Decreased functional connectivity of supplementary motor area under tactile stimulation in Parkinson's disease: An fMRI study

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Introduction

Recent researches have completely overthrown the traditional view that PD is simply a movement disorder. It is now clear that PD is characterized by a large number of non-motor clinical features, among them the somatosensory deficit, such as tactile perception and discrimination, is a significant part. Previous studies suggested that these deficits came from the abnormal integration or organization of somatosensory networks in Parkinsonian brain. Although some work has found out some abnormal active brain regions in PD compared to the normal during tactile stimulation, the exact neural mechanism of this impaired brain network is still scarcely known. This study aims to find out how the brain network is modulated during tactile stimulation in the PD patients using fMRI.

Materials and Methods

17 PD patients and 19 age-matched healthy volunteers were recruited in this study. All the subjects were instructed to passively perceive tactile stimulation on his right index finger using wood wheels with different texture. Each stimulus lasted for 3 seconds and 10 stimuli composed a task block. Then, a 30-second resting block was followed. The whole task consisted of 3 task blocks and 3 resting blocks. The subjects were scanned using a GE 1.5T MR scanner with GRE-EPI sequence (TR=3s, TE=35ms, flip angle=90°, FOV=24×24cm, matrix=64×64, slice number =22, slice thickness=5mm, slice space =1mm).

The images were analyzed with SPM2. Individual task-related activation map was obtained based on a general linear model. Then, a two-sample t-test was used to explore the difference between PD patients and normal subjects under the tactle task. Both the hyperactive and the hypoactive brain regions showed in the activation map of the two-sample t-test constituted an abnormal tactile network for PD patients. We used a method based on the graph theory to measure the functional connectivity of above abnormal somatosensory network. All the brain areas in the network are referred to as the "nodes" and the connections among them are considered as the "links". We calculated the total connectivity degree (Γ) of each "node" of each subject. A larger Γ reflected this "node" had more functional connections with other "nodes", therefore, played a more important role in the network. We also calculated the connectivity strength between each "node" to find out which pathway was changed in the network. The connectivity strength r was converted into Fisher's z value. Then, a two-sample t-test was implemented to compare the differences in Γ value of each "nodes" and z value of each "links" between the PD patients and normal subjects.

Result

According to the activation map of the two-sample t-test, 5 brain regions showed hypoactive and 12 regions showed hyperactive under the tactile stimulation in PD patients compared with normal subjects. All above regions constituted the abnormal tactile network for PD patients. In this brain network, a significant decline of Γ value was showed in ispilateral supplementary motor area (SMA) in PD patients compared to the normal subjects (p=0.032) (Fig 1). Furthermore, the Γ value was negatively correlated with UPDRS (r=-0.57, p<0.01) (Fig 2). An increase of z value was found in 15 links in PD patients. In general, these increased links may constitute four separate loops, namely, striato-PFC loop, cerebello-PFC loop, striato-cerebello loop and cerebello-cerebello loop.

Conclusion

Our study showed that SMA is the most important "node" of the abnormal tactile network for PD patients, which indicated that the dysfunction of SMA might be the key point of abnormal function of somatosensory networks in Parkinsonian brain. Besides, our study also suggested that at least four different loops may play a compensatory role in the dysfunction of SMA.

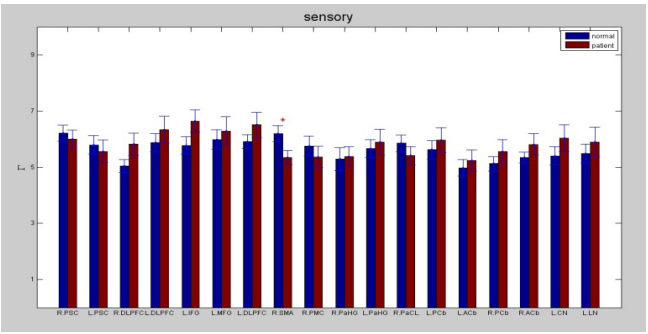

Fig 1. Comparison of each ROI in Γ value between PD and the controls. * p<0.05

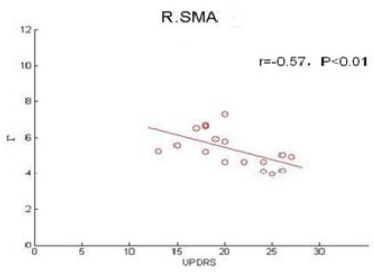

Fig 2. Pearson's correlation between Γ value and UPDRS in R SMA in PD.