8

Are brains "gay"?

You have a sexual brain. Right?

Women's brains are innately different from men's brains. Right?

Homosexual brains are innately different from heterosexual brains. Right?

Transgendered brains are innately different from heterosexual brains. Right?

You're born with these brains, and can't change them. Right?

Well—we don't think so. It's the subject of a continuing scientific scrap. But this chapter shows that the brain is surprisingly unsexy, and there's little argument about it. The clearest conclusion from this chapter is that the brain is plastic, changeable, and that you are able to change your brain and your sexual feelings, though this may sometimes take considerable effort.

We'll try and trace the thinking of scientists about this.

X and Y chromosomes produce sharp gender differences

The X and Y chromosomes are very different. The X chromosome is very long and complex, the Y chromosome is short and simple! You would expect this huge difference to be as strongly reflected in the brain as it is in physical differences between male and female. **Figure 21** shows this clear differentiation in male and female bodies, particularly the genitalia. Intersex conditions are rare.

The old organizational/activational hypothesis

From the mid 1930's scientists were able to chemically isolate sex hormones for the first time and it was clear they had effects on sexual activity. They also found that in male fetuses but not female, there was a testosterone surge prenatally, at about week 8-24, and it was supposed that this created a male brain, different from a female brain. After WWII the effects of the sex hormones were becoming well known—the mature sexual behaviours of laboratory animals could be altered by injecting sex hormones in young ones. Phoenix et al.[1] summarised findings by creating the Organizational/Activational Hypothesis in the late '50s. According to this hypothesis, the brain was irreversibly masculinised by the prenatal testosterone surge, but sexuality was not expressed in childhood and only become obvious at puberty—when there was a kind of activation. There was also an activation at puberty for females.

This idea had immense influence on the research that followed, and at least a thousand papers directly quoted the work. Although the theory

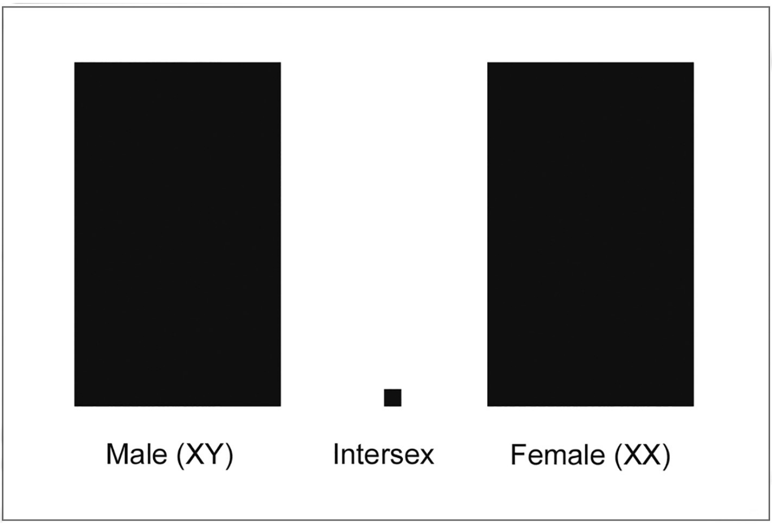

Figure 21.Diagrammatic illustration of intersex frequency (data from Wikipedia, Intersex)

wasn't established well by the experiments, most scientists believed that the whole brain was affected by these surges—i.e., was sexy. The theory still is important today, but the research findings summarised in this chapter are slowly undermining and supplanting it.

At this time it was thought that the brain was quite statically organised—for example, a calculating part, always stayed a calculating part—and any positive change was slow and difficult.

It had long been known from dissections that at birth boy's brains tended to be about 5% larger than girl's brains. This is still well established and not controversial. Even then the brain structures appeared to be very similar, only becoming more dimorphic (differentiated) with age. Any differences seemed a matter of degree, rather than reflecting the independent paths of **Figure 21**, i.e., there was a lot of overlap.

Brain anatomy not strongly gendered

From the mid 1970's, following many dissection studies on post-mortem material, researchers started to use a technique called MRI (Magnetic Resonance Imaging). It became possible to see small details in the brain and make more detailed comparisons, without exposing the subject to x-rays. Many researchers then began looking for brain differences between male and female, homosexual and heterosexual and transgendered people.

There was general agreement that the differences between male and female structures in the brain at birth were not like the clear-cut differences between male and female genitalia. Whatever brain structure was examined there was overlap in size; nearly a complete overlap, as in **Figure 22**.This result is well established.

Figure 22 is very different from **Figure 21**.

Figure 23 shows a similar overlap in adult brains. There is less overlap for adults than for infants. In other words most gender differentiation in the brain arises after birth into adulthood, not during a prenatal testosterone surge.

Figure 24 shows the brain and parts referred to throughout this chapter.

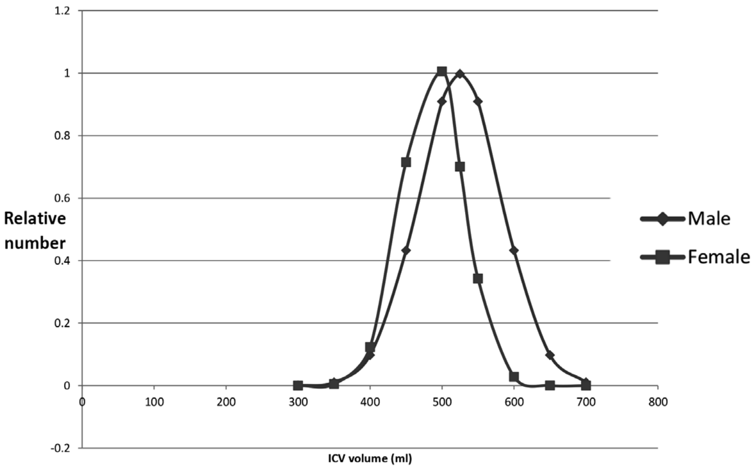

Figure 22. Overlap of male and female brain-space volume sizes (ICV) of *infant* brains.[2]

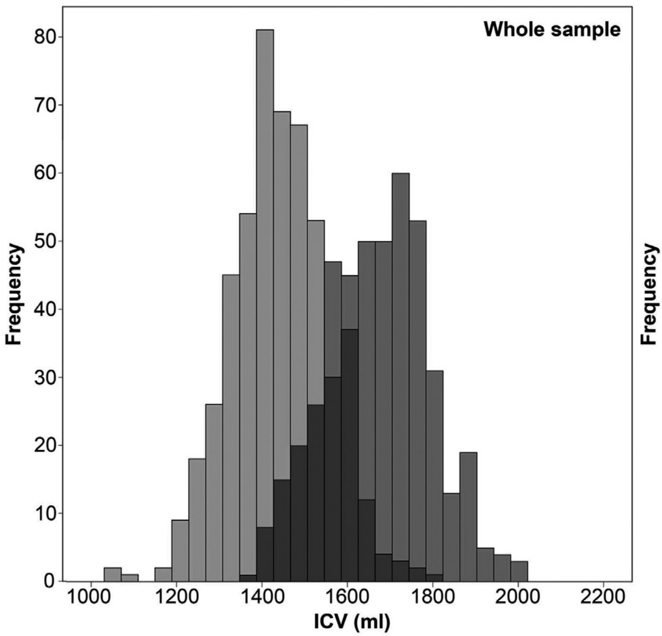

Figure 23. Overlap in ICV volumes for *adults*. The darkest area is the area of overlap

The parts usually thought to be associated with gender/ sexuality are the thalamus, amygdala, and hypothalamus. Research in the '70s

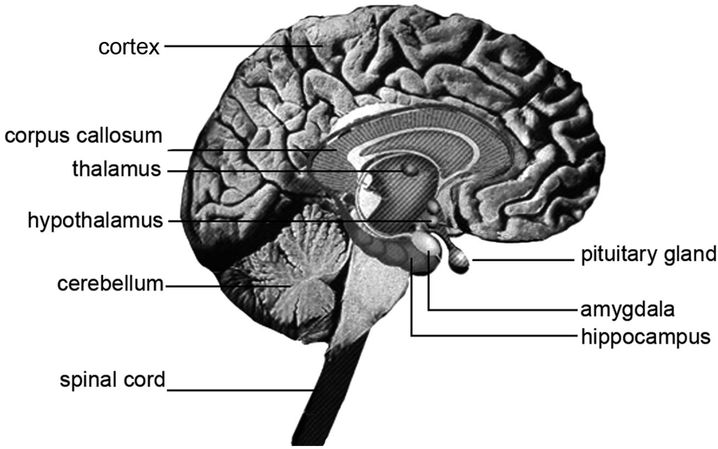

Figure 24. Brain from the right side

often found sizes (or groups) of features in adult brains that differed by gender, but this was often not confirmed by repeat surveys using new datasets. When researchers tied to predict the gender of an adult brain based on an apparent set of features they frequently got it wrong. The record high success was 89%.[3] There is no argument that predictions from brain features are very fuzzy compared with those from the chromosomes.

By 2016 the situation was not much better. Major studies contradicted each other. The claimed 89% success rate clashed with findings from another large study that could find no differences at all. That latter paper rather controversially concluded,

> "…brains do not fall into two classes, one typical of males and the other typical of females, nor are they aligned along a male-female brain continuum. Each brain is a unique mosaic of [male and female] features."[5]

Another similar paper concluded,

> To date there is no consensus whether sexual dimorphism exists, or if such differences are caused by differences in… [instrument] correction methods. [6]

Another paper,

> We do not even know what a female brain is other than that it is not male.[7]

So is there really a gendered brain?

Gene studies show gender in the brain is very minor

More evidence accumulated from study of the genes. If there is a very gendered brain one would expect the genes expressed in the brain to be quite different for males and females. And one would expect most of the genes to show the gender effect.

Some researchers studied brains of rats just after birth, during the critical period for gender differentiation.[8] Concentrating on the small parts of the brain which seemed likely to be involved within the hypothalamus, they found a region called the POA, (the Pre Optic Area) in which only 9% of the genes were differently expressed for male and female. For the medial basal part of the hypothalamus the figure was only 0.9%. Other regions had even fewer differences. This seems to say that almost all of the rat brain is not "sexy" or gendered, and even for the regions which are, only a small number of genes are different for male and female. The rat brain is mostly not gendered, and the division is not sharp. There is almost no such thing as a "male rat-brain" or "female rat-brain" and we need to adjust our thinking.

Does this hold for humans?

A parallel to the rat study would require analysing the brains of many recently deceased babies, so is not done. The best we can do is look at the brains of just-dead adults[9]. The work looked at the "sexiness" of other organs too.

Figure 25 is remarkable because it shows the liver is very strongly gendered, with more than one third of genes differently activated in men and women. But it is a puzzle why is it much more gendered than

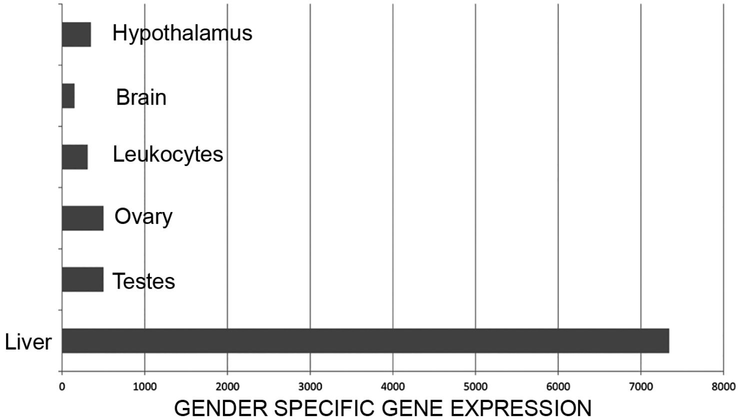

Figure 25. The relatively "unsexy" nature of human gene expression in the adult brain.

the ovary and testis! The leucocytes (blood white cells) are about as gendered as the hypothalamus—which contrary to expectations was barely gendered. Genes in the brain, even in the hypothalamus, are not strongly gendered.

This undermines the whole idea of a sexual brain, and shows our universal tendency to over-sexualise many things. Yes, the brain is sexy, but only slightly sexy.

What of the future? Probably in line with the frequent finding of multiple pathways for development of sexual behaviours we will find smaller than expected contributions from gendered parts of the brain but also input from prenatal environment, hormones, birth,post-natal hormones, maternal socialisation, puberty, and sexual experiences.

Given that it is so hard to distinguish a male brain from a female brain, it is an unproductive exercise to look for differences between homosexual and heterosexual brains. There have been many papers on intrinsic homosexual/heterosexual brain differences but there is no agreement on a clear differentiating feature—even though this type of research is nearly half a century old. This also holds true for transgendered brains. The adult brains of homosexuals and transgendered people are reflecting many years of exposure to environmental influences which almost certainly confuse outcomes. For example, as we shall see, even intense and prolonged thinking about sexual matters changes the brain.

The work comparing homosexual and heterosexual brains has reached a kind of stalemate; a meta review by Byne and Parsons in 1993[10] concluded that there was much confusion and little which agreed universally. All agreed however that there was a lot of overlap and differences were nothing like what might have been expected from the sharp differences between X and Y chromosomes in cells.

Reviewing the whole controversial and poorly replicated field, Byne later doubted whether there was even a specifically male organisation of the brain,[11] partly because some individual males with extremely low levels of testosterone were completely male and performing sexually as males in spite of it.

Some researchers claim to have found some differences—again not sharp—between transgendered and heterosexual brains, concluding that male to female transsexuals tended to have female brain features. But other researchers have found no differences between male to female transsexual brains and heterosexual male brains. As Byne said 20 years ago (and there has been no change):

> No presumed sexually dimorphic cognitive or behavioral brain function has been shown to be independent of learning and experience.[12]

Current thinking on hormone influences in humans

It is now known that the original early testosterone surge in human males is only the first of four (as it is in rats). There is a second one in the last nine weeks of pregnancy, a third in the first six months after birth,[13] and of course the one at puberty.[14,15] The latter three last much longer than the first one, and may well be predominant influences. If the postnatal surge is blocked in experimental animals the subsequent male behavior is badly affected and this is a current hot topic of research.[8,13]

The neuroscientists observe that the largest anatomical changes making brains sexually dimorphic (though it takes an expert to tell) are during puberty[16] and the longer the hormonal exposure the greater the differentiation. They believe puberty is only one of the factors in development of male and female and not merely an activation of a previously existing state as held by the organisational activation hypothesis. As summarised by Kauffman:[1]

> most identified sex differences in the brain and behavior are produced under the influence of postnatal sex steroid signaling

and

> Sex differences in the brain are not an inherent emergent property, but are instead largely determined by extrinsic factors[7]

which being interpreted, means most brain sex differences depend on circumstances after birth, not before. In other words the social environment could be strongly contributing.

Neuroscientists no longer believe that the brain is once-for-all completely organised in a male way during pregnancy, or that brain structure is rigid and unchanging. Authors of about 15 papers in the last decade have independently concurred:

> …our current knowledge of sex-based neurobiology has outgrown this simplistic model. Multiple lines of research have contributed to this conclusion.[18]

Biochemical male/female differences in young rats depend on environment

We now look at recent research showing that male/female brain differentiation in rats is strongly influenced by the environment, particularly by maternal grooming. This probably has implications for human brain development.

This work on rats by the University of Virginia School of Medicine[19] is important. Researchers couldn't find any male/female biochemical differences in fetal rat brains during all of pregnancy, in the places where they expected them—the amygdala, pre-optic area and hypothalamus. Instead there was a huge male/female difference (30%) in the cortex and hippocampus a few days before birth, as measured by epigenetic markers (see Chapter One). The differences in the cortex and hippocampus seem to lead to male or female processing and memory differences—let's call them different thinking styles. But many of the markers dropped back to the same levels in both males and females in the first six days after birth, i.e., the difference dropped from 30% to zero. This doesn't seem to reflect a permanent differentiation between male and female brain structures. However, the 30% male/female difference in a few other markers remained different in males and females after birth.

So, there are some real biochemical differences in rat brains between male and female,.

But these pale into insignificance compared with effects on sexuality caused by the environment—especially maternal grooming which we look at now.

Maternal interaction and grooming

Maternal interaction with the newborn rats has a profound effect on the structure of the brain and later full heterosexual orientation. Even rats need their mothers! If rats are deliberately brought up with mothers absent, in an echo of the devastating effects of complete maternal deprivation on children described in Chapter Three, neither rat sex develops full heterosexual orientation but behaves in stunted male and female ways[19] and their brains are observably anatomically and biochemically different from maternally groomed rats. The absence of the mother has led to brain changes.

With this clue from the rats it is probably not surprising that institutionalised children (who have had no mothering) have difficulties in later opposite-sex relationships (see Chapter Three).

The early prenatal, the late prenatal, the early postnatal and pubertal testosterone/estrogen surges were not enough on their own to fully sexually program the rats. They also needed maternal presence and grooming. Similarly hormonal surges were not enough on their own to fully gender-program the brains of institutionalised children who had no mothering. (Though later nurture can help reverse early damage (see Chapter One).

Earwigs brought up in isolation are unable to provide good maternal care[20] and male fruitflies bought up alone, show various behaviour disturbances including a notable increase in same-sex behavior.[21]

Brain development points to strong environment input

When a baby is born, its brain is only one third of the size of the adult brain,[2] and many of the neural connections are only established in the first three years through the stimulation and exercise which babies receive. This proceeds with extraordinary intensity; after only one year the brain is already 70% of adult size. At the point of peak formation of neural paths this corresponds to *two million* fresh connections every second.

This leads to two other brief arguments in favour of an environmentally-based sexuality.

One: If only about one third of the neurons in the adult brain are present at birth, and the form and structure of the remaining 66% that develop depend heavily on learning, experience, exercise and behaviour, then we might conclude that about one third of brain structure is biologically fixed and two thirds is the result of environmental interaction. We could further argue that because the child experiences so little in the womb in comparison with the bombardment of stimuli he or she begins to receive after birth, the environmental contribution to brain microstructure is in fact, even at a conservative estimate, much closer to 90%. (This roughly approximates the 90% environmental and 10% biological contributions to sexuality proposed throughout this book.)

Two: The DNA in all 23 pairs of chromosomes in a single fertilised cell is three billion rungs long (See Chapter One), but there are 200,000 billion synapses or neuron junctions in the brain. Even if each rung coded for one junction (which it doesn't, see Chapter One) all the rungs together could only specify about one junction in 66,000![22] The rest would have to rely on cues from the wider environment. DNA can only specify a negligibly small fraction of neuronal details.

Brain plasticity

It is fair to say the brain, but particularly the immature brain, is like a computer which is constantly reprogramming itself, but including genuinely random actions as well. Particularly in children, neurons fire at random, and if that neural path is reinforced through experiences the path becomes fairly permanent, though not set in concrete. If it is not reinforced, the path becomes hard to excite, and eventually its neurons get pruned. Extensive stimulation is needed or pathways do not develop, and some periods are more important for certain kinds of stimulation than others. For example, if a child is deprived of light to the eyes in a critical early period, it develops childhood cataracts and becomes blind. If an adult is deprived of light for a few weeks, no such damage happens.[23]

Similarly, if a Japanese child does not hear the difference between "l" and "r" sounds in speech they will find it hard as an adult to hear any difference, or to pronounce those letters differently, but even so, enough concentrated practice will slowly change that.

The size of the brain does not change after age five but lots of internal structural change occurs in both sexes.[24]

The maturation of the brain happens in many cycles of neuronal growth and pruning. The last of these cycles is in the early twenties, and cycles can vary from a few months to several years.[25]

For each growth cycle, experiences reinforce some of the neuronal pathways and the rest get pruned. One consequence of this is the important lesson, *Don't take too much notice of assertions about sexual orientation in adolescence.* Change is still happening. For any adolescent reading this—don't prematurely label yourself as SSA, you will probably change! Changes in adolescence are described in detail in Chapter Twelve.

Changes also take place in the adult brain, particularly with training. Monkey experiments have shown that artificial exercise of three digits on the hand increases the area of the brain associated with those fingers and decreases the other regions proportionately.[23]

Violinists have a grossly enlarged area of the brain devoted to the fingers of their left hands which routinely get much use. Non-jugglers who learn a juggling routine for three months produce observable small changes in the small- scale structure of the brain, and these changes can also be reversed if juggling stops.[26]

Importantly, mental rehearsal of some physical skills can be almost as effective as the real thing. Thinking about something changes your brain. One of several examples is internet addiction. It does not involve new physical skills but mainly brain activity, however it causes detectable changes in the grey matter of the brain.[27] Now consider: how many times do most people think about sexual activities? How much brain change would you expect? Breedlove[23] showed that sexual experience altered neuronal size in rats by 15-20%. Sex, probably even thinking about sex, alters the brain. As does addictive viewing of internet porn[28] which has more effect on brain structure and activity than actual sex.

London taxi drivers have an enlarged area of the brain dealing with navigation. Is this innate? No. London bus drivers on set routes did not have this enlarged area, and after retirement of the taxi drivers, the brain area involved diminished.[29] Taxi-drivers were not born that way, but developed the brain area through huge amounts of navigation and learning, and only maintained it through constant use.

Childbirth changes the brain. Neuroimaging shows the brain in mothers is younger than for childless peers, but it is not clear whether this "baby brain" complaint of new mothers, results from playing with children, or birth trauma, but one might have expected an older brain in mothers from all the stresses![4]

One amazing story from Berlin describes a patient with a brain tumour who was operated on progressively over 18 months. Researchers were able to show that the main centres controlling limb movement migrated within the brain through self-reprogramming, so that although the surgery removed some of the former control sites the patient was able to maintain movement skills.[30]

We change our brains at the micro-level through the way we exercise, and anything we do repetitively especially if associated with pleasure, e.g., sexual activity. So, even if researchers eventually do find real differences in the brains of homosexual people compared with heterosexual, they could well be the result of their homosexual activity, not the cause of it.

There is now a lot of clear evidence that environmental factors alter the brain. Early stress in rats causes many visible changes in their brains.[31] Huge stress creating Post Traumatic Stress Disorder in humans, causes changes in the brain part called the frontal-limbic system.[32] Another researcher finds that stress and maltreatment in childhood cause changes in the corpus callosum, left neocortex, hippocampus, and amygdala.[33] Most of these changes are atrophy of the affected parts.

Perhaps most relevant to the present subject (though it needs replication) is the discovery that sexual abuse of girls causes age-specific brain changes. If it is at ages 9-10 the change is to the corpus callosum, if at 14-16 the frontal cortex is affected.[35]

Sexual experience affects the brain—no surprise!

The brain that changes itself

We strongly recommend the book by Doidge: *The Brain that Changes Itself.*[36] This remarkable but very accessible work describes the overthrow of 20th century beliefs about the unchanging nature of the brain. The brain can change a huge amount, very encouraging news to anyone who is stuck in any habitual behaviour.

Doidge gives numerous illustrations of the brain's plasticity. One is about people who get intense pain in phantom limbs which "remain" after amputation. There is no longer any physical reason for the pain, except within the brain itself. About half the patients were able to get relief from, e.g., cramp in a phantom limb, merely by intensely imagining over a long time that the imaginary limb was in a different position. In other words imagination changed the brain's perception of pain. He describes how intense exercises targeting weakly performing areas of the brain can make differences which seem almost miraculous, and how any vigorous training causes changes in the observed microstructure of the brain. The level of training needed to make the changes was tiring and extended.

Doidge emphasised the neurological principle coined by well-known neuropsychologist, Hebb: *Neurons which fire together wire together.* By deduction, in human sexuality, this means that if something non-sexual is often associated with sexual arousal it will tend to become part of it. In brain maps genital response regions lie alongside the response region for feet, and Doidge wonders if this might relate to sexual fetishes involving feet. (And could it explain the Victorian ankle fetish?) It also becomes reasonable to deduce that, e.g., if intense emotional focus on someone of the same sex is triggered together with sexual excitement, and frequently repeated it could become homosexuality.

Brain plasticity means it is not unreasonable to expect that homosexuals could become more heterosexual.

Doidge shows that although various skills and behaviours are organised in distinct brain regions the micro-details (or "brainmap") are dynamic and changing on a day-to-day basis. If one part of the brain is suddenly not used, the areas around it quickly start to recruit these unused brain pathways for other purposes, reprogram them and use them, e.g., parts of the brain involved in the functioning of a lost limb can be re-purposed; parts of the brain used in a now-discarded skill can be recruited for another very different skill. Doidge sums up the extraordinary plasticity of the brain with the words, *Use it or Lose it.* (Or we could say, use it and grow it.)

Sometimes the loss seems permanent—a childhood language can get completely lost, though "fossil" inaccessible or forgotten language has been found in the brain, and the person has no conscious memory of it. Sometimes it is partial—a musician may find it hard to retrieve accurately a difficult musical piece after some years. But it will return quickly if practised again. Some development windows in early life may even re-open in adulthood given the right circumstances.[37]

Even if part of the brain is strongly associated with a particular sexuality it should be possible to change it. Stopping a sexual activity and avoiding sexual stimulation, while giving oneself to another absorbing brain activity for months, e.g., thoroughly mastering a musical instrument, would lead to a diminishing of the intensity of that sexual response. Months is about the time-scale of first significant change. That can be true for learning a musical instrument too! But detectable structural change for some activities can happen in as little as two hours.[38]

It could be expected—though this is not mentioned by Doidge—that any brain structures associated with sexual activity would be much changed in those very elderly people for whom such activity has long ceased. MRI scans already show declines in brain activation in response to erotic stimuli in middle age compared to younger ages.[39]

Doidge's conclusion about sexuality is that human libido is not a hard-wired invariable biological urge, but can be curiously fickle, easily altered by our psychology and the history of our sexual encounters and "It's a use-it-or-lose-it brain, even where sexual desire and love are concerned." This would apply both to same-sex attraction and opposite-sex attraction.

If we train hard enough, an activity can become automatic and we pay it less conscious attention. Details of driving, throwing a ball, reading, even tying shoelaces, don't and often can't demand full attention. Martial arts experts strive to reach this level of automatic response, because there is no time in a fight to work out the best counter-attack. It is also particularly true of playing a musical instrument. Many of the basic techniques like chords, scales and arpeggios, are so deeply learned that we don't think about the details and indeed can't if the music is fast. Doidge says this degree of training alters brains so much that after death the brain of a musician is uniquely different from other brains.

Studies show that we make decisions, e.g., to move an arm, a fraction of a second before they are conscious. We have delegated even some of our decision-making to unconscious levels. This does not mean free-will is an illusion, but that we have trained ourselves to the point that the response is ingrained and automatic; part of us is now a well-functioning machine.

In the same way it can seem that sexual orientation is so deeply embedded that it is innate. But, really, it is no more innate than any complex skill we have spent a long time developing. From what we now know about the brain, it is possible to reprogram it by changing our thinking, fantasies and behaviour. It may take several years of intense effort but our sexuality is not dictated by our brains—instead our brains can begin to reflect changes in the way we live.

Summary

Scientists have not been able to find clear structural differences between the brains of boys and girls at birth except size. At that stage of life their properties and functions and behaviours overlap almost entirely. Male and female behaviours—let alone homosexuality and heterosexuality—are not hard-wired into the brain at birth.

Mother-child interactions after birth influence the brain structure and future sexual orientation. This means early hormonal effects on the brain are far from inevitable. In fact, only one third of the brain is formed in a new-born child; the rest is developed through learning and experience (environmental input).

There is strong evidence that very little of the brain is actually "sexy," and, e.g., the liver is much more so. Male/female differences are generally much smaller than expected.

Many early attempts (in the nineties) to find male/female, heterosexual/homosexual differences in adult brains based on size of structures gave contradictory results. Where differences appeared to exist, further studies failed to reproduce them, or they could be attributed to influences in the environment. There is no well-established method for correctly differentiating adult male and female brains, let alone homosexual or transgendered brains.

We can be confident that any replicable male/female differences found in adult brains (or between "homosexual" and "heterosexual" brains), will have been shaped largely by learning and behaviour.

What learning and experiences do to the brain is not set in concrete. The dynamic nature of brain connections, means that new neuronal pathways can be formed and old ones reshaped. Intensive exercise, training or imagination changes the brain microstructure.

We are not victims of our biology or the experiences which shape the detail of our brain. Anatomy is not destiny; change is always possible. The brain is plastic and is in a constant state of change. Indeed the question is rather: what change is not possible?

We are not saying that the structure of the brain you were born with has no effect. It has. It can be profound. But that structure can also be profoundly changed, and we don't yet know the limits. They are probably sky-high.

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