Acupuncture and brain imaging: what do we have to consider?

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Advances in functional neuroimaging techniques have made it possible to study both the neuroanatomical and neurophysiological responses associated with acupuncture. An impressive body of literature has identified a distributed network of brain activity that is evoked by stimulation with acupuncture needles and is subject to considerable modulation by a variety of stimulus parameters, contextual factors and clinical conditions.1 2 Several studies have documented that stimulation of various acupuncture points elicits overlapping brain responses in a number of cortical and subcortical brain regions, including activation in the sensorimotor cortical network (the insula, thalamus, anterior cingulate cortex and primary and secondary somatosensory cortices) and deactivation in the limbic-paralimbic-neocortical network (the medial prefrontal cortex, caudate, amygdala, posterior cingulate cortex and parahippocampus).3–5 These distributed brain areas are closely associated with a wider pain matrix that is responsible for modulating both the sensation of pain and affective pain perception.6

When a needle is inserted into the body and manipulated, it usually evokes a painful sensation. The combination of simultaneously evoking pain and producing analgesia is a unique characteristic of acupuncture treatment. There are substantial overlaps in the pain matrix within the brain networks associated with both ordinary pain stimulation and acupuncture needle stimulation.7 A recent meta-analysis of functional MRI (fMRI) studies revealed common activation patterns in the sensorimotor cortical network and deactivation patterns in the limbic-paralimbic-neocortical network following acupuncture needle stimulation.8 The brain haemodynamic responses to acupuncture stimulation reflect sensory-discriminative and also cognitive and affective dimensions of pain. The activation and deactivation patterns that are specific to acupuncture stimulation alone are still a matter of debate. Interfering factors such as pain or emotion during acupuncture are considered to contribute, at least in part, to the pattern of brain activity. Thus, it is difficult to dissociate the neural substrates of the acupuncture efficacy-associated component from the painful sensation-associated component during acupuncture stimulation in a block-designed fMRI.

Acupuncture treatment has both immediate and cumulative effects, but the block design of an fMRI study is insufficient to see any cumulative effect. Because the exact duration of the post-effect is unknown, it requires enough recovery time between each block in fMRI experiments. Recently, the resting-state design has been considered a new strategy in acupuncture research to overcome these limitations. A new method, regional homogeneity (ReHo), has been developed to analyse the blood oxygen level-dependent signal of the brain in the resting state.9 It assumes that voxels within a functional brain area are more homogeneous temporally when this area is involved in a specific condition. Using ReHo methods, the brain region activated following acupuncture point stimulation is the ipsilateral pain-related brain region which may be related to the therapeutic effect of acupuncture on pain relief.10 Amplitude measures such as amplitude of low-frequency fluctuation (ALFF) have proved to be a reliable means of assessing local brain activity and have also been used to investigate various clinical disorders.11 12 Using ALFF methods, a previous study showed that acupuncture at PC6 could change the amplitude of the intrinsic cortical activity of the brain, suggesting that acupuncture could potentially affect both psychiatric and neurological disorders.13

Efforts have been made to provide scientific support for the sustained effect of acupuncture treatment, and the recent article by Zheng et al aims to observe the activation/deactivation of cerebral functional regions after 30 min of electroacupuncture at EX-HN5 and GV20 using ReHo and ALFF methods.14 Electroacupuncture showed brain responses in the frontal cortex, the cingulate cortex and the cerebellum using a resting-state fMRI design. Although this study appeared to have a new scientific design and its results seemed to provide evidence that acupuncture stimulation at EX-HN5 and GV20 could change psychiatric disorder-related cerebral functional regions, several questions arise. First, the researchers only demonstrated brain changes 5 and 15 min after acupuncture needle removal, with no control group. This raises the concern that these activation/deactivation patterns after acupuncture stimulation might be derived from other confounding factors such as non-specific factors or participant fatigue, not just acupuncture stimulation. Second, the authors suggested that the changes in those brain areas accompanying electroacupuncture stimulation might bring about psychiatric and emotional adjustments. Although discussing the clinical implications of a scientific experimental study is important, the question of clinical efficacy cannot be finally answered by such an experimental study.

The logical question is whether acupuncture stimulation (and its therapeutic effects), defined as inserting a needle into the body, can be specifically linked to the activations and deactivations that occur in the brain network following insertion of the needle. To explore the neural responses to acupuncture-specific stimulation, it is necessary to investigate the neural responses to other
types of stimulation that can serve as appropriate control stimuli. However, finding appropriate controls for acupunctural stimuli is actually a far more complex problem than it might initially appear, for three major reasons. First, it is thought that acupuncture treatment is only effective when specifically defined acupuncture points are stimulated, but opinions differ regarding the exact sets of points that constitute appropriate acupuncture points or non-acupuncture points (‘acupuncture point specificity’). Second, fundamentally different stimulation methods exist that could lead to different results, such as minimal acupuncture, laser acupuncture and electroacupuncture (‘different stimulation methods’). Finally, various contextual and interfering factors such as expectations and emotions are thought to contribute, at least in part, to the patterns of brain activity that have been measured during acupunctural stimulation in neuroimaging studies (‘non-specific effects’).

Before we implement a new neuroimaging technique in acupuncture research, we should understand the characteristics of the experimental design and conduct appropriate statistical analyses. Further studies are needed to determine the associations between changes in brain response patterns to acupuncture and the therapeutic effects of acupuncture across different disorders.

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