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Processing of disyllabic compound words in Chinese aphasia: Evidence for the processing limitations account☆

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Abstract

The current study addresses the debate between so-called 'structural' and 'processing limitation' accounts of aphasia, i.e., whether language impairments reflect the 'loss' of linguistic knowledge or its representations, or instead reflect a limitation in processing resources. Confrontation-naming task and category-judgment tasks were used to examine and compare the performance of non-fluent and fluent aphasics on different compound types of nouns and verbs. We demonstrate that aphasic patients' performance is modulated by the canonicity of the particular compound type, a result that holds true even for the category in which patients show a 'selective category deficit.' These findings weigh against the 'loss' of linguistic representations as the underlying cause of noun–verb deficits, instead supporting a 'processing limitations' approach.

Keywords: Aphasia; Chinese; Linguistic category; Nouns; Verbs; Processing limitation; Structural deficit; Selective deficit; Double dissociation

1. Introduction

Since the 1970s, much research on language breakdown has been aimed at understanding the relationship between the disrupted language performance of aphasic patients and the site of their brain lesions, with the goal of uncovering the structure of the human cognitive system for language. The study of selective deficits has been particularly emphasized, given that ''strong neuropsychological evidence for the existence of neurologically distinct functional systems depends on double dissociation of function'' (Shallice, 1979, p. 260). Accordingly, many investigators (for example, Caramazza, 1986; Grodzinsky, 2000) suggest that language impairments can be considered indices of the 'loss' of linguistic structure, where selective or dissociable language deficits are taken to evidence the boundedness or modularity of the linguistic representation or the mechanisms underlying processing. 'Agrammatism' is perhaps the best example of this approach. So-called agrammatic aphasics are notable for their limitations in the use of pure grammatical elements ('closed-class' words) such as auxiliaries, inflections, and (non-lexical) prepositions (Goodglass, 1993); more controversially, agrammatic aphasics are said to suffer from a 'central syntactic deficit,' where aspects of syntactic knowledge are lost (e.g., the 'Trace Deletion Hypothesis,' Grodzinsky, 1990, 1995, 2000).

Agrammatism is said to be a hallmark of patients with Broca's aphasia (Grodzinsky, 2000); these patients are also distinguished by their effortful and labored speech output, with relatively spared auditory comprehension (Goodglass, 1993). Conversely, Wernicke's aphasic patients are said to be 'paragrammatic,' in that they often speak fluently but with a high rate of

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substitution errors; these patients also are severely impaired in their auditory comprehension of language, and have particular problems with open-class words. Broca's and Wernicke's aphasics can also be distinguished by their performance in semantic priming paradigms. Several studies (e.g., Blumstein, 1997; Blumstein & Milberg, 2000) showed that Broca's aphasics show very little semantic priming in online lexical decision tasks (particularly in the face of acoustically degraded exemplars) but are able to make off-line semantic judgments. In contrast, Wernicke's aphasics tend to show exaggerated semantic priming in such online tasks, but perform at chance levels for off-line semantic judgment tasks. Finally, Broca's and Wernicke's aphasics show dissociable profiles of noun/verb production and comprehension, with Broca's aphasics said to show deficits in verb use, and Wernicke's aphasics showing deficits in noun use (Caramazza & Hillis, 1991). The putative double dissociations observed in Broca's and Wernicke's aphasic patients are often cited as evidence for cognitive and neural modularity—a position succinctly stated by Shallice (1988, p. 248): "If modules exist, then ... double dissociations are a relatively reliable way of uncovering them. Double dissociations do exist. Therefore modules exist."

However, there is increasing evidence arguing against the above position. To begin with, the results of studies purporting to show a double dissociation between nouns and verbs tend to show a gradient of deficits instead of a distinct all-or-none contrast between the two grammatical categories. Moreover, despite the limitations of the grammaticality/acceptability judgment task (Linebarger, Schwartz, & Saffran, 1983; Zurif & Grodzinsky, 1983), the finding that agrammatic patients can make grammaticality judgments with above-chance accuracy strongly suggests that these aphasic patients' syntactic knowledge is actually not 'lost,' a situation that is problematic for the 'structural deficit hypothesis' (Lu et al., 2000; Shankweiler, Crain, Gorrell, & Tuller, 1989; Wulfect & Bates, 1991; but see discussion in Linebarger et al., 1983; Zurif & Grodzinsky, 1983 concerning limitations of the grammaticality judgment task). In addition, there is increasing evidence that there is no systematic relationship between clinical aphasic classification and deficits in discrete aspects of language use (Bates, Wulfeck, & MacWhinney, 1991; Blumstein, 1997). Indeed, aphasic patients' behavioral patterns are often paralleled in neurologically intact subjects in a wide range of language assays, including phonological deficits in speech production, perceptual errors in speech perception, as well as production and comprehension of morphology, sentence comprehension, and the production of grammatical errors. (Aydelott & Bates, 2004; Blackwell & Bates, 1995; Crain, Ni, & Shankweiler, 2001; Dick, Bates, & Ferstl, 2003; Dick et al., 2001; Goodglass & Menn, 1985; and see Bates & Wulfeck, 1989; Blumstein, 1997 for comprehensive reviews.) In these studies, different groups of aphasic patients and normals under stress demonstrate similar patterns, performing more poorly as linguistic structure becomes more complex and/or difficult.

In view of these data, several investigators have suggested a different theoretical approach, one that attributes the decrement of language ability in aphasic patients to limitations in processing capacity (Bates & Wulfeck, 1989; Blackwell & Bates, 1995; Blumstein, 1997; Blumstein & Milberg, 2000). On this view, aphasic patients' language difficulties are often caused by deficits in accessing and processing representations, rather than resulting from damage to the representation itself. This approach considers language comprehension and production to be dynamic processing operations that occur under severe time constraints (Blumstein, 1997). Graded disruptions of this dynamic system may cause seemingly isolable language impairments in phonological, lexical, and semantic processing, ones that appear to segregate aphasic subgroup. For instance, Blumstein and Milberg (2000) suggest that changes in lexical activation profiles can account for the pattern of semantic deficits observed in Broca's and Wernicke's aphasics. Bates and Wulfeck (1989) suggest that "dissociations can occur in a highly interactive system, if the whole system changes in ways that affect some items more than others. Selective sparing and impairment may result from perturbations in timing, from restrictions on a data source that is especially important for a given class of items, and/or through adaptations that the patient make to his aphasic condition (that is, self-induced task demands). We do not have to postulate separate modules for each item type, or disconnections in the wires running from one component to another. (p. 329)" As pointed out by Bates and Wulfect (1989), and demonstrated in computational simulations (Juola & Plunkett, 1998; Plaut, 1995) double dissociations can emerge from the interaction of resource requirements and the processes of lexical access without the presence of any 'modular' lesions (also see McClelland & Rumelhart, 1986; Rumelhart & McClelland, 1986).

The present study tests predictions of the structural and processing deficits hypotheses by investigating the apparent double dissociation between nouns and verbs in fluent and non-fluent aphasics by testing their ability to produce or categorize various subtypes of nouns and verb. As noted above, differences between Broca's and Wernicke's aphasics in their ability to use and comprehend nouns and verbs has been cited as strong evidence for 'loss of linguistic representations' and the modularity of language. For instance, results of several studies show that in connected speech, main verbs, and object nouns can be selectively dropped in different groups of aphasics. Non-fluent and agrammatic aphasic patients tend to produce far fewer verbs than nouns (McCarthy &

Warrington, 1985; Miceli, Silveri, Nocentini, & Caramazza, 1988; Miceli, Silveri, Villa, & Caramazza, 1984; Myerson & Goodglass, 1972; Zingeser & Berndt, 1990), while fluent patients, particularly Wernicke's aphasics and anomics, demonstrate the opposite pattern (Zingeser & Berndt, 1988, 1990). Similar results have also been shown in confrontation naming tasks (Miceli et al., 1984; Osman-Sagi, 1987).

Many explanations have been proposed to elucidate the double dissociation of nouns and verbs. Each of these accounts has its own emphasis, for instance, on the importance of grammatical structures or semantic-conceptual meanings (for discussion, see Bates et al., 1991). The 'grammatical' approach (Lapointe, 1985; Shapiro, Zurif, & Grimshaw, 1987) emphasizes a causal link between the agrammatism and verb generation deficits in non-fluent aphasics. Some researchers emphasize the morphological loading of the verbs (but see Bates et al., 1991; and Lee, Tzeng, Hung, Fuh, & Wang, 1998 for counterevidence); others recognize the pivotal role the verbs play in the construction of a sentence (Berndt, Haendiges, Mitchum, & Sandson, 1997; Saffran, Schwartz, & Marin, 1980 but see Shapiro & Levine, 1990; for evidence regarding the preservation of argument structure, and Goodglass & Menn, 1985; Menn & Obler, 1990; Miceli et al., 1984; for data showing the preservation of word order in non-fluent and agrammatic aphasics).

The 'semantic-conceptual' approach emphasizes the similarities and differences in the semantic features of nouns and verbs, including abstractness/concreteness (Berndt et al., 1997), perceptual features and their functional/associative features (Bird, Howard, & Franklin, 2000; Marshall, Pring, Chiat, & Robson, 1996a; Marshall, Chiat, Robson, & Pring, 1996b), and the conceptual complexity and abstractness of actions (Williams & Canter, 1987). Unfortunately, the lack of consistent results makes it difficult to arrive at any conclusion with confidence.

Most hypotheses regarding this dissociation base their arguments on the hypothesized independence of the neural mechanisms responsible for processing nouns and verbs. Furthermore, all the above-mentioned proposals are based on the 'structural deficit' assumption, one that assumes an absolute dichotomy between 'intact' and 'impaired' performance. Since little research has been conducted on the internal structure of these categories, there is little empirical evidence to decide between theories positing loss of category information, or difficulty in accessing the (intact) linguistic representation. In order to address this problem, in the present study we explore the inner structure of the two linguistic categories by having normal and aphasic subjects produce and make category judgments on compound nouns and verbs in Mandarin Chinese. These noun and verb compounds differ in terms of the 'canonicity' of their morphological composition—a property that has been shown to affect subjects' reaction times (Hsu, 1998). Hence, whether aphasic patients' performance on their 'selective impaired' linguistic category is modulated by the typicality of that category would serve as an index for the absence or the intactness of their linguistic representation.

As acknowledged by Li and Thompson (1981), there is no completely satisfactory definition of Chinese compounds, since "no matter what criteria one picks, there is no clear demarcation between compounds and non-compounds." (p. 45). In view of this problem, the current study adopts the traditional Chinese definition of compounds, which is the one assumed in Li and Thompson, where compounds are defined as "... all polysyllabic units that have certain properties of single words and that can be analyzed into two or more meaningful elements, or morphemes, even if these morphemes cannot occur independently (i.e., as words) in modern Mandarin."(p. 46). Since the overwhelming majority of words in modern Mandarin Chinese are disyllabic, we used only disyllabic compounds.

One of the intriguing characteristics of Chinese grammar is that Chinese allows for a tremendous flexibility in creating compound nouns and verbs; stems of all linguistic categories, except for prepositions, can be combined to forge a compound (Huang, 1998). To narrow our focus, and avoid confounding from other linguistic categories, we use disyllabic compounds composed of nominal (N) and verbal (V) stems only, i.e., the four possible combinations—VV, VN, NV, and NN. In verbs, however, NN combinations are rare, comprising only 2% of the Mandarin Daily Dictionary (a database containing nearly 24,000 disyllabic compounds). Because it is so rare, we have eliminated the NN combination from our study—thus verb compounds only include the other three compound types (NV, VN, and VV). Examples for each combination in nouns and verbs are given in Tables 1 and 2.

Table 1
Compound types of nouns used in this study

Type	Pinyin	Transliteration	Glossary
VV	*Kaiguan*	turn on–turn off	'switch' (noun)
VN	*Weiqun*	surround-skirt	'an apron'
NV	*Fangzu*	house-rent	'rent' (noun)
NN	*Haishui*	sea-water	'seawater'

Table 2
Compound types of verbs used in this study

Type	Pinyin	Transliteration	Glossary
VV	*Dating*	hit-listen to	'to make inquiries about'
VN	*Fenxin*	divide-heart	'to stray from'
NV	*Piaoxuan*	ballot-elect	'to elect by ballot'

As argued in Huang (1998), although the Chinese noun compounding is more right-headed, while the verb compounding is more left-headed, Chinese is essentially a headless language, in which neither the rightmost or the leftmost member uniquely determines the category of a disyllabic compound. Huang (1998) notes further that "... the Chinese lexicon is organized on the principle of syntactic compounding, whereby any two lexical items concatenable by syntactic rule constitute well-formed compounds" and "... both the syntax and the lexicon of Chinese are realizations at different levels of the same basic structural principles." (p. 279). Thus, we base our estimate of each compound's 'canonicity' through means of an empirical measure, namely a count of individual tokens in a large corpus.

According to the survey of Huang (1998), the degree of productivity of the compound type ordered from the highest to the lowest in nouns is NN > VN > NV > VV, and that for verbs is VV > VN > NV. As shown by Hsu (1998) in a category judgment study with normal college students, relative compound productivity is reflected in lexical access, where judgments were faster and more accurate with increasing productivity. The reaction times for disyllabic compound nouns were ordered NN < VN < NV < VV, and disyllabic compound verbs were VV < VN < NV; accuracy data more or less mirrored these effects, with compound noun accuracy NN > VN > NV > VV, and verb accuracy VV > VN > NV. This effect likely reflects subjects' knowledge about possible compounds and the subtype distribution probability of that particular linguistic category. Based on this prior study, we sketch the following two scenarios predicted by the two approaches dominant to aphasia research. The structural deficit account should predict that, because of selective loss of linguistic representations (the grammatical categories 'noun' or 'verb'), impaired patients should not exhibit any difference between compound types that vary in 'canonicity,' and their behavioral performance should be very different from that of the preserved group, not to mention the normal controls. Conversely, on the processing limitation account, the canonicity of the compound type should play a role in impaired patients' performance, as their deficit is thought to be caused by lexical access or processing difficulties, and not loss of lexical representations. In other words, behavioral similarities in between the impaired aphasic group, the preserved aphasic group, and the normal controls are expected under a processing limitation analysis.

Two experiments are reported here. The first one is a picture-confrontation naming task, one of the most commonly used paradigms in aphasia research, with the other a linguistic category judgment task. With these two experiments, we test the prediction of the processing limitation account of language disadvantages in aphasic patients.

2. Experiment 1—A picture confrontation naming task

In this experiment, we investigated aphasic patients' performance producing disyllabic compound words in a picture confrontation naming task. Following the results of Hsu (1998), we expect normal subjects to show a VV > VN > NV profile of accuracy on compound verbs and a NN > VN > NV > VV profile for compound-nouns. Based on prior findings (see above), we expect to see a double dissociation pattern at the whole word/category level, with non-fluent aphasics more impaired in verbs, and fluent aphasics more impaired in nouns. However, in terms of performance within category types we predict that these two groups of aphasic patients will display similar sensitivity to compound canonicity—one that will pattern after normal performance.

2.1. Methods

2.1.1. Participants

Participants in this experiment were five non-fluent aphasics, five fluent aphasics,[1] and five non-impaired subjects, matched approximately for age and education. All of the participants were native speakers of Mandarin Chinese or Taiwanese. The general subject information is listed in Table 3 (see Appendix A for patient details). Patient classification was carried out using a Chinese version of the Boston Diagnostic Aphasia Examination (BDAE); speech pathologists' clinical observations were also taken into account. Exclusionary criteria were the following: (a) history of multiple strokes; (b) significant hearing and/or visual disabilities; (c) severe gross motor disabilities; (d) severe motor-speech involvement such that less than 50% of the subject's speech attempts were intelligible; (e) neurological or physical instability; (f) less than one month between stroke onset and date of testing. Imaging data on lesion site is provided for the reader's reference, but was not used for classification purposes.

2.1.2. Materials

One hundred and seventy-five black-and-white line drawings of objects and actions were used to elicit participants' speech production. All items were common objects and actions in people's daily life. The names of objects are classified into the four compound types—VV, VN, NV, and NN, and those of three action types—VV, VN, and NV. As many pictures could be named in more than one way, the compound types of the names of these

[1] The non-fluent aphasic group includes three Broca's aphasics and two Transcortical Motor aphasics, and the fluent aphasic group includes three Wernicke's aphasics and two Anomics. All aphasic subjects are outpatients and inpatients recruited from National Taiwan University Hospital, Xin-Guang Hospital, and Zhen-Xing Rehabilitation Hospital in Taipei, Taiwan.

Table 3
Subject information

Subject group	Subject No.	Sex		Age	Ed. (years)	Onset (months)
		F	*M*	Mean(*SD*)	Mean(*SD*)	Mean(*SD*)
Non-fluent aphasics	5	2	3	47.2(14.03)	11(3.74)	9(8.12)
Fluent aphasics	5	0	5	48.4(11.26)	14.2(5.4)	10(7.04)
Normals (Experiment 1)	5	3	2	47.6(13.13)	16.6(1.34)	—(—)
Normals (Experiment 2)	20	14	6	56(7.2)	12.95(2.52)	—(—)

pictures are set according to the most widely used names.

2.1.3. Design and procedure

Each experimental picture was shown on a separate sheet of paper. Subjects were instructed to name the objects or actions on the sheet as succinctly as possible. For all subjects, the action-naming task preceded the object-naming task.[2]

During the experiment, if the subject produced a non-target name, the experimenter would point to the picture and ask the subject to name it again. When a subject produced a semantically related word from a different category (e.g., produced a noun rather than a verb), the experimenter would remind the subject of the proper task by saying 'What do you call this object?' or 'Then, how about this action?' By doing this, we avoid confounding response errors due to shifting grammatical categories with subjects forgetting the instructions. Due to the large number of pictures, the experiment was usually conducted in more than one session lasting no more than 1 h; the session was stopped whenever the subject showed any signs of fatigue. Depending on each subject's naming abilities, the number of sessions to complete the task varied. Nevertheless, all participants finished within one and a half months after having begun testing.

2.1.4. Scoring

Because many patients produced circumlocutions (especially the fluent aphasics), we did not include all the words uttered during the word-finding process but only the last response or the responses that subjects were satisfied with. In regard to overall task accuracy, we adopted the scoring criteria used by Bates et al. (1991) and Chen and Bates (1998). Semantically proper responses of the same grammatical category as the target would be scored as correct. The super-ordinates or sub-ordinates of the targets were counted as correct responses as well. For example, if the picture of the target noun *yaoyi* 'a rocking chair' was shown, *yizi* 'a chair' would be a correct response. Notice that the semantically proper response did not have to be of the same compound structure as the target. For example, for the picture of a NV compound noun, *penzai* 'a potted plant,' the synonym *penjing* 'a potted plant or landscape,' a NN compound noun, would also count as a correct answer.

2.2. Results

2.2.1. Normal participants (age-matched controls)

The percentage of correct responses in the non-impaired subjects were close to ceiling, with 96% accuracy for object naming and 97% for action naming. No significant difference was found between the two naming tasks ($T(1,4) = 1.181$, $p = .3$).

2.2.2. Aphasic participants

Non-fluent aphasics were 63.01% accurate in object naming and 67.74% in action naming, with fluent aphasics 38.94% accurate in object naming and 47.74% in action naming. A 2 (non-fluent vs. fluent groups) × 2 (object naming vs. action naming) ANOVA showed a significant main effect of compound type ($F(1,8) = 8.189$, $p = .0211$). To examine whether there is any significant difference between object naming and action naming for the aphasic patients, two planned comparisons were conducted. For the fluent group, object naming accuracy was significantly lower than that for action naming ($T(1,4) = 4.865$, $p = .0083$), while the difference between action and object naming for the non-fluent group did not reach statistic significance ($T(1,4) = 1.083$, $p = .34$). Individual scores for this comparison are reported in Table 4 and the results of the three groups are shown in Fig. 1.

2.2.3. Comparisons of the four compound noun types

Having established the traditionally termed 'selective noun deficit' in the fluent group, we further compare the three groups' performance on the four subtypes of compound nouns. The individual scores are tabulated in Table 5.

[2] Xu (1990) reported that 'people tended to name the static objects in a picture when asked to describe it, and this tendency created a special difficulty of switching from object to action naming in at least one patient when object pictures were given before the action pictures in pretests.' (p. 31)

Table 4
Individual correct percentages of picture naming of aphasic groups

Subject	Non-fluent aphasics		Fluent aphasics	
	Object naming	Action naming	Object naming	Action naming
1	80.53	79.03	71.68	82.26
2	78.76	88.71	73.45	75.81
3	90.27	82.26	9.73	17.74
4	44.25	61.29	33.63	43.55
5	21.24	27.42	6.19	19.35
Average	63.01	67.74	38.94	47.74

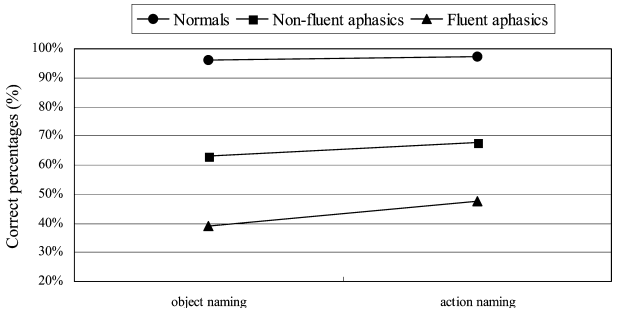

Fig. 1. The correct percentage of object naming vs. action naming.

2.2.4. Normal participants

We compared the performance of the control group on the four types of the object names using a repeated measures one-way ANOVA. Perhaps because of ceiling effects, no significant differences were found.

2.2.5. Aphasic participants

A 2 (non-fluent and fluent groups) × 4 (noun types) two-way ANOVA were performed, showing a significant main effect of noun type ($F(3, 24) = 19.507$, $p < .00001$). A post-hoc Tukey test showed that the VV type was produced significantly less accurately than VN, NN, and NV types. In addition, the NV type was produced less accurately than the NN type (all comparisons $p < .01$). No significant main effect of group or interaction was found. To further investigate performance across compound types, we performed two planned

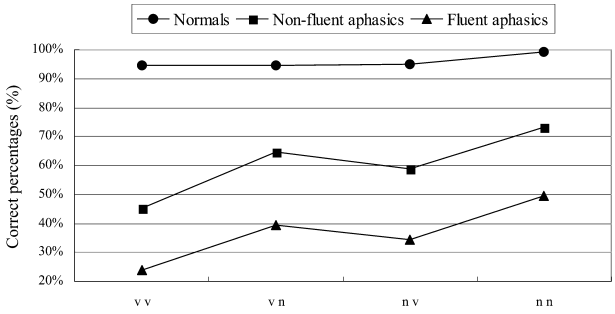

Fig. 2. The correct percentage of compound types of the object nouns in picture naming.

comparisons within the non-fluent and fluent groups, with compound type (NN, VN, NV, and VV) as the within-subject variable in a repeated measure ANOVA. For non-fluent aphasics, performance on the VV type was significantly less accurate than on the VN type ($p < .05$) and the NN type ($p < .01$). Fluent aphasics performed less accurately on the VV type than on the VN type ($p < .05$) and the NN type ($p < .01$); the NV type was also produced less accurately than the NN type ($p < .05$). (Percent correct for the four types of compound nouns in each of the three subject groups are presented in Fig. 2).

2.3. Summary

This experiment examined aphasic patients' performance on object naming and action naming tasks. The data were analyzed first at the whole word level to confirm the predicted behavioral dissociation between nouns and verbs—as predicted, we found fluent aphasics to be less accurate in naming objects than actions. However, we did not observe the opposite dissociation in non-fluent aphasics. Having established a dissociation in fluent aphasics, we further compared the performance of the fluent group on their traditionally 'impaired' category, nouns. Results showed that, like the normal participants and the 'noun-preserved' non-fluent group, fluent aphasics' performance across the four compound types were modulated by the typicality of the morphological composition (see Fig. 1). Thus, it is unlikely that

Table 5
Individual correct percentages of nominal compound types in naming by aphasic groups

Subject	Non-fluent aphasics				Fluent aphasics			
	VV	VN	NV	NN	VV	VN	NV	NN
1	53.33	85.29	77.42	90.91	46.67	73.53	58.06	93.94
2	53.33	76.47	77.42	93.94	46.67	73.53	70.97	87.88
3	73.33	97.06	83.87	96.97	0.00	5.88	6.45	21.21
4	33.33	44.12	29.03	63.64	26.67	35.29	32.26	36.36
5	13.33	20.59	25.81	21.21	0.00	8.82	3.23	9.09
Average	45.33	64.71	58.71	73.33	24.00	39.41	34.19	49.70

Table 6
Average item frequencies of stimuli for category judgment task

	Nouns				Verbs		
	VV	VN	NV	NN	VV	VN	NV
	363.76	100.76	111.56	191.96	422.84	465.59	231.56
Average	192.01				373.33		

Table 7
The percentage of the compound words being treated as a noun or a verb in Sinica Corpus

Stimuli	Used as	VV	VN	NV	NN	Mean
Noun	Noun	97.61	99.35	98.40	100	98.84
Verb	Verb	98.31	98.34	99.24	—	98.62

the fluent aphasics lack the 'structural representation' of nouns.

3. Experiment 2—Category judgment task

This experiment included the same variables as in the previous experiment, but required subjects to make a decision on the linguistic category of the target word. To successfully complete this task, subjects have to have a deeper and more thorough processing of the words, including an understanding of the referent of the displayed stimuli (the semantic content), as well as its typical position in a sentence (syntactic role).

3.1. Methods

3.1.1. Participants

In addition to the aphasic participants from Experiment 1,[3] 20 non-impaired adults participated in this experiment (see Table 3).

3.1.2. Materials

The experimental materials were of the same compound types for nouns and verbs used in the first experiment, and were selected from The Frequency Dictionary of written Mandarin Chinese (Chinese Knowledge Information Processing Group, 1994). The frequency dictionary is based on a corpus of written materials from newspapers and magazines, and contains 14,457,534 characters (approximately 10 million words). Average frequencies for the selected nouns and verbs are listed in Table 6. There were no significant frequency differences between the two linguistic categories ($T(1,99) = 1.553$, $p = .1352$) nor among noun subtypes ($F(3,72) = 2.426$, $p = .0726$) or among verb subtypes ($F(2,62) = .505$, $p = .6062$).

There were 150 trials total, with 25 targets for each noun compound type, and 32 targets for verb compound types. Fillers were disyllabic adverbials, for instance, *suiran* 'in spite of,' *miande* 'so as not to,' and *yushi* 'as a result.' Different adverbials were used in the noun and verb tasks.

Since most verbs and nouns in Mandarin have homophones, and there are almost no overt inflections or conjugations in Mandarin to distinguish grammatical categories, it is hard to tell a word's grammatical category out of context. Because of this, we labeled the target compounds as noun (or verb) if the percentages of that compound being treated as a noun (or a verb) in the balanced corpus of Academia Sinica in Taiwan[4] is the dominant one and makes up more than 95% of the usage. Usage statistics for the target linguistic category of each compound type are listed in Table 7.

3.1.3. Design and procedure

As with the previous experiment, this category judgment study employed a within-subjects design with two variables: (1) grammatical class, and (2) morphological formation of compounds. The experiment was divided into two blocks: noun judgment and verb judgment. Stimuli were displayed vertically on a laptop screen. The procedure for a single trial was the following: first, a fixation cross appeared in the center of the screen for 750 ms. Immediately after the fixation cross disappeared, the compound word was displayed until the subject decided whether the displayed word was a noun in the noun judgment block, or a verb in the verb

[3] Among the 10 aphasics, three non-fluent and three fluent aphasic patients undertook this task after the category judgment task, while the other two non-fluent and two fluent patients did this task prior to the category judgment task. For those who did the category judgment task first, there is a more-than-a-month time lag between the two tasks. Hence, there should be no practice effect here.

[4] The balanced corpus of Academic Sinica in Taiwan labels the words on the basis of 'zhong wen ci lei fen xi' published in 1993.

judgment block. Subjects responded to the trials by pressing on one of the two keys labeled 'yes' and 'no' on the two sides of the keyboard.

There was no time limit for subjects to respond. At the end of each trial, after confirming that the subject was ready to continue with the experiment, the experimenter initiated the next trial by clicking on the mouse. If the subject, especially the aphasic patients, needed to rest, the task would be put on hold until the subject was ready to continue.

The order of the two blocks was counterbalanced within each group. Before each experimental block subjects practiced the task with 24 practice items: four for each compound type plus eight fillers in the noun judgment task, and 12 fillers in the verb judgment task. In both blocks, the order of targets and fillers was randomized.

3.2. Results

We used D' analysis approach to correct for possible response biases. Because of sample size differences and inhomogeneity of variance over groups, aphasic patients and normal participants will not be compared directly in statistical analyses.

3.2.1. Normal participants

The D' value for normal participants was 4.1592 in noun judgment and 2.9293 in verb judgment, but the difference was marginally significant. ($T(1,19) = 1.99$, $p = .0612$)

3.2.2. Aphasic participants

The D' value for non-fluent aphasics was 1.94002 for noun judgment and 0.96248 for verb judgment, while the D' value for fluent aphasics was 1.71092 for noun judgment and 1.2408 for verb judgment. A 2 (non-fluent and fluent groups) $\times$ 2 (noun vs. verb judgment) mixed ANOVA showed a significant main effect of category type ($F(1,8) = 13.204$, $p = .0066$). To see if there was any dissociation between the two categories, two planned comparisons within both groups were performed.

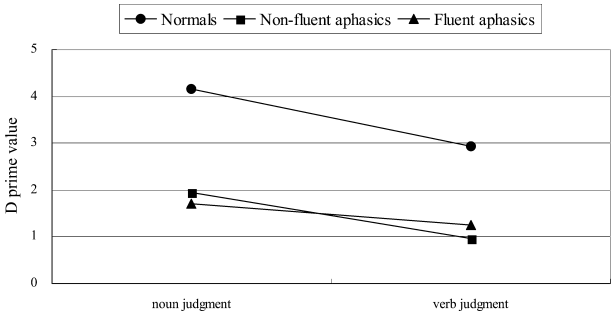

Fig. 3. The D' value of noun judgment vs. verb judgment.

Results showed that the non-fluent group performed significantly worse on verb judgment than on noun judgment ($T(1,4) = 2.83$, $p = .0474$). The fluent aphasic group also perform more poorly on the verb part, but the difference between the two tasks was only marginally significant ($T(1,4) = 2.4$, $p = .0746$). The individual scores are tabulated in Table 8, and the result is graphed in Fig. 3.

3.2.3. Comparisons of performance on the three compound verbs

Given the 'selective' impairment of non-fluent aphasics on verbs, we compared each group's performance on the three compound types of verbs.

3.2.4. Normal participants

A repeated measure one-way ANOVA comparing the three compound types of verbs showed a significant effect of compounding ($F(2,38) = 4.162$, $P = .0232$), where accuracy on the NV type was significantly lower than that on the VV type ($p < .05$).

3.2.5. Aphasic participants

A 2 (non-fluent and fluent groups) $\times$ 3 (verb types) two-way ANOVA was performed. The analysis did not show any statistically significant main effects or interaction. Two repeated-measure one-way ANOVAs were then performed to examine performance on the three types of compound verbs within each group. However,

Table 8
Individual D' values of category judgment of aphasic groups

Subject	Non-fluent aphasics		Fluent aphasics	
	Noun judgment	Verb judgment	Noun judgment	Verb judgment
1	2.0484	1.3193	2.5492	2.5630
2	2.3204	1.8927	1.2867	0.4810
3	2.3612	0.0546	0.7890	0.8030
4	1.3831	0.4280	2.2465	1.4160
5	1.5870	1.1178	1.6832	0.9410
Average	1.94002	0.96248	1.71092	1.2408

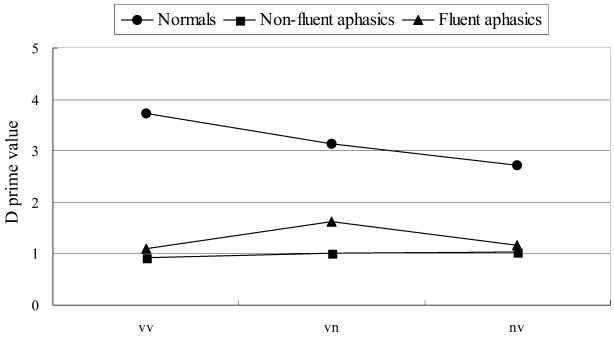

Fig. 4. The D' value of compound types of verbs in verb judgment.

Table 9
Individual D' of verbal compound types in category judgment by aphasic groups

Subject	Non-fluent aphasics			Fluent aphasics		
	VV	VN	NV	VV	VN	NV
1	1.557	1.013	1.557	2.6	3.145	2.169
2	1.659	2.231	1.857	0.332	0.332	0.833
3	0.055	0.055	0.055	0.428	1.167	0.999
4	0.428	0.625	0.251	1.318	1.794	1.223
5	0.885	1.082	1.456	0.761	1.677	0.596
Average	0.9168	1.0012	1.0352	1.0878	1.623	1.164

statistical significance was not obtained (the fluent group: $F(2,8) = 3.445$, $p = .0833$; the non-fluent group: $F(2,8) = 0.262$, $p = .7758$; see Fig. 4). The individual scores are tabulated in Table 9.

3.3. Summary

This experiment employed a linguistic category judgment task to tackle aphasic patients' access of nouns and verbs. In the normal group, verbs of the VV type have the best performance were judged most accurately, followed by the VN and NV types (with the latter evoking the lowest accuracy). These results converge with the patterns reported in Hsu (1998). As for aphasic subjects' performance, our data revealed that the traditional 'verb-damaged' group, the non-fluent aphasics, did not deviate from the fluent aphasics in their 'impaired' category. The reason that the comparison among the three verb types did not reach statistical significance for both aphasic groups may be due to the floor effect of their performance, or because the compound type differences in verbs were less clear and contrastive than in nouns. In sum, these two groups of aphasic patients indeed behaved differently from the normal group, but more importantly, these two groups' patterns did not deviate from one other and in fact were quite similar.

4. Discussion

The above two experiments demonstrate that fluent and non-fluent aphasics share similar behavioral profiles in noun and verb compound production. For nouns, the two aphasic groups perform the best on NN noun compounds, the most productive type, and the worst on VV noun compounds, the least productive type. This pattern is exactly what had been reported in normal college students in terms of reaction time and accuracy measures. As for verbs, although the aphasic profile differed from that of the normal subjects, the two groups of aphasics behaved alike in that they both performed least accurately with the VV type.[5]

The fact that the canonicity of noun/verb compounds has an effect on the performance of the two aphasic groups suggests that their lexical representations are still 'intact.' The 'selective' deficit that emerged in our data may not be so 'selective,' but rather may reflect an interaction of: (1) the different processing costs of nouns and verbs, (2) the different patterns of diminution of the processing resource of the aphasic types, and (3) the subsequent spreading of activation from one lexical representation to another (Blumstein & Milberg, 2000; MacWhinney and Bates, 1989).

This view is consonant with the Competition Model proposed by MacWhinney and Bates (1989): "It is possible that all vocabulary items are represented together in the same lexicon, and subjected to the same set of items access processes."(Bates & Wulfeck, 1989, p. 353), and the assumptions of the processing limitation view: "..., there is a common mechanism for lexical activation that serves the entire vocabulary of the language." (Blumstein & Milberg, 2000, p. 175). Within a unitary lexicon, different categories of words, nouns and verbs for example, may be responded to differently due to an array of factors involved in the processes of lexical access or lexical retrieval, and hence may display different behavioral patterns or different forms of language breakdown.

On the other hand, the difference between the Broca's and the Wernicke's aphasics is also acknowledged by the processing limitation approach. Assuming the framework of distributed models of language processing (cf. Masson, 1995; McClelland & Rumelhart, 1986), and based on their research over the decades on semantic priming, Blumstein and Milberg (2000) believe that the clinical characteristics of the Broca's aphasics can be ascribed to a reduction in the activation of lexical entries (hypo-activation), while with Wernicke's aphasics, the problem may involve the over-activation of the lexical entries (hyper-activation). Moreover, as Blumstein and Milberg (2000) point out, the characteristics differentiating Broca's aphasics and the Wernicke's

[5] The preservation of the morphological structures had been reported in several studies (Delazer & Semenza, 1998; Semenze, Luzzatti, & Carabelli, 1997). However, the influence of different degrees of the productivity of morphological structures on neither normal people nor aphasic patients' linguistic behaviors seems not to be widely investigated yet. In the light of the Structural Priming Model proposing that structural priming is a kind of implicit learning—a grammatical structural could be picked up when a recurrent network was trained to anticipate the next word in a sentence. (Chang, Griffin, Dell, & Bock, 1997; cited in Dell, Chang, & Griffin, 1999), we suggest that the effect of the canonicity of compound types may be an implicit learning of structure. The morphological structures are implicitly learned with their repeated occurrence, hence the better performance on the more typical compound types. However, this proposal requests for further experimentation.

aphasics may not only reside in the under- or hyper-lexical activation but also the ultimate intra-lexical (integrating each word in a sentence) and inter-lexical (integrating each word 'into' a sentence) semantic integration. Future work will focus on how nouns and verbs differ in semantic activation, and how semantic activation of the two linguistic categories occurs within a sentential context.

Appendix A. Subject information

Aphasic type	Name	Sex	Age (years)	Ed. (years)	Handedness	lg spoken other than the tested lg	Etiology	Post onset (month)	Lesion site
Personal particulars of aphasic subjects									
B	KL	F	43	9	RH	Taiwanese	CVA	9	Left MCA area
T	SU	M	43	12	RH	Taiwanese	CVA	5	Left MCA area
T	KJ	M	38	12	RH	Taiwanese	Head injury	5	Bi-frontal regions
B	SC	F	40	16	RH	Taiwanese	CVA	3	Left FT region
B	YD	M	72	6	RH	Taiwanese	CVA	23	L frontal and Occipital PVWM and L basal ganglia
W	TU	M	61	21	RH	Taiwanese English	CVA	17	Left temporal parietal
A	FS	M	55	6	RH	Taiwanese	CVA	17	Left temporal parietal
W	SL	M	53	14	RH	Taiwanese	CVA	2	Left MCA territories and right temporal area
W	CS	M	37	14	RH	Taiwanese	Head injury	10	Bilateral frontal
W	FC	M	36	16	RH	Taiwanese	CVA	4	Not available

CVA, cerebral vascular accident.

Appendix B. Word stimuli for picture-confrontation naming task

Object	Glossary of the morphemes	Glossary of the compounds	Action	Glossary of the morphemes	Glossary of the compounds
Picture naming—VV type					
Bao guo	To wrap—to wrap	A parcel	Ke sou	To cough up—to cough	To cough
Dao ian	To direct—to act	A director	Bao zha	To explode—to explode	To explode
Jie yun	Quick—to transport	Mass rapid transportation	She ji	To shoot—to hit	To shoot
Pu man	To beat—filled	A piggy bank	Diao ke	To carve—to carve	To carve
Kai guan	To switch on—to switch off	A switch	Dao gao	To pray—to tell	To pray
Bang cheng	To weigh—to weigh	Platform scales	Fa gui	To punish—to kneel	To punish sb to kneel
Cun zhe	To save—to fold	A bankbook	He chang	To unite—to sing	To sing in chorus
Cai feng	To cut—to sew	A tailor	Die dao	To fall down—to topple	To fall down
Wei dou	To surround—to carry	A pinafore	Ian jiang	To act—to speak	To give a lecture
Shao mai	Hot—to sell	A kind of Hong Kong food	Sai pao	To compete—to run	To run a race
Gua gou	To hang—to hook	A hanger	Qian gjie	To rob—to rob	To rob
Zhen tan	To detect—to detect	A detector	Fa shao	To show—heat	To have a temperature
Cai pan	To cut—to judge	A judge	Fa zhan	To punish—to stand	To punish sb. to stand
Zhu bou	Main—to broadcast	News announcer	An mo	To press—to rub	To massage
Ci xiou	To stab—to embroider	Embroidery			
Picture naming—VN type					
pin tu	To piece together—a picture	A jigsaw puzzle	Xi tzao	To wash—a bath	To take a bath
Shan dian	To flash—electricity	A lightening	Liou gou	To walk—a dog	To walk a dog
Jian dao	To cut—a knife	Scissors	Da tie	To hit—iron	To forge iron
La lian	To pull—a chain	A zip	huachuan	To row—a boat	To row a boat

Appendix B (*continued*)

Object	Glossary of the morphemes	Glossary of the compounds	Action	Glossary of the morphemes	Glossary of the compounds
Yun dou	To iron– an object resembling a dipper or cup	An iron	tiaosheng	To jump—a rope	To jump the rope
	To surround—cloth		Wa tu	To dig—soil	To shovel
Wei jin	To hang—a fan	A scarf	Tso ian	To inhale—smoke	To smoke
Diao shan	To pillow—the head	A ceiling fan	Jia hua	To sprinkle on—flowers	To water flowers
Zhen tou	To distribute—a ticket	A pillow	Du shu	To read—books	To study
Fa piao	To hang—a light	A receipt	Liou bing	To slide—ice	To skate
Diao deng	To protect—a person	A ceiling light	He cha	To drink—tea	To drink tea
Hu shi	To sweep—a handle	A nurse	Kua lan	To straddle—a fence	To hurdle
Sao ba	To leak–an object resembling a dipper or cup	A broom	Tiao shui	To jump—water	To dive
Lou dou	To print—a stamp		Shua ia	To brush—teeth	To brush the teeth
	To rock—a chair	A funnel	Hua hua	To draw—paintings	To paint
In zhang	To fly—a machine	A stamp	Pai shou	To hit lightly—hands	To applaud
Iao yi	To cure—a person	A rocking chair	Tiao wu	To jump—dance	To dance
Fei ji	To serve as background—a shirt	An airplane	Diao yu	To hook—fish	To fish
Yi sheng	To hang—a bridge	A doctor	Cha hua	To stick into—flowers	To arrange flowers
Chenshan	To pluck—the head	A shirt	Da jia	To hit—a fight	To fight
Diao qiao	To suck—a tube	A suspension bridge	Shang ke	To go to– classes	To attend class
Cha tou	To sleep—clothes	A plug	Pao bu	To run—a step	To run
Xi guan	To calculate—a plate	A straw	Qia men	To knock—a door	To knock at the door
Shui yi	To mop—a handle	Pajamas	Hua xue	To slide—snow	To ski
Suan pan	To stretch tight—a belt	An abacus	Kai che	To start—a car	To drive
Tuo ba	To explode—a ball	A mop	Cun qian	To save—money	To save money
Beng dai	To surround—a skirt	A bandage	Shui jiao	To sleep—a sleep	To sleep
Zha dan	To fish—a bamboo pole	A bomb	Iou yung	To swim– swim	To swim
Wei qun	To limp—a stick	An apron	Dengshan	To climb—mountains	To climb a mountain
Diao gan	To draw—a set of removable trays	A fishing pole	Huai yun	To carry–pregnancy	To be pregnant
Guaizhang	To drag—shoes	A crutch	Ju zhong	To lift—weight	To lift weight
Chou ti	To clip—a needle	A drawer	Xi lian	To wash—a face	To wash a face
Tuo xie	To catch—a person	Slippers	Ju gung	To bow– bow	To bow
Bie zhen	To disturb—a clock	A pin	Sao di	To sweep—the floor	To sweep the floor
Bu shou		A catcher	Jing li	To offer something politely–courtesy	To render a salute
Nao zhung		An alarm clock	Jie qiou	To receive—a ball	To catch a ball
			Xi wan	To wash—a bowl	To wash dishes
			Wan pai	To play—cards	To play cards
			Pa shu	To climb—trees	To climb a tree
			Dou diou	To fight—a bull	To have a bull-fight
Picture naming—NV type					
Pi bao	Leather—to wrap	A leather bag	Fen shua	Powder—to brush	To whitewash
Tie chui	Iron—to pound	A hammer	Zi sha	Self—to kill	To commit suicide
Niou kou	A button—to button	A button	In gin	A shadow—to print	To photocopy
Jing cha	The police—to detect	A policeman	Zhi hui	Fingers—to wave	To conduct
Iou chai	Mail- to send on an errand	A postman	Kong tou	The sky—to throw	To airdrop
Xin feng	A letter—to seal	An envelope	Di zhen	The ground—to shake	Having an earthquake
Yu shua	Rain—to brush	A windscreen wiper	Meng iou	Dream—to travel	To sleepwalk
Sha lou	Sand—to leak	A sandglass	Quan ji	Fists—to hit	To box
In xiang	Sound—to make a sound	Audio			
Er chui	Ears—to hang down	An earlobe			
Kou zhao	Mouth—to cover	A gauze mask			
Yue liang	The moon—to light	The moon			
Ia shua	Teeth—to brush	A toothbrush			
Dian zuan	Electricity—to drill	An electric drill			
Pen zai	A pot—to plant	A potted plant			
Wai tao	Outside—to cover	A jacket			
Deng zhao	A light—to cover	A lampshade			
Shou kao	Hands—to handcuff	Handcuffs			
Shou tao	Hands—to cover	Gloves			

Appendix B (*continued*)

Object	Glossary of the morphemes	Glossary of the compounds	Action	Glossary of the morphemes	Glossary of the compounds
Hai dao	The sea—to rob	A pirate			
Pi jia	Leather—to clip	A wallet			
Xie ba	Shoes—to pull out	A shoehorn			
Ban ca	A board—to wipe	A blackboard eraser			
Shou juan	Hands—to roll	A kind of Japanese food			
Jiao dian	Feet—to pad	A mat			
Tie pa	Iron—to rake up	A rake			
Ping gai	A bottle—a cap	A cap			
Fa jia	Hair—to clip	A hairpin			
Dou fu	Beans—to rotten	Bean curd			
Qiou pai	A ball—to pat	A racket			
Iou chuo	Mail—to poke	A postmark			
Picture naming—NN type					
Bing xiang	Ice—a box	An icebox	—	—	—
Chuanglian	A window—a curtain	Window curtains			
Qi qiou	Air—a ball	Balloon			
Ma tong	A horse—a bucket	A stool			
Ian jing	Eyes—eyes	Eyes			
Ling dang	A bell–the sound of striking a gong	A bell			
Huo chai	Fire—firewood	A match			
Dan gao	Eggs—a pudding	A cake			
Yu mao	A feather—hair	A feather			
Guan tou	A jar—nominal suffix	A can			
Ing er	A baby—a son	A baby			
La zhu	Wax—a candle	A candle			
Nai ping	Milk—a bottle	A baby's bottle			
Bei xin	Back—heart	A vest			
Yi jia	Clothes—a rack	A clothes-rack			
Yu san	Rain—an umbrella	An umbrella			
Fu tou	An ax—nominal suffix	An ax			
Tou fa	The head—hair	Hair			
Ian cung	Smoke—a chimney	A chimney			
Yu mi	Jade—rice	Corn			
Ping guo	An apple—fruit	An apple			
Qian bi	Lead—a pen	A pencil			
Ian jing	Eyes—glasses	Glasses			
Fengzheng	Wind–a Chinese zither with 21 or 25 strings	A kite			
Iang tai	The sun—a terrace	A balcony			
Gu tou	Bone—nominal suffix	A bone			
Dian hua	Electricity—speeches	A telephone			
Qi che	Gas—a car	A car			
Pi dai	Leather—a belt	A leather belt			
Ling dai	A neck—a belt	A necktie			
Deng pao	Light—a bubble	A light bulb			
Shu zhuo	A book—a desk	A desk			
Gang qin	Steel—an instrument	A piano			

Appendix C. Word stimuli for category judgment task

Stimuli	Glossary of the morphemes	Glossary of the compounds	Frequency
Category judgment—noun (VV type)			
Tong gao	To pass through—to tell	Public notice	56
Zhu chi	To live—to hold	Abbot	41
Fu lu	To attach—to record	Appendix	10
Shui mian	To sleep—to sleep	Sleep	51
Kai guan	To switch on—to switch off	Switch	97

Appendix C (*continued*)

Stimuli	Glossary of the morphemes	Glossary of the compounds	Frequency
Tan tu	To talk—to spew	Style of speech	13
Zao hua	To construct—to change	Good fortune	13
Que xian	To lack—to sink	Defect	36
Jian zhu	To construct—to construct	Building	1378
Zhu li	To assist—to manage	Assistant	252
Jian wen	To see—to smell	What one sees and hears (knowledge)	18
Shou ju	To receive—to base on	Receipt	45
Xu qiou	To need—to request	Requirement	1493
Gan xiang	To feel—to think	Reflection	63
Dao iou	To guide—to travel	Tour guide	52
Zhe kou	To fold—to distract	Discount	172
Dong jing	To move—to remain still	Movement	65
Xing wei	To walk—to act	Behavior	2061
Xue shuo	To learn—to speak	Theory	34
Cai pan	To trim—to decide	Judge	235
Du xue	To supervise—to learn	School inspector	125
In shi	To drink—to eat	Diet	140
Du zhu	To gamble—to pour	Bet	28
Ju dong	To lift—to move	Movement	190
She bei	To establish—to prepare	Facilities	2426
Category judgment—noun (VN type)			
Xiao sheng	To laugh—a voice	Laughter	57
Guan dian	To view—a point	Viewpoint	378
Shu jia	To lose—a person	Loser	12
Tiao zao	To jump—a flee	Flee	41
Qi lou	To ride—a building	Porch	104
Shui dai	To sleep—a bag	Sleeping bag	12
Kan tai	To watch—a stage	Grandstand	34
Ian yuan	To act—a person	Actor	387
Pei jiao	To cooperate with—a role	A supporting role	50
Da shou	To hit—a person	Hired thugs	17
Kao xiang	To bake—a box	Oven	15
Diao qiao	To hang—a bridge	A suspension bridge	40
Fa dan	To punish—a sheet of paper	Ticket	100
Du tu	To gamble—a person	Gambler	105
Guan jia	To manage—a specialist	Steward	123
Zhao pai	To attract—a board	Shop sign	185
Kai shui	To boil—water	Boiled water	50
Uo shi	To lie—a room	Bedroom	101
Chuang yi	To create—an idea	Originality	158
Zou dao	To walk—a path	Path	22
Bao mu	To protect—mother	Babysitter	119
Zuo jia	To writhe—a specialist	Writer	278
Zhi ji	To understand—self	Soul mate	22
Tie zhi	To stick—paper	Sticker	31
Jiang shi	To lecture– teacher	Lecturer	78
Category judgment—noun (NV type)			
Ming cheng	A name—to address	Title	401
Xin feng	A letter—to seal	Envelope	47
Pi jia	Leather—to clip	Wallet	43
Men jin	A door—to forbid	Entrance guard	20
Qiou mi	A ball—to be crazy about	Ball game fan	99
Xung zhao	Breasts—a cover	Bra	12
Ia shua	Teeth—to brush	Toothbrush	20
Ren zheng	People—to testify	Witness	33
Mai dong	The vein—to move	Pulsation	70
Nian xian	Years—to limit	Fixed number of years	115
Qiou pai	A ball—to pat	Racket	18
Shou kao	Hands—to handcuff	Handcuffs	48
Bi ji	A pen—to take notes	Notes	91
Ti jian	Body—to examine	Physical examination	109
Kou zhao	Mouth—a cover	Mask	55
Bi lu	A pen—to record	Records of crimes	187

Appendix C (*continued*)

Stimuli	Glossary of the morphemes	Glossary of the compounds	Frequency
Ke yun	Passengers—to transport	Passengers transport	655
Fang zu	A house—to rent	Rent	110
Mu lu	Eyes—to record	Table of contents	37
Pen zai	A pot—to plant	Potted plants	57
Zui fan	Crime—to violate	Criminal	122
Shui shou	Tax—to gather	Taxation	311
Qi kan	Periods—to publish	Periodical	21
Ri ji	Days—to record	Diary	41
Jie zou	A node—to play	Rhythm	67
Category judgment—noun (NN type)			
Ka dai	A card—a type	Tape	58
Bei xin	Back—heart	Vase	39
Mu di	Eyes—the goal	Goal	1464
Cha hu	Tea—a pot	Teapot	41
Di pan	Ground—a plate	Territory	91
Ia gao	Teeth—grease	Tooth paste	13
Cha bei	Tea—a cup	Cup	19
Tou mu	Head—eyes	Leader	30
Deng huo	Light—fire	Lights	46
Shou zu	Hands—feet	Brothers and sisters	19
Dian deng	Electronics—lights	Electric light	18
Che piao	Cars—tickets	Ticket	106
Ka pian	Cards—pieces	Card	98
Fang zu	House—house	House	897
Cao mei	Grass—berry	Strawberry	51
Niou rou	Cattle—mean	Beef	186
Xiang pian	Appearance—pieces	Photograph	81
Bing xiang	Ice—box	Refrigerator	105
Yue tai	Moon—stage	Platform	38
Si miao	Temple—temple	Temple	241
Huo guo	Fire—pot	Chafing dish	127
Hai shui	Sea—water	Seawater	271
Shu bao	Book—papers	Books and newspapers	23
Pi xie	Leather—shoes	Leather shoes	37
Men lu	Door–roads	Knack	700
Category judgment—verb (VV type)			
Kan jian	To see—to see	To catch sight of	236
Da ting	To hit—to listen	To enquire	79
Pan deng	To climb—to ascend	To climb up	18
Wang ji	To forget—to memorize	To forget	130
Ia zha	To press—to extract by pressing	To extort	24
Xi shua	To wash—to brush	To wash (or to clear sb. of)	28
Tou ben	To throw—to run quickly	To seek shelter	30
Qian yi	To move—to move	To move	385
Ian shou	To check—to receive	To check before acceptance	178
Tao zou	To escape—to walk	To escape	65
Wan jiou	To pull—to save	To rescue	149
Kai cai	To open—to mine	To mine	91
Diao pai	To adjust—to send	To assign	144
Bian mai	To change—to sell	To sell something for urgent need	92
Guai pian	To abduct—to cheat	To abduct	13
Mu juan	To recruit—to donate	To solicit donations	33
Qi ia	To deceive—to press	To bully and oppress	42
Liou shou	To stay—to guard	To stay and guard	52
Can jia	To take part in—to add	To take part in	4904
Jie shou	To accept—to accept	To accept	3361
Bou xue	To shell—to pare	To exploit	120
Mai zang	To cover up—to inter	To bury	24
Ing qu	To greet—to marry	To greet the girl and take her as wife	13
Ling iang	To receive—to raise	To adopt (a kid)	36
Bao wei	To wrap—to surround	To surround	155
Bu zhuo	To catch—to seize	To chase or hunt	63

Appendix C (*continued*)

Stimuli	Glossary of the morphemes	Glossary of the compounds	Frequency
Tun shi	To swallow—to eat	To raven	16
Pei dai	To match—to wear	To wear (an ornament)	27
Tou lou	To penetrate—to reveal	To reveal	1176
Gai jia	To change—to marry	(For a woman)To remarry	12
Lian he	To alley with—to combine	To unite	1801
Di bu	To hand over—to mend	To fill a vacant position	34
Category judgment—verb (VN type)			
Dao dan	To pound with a pestle—the egg	To make trouble	29
Mai dan	To buy—the bill	To pay the bill	78
Bao ming	To announce—the name	To sign up	1167
Deng lu	To ascend—the land	To land	136
Tan pai	To spread out—the card	To come to a showdown	23
Fen xin	To divide—the heart	To be distracted	14
Tan qin	To visit—people with blood relation	To visit with one's relatives	199
Jiou ie	To engage in—a business	To get a job	597
Pou chan	To break—the wealth	To be bankrupt	182
Zhao xiang	To photograph—pictures	To take a picture	65
Jiou huo	To rescuer—the fire	To fire-fight	156
Wa jiao	To dig—a role	To recruit talents from other corporations	88
Chou qian	To draw out—a label	To draw lots	175
Kan bing	To see—an illness	To see a doctor	86
Mou yu	To stroke—a fish	To lie down on the job	10
Ue jie	To get over—the boundary	To step beyond the boundary	33
Tiao cao	To jump—a trough	To move from one's firm to another	48
Ian shang	To examine—a wound	To examine the wound	49
Du jia	To spend—a vacation	To enjoy a vacation	131
Zhuan che	To shift—a vehicle	To transfer	121
Liao tian	To chat—the sky	To chat	143
Pao mao	To throw—an anchor	To anchor	24
Fa huo	To show—fire	To burst into flames	17
Gao zhuang	To tell—a writer complaint	To complain about someone	37
Kai dao	To open—a knife	To operate	163
Peng chang	To hold up—a open space	To act as a claque member	64
Shi gong	To perform—a work	To construct	1976
Tou zi	To throw—money	To invest	6677
Zhi dao	To know—a path	To know	2061
Lai zhang	To blame– accounts	To refuse to pay a debt	13
Diao bao	To drop—a bag	To exchange one package	13
Ban jiang	To bestow on—an award	To award prizes	324
Category judgment—verb (NV type)			
Li yung	Benefit—to use	To make use of	2861
Li rang	Courtesy—to yield	To give precedence out of courtesy	58
Fen shua	Powder—to brush	To whitewash	16
Wei sui	The tail—to follow	To follow at the heels	122
Di shi	An enemy—to view	To be hostile to	22
Iou zha	Oil—to fry in oil	To fry in oil	21
Gu chui	A drum—to blow	To promote	83
Lu guo	A road—to pass by	To pass by	118
Ti liang	A body—to forgive	To show understanding for	118
Xin dong	The heart—to move	To intend for	28
Zi zhu	The money—to help	To give financial assistant to	77
Xhang tan	Business—to talk	To exchange views	59
Wa jie	A roof tile—to separate	To disintegrate easily	105
Tuan jie	A group—to unite	To unite	443
Sheng yuan	Voice—to help	To express support for	324
Er wen	The ear—to hear	To hear about	37
Gua fen	A melon—to divide	To dismember	46
Ing in	The shadow—to copy	To photocopy	52
Ge chang	A song—to sing	To sing	252
Jie sheng	Reduction—to save	To be frugal	385
Zhou zhuan	Circle—to turn	To have enough to meet the need	112
Shu li	Trees—to set up	To establish	87

Appendix C (*continued*)

Stimuli	Glossary of the morphemes	Glossary of the compounds	Frequency
Gen zhi	The root—to cure	To cure completely	15
Ian qing	A banquet—to treat	To give a banquet to	104
Mu du	Eyes—to see	To witness	165
Piao xuan	Tickets—to elect	To elect by ballot	71
Pao hong	A cannon—to bombard	To bombard with a cannon	68
Ke chuan	A guest—to string up	To be a guest performer	21
Mian lin	The face—near	To confront	1453
Li pin	Courtesy—to engage the service of	Cordially invite the service of	21
Qiang bi	Firearm—to shoot	To execute someone by shooting	19
Kuan dai	Hospitality—to act as host to	To treat hospitably	47

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