Analysis of acupuncture principle on subjects using k Singular Value Decomposition

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ABSTRACT

Promising fMRI(functional Magnetic Resonance Imaging) analysis methods have provided insight into the brain networks and brought reconciliation to acupuncture effects. In this present study, Ksvd(k Singular Value Decomposition) Technique is employed to identify the brain network involved in acupuncture activation for a old age shaky hand subject. Task analysis mostly employ ‘seed voxel’ method ,where a voxel or group of voxel’s averaged time course from the seeding area is correlated with the time course of each voxel over the entire brain to generate connectivity maps . In Ksvd analysis , a dictionary is constructed and trained to identify the activated voxels of single subject . In this acupuncture analysis study, brain behavior after short stimuli , such as MA at acupoint LI 11,GB 34, identifies change with amygdale brain network for pain perception and pain modulation, sensory motor cortex for shaky hand were identified and these specific effect arise from the cooperation of brain regions engaged in Task and rest fMRI.

Key words : fMRI , Ksvd , MA , LI 11,GB 34,sensory motor cortex, pain perception.

1. INTRODUCTION

fMRI ,investigatation on the hemodynamic BOLD effect, has come to dominate the brain mapping field due to its minimal invasiveness, no radiation exposure, good spatial resolution and wide availability. In previous decade an increasing number of studies applied fMRI to investigate acupuncture stimulation. Acupuncture is one of the most important therapeutic modalities in traditional Chinese medicine (TCM). It utilizes fine needles that may pierce through specific anatomical points (named ‘acupoints’) so that certain healing effects are produced[1]. Meta-analysis for verum acupuncture stimuli confirmed brain activity within many of the regions ,brain stem,cerebellum.[2]Acupuncture studies in fMRI did not quantify and explicitly distinguish subjects into de-qí and sharp pain based on needle sensations, which made striking discrepancies between results of different studies. What are the de-qí related BOLD responses, that is, are they dominated by activation or deactivation? What is the relationship between the de-qí related and the sharp pain related BOLD responses?The different regions were defined as regions of interest (ROIs) and correlated with the scores from the needling sensations.[3] Neuroimaging studies have shown that acupuncture stimulation activates the brain regions, primary somatosensory cortex, secondary somatosensory cortex, anterior cingulate cortex insular cortex, prefrontal cortex, amygdala, hippocampus, periaqueductal gray and hypothalamus.[6]The comparisons between different resting states disclosed the discrepancies between the pre and post needling effects in the Brain[4];The canonical HRF is the basis of a parametric model that estimates changes in the fMRI blood oxygen level dependent (BOLD) signal. The major problem in the hypothesis-driven method is the nonadaptivity of the canonical HRF [7]. To overcome these drawbacks, a variety of data-driven methods have been suggested[8] including PCA, ICA. In this study , a manual acupuncture at acupoint LI 11,GB 34 for a shaky hand aged subject is analysed to identify the difference in activation in sensory motor cortex using Ksvd, a multivariate analysis method, as this method has the potential of exploring the effect of acupuncture on brain activities.

2. MATERIALS AND METHODS

In this fMRI experiment of single trial, slices of images are acquired for 110 scans , with each image consisting of roughly 200,000 voxels. Though a good number of these voxel consist solely of background noise and can be excluded from further analysis, the data that needs to be analyzed is staggering. The second author with in clinical practice for over 25 years, administered acupuncture manually. Stainless steel needles used for LI 11,GB 34 are 0.2 mm in diameter and 40 mm in length. The experiment is repeated twice for the same subject with rest fMRI in between and have 2 runs for comparison of analysis which facilitates population inference. The subjects eyes were closed,so they can’t observe the procedures.

2.1 SUBJECT AND ACUPUNCTURE

Figure:1Block run with acupuncture stimulation points and Rest fMRI.

Figure:2:Activation reduced due to acupuncture in accupoint GB 34 and LI 11.Sagittal output is shown.
Figure 3: Acupoint GB 34 and LI 11 for improving the localization in sensory motor cortex.

Subjects were scanned in a 3.0 Tesla MR whole body Scanner. Functional images were collected in a sagittal orientation parallel to the AC-PC plane with 5 mm slice thickness using a single-shot gradient-recalled echo planar imaging (EPI) sequence. The EPI pulse sequence had the following parameters: TR = 1500 ms, TE is 40 ms, flip angle = 90 degree; matrix size = 64 × 64, FOV 240 × 240 mm$^2$, giving an in-plane resolution = 1.8 × 1.8 mm. The scan covered the entire brain. Structural scans were acquired using 3D MRI sequences with a voxel size of 1 mm$^3$ for anatomical localization.

2.2 Sparse k SVD

The natural signals can be compactly expressed, or efficiently approximated, as a linear combination of prespecified atom signals, where the linear coefficients are sparse (i.e., most of them zero). Sparse coding approximates an input signal, $Y$, by a sparse linear combination of items from dictionary $D$. K-SVD algorithm is a powerful iterative algorithm for training sparse dictionaries. The K-SVD algorithm can find the dictionary $D$ that yields sparse representations for a set of training examples.

$$\text{min}_{D,X} \left\{ \|Y - DX\|_F^2 \right\} \text{ Subject to } \forall i, \|x_i\|_0 \leq T_0$$

(1)

Where $Y$ is the data elements, $X$ the coefficients of the signal. The K-SVD algorithm is a two steps process: Sparse coding step, Code book update step. Exact determination of sparsest representations proves to be an NP-hard problem, approximate solutions are considered instead. The simplest ones are the Matching Pursuit (MP), the Orthogonal Matching Pursuit (OMP) algorithms. With estimated $X$, K-SVD puts only one column in the dictionary $d_j$, and corresponding $x_j$, the $j^{th}$ row of $X$. This is solved using Single Value Decomposition (SVD)[8]. The columns of dictionary are sequentially changed and corresponding coefficients are updated.

2.3 Method of Optimal Direction (MOD) algorithm

This method closely follows the K-Means Algorithm. The sparse coding stage uses OMP algorithm. Assuming the coding for each example is known, the error is defined as

$$e_i = y_i - DX$$

(2)

Assuming $X$ is fixed, an update to $D$ such that the above error minimizes

$$D(n+1) = D(n) + \eta EX(n)T$$

(3)

Using infinitely many iteration and small $\eta$, leads to a steady state outcome and that is the MOD update matrix. MOD method assumes known coefficients at each iteration, and derives the best possible dictionary. After the dictionary learning with optimum $k$ at each voxel, the non zero $k$ atoms are used as the design matrix. Then $F$-map is calculated and degree of freedom should be imported to the SPM12 tool box to obtain the activation map for a given $p$-value.

3. INFEERENCE AND DISCUSSION

Table 1: 110 acquisition arranged as columns against detrended voxels of whole brain.

Table 2: K-10, Iteration =30, Sparse dictionary learning using Ksvd Algorithm.

The input scans are preprocessed in SPM12 for co-registration, motion correction, slice time correction, Normalization and arranged as $Y$ matrix as shown in table 1. Applying kSVD to $Y$ results in sparse dictionary for optimum value of $k$-6. The activations projected in fig 2 implies that, before acupuncture on the specified acu points, the more voxels are seen in sensory motor cortex. After the acu point pressure, the region is equivalent to a healthy subject activation. Few highlights are also seen in fig 2. Which states that the activation may be due to hearing during experiment paradigm, lateral unwanted thinking, some expectations or disappointments, fear. With 30 iterations, the leaning is considerable for $K$=6. If the $K$ value is above or below this, provides deviation in activation.
4. CONCLUSION

The acupuncture points LI 11, GB 34 activation on a shaky hand subject is analysed and the functional localization on the block paradigm using kSVD is obtained. Our fMRI study confirmed that acupuncture at these two points can activate certain cognitive-related regions in shaky hands patients. These results also explain methodology in acupuncture research. The future direction is to classify the healthy controls and ET subjects using the identified spatial map and time series. The only demerit is the deactivations could not be accountable.

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REFERENCES


