The Neuroscience of Spirituality

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Introduction

This article is the text of a presentation which was given at the Royal College of psychiatrists on 4 March 2011. The first paper, by Dr Ian McGilchrist, reviewed the divided brain, and the second paper, by Canon Andrew Shanks, dealt with the philosophy of Hegel and pointers in the story of the divided brain which helped explain and enlarge some Hegelian concepts. The aim of this, the third paper was to look at new research related to spirituality and to see what cerebral structures are activated in neuroimaging during the very wide feelings of mystical experience and the practice of meditation.

The definition of spirituality which was used was that suggested by the consensus conference on 'Improving the quality of spiritual care as a dimension of palliative care': 'the aspect of humanity that refers to the way individuals seek and express meaning and purpose and the way they experience their connectedness to the moment, to self, to others, to Nature, and to the significant or sacred'. This definition of spirituality was used throughout the presentation.

Mystical and Religious Experiences

Mystical and religious experiences have occurred in all cultures and in all ages. They clearly use brain-based mechanisms but the fact that the brain is involved does not in any way devalue 'God consciousness'. Imaging studies only give correlates; these are not causative but simply vary in parallel with the subjective experiences being studied. Hay and co-workers in 2002 reported on the frequency of religious or spiritual experiences in Britain in those not attending church, for the years 1987 to 2000. Their questionnaire was a comprehensive one and it showed that there was a decreased awareness of the presence of God since 1987 although the awareness that prayer was answered, the awareness of a sacred presence in Nature and the awareness of the presence of the dead had all increased. The awareness of the presence of God had however decreased from 27% to 8%. This study clearly shows that religious and transcendent experiences are very common in the population, but increasingly not attributed to God.

Thetis Blacker

Thetis Blacker, one of the leading religious painters in the UK, had a transcendent experience in her early 20s. She claimed that this experience, which was extremely powerful, significantly influenced her future painting career. During the experience Thetis was walking in the countryside when suddenly the mystical experience dawned. She felt that love and light interpenetrated even the smallest aspects of the materiality of the universe, that she understood the beginning and end of all things

and she felt as if the wind, (there was none), was brushing against her face like the flames she had read of in Pentecost. The whole experience was composed of universal love and light and must have lasted about one hour. She tried to write the experience down after it had happened but as she says, ‘there were no words’.

This experience led to religious themes in her painting, using the method of batik. She was a highly successful artist. Banners painted by Thetis are hung in Winchester Cathedral throughout the long nave, at certain times of the year. The Phoenix has always been an important symbol of spiritual renewal for Thetis, and a large Phoenix has its place in an Oxford college. I knew Thetis well and, after she had developed cancer, we agreed that I would contact her shortly before her death. We discussed her mental state about a week before she died; she described golden rivers of light and love which flowed through her room and which she could see out of the window.

Brain function and belief

One of the latest fashions in neuroimaging is looking at different groups of people to see whether their brain function reflects their beliefs. This has had some success amongst political groupings. In 2010 Lorenza et al. carried out a study looking at perceptual styles among different religious groups. They used a perceptual test which measured whether the subjects were able to extract the local or the global contours of a pattern preferentially. They found that Jews and Catholics were quicker with the more global styles while secular people were found to be quicker with the local. They argued that this was because of the greater social structure of the Jewish and Catholic groups. Atheists had a higher global style compared to conservative Calvinists and again the authors argued for the atheists requiring a much larger social group for their support rather than the individualistic emphasis of the Calvinists. This means, the authors claimed, that deeply held belief altered cerebral function.

Spirituality and health

Many studies have shown the positive and transformative effects on health of religious or spiritual experiences or practice. I will not review this area as I know the Special Interest Group has already had several meetings on this subject. Its importance is shown by the study by Koenig et al. in 1999 on the survival rate of around 4000 people aged 65 and over during a six-year period. They showed that those who went to Church once or more a week were likely to live about 10 years longer than those who did not. There has been much discussion as to why religion should protect believers from mental illness and why they should be healthy. This is not a question for this afternoon but I do want to focus on one aspect of this area which is the way that the immune system is affected by spiritual beliefs.

Stress

In summary, stress mediated by the frontal lobes of the brain stimulates the hypothalamus, which releases corticotrophin releasing hormone, and this leads the pituitary gland to secrete ACTH which stimulates the adrenal gland to release cortisol. Cortisol is a stress hormone and high levels of it lead to anxiety and depression but it is also an important hormone as it acts with the immune system modifying the immune cell profiles. These immune cell profiles feedback via the cytokine system onto the hypothalamus and thus modify the cortisol cycle. This system shows that the brain is very sensitive to immune system changes. One paper shows that after their spouse's death, a number of subjects developed cancer: those who did had a high traumatic grief score. Thus mental state is important in determining the likelihood of developing a cancer. The opposite is also true. Uchino et al. in 1996 carried out a review of studies which looked at immune functioning and social support. Their review showed that in groups that had social support, improved immune functioning, more stable cardiovascular systems and reduced cortisol levels were found. Thus there is clear evidence of mental state and support being very important in maintaining physical health.

Empathy

A recent paper by Heine and Singer 2008, 'I feel how you feel but not always: the empathic brain and its modulation' reviews the latest neuro-imaging studies on the effects of empathy on brain function. They define empathy as 'the ability to share the other's feelings…' And they review converging evidence that empathy with, for example, the pain of another person, activates part of the neuronal pain network of the empathiser, without first-hand pain stimulation to the empathiser's body. They continue, 'the amplitude of empathic brain response is modulated by the intensity of the displayed emotion, the appraisal of the situation, characteristics of the suffering person such as perceived fairness, and features of the empathiser such as gender or previous experience with pain inflicting situations.'

They note two dimensions to empathy. The cognitive perspective is taken as the ability to understand intentions, desires and beliefs of another person, resulting from (cognitive) reasoning about the other's state; the other dimension is that of feeling, and here empathy is defined as an affective state, caused by sharing of the emotions or sensory states of another person. The imaging results show that the anterior cingulate cortex, the anterior insular and the secondary somatosensory cortex are all activated in empathic situations. These areas are seen in response to pain, disgust, taste, or touch. Cognitive understanding leads to stimulation of the left temporal pole, the left superior temporal sulcus, and the left temporal parietal junction. There is also some activation in the medial frontal cortex on the right.

The take-home message from this paper is that empathy causes specific activity in the nervous system of the person who is showing empathy. There is thus internalised brain activity of the other's mental state. Your body language is internalised by others and changes their brain function, so don't fill their lives with negativity, if possible be happy and joyful! We are not islands but very closely interconnected by the linking of one person's affect directly to another's brain.

Finally, and of significant import, is the observation that the reward circuits are activated when empathy is felt. The empathic person receives a strong reward. So to reiterate, it matters what you think and how you are supported.

Meditation

Meditation can be defined as a spiritual practice undertaken for its positive effects on both the behaviour and mental state of the meditator. The question for neuroimaging is whether there are specific brain changes which accompany meditation or whether the experienced benefits of the meditator are simply 'imagination'. There have now been a number of papers looking at different methods of meditation and at different aspects of the technique. However in 2010 a review paper was published on 'The neural substrates of mindfulness: an fMRI investigation' by Ives-Deliperi et al. They were able to show that there was a network of areas all close to the midline, which responded during the meditation with a significant signal *decrease*. The main areas were the anterior insular, the left ventral and anterior cingulate cortex, the right medial pre-frontal cortex, and the bilateral precuneus. The anterior insular is an area that plays a key role in the experience of emotion by processing convergent information to produce an emotionally relevant context for sensory experience. The left ventral and anterior cingulate cortex, with its posterior dorsal regions, has been shown to be associated with executive, evaluative and cognitive functions respectively; the ventral area plays a central role in emotion. The right medial pre-frontal cortex is involved in processing and evaluating self-referential stimuli and judgement of emotional stimulation. The precuneus is another region that is influential in self-referential thought or first person perspective and, more generally, processing and integrating self-referential stimuli. This paper suggests a network of central areas which are involved in meditation and most importantly that these *down-regulate* many of the areas dealing with self-referential thought or integration.

Brain size

Does meditation cause an increase in the size of the brain in specific areas? Further, does the number of years meditating affect brain size? A recent paper by Brita et al. in 2008 investigated these questions. They used mindfulness meditation practitioners, 20 meditators and 20 controls, and measured voxel-based morphometry. They found that meditation affected three distinct areas; the left inferior temporal gyrus, the right anterior insular and the right hippocampus. They noted that the temporal lobe has been implicated in religious activity and mystical experiences; also that all these areas were essentially temporal and thus could relate to the feelings of mystical experience in the meditation sessions that had led to brain growth in these areas. They next asked whether there was a correlation between the growth of different brain areas and the length of meditation practice. They found one specific area in the medial orbital frontal cortex, which correlated with the total hours of meditation training. They argued that the orbital frontal cortex played a crucial role in emotion regulation by down-regulating the activity of the amygdala. They also pointed out that the medial orbital frontal cortex is directly involved with extinction retention after fear conditioning and suggested that the

increase in size in this area might explain the improved ability of meditators to modify their emotional responses. They noted that Saver and Rabin (1997) agreed with the possibility of temporal structures being involved, although these authors' mechanistic view was commented on.

Brain electrical activity

An old but important paper by Aftanas and Golocheikine (2001) looked at the electrical changes of the brain by means of the EEG during Sahaja Yoga meditation. They examined 11 short-term meditators with about half a year's experience and compared these with 16 long-term meditators who had 3 to 7 years of experience. The meditation session took over an hour, with an introductory phase, an hour-long session of thoughtless awareness and feelings of bliss, then an outgoing phase. They showed that the short-term meditators were very little different from controls in their resting EEGs. They also showed that long-term meditators had increased theta and alpha activity centrally and frontally. At the height of the session there was a change in coherence (coherence is another word for frequency correlation coefficient) in the brains of the long term meditators, who showed a controlling area in the left anterior frontal region and a high coherence with many other areas more posteriorly and within both hemispheres.

Most importantly, they also found that at the time of the appearance of the experience of bliss, high power in the theta band was seen frontally, and this was also seen in states with reduced appearance of thoughts. There is thus a close relationship between the meditators experience of bliss and thoughtlessness and the EEG picture. This interestingly supports the notion of a role for the left frontal region in intense emotion and in states of attention.

Lesion studies

A study by Urgesi et al. in 2010 looked at the release phenomena related to transcendence that occurred in the brain after it had been damaged. They took 24 patients each with high and low grade gliomas, 20 patients with recurrent gliomas and 20 patients with brain meningiomas. With neuroimaging they studied the distribution of the tumours and so were able to obtain a measure of the areas of the brain which had been damaged. They correlated these damaged brain areas with a self- transcendence score which came from a self-rated self-transcendence scale. They predicted that neural activation of a large fronto-parieto-temporal network may underpin a variety of spiritual experiences. They found that there was a high correlation between transcendence scores and the left inferior parietal lobule as well as the right angular gyrus. They suggest that their results hint at the role of left and right parietal systems becoming activated in the experience of self transcendence. They also add, interestingly, that alterations in religious attitudes and behaviours in neurological and mental disorders may occur if these structures are damaged.

The neural correlates of mystical experiences in Carmelite nuns

Beauregard and Paquette (2006) imaged brain activity of 15 Carmelite nuns while they were experiencing the feelings they had whilst recalling the memory of intense meditation. The meditation, they said, led to a sense of having touched the ultimate ground of reality, experience of timelessness and spacelessness, feelings of positive affect, peace, joy and unconditional love and finally a sense of union with humankind and the universe. The results of the imaging again showed a predominantly mid-line network of areas, the left dorsal anterior cingulate cortex reflecting emotional awareness and the left brainstem associated with somato-viseral changes from the feelings of joy and unconditional love. The right middle temporal area was related to impressions of a spiritual reality, while the left insular activation was associated with feelings of joy and unconditional love. Posteriorly, occipital sites were probably activated by visual mental imagery while the caudate nucleus was also linked to feelings of joy and love. The inferior parietal lobules related to the dissolving of the body image in the mystical condition and this was also seen as involving the right superior parietal lobule. There was thus evidence that the structures activated by this meditation technique reflected the experiences of the nuns. It adds further support to there being special brain networks which are involved in meditation, and that some of these are down regulated as in mindfulness meditation while others are activated as shown in the above compassion meditation.

There is thus the beginning of a definite neuroscience of spirituality and spiritual experience with the highlighting of a network of structures within the brain which are involved in these important spiritual exercises.

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