Clowning about in brain scanners

CRAIG AAEN-STOCKDALE, *winner in the postgraduate category, on how psychologists have found their playful side to shed light on the plasticity of the brain.*

THE work of modern psychologists and neuroscientists is now almost universally informed by the idea that the mind is a product of the physical brain (and anybody taking a different line probably shouldn't be sat next to at conferences). If this assumption is correct, then it is reasonable to expect that changes occurring in the mind would show up somewhere in the physical matter of the brain.

In the past, this simple idea has led the study of the mind astray. Franz Joseph Gall's phrenology, hugely popular in the 19th century, suggested that a person's character could be read from the bumps of the head. He proposed that different 'organs' in the brain were responsible for different personality attributes and the relative size of these organs deformed the skull around them. Cesare Lombroso went so far as to suggest that a person's 'savage nature' and, therefore, propensity to commit criminal acts could be determined from the shape of the skull and facial features, an idea heartily embraced by genocidal lunatics throughout the ages. Fortunately, the practices of phrenology and 'criminal physiognomy' both rested on several dodgy assumptions; and as each one was discredited, they fell into disrepute.

However, if the mind and the brain are indeed the same thing, then it should be possible to see the physical changes that occur when we learn a new skill. Upon casual inspection of the human brain (and please note that I'm not recommending casual inspection of human brains), they look pretty much alike whether you are a composer or a carpenter, so the orthodox view of learning has long been that adult brains can only change their functional structure (the small-scale pattern of connections between neurons) not their anatomical structure (the measurable size and shape of the lumps and bumps of the brain).

However, Bogdan Draganski, Arne May and their team at the University of Regensburg have recently published findings that contradict this view (Draganski *et al*., 2004). For the first time ever in humans, the acquisition of new skills has been shown to change the large-scale anatomical structure of the brain.

'We were interested in how the brain responds to changes in the environment,' Arne May told me, 'and we chose a task that we all can learn and will not forget.' The skill that immediately sprang to mind was riding a bicycle, but since most adults can do that already, they decided to teach their participants to juggle.

Jugglers show a significant increase of grey matter in brain area V5

Participants with no prior juggling skills had their brains scanned in a magnetic resonance imaging (MRI) scanner and were then taught the relatively simple task of juggling three balls. The participants were given three months to practise their new-found talent to the point where they could juggle for 60 seconds without dropping a ball. They were then scanned a second time.

Draganski and colleagues were looking for changes in the distribution of brain matter as the jugglers learned a new skill. Using a technique called morphometry, which compared brain scans for the 'jugglers' with scans from non-juggling control participants, the team could identify subtle changes in the volume of grey and white matter in the brain.

The jugglers showed a significant increase of grey matter in brain area V5, which, surprisingly, is an area implicated in the processing of visual movement. 'I would have predicted that it should have changed in areas known to be used for motor skills,' said Dr May. 'However, it makes sense. What you need most in juggling, as a beginner, is to estimate where the ball will go and to move your hand in that direction before the ball gets there.'

In order to investigate what happens when newly acquired skills are allowed to stagnate, the participants were asked not to practise their juggling skills and were scanned for a third time after another three-month period. The amount of grey matter in V5 had reduced, supporting the idea that the brain operates in a use-it-or-lose-it fashion.

The importance of these findings is that an anatomical change has been found in adults as a direct result of the manipulation of an experimental variable: the subjects' acquisition of juggling skills. Some recent studies of anatomical brain plasticity, such as Eleanor Maguire's (2000) finding that London cab drivers have enlarged hippocampi, have been criticised, perhaps unfairly, for conflating correlation with causation. Does the acquisition of 'The Knowledge' inflate the hippocampus in taxi drivers, or are people with abnormally large hippocampi naturally drawn towards work the public transport sector? The Taxi Driver study even 'won' its author the dubious accolade of an IgNobel Prize, for research that makes you laugh and then makes you think. It certainly takes something special to get the public interested in hippocampal plasticity.

The study of neural plasticity isn't all fun and games though. The Draganski *et al*. study demonstrated neuroplasticity occurring in the occipitotemporal pathway, areas of which are implicated in the social-emotional aspects of face processing (Streit *et al.,* 1999) and form part of the pathway for threat perception (Pine, 2003). This part of the brain contains many regions connected with visual object perception, but exposure to evocative stimuli shows that these areas are tightly coupled with structures involved in emotion, such as the amygdala. A team lead by Christopher Monk at the US National Institute of Mental Health has shown that exposure to threatening and non-threatening facial expressions leads to an attentional bias away from threat, which is correlated with increased activity in the occipitotemporal pathway. As Draganski and colleagues have shown, this part of the brain is capable of undergoing semi-permanent structural changes as a result of experience, and Monk *et al*. have made the tentative suggestion that the long-lasting structural changes in the brain's response to threatening stimuli could result in chronic anxiety disorders. The suggestion being that, due to the plasticity evident in this part of the brain, patients may become permanently fearful of certain stimuli.

Lumps and bumps

Thankfully, Maguire *et al.* and Draganski, May and colleagues have not provided support for anything as ludicrous as phrenology (for a discussion of the parallels, see Terrazas & McNaughton, 2000), but they have demonstrated that the large-scale lumps and bumps of the brain can change as a result of changes in the environment. The fact that this change is reversible shows that the brain maximises its efficiency by pruning away redundant neurons to free up precious skull-space for other, more useful, tasks. Mental muscle will weaken if not exercised, but you don't need to memorise Shakespeare to keep the brain in shape. 'Learning any skill will challenge your brain,' concludes Dr May. Acquisition and practice of new skills, be they physical or cognitive, keeps our little grey cells fit – and that can only be a good thing.

■ *Craig Aaen-Stockdale is a postgraduate research fellow at McGill University, Montreal. E-mail: craig.aaenstockdale@mail.mcgill.ca.*

WEBLINKS

Regensburg Neurology: *tinyurl.com/fbul7*

Introduction to morphometry: *tinyurl.com/gjyjt*

The IgNobels: *improbable.com/ig*

The Skeptic's Dictionary (phrenology):

skepdic.com/phren.html

References

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U. & May, A. (2004) Neuroplasticity: Changes in grey matter induced by training. *Nature, 427*, 311–312.

Maguire, E.A., Gadian, D.G., Johnsrude, I.S. *et al.* (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences of the United States of America, 97*(8), 4398–4403.

Monk, C.S., Nelson, E.E., Woldehawariat, G. *et al* (2004). Experience-dependent plasticity for attention to threat: Behavioral neurophysiological evidence in humans, *Biological Psychiatry, 56*(8), 607–610.

Pine, D.S. (2003). Developmental psychobiology and response to threats: Relevance to trauma in children and adolescents. *Biological Psychiatry, 53*, 796–808.

Streit, M., Ioannides, A.A., Liu, L. *et al.* (1999). Neurophysiological correlates of the recognition of facial expressions of emotion as revealed by magnetoencephalography. *Cognitive Brain Research, 7*, 481–491.

Terrazas, A. & McNaughton, B.L. (2000). Brain growth and the cognitive map. *Proceedings of the National Academy of Sciences USA, 97*(9), 4414–4416.

Judges' report

This was the eighth annual Student Writer Competition, sponsored by **The Psychologist**, the Research Board and the Professional Practice Board. We received 25 entries, down considerably on 2005; we hope this year's winners inspire more of you to give it a go next year! Articles were rated blind on quality of writing; clarity of argument; and accessibility, relevance and interest for **The Psychologist**'s audience. We hope you agree that the chosen winners score highly on all criteria. We thought that the winner in the undergraduate category presented a solid argument about the role of psychology in a topic that is interesting and important. The winner in the postgraduate category went to some lengths to address our audience, even adding in a bit of journalistic digging. The winners get an expenses-paid trip to the Society's London Lectures or Annual Conference. We look forward to all your entries next year.

Jon Sutton (Editor, The Psychologist)
Paul Redford (Chair, Psychologist Policy Committee)