Research paper

# Nouns and verbs in Chinese are processed differently: Evidence from an ERP study on monosyllabic and disyllabic word processing

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## ARTICLE INFO

## ABSTRACT

This event-related potential (ERP) study aims to investigate the neural processing of nouns and verbs in Chinese, especially the processing of monosyllabic nouns (MNs) and verbs (MVs) versus disyllabic nouns (DNs) and verbs (DVs). All four types of words were embedded in syntactically well-defined contexts and a semantic relatedness judgment task was performed. Results showed that, regardless of the number of syllables, verbs elicited more negative N400 than nouns, which may be due to the semantic difference between object and action rather than concreteness or imageability. Furthermore, DVs elicited a greater N1 and a smaller late positive component than DNs whereas such differences were absent in the comparison between MNs and MVs. The N1 and late positive component seem to reflect the early detection and late integration of the syntactic mismatch between the verb contexts and noun usage of DVs, respectively. The findings of the current study indicated that the word class effect in Chinese is due to the semantic differences between nouns and verbs, calling into attention the importance of distinguishing monosyllabic words from disyllabic words when examining the word class effect in Chinese.

## 1. Introduction

Nouns and verbs are fundamental members of word classes in languages. They differ systematically at several linguistic levels, e.g., semantic level, syntactic level, and pragmatic level. In languages with rich morphology, the grammatical class difference is also realized at the morphological level. Such linguistic differences raise the question of whether there are distinct neural implementations for noun vs. verb processing.

Numerous studies have tried to address this question. Research on aphasic patients has found a dissociation between nouns and verbs at the semantic (e.g., McCarthy & Warrington, 1985), lexical (e.g., Caramazza & Hillis, 1991) and morphological levels (e.g., Miceli & Caramazza, 1988). The distinctive lesions in the brain were taken as evidence that specific regions

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respond to the noun and verb representations. Such a dissociation between nouns and verbs in the brain areas was found in some research on normal people. These neuroimaging studies suggested that verbs tend to generate greater activations than nouns in left frontal regions (e.g., Palti, Ben-Shachar, Hendler, & Hadar, 2007; Perani et al., 1999; Shapiro et al., 2005; Yokoyama et al., 2006) and nouns tend to activate temporal regions more strongly than verbs (Shapiro et al., 2005; Tyler, Randall, & Stamatakis, 2008). However, some other studies failed to find segregated brain regions for nouns and verbs (e.g., Longe, Randall, Stamatakis, & Tyler, 2007; Momenian, Nilipour, Samar, Oghabian, & Cappa, 2016; Tyler, Russell, Fadili, & Moss, 2001). The inconsistency across studies may have stemmed from the differences in experimental paradigms, materials, and techniques. To assess the convergence of results in the previous studies, Crepaldi, Berlingeri, Paulesu, and Luzzatti (2011) reviewed the studies in which same techniques and similar tasks were employed but were not able to find compelling evidence supporting the segregation of nouns and verbs in the brain. The conflicting results in the previous studies indicated that nouns and verbs engage overlapped rather than separated neural networks. This claim was further confirmed by a meta-analysis of neuroimaging studies (Crepaldi et al., 2013).

Although the data obtained so far failed to demonstrate spatial segregation between the processing of nouns and verbs, the studies that used event-related potential (ERP) showed that nouns and verbs are processed differently online. According to stimulus presentation, the previous ERP studies could be roughly divided into two major groups: studies with stimuli presented in isolation and studies with stimuli presented in contexts. For the first group of studies, the processing differences between nouns and verbs were mainly reflected on two ERP components, P200 and N400. Verbs elicited more positive P200 than nouns (Kellenbach, Wijers, Hovius, Mulder, & Muler, 2002; Preissl & Pulvermüller, 1995; Pulvermüller, Mohr, & Schleichert, 1999; Xia, Lü, Bai, & Shi, 2013; Zhang, Ding, Guo, & Wang, 2003) while nouns activated more negative N400 than verbs (Barber, Kousta, Otten, & Vigliocco, 2010; Khader, Scherag, Streb, & Rösler, 2003; Tsai et al., 2009; Xia et al., 2013; Zhang et al., 2003). For the second group of studies, the results seem to be less consistent. Federmeier, Segal, Lombrozo, and Kutas (2000), Lee and Federmeier (2006, 2008) found that, regardless of ambiguity, English nouns elicited more negative N400 than verbs over central-posterior sites when they were embedded in the syntactically specified contexts. A sustained frontal positivity was additionally found only for unambiguous words, with more positive amplitudes elicited by verbs than by nouns. Nonetheless, a reversed ERP pattern was reported in a German study. When primed with the words of the same word classes (verbs primed by verbs and nouns primed by nouns, respectively), verbs elicited a more negative potential than nouns over the time window of 360–600 ms (Rösler, Streb, & Haan, 2001).

Similar to German studies, studies on Chinese also showed that a negative potential (N400) was more negative for verbs than for nouns when the target words were presented in the contexts. Liu, Shu, and Weekes (2007) selected monosyllabic nouns and verbs as stimuli. When the stimuli were primed by animal nouns, verbs elicited more negative N400 than nouns, and nouns elicited more positive P200 and P600 than verbs. When they were primed by tool nouns, the word class effect could only be observed on N400, which was more negative for verbs as compared with nouns. These results indicated that the N400 is a relatively reliable index of the noun-verb distinction, irrespective of the category of primes. In addition to monosyllabic words, Liu et al. (2008, 2011) examined the word class effect by employing disyllabic nouns and verbs in Chinese. Two types of syntactic contexts, noun context 'one + noun classifier' and verb context 'not + auxiliary', were presented prior to nouns and verbs respectively. The results showed that verbs elicited more negative N400 than nouns, while nouns activated more positive P600 than verbs, implying the modulating effects of both semantic and syntactic features in the processing of Chinese nouns and verbs. Taken together, the previous ERP studies have found distinct neural processing of nouns and verbs, even though the detailed patterns observed were not consistent.

The above ERP studies generally support the neural distinction between nouns and verbs. However, the nature of noun-verb distinction is not well understood. Some studies suggested that the dissociation between the two word classes arises from the semantic differences associated with nouns and verbs (Barber et al., 2010; Bird, Franklin, & Howard, 2001; Pulvermüller, Lutzenberger, & Preissl, 1999; Warrington & McCarthy, 1987; also see Kemmerer, 2014 for review), while some other research indicated that the word class effect is due to the morphological differences between the two word classes. Once the semantic factors were controlled for, the word class effect could be found only when morpho-syntactic processing was involved (Longe et al., 2007; Tyler, Bright, Fletcher, & Stamatakis, 2004; but see Momenian et al., 2016 for a different view). It is still unclear, given the inconsistency across studies, whether the neural distinction between nouns and verbs should be attributed to the morpho-syntactic differences or the semantic feature differences between these two word classes (see Vigliocco, Vinson, Druks, Barber, & Cappa, 2011 for a discussion). Since the previous studies mainly focused on the languages rich in morphology, the processing of nouns and verbs may always involve both semantic and morphological processing. It is, therefore, reasonable to investigate the word class effect in a language with a simple morphological system, such as Chinese. In Chinese, there is virtually no declension for nouns or conjugation for verbs (Wang, 1973), which makes it unlikely to induce the processing of inflection. The results from the previous studies on the Chinese speakers with noun or verb impairment revealed that the neural distinction between nouns and verbs might be due to the semantic differences (Bates, Chen, Tzeng, Li, & Opie, 1991; Bi, Han, Weekes, & Shu, 2007; Chen & Bates, 1998; Lin, Guo, Han, & Bi, 2011). Such a finding was supported by neuroimaging studies. By employing monosyllabic and disyllabic nouns and verbs and using semantic tasks, Yu, Law, Han, Zhu, and Bi (2011) and Yu, Bi, Han, Zhu, and Law (2012) found the left posterior superior and middle temporal cortices were specifically activated for Chinese verbs. On the contrary, when only disyllabic nouns and verbs were selected and a lexical decision task was performed, no cortical region was significantly activated for either nouns or verbs (Chan et al., 2008; Li, Jin, & Tan, 2004; Yang, Tan, & Li, 2011).