Acupuncture-stimulated Auditory-cortical Activation observed by fMRI – A case of Acupoint SJ5 Stimulation

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Introduction

Recently, functional Magnetic Resonance Imaging (fMRI) has been used to visualize many classes of behavior of the human brain by visualizing changes in blood oxygenation and the related regional Cerebral Blood Flow (rCBF) with high temporal resolution from a few seconds to minutes. In the brain, blood deoxygenation and oxygenation as well as rCBF are presumably related to neural activity measurable by fMRI and PET which can measure brain activity when subjects perform specific tasks or are exposed to specific stimuli.

Recent studies we performed with fMRI revealed that there is a strong correlation between acupoint stimulation and activation of its corresponding cortical area. As they have been reported, a vision-related acupoint (BL67) is located in the lateral aspect of the foot, and when the acupoint stimulation is performed there, the activation of the occipital lobes was observed by fMRI. In this paper we have verified another auditory-related acupoint by using fMRI, namely acupoint SJ5 (Waiguan : known as on Triple Energizer Meridian Channel), which is believed to be an effective acupoint to treat ear-related disorders, such as tinnitus (ringing) in the ear and deafness. [1-2]

Methods

Experiments were carried out using multi-slice gradient-echo EPI on a standard clinical GE 1.5 T Signa MRI system. Sixteen healthy human volunteers were studied for both acupuncture and auditory stimulations. For each fMRI experiment, spin-echo T_1-weighted images were obtained as the reference anatomical image set of the whole brain. For the experimental study, a repetition time of 3 sec., an echo time of 50 msec., a flip angle of 90^o, a Field of View (FOV) of 260 mm, a slice thickness of 10 mm, and a matrix size of 128×128 were used. Eight slices were acquired within one repetition time and 60 sequential time-series images were obtained.

For direct auditory stimulation, light music was played, which was turned "on" and "off" for 60 seconds each for the auditory stimulation paradigm. For the acupuncture stimulation, we used electro-acupuncture and inserted the electric acupuncture needle into the SJ5 point on the Triple Energizer Meridian Channel located in the left arm (see Fig. 1(a)). The acupoint (SJ5) is known as a treatment point for ear-disorders. The stimulation paradigm of acupuncture was made the same as the auditory stimulation, i.e., the electric acupuncture (wide range of frequences from the low of 2-3 Hz to as high as 1KHz by sweeping from low to high frequency) was turned "on" and 'off" for a period of 60 seconds for each stimulation paradigm. The results of the acupoint stimulation were then compared with the auditory stimulation experiment.

Signal processing of data was carried out by using the standard correlation coefficient method for each pixel with a box-car waveform as a reference [3].

Experimental Results

The first three representative slices (the IIIth, IVth, and Vth slices) among the eight slices were selected for demonstration of the correlation of cortical activation between conventional auditory stimulation and acupuncture stimulation of acupoint SJ5. Results of selected representative activation are shown in Fig. 1(b) and (c) for simple auditory stimulation and acupuncture stimulation of acupoint SJ5. Among the 16 volunteers, only 8 volunteers showed cortical activation during acupuncture stimulation. In Fig.2, eight averaged or overlayed cortical activation images of four selected slices for the conventional auditory stimulation and acupoint stimulation of acupoint SJ5, respectively, are shown for demonstration. In the lower part of Fig.2, a set of corresponding image templates with related cortical areas, including auditory cortex, are shown for reference. Quite remarkable correspondence is seen between direct auditory stimulation and acupuncture stimulation of SJ5 for slices III, IV, and V. In addition, for acupuncture stimulation we have seen substantial activation in the areas of the anterior cingulate gyrus (Brodmann's areas 32 and 24) and, although it is not statistical significant, we observed small noticeable activation in the left frontal lobe in slice VI of the acupuncture stimulation (see Fig. 2(b)). It is interesting to observe that acupuncture stimulation affected higher centers of the Central Nervous System (CNS), both sensory cortices (auditory cortex), as well as the limbic system (anterior cingulate gyrus). The latter is believed to be the central cortical area related to survival of the organism (limbic areas).

It is unclear why acupuncture stimulation is not always reproducible. We believe, that there are several factors that could contribute to the reproducibility of acupuncture stimulation and its corresponding cortical activation. Some factors include the variability or uncertainty in choosing the accurate acupoint location, consistent and accurate stimulation by individual acupuncturists, and the variability of the peripheral nervous system of individual volunteers. If variability of the nervous system is the main cause of the uncertainty, more accurate localization of the peripheral nervous system would help. We are studying this problem with both the MRI neurography technique as well as the Optical Coherent Tomography technique for the location of the desired peripheral nerves.

Conclusions

The present study is a step toward understanding Oriental acupuncture in relationship to brain function of the CNS, which has largely been ignored in classical Oriental medicine. It also represents an important step toward understanding the pathways of brain activations by the peripheral nervous system of our body.

References

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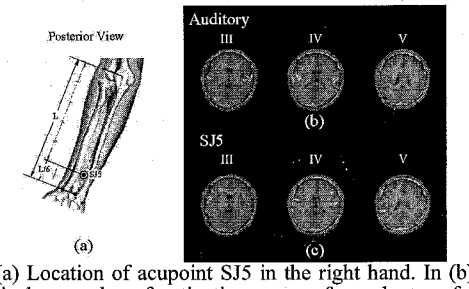

Fig. 1 (a) Location of acupoint SJ5 in the right hand. In (b) and (c), typical examples of activation maps of a volunteer for the three selected slice images obtained by direct auditory stimulation (b), and by acupuncture stimulation of the acupoint SJ5(c), respectively, are shown for reference.

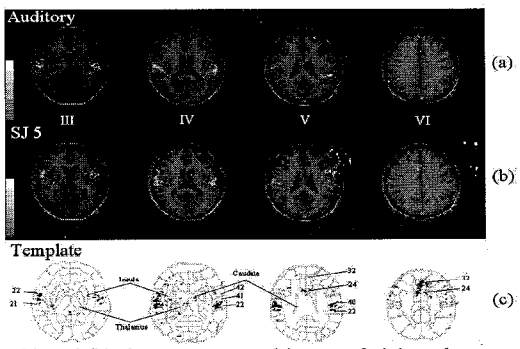

Fig. 2 (a) and (b) show an averaged image of eight volunteers of the auditory reference and acupuncture stimulation of SJ5, respectively. (c) Displays of a set of templates corresponding to the activation areas of interest are shown for reference.