Neuroscience, learning and change

Modern technology has revealed many of the secrets of the geography of our brains and the functions of its different areas. Kai Peters summarises the latest developments in neuroscience, and suggests how the findings can be used in designing learning interventions in executive education.
Early brain research must have been fascinating in a macabre sort of way. Serious head injuries were much prized, as long as the victim did not die immediately. Bullets, lodged iron bars, and other random bits of metal would destroy various segments of the brain, and doctors would excitedly see what still worked and what did not. Was memory affected? Did behaviour change? Was language affected? Was learning still possible?

Over time, science matured, but the principles remained the same. Brain surgery became possible. In the 1950s, electrodes were used to stimulate the brain. Maps were created linking parts of the brain to related body parts and mental functions. Perhaps unsurprisingly, finding volunteers who wanted electrodes shoved into their brains was a challenge and new methods were developed. Today, OIS (optical imaging of intrinsic signals), where cameras track blood flow around the brain, is used on the rare occasions when the brain is exposed. A less precise, but non-invasive procedure is fMRI (functional magnetic resonance imaging). Using MRI machines has allowed researchers to study what happens in the brain when a variety of tasks are performed: moving a finger, confronting a dilemma, comparing Coke and Pepsi and even having an orgasm. (Bet that got your attention!)

Structure of the brain

As James Shreeve colourfully describes it, your brain is “a 1.5 kg bolus of fat and protein, wrinkled like a cleaning sponge and with the consistency of curdled milk”. The brain is made of two fundamental parts. The limbic system, which is the older, more primitive, brain and the seat of emotion – the fight or flight centre. The cerebral cortex is the thinking area surrounding the limbic system where language, learning, memory and judgement reside. As an aside, there are also significant numbers of nerve cells, or neurons, in your heart and in your stomach which interact with your brain. If someone talks about a “good gut feeling”, it really is true!

The brain is an electro-chemical wonder. Weeks after conception, half a million neurons are produced every minute leading ultimately to about 100 billion neurons in your brain. In the first and second trimester, these neurons reach out to each other to create points of contact called synapses. These synapses, which are created at the rate of 2 million connections a second during this period of gestation, can perhaps be metaphorically seen as the pathways of connection. Over time, some of these pathways get used regularly and turn into roads or even highways. Others, never used, grass over and disappear. At birth, for example, all children have the neural capacity to hear and pronounce all of the sounds in all languages yet they only maintain those that get properly developed while the others fade away. During the first 18 months of life, the brain is an information sponge. Stimulation creates strong synaptic connections. Non-use leads to atrophy. In learning terms this is critical. Children who are not mentally stimulated at an early age will not be able to develop as well as children who do. Intelligence, which is theoretically equal at birth, is defined by how the brain is developed by one’s surrounding. If children are not played with, read to and attended to, neuroscience has shown that they will fall behind.

At age 2, the prefrontal cortex comes on line and with it comes a conception of space, language and thought. Interestingly, the last part of the “thinking” brain which develops is the part of the cortex which is responsible for social judgements, for weighing alternatives, planning for the future and for managing behaviour. This only occurs at the age of about 25. If you had always wondered about what was going on in teenagers’ heads – their judgement really is not all that developed and there is nothing that one can do about it!

While the historical view had been that specific functions were contained in certain areas of the brain, modern research has shown that brains are much more nuanced. Functions are indeed weighted to general areas, but the brain is plastic and movement can occur. Parts of the brain can grow or shrink and even areas which are injured can have their tasks partially shifted to neighbouring zones.

So over time, your brain has developed a certain set of synapse connections and a knowledge and behaviour repertoire. When something new comes along, you have somato-sensors in your brain which receive input from your senses of hearing, vision, touch, taste and smell. Impulses from the somato-sensors are processed in the hippocampus which compares incoming information with stored knowledge. The limbic system also adds emotional signifiers to this information. If the new input is judged to be positive, the hippocampus sends a pulse of dopamine which is both pleasant and stimulates memory. It also promotes the release of acetylcholine which increases attention. If, however, the new impulse is judged to be bad or an overload, your amygdala, part of the emotional limbic system, blocks up and creates a sense of anxiety or panic. This amygdala hijack actually draws energy away from your cognitive prefrontal cortex, causing you to think less.

While some of this may seem rather abstract, it is nonetheless fascinating when applied to learning and change which are, in effect, the same from a neuroscientific perspective. Most of the time, you are on autopilot. Driving the same way to work everyday does not require thinking. Performing similar work tasks regularly is equally unstimulating. Something really new, however, requires brain processing and this takes real energy. It is, in effect, tiring.
Neuroscience and learning

Brain research is an emerging field. Ninety percent of brain research is less than ten years old. Almost all of the brain research which has been conducted in relation to learning and education has focused on early childhood education. That said, real lessons for adult learning are emerging. If, as noted earlier, positive inputs release dopamine and create a virtual cycle of positive feeling and memory activation, creating a happy learning environment genuinely makes a difference. More fascinating is to think about novelty. Good novelty reinforces the positive. Bad novelty which induces an amygdala hijack or boredom actually works against learning.

In designing learning interventions, there are numerous lessons here. First, think of something novel that enlivens the learning. Do something fun and unexpected and participant learning will increase. Do something which participants do not like, or find boring, and you will have neurologically lost them. In a traditional classroom, this would mean that it is critical to teach new and interesting material first and not review last week’s lesson again for reinforcement. In executive education, where simulations are used, be sure to use a believable, relevant activity.

Neurons and synapses are also critical to learning. The new needs to create new synaptic paths. Walking metaphorically through the bush is simply not enough to create a new path, never mind a new highway. Repetition and reinforcement are necessary. New information needs to progress from working memory into stored memory. If something is not reinforced, it does not make this journey. If you have ever wondered why you cannot remember someone’s name when you have been introduced, it is because you have not repeated it to yourself several times and it has simply disappeared from your working memory. Through knowledge, your brain can actually grow. London cabbies, having had to learn “The Knowledge” of 25,000 streets in Central London and important ones beyond, have an enlarged rear hippocampus. Blind people have an enlarged somato-sensory cortex where spatial senses which would have been provided entirely through sight, are replaced by spatial abilities developed through hearing, sound and feeling. This process would begin in anyone who is blind-folded for more than a few hours but would disappear once the blindfold is removed.

Learning to do something differently is a far greater challenge than simply having to learn something new. You already have a developed synaptic superhighway which causes certain types of knowledge analysis and behavioural reaction. The longer one has reinforced this particular world-view, whether correct or not, the harder it is to alter. A brand new path needs to be created, cultivated and developed so that it becomes the new highway and the old one grows over. This can be accomplished through really hard work, but it is indeed hard to teach an old dog different tricks. Research has been conducted looking at the brains of different functional roles. As will be apparent, accountants really do have different brains than marketing people do. Getting them to see eye-to-eye requires some real neurological development.

Neuroscience and change

As with learning to do something differently rather than learning to do something new, so too with change. When one speaks about change, what one is really looking for is behavioural change. Behaviour is even more deeply embedded than is cognition and is almost guaranteed to create an amygdala hijack with the related physiological discomfort. Ironically, people with more experience in a variety of settings tend to react better to change than those with a more limited experience set.

Younger colleagues who have only known one reality can find change very tough.

In looking at the neuroscience of change, what one is in effect doing is throwing a hard science at the field of psychology and testing the assumptions. Many prove to be incorrect. Thinking about one’s mistakes, for instance, simply reinforces the bad experiences rather than allowing you to move on. It is much better to use positive psychology to focus on what went right rather than on what went wrong. Appreciative Inquiry events are thus a very sensible approach to large group events.

As with behaviourism, a humanistic approach is problematic as one is in effect telling people to change in a nice manner.

From the neuroscience of education, we have seen that attention and focus are necessary to create an environment in which neurological development can happen. Repetition and reinforcement, in a positive way, are critical for new behaviours to develop. We all, however, have a limited capacity to pay attention. Working memory is limited and novelty must be embedded. Shorter, regular discussions are much more useful than multi-day marathons. If longer periods of concentration are needed because of scheduling requirements, then breaking the day up with other activities actually stimulates the brain, which continues to work in the background, rather than turning the brain off.

Change must be owned. If a group is presented with the goals and how to get there, the natural neurological reaction is one of rejection. If, instead, the goals are presented and constraints are given but the path can be chosen by participants, successful outcomes are much more likely. If as a manager, you can paint a positive picture of a strived for future, and ask colleagues for help in getting there, the ideas they generate lead to positive dopamine release. Avoiding long discussions about
problems is also critical. A recent study, interestingly, has used MRI scanning on people with positive and negative outlooks. It is actually possible to identify glass-half-empty people through a brain scan which reveals that the more electro-chemical activity that happens on the left side rather than on the right side of the prefrontal cortex, the more positive you are. The study also showed that meditation moved activity to the left – at least for the monks who participated.

**Neuroscience in the real world**

Neuroscientific principles are already being actively applied in real settings. Positive psychology, visualisation, repetition and taking charge of the challenges are all key components of the US Army Center for Enhanced Performance at West Point, a centre based on cognition, neuroscience and health. It is a fascinating and emerging field which will become increasingly central to learning and change.

**Further reading**


Shreeve, J. (2005) Beyond the Brain, National Geographic
