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The Noun–Verb Problem in Chinese Aphasia

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Previous studies have shown that Broca's aphasics experience a selective difficulty with action naming inside or outside of a sentence context. Conversely, it has been suggested that Wernicke's aphasics are particularly impaired in object naming. A number of explanations have been offered to account for this double dissociation, including grammatical accounts according to which the main verb problem in agrammatic Broca's aphasics is viewed as a by-product of their syntactic and/or morphological impairment, due perhaps to the greater morphological load carried by verbs (compared with nouns). In the Chinese language, there are no verb conjugations and no declensions. Hence there is no reason to expect a relationship between morphological impairment and deficits in action naming. We examined comprehension and production of object and action names, outside of a sentence context, in a sample of Chinese-speaking Broca's and Wernicke's aphasics. There was an interaction between patient group and object/action naming, but no corresponding interaction on the comprehension task. We conclude that action-naming deficits in Broca's aphasia (and/or the corresponding sparing

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of action names in Wernicke's aphasia) cannot be attributed to morphological differences between nouns and verbs. We also found a sublexical variant of the noun/verb dissociation applied to the internal structure of compound words made up of a verbal and a nominal element: Broca's aphasics tended to lexicalize the verbal portion of these words more often than the nominal compound, while Wernicke's showed the opposite pattern. These sublexical effects are difficult to explain in syntactic terms nor do they fit the standard lexical view. A modified lexical account is proposed, emphasizing semantic/conceptual effects in a distributed lexicon.

One of the more puzzling findings in the literature on language breakdown in aphasia revolves around the contrast between nouns and verbs (Goodglass, 1976; Berndt, 1989). As a group, Broca's aphasics seem to experience particular difficulty in the production of main verbs compared with names for common objects (Goodglass & Menn, 1985; Caramazza & Berndt, 1985). They tend to omit verbs in their spontaneous speech and/or to substitute a nominal form in the verb's place (e.g., "Bunny . . . tears" instead of "Bunny cry"). The opposite pattern has been reported for fluent aphasics, including anomics (Miceli, Silveri, Villa, & Caramazza, 1984; Miceli, Silveri, Nocentini, & Caramazza, 1988; Zingeser, 1989) and Wernicke's aphasics (Gleason, Goodglass, Obler, Green, Hyde, & Weintraub, 1980; Miceli et al., 1988; Osmán-Sági, 1987). For these patients, word-finding difficulties are most apparent when they are trying to name a common object, resulting in an overuse of pronouns and other vague forms ("This thing here, whatever it's called, it's crying") and/or in production of the wrong noun form (including some "neologisms" or invented words).

According to Miceli et al. (1984), and to Osmán-Sági (1987), this noun–verb contrast is not restricted to spontaneous speech. When fluent and nonfluent patients are asked to describe the same set of simple objects and actions, they reportedly show opposite patterns of naming difficulty. Broca's aphasics make more errors in action naming; fluent patients make more errors in object naming or, at the very least, they do not show the selective deficit in action naming reported for nonfluent patients. Miceli et al. (1988) report a similar double dissociation between nouns and verbs in comprehension of isolated names for objects and actions (although this dissociation appears to be much weaker than the one observed for single-word production—we will return to this point later).

Potential explanations for this noun–verb dissociation can be divided into three basic categories: semantic–conceptual, grammatical, and lexical.

SEMANTIC–CONCEPTUAL EXPLANATIONS

Explanations at this level revolve around the different meanings conveyed by nouns and verbs, and (by extension) the differential participation of anterior and posterior cortex in the representation and/or construction

of action and object meanings. This approach is plausible on neurological grounds, if we assume that the brain regions responsible for the semantic representation of actions lie closer to motor cortex (which is, in turn, more often the site of damage for nonfluent Broca's aphasics); conversely, the representations that underlie object names may involve more input from sensory association areas (i.e., the areas that are usually implicated in fluent aphasia).

Indirect support for the semantic–conceptual hypothesis comes from a recent study of brain metabolism in normal subjects who are asked to read and process individual words (Petersen, Posner, Fox, Mintun, & Raichle, 1988). During passive reading of object names (compared with nonlinguistic visual stimulation), activity appears to be restricted primarily to occipital and sensory association cortex; the classical language areas are bypassed altogether. When subjects are asked to read the same words aloud, the classical language areas are called into play. However, when subjects are then asked to think of an action that is associated with each object name, a region anterior to Broca's area shows a marked increase in metabolic activity. This report is compatible with an observation by Luria, who claims that patients with frontal damage anterior to Broca's area experience severe problems in action naming, one symptom within a syndrome called "dynamic aphasia" (Luria, 1962; Luria & Tsvetkova, 1968). Because many Broca's aphasics have lesions that extend forward beyond Broca's area itself (Lieberman, 1984), the main-verb problem could reflect damage to this frontal domain. (See also Brown, Marsh, & Smith, 1976, 1979, for electrophysiological evidence suggesting an anterior/posterior distribution for verbs and nouns, respectively).

Because the semantic–conceptual account is independent of the particular surface forms (lexical or grammatical) used to convey noun and verb meanings, it leads to the prediction that the noun–verb dissociation observed in fluent and nonfluent aphasia will be found in every natural language—including Chinese, the language to be investigated in the present study.

GRAMMATICAL EXPLANATIONS

Explanations within this category all revolve around the correlation between agrammatism and the main-verb problem in Broca's aphasia. There are two versions of this argument. First, because verbs tend to carry a heavy load of grammatical marking in languages like English, they may be particularly difficult for agrammatic patients to produce. We will refer to this as the *morphological account.* Second, verbs also play a crucial role in syntactic processing. Specifically, the number and range of optional and obligatory noun arguments taken by a given verb determine the set of well-formed sentence frames that a speaker may select. This cause-and-effect relationship may lead to a correlation between syntactic

deficits and problems in verb retrieval; we will refer to this as the *syntactic account* (see Lapointe, 1985, and Shapiro, Zurif, & Grimshaw, 1987, for discussions of the relationship between syntax and verb argument structure).

Indirect support for some kind of grammatical account of the main-verb problem comes from the literature on language acquisition in normal children (Bates, Bretherton, & Snyder, 1988; Gentner, 1982; Bloom, Hafitz, & Lifter, 1980). In the first stages of language learning, before children are able to produce word combinations, their production is restricted primarily to names for common objects, together with a heterogeneous class of vocal procedures or routines (e.g., "Bye-bye," "Up!"). Somewhere in the middle of the second year of life, the lexicon changes markedly in size and composition. In particular, children begin to produce a significant number of verbs. This is not a trivial by-product of overall vocabulary growth, because verbs and other predicate terms also come to occupy a larger *proportion* of each child's total vocabulary. Most pertinent for our purposes here, the onset of verb production is correlated with a passage from single-word utterances to combinatorial speech, followed soon thereafter by a sharp spurt in the acquisition of grammatical morphology. There does, then, appear to be a privileged connection between acquisition of verbs and acquisition of grammar—although the nature of that link is far from clear.

These two grammatical accounts make different predictions for Chinese. As we shall see in more detail below, there is virtually no inflectional morphology of any kind in Chinese; it therefore follows that there is no overall difference between nouns and verbs in morphological complexity. However, verb–argument structure does play a crucial role in sentence organization (i.e., syntax) in Chinese and in every other language studied to date. The morphological account would predict no dissociation between nouns and verbs in Chinese aphasics; by contrast, the syntactic account would lead us to expect the usual noun–verb dissociation in Broca's aphasics. Some constraints on these predictions that derive from the internal structure of Chinese verbs will be discussed later.

LEXICAL EXPLANATIONS

Miceli et al. (1984, 1988) have criticized both the conceptual and the grammatical accounts of the main-verb problem in Broca's aphasia, arguing instead that the noun–verb dissociation observed in fluent and nonfluent patients reflects a breakdown in processing that is located entirely within the lexicon. Specifically, they suggest that words and morphemes are listed separately in the lexicon according to *form class* or *part of speech*—a listing which may also be reflected in the spatial organization of the cortical areas responsible for lexical processing (that is, nouns and verbs may be stored in separate spatial loci). This proposal is compatible

with other reports of category-specific lexical and morphological deficits, including the claim that derivational and inflectional morphology can be selectively dissociated in aphasia (Miceli and Caramazza, 1988), and with reports of patients who experience selective impairment in accessing specific lexical categories like fruits and vegetables (Hart, Berndt, & Caramazza, 1985). In contrast with grammatical accounts of the noun–verb dissociation, the lexical account is in no way dependent upon a correlation between verb deficits and agrammatism. Instead, Miceli et al. (1988) suggest that the oft-cited correlation is a by-product of the fact that verbs and grammatical morphemes are processed in adjacent but independent areas of cortex. In contrast with conceptual explanations for the noun–verb dissociation, the lexical account also makes no claims whatsoever about the participation of motor cortex in the representation of action meanings. Indeed, Miceli et al. are careful to underscore the difference between conceptual organization (a nonlinguistic domain) and lexical organization (an autonomous component of the language processor).

In criticizing the semantic–conceptual approach, Miceli et al. (1984) remind us that patients who experience selective deficits in verb retrieval often substitute a nominal form to describe the same pictured event (e.g., TEARS for CRY or FLIPPERS for SWIM). Hence these patients are clearly able to understand, interpret, and refer to the actions depicted in a scene. Their problem must therefore lie at the point in processing at which the speaker must retrieve a verb form to stand for the depicted action.

In criticizing the grammatical approach, Miceli et al. (1984) argue that there is to date no coherent theory to explain the cooccurrence between verb errors and problems with grammatical processing. We find this criticism somewhat less compelling, insofar as the morphological and the syntactic accounts outlined above appear to have at least some *a priori* credibility. A more compelling criticism derives from their demonstration that fluent and nonfluent patients display the same dissociations in description of isolated objects and actions outside of a sentential context. They consider the possibility that patients who are describing isolated pictures pass through a stage of covert sentence construction, activating sentential fragments like "BOY KISS GIRL" to arrive at the required action name. However, if the breakdown in verb retrieval does lie at a putative stage of covert sentence planning, then it is difficult to explain how or why nonfluent patients arrive at nominalized forms like "LOVE" or "KISSING" to describe the same event. Presumably, these nominalized forms would require a similar stage of covert sentential planning.

Another problem with the syntactic account revolves around the fact that Broca's aphasics are usually able to order noun phrases correctly around the verb slot, whether or not the verb itself is ultimately expressed (e.g., "BOY . . . GIRL," in describing a picture of a boy kissing a girl).

In fact, a wide range of studies have shown that canonical word order is very well preserved in sentence production by agrammatic patients in several different languages including English, Italian, German, Dutch, Turkish, Hungarian, Chinese, and Japanese (Bates, Friederici, Wulfeck, & Juarez, 1988; Caramazza & Berndt, 1985; Menn & Obler, 1990; Caplan, 1985; Kolk, Van Grunsven, & Keyser, 1985; Pastouriaux, 1982, cited in Goodglass & Menn, 1985, p. 18; Slobin & Talay, 1988; MacWhinney & Osmán-Sági, 1988; Tzeng & Chen, 1988). There is also solid evidence for preservation sensitivity to canonical word order in receptive processing by agrammatic patients in comprehension (Bates, Friederici, & Wulfeck, 1987a; MacWhinney & Osmán-Sági, 1988) and in grammaticality judgment (Wulfeck & Bates, 1990; Wulfeck, Bates, & Capasso, 1991). If it is the case that agrammatic patients retain access to language-specific sentential frames for ordering nouns and verbs, then it is difficult to defend the notion that their problem in the realization of main verbs stems from an inability to construct ordered syntactic frames. Indeed, it would seem to be the other way around: phrase structure frames are preserved, but the patient often cannot find the item he needs to fill the verb slot.

In our view, the morphological account is the only *grammatical* explanation that is compatible with all the phenomena described so far. Specifically, agrammatic patients may experience difficulty in verb production (even within a simple action-naming task) because they are forced to select one form of the verb from a large array of morphological variants (e.g., KISS, KISSES, KISSING, KISSED). Note, however, that this explanation rests on the assumption that there are more morphological variations for verbs than nouns. As we have noted, this assumption does not hold in Chinese, a language in which there is virtually no inflectional morphology for either nouns or verbs. If we find the same noun–verb breakdown in fluent and nonfluent Chinese aphasics, then we must reject the morphological account in favor of some kind of lexical or conceptual explanation for this dissociation.

The Chinese language also has some special properties that will permit us to reject at least one version of the lexical account. In this language, many individual nouns and verbs are compounds made up of two or more smaller elements (single-syllable morphemes) that each carry their own separate noun or verb meanings. In particular, many verbs are made up of both a nominal and a verbal component (Li & Thompson, 1981).[1] If

[1] There is some controversy among Chinese linguists regarding the status of V-N compounds. On the one hand, these words have some of the characteristics of a complete verb phrase. To illustrate, consider the compound word KAN-SHU ("read," literally *look-book*). The noun element within this word can be substituted by another noun when the speaker wants to be more specific about the object being read (e.g., KAN-XIAO-SHUO or *look-novel*). The noun and verb elements must be separated by a classifier if the speaker wants to quantify or qualify the object of reading in some way (e.g., KAN-LIANG-BEN-SHU

we find evidence for a noun/verb dissociation *within* these lexical compounds (e.g., if Broca's aphasics have more difficulty with the verbal component in a compound verb, while Wernicke's aphasics show the opposite pattern), then we will have to reject the view that whole nouns and whole verbs are spatially segregated in the brain according to form class. At the very least, we will need a more subtle version of the lexical hypothesis, in which the conceptual and/or grammatical differences between nouns and verbs are represented at a sublexical level, with different sublexical components stored at different sites in the brain.

Before we proceed, we need a more detailed account of the relevant facts in Chinese.

GRAMMAR AND AGRAMMATISM IN CHINESE

The Chinese language has what may be the simplest and most austere grammatical system in the world (Wang, 1973; Li & Thompson, 1981). Most of the world's languages offer a wealth of different markers on nouns, pronouns, adjectives, and/or verbs. These include verb conjugations (e.g., markings for person, number, tense), noun declensions (e.g., plurals and/or case inflections to indicate sentence roles like actor, receiver of action, instruments, location, etc.), and various elements to indicate agreement between subject and verb (e.g., "The man is" versus "The men are"), between nouns and their modifiers, and/or between pronouns and the elements that those pronouns represent. In languages like Spanish or Italian, a single verb can take up to 40 different forms; and in case-inflected languages like Hungarian, noun markers of various kinds can be piled up to create up to 100 different forms for a single noun. Compared with these languages, English has a fairly minimal system of grammatical marking—but it is still considerably richer than grammatical marking in Chinese, a language with essentially no inflectional morphology, i.e., no verb conjugations and no noun declensions of any kind.

Although there are no inflectional markers to indicate sentence roles like subject or object, the Chinese grammar does provide for a set of standard word orders. Most sentences occur in the order "subject–verb–object," but it is often possible to leave the subject out altogether (e.g., "Eat chicken" instead of "I eat chicken"), and word order can be varied in a number of ways if the speaker wants to emphasize one element more

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or *look-two-piece-book*). The noun element can also be moved to the front in response to a topicalizing question (e.g., "What are you going to do to the book?"—SHU-WO-KAN or *book-I-read*). On the other hand, V-N compounds also fill the diagnostic criteria associated with the citation form of verbs in Indo-European. For example, the full compound form is obligatory in intransitive contexts (when no particular object is intended) and in nominalizations like KAN-SHU YOU-QU, or "Reading is interesting," literally *look-book have-interest.* In the task adopted here, action names are requested out of context in their most neutral form.

than another (e.g., "Chicken eat," where the speaker is emphasizing that he wants to eat chicken as opposed to some other dish). The rest of Chinese grammar consists primarily of one-syllable words or particles, similar in some respects to short function words like "is," "in," or "this" in English. For example, temporal notions are indicated with syllables that have a transparent aspectual meaning (equivalent to saying something like "Eat-finish" in English to indicate an activity that has already come to an end). Noun-related notions like number are also indicated with a single syllable. For example, the affix ZI is widely used as a diminutive;[2] this morpheme can be translated literally as "small," but is also the ancient word for "son." Similarly, although the expression HAIZI-MEN is the appropriate translation of the English word "children," it can be translated literally as *child-many*. In addition to these "word-like" markings on nouns and verbs, the Chinese language also has free-standing pronouns and words to indicate location; the latter include the preposition ZAI and so-called locative nouns (e.g., MAO-CHUANG-SHANG, literally *cat-bed-top,* meaning *the cat is on the bed*).

Among the free-standing function words in Chinese, the most interesting and difficult are the noun classifiers. Under some circumstances, Chinese speakers have to specify the general class to which a noun belongs (human, animal, flat objects, round objects, and so on). These special classifier words are obligatory whenever a quantifier or a determiner is used; for example, instead of saying the equivalent of "SAN SHU" or *"three book,"* one must say "SAN BEN SHU," roughly equivalent to *"three piece book."* Like the English determiners "this" and "that," a Chinese numeral + classifier or a demonstrative + classifier can occur as a modifier before the noun (e.g., "I want this-piece book") or it can occur all alone as a proform that stands for the noun (e.g., "I want this-piece"). There are also many circumstances in which no classifier is needed at all—a fact that is true for all function words and grammatical particles in Chinese. Taken out of context, a sentence with no function words or particles of any kind can be perfectly grammatical; in other words, a complete sentence in Chinese can sound exactly like an English telegram!

These properties of Chinese grammar raise some fascinating questions about grammatical impairment in Chinese aphasics: since it is possible to produce sentences with no grammatical markers of any kind, how can we identify the symptom patterns that characterize Broca's and Wernicke's aphasia in other languages? At a superficial level, grammatical symptoms do take a qualitatively different form in Chinese. However, at a deeper

[2] Compound words made up of two syllables constitute the most frequent "word type" in modern Chinese. In fact, there appears to be a historical trend toward "regularizing" single-syllable words by adding a semantically empty or relatively neutral syllable like the diminutive ZI.

level of analysis, the symptoms displayed by Chinese aphasics are quite compatible with 100 years of research on aphasia in Indo-European languages, suggesting that the left hemisphere has a special role to play in the storage and retrieval of grammatical forms (Tzeng and Chen, 1988; Packard, 1990).

First, the patterns of grammatical sparing observed in Chinese patients are similar to those reported for Indo-European languages. For example, there is very little evidence for a disruption of word order principles in Chinese aphasics (fluent or nonfluent). Patients tend to produce sentences in the order "subject–verb–object," and most deviations from this standard order appear to be quite legal. Also, when function words and particles are used, they are placed exactly where they ought to be: prepositions, demonstratives, quantifiers, and classifiers are placed before nouns, and locative nouns are placed in the appropriate postnominal position (as in the above *cat bed-top* example).

Second, Chinese patients display selective impairments that are similar to those observed in their Indo-European counterparts. For example, Chinese Broca's aphasics display marked difficulty in the production of function words, particularly the difficult system of noun classifiers. As we noted earlier, a sentence with no function words at all may be perfectly legal in Chinese, depending on the discourse situation. Interestingly, however, the patients that we have studied so far do not "hide" behind this option. Like aphasic speakers of richly inflected languages, Chinese aphasics often err by substitution instead of omission. Chinese Broca's aphasics often omit the classifier, but we have also seen many instances in which Broca's aphasics err by substituting a more frequent classifier where a less frequent form was required. By contrast, the substitution errors of Wernicke's aphasics are much less systematic, suggesting that a more random selection process is at work. This contrasting pattern of substitution errors accords with the pattern observed in richly inflected languages for Broca's and Wernicke's aphasics, respectively (Bates, Friederici, & Wulfeck, 1987b; Grodzinsky, 1986; MacWhinney & Osmán-Sági, 1988; Menn & Obler, 1990; Miceli & Mazzucchi, 1990).

In addition to these observations on Chinese grammar, the internal structure of Chinese nouns and verbs offers us a special opportunity to investigate the processes associated with word retrieval and derivational morphology in fluent and nonfluent patients. In Chinese, there is usually a one-to-one relationship between syllables (a phonological unit) and morphemes (a minimal unit of meaning). This one-to-one relationship is also preserved in the written language, where each individual syllable/morpheme is represented by a single character (although some homophonous morphemes can be represented by several different characters, depending on the particular meaning that the speaker/writer has in mind). All Chinese words are made up of one or more of these monosyllabic

units.[2] Chinese content words (nouns, verbs, adjectives) fall into two basic categories: free-standing monosyllables (represented by one character) and compounds made up of two or more of these single-syllable morphemes (represented by two or more written characters). Most of the monosyllabic elements that make up compound words can also occur alone, although the meaning of an isolated element may alter when it is combined with others to form a compound. Within this lexical framework, the contrast between nouns and verbs can be marked in at least three ways.

First, the same monosyllabic word may serve either as a noun or as a verb, depending on the context. This is similar to the noun–verb homophony that is so often encountered in English, for example, the word COMB in "comb your hair" versus "get your comb."

Second, the difference between a noun and a verb reading of the same syllable may be signaled by tone. For example, the same root syllable LIANG is equivalent to the noun "volume" when spoken with a falling tone, but it is equivalent to the verb "to measure" when spoken with a rising tone. This form of tonal marking is no longer productive in Chinese (except for a productive use of tones to mark the diminutive in Cantonese—Wang, 1973). Note also that tonal contrasts are also used to mark distinctions within every form class, and the same word with the same tone may still carry several different meanings. For example, the syllable MA means "mother" with a high flat tone, "horse," "ant," or "agate" with a dipping tone, and "to scold" with a falling tone. In short, tonal marking is a lexical convention in Chinese; it should not be construed as a form of productive derivational morphology.

Third, the difference between nouns and verbs may be built up compositionally. In most cases, these compounds involved two or more syllables from the same form class. For example, a typical noun–noun compound would be HUO-CHE, literally *fire-car,* which means "train." Nouns may also be built up by a base noun plus a suffix. A typical example would be PAN-ZI, literally *dish-little,* meaning "dish" or "small plate." There are also cases in which a noun compound consists of a noun plus an adjective (similar to English words like "blackbird"); a typical example is DA-DOU, literally *big-bean,* meaning "soybean." Verbs can also be built up compositionally, with typical compounds consisting of two verbal elements, as in JIN-QU, literally *enter-go,* which means "to enter."

Most interesting for our purposes here are a set of compounds that mix noun and verb units. There are at least a few verb–noun compounds which have a nominal interpretation. An example is the word JIAO-TANG, the Chinese term for "church," which can be translated literally as *teach-house* or *enlightenment-house.* However, verb–noun compounds are used much more often in the verb role. For example, the word for *book* is SHU, the word for *look* is KAN, and the word for "read" is

KAN-SHU, literally *look-book*. This full V-N form is the one that must be used (complete with incorporated object) to translate the intransitive English sentence "I was up reading all night." Similarly, the English word "sing" in the sentence "I like to sing" would be translated as CHANG-GE, literally *sing-song*.

In the task that we will present to our patients here, where actions must be named out of context, 27 of 37 of our action-naming items fall into this verb–noun category. Although compounding is a highly productive process in Chinese (permitting a potentially infinite list of novel forms), the most common compounds (including the V-N compounds that we will focus on here) are usually listed as whole forms in conventional dictionaries. There is no a priori reason to believe that these common compounds are constructed on-line from their separate parts; although this is certainly a question that merits more detailed investigation, the intuitions of native speakers suggest instead that the most common compound forms are accessed as wholes. We will return to this point later.[1,2]

These features of Chinese yield some interesting predictions for the noun/verb problem in aphasia. First, because all nouns and verbs come in only one uninflected form, there is no reason to predict an association between morphological impairment and verb retrieval. If anything, the morphological account should predict that Chinese Broca's aphasics will experience a selective problem with nouns, because nouns are associated with the most difficult aspect of Chinese morphology, the system of free-standing classifiers. Second, because many compound verbs contain a nominal element, we may find a version of the noun/verb dissociation operating *within* individual lexical items. That is, Broca's aphasics may experience more difficulty producing the verbal portion of a compound, while Wernicke's aphasics have more difficulty with the nominal element. If the noun/verb dissociation applies to the internal structure of lexical items, then we must reject theories in which whole nouns and verbs are listed separately in the lexicon and stored separately in the brain (i.e., the theory implied by Miceli et al., 1988).

METHOD

Subjects. Subjects for this experiment were 6 Broca's aphasics, 7 Wernicke's aphasics, and 11 normal controls, matched roughly for age, sex, and social class. All were in-patients or out-patients at National Veterans Hospital or the Taiwan University Hospital in Taipei and all were native speakers of one or more dialects of Chinese (in particular, Mandarin and Taiwanese). Controls had intact speech, language, and cognitive abilities as measured by a clinical interview. Appendix 1 summarizes pertinent demographic and neurological features for each patient in the study.

Aphasic patients were selected according to criteria outlined by Bates and colleagues, within a larger cross-linguistic investigation of grammatical impairment in fluent and non-fluent aphasia (Bates and Wulfeck, 1989a). In this cross-linguistic project, investigators at each research site are asked to select Broca's and Wernicke's aphasics on behavioral grounds, according to their fit to a prototype that practitioners in that community have developed

for each clinical category. Specifically, they are asked to select Broca's aphasics who meet the following definition: **reduced fluency and phrase length and a tendency toward omission of function words—*relative to normals in that language*.** Similarly, they are asked to select Wernicke's aphasics who fit the following definition: **fluent or hyperfluent expressive language, with an apparently normal melodic line; this fluency should be accompanied by marked word-finding difficulties, semantic paraphasias, and perhaps paragrammatisms, together with clinical evidence of an impairment in language comprehension.** Hence patients are matched across languages only in the sense that they represent degrees of deviation from a prototype developed out of observed variation within each language community.

In the present study of Chinese, participating neurologists and speech pathologists based their diagnoses on a combination of clinical observations and (in many cases) results from a Chinese adaptation of the Boston Diagnostic Aphasia Examination (BDAE). Note, however, that we did not *require* our collaborators to use the BDAE or any other specific aphasia examination, because there is currently no reliable information concerning the comparability of aphasia scores across structurally distinct languages. In fact, we believe that use of a single instrument and a single set of cutoff points could lead to a serious *mismatch* over languages. For example, normal speakers of Italian have to produce roughly three times the number of morphemes produced by normal English speakers to describe the same set of pictured stimuli. Our cross-linguistic studies of sentence production in aphasic patients suggest that Italian Broca's aphasics also produce a larger number of morphemes than their English counterparts. By the same token, the Chinese language requires a much smaller set of morphological contrasts than we would usually obtain in a sample of English free speech. It is therefore not surprising that Chinese Broca's aphasics also produce fewer function words than their English counterparts. Any attempt to match patients from these three languages according to a single quantitative metric would be doomed to failure, until we have a large enough body of comparative data to permit assignment of percentile scores that preserve the *relative* contrasts between normals and target patient groups within each language community (see Bates & Wulfeck, 1989b, for a discussion). For these reasons, we restrict ourselves to the relatively conservative definitions of Broca's and Wernicke's aphasia provided above, as they are applied *within* each language participating in our cross-linguistic project. It is an empirical question whether or to what extent Chinese patients who meet these contrasting definitions will display the double dissociation between object and action naming that has been reported for other language groups.

In addition to these inclusionary criteria, patients were rejected from the study if they met any of the following exclusionary criteria:

1. History of multiple strokes.
2. Significant hearing and/or visual disabilities.
3. Severe gross motor disabilities.
4. Severe motor–speech involvement such that less than 50% of the subject's speech attempts are intelligible.
5. Evidence that the subject was neurologically or physically unstable and/or less than 3 months postonset.

Although CT scans were available for many of the patients who participated in this study, we did not use the neurological data to define the contrast between Broca's and Wernicke's aphasia. Instead, the CT information was used to exclude patients with evidence of multiple strokes or other forms of diffuse brain damage.

Finally, because we have elected a comparison of two different aphasic groups, we have clearly taken a stand in the current controversy over the relative merits of single-case studies versus group designs in neuropsychological research (Caramazza, 1986; Caplan, 1988). Our reasons for this decision are outlined in much more detail elsewhere (Bates, McDonald, MacWhinney, & Appelbaum, 1991); we will not repeat them here. However, it is worth noting that we are quite aware of the problems associated with group designs, especially

the problem of wide within-group variation in studies of brain-damaged patients. To deal with this problem here, we will present a combination of parametric statistics and individual data, clarifying how representative the group results are for the individual patients within each group.

Materials. Two sets of materials were used for the present study:

(1) An 85-item naming test consisting of 48 black and white line drawings of common objects and 37 line drawings of common activities.

(2) A 95-item word comprehension test with 48 items designed to elicit comprehension of object names and 47 designed to elicit comprehension of action names (after one culture-specific action comprehension item was eliminated—see above). Each object-choice item consisted of three depicted objects arranged vertically (with the position of the target randomized over items). One of the two foils was a semantic associate of the target (e.g., hand versus foot),[3] and the other was unrelated. Similarly, each action comprehension item consisted of the target plus one related and one unrelated action (also vertically arranged). The related actions were either antonyms (e.g., push versus pull) or associates (e.g., walk versus run). The comprehension targets included all the items represented in the naming task.

These materials were originally designed by Miceli et al. (1988) for use in Italian. The original Italian stimuli contained more object names than action names, because it proved somewhat more difficult to obtain consensus among normal speakers regarding the word that should be used to describe a pictured action. Because of these differences in the total number of action versus object items, we will follow the example set by Miceli et al. and use proportion scores to compare performance on these two lexical types. In addition, one action name item was dropped from the original comprehension set, because it was too culture-specific for use with Chinese subjects (normals or patients). All the remaining stimuli were translated into their Chinese equivalents (i.e., we assigned the Chinese word that best described the depicted object or action). The target noun and verb items in Chinese are listed in Appendix 2 in Pinyin orthography for the expected Chinese targets together with English translations. Although there is not a perfect balance for target type, these items included a representative range of single-syllable and compound forms.

In the original Italian stimuli, the target object and action name materials were balanced for length and frequency. There is of course no way of guaranteeing that this balance was preserved in translation to a radically different language. Unfortunately, we know of no equivalent frequency norms for spoken or written Chinese. However, as the reader can see from a cursory examination of Appendix 2, all the pictured items involve concepts that are relatively simple and concrete; these items are a familiar part of everyday life in Chinese as well as Italian culture. Although it would probably not be appropriate to attempt a direct statistical comparison between the Chinese and Italian results, we believe that the results should be comparable at a more abstract level.

Procedure. Because the respective comprehension and production tests involved many of the same items, the object- and action-naming tests were always administered before the comprehension task to avoid biasing patients toward the target words. In this and other respects, we followed the procedure outlined for Italian in Miceli et al. (1988). For many

[3] The Miceli et al. materials involve several different kinds of semantic associates, including members of the same semantic class (e.g., hand versus foot), items that stand in a part–whole relation to one another, and items involving opposites (e.g., enter versus exit). Although it might have been desirable to control more systematically for types of semantic distractors, we adopted the Miceli et al. stimuli in their current form to preserve comparability between studies. In any case, since we will conduct no analyses of comprehension error types (indeed, there were too few comprehension errors to permit such analyses), these variations in distractor type are of relatively little interest in the present study.

patients, the four test administrations had to be broken up into separate sessions; in all these cases, testing was completed within 3 weeks.

On the naming tasks, the stimulus pictures were presented one at a time, with no time limits for response. Patients were asked to "please say the name of the (object/action)," without further instructions about the nature of the response we had in mind. Object names and action names were administered in different blocks, but within blocks items were presented in a single, fixed random order. All responses were tape-recorded. The comprehension tasks were also divided into blocks, presented in a fixed random order. Patients were told to point to one of the three pictures on each page, according to the name presented on the tape recorder. Only one taped presentation was allowed for each comprehension item (i.e., there were no repetitions).

Responses on the naming task were scored as correct if they contained a plausible single-word description of the picture, whether or not the subject actually produced the target word intended by the experimenters. We gave credit for paraphrases or alternative lexicalizations of the pictured material, as long as the paraphrase was a member of the target form class (i.e., a noun on a noun item; a verb on a verb item). Incorrect responses were categorized as follows: **complete omissions** (no noun or verb provided), **complete substitutions** (an implausible lexicalization with no overlap to a target compound word), **partial omissions** (in which only one portion of a noun or verb compound was produced), and **partial substitutions** (applied to only one portion of a compound word). For those compounds that involve a combination of nominal and verbal elements, we also noted which component was involved in a partial omission or substitution. Because the number of errors within any category is relatively small, we have not broken the error types down further according to the type of substitution produced (a complete list of errors and error coding is available from the authors on request).

RESULTS AND DISCUSSION

Comprehension test. Because there was a small difference in the number of object (48) and action (47) items, all analyses were carried out on proportion correct.[4] Normal controls performed at ceiling on this com-

[4] There are two potential problems with the application of a mixed analysis of variance to proportion scores. First, it is often the case that proportion scores fail to meet the assumptions of normality required for analysis of variance. If the data do not meet assumptions of normality, they should be normalized through some kind of transformation. However, in the present case (with large and constant denominators—47 and 48 in the comprehension analysis, 48 and 37 in the naming analysis, and 27 in the V-N compound analysis), data for the two patient groups met assumptions of normality without further transformation. Second, proportion scores often fail to meet the assumption of independence of observations. For example, if we derive two proportion scores from a single passage of free speech (e.g., "percent nouns over all words produced" versus "percent verbs over all words produced"), it would be inappropriate to treat those two proportion scores as levels of a single independent variable, because variance on one measure is necessarily affected by variance on the other. However, our data do meet the independence assumption, because the two respective proportion scores in each analysis are based on separate items; in principle, performance on action words could vary independently from performance on object words. A different problem relates to the assumption that action and object items can indeed be treated as two levels of a common within-subjects factor, with a single dependent variable called "percent correct." To illustrate the point, it would certainly not be appropriate to treat percent correct on a block design task and percent correct on a vocabulary test as two levels of a single within-subjects factor called "cognitive abilities." Because block construc-

prehension test: 97.7% correct on object names, 97.7% correct on action names. This is comparable to the range reported by Miceli et al. (1988) for their normal controls. Because normals performed so close to ceiling, restrictions on homogeneity of variance required us to exclude normals from all statistical analyses involving patient groups.

We conducted an analysis of variance for the aphasic patients only in a mixed two (patient group) by two (object versus action item types) design, with Patient Group treated as a between-subjects variable and Item Type treated as a within-subjects variable. The main effect of patient group just missed significance ($F(1, 11) = 4.71, p < .06$), reflecting poorer performance across the board by Wernicke's aphasics (75.8%) compared with Broca's (87.2%). There were no other significant or near-significant effects.

These data appear to contradict Miceli et al. (1988). Based on individual patient data (without group statistics), these authors report a double dissociation between object and action naming in comprehension. Although overall error rates were also very low for their seven patients (4% error on object names with a range from 0 to 12%; 6.5% error on action names with a range from 0 to 16%), they point out that two nonfluent patients were more impaired in verb comprehension (16%) compared with nouns (0%), while one fluent patient (a Wernicke's aphasic—Miceli, personal communication) committed more errors on object names (12%) than action names (0%). In line with recommendations by Shallice (1988), we believe that such weak dissociations should not be used to establish strong theories of brain organization. We conclude that evidence for a noun–verb dissociation in word comprehension is still rather slim.

Naming test. Because the total number of object items (48) exceeded the total number of action items (37), all analyses were conducted using proportion scores.[4] Once again, normal controls performed close to ceiling: 98.5% correct on object naming (from 93.8 to 100%) and 98.5% correct on action naming (from 91.9 to 100%). Overall error rates were much higher for both patient groups compared with normal controls. Because of these large differences in within-group variance across cells,

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tion and vocabulary are two distinct processes under any coherent psychological theory, the two tasks should be treated as separate *dependent* variables, which could (at best) be entered into some kind of multivariate design to see whether they are affected by the same *independent* variables (e.g., age, patient group). However, we have sound theoretical grounds for assuming the existence of a single process called "lexical access"; under this assumption, it is appropriate to consider the action versus object inputs as two different levels of a single independent variable, just as one might examine eating behavior in rats in the presence of a red versus a green light. This is obviously a judgment call, but we feel comfortable making it; indeed, it would be difficult to test the predicted double dissociation between nouns and verbs if we could not make this assumption.

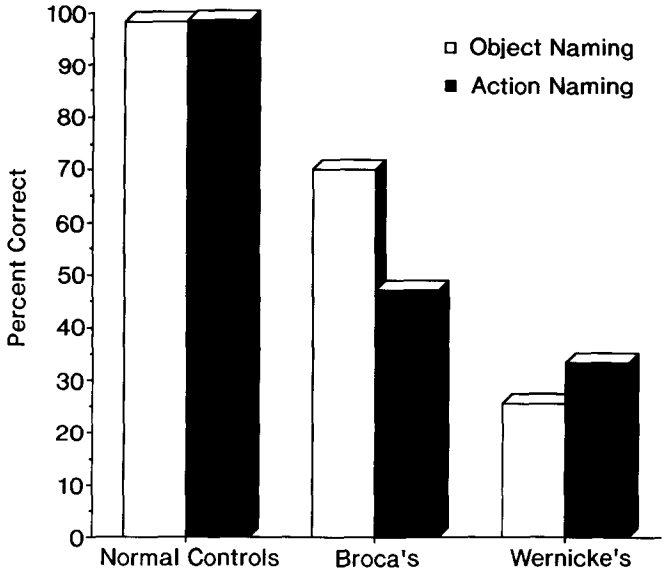

FIG. 1. Percent correct for Group by Object/Action Naming.

we excluded normal controls from further statistical analyses and restricted ourselves to a direct comparison of Broca's and Wernicke's aphasics.

We conducted a two (patient group) by two (object naming versus action naming) mixed analysis of variance on the proportion of items for which patients provided a correct name, with Patient Group treated as a between-subjects variable and Item Type treated as a within-subjects variable. This analysis yielded a significant interaction between patient group and item type ($F(1, 11) = 14.74$, $p < .01$) as illustrated in Fig. 1. There was also a significant main effect of patient group ($F(1, 11) = 10.01$, $p < .01$), reflecting worse performance overall by Wernicke's aphasics (29.5% with a range from 2.1 to 59.6%) compared with Broca's aphasics (58.6% with a range from 32.4 to 87.5%). There was no significant main effect for item type (i.e., no overall difference between object and action naming).

We explored the interaction in Fig. 1 with four planned t tests (using a one-tailed test of significance for each predicted effect). First, there was a large and reliable difference between Broca's and Wernicke's aphasics within the object-naming category ($t = 4.27$, $df = 11$, $p < .001$), favoring the Broca's aphasics (70% correct with a range from 43.8% to 87.5%) over Wernicke's aphasics (25.6% correct with a range from 2.1% to 47.9%). By contrast, the group difference missed significance for the action-naming items ($t = 1.43$, $df = 11$, $p < .09$). Furthermore, in contrast with the predicted "verb advantage" for Wernicke's aphasics, the direction

of difference on the action-naming items actually favors Broca's aphasics (47.1% correct with a range from 32.4 to 73%) over Wernicke's (33.4% with a range from 16.2 to 59.5%). In other words, these Chinese Wernicke's aphasics performed more poorly than Broca's aphasics *across the board.* However, the Broca advantage was much smaller on action-naming items, and correspondingly, larger on nominals, in line with the predicted double dissociation. This picture is completed by *t* tests comparing object and action names *within* each group. Broca's aphasics scored significantly better on object names (70%) compared with action names (47.1%; $t = 2.83$, $df = 5$, $p < .02$). At the individual level, this N > V pattern held for all six of the Broca patients. Conversely, Wernicke's aphasics performed significantly better on action-naming items (33.4%) than object naming items (25.6%; $t = 2.89$, $df = 6$, $p < .02$). At the individual level, this V > N pattern held for five of the seven Wernicke patients.

Substitution vs. omission. We were also interested in the kinds of naming errors displayed by Chinese Broca's and Wernicke's aphasics on the naming task. Toward this end, we first divided all errors into substitutions (full or partial) and omissions (full or partial) and created a single variable reflecting the percentage of each patient's errors in which some kind of substitution took place (i.e., "Substitutions/(Substitutions + Omissions)"). This variable was entered into a two (patient group) by two (object/action) mixed analysis of variance, with Patient Group as a between-subjects factor and Item Type as a within-subjects factor. We found a very large and significant effect of patient group ($F(1, 11) = 8.72$, $p < .02$) in the direction predicted from the literature on Broca's and Wernicke's aphasia (i.e., 79.7% substitutions vs. 20.3% omissions among the Wernicke's; 45.7% substitutions vs. 54.3% omissions among the Broca's). There was no main effect of item type ($F(1, 11) = .073$, $p < .80$). The group by item type interaction did not reach significance ($F(1, 11) = 3.90$, $p < .08$), but the trend is interesting. Specifically, Broca's were more likely to err by substitution (53.7%) than omission (46.3%) on object-naming items; at the same time, they were more likely to err by omission (62.2%) than substitution (37.8%) on action-naming item. We take this to mean that the Broca's aphasics *attempt lexicalization* more often on object naming than action naming. Wernicke's aphasics showed the opposite pattern: on action-naming items, their errors consisted of 84.9% substitutions and 15.1% omissions; on object-naming items, their errors included 74.5% substitutions and 26.5% omissions. This suggests that Wernicke's aphasics *attempt lexicalization* more often on action naming than object naming. (See Appendix 3.)

Verb–noun compounds. As noted earlier, Chinese verb–noun compounds provide a particularly interesting test of the verb–noun dissociations that have been reported to date for other languages. Such compounds constitute the most likely response for 27 of the 37 action-naming items

used in this experiment. It is difficult to carry out a detailed analysis of substitution vs. omission errors *within* these compounds for a variety of reasons (including the fact that some partial substitutions are technically well formed even though they sound rather odd to native speakers and the fact that it is often difficult to distinguish between partial omissions and whole-word substitutions in many cases). However, there is one robust form of within-word analysis that was easy to conduct on the V-N compounds: Whether the patient was successful or not, did the patient *lexicalize* the respective verb and noun elements of a compound word (i.e., did the patient produce a syllable from the appropriate form class?) In this analysis, credit was given for lexicalizing the noun element in a V-N compound if the patient produced (1) the target form (e.g., "FAN" *rice/meal* in "CHI-FAN" *eat-rice/meal*), (2) a more specific form (e.g., "CHI-MIAN" *eat-noodles,* or (3) an incorrect or overly vague nominal form (e.g., "CHI-DONGXI" *eat-thing*). The same criterion applied for lexicalization of the verb element in a target V-N compound (i.e., the patient received credit for producing the typical or generic form, an overly specific form, an incorrect or overly general form of the verb element). Patients did *not* receive credit for lexicalization of the target element if (1) they omitted that element altogether (e.g., "CHI" *eat*) or (2) they produced an element from another form class in the respective verb or noun position (e.g., "CHI-WAN" *eat-finish* or "CHI-DIAO" *eat-up*). Hence this analysis focusses on the degree to which patients were sensitive to the target V-N structure of these compound words, whether or not they were completely successful in filling out that target structure.

The lexicalization analysis worked quite well for the normal controls. On average, normals produced the verb element 99.4% of the time and the noun element 96.6% of the time on these 27 V-N items. Although this difference in lexicalization rates for V vs. N elements is very small, it did reach significance by a two-tailed t test ($t = 3.12$, $df = 10$, $p < .02$). Hence we may infer that the V element is viewed as "more obligatory" by normal Chinese speakers in their description of the V-N action-naming items. In fact, among the six normals who produced any V- or N-element omissions on V-N compounds, all six were more likely to omit the noun component (see Appendix 4 for individual patient and normal control data on the V-N analyses).

Because normal performance was so close to ceiling, controls were excluded from group comparisons involving the two groups of aphasic patients. Using "percent lexicalization" as the dependent variable, we conducted a two (Broca's vs. Wernicke's) by two (V element vs. N element) analysis of variance. Patient group served as a between-subjects factor, and the V/N contrast served as a within-subjects factor. The main effect of group failed to reach significance ($F(1, 11) = 3.01$, $p < .12$), although there was a trend toward more lexicalization overall by the

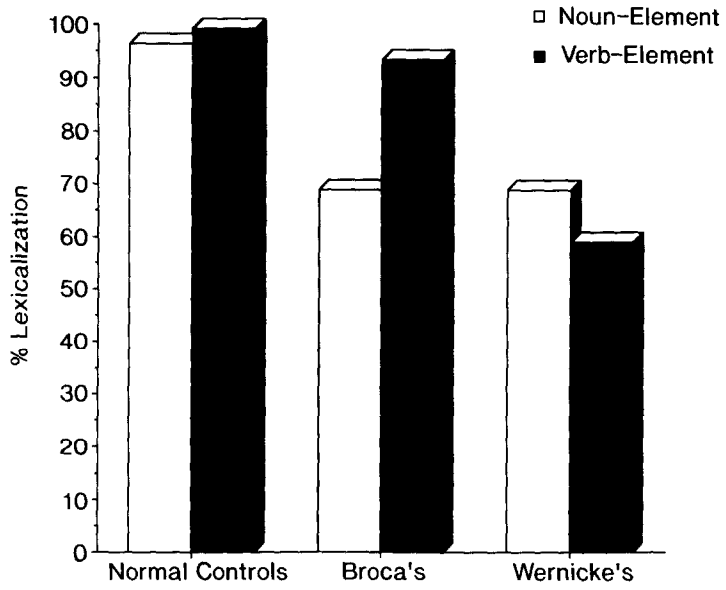

FIG. 2. Percent lexicalization of the Verb vs. Noun element in V–N compounds.

Broca's aphasics (64%) than the Wernicke's (78.6%). This trend reflects the fact that Broca's aphasics are more likely to err by omission (see substitution vs. omission analyses above). The main effect of V vs. N lexicalization also failed to reach significance ($F(1, 11) = 3.153$, $p < .11$); this nonsignificant trend was in the same direction reported above for normals, i.e., higher rates of lexicalization for the V element (77.6%) than the N element (66.2%). Most important for our purposes here, there was a significant interaction between patient group and the V/N contrast ($F(1, 11) = 9.185$, $p < .02$) as illustrated in Fig. 2.

We had predicted a verb-element advantage for Wernicke's aphasics and a corresponding noun-element advantage for Broca's aphasics in production of compound words. To test these predictions, we carried out four planned one-tailed t tests on the results illustrated in Fig. 2. First, we looked for the predicted between-group differences within the respective noun vs. verb component of V-N compounds. On the verb component, there was a significant difference favoring the Wernicke's aphasics (93.4%) over the Broca's (59.2%; $t = 3.84$, $df = 11$, $p < .002$). On the noun component, the group difference failed to reach significance (63.9% N lexicalization for the Wernicke's aphasics compared with 68.8% for the Broca's; $t = .41$, $df = 11$, $p < .35$). Second, we looked for the predicted noun vs. verb-element difference within the two respective groups. Among the Wernicke's aphasics, some version of the verb element in V-N compounds was produced 93.4% of the time (with a range from 78 to 100%)

compared with a lexicalization rate of only 63.9% for the noun element (with a range from 15 to 85%). This "verb-element advantage" reached significance by a one-tailed test ($t = 4.56$, $df = 6$, $p < .003$). The difference held up at an individual level for all seven of the Wernicke's patients (see Appendix 4). By contrast, Broca's aphasics showed no difference in lexicalization rates for the noun element (68.8% with a range from 48 to 96%) compared with the verb element (59.2% with a range from 29 to 89%; $t = .82$, $df = 5$, $p < .23$, one-tailed). At the individual patient level, a N > V-element pattern was displayed by only two of the Broca's aphasics (Appendix 4). It may be the case that Broca's aphasics are (despite their action-naming problem) still sensitive to the fact that V elements are "more obligatory" in V-N compounds (i.e., the pattern displayed by Chinese normals).

Because the V-N difference failed to reach significance within the Broca group, and because there was no significant patient group difference within the N category, the double dissociation illustrated in Fig. 2 cannot be regarded as a full cross-over interaction of the sort required for the claim that the two functions are strongly dissociated (Jones, 1983; Shallice, 1988). However, when we compare the interaction obtained on this analysis of compound verbs (Fig. 2) with the cross-over interaction obtained in a full comparison of object vs. action naming (Fig. 1), there seems to be fairly good support for the view that Broca's and Wernicke's aphasics are suffering from complementary deficits: Broca's have a greater advantage (or less of a disadvantage) on nouns, and Wernicke's have a greater advantage (or less of a disadvantage) on verbs.

Verb–verb substitutions. Additional support for a verb advantage in Wernicke's aphasia comes from an unexpected effect that showed up in our analysis of the V-N compound data. We noticed that our Wernicke's aphasics often produced a two-syllable V-V structure on V-N targets (e.g., SHANG-QU *ascend-go* instead of SHANG-LOU-TI *ascend-floor-stair*). This occurred 19% of the time on the 27 V-N items (with a range from 7 to 37%). By comparison, Broca's aphasics produced V-V structures on V-N items only 5.7% of the time (with a range from 0 to 11%). This difference reached significance by a simple one-way analysis of variance ($F(1, 11) = 7.75$, $p < .02$). We suggest that Wernicke's aphasics are still quite sensitive to the statistical predominance of two-syllable words in Chinese.[2] Hence, if they cannot find a noun element to fill the second position in a V-N compound, they substitute a V-V structure instead. In fact, Wernicke's aphasics produced some kind of multimorpheme structure on V-N items 85.6% of the time (with a range from 59 to 100%—see Appendix 4). Note, however, that Broca's aphasics also retain some knowledge of or sensitivity to the frequency of two-morpheme words in Chinese. Overall, 55.5% of their descriptions on V-N items were multimorpheme compounds of some kind (with a range from 30 to 89%—see

Appendix 4). The role of high-frequency two-syllable "templates" in speech production by Chinese aphasics deserves further consideration.

CONCLUSION

In contrast with our findings for word comprehension, our word production results suggest that there is a double dissociation between object and action naming in Chinese Broca's and Wernicke's aphasics. Even though there are no differences between Chinese nouns and verbs in the amount of inflectional morphology associated with root words, Chinese Broca's aphasics demonstrate a selective deficit in action naming (and/or a selective sparing of object naming) that we do not see in Chinese Wernicke's. This finding permits us to reject a morphological account of the main-verb problem in Broca's aphasia.

For reasons that we outlined earlier, a syntactic account of this noun–verb dissociation can also be rejected. Nonfluent Chinese patients who experience verb retrieval problems are nevertheless able to order major sentence constituents correctly, whether or not a verb is produced (Tzeng and Chen, 1988). If Broca's aphasics are able to plan sentence frames around the troublesome verb slot, then we cannot ascribe their action-naming problem to deficits at this syntactic level. The existence of partial errors on the verbal element *within* a compound verb also weakens the credibility of a syntactic account. In view of these findings, we must fall back on either a lexical or a semantic–conceptual explanation for the observed group difference in action and object naming.

Miceli et al. (1984, 1988) have criticized the semantic–conceptual account, because patients with verb retrieval problems are often able to produce a nominalization that captures the same basic event structure. Presumably, this means that agrammatic patients control the semantic features that underlie action naming. For this reason, Miceli et al. prefer an account of the noun–verb dissociation in aphasia that is restricted entirely to an autonomous and purely linguistic lexical component. However, the results that we have obtained for Chinese compounds place strong constraints on any lexical account. Faced with pictured actions that normal Chinese speakers describe with a verb–noun compound, Wernicke's aphasics show a selective advantage (and Broca's aphasics show a selective disadvantage) in production of the verb segment. Miceli et al. have suggested that nouns and verbs are listed separately in the lexicon; presumably, the differential disruption of nouns and verbs in different forms of aphasia reflects the spatial organization of those brain regions that are responsible for lexical processing. On this account, it is difficult to explain patient group differences at the *sublexical* level, i.e., a double dissociation that penetrates the internal structure of compound words.

One alternative may be to assume that the Chinese lexicon is organized along somewhat different lines: Monosyllabic roots are listed in the lexicon

according to form class, but *all* compound words are constructed on-line by some kind of derivational process. The noun–verb dissociation might therefore apply to monosyllables with a noun or verb meaning before the needed compounds are composed. It might be possible to develop on-line procedures to test this hypothesis with Chinese normals and aphasics along the lines proposed by Caramazza, Laudanna, and Romani (1988) for Italian or by Forster (1978) and others who have explored on-line processing of English derivational morphology. At this point, however, a single-syllable view of the Chinese lexicon is quite speculative and runs counter to native-speaker intuitions that the most frequent compound forms are accessed as a whole.

Another alternative would be to assume that the Chinese lexicon is quite heterogeneous, with monosyllabic morphemes and high-frequency compound forms stored in a common format. However, the phonological and semantic representations that make up individual lexical items may take a highly distributed form with a rich internal structure (Rumelhart & McClelland, 1986; Seidenberg, McClelland, & Patterson, 1987). If this approach to lexical organization is correct, then we may be able to preserve a semantic–conceptual account of the noun–verb problem: Specifically, patients with anterior damage may experience selective difficulty with the actional *components* of a simple or complex word. They are able to produce nominalized forms because the target action meaning is *partially* activated, i.e., active enough to "fill out" in a nominalized form with the assistance of those (intact) brain regions that contribute more heavily to the representations that underlie object names.

A different (but related) alternative could be offered to salvage the autonomous lexical account proposed by Miceli et al. Once again, let us assume a lexicon in which individual items are represented in a spatially distributed form across the brain. In this case, however, let us assume that these lexical representations consist of abstract symbols with little or no relationship to semantic/conceptual content. Within such an autonomous but distributed lexicon, it is possible that the sublexical symbols associated with a noun usage are located in a different part of the brain than the sublexical symbols associated with the verb role. This would constitute a fractal variant of the autonomous lexical proposal offered by Miceli et al., i.e., a variant applied to sublexical rather than lexical representations. However, in our view this autonomous sublexical model suffers from the same problem we find in the original proposal—that is, there is no obvious neurological reason for such a representational system (e.g., why should the sublexical symbols associated with verbs be mediated to a greater degree by anterior cortex?). For this reason, we are more attracted to the semantic–conceptual account. Although this is still a matter of speculation, there is at least some a priori credibility to the notion that motor cortex participates in action meanings, while sensory

cortex participates to a greater extent in object meanings. This notion maps, in turn, onto the sites of brain damage that are most common in Broca's and Wernicke's aphasia, respectively.

We cannot decide among these alternatives at this time, but it is hopefully clear why a cross-linguistic approach can make important contributions to a classic problem in neurolinguistics. The Chinese language offers a different perspective on the noun–verb problem, permitting us to narrow down the range of plausible explanations for this puzzling phenomenon. It would be very useful to extend the analyses presented here to other kinds of compound words, including (1) variations in the number of morphemes in a word target (one, two, or more), (2) variations in the type of internal elements that make up compound words (noun, verb, adjective, affix), (3) variations in the order of elements within a compound (e.g., V-N vs. N-V) and/or variations in their modifier–head relations, (4) variations in the form class of the compound as a whole, and (5) systematic variations of whole-word frequency, the frequency of individual compounds within a compound word, and the frequency of each compound type or "template." Studies of this sort are currently underway in our laboratories.

APPENDIX 1

Subject Information

ID No.	Age	Sex	Handedness	Etiology	Diagnosis	Lesion
Broca						
13	60	F	R	CVA FH	BDAE	CT N/A
14	58	M	R	Hemrr LH	BDAE	F-P
31	30	M	R	Trauma LH	BDAE	F-T
32	83	M	R	CVA LH	clin. obs.	CT N/A
55	55	M	R	Hemrr LH	BDAE	CT not available
58	38	M	R	CVA LH	BDAE	CT not available
Wernicke						
10	60	M	R	CVA LH	BDAE	T-P
27	70	F	R	CVA LH	BDAE	F-T-P
29	50	M	R	Hemrr LH	BDAE	Thalamus
33	59	M	R	CVA LH	clin. obs.	P
53	64	M	R	CVA LH	BDAE	T-P
54	54	F	R	Hemrr LH	BDAE	P
56	67	M	R	CVA LH	BDAE	CT N/A
Control						
06	54	F	R			
36	53	F	R			
38	68	M	R			
43	27	F	R			
44	31	M	R			
48	56	M	R			
63	61	F	R			
65	38	M	R			
67	77	M	R			
68	34	M	R			
69	66	M	R			

Note. CVA, cerebrovascular accident; LH, left hemisphere; Hemrr, hemorrhage; T, temporal lobe; F, frontal lobe; P, parietal lobe; BDAE, diagnosis based on a Chinese adaptation of the Boston Diagnostic Aphasia Examination; clin. obs., diagnosis based on clinical observation only.

APPENDIX 2

Object naming			
1. N-Afx	xie-zi	'shoe-afx.	shoe
2. N-Afx	long-zi	'cage-afx.'	cage
3. N	xiang	'elephant'	elephant
4. N-N	pi-bao	'leather-bag'	leather bag
5. N	hai	'sea'	sea
6. N-N	deng-pao	'lamp-bulb'	lightbulb
7. N-Afx.	che-zi	'car-afx.'	car
8. N-N	la-zhu	'wax-candle'	candle
9. N-N	jian-bang	'shoulder-shoulder'	shoulder
10. N-N	lou-fang	'building-house'	house
11. N-N-Afx.	nan-hai-zi	'male-child-afx.'	boy
12. A-N	hong-luobo	'red tuber'	carrot
13. N-N	huo-che	'fire-car'	train
14. N-Afx.	ping-zi	'bottle-afx.'	bottle
15. N-N-N	ma-ling-shu	'horse-bell-root'	potato
16. N-N	yu-gang	'bath-tub'	bathtub
17. N	shou	'hand'	hand
18. N-N	hu-die	'butterfly-butterfly'	butterfly
19. N-N	li-wu;	'ritual-thing'	gift
	bao-guo	'wrap up-wrap up'	parcel
20. N	jiao	'foot'	foot
21. N-N-Afx.	nu-hai-zi	'female-child-afx.'	girl
22. N	shui	'water'	water
23. N	hua	'flower'	flower
24. V-N	jiao-tang	'enlighten-house'	church
25. N-Afx.	ye-zi	'leaf-afx.'	leaf
26. N-Afx.	xue-zi	'boot-afx.'	boot
27. N-N	xing-xing	'star-star'	star
28. A-N	tai-yang	'highest-light'	sun
29. N-N-N	tie-si-wang	'steel-thread-net'	barbed wire
30. N	laba	'trumpet'	trumpet
31. N-N	fan-qie	'foreigner-eggplant'	tomato
32. N-N	gang-qin	'steel- musical instrument'	piano
33. N-Afx.	pan-zi	'dish-afx.'	dish
34. N-Afx.	bei-zi	'cup-afx.'	cup
35. N-N	yan-jing	'eye-pupil'	eye
36. N-N	shou-bi	'hand-arm'	arm
37. N-N	ping-guo	'water plant-fruit'	apple
38. N	huo	'fire'	fire
39. N-N	guo-wang	'country-king'	king
40. N-N	er-duo	'ear- flower shape'	ear
41. A-N	hei-ban	'black-board'	blackboard
42. N	qiao	'bridge'	bridge
43. N-N	tu-hua	'picture-picture'	picture
44. N-Afx.	ti-zi	'ladder-afx.'	ladder
45. N	shu	'tree'	tree
46. N-N	di-tan	'ground-carpet'	carpet
47. N	mian	'noodle'	noodle
48. N	xin	'letter'	letter

APPENDIX 2—*Continued*

Action naming			
1. VV	zhi-zhi	'point-point'	to point
2. VN	xiezi*	'write-character'	to write
3. VN	song-hua	'send-flower'	to give flower
4. VN	diao-yu	'hook-fish'	to fish
5. VN	hua-hua	'paint-painting'	to draw picture
6. VN	cui-kou-shao*	'blow-mouth-whistle'	to whistle
7. VV	gui-xia	'kneel-descend'	to kneel down
8. VN	la-che	'pull-cart'	to pull cart
9. VV	jin-qu	'enter-go'	to enter
10. VN	xia lou-ti	'descend floor-stair'	to go downstairs
11. VV	cha-diao	'erase-fall'	to erase-complete
12. VN	shu-tou	'comb-head'	to comb hair
13. VN	chi-fan	'eat-rice'	to eat (rice)
14. VN	shang lou-ti	'ascend floor-stair'	to go upstairs
15. VN	cui-la-zhu	'blow-wax-candle'	to blow candle
16. VN	xie-zi*	'write-character'	to write
17. VN	ni-shui	'drown-water'	to drown
18. V	ku	'cry'	to cry
19. VN	he-shui	'drink-water'	to drink
20. VN	ju-gong	'bow-bow'	to bow
21. VN	tui-che	'push-cart'	to push cart
22. VN	pai-shou	'clap-hand'	to clap
23. VN	cui kou-shao*	'blow-mouth-whistle'	to whistle
24. V	fei	'fly'	to fly
25. VV	song-xing	'send-go'	to see off
26. VV	die-dao	'fall-fall'	to fall
27. VN	dian-la-zhu	'point-wax-candle'	to light candle
28. VN	feng-yi-fu	'sew-clothes'	to sew clothes
29. VN	hua-tu	'paint-picture'	to draw picture
30. VN	an-men-ling	'push-door-bell'	to ring
31. VV	diao-ke	'sculpture-sculpture'	to sculpture
32. VN	jian-zhi	'cut-paper'	to cut paper
33. VN	qiao-men	'knock-door'	to knock on door
34. VN	pao-bu	'run-step'	to run
35. V	she	'shoot'	to shoot
36. VN	you-yong	'swim-swim'	to swim
37. VN	chang-ge	'sing-song'	to sing

* Two pairs of items in the action-naming task take the same verb as their "best response" in Chinese, even though they were encoded with separate verbs in the original Italian version of the test.

APPENDIX 3

	Action naming					Object naming				
	% Total correct	% Total errors				% Total correct	% Total errors			
		Omission		Substitution			Omission		Substitution	
		Partial	Total	Partial	Total		Partial	Total	Partial	Total
Broca										
C#13	32	49	5	3	11	88	2	0	4	6
C#14	61	3	8	3	25	70	0	17.5	0	12.5
C#31	73	5	5	3	14	83	0	0	2	15
C#32	43	16	24	11	6	83	2	11	2	2
C#55	35	5	41	11	8	44	0	37	4	15
C#58	38	13	38	3	8	53	4	39	2	2
Wernicke										
C#10	54	0	3	21	22	48	8	0	13	31
C#27	19	3	13	11	54	2	2	33	0	63
C#29	24	5	3	8	60	13	4	4	10	69
C#33	59	5	3	22	11	46	2	2	13	37
C#53	16	5	0	8	71	19	4	40	4	33
C#54	42	6	19	8	25	47	7	17	4	25
C#56	19	0	0	19	62	10	2	4	7	77
Control										
C#06	100	0	0	0	0	100	0	0	0	0
C#36	100	0	0	0	0	100	0	0	0	0
C#38	97	0	0	0	3	94	4	0	0	2
C#43	100	0	0	0	0	100	0	0	0	0
C#44	97	0	0	0	3	100	0	0	0	0
C#48	100	0	0	0	0	98	0	0	2	0
C#63	100	0	0	0	0	98	0	2	0	0
C#65	100	0	0	0	0	100	0	0	0	0
C#67	91	3	3	0	3	100	0	0	0	0
C#68	100	0	0	0	0	96	2	0	0	2
C#69	97	0	0	0	3	98	0	0	0	2

APPENDIX 4

Action Naming–Verb/Noun Compounds

	% Verb elements produced	% Noun elements produced	% Two-verb elements produced	% Two-morpheme elements produced
Broca				
#13	29	96	0	30
#14	81	73	8	81
#31	89	85	11	89
#32	48	59	0	33
#55	56	48	11	52
#58	52	52	4	48
Wernicke				
#10	96	85	7	96
#27	78	15	37	59
#29	96	67	22	89
#33	96	78	7	85
#53	100	63	26	89
#54	88	58	19	81
#56	100	81	15	100
Controls				
#06	100	100	0	100
#36	100	100	0	100
#38	100	93	7	100
#43	100	100	0	100
#44	100	96	4	100
#48	100	100	0	100
#63	100	96	4	100
#65	100	96	4	100
#67	93	85	7	93
#68	100	96	4	100
#69	100	100	0	100

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