Position Changes in Chinese Phrase: A fMRI Study*

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Abstract. Position changes in Chinese phrase are explained with light verb assumption in Generative Grammar. With regards to the idea that light verb is a hypothetical element, this study attempted to find the brain neural correlates in positions changes of Chinese phrases and whether this processing is launched by light verb or not. The results show that these phrases which can change the positions activated more brain areas than those that can’t change positions. In particular, the activated left inferior frontal gyrus indicated that this activation involved a syntactic process. It is possible that light verb made this process occur.

Keywords: Chinese phrase; fMRI; light verb; left inferior frontal gyrus

1. Introduction

There are some phrases which can change position in Chinese. These phrases are compound with nouns and verbs, these two words can exchange their position and keep the phrase with the original meanings. Such as fanrong shichang-shichang fanrong(make economy boomed); fengfu shenghuo-shenghuo fengfu (make life abundance). In Generative Grammar (Chomsky 1995) [1]the studies on these phrases are advisable. In fanrong jingji and jingji fanrong jingji(economy) and the verb fangrong has the same thematic relations. In second sentence of shichang shi jingji fangrong –shichang fangrong jingji (Market made the economy boomed), the element after inter argument is the verb position of first sentence. Shen (2001) [2] suggest that shi in the first sentence is a light verb. So in the sentences without shi, verb needs to move and not move with shi. Further study of Shi (2003) [3] indicate that this sentence including a light verb, the sentence “shichang fanrong jingji ” is equal to “shichang shi jingji fanrong ” actually. In second sentence, shi is a light verb, the omission of light verb shi result in the empty position of head-words. The empty position needs the predicate element in the back of the sentence to move this place and fill in the empty position. So, in Chinese fanrong take up the position of shi.

Some relevant studies in English are exploring the neural correlates of different phrases. For example, Newman, et al.(2001)[4]studied English phrases processing using fMRI. The results showed that English phrases processing activated the frontal, temporal lobe and the temporal parietal lobe. Kang, et al. (2001) [5]studies indicated English phrases processing which involves the left inferior and middle frontal lobe, the parietal lobe, and the anterior cingulate cortex. Mondini et al.(2002)[6] found Italian "nouns+verbs" and "verbs+nouns" combinations have different neural mechanism by aphasia patients with neuropsychological studies.

The concept of light verb comes from the VP-shell theory by Larson (1988) [7] originally. He studied the double object sentence and found we should project the verb to a VP-shell that can make the verb move to the position proceeding it. So we can explain the c-command of two objects in the sentence by the verb movement.

In other languages except English, such as Japanese (suru), korean (ha-ta、toy-ta) and Romanian (fi), light verbs or elements equal to light verbs.( Choi et al.2001,Miyamoto 2002,Alboiu2004) [8、9、10]are

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found. Therefore the existence of light verbs in Chinese needs necessary neurolinguistic evidence. Our aims in this study is to explore the brain correlates in position changes of Chinese phrases and the brain evidence supporting to the light verb assumption.

2. Method

2.1. Subjects
The participants were 19, healthy, right-handed, native Chinese speakers. 10 were males and 9 were females, with ages ranging from 20 to 26 years old. They were either recruited from the campus of the colleges. Informed consent approved by the institutional review board was obtained from each subject.

2.2. Stimuli and Procedure
The experiment materials include two types four characters phrases, which are position can change (PC) and can not change (PU). There are two serials in the experiment and different phrases in different serial. Every serial include 50 phrases (40 true and 10 false) using event-related design with an average SOA 12 seconds. And the stimulate time for each phrases is 300 ms. The subjects tasks in the fMRI experiment were to choose the verb in the former element or latter element in each visual stimuli phrase which were presented through a LCD projector.

2.3. fMRI Data Acquisition and Analysis
Scanning was performed on a 3T GE system using a standard head coil. Twenty-two axial slices of first scan using fast spin echo sequence(512×512×24, TR=15ms, TE=42ms, slice thickness=5mm, gap=0mm, FOV=220 mm, flip angle=90º) Twenty-two axial slices of functional images that covered the whole brain were acquired using a gradient-echo echo-planar pulse sequence (64×64×24, TR=2000 ms, TE=30 ms, FOV=220 mm, thickness=5mm, gap=0mm, flip angle=90º). Anatomical images were obtained using a standard 3D T1-weighted sequence from axial direction (resulting in a 256×256×128, TR=30 ms, TE=1.17ms thickness=1mm, gap=0mm).

We used the AFNI software (Cox 1996, 1997) [11, 12] for image processing. The images of the first five time points were discarded. Images were preprocessed using the iterated linearized weighted least-squares algorithm to correct small head motions. Then is spatial normalization to the Talairach and Tournoux[13] brain atlas, smooth the image with FWHM=5 mm and eliminate the liner excursion. After the completion of the above steps, we get the impact response function (IRF) of each task using Deconvolution. Then we average the impulse response function and get one time point signal of all subjects. Finally, we test the average impulse response function of different tasks using ANOVA analysis. After these steps, we can see the activated brain voxel positions in 3D brain mapping.

3. Results
Comparison of activations induced by phrases consisting of verbs that can change their position in the phrases (PC) V.S. those by phrase consisting of verbs that can’t change their position in phrases (PU).

Brain activations when contrasting the PC to PU: bilateral inferior frontal gyrus, left middle frontal gyrus and left inferior frontal gyrus, left superior temporal gyrus, left inferior parietal gyrus, anterior cingulate gyrus, and left medial frontal gyrus. (See Figure 1) shows the brain areas that were activated when contrasting the PC to PU. Figure2 shows standardized signal intensity (in percentage) in left inferior frontal gyrus elicited by PC and PU.
4. Discussion

It is noticeable that the overall brain activations elicited by PC are much stronger than those elicited by PU. The activated brain areas include left inferior frontal gyrus and left superior temporal gyrus that are traditionally treated as language brain areas, as well as brain areas that are newly found to be involved in language processing such as left middle frontal gyrus and superior frontal gyrus (Luke et al.2002, Tan et al.2005), [14,15]anterior cingulate(Li et al.2004)[16]It suggests that, when processing PC, the brain areas in left frontal lobe are intensively involved for both syntactic and semantic processing.

It also suggests that the brain distinguishes the two kinds of phrases, the PC and PU, and responds to them differently. As we have discussed, the main verb moves from the left to the right when “shichang fanrong”becomes “fanrong shichang”, while in PU such as “niandu kaohe” and “xingdong fangzhen”, such verb movement is absent. The verb movement in PC is a complex process. According to Generative Grammar, there is a light verb in PC, which is indeed a null light verb, a meaningful entity with syntactic function but lack of pronunciation. The syntactic function of the light verb in PC is to induce the main verb moves leftwards. The semantic aspect of the light verb, however, indicates the meaning of the whole phrase. The activation of left inferior frontal gyrus, the brain area involved in syntactic processing, and left superior frontal gyrus, the brain area assumed to be responsible for semantic processing, is therefore the neural reflection of the verb movement induced by the nil light verb.

It is worth noting that the processing of verb movement in the PC relies intensively on brain areas around the left Broca’s area. When contrasting the PC to PU, the major activations were found in left brain, especially in left inferior frontal gyrus. It is supported by this experiment that the processing of verbs in phrases involves left inferior frontal gyrus.

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6. References


