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Research Report

An event-related potential study of the concreteness effect between Chinese nouns and verbs

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ARTICLE INFO
Article history:

Accepted 29 October 2008

Available online 14 November 2008

Keywords:

Grammatical class

Imageability

N400

ERP

Topographic distribution

ABSTRACT

The effect of concreteness has been heavily studied on nouns. However, there are scant reports on the effect for verbs. The present research independently manipulated concreteness and word class of Chinese disyllabic words in tasks that required different depths of semantic processing: a lexical decision task and a semantic relatedness judgment task. The results replicated the concreteness effect for nouns, indicating that concrete nouns elicited larger N400 responses than abstract nouns with a broad distribution over the scalp, irrespective of the task demands. Similar to the findings from English unambiguous verbs, the concreteness effect for Chinese verbs was also robustly observed from frontal to posterior electrodes in both tasks. These results suggest that when Chinese nouns and verbs are typical and unambiguous in both meanings and word classes, the similar topographic distributions of the N400 components reflect the same underlying cause(s) of the concreteness effect for these two word classes.

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1. Introduction

The differences between nouns and verbs have been heavily examined in the previous research, with abundant evidence from neuropsychological studies, behavioral experiments, neurophysiological findings, and developmental observations between the two word classes. In neuropsychological studies, a double dissociation between deficits of nouns and verbs has been reported on aphasic patients at the lexical level (e.g., Caramazza and Hillis, 1991; Chen and Bates, 1998; McCarthy and Warrington, 1985; Miceli et al., 1984; Zingeser and Berndt, 1990) and the sublexical level (Bates et al., 1991). In behavioral

experiments using picture naming, verbs are named slower than nouns even when possible affecting factors are strictly controlled (Szekely et al., 2005). In neurophysiological research with event-related potentials (ERPs), nouns are associated with more intensified N400 than verbs over centro-parietal sites, and verbs elicit enhanced positivity at the left frontal sites (Federmeier et al., 2000; Lee and Federmeier, 2006). In developmental research, it is generally accepted that children learn many more nouns, and also earlier, than verbs in vocabulary acquisition (Gentner, 1978, 1982; Nelson, 1973; but see Choi and Gopnik, 1995; Tardiff, 1996).

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To account for such distinction between nouns and verbs, different characteristics of word classes have been emphasized. Phonologically, the stress pattern of verbs in English is less predictable, with shorter duration in sentences and fewer syllables (in terms of word length) than nouns, which demands more resources in language acquisition (Black and Chiat, 2003; Kelly, 1992). Morphologically, nouns and verbs carry different types of information. For example, temporal information such as tense is often carried on verbs, while plurality is often marked on nouns. Syntactically, the order of nouns and verbs in a sentence is fixed, and the different positions occupied by nouns and verbs are not interchangeable. In addition, the construction of a sentence (the argument structure) is determined by the verb (see Goldberg, 2003; Kemmerer, 2006). Once the verb is selected, the nouns then complete the sentence and serve different roles (e.g., the agent and the patient) according to the semantic constraints designated by the verb. Semantically, nouns encode entities, while verbs refer to relations between entities (Gentner, 1981; Langacker, 1987). It has been proposed that the slower developmental trend of verbs than nouns is caused by the greater conceptual complexity of verbs as compared to nouns (Gentner, 1982). As a result, only children at a certain age with enough cognitive ability can master the concepts represented by verbs. Also from a semantic viewpoint but different from the assumption of conceptual complexity, Pulvermüller et al. (1999) attributed the neurophysiological differences between nouns and verbs to different semantic networks (e.g., motor and visual associations) supporting the distinctions between these two word classes. Aligned with the discussion on the relationship between word class and semantics, Lee and Federmeier (2006) pointed out based on ERP data that the effect of word class could be intertwined by multiple dimensions such as semantic ambiguity. Black and Chiat (2003) reviewed the evidence from different perspectives and concluded that an interaction between all the aspects mentioned above had possibly contributed to the observed dissociation between nouns and verbs.

Among the studies examining the contribution of semantic factors to the word class effect, most research has concentrated on concreteness/imageability between nouns and verbs (e.g., Bird et al., 2001, 2003; Lee and Federmeier, 2008; Zhang et al., 2006). Concrete words are processed faster than abstract words when behavioral measures are used (Kounios and Holcomb, 1994; West and Holcomb, 2000). Physiologically, a larger N400 component is elicited by concrete than by abstract words (Kounios and Holcomb, 1994; Lee and Federmeier, 2008; West and Holcomb, 2000). Such effect of concreteness can be explained by a dual-coding theory (Paivio, 1986), which suggests that the processing of concrete words involves two systems: a verbal semantic system and an imagistic system, whereas the processing of abstract words lacks the assistance from the imagistic system (but see Schwanenflugel et al., 1988 for a different view). Further support for the dual-coding theory from ERP (Kounios and Holcomb 1994; Swaab et al., 2002) and fMRI studies (Giesbrecht et al., 2004) illustrate that the neural signals observed in the frontal sites is associated with imageability effects, whereas the effects observed in the central–posterior sites are associated with processing in the verbal system.

Based on the finding that nouns tended to be rated as more imageable than verbs when they were mixed in a questionnaire,

Bird et al. (2001) proposed that it was the semantic difference on the concreteness/imageability dimension that gave rise to the word class effects. When imageability was controlled, the dissociation between nouns and verbs was eliminated on aphasic patients who were previously diagnosed with verb deficits (Bird et al., 2003). However, recent findings have demonstrated the difference between nouns and verbs even when the concreteness/imageability is taken into account. For example, Berndt et al. (2002) reported a double dissociation between word class and imageability effects on patients. Similarly, Bedny and Thompson-Schill (2006) investigated the effects of word class and imageability independently in a semantic judgment task with fMRI. They found that the left superior temporal gyrus showed greater activation for verbs than for nouns after the imageability was matched across the two word classes. These results support the idea that the noun–verb dissociation and the semantic aspect (concreteness/imageability) of such distinction can be dissociated from each other.

Zhang et al. (2006) provided indirect evidence for the notion that nouns and verbs were processed differently when the concreteness between the two word classes was considered. Specifically, they employed Chinese stimuli in a lexical decision task in which they compared the concreteness effects for nouns and verbs separately. Their results indicated that concrete nouns were associated with a large N400 component that was broadly distributed over the scalp, including the frontal, central, and posterior sites. On the other hand, the concreteness effects for verbs were restricted in the left centro-parietal region. One possible explanation for these findings, as Zhang et al. have noted, is that the contrast of concreteness might be weaker in verbs than in nouns. Nevertheless, as the authors have stated, the question remains open in terms of whether the processing of concreteness is different between the two word classes.

Although Zhang et al. (2006) showed different patterns of the concreteness effect between nouns and verbs, Lee and Federmeier (2008), using English stimuli with a relatedness judgment task, offered a different explanation for the semantic distinction between word classes. Lee and Federmeier compared the concreteness effect, which was reflected in the N400 component of ERP, for English nouns and verbs. They found concreteness effects in the frontal and centro-parietal electrodes for unambiguous verbs, whereas for verbs that were syntactically and semantically ambiguous, the frontal effects were not observed. In other words, for ambiguous verbs, the concreteness effects were observed only at central–posterior sites. Lee and Federmeier interpreted the inconsistent findings between Chinese and English verbs as a result of different linguistic characteristics between languages. They postulated that because Chinese verbs were potentially more class-ambiguous than English verbs, no frontal effect was observed for Chinese verbs as it was not observed for English class/semantic-ambiguous verbs.

Because Zhang et al. (2006) did not directly compare the concreteness effect between Chinese nouns and verbs, the question of whether the concreteness of the two word classes is processed differently remains unanswered. If the activation of the two word classes involves distinct semantic networks, the topographic distribution of the N400 patterns should be different between nouns and verbs. If the concreteness effect in

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