typically high level of

intelligence.

Guess which scientist said this shortly before his death: 'The exaggerated esteem in which my lifework is held makes me very ill at ease. I feel compelled to think of myself as an involuntary swindler.'

Albert Einstein. Not exactly an underachiever.

These two traits, impostor syndrome in intelligent people and illogical self-confidence in less intelligent people, regularly overlap in unhelpful ways. Modern public debate is disastrously skewed due to this. Important issues such as vaccination or climate change are invariably dominated by the impassioned rantings of those who have uninformed personal opinions rather than the calmer explanations of the trained experts, and it's all thanks to a few quirks of the brain's workings.

Basically, people rely on other people as a source of information and support for their own views/beliefs/sense of self-worth, and Chapter 7 on social psychology will go into this in more detail. But, for now, it seems the more confident a person is, the more convincing they are and the more others tend to believe the claims they make. This has been demonstrated in a number of studies, including those conducted in the 1990s by Penrod and Custer, who focused on courtroom settings. These studies looked at the degree to which jurors were convinced by witness testimonies and found that jurors were far more likely to favour witnesses who came across as confident and assured than those who seemed nervous and hesitant or unsure of the details of their claim. This was obviously a worrying finding; the content of a testimony being less influential in determining a verdict than the manner in which it is delivered could have serious ramifications for the justice system. And there's nothing to say it's limited to a courtroom setting; who's to say politics isn't similarly influenced?

Modern politicians are media-trained so they can speak confidently and smoothly on any subject for prolonged periods without saying anything of value. Or worse, something downright stupid like, 'They misunderestimated me' (George W. Bush), or, 'Most of our imports come from overseas' (George W. Bush again). You'd assume that the smartest people would end up running things; the smarter a person is, the better job they'd be able to do. But as counterintuitive as it may seem, the smarter a person is, the greater the odds of them being less confident in their views, and the less confident they come across as being, the less they're trusted. Democracy, everyone.

Intelligent sorts may be less confident because there can often be a general hostility to those of the intellectual persuasion. I'm a neuroscientist by training, but I don't tell people this unless directly asked, because I once got the response, 'Oh, think you're *clever*, do you?'

Do other people get this? If you tell someone you're an Olympic sprinter, does anyone ever say, 'Oh, think you're *fast*, do you?' This seems unlikely. But, regardless, I still end up saying things like, 'I'm a neuroscientist, but it's not as impressive as it sounds.' There are countless social and cultural reasons for anti-intellectualism, but one possibility is that it's a manifestation of the brain's egocentric or 'self-serving' bias and tendency to fear things. People care about their social standing and well-being, and someone seeming more intelligent than them can be perceived as a threat. People who are physically bigger and stronger can certainly be intimidating, but it's a known property. A physically fit person is easy to understand; they just go to the gym more, or have been doing their chosen sport for far longer, right? That's how muscles and such work. Anyone could end up like them if they do what they did, if they had the time or inclination.

But someone who is more intelligent than you presents an unknowable quantity, and as such they could behave in ways that you can't predict or understand. This means the brain cannot work out whether they present a danger or not, and in this situation the old 'better safe than sorry' instinct is activated, triggering suspicion and hostility. It's true that a person could also learn and study to become more intelligent as well, but this is far more complex and uncertain than physical improvement. Lifting weights gives you strong arms, but the connection between learning and intelligence is far more diffuse.

The phenomenon of less-intelligent people being more confident has an actual scientific name: the Dunning–Kruger effect. It is named for David Dunning and Justin Kruger of Cornell University, the researchers who first looked into the phenomenon, inspired by reports of a criminal who held up banks after covering his face with lemon juice, because lemon juice can be used as invisible ink, so he thought his face wouldn't show up on camera.[5]

Just let that sink in for a moment.

Dunning and Kruger got subjects to complete a number of tests, but also asked them to estimate how well they thought they had done on the tests. This produced a remarkable pattern: those who performed badly on the tests almost always assumed they'd done much *much* better, whereas those who did well invariably assumed they'd done worse. Dunning and Kruger argued that those with poor intelligence not only lack the intellectual abilities, they also lack *the ability to recognise that they are bad at something*. The brain's egocentric tendencies kick in again, suppressing things that might lead to a negative opinion of oneself. But also, recognising your own limitations and the superior abilities of others is something that itself requires intelligence. Hence you get people passionately arguing with others about subjects they have no direct experience of, even if the other person has studied the subject all their life. Our brain has only our own experiences to go from, and our baseline assumptions are that everyone is like us. So if we're an idiot …

The argument is that an unintelligent person actually cannot 'perceive' what it is to be considerably more intelligent. It's basically like asking a colour-blind person to describe a red and green pattern.

It may be that an 'intelligent' has a similar take on the world, but expressed in different ways. If an intelligent person thinks something was easy then they may assume everyone else finds it easy too. They assume their level of competence is the norm, so they assume their intelligence is the norm (and intelligent people tend to find themselves in jobs and social situations where they're surrounded by other similar types, so they are likely to have a lot of evidence to support this).

But if intelligent people are generally used to learning new things and acquiring new information, they're more likely to be aware that they *don't* know everything and how much there is to know about any given subject, which would undercut confidence when making claims and statements.

For example, in science, you (ideally) have to be painstakingly thorough with your data and research before making any claims as to how something works. A consequence of surrounding yourself with similarly intelligent people means if you do make a mistake or a grandiose claim, they're more likely to spot it and call you on it. A logical consequence of this would be a keen awareness of the things you don't know or aren't sure about, which is often a handicap in a debate or an argument.

These occurrences are common enough to be familiar and problematic, but obviously aren't

absolute; not every intelligent person is racked with doubt, and not every less-intelligent person is a self-aggrandising buffoon. There are plenty of intellectuals who are so in love with the sound of their own voice that they genuinely charge people thousands to hear it, and there are ample less-intelligent people who freely admit their limited mental powers with grace and humility. It may also have a cultural aspect; the studies behind the Dunning–Kruger effect almost always focus on Western societies, but some East Asian cultures have shown very different patterns of behaviour, and one explanation put forward for this is these cultures adopt the (healthier) attitude that a lack of awareness is an opportunity for improvement, so the priorities and behaviours are very different.[6]

Are there actual brain regions behind this kind of phenomenon? Is there a part of the brain responsible for working out: 'Am I any good at this thing that I'm doing?' Amazing as it may seem, there might well be. In 2009, Howard Rosen and his colleagues tested a group of about forty patients with neurodegenerative diseases and concluded that accuracy in self-appraisal correlated with the volume of tissue in the right ventromedial (lower part, towards the middle) region of the prefrontal cortex.[7] The study argues that this area of the prefrontal cortex is needed for the emotional and physiological processing required when evaluating your own tendencies and abilities. This is relatively consistent with the accepted functioning of the prefrontal cortex, which is largely all to do with processing and manipulating complex information and working out the best possible opinion of it and response to it.

It's important to note that this study in and of itself is not conclusive; forty patients isn't really enough to say that the data obtained from them is relevant to everyone ever. But research into this ability to assess your own intellectual performance accurately, known as a 'metacognitive ability' (thinking about thinking, if that makes sense), is considered to be quite important, as an inability to perform accurate self-appraisal is a well-known feature of dementia. This is particularly true of frontotemporal dementia, a variation of the disorder that attacks largely the frontal lobe, where the prefrontal cortex is. Patients with this condition often show an inability to assess their performance on a wide variety of tests accurately, which would suggest their ability to assess and evaluate their performance has been seriously compromised. This wide-ranging inability to judge one's performance accurately isn't seen in other types of dementia that damage different brain regions, suggesting an area of the frontal lobe is heavily involved in self-appraisal. So this adds up.

Some propose that this is one reason why dementia patients can turn quite aggressive; they are unable to do things but cannot understand or recognise why, which must be nothing short of enraging.

But even without a neurodegenerative disorder and while in possession of a fully functioning prefrontal cortex, this means only that you are capable of self-appraisal; there's nothing to say your self-appraisal will be correct. Hence we end up with confident clowns and insecure intellectuals. And it's apparently human nature that we pay more attention to the confident ones.

Crosswords don't actually keep your brain sharp

(Why it's very difficult to boost your brain power)

There are many ways to *appear* more intelligent (using pompous terms such as '*au courant*', carrying *The Economist*), but can you *actually become* more intelligent? Is it possible to 'boost your brain power'?

In the sense of the body, power usually means the ability to do something or act in a particular

way, and 'brain power' is invariably linked to abilities that would come under the heading of intelligence. You could feasibly increase the amount of *energy* contained within your brain by using your head to complete a circuit connected to an industrial generator, but that's not going to be something that benefits you, unless you're especially keen to have your mind literally blown (to bits).

You've probably seen ads for things that claim to offer substances, tools or techniques for boosting your brain power, usually for a price. It's highly unlikely that any of these things will actually work in any significant way, because if they did they'd be far more popular, with everyone getting smarter and bigger-brained until we're all crushed under the weight of our own skulls. But how does one genuinely increase brain power, boosting intelligence?

For this, it would be useful to know what differentiates the unintelligent brain from the intelligent one, and how do we turn the former into the latter? One potential factor is something that seems completely wrong: intelligent brains apparently use *less* power.

This counterintuitive argument is something that arose from scanning studies directly observing and recording brain activity, such as functional magnetic resonance imaging (fMRI). This is a clever technique where people are placed in MRI scanners and their metabolic activity (where the tissues and cells in the body are 'doing stuff') is observed. Metabolic activity requires oxygen, supplied by the blood. An fMRI scanner can tell the difference between oxygenated blood and deoxygenated blood and when one becomes the other, which occurs at high levels in areas of the body that are metabolically active, like brain regions working hard at a task. Basically, fMRI can monitor brain activity and spot when one part of the brain is especially active. For example, if a subject is doing a memory task, the areas of the brain required for memory processing will be more active than usual, and this shows up on the scanner. Areas showing increased activity would be identifiable as memory-processing areas.

It isn't as simple as that because the brain is constantly active in many different ways, so finding the 'more' active bits requires much filtering and analysis. However, the bulk of modern research about identifying brain regions that have specific functions have utilised fMRI.

So far, so good; you'd expect that a region responsible for a specific action would be more active when having to do that action, like a weightlifter's bicep is using more energy when picking up a dumb-bell. But no. Bizarre findings from several studies, such as those from Larson and others in 1995,[8] showed that in tasks designed to test fluid intelligence, activity was seen in the prefrontal cortex … except when the subject was *very good* at the task.

To clarify, the region supposedly responsible for fluid intelligence apparently wasn't used in people who had high levels of fluid intelligence. This didn't make a lot of sense – like weighing people and finding that only lighter people show up on the scales. Further analysis found that more intelligent subjects *did* show activity in the prefrontal cortex, but only when their tasks were challenging, as in difficult enough for them to have to put some effort into it. This lead to some interesting findings.

Intelligence isn't the work of one dedicated brain region but several, all interlinked. In intelligent people, it seems these links and connections are more efficient and organised, requiring *less* activity overall. Think of it in terms of cars: if you've got a car with an engine roaring like a pack of lions impersonating a hurricane, and a car making no noise whatsoever, the first one isn't automatically going to be the better model. In this case, the noise and activity is because it's trying

to do something the more efficient model can do with minimal effort. There's a growing consensus that it's the extent and efficiency of the connections between the regions involved (prefrontal cortex, parietal lobe and so on) that has a big influence on someone's intelligence; the better he or she can communicate and interact, the quicker the processing and the less effort is required to make decisions and calculations.

This is backed up by studies showing that the integrity and density of white matter in a person's brain is a reliable indicator of intelligence. White matter is the other, often overlooked, kind of tissue in the brain. Grey matter gets all the attention, but 50 per cent of the brain is white matter and it's also very important. It probably gets less publicity because it doesn't 'do' as much. Grey matter is where all the important activity is generated, white matter is made up of bundles and bands of the parts that send the activity to other locations (the axons, the long bit of a typical neuron). If grey matter were the factories, white matter would be the roads needed for delivery and resupply.

The better the white-matter connections between two brain regions, the less energy and effort is required to coordinate them and the tasks they're responsible for, and they're harder to find with a scanner. It's like looking for a needle in a haystack, only instead of a haystack it's a massive pile of slightly bigger needles, and the whole thing is in a washing machine.

Further scanning studies suggest that the thickness of the corpus callosum is also associated with levels of general intelligence. The corpus callosum is the 'bridge' between the left and right hemispheres. It's a big tract of white matter, and the thicker it is the more connections there are between the two hemispheres, enhancing communication. If there's a memory stored on one side that needs to be utilised by the prefrontal cortex on another, a thicker corpus callosum makes this easier and faster. The efficiency and effectiveness of how these regions are connected seems to have a big impact on how well someone can apply their intellect to tasks and problems. As a result of this, brains that are structurally quite different (the size of certain areas, how they're arranged in the cortex, and so on) can display similar levels of intelligence, like two games consoles made by different companies that are similarly powerful.

Now we know efficiency is more important than power. How does that help us go about making ourselves more intelligent? Education and learning is an obvious answer. Actively exposing yourself to more facts, information and concepts means every one you remember will actively increase your crystallised intelligence, and regularly applying your fluid intelligence to as many scenarios as possible will improve matters there. This isn't a cop-out; learning new things and practising new skills can bring about structural changes in the brain. The brain is a plastic organ; it can and will physically adapt to the demands made of it. We met this in Chapter 2: neurons form new synapses when they have to encode a new memory, and this sort of process is found throughout the brain.

For example, the motor cortex, in the parietal lobe, is responsible for planning and control of voluntary movements. Different parts of the motor cortex control different parts of the body, and how much of the motor cortex is dedicated to a body part depends on how much control it needs. Not much of the motor cortex is dedicated to the torso, because you can't do much with it. It's important for breathing and giving your arms somewhere to connect to, but movement-wise we can turn it or bend it slightly, and that's about it. But much of the motor cortex is dedicated to the face and hands, which require a lot of fine control. And that's just for a typical person; studies have

revealed that classically trained musicians such as violinists or pianists often have relatively huge areas of the motor cortex dedicated to fine control of the hands and fingers.[9] These people spend all their lives performing increasingly complex and intricate movements with their hands (usually at high speeds), so the brain has adapted to support this behaviour.

Similarly, the hippocampus is needed for spatial memory (memory for places and navigation) as well as episodic memory. This makes sense, given that it is responsible for processing memory for complex combinations of perceptions, which is necessary for navigating your environment. Studies by Professor Eleanor Maguire and her colleagues showed that London taxi drivers with the 'Knowledge' (the required intricate awareness of London's incredibly vast and complicated road network) had an enlarged posterior hippocampus – the navigation part – when compared to non-taxi drivers.[10] These studies were conducted mostly in the days before satnavs and GPS though, so there's no telling how they'd pan out now.

There is even some evidence (although much of it from studies using mice, and how smart can they be?) to suggest that learning new skills and abilities does lead to the white matter involved being enhanced, by increasing the properties of the myelin (the dedicated coating provided by support cells that regulates signal transmission speed and efficiency) around the nerves. So, technically, there are ways to boost your brain power.

That's the good news. Here's the bad.

All of the things mentioned above take much time and effort, and even then the gains can be fairly limited. The brain is complex and responsible for a ridiculous number of functions. As a result, it's easy to increase ability in one region without affecting others. Musicians may have exemplary knowledge of how to read music, listen to cues, dissect sounds and so on, but this doesn't mean they'll be equally good at maths or languages. Enhancing levels of general, fluid intelligence is difficult; it being produced by a range of brain regions and links means it's an especially difficult thing to 'increase' with restricted tasks or methods.

While the brain remains relatively plastic throughout life, much of its arrangement and structure is effectively 'set'. The long white-matter tracts and pathways will have been laid down earlier in life, when development was still under way. By the time we hit our mid-twenties, our brains are essentially fully developed, and it's fine-tuning from thereon in. This is the current consensus anyway. As such, the general view is that fluid intelligence is 'fixed' in adults, and depends largely on genetic and developmental factors during our upbringing (including our parents' attitudes, our social background and education).

This is a pessimistic conclusion for most people, especially those who want a quick fix, an easy answer, a short-cut to enhanced mental abilities. The science of the brain doesn't allow for such things. Sadly but inevitably, there are many people out there who offer them anyway.

Countless companies now sell 'brain-training' games and exercises, which claim to be able to boost intelligence. These are invariably puzzles and challenges of varying difficulty, and it's true that if you play them often enough you will get increasingly better at them. But *only* them. There is, at present, no accepted evidence that any of these products cause an increase in general intelligence; they just cause you to become good at a specific game, and the brain is easily complex enough not to have to enhance everything else to allow this to happen.

Some people, particularly students, have started taking pharmaceuticals such as Ritalin and Adderall, intended to treat conditions like ADHD, when studying for exams, in order to boost

concentration and focus. While they might achieve this briefly and in very limited ways, the long-term consequences of taking powerful brain-altering drugs when you don't have the underlying issue they're meant to treat are potentially very worrying. Plus, they can backfire: unnaturally ramping up your focus and concentration with drugs can prove exhausting and depleting to your reserves, meaning you burn out much faster and (for example) sleep through the exam you're studying for.

Drugs meant to improve or enhance mental function are classed as Nootropics, aka 'smart drugs'. Most of these are relatively new and affect only specific processes such as memory or attention, so their long-term effects on general intelligence are currently anyone's guess. The more powerful ones are restricted largely to use in neurodegenerative diseases such as Alzheimer's, where the brain is genuinely degrading at an alarming rate.

There is also a wide variety of foods (for instance, fish oils) that are supposed to increase general intelligence, too, but this is also dubious. They may facilitate one aspect of the brain in one minor way, but this isn't enough for a permanent and widespread boost of intelligence.

There are even technological methods being touted these days, particularly with a technique known as transcranial direct-current stimulation (tCDS). A review by Djamila Bennabi and her colleagues in 2014 found that tCDS (where a low-level current is passed through targeted brain regions) does seemingly enhance abilities such as memory and language in both healthy and mentally ill subjects, and seems to have few to no side-effects thus far. Other reviews and studies have yet to establish a viable effect of the method though. Clearly, there's a lot of work to be done before this sort of thing becomes widely available therapeutically.[11]

Despite this, many companies currently sell gadgets that claim to exploit tCDS for improving performance on things like video games. To avoid libelling anyone, I'm not saying these things don't work, but if they do, that means companies are selling items that actively alter brain activity (as powerful drugs do) via means that aren't scientifically established or understood, to people without any specialist training or supervision. This is a bit like selling antidepressants at the supermarket, next to the chocolate bars and packs of batteries.

So, yes, you can increase your intelligence, but it takes a lot of time and effort over prolonged periods, and you can't just do things you're already good at and/or know. If you get really good at something then your brain becomes so efficient at it, it essentially stops realising it's happening. And if it doesn't know it's happening, it won't adapt or respond to it, so you get a self-limiting effect.

The main problem seems to be that, if you want to be more intelligent, you have to be very determined or very smart in order to outsmart your own brain.

You're pretty smart for a small person

(Why tall people are smarter and the heritability of intelligence)

Tall people are smarter than shorter people. It's true. This is a fact that many find surprising, even offensive (if they're short). Surely, it's ridiculous to say that someone's height is related to their intelligence? Apparently, it isn't.

Before I get besieged by an enraged but diminutive mob, it's important to point out that this is not an absolute by any means. Basketball players are not automatically more intelligent than jockeys. André the Giant was not smarter than Einstein. Marie Curie would not have been

outwitted by Hagrid. The correlation between height and intelligence is usually cited as being about 0.2, meaning height and intelligence seem to be associated in only 1 in 5 people.

Plus, it doesn't make a big difference. Take a random tall person and a random short person and measure their IQs; it's anyone's guess as to who'll be the more intelligent. But you do this often enough, say with 10,000 tall people and 10,000 short people, and the overall pattern will be that the average IQ score of taller people will be slightly higher than that of the shorter people. Might be just 3–4 IQ points' difference, but it's still a pattern, one persistent across numerous studies into the phenomenon.[12] What's going on there? Why would being taller make you more intelligent? It's one of the weird and confusing properties of human intelligence.

One of the more likely causes of this height–intelligence association, according to the available science, is genetic. Intelligence is known to be heritable to a certain degree. To clarify, heritability is the extent to which a property or trait of a person varies due to genetics. Something with a heritability of 1.0 means all possible variation of a trait is due to genes, and a heritability of 0.0 would mean none of the variation is genetic.

For example, your species is purely a result of your genes, so 'species' would have a heritability of 1.0. If your parents were pigs, you'll be a pig, no matter what happens as you grow and develop. There are no environmental factors that will turn a pig into a cow. By contrast, if you are currently on fire, this is purely the result of the environment, so has a heritability of 0.0. There are no genes that cause people to burst into flames; your DNA doesn't cause you to burn constantly and produce little burning babies. However, countless properties of the brain are the result of both genes and environment.

Intelligence itself is heritable to a surprisingly high degree; a review of the available evidence by Thomas J. Bouchard[13] suggests that in adults it's around 0.85, although interestingly it's only about 0.45 in children. This may seem odd; how can genes influence adult intellect more than children's? But this is an inaccurate interpretation of what heritability means. Heritability is a measurement of the extent to which variation among groups is genetic in nature, not the extent to which genes *cause* something. Genes may be just as influential in determining a child's intelligence as an adult's, but with children it seems there are *more* things that can also influence intelligence. Children's brains are still developing and learning, so there's a lot going on that can contribute to apparent intelligence. Adult brains are more 'set'; they've gone through the whole development and maturing process, so external factors aren't so potent any more, so differences between individuals (who in typical societies with compulsory education will have roughly similar learning backgrounds) are more likely to be due to more internal (genetic) differences.

All of this may giving a misleading idea about intelligence and the genes, implying it's a far simpler and more direct arrangement than it is. Some people like to think (or hope) that there is a gene for intelligence, something that could make us smarter if it was activated or strengthened. This seems unlikely; just as intelligence is the sum of many different processes, so these processes are controlled by many different genes, all of which have a part to play. Wondering which gene is responsible for a trait such as intelligence is like wondering which piano key is responsible for a symphony.[*]

Height is also determined by numerous factors, many of them genetic, and some scientists think that there might be a gene (or genes) that influences intelligence that also influences height, thus providing a link between being tall and being intelligent. It's entirely possible for single genes to

have multiple functions. This is known as pleiotropy.

Another argument is that there's no gene(s) that mediate both height and intelligence, but rather the association is due to sexual selection, because both height and intelligence are qualities in men that typically attract women. As a result, tall intelligent men would have the most sexual partners and be more able to spread their DNA through the population via their offspring, all of whom would have the genes for height and intelligence in their DNA.

An interesting theory, but not one that is universally accepted. Firstly, it's very biased towards men, suggesting that they only need to have a couple of attractive traits and women will be inexplicably drawn to them, like moths to a gangly, witty flame. Height is far from the only thing people are attracted to. Also, tall men tend to have taller daughters, and a lot of men are put off and intimidated by tall women (or so my tall female friends tell me).

Same goes for intelligent women (or so my intelligent female friends tell me, which for the record is *all* of them). There's no real actual evidence to suggest that women are invariably attracted to intelligent men either, for various reasons; for instamce, confidence is often considered sexy and, as we've seen, intelligent people can be *less* confident overall. This isn't to mention the fact that intelligence can be unnerving and off-putting; the terms 'nerd' or 'geek' may have been largely reclaimed these days, but they were insults for much of their history, and the stereotype is of them being typically dreadful with the opposite sex. These are just a few examples of how the spread of genes for both height and intelligence could be limited.

Another theory is that growing tall requires access to good health and nutrition, and this may also facilitate brain and therefore intelligence development. It could be as simple as that; greater access to good nutrition and a healthier life during development may result in both increased height and intelligence. It can't be *just* that though, because countless people who have the most privileged and healthy life imaginable end up being short. Or an idiot. Or both.

Could it be to do with brain size? Taller people do have typically bigger brains, and there is a minor correlation between brain size and general intelligence.[14] This is quite a contentious issue. The efficiency of the brain's processing and connections play a big part in an individual's intelligence. but then there is also the fact that certain areas, such as the prefrontal cortex and the hippocampus, are bigger and have more grey matter in people of greater intelligence. Bigger brains would logically make this more likely or possible just by presenting the resources to expand and develop. The general impression seems to be that a bigger brain is maybe yet another contributing factor, but not a definite cause. Big brains perhaps give you more of a chance of becoming intelligent, rather than it being an inevitability? Buying expensive new trainers doesn't actually make you faster at running, but they might encourage you to become so. The same can be said of specific genes, actually.

Genetics, parenting styles, quality of education, cultural norms, stereotyping, general health, personal interests, disorders; all of these and more can lead to the brain being more or less able or likely to perform intelligent actions. You can no more separate human intelligence from human culture than you could separate a fish's development from the water it lives in. Even if you were to separate a fish from the water, its development would only ever be 'brief'.

Culture plays a massive role in how intelligence manifests. A perfect example of this was provided in the 1980s by Michael Cole.[15] He and his team went to the remote Kpelle tribe in Africa, a tribe that was relatively untouched by modern culture and the outside world. They wanted

to see if equivalent human intelligence was demonstrated in the Kpelle people, stripped of the cultural factors of Western civilisation. At first, it proved frustrating; the Kpelle people could demonstrate only rudimentary intelligence, and couldn't even solve basic puzzles, the kind a developed-world child would surely have no problem with. Even if the researcher 'accidentally' gave clues as to the right answers, the Kpelle still didn't grasp it. This suggested that their primitive culture wasn't rich or stimulating enough to produce advanced intelligence, or even that some quirk of Kpelle biology prevented them from achieving intellectual sophistication. However, the story is that, frustrated, one of the researchers told them to do the test 'like a fool would', and they immediately produced the 'correct' answers.

Given the language and cultural barriers, the tests involved sorting items into groups. The researchers decided that sorting items into categories (tools, animals, items made of stone, wood, and so on), something that required abstract thinking and processing, was more intelligent. But the Kpelle always sorted things into function (things I can eat, things I can wear, things I can dig with). This was deemed 'less' intelligent, but clearly the Kpelle disagreed. These are people who live off the land, so sorting things into arbitrary categories would be a meaningless and wasteful activity, something a 'fool' would do. As well as being an important lesson in not judging people by your own preconceptions (and maybe about doing better groundwork before beginning an experiment), this example shows how the very concept of intelligence is seriously affected by the environment and preconceptions of society.

A less-drastic example of this is known as the Pygmalion effect. In 1965, Robert Rosenthal and Lenore Jacobson did a study where teachers in elementary schools were told that certain pupils were advanced or intellectually gifted, and should be taught and monitored accordingly.[16] As you'd expect, these pupils showed tests and academic performance in line with being of higher intelligence. The trouble was, they weren't gifted; they were normal pupils. But being treated as if they were smarter and brighter meant they essentially started performing to meet expectations. Similar studies using college students have shown similar results; when students are told that intelligence is fixed, they tend to perform worse on tests. If told that it's variable, they perform better.

Maybe this is another reason why taller people seem more intelligent overall? If you grow taller at a young age, people may treat you as if you're older, so engage you in more mature conversation, so your still-developing brain conforms to these expectations. But in any case, clearly self-belief is important. So any time I've mentioned that intelligence is 'fixed' in this book, I've essentially been hampering your development. Sorry, my bad.

Another interesting/weird thing about intelligence? It's increasing worldwide, and we don't know why. This is called the Flynn effect, and it describes the fact that general scores of intelligence, both fluid and crystallised, are increasing in a wide variety of populations around the world with every generation, in many countries, and despite the varying circumstances that are found in each one. This may be due to improved education worldwide, better healthcare and health awareness, greater access to information and complex technologies, or maybe even the awakening of dormant mutant powers that will slowly turn the human race into a society of geniuses.

There's no evidence to suggest that last one is occurring, but it would make a good film.

There are many possible explanations as to why height and intelligence are linked. They all may be right, or none of them may be right. The truth, as ever, probably lies somewhere between these

extremes. It's essentially another example of the classic nature v. nurture argument.

Is it surprising that it would be so uncertain, given what we know about intelligence? It's hard to define, measure and isolate but it's definitely there and we can study it. It is a specific general ability made up of several others. There are numerous brain regions used to produce intelligence, but it may be the manner in which these are connected that makes all the difference. Intelligence is no guarantee of confidence and lack of it is no guarantee of insecurity, because the manner in which the brain works flips the logical arrangement on its head, unless people are treated as if they are intelligent, in which case it seems to make you smarter, so even the brain isn't sure what it's meant to do with the intelligence it is responsible for. And the level of general intelligence is essentially fixed by genes and upbringing, except if you're willing to work at it, in which case it can be increased, maybe.

Studying intelligence is like trying to knit a sweater with no pattern, using candy floss instead of wool. Overall, it's actually incredibly impressive that you can even make the attempt.

Notes

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* Admittedly, there are some genes that are implicated in having a potentially key role in mediating intelligence. For example, the gene apolipoprotein-E, which results in the formation of specific fat-rich molecules with a wide variety of bodily functions, is implicated in Alzheimer's disease and cognition. But the influence of genes on intelligence is breathtakingly complex, even with the limited evidence