

Selective grammatical-class deficits:

Implications for the representation of grammatical information in Chinese

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**Abstract**

The selective deficits of words belonging to certain grammatical classes (e.g., nouns or verbs) due to brain damage are compelling discoveries and serves as a tool to uncover the representation of grammatical class information in the brain. In this area, studying Chinese brain-damaged individuals provides special insights because of the unique linguistic features of Chinese nouns and verbs. In this chapter we review relevant discoveries in the literature and their theoretical implications on the representation of grammatical class information in Chinese, including for compound words.

## 1 Introduction

Grammar, the rules that allow infinite sentences to be built based on a finite set of words, is an essential component of languages. Although the question of how the human brain represents and processes grammatical information has attracted the attention of philosophers and linguists for centuries, most psycholinguistic studies have focused on a specific class of single words – concrete nouns with less consideration of the grammatical aspects of the words. How are grammatical properties of words of various classes captured by the cognitive/neural system? How does the brain “compute” the agreements (e.g., case, tense, grammatical gender) between words so that grammatical sentences are produced to convey a message? How do the language-specific linguistic factors affect the cognitive processes? Recent development of new techniques such as neuroimaging (e.g., Li, Jin, & Tan, 2004; Shapiro, Moo, & Caramazza, 2006; Tyler, Bright, Fletcher, & Stamatakis, 2004) have promoted some new ways of looking at these theoretical questions. Nevertheless, the most consistent and revealing evidence has come from the study of brain-damaged individuals.

Historically, the 1970s saw a revolution in the way to study patterns of break-downs induced by brain-damage, starting with the study of so-called “agrammatic” speakers. People observed that the individuals with typical Broca’s aphasia, who produced speech with poor grammatical structure and made errors on grammatical morphemes, often also had difficulty in comprehending sentences for which grammatical structure interpretation was necessary. This evoked excitement

among the researchers and led them to propose that there would be a functionally (possibly neurologically) independent “grammar module” shared by language production and comprehension and that it could be impaired selectively (see Caramazza, Berndt, Basili, & Koller, 1981). This hypothesis, although elegant, was soon proven to be wrong. Individuals with various profiles, such as those with only agrammatic speech but intact comprehension, or with deficit on only one type of morphological morphemes, were reported (e.g., Bastiaanse, 1995; Miceli, Mazzucchi, Menn, & Goodglass, 1983; Nespoulous et al. 1988). Later research, instead of trying to find a general mechanism underlying brain-damaged individuals classified as a syndrome group with “grammatical impairment”, has focused more on the understanding of how each subcomponent of the grammatical system is organized by looking at single cases with specific profiles. Among them, the representation of nouns and verbs has been one of the most fundamental issues of interest.

In this chapter we do not intend to give a complete review of the progress in understanding grammatical processes; rather, we focus on a compelling type of individuals who show varied types of noun/verb dissociations in their deficit patterns and discuss how the study of such patterns inform us of the representation of these two major grammatical categories in the brain. In particular, we try to understand how the contrast between Chinese language and Indo-European languages might give us special insights into the issue. The chapter is organized into three sections. First, we discuss briefly some specific properties of the Chinese grammar and whether and how such properties might affect cognitive processing. Then we present what we have

learnt about the grammatical system by studying speakers with noun/verb dissociations, especially Chinese ones. Finally, some future research directions are laid out.

## **2 Chinese grammatical system**

Certain aspects of grammar are most likely to be universal across languages, such as the existence of a “noun” class and a “verb” class. Nouns act as the objects or subjects in a sentence, while verbs act as their predicates. However, the detailed grammatical rules differ widely among languages. Packard (1993) conducted a comprehensive review on the specific characteristics of the Chinese grammatical system. Here we will discuss only those that are potentially significant for cognitive theory building. A marked characteristic of the Chinese language is the paucity of inflectional morphology, which, by contrast, is very prevalent in Indo-European languages. For example, one Hungarian noun sometimes can take up to one hundred different inflectional forms. A Chinese word, however, has only one form, no matter what the word’s person, case, gender, tense or number attributes are. The consequences of the near absence of inflection for the cognitive system then become interesting. On the one hand, it is possible that the difference in the morphological processing mechanisms associated with nouns and verbs seen in Indo-European languages (see more detailed discussion in 3.3) may not be visible in Chinese (see Shapiro & Caramazza, 2003). On the other hand, the paucity of explicit inflectional morphemes might not necessarily imply the absence of an abstract morpho-syntactic

processing mechanism.

In Chinese, information like tense and case is sometimes carried by various types of grammatical markers that are free-standing morphemes, such as classifiers, co-verbs, affixations, negative markers, aspect markers (see Law & Cheng, 2002). Some of them are specific for open-class words of a certain grammatical category. For instance, between a determiner and a noun, a classifier is obligatory. Prepositions were treated by Packard as co-verbs, given that they contain some attributes of verbs. Grammatical markers that are associated with verbs include aspect markers, which are used to express aspectual relations (过, /*guo4*<sup>1</sup>/, indicating the completion of the verbal action; 了, /*le0*/, indicating the completion of the verbal action or change of the sentence situation; 着, /*zhe0*/, or 在, /*zai4*/, indicating continuative aspect of verbal action).

The most productive morphological procedure in forming Chinese words is compounding. Worth noting is that, the morphemes that comprise the compound could be from various grammatical classes that might either be the same as the compound or different. For example, the word 火车 (/*huo3che1*/, train) is composed of two nominal morphemes 火 (/*huo3*/, fire) and 车 (/*che1*/, car), referred to as a “N=nn” compound. The noun 讲台 (/*jiang3tai2*/, dais), on the other hand, is constituted of a verbal element 讲 (speak) and a nominal element 台 (platform) (N=vn). A verbal compound example is 跳水 (/*tiao4shui3*/, to dive), which is

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<sup>1</sup> The pinyin system is used for phonetic transcription of Chinese characters. The number represents the tone of the syllable preceding it. There are five tones in Mandarin Chinese, level (1), rise (2), fall-rise (3), fall (4), and unstressed (0).

constituted of a verbal element 跳 (jump) and a nominal element 水 (water) (V=vn).

The richness of word internal structures therefore provides us with opportunities to study the grammatical aspects of word composition.

Finally, the word order in Chinese is more flexible relative to other languages. Although the common word order is subject-verb-object (SVO), this order is often changed in order to focus on or emphasize the object. Furthermore, some elements, such as noun phrases and pronouns, are more frequently omitted in Chinese than in other languages. These characteristics make evaluating “grammatical” deficits in language production in Chinese speakers less straightforward. The approaches taken include obtaining speech generating norms of normal speakers and giving tasks with highly constrained grammatical components.

It is theoretically significant whether such linguistic differences affect the cognitive system, and if so, how. Packard (1993), based on the analyses of one single case of “agrammatic” Chinese case (Chen), compared the “agrammatic” speech patterns in Chinese to the common profiles observed in Western language speakers. Similar to brain-damaged individuals of western languages, Chen’s speech showed short phrases, slow speech rate, syntactic simplification, function-word omission and underemployment. However, in contrast to the frequent substitutions of functional morphemes observed in western individuals with aphasia, no substitution errors were observed in this Chinese agrammatic person. The author argues that this difference is of theoretical importance because there are two potential origins for the substitution errors in alphabetic languages: deficits at the inflectional morphology system and

deficits at selecting bound morphemes. Since Chinese has bound morphemes but little inflectional morphology, the absence of substitution errors in the Chinese case indicates that the substitution errors in western languages might originate from the inflectional system. Now we know that agrammatic individuals are not a homogeneous set, and the patterns reported by Packard could either be due to the language difference or to that particular case. However, his work inspired us with the possible ways to address the issue.

Some researchers propose that the linguistic features of Chinese might also influence the acquisition pattern for nouns and verbs. While it has been widely reported that nouns are acquired earlier than verbs in many Indo-European languages (e.g., Bornstein et al. 2004), Tardif and colleagues (Tardif, 1996; Tardif, Shatz, & Naigles, 1997; Tardif, Susan, & Fan, 1999) observed a reverse trend in Chinese children. These authors attributed such differences to a set of variables, including concept imageability, linguistic status as well as the parental speech input frequency. For instance, they observed that the early-acquired verbs by Chinese children had higher imageability than those by English-speaking children, leading them to postulate that imageability affects verb-learning because actions with high imageability are more easily to be segmented and labeled with verbs. They also proposed that in Mandarin verbs tend to occur at the end position of utterances without complex morphological changes, making them easier to be segmented and learnt. A further observation that might underlie the verb acquisition difference is that Chinese mothers' speech to children contained more verbs than those produced by



English-speaking mothers.

Li et al. (2004) proposed that the paucity of inflectional morphology in Chinese may affect how nouns and verbs are represented in the brain. Indeed, in a fMRI study where Chinese participants were asked to perform lexical decision task on Chinese nouns and verbs, they failed to detect any difference in the neural activation between these two classes of words. This was different from the results with English speakers (e.g., Federmeier, Segal, Lombrozo, & Kutas, 2000; Shapiro et al. 2006; but see Tyler et al. 2004). One may argue that the lexical decision task used in their study is not sensitive to grammatical information and therefore the null result should not be taken as evidence that Chinese nouns and verbs do not have distinguishable neural substrates. In the following section, we lay out several kinds of representations/processes in which nouns and verbs might differ and the possible ways in which nouns and verbs as grammatical entities are represented in Chinese speakers.

### **3 Selective noun-verb deficits**

The pursuit of noun/verb representation difference was started by the seminal work by Mr. G. B. Vico (1688-1744), who first described a brain-damaged male with selective impairment of verbs relative to nouns (see Denes & Barba, 1998). Subsequent researchers reported similar dissociations in both directions, including more severe impairment with verbs than nouns (e.g., Berndt, Haendiges, Mitchum, & Sandson, 1997; Berndt, Mitchum, Haendiges, Sandson, 1997; Breedin, Saffran, &

Schwartz, 1998; Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Hillis, Wityk, Barker, & Caramazza, 2002; Kim & Thompson, 2000; Kohn, Lorch, & Pearson, 1989; Laiacona & Caramazza, 2004; McCarthy & Warrington, 1985; Miceli, Silveri, Nocentini, & Caramazza, 1988; Miceli, Silveri, Villa, & Caramazza, 1984; Rapp & Caramazza, 1998; Silveri & di Betta, 1997; Williams & Canter, 1997; Zingeser & Berndt, 1990) and more impairment with nouns than verbs (e.g., Laiacona & Caramazza, 2004; Miceli et al. 1984; 1988; Rapp & Caramazza, 1997; Robinson, Rossor, & Cipolotti, 1999; Shapiro, Shelton, & Caramazza, 2000; Silveri & di Betta, 1997; Zingeser & Berndt, 1990).

The double dissociation between nouns and verbs has also been found in Chinese brain-damaged individuals. Bates, Chen, Tzeng, Li, & Opie (1991) conducted the first group study on Chinese speakers with noun/verb production by giving an oral picture naming task to two groups of individuals, Broca's individuals and Wernicke's ones. They reported that Broca's individuals had more severe impairment in naming verbs/actions than nouns/objects, but Wernicke's ones presented a reversed pattern. More recently, Bi, Han, Shu, & Caramazza (2005; submitted) conducted substantive investigation on a single case, ZBL, who had more difficulty in orally producing nouns relative to verbs.

Does the existence of such noun/verb dissociations indicate that the lexical representations of nouns and verbs are supported by different neural substrates and therefore can be impaired selectively? Not necessarily. There are at least three levels of cognitive processing in which nouns and verbs might differ: the conceptual system,

the lexical system, and the grammatical processing (e.g., morpho-syntactic) system (see a similar position in Bates et al. 1990; Shapiro & Caramazza, 2001, 2003; Laiacona & Caramazza, 2004). The grammatical dissociations observed in the brain-damaged individuals have been argued to be attributable to any one or combination of these levels. Below we will discuss whether and how the noun/verb grammatical distinction plays a role in each of these three kinds of cognitive systems.

### **3.1 Semantic/conceptual organization of nouns and verbs**

The semantic/conceptual system is the cognitive component that is most unlikely to be affected by language-specific parameters (but see Whorf, 1956). Therefore, if the noun/verb dissociation originates from the representation and/or processing difference in the conceptual system, it is likely to be universal among all languages, including Chinese. The school of semantic/conceptual accounts reduces the cause of noun-verb dissociation to a conceptual basis, which claims that the grammatical-class effects in such dissociations are due to certain conceptual differences between nouns and verbs, such as concreteness/abstractness (Marshall, Chiat, Robson, & Pring, 1996; Marshall, Pring, Chiat, & Robson, 1996), imageability (Bird, Howard, & Franklin, 2000, 2001), semantic complexity (or specificity, Breedin et al. 1998), or semantic feature compositions (e.g., Vigliocco, Vinson, Lewis, & Garrett, 2004; Vinson, Vigliocco, Cappa, & Siri, 2003). These accounts argue that verbs tend to be more abstract or have less-specific semantic representations than nouns. The selective noun or verb deficits may arise from, for example, deficits in the

semantic system itself which is affected by concreteness and/or conceptual complexity. Some individuals with grammatical specific deficits can indeed be explained by these accounts (e.g., Marshall, Chiat et al. 1996; Marshall, Pring et al. 1996; Berndt, Haendiges et al. 1997), but some speakers' noun/verb dissociation persists even after the concreteness and imageability are matched between noun and verb stimuli.

The most prevailing conceptual theories are the object/action theory for the noun/verb dissociations. While nouns/verbs are terms addressing the grammatical dimensions, objects/actions are relevant in the conceptual system. Because noun/verb production is usually studied by using object and action naming tasks, there is confound between the noun/verb dimension and the object/action dimension. Therefore the observed noun/verb dissociation might be nothing grammatical but simply the disproportionate impairment of object concepts or action concepts, if it is assumed that the concepts of objects and actions in the semantic system are independently represented and can be selectively impaired (e.g., Damasio & Tranel, 1993; McCarthy & Warrington, 1985)<sup>2</sup>.

There are recent theoretical accounts that specify in greater detail how the conceptual system is organized such that nouns and verbs (objects and actions) can emerge as categories, such as the “extended sensory/functional theory” (ESFT, Bird et al. 2000; 2001) and the “featural and unitary semantic space” (FUSS) theory (e.g., Vigliocco et al. 2004; Vinson et al. 2003). The core assumptions of these theories are

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<sup>2</sup> Whenever we cannot distinguish these two dimensions, we acknowledge such confound by using these two sets of terms interchangeably. The major limitation of this explanation is that it is unspecified on the presentation manner of abstract nouns and abstract verbs (see Laiacona & Caramazza, 2004).

the following: conceptual knowledge is organized by distributed, modality-specific features (e.g., sensory, functions, motoric, etc.); different categories of concepts (e.g., living things, artifacts, tools, body parts, actions) have different compositions of various types of features; the higher proportion of a certain feature type a concept has, the more “important” that feature type is for the concept. Category-specific semantic deficit arises because of damage to one feature type, resulting in more severe impairment to the category to which that feature type is most important. In one specific model, for instance, Bird and colleagues (2000) assumed that the concepts of animate things (nouns), inanimate things (nouns), and actions (verbs) are represented by a gradual decreasing proportion of sensory features to functional features. As a result, damage to sensory features will affect animate nouns the most, inanimate nouns less and action verbs the least. Although there are cases reported being consistent with this prediction (Bird et al. 2000), showing disproportionate noun (object) deficit and also animacy effect (better with animate things than inanimate things) within the object domain, there are also cases that contradict the prediction of this theory (see discussions in Laiacona & Caramazza, 2004).

Bi et al. (2005; submitted) reported a Chinese-speaking case, ZBL, who showed a pattern opposite to what ESFT predicts. ZBL suffered two strokes, and a MRI scan revealed a lesion of the territory of the left posterior cerebral artery, involving the occipital lobe and extending into the mesial surface of the left temporal lobe, and laterally into the temporal occipital junction. In the testing sessions after the acute stage, he showed mild difficulty in visual and auditory comprehension tasks and more

severe deficit in oral production tasks. His naming errors were not due to any peripheral motor impairment, but instead, were predominantly semantic errors. Significantly, he was better in oral naming verb/action pictures than in oral naming noun/object pictures ( $\chi^2(1) = 7.43, p < .01$ ). Given that the object pictures and action pictures were matched on various factors including word surface frequency, word token frequency, number of syllables, name agreement, age of acquisition and familiarity ratings (see details in Bi et al. submitted), it is hard to argue that ZBL's noun/verb (object/action) oral naming differences were due to differences in the difficulty level. An attribute judgment task, where ZBL was required to decide whether an attribute of a given thing was true or false (e.g., "a rooster has a short curly tail"), was used to examine ZBL's conceptual knowledge. The results indicate that, compared with the control group, ZBL was impaired in attribute judgment for inanimate objects ( $\chi^2(1) = 24.37, p < .0001$ ), but not for animate objects ( $\chi^2(1) = 1.40, p = .24$ ). Furthermore, there was a trend for his performance on nonvisual features to be better than his performance on visual features ( $\chi^2(1) = 3.77, p = .05$ ). The difference was carried mainly by the inanimate objects (animate items:  $\chi^2(1) = 1.26, p = .26$ ; inanimate items:  $\chi^2(1) = 3.23, p = .07$ ). The reverse animacy effect (better performance in animate things than inanimate things) was also observed in an oral picture naming task to object pictures of a range of categories, again after various nuisance factors (lexical frequency and familiarity) controlled for. The presence of the reverse-animacy effect and the disproportionate noun deficit compared with verbs in the same case directly challenges the assumptions of ESFT.

The failure of one particular theory to account for the noun/verb (action/object) dissociation does not imply that noun concepts and verb concepts do not differ in a systematic way. It is possible that the conceptual system indeed is organized by modality-specific features and featural composition differences underlying noun/verb categories. What is problematic is the assumptions about the deficit mechanisms. It is also possible that the assumptions about the feature distributions are to be modified (see Vigliocco et al. 2004; Vinson et al. 2003, for an alternative featural theory, FUSS). Most likely, however, given the rich profiles of the brain-damaged cases with noun/verb dissociations that cannot be explained by existing conceptual theories, the grammatical class effects have other sources, such as the lexical and morpho-syntactic processing.

### **3.2 Lexical organization of nouns and verbs**

There is a line of evidence suggesting that the organization of the lexical system regarding grammatical class distinction comes from cases with modality-specific grammatical deficits. Several cases have been reported to show the grammatical category-specific deficits in only one modality. For example, HW had selective difficulty in speaking verbs (oral picture naming and oral reading), and had intact ability in speaking nouns, writing both nouns and verbs (written picture naming and writing to dictation) (Caramazza & Hillis, 1991). Even when homonym pairs (e.g., “the watch”/“to watch”) were used, he was impaired in speaking the verbs (“to watch”), but not nouns (“the watch”). Given that HW was flawless in writing tasks,

his semantic knowledge of concepts was intact and his verb deficits in oral production cannot be attributed to a semantic basis. Such modality-specific selective grammatical class deficits lead researchers to propose that the organization of the lexical system includes a grammatical dimension such that verb can be selectively impaired within the phonological (output) lexicon (see also Caramazza & Hillis, 1991; Hillis et al. 2002).

One might argue that the Chinese lexicon is less likely to be organized by grammatical categories because of the abundance of homographs/homophones, the frequent nominal use of verbs, and the prevalence of compounds with morphemes of various grammatical types. The observation of noun/verb dissociation at the lexical level in Chinese would be strong evidence that lexical distinctions are made along grammatical class dimensions. Indeed, there are virtually no documented Chinese individuals with modality-specific selective noun or verb deficits.

Han, Shu, Zhang, and Zhou (2005) presented a Chinese speaker with primary progressive aphasia, MPJ, who suffered from the atrophy of left frontal and temporal lobes. He did not show significant noun/verb difference in visual comprehension (visual word-picture matching: nouns: 25/25; verbs: 22/25;  $p = .23$ ) and oral word reading (nouns: 16/34; verbs: 11/34;  $p = .22$ ). However, in written picture naming using the same well-matched stimulus sets mentioned earlier (see also Bi et al. 2005; submitted, for detailed information), he wrote nouns (18/34) better than verbs (6/34) ( $\chi^2(1) = 9.27, p < .01$ ). And such a pattern was replicated using an independent set of stimuli where nouns and verbs were matched on word frequency, nouns: 43/100;



verbs: 14/100;  $\chi^2(1) = 20.63, p < .001$ ). He was equally impaired with nouns and verbs in auditory comprehension and oral naming. However, because his performance in these two modalities was at floor, we could not be certain about whether the noun/verb difference was selective to the written production modality.

In a recent preliminary study, we observed a Chinese dysgraphic case, SJS, who showed a noun/verb dissociation only in written naming. He was a 57-year-old, right-handed male with college education. He demonstrated relatively preserved ability in a variety of lexical comprehension and oral production tasks, including auditory word/picture matching (nouns: 25/25, correct; verbs: 24/25), visual word/picture matching (nouns: 25/25; verbs: 25/25), and oral picture naming (nouns: 31/34; verbs: 32/34). By contrast, he made frequent omission errors in written production tasks, and showed more severe deficit for verbs than nouns, including written picture naming (nouns: 27/34; verbs: 17/34;  $p < .05$ ) and writing to dictation (nouns: 30/34; verbs: 20/34;  $p < .05$ ) using the same set of well matched noun/verb items on which ZBL and MPJ were tested. Such noun advantage in writing to dictation is not likely to be attributed to some kind of sublexical mechanisms because there is no transparent grapheme-phoneme-conversion in writing Chinese.

If one were to accept such modality-specific noun/verb difference as evidence for the existence of a grammatical dimension in the lexical system, one further interesting question is how compounds are treated within such a lexical organization. As we laid out in Section 1, Chinese compounds quite often are composed of morphemes from different grammatical classes, e.g., 开关 (light-switch, open-close).

Are words like light-switch represented in the noun “section” or in the verb “section”?

Bates et al. (1991) argued that a straightforward distinction between a “verb lexicon” and a “noun lexicon” where compounds are treated as nouns and verbs by their composite class cannot be the full story. In their study, they found that Chinese-speaking individuals with Broca’s aphasia named verb/action pictures worse than noun/object pictures, and individuals with Wernicke’s aphasia named noun/object pictures worse than verb/action pictures. Most interestingly, they observed that Broca’s individuals were significantly less likely to substitute the verbal element with another verb in V=vn compounds, while Wernicke’s individuals were less able to substitute the nominal element with another noun in the same compound words. Based on these findings, Bates and colleagues postulated that there is a “sublexical” level in which the grammatical category information also plays a role. Either the dissociation between verbs and nouns (nouns vs. verbs) was due to the distinction of their sublexical level (nominal elements vs. verbal elements), or that dissociation could occur both at the word level (nouns vs. verbs) and at the sublexical level (nominal elements vs. verbal elements). It was further observed that the effects of the sublexical components were mostly present in Wernicke’s individuals and but not in Broca’s ones. Under the assumption that the speakers with Wernicke’s aphasia had more conceptual impairment than speakers with Broca’s aphasia, the authors speculated that the distinction of nominal and verbal components in compounds has its roots in the semantic system.

However, subsequent studies failed to replicate the pattern described by Bates et

al. (1991). For example, ZBL, the case described earlier who had disproportionate noun deficit, was tested on three types of pictures. The picture names corresponded to Chinese two-character compounds, including V=vn (跳水, /tiao4shui3/, to dive), N=vn (讲台, /jiang3tai2/, dais), and N=nn (火车, /huo3che1/, train). Each type of words had 14 items. The items in the three types were matched on relevant variables including name agreement, concept agreement, familiarity, word frequency and syllable frequency. The task was oral picture naming. ZBL was better at naming V=vn pictures than N=vn pictures ( $\chi^2(1) = 5.859, p < .05$ ), although the two classes of words have completely the same sublexical structure. By contrast, he showed no difference between naming N=vn pictures and N=nn pictures ( $\chi^2(1) < 1$ ) (see Figure 1). It seemed that only the grammatical class of the whole word, not the components, mattered. The same pattern was also observed in SJS, using this same set of stimuli, whose writing performance was affected by the grammatical class of the compound as a whole, but not components (V=vn: 57%, correct; N=vn: 79%; N=nn: 71%). It is possible that, as argued by Zhou, Ostrin, and Tyler (1993), some compounds in Bates et al's study (1991) were actually phrases, and the "sublexical" grammatical effects were lexical effects after all. It can also be argued that the lack of sublexical grammatical effect in ZBL and SJS were null results with the danger of Type II error. Further studies on the representation of compounds along grammatical class dimensions would be necessary to resolve the issue.

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Figure 1  
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### **3.3 Morpho-syntactic processing of nouns and verbs**

The grammatical category has also been proposed as a dimension along which syntactic processing and/or morphological processing of nouns and verbs operate differently. First, it is possible that nouns and verbs play different roles in sentence construction and a syntactic processing deficit might affect one class of words more than the other. For instance, it has been proposed that compared with nouns, verbs involve greater syntactic complexity in a sentence (see Zingeser & Berndt, 1990; Berndt, Haendiges et al. 1997, for discussion). In this case, when brain damage causes deficits of the representation and/or processing of syntactic knowledge, verbs will be more severely impaired than nouns. This syntactic account can give a reasonable interpretation of the origins of some verb specific deficits (e.g., Kim & Thompson, 2000; Miceli et al. 1984), but it has inherent difficulty in accounting for noun specific deficits.

Morpho-syntactic accounts argue that some speakers' noun/verb dissociation in picture naming (or other single word naming) tasks can be due to the selective deficit of the morphological operation to one grammatical class. A piece of evidence is derived from the association between picture naming deficit of one grammatical class and the deficit in carrying morphological operations for that class. For example, JR (Shapiro et al. 2000) had more difficulty in naming object pictures with nouns than in

naming action pictures with verbs. When required to complete orally presented sentences with noun and verb homonyms that involved the addition/deletion of a nominal or verbal suffix (e.g., “This is a guide; these are \_\_\_”; “This person guides, these people \_\_\_”), she was worse at producing nominal plural/singular forms than at producing verbal third-person singular/plural forms. The same pattern persisted even when pseudowords were used. For instance, JR was able to complete the sentence “This person wugs, these people \_\_\_”, but not the sentence “These are wugs, this is a \_\_\_”. A reverse pattern was observed in case MR (Laiacona & Caramazza, 2004), who presented a selective deficit in processing verbal as opposed to nominal morphology. Based on these findings, it was proposed that morpho-syntactic operations for nouns and verbs can be selectively impaired, and it is one of the causes for the noun/verb dissociation observed in the noun/verb (object/action) naming tasks. It seems that content words are always “inflected”, even when a single word is to be produced in “bare forms”.

Can some of the Chinese brain-damaged speakers showing noun/verb dissociation be explained by grammatical processing to one particular class? On the one hand, the rare occurrence of morphological inflection on word forms in Chinese could mean that there is no comparable mechanism to be selectively impaired and to cause noun/verb dissociation in single word naming. The noun/verb dissociations in Chinese can only be explained by the conceptual account and the lexical account. If a Chinese individual with noun/verb dissociation has intact conceptual knowledge of both classes of words (e.g., SJS), it then becomes strong evidence for the theory that

nouns and verbs are represented in the lexical system such that they can be differentially affected.

Alternatively, it can be argued that the morpho-syntactic processes for different grammatical classes are some abstract and universal properties and can be realized differently in different languages. While it is reflected by morphological inflection in Indo-European languages, the morpho-syntactic process may underlie noun and verb production by other means in Chinese, for instance, by the association with the grammatical markers that were introduced in Section 2. Information including aspects and numbers can be expressed by certain grammatical markers, such as particles, classifiers, negative markers, etc. Some markers are related with nouns, such as determiners and classifiers, and some with verbs, such as negative markers and aspect markers. Law and Cheng (2002) developed a comprehensive “Cloze test” to examine the production of these different types of grammatical morphemes in Cantonese aphasia. A wide range of factors were investigated in the test, including aspect markers, negative markers, classifiers, pro-forms, coverbs, particles, and structural particles. They studied six fluent and four non-fluent Cantonese-speaking individuals with aphasia, along with five control participants. The participants were required to supply the missing factors of the sentences in the highly constrained contexts. For example, a fragment sentence “daidai hai naamtsai; muimui\_\_\_hai naamtsai” (the brother is a boy; the sister\_\_\_a boy”) needed to be supplied a negative marker as “daidai hai naamtsai; muimui m hai naamtsai” (the brother is a boy; the sister isn't a boy”). They compared the relative accessibility of different grammatical morphemes

between different aphasia types. The results revealed a tendency that the individuals with fluent aphasia presented better performance in various morpheme types, relative to the speakers with non-fluent aphasia. However the difference between the two groups was quantitative rather than qualitative. This is not surprising because we now know that these “syndrome” groups are not homogeneous and averaging across cases with different underlying deficit mechanism can be misleading.

Further investigation along this line, we propose, is to study whether grammatical markers of one particular type can be selectively impaired by brain damage and the relationship between such categorical effect and the grammatical class effect in single word production. For instance, if a brain-damaged individual is observed to have more difficulty in producing verbs (action names) than producing nouns (object names) in picture naming or other naming tasks, the question one may ask is whether she or he also shows a selective deficit in producing grammatical markers for verb category, e.g., aspect markers and coverbs, compared to nominal grammatical markers such as classifiers. We know that individuals showing noun/verb dissociation do not necessarily also show dissociation between nominal markers and verbal markers, given that some noun/verb dissociation may have a conceptual cause. However, it is an open issue whether a speaker with a selective deficit with grammatical markers of one class will also show more severe difficulty in single content-word production in the corresponding category. If such association is prevalent, it would be evidence consistent with the view that morpho-syntactic processes are universal and are sensitive to grammatical classes. However, if cases are

observed with selective impairment to grammatical markers of one grammatical class but intact single word production, they would suggest that lexical retrieval of content words and the corresponding grammatical markers are rather independent, and that the grammatical effects in single word naming in Chinese are not readily explained by some of the grammatical class effect in the morpho-syntactic processes.

#### **4 Further directions**

We have argued that the selective deficits to one grammatical class of words (nouns or verbs) displayed by individuals with brain damage offer us an opportunity to study how grammatical knowledge is represented and processed in the brain. With the understanding that there are heterogeneous causes for such dissociations, we propose the following lines for future research.

To tease apart the different sources of noun/verb dissociation, we should focus more on single cases using tasks and test stimuli with more dimensions of manipulation. For example, using the materials of abstract nouns and verbs helps to discriminate the conceptual explanation from others. Also, cross-linguistic comparisons would be particularly informative in unveiling the core, universal aspects for grammatical processing. In this context, it is crucial to integrate multiple research methods, including the cognitive neuropsychological approach with brain-damaged individuals, functional imaging and behavioral techniques with normal population.

Instead of finding a unified reason for the observed noun/verb dissociation in clinical settings, the goal of this line of pursuit is to answer the following questions.



How does the knowledge of a word being noun or verb be represented and processed in the brain? How does conceptual knowledge be organized? And how do the lexical knowledge and grammatical operations be integrated together. In a word, how does the brain know a noun is a noun and how to use a noun as a noun?

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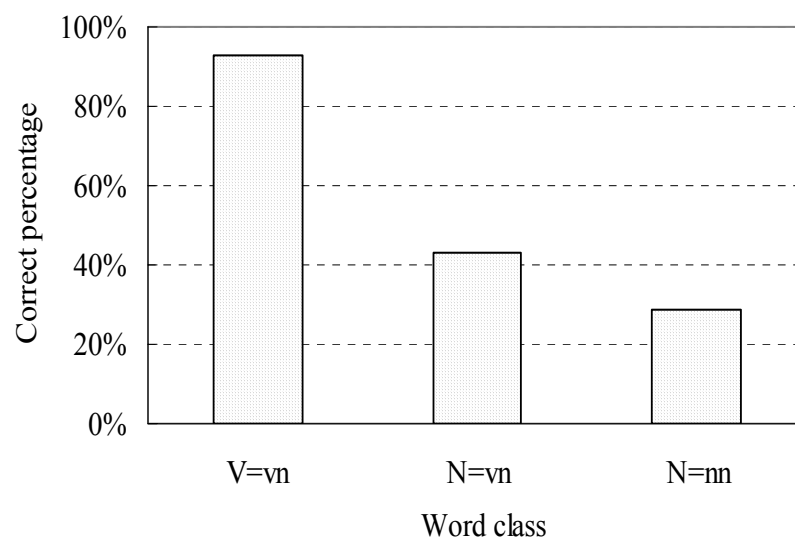


Figure 1 ZBL's performance as a function of grammatical word class in oral picture naming