

# Chapter 37

## Effects of Acupuncture on Anxiety Levels and Prefrontal Cortex Activity Measured by Near-Infrared Spectroscopy: A Pilot Study

K. Sakatani, M. Fujii, N. Takemura, and T. Hirayama

**Abstract** There is increasing evidence that acupuncture is useful in treating somatic and psychological disorders caused by stress; however, the physiological basis of the effect remains unclear. In the present study, we evaluated the effect of acupuncture on psychological conditions (i.e., anxiety) and prefrontal cortex (PFC) activity. We studied 10 patients with anxiety disorders and measured anxiety levels by means of the State-Trait Anxiety Inventory (STAI), including state anxiety (STAI-1) and trait anxiety (STAI-2). Employing a two-channel NIRS device, we measured oxy-Hb concentration in the bilateral PFC at rest, and evaluated asymmetry of the PFC activity by calculating the Laterality Index at Rest (LIR). The patients were treated by acupuncture at Yui Clinic in Osaka. The treatment significantly decreased the STAI-1 score ( $p < 0.001$ ), but not the STAI-2 score ( $p > 0.05$ ). The NIRS measurements indicated the presence of spontaneous oscillations of oxy-Hb in the bilateral PFC at rest before and after the treatment. Notably LIR decreased significantly in 7 out of the 10 subjects ( $p < 0.01$ ), while 3 subjects showed an increasing tendency. The present pilot study indicates that acupuncture is effective in decreasing anxiety levels in patients with anxiety disorders. Our NIRS data suggest that acupuncture may alter the balance of PFC activity at rest, resulting in relaxation effects. Our NIRS data suggest that acupuncture changes the

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balance of PFC activity toward left-dominant, resulting in relaxation effects on the patients.

**Keywords** Acupuncture • Depression • NIRS • Prefrontal cortex • Stress

## 1 Introduction

It has been reported that acupuncture is useful in treating various neuropsychological diseases. For example, acupuncture has been used for the treatment of depression [1]. In addition, it was reported that acupuncture at certain points could reduce stress responses of the autonomic nervous system [2, 3]. However, the neurobiological basis of these effects is not yet clear.

The prefrontal cortex (PFC) plays an important role in emotion. Interestingly, left/right asymmetry of PFC activity is correlated with specific emotional responses to mental stress and personality traits [4–6]. For example, negative emotional stimuli increase relative right-sided PFC activation [6], whereas induced positive affective stimuli elicit an opposite pattern of asymmetric activation [7]. In addition, a functional near-infrared spectroscopy (NIRS) study found that subjects with right-dominant activity at rest showed higher scores in the State-Trait Anxiety Inventory (STAI), while those with left-dominant activity at rest showed lower STAI scores. These results suggest that NIRS-measured asymmetry in PFC activity at the resting state can predict emotional state. In the present study, we employed NIRS to examine the effect of acupuncture on psychological state (i.e., anxiety) and prefrontal cortex (PFC) activity at rest in patients with anxiety disorders.

## 2 Methods

### 2.1 Subjects

We studied 10 patients (male 1, female 9, mean age  $41.8 \pm 6.8$  years) with anxiety disorders; anxiety levels were evaluated with the State-Trait Anxiety Inventory (STAI). The STAI assess state anxiety (STAI-1) and trait anxiety (STAI-2) separately; each type of anxiety has its own scale of 20 different questions that are scored. Scores range from 20 to 80, with higher scores correlating with greater anxiety. The patients were treated by acupuncture at Yui Acupuncture Clinic in Osaka. The following acupoints were used depending on the Traditional Chinese Medicine diagnosis of each patient: WHO-GV23, GV20, GV9, GV14, BL7, GV4, BL17, BL19, BL20, TE5, GB41, PC6, and SP4. The stimulation method was needle retention for 15 min. All subjects provided written informed consent as required by the Human Subjects Committee of Yui Acupuncture Clinic.

## 2.2 NIRS Measurements and Data Analysis

We employed NIRS to evaluate the asymmetry of PFC activity at rest, as in our previous study [8]. Briefly, oxy- and deoxy-Hb concentration changes in the bilateral PFC at rest were measured with a two-channel NIRS (PNIRS-10, Hamamatsu Photonics, Japan). The NIRS probes were set symmetrically on the forehead. The distance between the emitter and detector was set at 3 cm. Changes in t-Hb and oxy-Hb reflect changes in cerebral blood volume and flow, respectively [9, 10]

In order to analyze left/right asymmetry of PFC activity at rest, we calculated the laterality scores [8]. Consider

$$\Delta oxyR_{\min} = \min_{t \in \text{analysis interval}} \Delta oxyR_t \quad (37.1)$$

$$\Delta oxyL_{\min} = \min_{t \in \text{analysis interval}} \Delta oxyL_t \quad (37.2)$$

where  $\Delta oxyR_t$  and  $\Delta oxyL_t$  denote oxy-Hb concentration changes of the right and the left PFC. The quantities defined by Eqs. (37.1) and (37.2) are the variations with respect to their minimum values, so that they are always non-negative. Based on these quantities, we defined the *Laterality Index at Rest (LIR)* as follows:

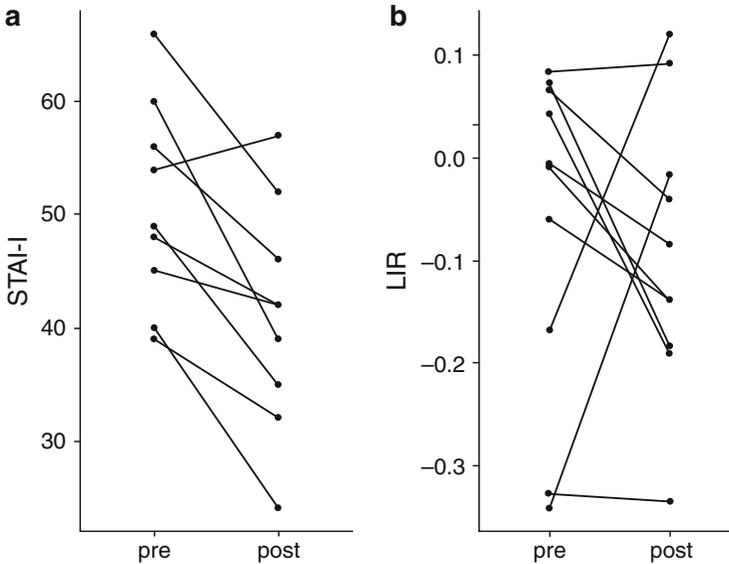
$$LIR = \frac{\sum_{t \in \text{analysis interval}} ((\Delta oxyR_t - \Delta oxyR_{\min}) - (\Delta oxyL_t - \Delta oxyL_{\min}))}{\sum_{t \in \text{analysis interval}} ((\Delta oxyR_t - \Delta oxyR_{\min}) + (\Delta oxyL_t - \Delta oxyL_{\min}))} \quad (37.3)$$

The numerator of (37.3) consists of the difference between oxy-Hb concentration changes of the right and the left PFC summed over the analysis period (3 min). The index defined by Eq. (37.3) provides values in the range of  $[-1, +1]$ . A positive LIR indicates that the right PFC is more active at rest than the left PFC, while a negative LIR indicates that the left PFC is more active at rest than the right PFC. We previously found a positive correlation between LIR and STAI-1 (state anxiety) [8].

## 3 Results

All subjects exhibited fluctuations of oxy-Hb (reflecting neuronal activity) in the bilateral PFC at rest, both before and after acupuncture treatment. Acupuncture treatment significantly decreased the STAI-1 score from  $50.8 \pm 9.04$  to  $41.0 \pm 10.1$  ( $F(1,8) = 15.9$ ,  $p < 0.005$ ) (Fig. 37.1a). However, there was no significant effect on the STAI-2 score ( $p > 0.05$ ).

The NIRS measurements indicated the presence of spontaneous oscillations of oxy-Hb in the bilateral PFC at rest before and after the treatment. Interestingly, LIR decreased in 7 out of the 10 subjects, indicating that the treatment changed the



**Fig. 37.1** Changes of STAI-1 score (a) and LIR (b) after acupuncture

balance of PFC activity toward left-dominant, at least in these subjects. The other three subjects showed an increasing tendency in LIR.

## 4 Conclusions

Acupuncture has been widely used for treatment of depression, especially over the last 10 years [1]. The present pilot study demonstrated that treatment by acupuncture significantly reduced state anxiety levels but not trait anxiety level. These results suggest that acupuncture is effective to decrease anxiety levels in patients with mood disorders. Indeed, a number of studies have indicated the effectiveness of acupuncture on depressive symptoms [11]. It should be noted, however, that a recent review concluded there was insufficient evidence of the effectiveness of acupuncture to treat depression, and that the studies indicating effectiveness contained methodological flaws [12].

Recently, our research group developed a new technique for objective assessment of mental stress levels by measuring fluctuation of oxy-Hb concentration in the bilateral PFC at rest, employing NIRS, and we used it to analyze left/right asymmetry of PFC activity by calculating the LIR [8]. In the present study, NIRS demonstrated that LIR decreased after acupuncture in 7 out of the 10 subjects, which indicates that the balance of PFC activity at rest changed toward the left side in those subjects. Notably, it was reported that LIR was positively correlated with STAI-1 (i.e., state anxiety) scores [8], which is consistent with the reported

lateralization of emotion; the right hemisphere is dominant for negative emotions and the left hemisphere is dominant for positive emotions [13], although the lateralization of emotion is still an issue of debate.

Thus, it seems plausible that acupuncture changed the balance of PFC activity toward left-dominant, resulting in relaxation effects on the patients. However, it should be noted that acupuncture did not decrease LIR in 3 out of 10 patients. Further studies are necessary to clarify the physiological mechanism of acupuncture therapy.

The present pilot study has a number of limitations. First, it was not a randomized control study. Second, we did not measure changes of PFC activity during acupuncture since NIRS measurements during acupuncture could have influenced the putative treatment effects of acupuncture. Our previous study on normal adults revealed that acupuncture caused both activation and deactivation of the PFC [14]. Finally, the point of acupuncture stimulation varied among the subjects depending on the diagnosis according to Traditional Chinese Medicine, and the number of subjects was small. Nevertheless, our results suggest that further study in a larger group would be worthwhile.

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