The Impact of Tenderness on Prefrontal Cortical Hemodynamics: An Objective Measurement of Wrist-ankle Acupuncture Analgesic Bracelet

Jiahao Du
University of Shanghai for Science and Technology
Junwen Liu
University of Shanghai for Science and Technology
Fanfu Fang
Changhai Hospital
Hongliu Yu
University of Shanghai for Science and Technology
Ping Shi (rehabishi@163.com)
University of Shanghai for Science and Technology

Research

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Abstract

Background: Determining an objective measure for pain is one of the most significant challenges in neuroscience and clinical medicine. The response of the cerebral cortex to noxious stimuli/pain can be detected by functional near infrared spectroscopy (fNIRS). The study aimed to examine the law of pain relief and cerebral blood volume dynamics based on the wrist-ankle acupuncture (WAA) analgesic bracelet, and determined the reliability of the cortical activation patterns as objective measurements of pain.

Methods: Tenderness was performed on the left point Jianyu of volunteers (age, 23.9 ± 1.9 years, mean ± SD) suffering from the cervical-shoulder syndrome (CSS) as tasks. A transcutaneous electrical nerve stimulation analgesic bracelet based on WAA in traditional Chinese medicine (TCM) was used for treatment. A 24-channel fNIRS system was used for measuring cerebral oxygenated hemoglobin (Oxy-Hb) levels. Oxy-Hb concentration changes in each channel were determined by calculating the differences of Oxy-Hb levels between task and rest. Paired t-tests ($p < 0.05$) were used to assess the difference in data during tasks and rest.

Results: A significant increase in Oxy-Hb was found in all 12 channels of the participants' right hemisphere during the three tenderness tasks. The mean ± SD of Oxy-Hb levels changes in three tenderness were 0.50±1.22 mM mm, 0.28±1.36 mM mm, 0.09±0.81 mM mm, respectively, and the amount of the change gradually decreased with the participation of the analgesic bracelet. Group analysis of the three tenderness tasks showed that the main activation channels of the cerebral cortex for tenderness were CH6, CH11, CH12, and cortical regions response to tenderness were the frontopolar area, dorsolateral prefrontal cortex, and includes frontal eye fields. With the participation of the analgesic bracelet, the activation area of the cerebral cortex for tenderness gradually decreases.

Conclusions: These findings describe the cerebral blood volume dynamics and cortical activation patterns during shoulder tenderness measured by fNIRS, which can not only be used to assess patients with CSS and other shoulder pain, but also to determine the reliability of the cerebral blood volume dynamics and cortical activation patterns pain assessment indicators. Further, this research explores the objective evaluation of the efficacy of an analgesic bracelet based on WAA in TCM for the first time, and provides a new research direction for further pain relief.

Trial registration: Chinese Clinical Trial Registry, ChiECRCT20200243. Registered 12 May 2020.

Full Text

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Figures

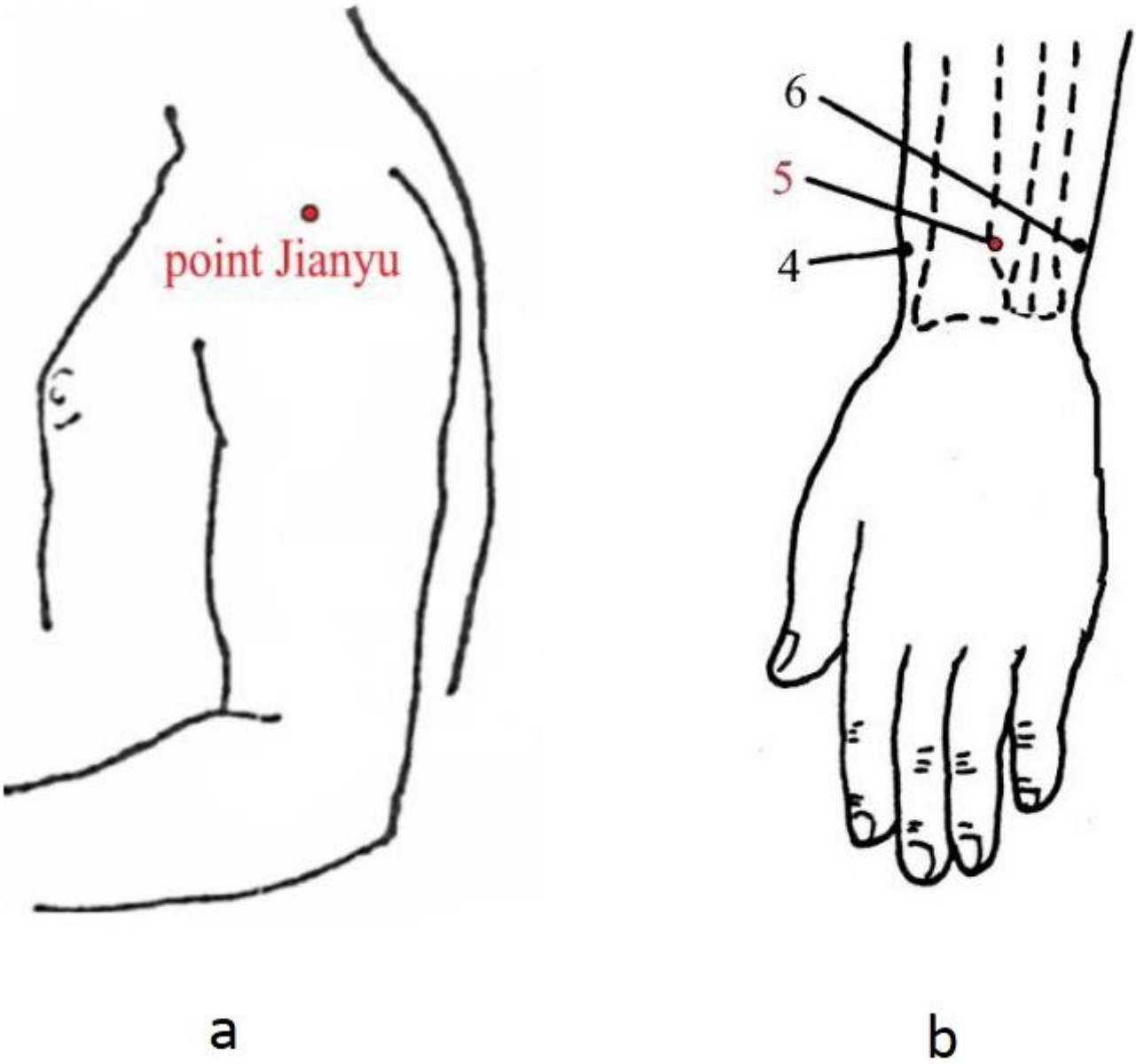

Figure 1

Schematic diagram of the positions of the experimental devices. (a) Tenderness stimulation site—point Jianyu. (b)Treatment site—the upper 5 area of the wrist. 4, 5, and 6 correspond to the upper 4 area, the upper 5 area, and the upper 6 area, respectively. The upper 1-3 areas are approximately opposite to 6,5,4 in the palm, which is easy to cause confusion and hide.

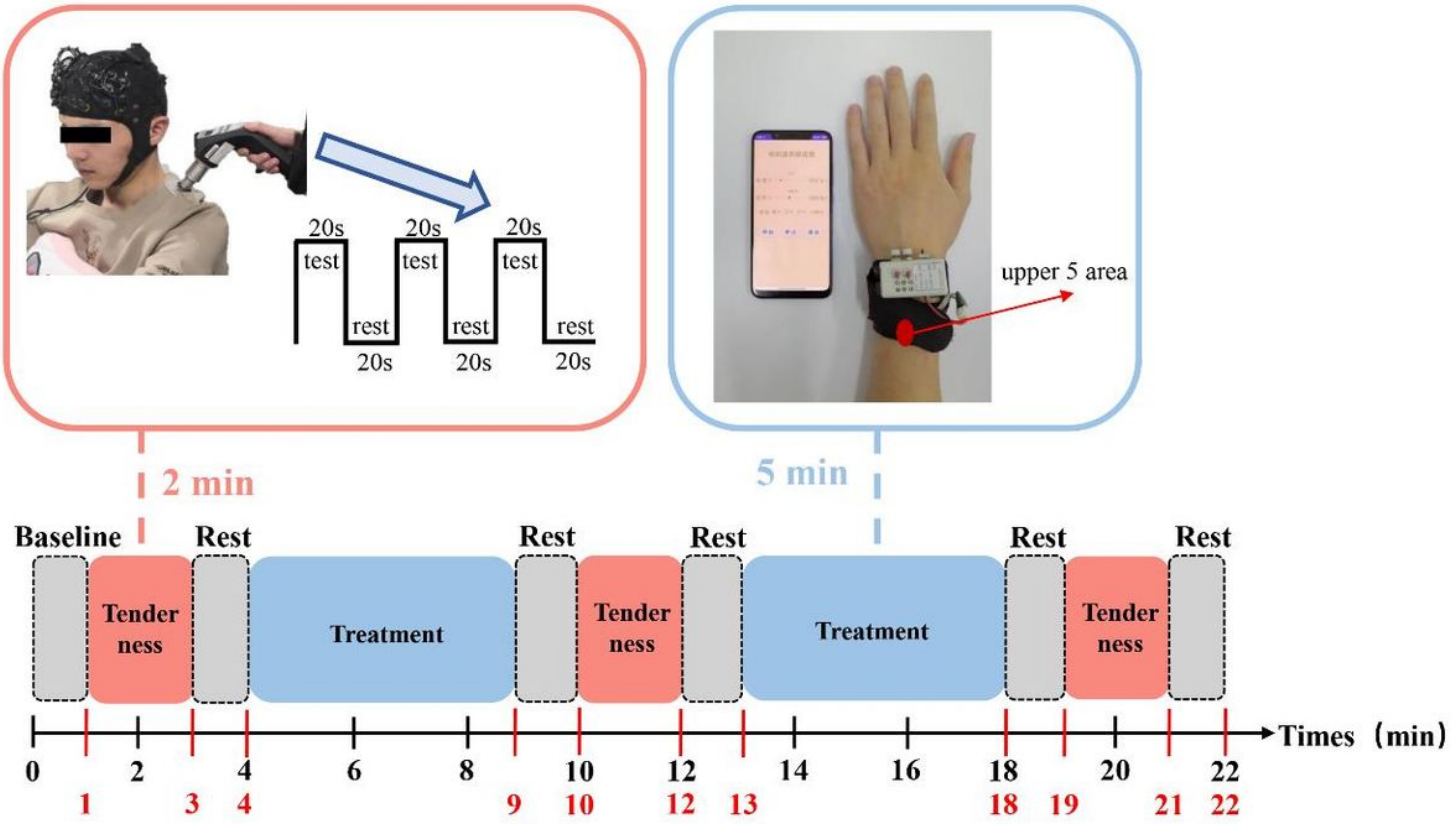

Figure 2

Experimental procedures: The experiment includes one total of 5 sets preceded by a 1-minute rest.

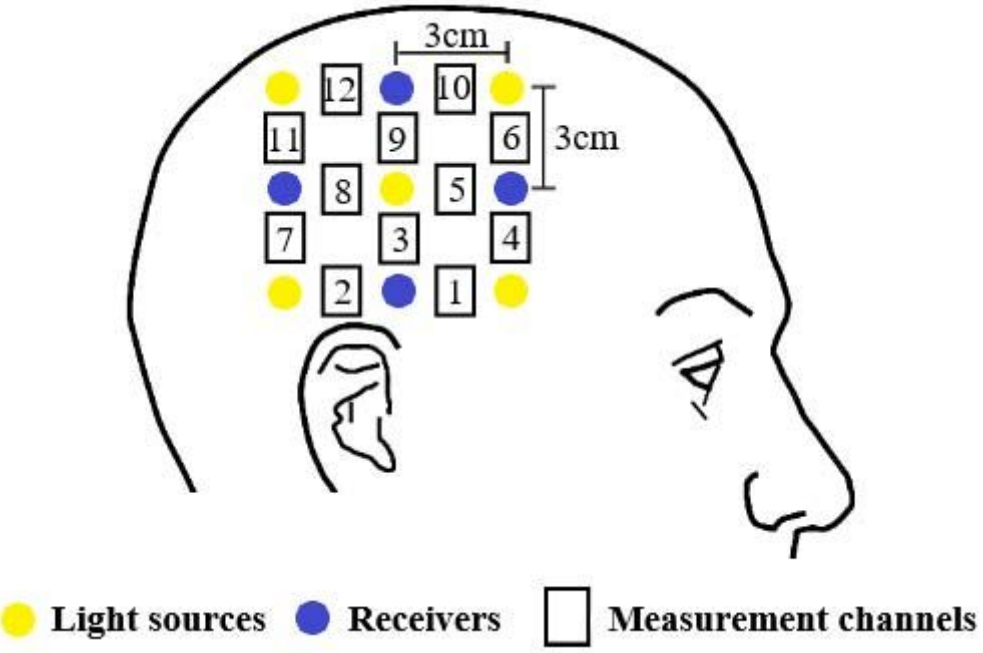

Figure 3

Probe configuration, right hemisphere (CH1–CH12).

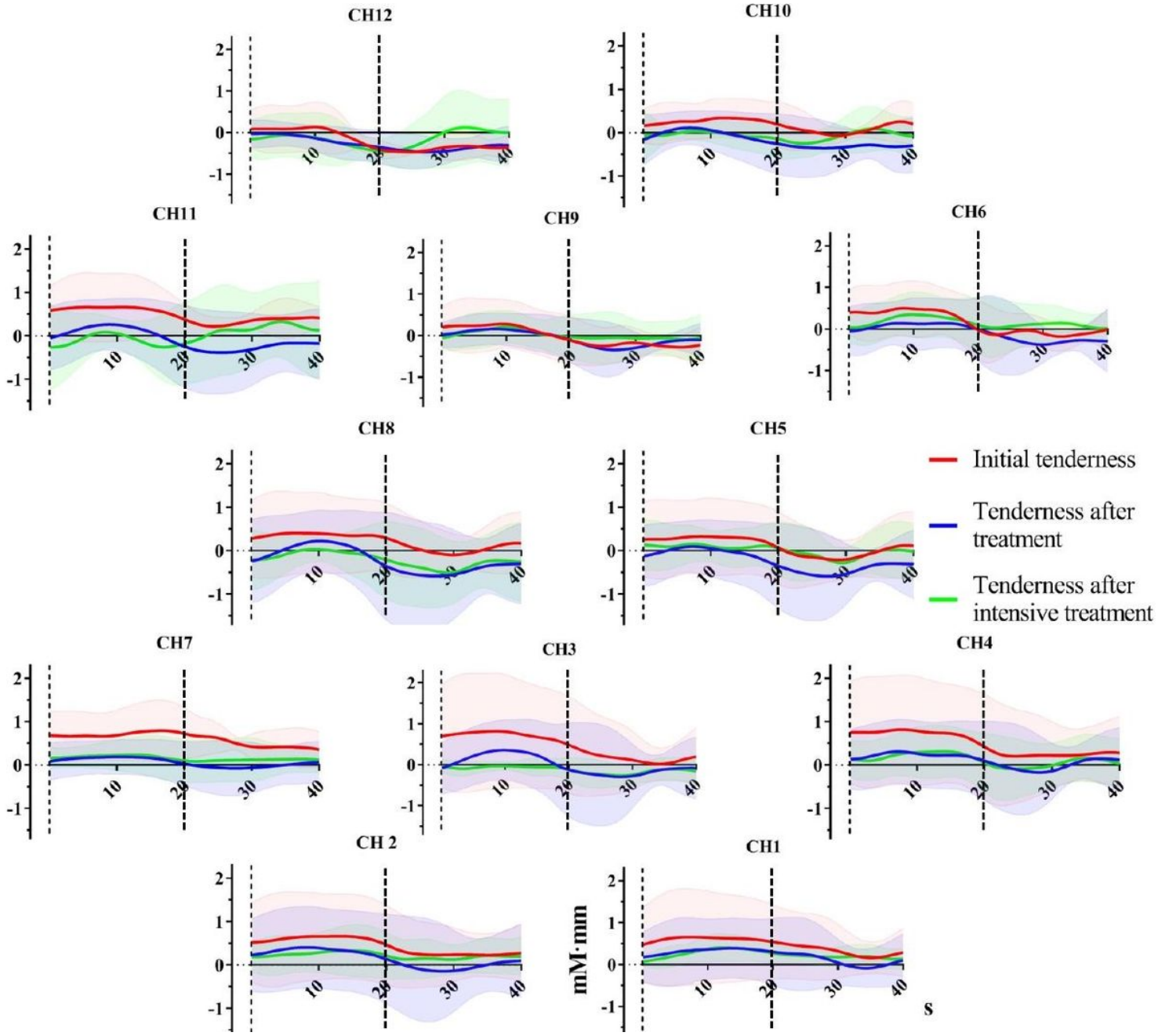

Figure 4

Average Oxy-Hb levels during tenderness loading. Lines indicate mean (±SD) Oxy-Hb levels. The vertical axis shows the measured values (unit: mM mm), and the horizontal axis shows time (unit: second). In this study, the analysis was conducted on Oxy-Hb levels obtained from 12 channels placed over the right hemisphere's prefrontal cortex. The numbers showed represent channel numbers.

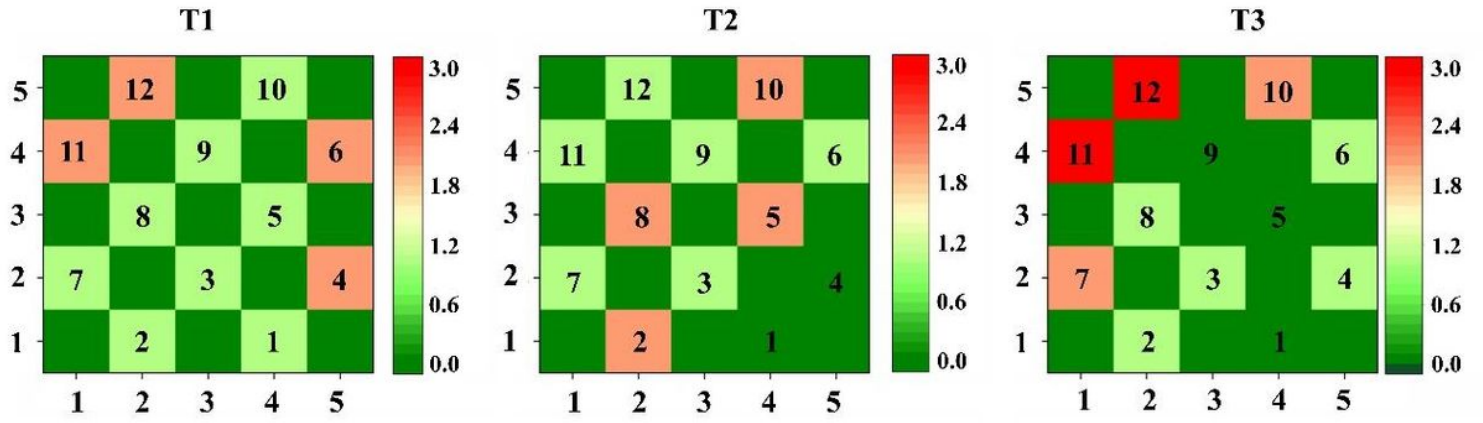

Figure 5

Channel activation statistics of three tenderness experiments (Unit: Times). T1 means initial tenderness, T2 means tenderness after treatment, T3 means tenderness after intensive treatment.

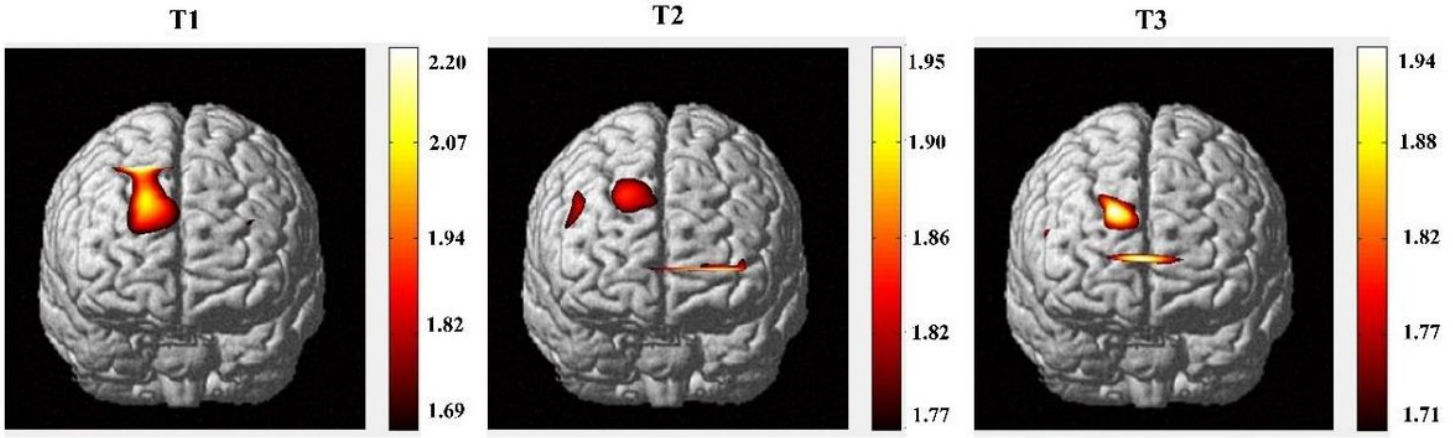

Figure 6

Cerebral cortex activation map obtained by group analysis of three tenderness experiments (Unit: Mm mm).