Neuroscience and Wellbeing

Despite there being strong evidence that subjective wellbeing measures produce statistically significant and often highly informative results, due to their subjective nature there will always be some scepticism surrounding them. In order to help prove the doubters wrong, and to understand wellbeing better, neuroscientists and psychologists have started to investigate the relationship between our functional neuroanatomy and our sense of wellbeing. They've been making good progress too – although there is still some way to go before we can say we completely understand how different functions of our brain affect our wellbeing. The most encouraging results from the recent research has been evidence to show that through our own actions we can shape the connections of our brains to more positively affect our wellbeing. We have split this paper into three sections, with our aim being to give an overview of where we currently stand in our understanding of neuroscience and wellbeing. In section 1, we map out the main sections of the brain and discuss which areas are most related to wellbeing. In section 2, we discuss a few key concepts. And in section 3, we outline the main findings from the literature.

Mapping the brain

The 1960's saw the beginning of an age of 'Neuroscience'. Previously, neuroanatomists, neurophysiologists, psychologists and neuropsychologists studied the brain separately, examining it from their approach and using differing terminology. 'Neuroscience' was born when these disciplines started working together and sharing their knowledge to understand the structure and function of the brain, both the normal and the abnormal.

To put into perspective how cool the brain is – it's a bundle of cells, like all the other organs in the body, but it's a bundle of cells that has sent man to the moon, performed awake operations on other brains, re-engineered genes and created Jay-Z's Black Album (Elliot's favourite). Let's go on a tour of these cells. Although there are well accepted areas of the brain that control certain things, it is important to note that these are not hard and fast. We're going to talk a lot about damaged brains, such as after traumatic brain injury or stroke, as these teach us so much about how the brain works. Each brain is unique, like our hands and faces, meaning that our mappings of abilities within and on the surface of the brain are not identical to one another.

Firstly, the brain is made of two hemispheres, the left and the right. Generally speaking, the left cerebral hemisphere controls the right of the body and the right controls the left. As a side note, some amazing evidence of evolution is how the muscles of the throat (pharynx) and voice box (larynx) are controlled. They have double sets of nerves, one coming from the left and splitting to control both sides of the laryngopharynx and one from the right, also controlling both sides. This double set of nerves means the airway and swallow is protected if one set of nerves are damaged. Humans have to breathe and swallow to survive. It is theorised we likely evolved this pattern of nerves, as those who didn't have this type would have died following a stroke or other assault (more likely a sabre-tooth tiger attack back in those days).

Anyway, we split these two hemispheres into four 'lobes' according to their unique functions: frontal, temporal, parietal and occipital. The frontal is sometimes referred as the 'human' part of the brain, as it helps us to read emotions, solve problems, plan, memorise, make judgements, inhibit sexual behaviours and order our language. It also orchestrates these behaviours, so we can use them in synchronisation to help us do a task. For example, we might be walking around the supermarket remembering what was on our shopping list, planning which aisle we want to go to next, reading the expression on the grizzly baby's face in the trolly next you, while reasoning between getting the basics tin of beans verses treating yourself to the branded tin of beans. The frontal lobe also holds the 'motor strip', which as the name suggests, controls motor movements on the opposite side of the body.

The temporal lobe is one of Jess's favourites. Here we process sounds, which are turned into electrical signals, read by the brain through the cochlear. We also distinguish sounds like, slamming a door or a dog barking, from speech sounds, in this part of the brain. On the left side (in most cases – some people have their dominant hemisphere swapped) we have the verbal expression of language. People with damage to this part (traditionally called Broca's area) can have 'aphasia', characterised by difficulty finding and saying the word they want to use, or maybe saying words that are similar, such as 'sack' for 'tea bag'. These people usually have quite non-fluent speech with many

pauses or fillers like 'um', 'er', 'hmmm'. Importantly – they usually can understand language well. We also know our knowledge of words is stored here because of a rare type of dementia called Primary Progressive Aphasia (PPA). Dementia is caused by brain atrophy – the cells in the brain reduce in size and in their connections between one another. Because of the atrophy we see in PPA is localised to the temporal lobe, we see words disappear from the persons knowledge. They may own a cat, but the word cat may one day disappear. Because it has gone from existence in the brain, the person doesn't know that they ever knew the label for the hairy four-legged creature sitting in their window. They have to re-learn these labels, which unfortunately hasn't been proven successful.

The parietal lobe holds the 'sensory strip', neighbouring the motor strip but instead giving the brain feedback about sensation. It also processes and conceptualises visual information, language and importantly mathematics. On the left side again, someone with damage here (specifically in the Wernike's area) will often have difficulty understanding language, but will be able to talk fluently, sometimes in jibberish, sometimes with real words. Because of their understanding difficulties, they can't usually understand themselves, so are unaware they are not making sense.

Finally, the occipital lobe. Here visual information is processed and understood correctly. Damage here may cause people to neglect half of their vision, such as reading one half of a word, or not knowing where a sentence finishes on a page. They may also acquire Charles Bonnet syndrome; visual hallucinations of repetitive patterns, faces, people, animals, objects and/or landscapes in both colour and black and white.

We have now covered the four lobes of the brain. The last part of our mapping process looks at areas of the brain that we are most interested in as happiness economists. We mentioned a study in a previous article that investigated the relationship between grey matter volume and subjective happiness measures. The researchers focussed on the part of the brain called the precuneus, known to play an important role in consciousness, our sense of self and consequently, happiness. The researchers found that those who scored highly on the happiness survey – feeling joy more intensely and sadness mildly – exhibited significantly more grey of matter on this part of their brain, than those with lower scores. So, this is one area that we will look to focus on. Another important area of focus is the connection between the Amygdala and the medial prefrontal cortex (MPFC), which is the brain circuit that is relevant for emotion regulation. The Amygdala is deep into the brain and is seen as a command centre that mobilises the body to a frightening stimulus – the fight or flight syndrome. Raw emotions are triggered from here and are often done so sub-consciously.

Our conscious experience is more linked to our frontal lobes than the deeper parts of our brains. Typical neuroscience studies involve putting electrodes all over the scalp and reading the electrical activity. These measurements are then related to the feelings people report. Positive emotions lead to more activity in the left front side of the brain and negative emotions lead to more activity in the right front side of the brain. These studies have shown there is a direct connection between brain activity and mood. People whose left-side is especially active ("left-siders") report more positive feelings and memories than "right-siders" do. This research can and has been providing objective evidence to support previously completed subjective wellbeing studies. This is the future and its looking like a left-siders brain.

Key concepts for neuroscience and wellbeing

Before we discuss how neuroscience and wellbeing can relate to one another, we will to start with a couple of key concepts. The first is 'neuroplasticity', also known as brain plasticity and it is defined as the ability of the brain to form and reorganize synaptic connections, especially in response to learning or following injury. Neuroplasticity can offer hope to everyone from stroke victims to dyslexics, or even happiness economists. Neuroscience research has shown that many aspects of the brain can be altered (or are "plastic"), and even through to adulthood. Although, the developing brain has been shown to exhibit a higher degree of plasticity than the adult brain. This is very encouraging news for anyone interested in wellbeing. Most of the time our brains are being shaped subconsciously but through training we can do more to affect how our brains function than we previously thought. For example, Richard Davidson – a very famous neuroscientist who has led experiments in co-operation with the Dalai Lama – has shown that meditation or mindfulness training can lead to changes in the physical structure of the brain, in areas that are associated with higher wellbeing. Much more on this later.

The second key concept that we want to introduce is "epigenetics" – the literal meaning for this is 'above genetics' – as it does not refer to a change in a person's DNA but rather how much or whether some genes are expressed in different cells in your body. Over the course of a person's life recent research has shown that epigenetics change based on a person's experiences or life choices, for example by eating a bad diet or choosing to smoke. Even more interesting than this, recent research is starting to prove that these effects can also be hereditary. Consequently, choosing to smoke will not only affect your own epigenetics but it will also affect your children's too.

What we currently know about neuroscience and wellbeing

So why are these two concepts interesting for a happiness economist? The main answer is that they show that through our own actions we can produce objective results on our mind and body. This is more than just how particular life events affect a person's self-reported subjective happiness score. This research shows how these events produce tangible outcomes that are measureable. Below we have split this into four broad topic areas to discuss some recent studies that support this hypothesis and also papers that we found particularly interesting:

1. Resilience: this is a vital skill that is thought to be developed through meditation training. To be clear, by resilience we mean the ability to improve mood and emotion regulation. For example, by responding to extreme emotions (positive or negative) less, suggesting a person has developed robustness and stability. A study completed by Kral et al. (2018) evaluated the impact of long and short-term mindfulness meditation training on the amygdala response to emotional pictures in a healthy, non-clinical population of adults using magnetic brain imaging. Long-term meditators (N = 30, 16 female) had 9081 hours of lifetime practice on average, primarily in mindfulness meditation. Short-term training consisted of an 8-week Mindfulness Based Stress Reduction (MBSR) course (N = 32, 22 female), which was compared to an active control condition (N = 35, 19 female) in a randomized controlled trial.

   The researchers found there was a greater difference in the results for the long-term meditators with the control group, than there was for the short-term meditators. For those on the MBSR course they found less amygdala reactivity to positive pictures relative to controls, but there were no group differences in response to negative pictures. Reductions in reactivity to negative stimuli may require more meditation experience or concentrated practice, as hours of retreat practice in long-term meditators was associated with lower amygdala reactivity to negative pictures.

   Short-term training, compared to the control intervention, also led to increased functional connectivity between the amygdala and the MPFC – during affective pictures. Thus, meditation training may improve affective responding through reduced amygdala reactivity. And heightened amygdala–MPFC connectivity during affective stimuli may reflect a potential mechanism by which MBSR exerts beneficial effects on emotion regulation ability.

2. Attentiveness: the research relating to attentiveness is really very simple but also just as encouraging as what we've seen before. Essentially the message is that we have the capacity to regulate our attention, it is something that can be educated, and this will help to develop all other forms of learning too. An interesting paper was written in 2010, titled "A wandering mind is an unhappy mind", written by Matthew Killingsworth and Daniel Gilbert. They developed an app to create an extremely large database of real-time reports of thoughts, feelings and actions of a broad range of people as they went about their daily lives. The database contains responses from 5000 people across 83 countries, ranging from 18 to 88 years old and this group have produced more than 250,000 responses.

   The respondents were asked the following three questions each time they opened the app: (i) how are you feeling right now? (on a scale from 0-100); (ii) what are you doing right now? (with 22 activities to choose from); and (iii) are you thinking about something other than what you're currently doing? (four answers: no; yes, something pleasant; yes, something neutral; yes, something unpleasant).

   There were three main findings from their research. First, people's minds wander frequently, regardless of what they are doing. Mind wandering occurred in 46.9% of the samples and in at least 30% of the time during every activity except making love. Second, people are less happy when their minds are wandering

than when they are not. And third, what people were thinking about was a better predictor of their happiness than what they were actually doing at the time.

Now this is all good and well, but I am sure some of you are questioning what this has to do with neuroscience. The answer is that this particular has nothing to do with neuroscience. But it does show that not being attentive is negative for a person's wellbeing or happiness. Therefore, recent evidence produced in neuroscience research is highly encouraging for developing wellbeing. For example, Lutz et al (2009) shows that mental training can significantly affect attention and brain control. So, the conclusion here is if you can train your mind to wander less, this can only be good for your wellbeing.

3. Connection: relationships with either friends, work colleagues, family or romantic partners are one of the most important determinants of whether a person can achieve happiness. The ability to understand emotional experiences of others, empathy, is an important skill for effective social interactions and allows a person to develop deeper personal relationships. An extremely interesting and unique study was completed last year to test how training empathy in adolescents impacts their brain circuits. The authors of the paper created their own video game (not joking), called Crystals of Kaydor and investigated whether playing the game increased empathic accuracy and related brain activation in adolescents (N=74; 27 female; age range 11-14 years). The authors found that connectivity in empathy-related brain circuits was stronger after gameplay and that the training produced behaviourally-relevant, functional neural changes in the brain. In addition, the greater an individual's empathy accuracy increased, the stronger their connectivity in brain circuits relevant for emotion regulation was.

4. Purpose: psychologists have believed for a long time that the two main key ingredients needed for a happy life are pleasure and meaning. More recently, positive psychologists have looked to add a third ingredient, eudemonia, which essentially relates to feeling worthwhile. Our view is that purpose could fit into either meaning or eudemonia, but we agree that its certainly important. There are two studies that caught our eye on this topic. The first study by Boyle et al. (2009) used data for 1238 older persons and found that a greater purpose in life is associated with a reduced risk of mortality, holding all else constant. They used life evaluation surveys over a 5-year period and controlled for a large number of variables that will have also impacted the result. So, maybe having something to live for really does make a difference to us. Clearly causation in this study could be an issue but the result is interesting nevertheless.

   More related to neuroscience, the paper from Shaefer et al. (2013), found that purpose in life can predict a better recovery from negative stimuli. In a large sample of adults (aged 36-84 years) the authors tested whether purpose in life was associated with better emotional recovery following exposure to negative picture stimuli indexed by the magnitude of the eyeblink startle reflex (EBR), a measure sensitive to emotional state. Greater purpose, assessed over two years prior, predicted better recovery from negative stimuli indexed by a smaller eyeblink after negative pictures offset, even after controlling for initial reactivity to the stimuli during the picture presentation, gender, age, trait affect, and other well-being dimensions.

References

Andrew Octavian Sasmita, Joshua Kuruvilla & Anna Pick Kiong Ling (2018) *Harnessing neuroplasticity: modern approaches and clinical future*, International Journal of Neuroscience, 128:11, 1061-1077.

Antoine Lutz, Lawrence L. Greischar, Nancy B. Rawlings, Matthieu Ricard, Richard J. Davidson (2004). *Long-term meditators self-induce high-amplitude gamma synchrony during mental practice*. Proceedings of the National Academy of Sciences Nov 2004, 101 (46) 16369-16373

Darity, William and Goldsmith, Arthur (1996). *Social psychology, Unemployment and Macroeconomics.* Journal of Economic Perspectives. 10(1): 121-40.

Diener, E. and Lucas, R.E. (1999). *'Personality and subjective well-being'*, in Kahneman et al. (1999) chapter 11.

Diener, Ed & Suh, Eunkook & E. Lucas, Richard & L. Smith, Heidi. (1999). *Subjective Well-Being: Three Decades of Progress*. Psychological Bulletin. 125. 276-302. 10.1037/0033-2909.125.2.276.

Dolan, Paul and Metcalfe, Robert (2012) *Measuring subjective wellbeing: recommendations on measures for use by national governments.* Journal of social policy, 41 (2), pp. 409-427.

Hensch, T. K., & Bilimoria, P. M. (2012). *Re-opening Windows: Manipulating Critical Periods for Brain Development. Cerebrum*, The Dana forum on brain science, 2012, 11.

Killingsworth, M. A., and D. T. Gilbert. 2010. *A Wandering Mind Is an Unhappy Mind.* Science 330 (6006) (November 11): 932–932.

Kral, T .R. A., Schuyler, B. S., Mumford, J. A., Rosenkranz, M. A., Lutz, A., & Davidson, R. J. (2018*). Impact of short- and long-term mindfulness meditation training on amygdala reactivity to emotional stimuli.* NeuroImage, 181, 301-13.

Kral, T. R. A., Stodola, D. E., Birn, R. M., Mumford, J. A., Solis, E., Flook, L., Patsenko, E. G., Anderson, C. G., Steinkuehler, C., & Davidson, R. J. (2018). *Neural correlates of video game empathy training in adolescents: A randomized trial.* npj Science of Learning, *3*(13), 1-10.

Layard, Richard. (2011). *Happiness: lessons from a new science*. New York, N.Y: Penguin.

Lutz, A., Slagter, H., Rawling, N., Francis, A., Greischar, L. L., & Davidson, R. J. (2009). *Mental training enhances attentional stability: Neural and behavioural evidence.* Journal of Neuroscience, 29*(42), 13418 –13427.*

Sato et. al. (2015). *The structural neural substrate of subjective happiness.* Scientific Reports volume 5, Article number: 16891.

Schaefer, S. M., Boylan J. M., van Reekum C. M., Lapate R. C., Norris C. J., Ryff C. D., & Davidson R. J. (2013*). Purpose in life predicts better emotional recovery from negative stimuli. PLoS ONE*, *8*(11), e80329.

Terry Hyland (2016) *Mindful Nation UK* – Report by the Mindfulness All-Party Parliamentary Group (MAPPG), Journal of Vocational Education & Training, 68:1, 133-136.

Weng, H. Y., Fox, A.S., Hessenthaler, H. C., Stodola, D. E., & Davidson, R. J. (2015). *The role of compassion in altruistic helping and punishment behavior. PLoS ONE,*10(12), e0143794.