Influence of Context in Literature on Brain Processing Mechanism of Three-word Verb-object Metaphor

Hua Wang

ABSTRACT
This study believes that the differences in the nature of metaphors and speech levels in different researches may be an important reason directly influencing the metaphor processing mechanism and participation of the right hemisphere. Thus, this study starts with the metaphors commonly used in daily life, takes pairs as experimental materials, and uses the semantic related judgment tasks to explore whether the right hemisphere has a unique role in metaphor processing. ERP technology is used in the experiment to further clarify the processing time and brain mechanism of metaphors of different nature. A single-factor three-level experiment is designed. The research results support that metaphor processing is the whole brain processing instead of the advantage of a certain hemisphere. Whether the right hemisphere participates and the degree of participation is related to nature of metaphors and processing stages. The right hemisphere has the highest degree of participation in the early stage of processing of triggered metaphor while in the later stage of processing, the right hemisphere has more participation in metaphor and general meaning.

Key Words: Triggered Metaphor, Etymological Metaphor, General Meaning, Word Level, Right Hemisphere Processing

Introduction
Metaphorical expression is a unique and interesting phenomenon in human language in daily life. Metaphor is a metaphorical form without obvious metaphorical words but in implicit comparison, which is contrary to simile with obvious metaphorical words. Metaphor usually consists of two parts: one is the subject of metaphor, which is the party to be described and is often a relatively abstract concept or thing that is difficult to describe intuitively. The other part is the carrier of metaphor, which refers to the thing that has similar attributes to the subject and is more specific to be described (Stenvoll, 2015). For example, in the obvious metaphorical expression of “time—money”, “time” is an abstract concept difficult to describe and is the subject of metaphor; “money” is an intuitive and descriptive concrete thing and is the carrier of metaphor. The value of time can be explained by the preciousness of money (Stolberg, 2015).

Early researches on metaphor were mostly found in rhetoric, philosophy, and linguistics. By the 1970s, the concept of cognitive metaphor held that metaphor, as the basis of human's experience, cognition, thinking, language, and behavior, was the main and basic survival way for human beings, indicating that researches on metaphor have turned from a linguistic level to a cognitive level and also laid an important position for metaphor in cognitive science. Modern cognitive neuroscience treats metaphor
as an important way for humans to know and explore the external world. Along with the flourishing development of cognitive neuroscience, and continuous improvement of electrophysiological and neuro-imaging technologies, researches on metaphorical cognition have attracted much attention (Andrievskikh, 2015). Continuously deepening the research on metaphor can not only expand the research contents of rhetoric and linguistics, but be an important way for people to go toward advanced psychological processes such as thinking (Gn, 2016).

At present, researches on metaphor are roughly divided into two parts: one is the research on conceptual metaphor and the other is the research on metaphor cognitive processing mechanism. Among them, the researchers focus on two aspects: first, the similarities and differences between metaphor processing and general literal processing (Shaw et al., 2015). Is the metaphorical meaning directly accessible or through the literal meaning? Does the metaphorical meaning contain more processing contents than the literal meaning? The second is the role of the right hemisphere in metaphor processing. Does the right hemisphere participate in metaphor understanding? If yes, what is the degree of participation? The researchers used ethology technology, electrophysiological technology, and brain-imaging technology to conduct researches and answer these two questions. This paper only discusses the cognitive processing mechanism of metaphor and sorts out related literature (Ojemann et al., 2015).

In the previous ethology researches of metaphor cognitive processing, the usual practice was to compare the reaction time and accuracy of the subjects’ response to metaphorical content and literal content. If subjects’ reaction time of response to metaphor is larger and accuracy is lower, the initial evidence mostly comes from the study of brain injury patients for the problem of metaphor processing of the dominant hemispheric effect. Nowadays, sub-visual field technology combined with the initiation paradigm is used to study healthy subjects (Ho et al., 2015). The principle of sub-visual field technology is based on the characteristics of human visual nerve conduction cross-projection so that the information presented on any side of the field is quickly projected to the contralateral hemisphere. In the lateralization research on metaphor processing, if a subject reacts faster to the metaphorical material presented to the left visual field (right brain) than the metaphorical material presented to the right visual field (left brain) and the accuracy is higher, it can be considered that the right hemisphere participates in metaphor processing (Jang et al., 2016). For example, Anaki et al., used the sub-visual field presenting technology to examine the problem of hemispheric asymmetry in the processing of words containing metaphorical meanings. The experiment took Israeli word pair as the material, and the starting words presented in the center were polysemous words such as the word “stinging”. When paired with mosquitoes, the literal meaning (barbed-mosquito) was chosen. When paired with insult, the metaphorical meaning (barbed-insult) was chosen (Vilasboas et al., 2015). Subjects need to determine whether the target word is true or false. It was found that when SOA was 200 ms, literal meaning was only started in the left hemisphere while metaphorical meaning was started in both the left hemisphere and right hemisphere. When SOA was 800 ms, the literal meaning was only started in the left hemisphere while metaphorical meaning was only started in the right hemisphere. Therefore, researchers speculate that the right hemisphere has an advantage for understanding of metaphor (Mourad et al., 2015).

The role of right hemisphere in metaphorical processing of different natures

Experimental process
The sub-visual field paradigm is used to explore whether the right hemisphere participated in metaphor processing and plays a special role. 3 (word pair type: etymological metaphor/triggered metaphor/general literal meaning)×2 (visual field: left/right visual field) are used to design. The independent variable is the reaction time when the subject makes judgment on the semantic relationship. 36 undergraduate students, including 20 girls and 16 boys, volunteer to participate in the experiment with an average age of 19.7. All subjects whose native language is Chinese are healthy and have normal naked or corrected vision without any reading difficulties.

Experimental procedure
The sub-visual field technology requires the vision of the subjects to be focused on the fixation point. Once the vision is deflected, the lateralization will not be established. After word...
1 presents in the center for 1000 ms, the fixation point presents for 400 ms, while word 2 randomly presents in the left visual field or right visual field for 800 ms and the fixation point disappears along with word 2 (the fixation point presents for 1200 ms). In the absence of an eye tracker to monitor the eye movements, the chin strap is used to fix the head of the subjects without making large movements. And then the subjects are strictly required to pay attention to the fixation point during the experiment and perform multiple exercises before the formal experiment to reduce the effect of deflection of attention.

Experimental results and analysis
In the experiment process, the reaction time and accuracy of vocabulary judgement of subjects are automatically recorded. First, the data of 3 subjects with the accuracy of 80% or less is excluded and data of 33 subjects is obtained. Then the extreme data with error response and average reaction time beyond ±3 standard deviations is deleted. The deleted data accounts for 8.4% of the total data. SPSS 17.0 is used to perform repeated measures analysis of variance based on subjects and project respectively. In the left and right visual fields, the reaction time and standard deviation of the subjects for different types of word pairs are shown in Table 1.

### Table 1. Average reaction time and standard deviation (ms) of different word pair types in left and right visual fields

<table>
<thead>
<tr>
<th>Word pair type</th>
<th>Left visual field</th>
<th>Right visual field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Etymological metaphor</td>
<td>838.379</td>
<td>112.903</td>
</tr>
<tr>
<td>Triggering metaphor</td>
<td>882.205</td>
<td>126.037</td>
</tr>
<tr>
<td>General literal meaning</td>
<td>837.408</td>
<td>111.759</td>
</tr>
</tbody>
</table>

The experiment mainly uses the sub-visual field paradigm to explore the role of the right hemisphere in metaphor processing from the perspective of ethology. It is found that etymological metaphor and general literal meaning don't show differences in hemisphere while triggered metaphor shows faster response in the left visual field (right hemisphere) than in the right visual field (left hemisphere). To a certain extent, this can explain that the right hemisphere participates in triggered metaphor processing. Compared with the semantic processing of etymological metaphor and general literal meaning, the triggered metaphor processing does require the participation of the right hemisphere but it cannot be inferred from this ethological data that the right hemisphere plays an important role in which stage of triggered metaphor processing.

ERP experiment on processing stages and neural mechanism of metaphor processing of different natures

**Preparatory preparation**
From the perspective of neural mechanism, the author further investigates the neural activities of etymological metaphor and triggered metaphor so as to explore the inner processing process and neural mechanism of different metaphors of natures at the lexical level.

26 undergraduates (7 boys and 19 girls) volunteer to participate in the experiment with the age of 17-22 years old. All subjects whose native language is Chinese are healthy and have normal naked or corrected vision without any reading difficulties.

**Experimental process**
Reaction after the event is used, that is to say, during the stage of EEG acquisition, the subjects are only required to think carefully about the semantic relationship of word pairs and not to make any key reaction (as shown in figure 1). The word 2 presents 1000 ms, then the reaction interface “?” appears. The subjects are required to determine whether the word pairs are semantically relevant within 3000 ms as quickly as possible. If subjects do not respond within 3000 ms, they automatically enter the next trial. The entire experiment takes about 30 minutes. The reaction time, accuracy, and EEG data are automatically collected during the experiment.
**Experimental results and analysis**

The obtained ethology data and EEG amplitude data are collected: the data with the accuracy below 90% is deleted, then the data with error response and average reaction time beyond ±3 standard deviations is deleted. The deleted data accounts for 6.07% of the total data. Finally, valid data of 24 subjects are obtained. SPSS 17.0 is used to perform repeated measures analysis of variance of reaction time. The reaction time and standard deviation for three types of word pairs are shown in Table 2.

<table>
<thead>
<tr>
<th>Word pair type</th>
<th>Reaction time (M)</th>
<th>Standard deviation (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etymological metaphor</td>
<td>335.553</td>
<td>67.740</td>
</tr>
<tr>
<td>Triggering metaphor</td>
<td>357.951</td>
<td>80.207</td>
</tr>
<tr>
<td>General literal meaning</td>
<td>337.261</td>
<td>69.546</td>
</tr>
</tbody>
</table>

The variance analysis of the subjects indicates that the main effects of word types are significant with F(2,46)=3.806, p=0.030, and η²=0.142. Multiple comparisons find that the reaction time of triggered metaphor is significantly greater than that of the etymological metaphor (p=0.044, d=0.302), and the reaction time of triggered metaphor is significantly greater than that of the general literal meaning (p=0.009,d)=0.275), while there is no significant difference in the reaction time of the etymological metaphor and the general literal meaning (p=0.853).

The N400 results show that the processing of triggered metaphor contain more contents than those of the processing of etymological metaphors and general literal meaning. The study also finds that after the subjects judge the semantic relationship of word pairs, the average amplitude of N400 in the prefrontal cortex is the largest, followed by the middle brain area and the parietal lobe. In the prefrontal cortex, the average amplitude of N400 evoked by triggered metaphor and general literal meaning is larger; and in the middle brain area and parietal lobe, the average amplitude of N400 of triggered metaphor is the largest and it is significantly different from the general literal meaning and etymological metaphor. This result shows that the distribution of brain areas of metaphor processing is relatively large, and the difference between the triggered metaphor and etymological metaphor in the front and back brain areas further confirms the rationality and necessity of distinguishing metaphors into triggered metaphor and etymological metaphor. And significant differences in triggered metaphor and general literal meaning in the middle brain area and parietal lobe also indicate that these areas more actively participate in the processing of triggered metaphor. It is found by comparison of N400 activities in the left and right hemisphere under different experimental conditions that there was no significant difference between the three types of word pairs in the left hemisphere of the brain. In the right hemisphere, the average amplitude of N400 induced by triggered metaphor is significantly less than that of etymological metaphor while the difference between etymological metaphor and general literal meaning is not significant. That is to say, the right hemisphere has a higher degree of participation in triggered metaphor processing than general literal meaning and etymological metaphor. This result is consistent with the ethology result of experiment 2. In the right hemisphere, the reaction time of triggered metaphor is shorter than that of etymological metaphor and general literal meaning. This is also consistent with previous scholars’ conclusions.

![Figure 2. Average amplitude (μV) of N400 under different experimental conditions](image)

![Figure 3. Average amplitude (μV) of N400 in front and back brain areas of different lateralized brain areas](image)
Conclusions and outlook

From the perspective of metaphors of different natures, the word pair paradigm is used to discuss two controversial issues from the level of Chinese vocabulary: one is whether there is a substantial difference between metaphor processing and general meaning processing, and the other is whether the right hemisphere plays a special role in metaphorical comprehension. The following two conclusions have been drawn from the research. First, the research result supports the parallel hypothesis of metaphorical comprehension. The daily familiar Chinese metaphor processing is similar to the literal processing mechanism, but the triggered metaphor requires more cognitive resources than the etymological metaphor and general literal meaning processing. At the same time, in the semantic integration stage, metaphor processing is more complex than literal meaning processing. Second, in metaphor processing, participation of the right hemisphere and its degree of participation is related to metaphorical nature and processing stage. The right hemisphere has the highest degree of participation in the early stages of triggered metaphor processing; however, in the later stage of processing, the right hemisphere has much participation in both metaphor and general meaning.

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References


