Effects of Noun Neighbor Ratio on Grammatical Class Recognition of Disyllabic Compound Nouns in Chinese

Keyue Chen[1] Quansheng Xia[2]
(1.Division of Psychology and Language Science, University College London, London, United Kindom 2.College of Chinese Language and Culture, Nankai University, Tianjin, China)

Abstract: Research on the dissociation between nouns and verbs has been seeking explanations from the perspectives of morphological, syntactic, and semantic properties of nouns and verbs at the lexical level. However, sub-lexical processing seems to be left out in the discussion. Having the information of grammatical class of morpheme, Chinese disyllabic compounds are ideal materials to investigate the effects of sub-lexical properties on the dissociation between nouns and verbs. The present study investigated the effects of noun neighbor ratio of the first character (NNR1) on grammatical class recognition of disyllabic compound nouns in Chinese. Noun neighbor ratio (NNR) is defined as the ratio of the number of noun neighbors (NN) to the neighborhood size (NS) at the same position (e.g., NNR1=NN1/NS1). The experiment matched seventeen nuisance variables between two conditions: low NNR1 and high NNR1. Participants were asked to judge the grammatical class of the target word as quickly as possible. Results showed that words with high NNR1 were processed more quickly than words with low NNR1. The facilitative NNR1 effect suggests that grammatical categories and semantic information of sub-lexical morphemes and disyllabic neighbors are activated during word processing. The results support the semantic explanation of the dissociation between nouns and verbs and call for more attention to NNR in further research on the noun/verb dissociation.

Keywords: Noun Neighbor Ratio; Neighborhood Size; Grammatical Class Recognition; Disyllabic Compound Nouns

1 Introduction

Regardless of diverse language systems in the world, nouns and verbs are two fundamental grammatical classes in all human languages. Previous research has heavily examined the dissociation between nouns and verbs and discovered abundant yet incongruent evidence from different research approaches (i.e., neuropsychological and neurophysiological studies, behavioral experiments, and development observations) with different paradigm and tasks. Although it is demonstrated in many research that the processing of nouns and verbs is different to some extent, whether there is a neural separation of the two grammatical classes remains unclear (see Crepaldi et al., 2011; Vigliocco et al., 2010 for comprehensive reviews).

The explanations conceived to account for neural dissociation between nouns and verbs have mainly focused on morphology, syntax, and semantics. Indeed, nouns and verbs differ greatly in these three domains. Semantically, prototypical nouns refer to objects and entities while prototypical verbs refer to actions and relations. Morphologically, inflectional languages require noun declensions to express number, case, and gender and verb conjugations to indicate tense, aspect, and voice. Syntactically, nouns usually perform the role of subject or object whilst verbs function as the predicate (Yu et al., 2011).

Two types of theoretical hypotheses explain why nouns and verbs may dissociate at the neural level. Morphological and syntactic explanations suggest that the grammatical category is the organizational principle governing the lexical representation. Dissociation of nouns and verbs can only be observed when the morphosyntactic process is involved (Tyler et al., 2004; Longe et al., 2007). However, semantic explanations hold the idea that the se-

* Corresponding author. Email address: xiaqsh@nankai.edu.cn

mantic attribute of the two classes is the underlying determinant of the neural dissociation. The semantic differences between nouns and verbs lie in object-action (or sensory-motor) (Pulvermüller et al., 1999; Moseley & Pulvermüller, 2014) or concreteness (or imageability) (Zhang et al., 2006; Tsai et al., 2009).

Morphosyntactic processing is difficult to exclude in experiments if words in inflectional languages are employed. Chinese, a language with a simple inflectional system, can avoid confounding effects of morphology and semantics. Researchers have found much evidence of noun/verb dissociation in Chinese. Aphasic studies found dissociation between nouns and verbs with Broca's and Wernicke's aphasia of Chinese at both lexical and sub-lexical levels (Bates et al., 1991; Chen & Bates, 1998). Studies that used event-related potential (ERP) showed considerable distinction between nouns and verbs, which was mainly reflected on more negative N400 activated by nouns than verbs (Liu et al., 2007; Xia et al., 2013; Xia et al., 2016). While some neuroimaging studies (e.g., fMRI studies) obtained no significant neural dissociation of nouns and verbs in disyllabic Chinese words with the lexical decision task (Li et al., 2004; Chan et al., 2008), subsequent studies using semantic relatedness judgment and semantic associate generation identified the left posterior superior and middle temporal cortices (LpSTG&MTG) as a verb-specific region in the brain (Yu et al., 2011; Yu et al., 2012).

Research on word processing in Chinese mainly employs two types of experimental materials, monosyllabic and disyllabic Chinese words. As a morpho-syllabic language, in most cases, a syllable corresponds to a morpheme and is represented by a character in Chinese (e.g., 水 shui3, 'water', 跳 tiao4, 'to jump', etc.). Compared with monosyllabic words, disyllabic words are more common in Chinese vocabulary. According to the estimation of Zhou and Marslen-Wilson (1995), the proportion of disyllabic words is about 74% in Chinese by type. And a corpus study showed that dimorphemic words take up 80% of all the single-, two-, three- and four-morpheme words (Fan & Huang, 1998). Since two-character Chinese words contain more information (e.g., more constituent senses, morphological structures, etc.) than single character ones, the processing of the two types of words could not be identical. Indeed, research on Chinese compound processing has revealed the involvement of orthographic and semantic processing of sub-lexical morphemes (see Myers, 2007 for a review on Chinese compound processing).

Besides, the processing of disyllabic verbs can be more complex than that of disyllabic nouns because of possibly ambiguous syntactic functions. There is a tendency in progress that verbs, especially disyllabic written verbs, take up some of the syntactic functions of nouns (e.g., subjects and objects) in modern Chinese (Hu, 1996; Zhang, 1989). The automatic activation of both verbal and nominal syntactic information of disyllabic verbs could cause different neural activities. Xia et al. (2016) investigated the brain responses to the processing of monosyllabic and disyllabic nouns and verbs in semantic relatedness judgment task and found different ERP patterns between monosyllabic nouns vs. monosyllabic verbs and disyllabic nouns vs. disyllabic verbs. The differences were mainly reflected on N1 and LPC, which respectively related to local syntactic violation and syntactic complexity. Hence, they suggested that research on word processing in Chinese should distinguish monosyllabic words from disyllabic words.

In addition to syntactic functions, the difference in numbers of constituent syllables also leads to different definitions of neighborhood. In the studies on word processing in Chinese, orthographic neighborhood studies have been conducted on two levels, the character level and the word level. On the character level, neighborhood size is defined as the number of the characters that share the same radical with the target character (Li et al., 2011); while on the word level, neighborhood size is defined as the number of the words that share the same constituent character with the target word (Huang et

al., 2006). NS1 and NS2 respectively refer to the number of words sharing the first and second character (see table1). It is reported that larger neighborhood size can facilitate word recognition, irrespective of the word frequency and the tasks (Tsai et al., 2006; Li et al., 2015), at least in words without high-frequency neighbors (Huang et al., 2006).

The grammatical class of constituents of disyllabic words is another factor that influences the disyllabic word processing. According to the grammatical class of constituents, disyllabic compound nouns can be divided into five subtypes: [NN] (e.g., 竹椅 zhu2yi3, 'bamboo chair'), [VN] (e.g., 走狗 zou2gou3, literally walk-dog, 'lackey'), [NV] (e.g., 家训 jia1xun4, literally family-teach, 'family motto'), [VV] (e.g., 感想 gan3xiang3, literally feel-think, 'feelings and thoughts'), and [AN] (粗话 cu1hua4, 'vulgar language'). Among the five subtypes, [NN] compound nouns are the most typical (Fan & Huang, 1998). Hsu et al. (2004) discovered that [NN] compound nouns were processed faster than all the other subtypes of compound nouns in grammatical class judgment task. To quantify the internal word-class structure of compounds, noun neighbor ratio (NNR) is defined as the ratio of the number of noun neighbors (NN) to the neighborhood size (NS) at the same position (Xia et al., 2017) (see Table 1).

Table 1 Examples of NS, NN, and NNR on the word level in Chinese word

Character1		Character2	
羽yu3 'feather'		绒rong2 'down'	
Neighbor1	Grammatical class	Neighbor2	Grammatical class
羽绒-rong2 'down'	noun	羽绒yu3- 'down'	noun
羽毛-mao2 'feather'	noun	丝绒si1- 'velvet'	noun
羽衣-yi1 'feathered coat'	noun	毛绒mao2- 'plush'	noun
羽翼-yi4 'wing'	noun	驼绒tuo2- 'camel hair'	noun
羽球-qiu2 'badminton'	noun	平绒ping2- 'panne'	noun
羽化-hua4 'immortalize'	verb	簇绒cu4- 'tufting'	noun
Neighborhood size1 (NS1)	6	Neighborhood size2 (NS2)	6
No. of noun neighbor1 (NN1)	5	No. of noun neighbor2 (NN2)	6
Noun neighbor ratio1 (NNR1)	0.83	Noun neighbor ratio2 (NNR2)	1

Information was collected from Corpus Online - Modern Chinese Corpus - Word Search (open access: http://www.aihanyu.org/cncorpus/wdindex.aspx)

The role of NNR in word processing has been demonstrated in the studies on Chinese. To examine the effects of various possible factors on grammatical class recognition, Xia et al. (2017) conducted a regression analysis on the reaction times (RTs) of Chinese disyllabic compound nouns in grammatical class judgment task. Among eighteen candidates of predictive variables, noun neighbor ratio of the first character (NNR1), noun neighbor ratio of the second character (NNR2), and AoA showed significant effects. And NNR1 showed the strongest explanatory effect among these three variables in the stepwise regression analysis. The effect of AoA on word processing is along with the previous studies on monosyllabic Chinese words in word naming, semantic category judgment, lexical decision, and grammatical class judgment task, suggesting that the earlier a word is acquired, the more quickly and accurately it is processed (Chen et al., 2007; Chen & Zhang, 2010; Bai & Chen, 2011). Furthermore, the observed NNR effects might indicate that the information of grammatical class of morphemes was activated and may exert great influence during Chinese disyllabic word processing.

However, as NNR effect was discovered in the regression analysis, its strong effect in word processing is worth further examination and verification. Thus, the present study will directly manipulate the NNR1 of disyllabic compound nouns to investigate its role in word processing. It was expected that di-

syllabic compound nouns with higher NNR1 would be processed significantly more quickly than that with lower NNR1 in the grammatical class judgment task. Otherwise, the NNR effect might not exist.

2 Method

Participants

Thirty-five native Mandarin speakers and readers of the simplified Chinese script (19 females; mean age: 20.5, SD: 1.8) participated in the study. All the participants were undergraduate or graduate students from Nankai University. They were all right-handed and had normal or corrected-to-normal vision. None of the participants was majoring in linguistics, psychology, or any other related disciplines. They gave written informed consent and received a USB flash disk as compensation.

Materials

Data of NS and NN of both constituent characters of the disyllabic compound nouns were retrieved from Corpus Online - Modern Chinese Corpus - Word Search[①]. NNR is calculated from NS and NN (e.g., NNR1=NN1/NS1). All the materials were divided into two groups based on the value of NNR1, which were respectively low NNR1 group and high NNR1 group. The frequency of the two constituent characters and the entire word was also retrieved from the corpus mentioned above and was transformed into log value (with the formula '=LOG((F+1),2)' in Excel). Number of stroke was collected from Contemporary Dictionary of Chinese (2012). AoA, familiarity, concreteness, and semantic transparency were respectively rated by 32-33 people who did not participate in the experiment. Finally, the seventeen variables were matched between low NNR1 group and high NNR1 group (ps > 0.05) (see table 2).

There are two types of morphological structures of Chinese [NN] compound nouns: subordinate and coordinate. Subordinate compounds are composed of a head and a modifier (e.g., 花园 hua1yuan2 'flower garden', where 园 yuan2 is the head, and 花 hua1 is the modifier). Coordinate compounds contain two constituent morphemes of coordinating relationships. Normally, two morphemes have similar meanings (e.g., 沟渠 gou1qu2 literally ditch(n.)-canal). Previous studies have found that compared to the subordinate structure, lexical decision and word memorization were inhibited if the coordinate structure was activated (Liu & McBride-Chang, 2010; Liu, 2017). Therefore, the morphological structures of the target stimuli used in the experiment were controlled for.

Table 2 Lexical variables of stimuli for each condition

		Low NNR1	High NNR1	ANOVA
Example		瓦房 wa3fang2 'tile-roofed house'	菜汤 cai4tang1 'vegetable soup'	
Neighborhood size	NS1	18.91(10.54)	16.13(10.23)	0.369
	NS2	20.13(16.20)	17.39(8.71)	0.479
Noumber of noun neighbor	NN1	15.70(9.10)	15.96(10.01)	0.927
	NN2	18.87(14.89)	16.22(7.49)	0.449
Noun neighbor ratio	NNR1	0.81(0.10)	0.99(0.02)	***
	NNR2	0.95(0.05)	0.94(0.05)	0.603
Log frequency	F1	0.66(0.43)	0.60(0.53)	0.666
	F2	0.38(0.34)	0.48(0.39)	0.37
	FW	0.17(0.27)	0.07(0.05)	0.079
Number of stroke	NoS1	8.30(2.87)	8,74(2.43)	0.582
	NoS2	8.47(2.63)	8.52(2.43)	0.772
	NoSW	16.96(3.71)	17.26(3.41)	0.774
Age of Acquisition	AoA	3.97(0.88)	3.84(0.90)	0.674
Familiarity		5.86(0.58)	5.89(0.54)	0.839
Concreteness		5.21(1.28)	5.65(0.87)	0.176
Semantic Transparency	ST1	7.03(1.07)	7.19(0.92)	0.595
	ST2	7.27(1.01)	7.14(1.39)	0.724
Morphological structure		0.35(0.49)	0.35(0.49)	1

***p<0.001; For all abbreviations, 1 stands for the first character, 2 stands for the second character, and W stands for the entire word. The range of AoA, Familiarity, and Concreteness was 1-7. The range of Semantic Transparency was 1-9. For morphological structures, the subordinate structure was assigned a value of 0, and the coordinate structure of 1.

[①]Corpus Online - Modern Chinese Corpus - Word Search. open access URL: http://www.aihanyu.org/cncorpus/wdindex.aspx

After matching all the variables, 46 compounds were selected into two groups as (23 in low NNR1 group and 23 in high NNR1 group; see table 3 for examples). All of the stimuli were unambiguous nouns. And the constituent morphemes of the stimuli were mostly unambiguously nominal. A small number of them could be used as other parts of speech, but the nominal usage was 10 times more than other usages (except for 剧院 ju4yuan4 'theater', the nominal usage of 剧 ju4 is 8.7 times more than the adjective usage). Additionally, 138 disyllabic compounds were selected as fillers, including 46 nouns of other internal structures (i.e., [NV], [VN], and [VV] compound) and 92 compounds of other grammatical classes (46 verbs, 23 adjectives, and 23 adverbs or conjunctions). 184 words were divided into two blocks. Each block contains 23 target words and 69 fillers.

Table 3 Examples of experimental stimuli

Low NNR1 words			High NNR1 words		
Word	pronun ciation	Meaning	Word	pronun ciation	Meaning
板凳	ban3deng4	stool	宾馆	bin1guan3	Hotel
歌坛	ge1tan2	music circle	锅炉	guo1lu2	Boiler
眼科	yan3ke1	ophthal mology	姨娘	yi2niang2	maternal aunt
羽绒	yu3rong2	down	竹椅	zhu2yi3	bamboo chair

Procedures

The experiment used E-Prime to present experimental materials and record behavioral data. In each trial, a black fixation point was first presented on the white screen for 500ms, and then a stimulus was presented at the same position for 1500ms. The subjects were asked to determine whether the disyllabic word presented was a noun or not as quickly and accurately as possible. When the subject pressed the button, the stimulus would disappear immediately. The interval between each stimulus was 1500ms. All the stimuli appeared in random order within each block. It took about seven minutes to finish one block, and there was one-minute rest between the two blocks. Before the formal experiment, there were 20 practice trials. After the subjects confirmed that they were clear and familiar with the experimental procedure, the formal experiment was started. The subjects were required to press F or J on the keyboard to give responses. The presentation order of the two blocks was counterbalanced across subjects.

Results

Reaction errors (1.8%) and outliers of RTs (deviated from the mean value by 3 standard deviations, SD) (1.3%) were also excluded. Besides, one subject's reaction time data exceeded 3 SD from the overall means and were excluded to make sure that the data of both conditions (e.g., low NNR1 and high NNR1) were normally distributed. Table 4 displays the mean RTs and error rates in each condition for the remaining data. The overall accuracy rate of the participants' response was almost ceiling. The high accuracy assured that the participants paid attention to the stimuli during the experiment.

Table 4. Mean RTs and error rates of the two conditions (N = 35)

Low NNR1		High NNR1	
RT (ms)	Errors (%)	RT (ms)	Errors (%)
704.08 (70.07)	2.73	682.40 (76.60)	2.12

A subject-wise paired-samples t-test of the RTs showed that participants spent more time to recognize the grammatical class of the disyllabic compounds with lower NNR1 than that with higher NNR1 ($t(33)=3.395$, $p<0.01$). The result, consistent with our prediction, showed a facilitative effect of NNR1 in the grammatical class recognition of disyllabic Chinese compounds. The information related to neighborhood and grammatical categories of sub-lexical components were activated in the processing of disyllabic compounds. Item-wise paired-samples t-test of RTs showed no significant difference ($t(22)=1.725$, $p>0.05$) between the two conditions. Such null effect effect found in the item-wise test may be caused by the short RTs since [NN] nominal compounds are the most typical subtype of nominal compounds (Fan & Huang, 1998) and are processed fastest among all the five subtypes of compound nouns (Hsu et al., 2004).

3 Discussion

The results showed that, after strictly controlling for nuisance variables, high NNR1 compound nouns were processed more quickly than low NNR1 ones, indicating a facilitative NNR1 effect on grammatical class recognition in Chinese.These results are compatible with Xia et al. (2017). In the study of Xia et al. (2017), the regression analysis on the RTs examined the effects of eighteen possible factors on the grammatical class recognition of disyllabic compound nouns in Chinese. The results showed that NNR1 significantly correlated to the RTs. When NNR1 entered the multiple stepwise regression equation as the first variable, it explained 14.8% of the variation, which is the highest among variables (Xia et al., 2017). In the present study, the NNR1 was directly manipulated and the results also indicated a robust NNR1 effect on grammatical class recognition.

Previous studies mainly discussed whether morphological, syntactic, or semantic differences of nouns and verbs play a determinant role in their dissociation. Sub-lexical properties related to the grammatical categories of the entire word were rarely investigated. However, previous research on Chinese aphasia has indeed revealed a dissociation between nouns and verbs on the sub-lexical level by eliciting words of different grammatical classes of constituents from Broca's and Wernicke's aphasics through picture naming tasks. Bates et al. (1991) found that Chinese Broca's aphasics had greater difficulty with the verbal components in [VN] compound verbs, whereas Wernicke's aphasics made more errors when producing the nominal components in such [VN] compound verbs. Subsequently, Chen and Bates (1998) provided new data of experiments using compound nouns containing verbal components, such as [VN] and [VNN] nouns. Unexpectedly, the results showed that both Broca's and Wernicke's aphasics made more errors on the verbal components in [VN] nouns. They speculated that the atypicality of [VN] nouns may cause the discrepancy of the aphasics' responses between compound verbs and compound nouns.

This explanation is plausible. According to Fan and Huang's (1998) investigation, [VV] verbs take up 44.7% in all types of compound verbs, and [VN] verbs take up 34.1%, which is the second typical type of compound verbs. In contrast, [NN] nouns take up 57.2% in all types of compound nouns, while [VN] nouns take up only 11.6%. [NV] nouns are even more atypical, taking up 1.2% in all types of compound nouns. This typicality/atypicality of compound nouns may account for the discrepancy between the observations of Bates et al. (1991) and Chen and Bates (1998).

Atypicality of sub-lexical grammatical-class structure can also be a confounding factor in Xia et al. (2017). The 128 compound nouns they used consist of 45 [NN], 38 [NV], and 45 [VN]. The diversity of their experimental stimuli, on one hand, could suggest that the significant NNR effects of their study could be applied to compound nouns of different grammatical classes of morphemes. On the other hand, however, the results could be biased by the atypicality of the [VN] and [NV] nouns. [NN] nouns tend to have higher NNR1 than [VN] nouns and higher NNR2 than [NV] nouns. The facilitative effect of NNR found by Xia et al. (2017) may be ascribed to atypicality of [VN] and [NV] nouns rather than higher NNR itself.

The present study restricts the stimuli to [NN] and thus eliminates the possible confounding effect of atypical internal grammatical-class structures. Still, the result shows a significant facilitative NNR1 effect, indicating that NNR1 is an independent variable that exerts important influence on grammatical class recognition of Chinese compound nouns. Together with previous studies, it is indicated that not only the grammatical class of morpheme can influence the processing of compound nouns and verbs, but also the ability of constituent morphemes to generate words of certain grammatical categories (which is represented as NNR in this study) can be a significant factor in the dissociation

of nouns and verbs.

The results of the current study do not support the morphological and syntactic explanation of the dissociation of nouns and verbs. On the one hand, the present study presented isolated disyllabic compound nouns in grammatical class judgment task, and thus few syntactic functions of the constituent morphemes could be activated during the process. On the other hand, as Chinese is known as a language with simple morphology, there is probably no morphological forms of the entire words or their constituent morphemes that could influence word processing. Thus, the NNR1 effect found in this study could hardly be explained by either morphological or syntactic accounts.

NNR, as a variable derived from NS, is closely related to neighborhood information stored in the mental lexicon. NS is defined as the number of words that share the same constituent character with the target word. Both the changed and remained components are mostly meaningful. Neighbors of the same word are semantically similar or related (Huang et al., 2006) (e.g., 奔跑 ben1pao3, literally run-run, 'to run', 奔驰 ben1chi2, literally run-gallop, 'to gallop', 奔忙 ben1mang2, literally run-busy, 'to bustle about', 奔放 ben1fang4, literally run-release, 'bold and unrestrained'). Hence, the similarity among the neighborhood of a Chinese word can be considered both orthographic and semantic. NNR thus probably links to the orthographic and semantic information. Meanwhile, NNR is also concerned with the grammatical categories of both morphemes and neighbors of the target word. Higher probabilities of nominal morphemes to compose compound nouns corresponds with higher probabilities of nominal senses to be combined into larger nominal senses. In this sense, NNR reflects the ability of the nominal morphemes to generate compound nouns. Knowledge of NNR is collected and generalized by Chinese native speakers from the experience of processing lexical and sub-lexical orthography and semantics in everyday life. In short, the NNR effect suggests a close relationship between grammatical categories and semantics at both lexical and sub-lexical levels.

Although NNR1 is intuitively a rather subtle variable that may entail deep lexical processing demand, the results of the study showed the facilitative NNR1 effect on the processing of disyllabic compound nouns, indicating the information of morphemes is automatically activated during grammatical class recognition of the entire word in Chinese. Research on word recognition has revealed morphemic decomposition in entire-word processing (Taft, 1994, 2004; Taft & Nguyen-Hoan, 2010; Tsang & Chen, 2013; Tsang et al., 2014; also see Myers, 2007 for a review on Chinese compound processing). According to the interactive-activation model (McClelland & Rumelhart, 1981), visual input excites detectors for visual features and further activates consistent words which mutually inhibit each other. Previous studies have suggested that words with larger NS were processed faster than words with smaller NS, demonstrating that all the neighbors were activated in word processing and could facilitate lexical retrieval of the target word (Andrews, 1989; Tsai et al., 2006; Li et al., 2015). In the present study, since experimental subjects were asked to judge whether the word presented was a noun or not, not all the neighbors would exert a facilitative influence. While the activated noun neighbors would aid the grammatical class recognition of the target word, neighbors of other grammatical classes would impede the process. The higher the NNR is, the larger proportion of noun neighbors the target word has, and the more facilitative effects exert on the processing of the target word.

The lemma model, a model of the structure of the mental lexicon, could provide a possible explanation for the NNR effect in grammatical class recognition. Proposed by Taft and Nguyen-Hoan (2010), the lemma model is modified by Tsang and Chen (2013) to accommodate Chinese word processing. "Lemmas" are conceived to be an intermediate level between the form and function and store orthographic and semantic information of both the word and its

morphemes. The primary processing of visual words activates the lemma of the compound nouns and their nominal morphemes. Then these lemmas of morphemes assist the estimation of NNR – the ability of the morpheme to generate disyllabic compound nouns – by connecting lexical neighbors through orthographic and semantic similarities. High NNR leads to an intensive network that assembles the nominal neighborhood and thus facilitates grammatical class recognition. The modified lemma model provides the possible mechanism by which the dissociation between Chinese compound nouns and verbs is influenced by the sub-lexical properties.

4 Conclusion

In the present study, we aimed to investigate whether noun neighbor ratio of the first character (NNR1) affects grammatical class processing of Chinese disyllabic compound nouns with a grammatical class judgment task. Consistent with the previous study (Xia et al., 2017), the results of RTs revealed a facilitative effect of NNR1 on grammatical class recognition. Words with higher NNR1 were recognized more quickly than words with lower NNR1. As a variable related to orthographic, semantic, and grammatical information at both sub-lexical and lexical levels, NNR1 reflects the ability of the nominal morpheme to generate compound nouns. The facilitative NNR1 effect on grammatical class recognition indicates that the dissociation between nouns and verbs should be attributed to semantic differences associated with the two grammatical classes. Further study using different paradigms or other types of Chinese compounds could be done to investigate the role of sub-lexical grammatical classes in the dissociation between nouns and verbs.

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Reference

Andrews, S. (1989).Frequency and Neighborhood Effects on Lexical Access: Activation or Search? [J]. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15(5): 802–14.

Bai, L. & B. Chen. (2011).AoA Effects on Processing Grammatical Category Information of Chinese Characters (Hanzi xide de nianling dui cilei xinxi jiagong de yingxiang) [J]. Journal of Psychological Science (Xinli Kexue),, 34 (2): 343–47.

Bates, E., S. Chen, O. Tzeng, P. Li, & M. Opie. (1991).The Noun-Verb Problem in Chinese Aphasia [J]. Brain and Language , 41(2): 203–33.

Chan, A. H. D., K. Luke, P. Li, V. Yip, G. Li, B. Weekes, & L. H. Tan. (2008).Neural Correlates of Nouns and Verbs in Early Bilinguals [J]. Annals of the New York Academy of Sciences , 1145(1): 30–40.

Chen, B., W. You, & H. Zhou. (2007).Age of Acquisition Effects in Reading Chinese: Evidence in Favor of the Semantic Hypothesis (Hanyu cihui xide de nianling xiaoying: Yuyi jiashe de zhengju) [J]. Acta Psychologica Sinica (Xinli Xuebao), 39(1): 9–17.

Chen, S., & E. Bates. (1998)The Dissociation between Nouns and Verbs in Broca's and Wernicke's Aphasia: Findings from Chinese [J]. Aphasiology , 12(1): 5–36.

Chen, X. & J. (2010).Zhang, A Regression Analysis of Influencing Factors of Nouns and Verbs (Yingxiang hanyu dongci mingci shibie yinsu de huigui fenxi) [J]. Journal of Psychological Science (Xinli Kexue) , 33(1): 60–63

Crepaldi, D., M. Berlingeri, E. Paulesu, & C. Luzzatti. (2011). A place for nouns and a place for verbs? A critical review of neurocognitive data on grammatical-class effects [J]. Brain and Language, , 116(1): 33–49.

Contemporary Dictionary of Chinese (6th ed.)(2012). [W]. Beijing: Commercial Press.

Fan, C., & C. Huang. (1998).On Chinese Morpheme and Word Formation: A Study Based on Morpheme Database (Jiyu yusu shujuku de hanyu yusu ji gouci yanjiu) [J]. Chinese Teaching in the World (Shijie Hanyu Jiaoxue), 44(2): 7–12.

Hsu, J. C., O. J. Tzeng, & D. L. Huang. Syntactic Effects on Constituent Components in Word Recognition: Evidence from Compound Nouns and Compound Verbs in Chinese [D]. Univ. Maryland Working Pap. Linguistics 204, 13, 173–193.

Hu, Mingyang. (1996).A Study of Lexical Categories (Cilei

Wenti Kaocha) [M]. Beijing: Beijing Language Institute Press.

Huang, C., C. Lee, H. Huang, & C. Chou. (2011).Number of Sense Effects of Chinese Disyllabic Compounds in the Two Hemispheres [J]. Brain and Language , 119(2): 99–109.

Huang, H., C. Lee, J. Tsai, C. Lee, D. Hung, & O. Tzeng. 2006Orthographic Neighborhood Effects in Reading Chinese Two–Character Words [J]. Neuroreport, , 17: 1061–5.

Laiacona M., & A. Caramazza. (2004).The noun/verb dissociation in language production: Varieties of causes [J]. Cognitive Neuropsychology, 21(2–4): 103–123.

Lavidor, M., A. Hayes, R. Shillcock, & A. W. Ellis. (2004). Evaluating a Split Processing Model of Visual Word Recognition: Effects of Orthographic Neighborhood Size [J]. Brain and Language , 88(3): 312–20.

Li, M., W. Lin, T. Chou, F. Yang, & J. Wu. (2005).The Role of Orthographic Neighborhood Size Effects in Chinese Word Recognition [J]. Journal of Psycholinguistic Research , 44(3): 219–36.

Li, P., Z. Jin, & L. H. Tan. (2004). Neural Representations of Nouns and Verbs in Chinese: An FMRI Study [J]. NeuroImage , 21(4): 1533–41.

Li, Q., H. Bi, T. Wei, & B. Chen. (2011).Orthographic Neighborhood Size Effect in Chinese Character Naming: Orthographic and Phonological Activations [J]. Acta Psychologica , 136(1): 35–41.

Liu, D. (2017). The Influence of Morphological Structure Information on the Memorization of Chinese Compound Words [J]. Reading and Writing, , 30(8): 1813–34.

Liu, P. D., & C. McBride–Chang.(2010).Morphological Processing of Chinese Compounds from a Grammatical View [J]. Applied Psycholinguistics, 31(4): 605–17.

Liu, Y., S. Hua, & B. S. Weekes.(2007).Differences in Neural Processing between Nouns and Verbs in Chinese: Evidence from EEG [J]. Brain and Language , 103(1): 75–77.

Longe, O., B. Randall, E. A. Stamatakis, & L. K. Tyler. (2007).Grammatical Categories in the Brain: The Role of Morphological Structure [J]. Cerebral Cortex , 17(8): 1812–20.

McClelland, J. L., & D. E. Rumelhart.(1981).An Interactive Activation Model of Context Effects in Letter Perception: Part 1. An Account of Basic Findings [J]. Psychological Review , 88(5): 375–407.

Moseley, R.L., & F. Pulvermüller. (2014).Nouns, Verbs, Objects, Actions, and Abstractions: Local FMRI Activity Indexes Semantics, Not Lexical Categories [J]. Brain and Language , 132: 28–42.

Myers, J. (2007).Processing Chinese Compounds: A Survey of the Literature [M]. In The Representation and Processing of Compound Words, edited by Gary Libben and Gonia Jarema. Oxford University Press, 169–96

Pulvermüller, F., W. Lutzenberger, & H. Preissl. (1999). Nouns and Verbs in the Intact Brain: Evidence from Event–Related Potentials and High–Frequency Cortical Responses [J]. Cerebral Cortex, 9(5): 497–506.

Taft, M.(1994). Interactive– Activation as a Framework for Understanding Morphological Processing [J]. Language and Cognitive Processes, 9(3): 271–94.

Taft, M. (2004).Morphological Decomposition and the Reverse Base Frequency Effect [J]. The Quarterly Journal of Experimental Psychology Section A, 57(4): 745–65.

Taft, M., & M. Nguyen–Hoan. (2010).A Sticky Stick? The Locus of Morphological Representation in the Lexicon [J]. Language and Cognitive Processes, 25(2): 277–96.

Tsai, J., C. Lee, Y., Ovid Tzeng, & D. L. Hung. (2006).Neighborhood Size Effects of Chinese Words in Lexical Decision and Reading [J]. Language and Linguistics, 7(3): 659–75.

Tsai, P., B. H. Yu, C. Lee, O. J. Tzeng, D. L. Hung, & D. H. Wu.(2009).An Event–Related Potential Study of the Concreteness Effect between Chinese Nouns and Verbs [J]. Brain Research , 1253: 149–60.

Tsang, Y., & H. Chen.(2013). Early Morphological Processing Is Sensitive to Morphemic Meanings: Evidence from Processing Ambiguous Morphemes [J]. Journal of Memory and Language, 68(3): 223–39.

Tsang, Y., A. W. Wong, J. Huang, & H. Chen.(2014). Morpho– Orthographic and Morpho– Semantic Processing in Word Recognition and Production: Evidence from Ambiguous Morphemes [J]. Language, Cognition and Neuroscience, 29(5): 543–60.

Tyler, L. K, P. Bright, P. Fletcher, & E. A. (2004).Stamatakis. Neural Processing of Nouns and Verbs: The Role of Inflectional Morphology [J]. Neuropsychologia , 42(4): 512–23.

Vigliocco, G., D. P. Vinson, J. Druks, H. Barber, & S. F. Cappa. (2011).Nouns and Verbs in the Brain: A Review of Behavioural, Electrophysiological, Neuropsychological and Imaging Studies [J]. Neuroscience & Biobehavioral Reviews, 35(3): 407–26.

Xia, Q., Y. Lü, X. Bai, & F. Shi.(2013). An Erp Study on the

Semantic Processing of Unambiguous Noun, Unambiguous Verb and Verb−Noun Ambiguous Word in Mandarin Chinese [J]. Journal of Chinese Linguistics, 41(1): 197−218.

Xia, Q., Y. Lü, J. Wang & W. Gong.(2017). A Study on the Factors Affecting Word Class Recognition of Chinese Compound Words: Regression Analysis of the Processing of Subordinate Disyllabic Compound Nouns (Hanyu fuheci cilei shibie de yingxiang yinsu yanjiu: Shuangyinjie pianzheng fuhe mingci jiagong de huigui fenxi) [J]. Nankai Linguistics (Nankai Yuyanxue) , 29(1): 56−65

Xia, Q., L. Wang, & G. Peng. (2016).Nouns and Verbs in Chinese Are Processed Differently: Evidence from an ERP Study on Monosyllabic and Disyllabic Word Processing [J]. Journal of Neurolinguistics, 40: 66−78.

Yu, X., S.P. Law, Z. Han, C. Zhu, & Y. Bi. (2011).Dissociative Neural Correlates of Semantic Processing of Nouns and Verbs in Chinese − A Language with Minimal Inflectional Morphology [J]. NeuroImage, 58(3): 912−22.

Yu, X., Y. Bi, Z. Han, C. Zhu, & S. Law. (2012).Neural Correlates of Comprehension and Production of Nouns and Verbs in Chinese [J]. Brain and Language, 122(2): 126−31.

Zhang, G. (1989).On the Differences of Syntactic Functions between Monosyllabic and Disyllabic Action Verbs (Dan shuang yinjie dongzuo dongci chongdang jufa chengfen gongneng chayi kaocha) [J]. Journal of Huaibei Coal Division (Social Science) (Huaibei Meishiyuan Xuebao), (3): 116−123

Zhang, Q., C. Guo, J. Ding, & Z. Wang.(2006). Concreteness Effects in the Processing of Chinese Words [J]. Brain and Language, 96(1): 59−68.

Zhou, X., & W. Marslen−Wilson. (1995).Morphological Structure in the Chinese Mental Lexicon [J]. Language and Cognitive Processes, 10: 545−600.