Compounding in Aphasia: A Cross-Linguistic Review

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Abstract

Psycholinguistic data from patients with aphasia, a family of language disorders caused by brain damage, may help determine how compound words are represented in the lexicon. The errors produced by such patients may reflect whole-word storage or rule-based composition of compounds. Experimental investigations of compounding may also shed light on the deficits caused by aphasia. The noun-verb double dissociation observed in certain subtypes of aphasia may apply to the noun and verb components of compound words at the sublexical level as well. Studies of aphasic speakers of English, German, Italian, Finnish, Japanese, and Chinese are reviewed to assess whether processing of compound words differs among speakers of languages that differ in terms of morphological structure and orthography. There is evidence from all six languages for both componential and whole-word storage of compounds, suggesting dual representation of such words in the lexicon. While the possibility of a sublexical double dissociation in aphasia is supported, data from more languages is needed to confirm that the phenomenon is present in languages with different types of compounds. A critique of the experimental methods currently used to study compounding in aphasia is provided, and directions for further research are discussed.[*]

Introduction

A matter of continuing debate in linguistics is how much of our knowledge of language is memorized as opposed to rule-based. Evidence from psychology tells us that linguistic information must consist of some combination of the two types. Knowledge of language cannot be entirely memorized because humans are capable of producing and comprehending unusual sentences that they likely have never heard before. However, a minimum level of memorization is necessary to learn the basic forms that can be manipulated by rules. In morphology, the debate focuses on which word forms are memorized and stored whole in the mental lexicon and which are constructed through

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processing.

The status of compound words in the lexicon is unclear because while there are regular rules for forming compounds, their meanings are not entirely predictable. A compound like *apron string* must refer to a kind of string, rather than a kind of apron, because *string* is the head of the compound. If the order of the constituents is switched, the new compound *string apron* must instead refer to a kind of apron. However, within this constraint, almost any semantic relation between *apron* and *string* is possible (Selkirk 1982: 22-23).

Consider the novel compound "applehammer." Because English compounds are overwhelmingly right-headed, it is a reasonable assumption that "hammer" is the head of the compound, and that an applehammer is a type of hammer rather than a type of apple. Assigning a meaning to "applehammer" is more difficult because the meaning of a compound word is not fully predictable from the meanings of its constituents. Though "applehammer" is a relatively semantically transparent compound—its meaning is mostly derivable from the meanings of its constituent morphemes—it is still to some degree semantically opaque. An applehammer could be a hammer made from an apple, or shaped like an apple, or designed for smashing an apple. Since "applehammer" is constructed by predictable rules, and speakers of English are aware of these rules, it is possible that speakers would process this word as a combination of the lexical entries "apple" and "hammer". It is also possible that a separate lexical entry for "applehammer" would be created, since the meaning of "applehammer" cannot be entirely deduced by examining its component morphemes, Whole-word storage of compounds is even more plausible when one considers words like *moonshine* (a type of liquor), *faceplant* (a fall in

which the victim lands on his or her face), and *sausagefest* (a situation or event with many more males than females). The meanings of these semantically opaque compounds cannot be inferred from the meanings of their constituent morphemes.

Studies of patients with aphasia, a family of language disorders caused by brain damage, may help determine the status of compound words in the lexicon. In aphasia, deficits are seen in some aspects of language, while other features are preserved. These selective patterns of deficits can help address the issue of how compound words are produced and stored in the lexicon. In their review of the literature on morphology and aphasia, Badecker and Caramazza (1998) cite a case study of CSS, an English-speaking aphasic, who produced compound neologisms when unable to produce the target compound. Errors in the production of compounds at the level of the compound's constituents, rather than at the level of the whole word, would suggest that compounds are constructed rather than stored whole in the lexicon. Such errors might include substituting an inaccessible compound with another compound (e.g., "birdbath" to describe a birdhouse) or omitting one of the constituent morphemes (saying "dog" to describe a doghouse).

Although there are multiple classification schemes for organizing the various symptoms of aphasia into subtypes, the most common system used in the research on compounding in aphasia is the neoassociationist system. Of the neoassociationist subtypes, the two most commonly cited in this area are Broca's aphasia and Wernicke's aphasia. Broca's patients display the following linguistic deficits: *apraxia*, a difficulty in articulation, *agrammatism*, the tendency to avoid complicated syntax and to omit function words and inflectional markings, and *anomia*, a difficulty in finding the words

one wants to use. (In addition, there is an aphasia subtype called anomic aphasia, in which patients display anomia without the other deficits associated with Broca's aphasia.) While the speech of Broca's aphasics is labored and halting, it is somewhat intelligible, and comprehension of speech is preserved (Basso 2003).

In Wernicke's aphasia, the reverse is true: although speech is fluent, it is essentially meaningless, and comprehension is often impaired. Patients with Wernicke's aphasia display *paraphasia*, or incorrect word substitution, and may replace meaningful words with vague words like "thing." Other subtypes of aphasia in this system are transcortical aphasia, in which comprehension and production are impaired while repetition is preserved, and global aphasia, in which language is impaired in all modalities and at all levels of linguistic structure (Basso 2003).

Comparisons of the performance of Broca's aphasics and Wernicke's aphasics in comprehending and producing compound words may contribute to the understanding of the lexical status of compound words. A major difference between the two aphasias is known as the double dissociation: Broca's aphasics show relatively more impairment with verbs, while Wernicke's aphasics have more difficulty with nouns. Compounds can be constructed from words from different syntactic categories, such as *greenhouse* (n., adj. *green* + n. *house*) and *moonwalk* (v., n. *moon* + v. *walk*). If compounds are stored whole in the lexicon, English-speaking Broca's aphasics should have more difficulty with verbal compounds like *moonwalk* and Wernicke's aphasics should have more difficulty with nominal compounds like *greenhouse*. However, if compounds are instead constructed from their component morphemes, one would expect the double dissociation to apply at the sublexical level, meaning Broca's and Wernicke's aphasics would produce

errors on compound words' verbal and nominal components respectively (Bates, Chen, Tzeng, Li, & Opie 1991).

One caveat of applying the results of studies of aphasic patients to linguistic theories is that cross-linguistic differences cannot be ignored. Bates, Devescovi, and Wulfeck (2001) use aphasia as an example of the importance of comparing cross-linguistic data in psycholinguistic research. Since the 1960's, agrammatism has been associated with Broca's aphasia. However, most of the research on aphasia was done on speakers of English, a language with relatively little grammatical marking. Since omission errors are more salient than substitution errors, researchers incorrectly assumed that Broca's patients made more omission errors than other patient groups. Research that included speakers of other languages and other patient groups revealed that agrammatism could be found across aphasia types. Therefore, in order to draw conclusions about the status of compounding in aphasia and, by extension, in the lexicon of normal speakers, data from multiple languages must be considered.

In investigating a morphological phenomenon, it is important to take into account data from languages with diverse morphological structures. Languages differ in the headedness of their compounds (*birdhouse* is right-headed, but *rundown* has no head at all) and in the syntactic categories of words that can be combined to form compounds. Some languages allow inflection at the level of a compound's constituents, so that a compound like *people mover* is singular even though *people* is plural. Orthographic representation of compound words is also variable. While languages with logographic writing systems, where symbols typically map onto morphemes, represent each component of a compound with its own character, alphabetic writing systems, where

symbols map onto phonemes, may visually present compounds as a single word or as two separate ones.[1] There are also variations in the prevalence of morphological marking across languages. Some languages have a gender system (a variety of noun classes), and the gender of a compound noun may or may not be predictable from the genders of its components. Although researchers have conducted psycholinguistic studies of aphasia that have examined speakers of diverse languages, the status of compounding in aphasia across languages remains unresolved.

Compounding in English

Compared to other languages, English has a moderate number of morphological rules. Pronouns are the only nouns marked for case, and there is no gender system. However, derivation and compounding are both highly productive. Compounds are typically right headed, so that the rightmost element of the compound determines the syntactic category of the whole word, and internal inflection, though possible, is rare. English has an alphabetic script, but it also contains logographic elements; although *break* has a different pronunciation when it is a constituent in the compound word *breakfast*, the original spelling is preserved. In English, stress patterns differentiate between compounds and phrases: consider the difference in stress patterns between *blackboard* (a flat surface for writing on with chalk, usually black or green) and *black board* (a board that is black.)

Contrastive stress in English is not a phenomenon unique to compounding. Avrutin, Lubarsky, and Greene (1999) investigated the role of contrastive stress in Broca's aphasics' comprehension of reference. To control for the discourse effects present in the

[1] There is also a third category consisting of syllabic writing systems, in which symbols map onto syllables or morae. Unfortunately, there is presently no research on compounding by aphasic users of a writing system that represents compounds in terms of their syllables.

reference experiment, the authors also investigated subjects' use of contrastive stress in distinguishing between adjective-noun compound nouns (CNs) and adjective-modified nouns (AMNs[2]) outside of any discourse context. Broca's aphasics and normal controls listened to 40 sentences of the form "Show me an X," where X was an adjective-noun pair. Ten of these pairs had CN stress ("hotdog"), ten had AMN stress ("hot dog"), and twenty were adjective-noun pairs unaffected by contrastive stress patterns ("brown hat") or unmodified nouns ("orange"). Subjects were then presented with three pictures—the target picture, the picture corresponding to the contrastive stress minimal pair, and an unrelated picture—and were asked to select the picture corresponding to the adjective-noun pair they heard. The researchers found that the Broca's subjects performed better than chance at identifying the correct picture in CN stress sentences but not in AMN stress sentences. Unfortunately, since the compound study was only secondary to Avrutin et al.'s study of contrastive stress in reference, its outcome is discussed only briefly. The authors describe the Broca's aphasics' superior performance on CN stress sentences as surprising but offer no explanation for the result. One interpretation is that the Broca's aphasics showed a bias for interpreting adjective-noun pairs as compounds because a word pair like "hot dog" more frequently refers to a type of food and not a type of animal. Under this interpretation, stress had no influence on how the aphasic subjects interpreted adjective-noun pairs, but the issue of whether the compounds were stored whole or in parts is not resolved. Another possibility is that subjects stored the compounds as whole words, and thus the aphasic subjects found processing these unmodified nouns to be less complex than processing NPs that contained a modifying

[2] The authors use the term AP to describe these adjective-modified nouns, but since AP is already used in syntax for adjective phrases, their abbreviation is confusing.

AP.

Lambon Ralph, Sage, and Roberts (2000) investigated word-finding impairment in two patients with anomic aphasia, one of whom displayed tip-of-the-tongue tendencies. In a ToT state, which can temporarily affect normal speakers, a person is unable to recall a specific word yet is able to describe some properties of the word, such as component phonemes, length, and meaning. If an aphasic subject experiencing ToT is able to correctly identify whether or not a word is a compound, this ability would reflect awareness of the internal structure of compounds; making componential storage of such words plausible. In a picture-naming task, both subjects in this study performed significantly better than chance at deciding whether the target words were compounds or not, even though their anomia often prevented them from actually naming the target words. While this result clearly indicates awareness of compound structure and provides evidence for componential storage, the authors do not provide a list of the compounds used, so it is impossible to analyze the results further to see if there was a difference between subjects' performance on semantically transparent and opaque compounds or on compound nouns with components from different syntactic categories.

The mixed aphasic patient in Libben's (1993) case study demonstrated a tendency to provide semantically transparent readings for both transparent and opaque compounds. The subject was visually presented with 120 compound words and instructed to provide a paraphrase for each compound. For slightly more than half of the compounds, she gave a purely transparent reading. This tendency held true for both transparent compounds such as *birdhouse*, paraphrased as 'a house for a bird,' and opaque compounds like *blueprint*, described as 'a print that is blue' (115). However, for seventeen of the compounds, all of

which were opaque, the subject produced a paraphrase that combined transparent and opaque interpretations. For example, the subject defined *dumbbell* as 'stupid weights,' demonstrating some awareness of the meaning of the compound while still using the meanings of the constituents to come up with a meaning for the whole word. The patient's performance on words like *dumbbell* supports the whole-word and constituent storage hypotheses.

Another case study of an unclassified aphasic demonstrated this same tendency to process compounds in terms of their constituents. Badecker (2001) gave the subject picture-naming and naming-from-definition tasks with monomorphemic and compound target words. When the subject made errors, he tended to provide either one of the constituents or a different, sometimes neologistic, compound. This strategy was not observed for monomorphemic targets; no errors like producing "pen-bird" instead of the monomorphemic target *penguin* were recorded. The subject also produced compounds that switched the order of the constituents of the original compound. These characteristics of the subject's errors make it highly unlikely that the subject was accessing whole-word forms of the target compounds. As in Libben's (1993) study, the subject unsuccessfully used this componential approach even for semantically opaque compounds, creating neologisms that captured some of the meaning of the constituents and the entire target compound. Although the subject's compound processing strategy might at first glance be considered componential, his awareness of the meaning of the inaccessible target compound suggests some degree of whole-word storage.

Taken as a whole, these studies of compounding in English provide evidence for both the whole-word and constituent approaches to compound word production and storage.

The case studies by Libben (1993) and Badecker (2001) demonstrate use of both strategies by aphasic patients. The two subjects in these studies used compositional strategies to give compound responses to pictures, and even when these responses were incorrect, they still had meanings similar to the whole-word form of the target compounds. However, the results from English do not shed any light on the issue of sublexical double dissociation, since the authors of these studies did not distinguish between compounds with noun and verb components. It is unfortunate that none of the English studies of compounding in aphasia investigated the presence of the noun-verb double dissociation at the constituent or whole-word level. An important feature of English syntax not considered in the data is the fact that the same word can be used as both a noun and a verb in different contexts. For a NV[3] compound like *moonwalk*, which can be used as a noun or a verb, would Broca's aphasics be able to access the nominal form of *walk* and successfully produce the compound? Would the frequency with which *walk* is used as noun predict successful processing of the full compound?

Compounding in German

German displays a high degree of inflectional and derivational morphology, and case relations are expressed through inflectional marking. The language is famous for its frequent use of compounding to create new words and for the length of its compounds. German compounds are always right-headed (Luzzatti & De Bleser 1996), and morphological marking at the constituent level of compounds is permitted (Libben, Jarema, Dressler, Stark, & Pons 2002). Like English, German has an alphabetic writing

[3] The notation NV denotes a compound where the first constituent is a noun and the second constituent is a verb. Other abbreviations used in this notation are A (adjective) and P (preposition). This notation only describes the grammatical categories of the constituents, not that of the entire compound.

system.

In one of the earliest studies of German compounding, Hittmair-Delazer, Andree, Semenza, de Bleser, and Benke (1994) conducted a picture-naming task: patients with different subtypes of aphasia were presented with pictures and were asked to name the object in each picture. Some of the objects were best described by compound nouns, while others had single-word names. The authors found that the subjects made twice as many errors when naming the objects with compound words as the target names as they did when naming the objects with single-word target names. The compound and single-word target names were not matched for length, however, so it is possible that subjects made more errors on the compound words simply because they were longer. Although the authors report the frequency of the different types of errors made by the subjects when presented with the compound word target pictures, they don't provide a statistical analysis of their results, so it is not clear if there are any significant patterns of errors in the data. The most common errors are omissions and perseverations (repetitions), which could occur in whole-word or component storage of compounds. At best, the results of this study provide some evidence for awareness of the internal structure of compounds. When subjects produced semantic paraphasias (replacing an inaccessible word with a semantically-related one) and neologisms for objects with compound noun targets, they tended to produce compound nouns. These compounds, though incorrect, often included one of the morphemes of the target compound in the correct position and almost never violated the rules of German compounding. Nevertheless, without a statistical analysis, these results cannot be considered conclusive evidence for componential storage of German compounds.

German has compounds with both literal and idiomatic meanings, and context is required to determine which meaning is appropriate in a sentence. Hillert (2004) investigated whether aphasic subjects access both the literal and idiomatic meanings of these compounds when they hear sentences containing these words. Three aphasics and a normal control listened to idiomatically-biasing and literally-biasing sentences containing these idiomatic compounds and after each sentence were given a lexical decision task, in which subjects are presented with a string of letters or sounds and must decide as quickly as possible whether or not the string is a word. In the current experiment, some of the words in the lexical decision tasks were semantically related to the literal meaning of the target compound and some were related to the idiomatic meaning. The aphasic subjects and the non-aphasic controls all showed significant or near-significant priming effects for literally-related and idiomatically-related target words, suggesting that both meanings of the target compound were accessed, and this outcome was not affected by the presence of literally-biasing or idiomatically-biasing sentences. Since idioms, by definition, are semantically opaque, and since aphasics showed equal ability in accessing literal and idiomatic meanings, the results of this study could be interpreted as evidence that all compound words, even those with derivable meanings, are stored the same way: as whole-word forms.

Blanken (2000) investigated the effects of frequency on aphasics' performance in a picture-naming task. Based on a large corpus of German words, he generated a list of NN compounds with two frequent constituents (FF), two infrequent constituents (II), a frequent first constituent and an infrequent second constituent (FI), and a frequent first constituent and a frequent second constituent (IF). All the compounds were relatively

uncommon, regardless of the frequency of their constituents, and all were relatively transparent. Blanken found that while production of FF compounds was significantly better than production of II and IF compounds, performance on FF and FI compounds was statistically equivalent. This result provides evidence for both approaches to compound word storage. The compounds with more frequently-occurring constituents were more likely to be produced correctly. However, given the difference in performance on FI and IF compounds, correctly accessing the first constituent of a compound could help aphasics gain access to a compound stored whole in the lexicon.

As is the case for English, there is evidence from German-speaking aphasics for both compositional and whole-word processing of compounds, despite differences between the two languages in terms of morphological structure and the structure of compounds. Hillert's (2004) study of idiomatic compounds points to whole-word representations for compounds, while Blanken's (2000) aphasic subjects showed sensitivity to the frequency of the constituents of compound words. Also as in English, compounds with verb constituents have been ignored, and the results do not provide supporting or disconfirming evidence for the existence of a sublexical double dissociation in German compounding.

Compounding in Italian

Italian shares many characteristics with German. It is a morphologically rich language and displays a high degree of inflectional marking. Though it does not mark case, Italian does mark number and gender, and verbs mark person, tense/aspect, and mood. Additionally, the two languages both have alphabetic writing systems. However, German

and Italian are less similar in terms of the structure of their compounds. While both languages allow internal inflection, Italian compounds can be left- or right-headed, in sharp contrast with German.

Citing Hittmair-Delazer et al. (1994), Semenza, Luzzatti, and Carabelli (1997) investigated whether the awareness of compound structure displayed by German aphasics was present in Italian. Thirty-six aphasics, including some diagnosed with Broca's, Wernicke's, or anomic aphasia, completed a picture-naming task for pictures best described by compound or monomorphemic nouns. While the Wernicke's and anomic aphasics tended to give compound responses to compound targets, the Broca's patients were more likely to produce the second part of a compound. A second experiment with a larger sample of aphasics confirmed that Broca's aphasics were far more likely than other aphasics to omit the first constituent of a compound. Given that most of the target compound nouns were VN, these results provide some evidence for a double dissociation, although the authors give no explanation for why a parallel result was not observed among the Wernicke's aphasics. Nevertheless, the Broca's aphasics' performance strongly supports componential storage of compound words.

Delazer and Semenza (1998) carried out a case study of an uncategorized aphasic who showed deficits in processing compound words but not monomorphemic words. The patient performed five tasks across different modalities: picture-naming, naming from description, repetition, reading, and writing from dictation. On all tasks, the subject made fewer errors with monomorphemic words than with compounds, and the overall rate of errors on monomorphemic words was extremely low. Additionally, the most common errors on compound targets were substituting an existing or novel compound, and novel

compounds obeyed Italian compounding rules. The subject was also asked to provide definitions for transparent and opaque compounds. He made only two errors; both were on opaque compounds, and both of these compounds had metaphoric meanings. While the compound vs. monomorphemic word experiments taken as a whole provide good evidence for constituent storage of compounds in the lexicon, the issue of whether or not semantic opacity affects processing and storage of compounds requires and merits further study.

Nasti and Marangolo (2005) also performed a case study of a patient whose word-finding difficulties were limited to compound forms. The subject performed all the tasks from the Delazer and Semenza (1998) study, as well as written picture-naming and written naming from description. Like Delazer and Semenza's subject, the subject in this study showed a strong bias toward producing compound words when the target word was a compound, and compound paraphasias were frequent and well-formed. The only exception to this trend was the repetition task, in which all responses were correct; however, since repetition of a spoken word does not require knowledge of word structure or meaning, the overall results still point to a composition-based approach to compound word storage. Though the target compound words used were primarily nouns with a few adjectives, these words varied in the grammatical categories of their components. The subject had more difficulty with the verb component of compounds, and a comparison study of monomorphemic words confirmed that this deficit also affected simple verbs. Since the patient was not diagnosed with Broca's aphasia, this result does not itself provide evidence for a double dissociation at the constituent level, but it does indicate that aphasics can be sensitive to the grammatical categories of compound constituents.

As in Avrutin et al.'s (1999) study, Mondini, Jarema, Luzzatti, Burani, and Semenza (2002) compared aphasic subjects' performance on compound words and adjective-modified nouns (AMN). The target words were all compounds or AMNs, and all had the structure NA or AN. Two unclassified aphasics completed a reading task and a repetition task, as well as an inflectional ending task where subjects had to supply the correct (masculine or feminine) ending for the adjective in the compound or AMN. When subjects produced errors on the tasks, they were more likely to show difficulty on AMNs than on compounds. Since AMNs and compounds should require the same degree of processing if the constituents of a compound are stored separately, this result clearly points to whole-word storage for compounds.

Luzzatti and De Bleser (1996) also took advantage of gender marking to investigate compound processing. As part of a series of case studies of morphological processing in aphasia, they conducted two experiments on Italian compounds. In the first study, the two subjects were presented with NN and VN compound nouns and asked to repeat the nouns with the correct (masculine or feminine) determiner. One subject seemed to assign gender on the basis of the gender of the final constituent, while the other performed very well on right-headed compounds and very poorly on left-headed compounds. Since both approaches to determining the gender of compounds show awareness of constituent structure, the subjects' performance constitutes evidence for a constituent-based approach to compound word storage and processing.

In the second experiment, Luzzatti and De Bleser (1996) presented their subjects with compound nouns and asked them to give the plural forms. The plural affix usually attaches to the head of a NN compound, and the study included both left- and right-

headed compounds. In contrast, the VN compounds included in the study are not overtly marked as plural. For all compounds tested, both subjects tended to pluralize the second constituent. It is possible that the subjects accessed whole-word forms for all the compounds, and, lacking awareness of their internal structure, treated them as simple nouns and added the plural affix to the ends of the words. An opposite explanation is also possible: using an (incorrect) constituent processing approach, the subjects overwhelmingly identified the right constituent of compounds as the head and applied the plural affix accordingly.

For other types of Italian compounds, the distinction between compounds and phrases is less definite. Prepositional compounds like *freno a mano* 'hand brake' (lit. 'brake by hand') resemble phrases. However, these compounds can be semantically opaque, and the constituents of a prepositional compound cannot have intervening adjectives (*freno **difettoso** a mano) (Mondini, Luzzatti, Saletta, Allamano & Semenza 2005: 179, emphasis theirs). Mondini et al. (2005) presented six agrammatic subjects with a word-completion task involving NPN compounds. The experimenter produced the two nouns of each compound, separated by a pause, and subjects had to recite the target compound with its appropriate prepositional constituent. Furthermore, some NPN compounds in Italian have a clitic article attached to the preposition (cf. *freno* $\boldsymbol{a}_{Prep}$ *mano* and *pasta* $\boldsymbol{al}_{Prep+Art}$ *forno*) (Mondini et al. 2005: 179, emphasis mine) and to correctly pronounce the target compounds subjects needed to include this clitic where appropriate. All subjects were impaired on this task, and the most common error was providing an incorrect preposition. Since agrammatic patients show impairments in retrieving function words like prepositions, the authors take this result to be evidence for impaired processing of a

compound stored in separate parts in the lexicon. However, without a comparison test of NPN combinations that are clearly phrasal, this experiment does not address the issue of whether or not NPN compounds are truly compounds. If the compounds used in the experiment are actually phrases, the expected result would be a compositional approach to producing them.

Mondini et al. (2004) compared Broca's aphasics' and other aphasics' production of NN and VN compounds in Italian; both types of constructions are grammatical nouns. On a picture-naming task, thirteen of the thirty subjects showed more difficulty with simple verbs than with simple nouns, while seventeen demonstrated equal competence on both. Of the thirteen, six were worse at naming VN compounds, compared to three of seventeen for patients who were equally competent at naming nouns and verbs. However, this study included agrammatic and non-agrammatic patients, and type of aphasia did not predict competence with compounds. The authors suggest that patients in these groups have different processing mechanisms independent of brain damage, dividing their thirty subjects into seven groups and pointing out the commonalities among members of each group. Since the subjects were assigned to these groups based on their performance on the experimental task, this categorization seems ad hoc. Badecker and Caramazza's (1998) account of aphasia acknowledges that individual differences in morphological composition may predict impairments, an explanation consistent with the results of this study. It is also possible that this study could have produced more conclusive results if the authors had not tried to include so many types of words and if they had concentrated on patients with one type of aphasia.

Despite differences in the structure of compounds, the results from Italian are similar

to those from English and German and provide evidence for whole-word and constituent processing of compounds. More importantly, since compounds with both noun and verb components were studied, the Italian research provides limited evidence for a double dissociation at the constituent level. The Broca's aphasics in Semenza et al.'s (1997) study tended to omit the verb in VN compounds, while the patient in Nasti and Marangolo's (2005) case study showed more difficulty with the verb component of compounds. Neither study conclusively shows a sublexical double dissociation, since no parallel result for Wernicke's aphasics is reported, but these results allow for the possibility of a sublexical double dissociation and motivate the need for future research in Italian to directly investigate this phenomenon.

Compounding in Finnish

Finnish morphology is notoriously complex. The language has a grammatical system of fifteen cases, and verbs are marked for person, number, and tense (Mitchell, 2001). Compounding is a productive and widespread process in Finnish; in large corpora close to half the words found are compounds (Laine & Virtanen 1996, cited in Mäkisalo, Niemi, & Laine 1999). This process is used for inventing new words and for borrowing words from other languages. Finnish compounds are right-headed and the component immediately preceding the head may be inflected (Mitchell, 2001).

Mäkisalo et al. (1999) conducted a case study of a Finnish-speaking Broca's aphasic in order to determine whether compounds are constructed or accessed whole and, if they are constructed, if the first and second components are accessed differently. The researchers selected nominal compounds of various structural types. Some of these were

internally inflected, and the set included compounds with nominal, verbal, adjectival, and prepositional components. All compounds included in the study were semantically transparent. The subject was visually presented with these compounds, as well as monomorphemic and derived fillers, and was then asked to read each target word aloud. The subject produced significantly more errors when reading compound words than when reading either monomorphemic or derived words. Furthermore, correct production of the first constituent in a compound predicted production of an existing Finnish compound; this result was significantly less common when the second constituent was correctly produced.

The predictive power of first constituent production is more noteworthy when considered in conjunction with the results of Blanken's (2000) study of frequency effects in aphasic patients' naming of German NN compounds. Blanken reported that while his subjects were significantly better at naming frequent/frequent compounds than they were at naming infrequent/frequent or infrequent/infrequent, performance on frequent/frequent and frequent/infrequent compounds was not significantly different. Mäkisalo et al. (1999) suggest that the first and second constituents of a compound may function differently in lexical access because Finnish compounds, when headed, are right-headed (250). Since German compounds are always right-headed, Mäkisalo et al.'s claim that the first constituent guides lexical access is stronger when Blanken's results are considered. However, their claim could have been even stronger if they had reported error rates by compound type, since some Finnish compounds have a structure that is not found in German. Order effects aside, Mäkisalo et al. do provide some evidence for a componential approach to compound word processing, but it is also possible that

correctly accessing the first constituent of a compound allowed the aphasic patients to find the whole-word form.

Compounding in Japanese

Japanese has a moderate level of morphological activity. What distinguishes its morphological system from those of other languages is extensive derivation and compounding of verbs. In Japanese, compound verbs express the meanings of English verb + particle combinations like *look up at* and *watch over* (Vance 2001: 347). Furthermore, the Japanese writing system is partially logographic, with characters called *kanji* mapping onto root morphemes. The structure of Japanese compounds is more overt on a visual level, since each constituent in a compound is represented by a different *kanji* character.

Kudo's 1992 study of aphasia in Japanese included three experiments on compound word processing. In the first, aphasics and normal controls were presented with four kanji characters and were asked to construct two words made from two kanji each. Two types of errors were measured: selection errors (pairing incorrect kanji) and order errors (pairing the correct kanji in the wrong order). The Wernicke's aphasics demonstrated significantly more selection errors, while the Broca's and anomic aphasics made significantly more order errors. Kudo speculates that the Wernicke's aphasics had more trouble with selection because semantic information gives clues as to which components belong together and Wernicke's aphasics show impaired comprehension. This explanation supports the constituent-storage hypothesis of compound storage, since speakers could use semantic information to form compounds from their constituents.

In the second experiment, subjects were presented with two sets of two *kanji* in opposite orders and were asked to determine which combination represented an actual word. Each subject was tested twice, once with printed *kanji* and once with the characters read out loud. No effect of modality was found, and the anomic aphasics performed best at the task, followed by the Broca's aphasics and then by the Wernicke's aphasics. Considering that the Broca's and anomic aphasics showed more order errors in the first task, it is surprising that the Wernicke's aphasics performed worst on the second task. Additionally, since semantic information was not useful for selecting the correct order for the target kanji, the explanation provided for the differential performance across aphasia types in the first experiment does not apply.

The third experiment in the series tested subjects' ability to decompose three-character kanji words. These words were formed by adding a kanji onto a two-kanji word, either by adding a stem to form a three-letter compound or an affix to form a derived word. Furthermore, these words differed in terms of the position of the added kanji. The added kanji connects to the beginning of the two-letter word for head-type words or to the end for tail-type words. The aphasic subjects were not significantly worse at decomposing these compounds than the non-aphasics, and there were no significant differences in performance between patients with different subtypes of aphasia. The ability to decompose compounds requires knowledge of the internal structure of compounds and constitutes evidence for componential storage.

The results of these studies, and the first study in particular, support the constituent-storage view of compound processing. However, since Kudo (1992) does not provide a word list or describe the syntactic categories and constituents of the compound words

used, it cannot be determined whether the noun-verb double dissociation affected the aphasics' performance at the lexical or sublexical level. Given the prevalence of compound verbs relative to other languages, Japanese could provide an interesting test language for comparing processing of compound nouns and verbs.

Compounding in Chinese[4]

Unlike the other languages previously discussed, Chinese has minimal morphological marking. It does not mark gender, number, or case, verbs are only inflected for aspect, and there is no modifier-noun or subject verb agreement. Compounding is a major exception to this generalization: it is widespread in Chinese and frequently used to form new words (Zhu 2001). Chinese compounds freely combine components from different syntactic categories, and the syntactic category of a compound is not predictable from the syntactic categories or order of its constituents. Compounding is also unique in Chinese because the constituents of a compound can be separated[5]; thus, the compound *guan-xin* 'to care about' can occur as *guan-dianr-xin* 'to care a little bit about' (Zhou, Ostrin, & Tyler 1993). Chinese has a logographic writing system, and, as in Japanese, each morpheme in a compound is represented by two distinct characters.

Bates et al. (1991) argue that the structure of Chinese makes it an excellent test language for evaluating competing explanations for the double dissociation observed in Broca's and Wernicke's aphasia. The semantic conceptual account states that action

[4] Here, Chinese refers to Mandarin Chinese, a group of dialects spoken by a majority of the Chinese population.

[5] The separability of Chinese compounds raises the question of what it means for a word to be a compound word. Although it is true that the constituents of Chinese compounds may be separated and moved in a sentence, the range of possible syntactic movements is narrower than the range for phrases (Y. Y. Huang 1991, cited in Bates et al. 1993). Second, even when the constituents of a compound are separated, the compound itself retains its idiomatic whole-form meaning.

(verb) and object (noun) meanings are stored in different areas of the brain. The morphological account argues that verbs are difficult for Broca's aphasics because these words tend to bear grammatical marking. The syntactic account claims that this verb difficulty is a syntactic deficit and due to the importance of the verb in the sentence. Chinese provides an interesting test of these accounts because it lacks inflectional morphology and sentences that lack a subject or verb can be grammatical. In the present experiment, aphasic Chinese speakers were shown pictures and asked to name the appropriate object or action; subsequently, they were asked to listen to words and point to the corresponding picture in a group of three pictures. The most fascinating result was that Broca's aphasics had more difficulty with the verb component of VN compounds and Wernicke's aphasics struggled more with the noun component, suggesting that the double dissociation, well-attested at the lexical level, can apply at the sublexical level as well.

Zhou et al. (1993) argue that Bates et al.'s (1991) discovery of the double dissociation at the constituent level is actually due to a misconception about the status of compounds in Chinese. They claim that many of the VN verb compounds included in the Bates et al. study were actually verb phrases with N as the object of V. According to C.-T. J. Huang's (1984; cited in Zhou et al.) Phrase Structure Condition, verbs may take no more that one complement in Chinese. Thus, VN compounds may take a complement, because the N component of the compound is part of the verb and not acting as a complement. All of the VN verb compounds used by Bates et al. cannot take complements, and Zhou et al. argue that under the PSC these structures should not actually be considered compounds. Even under more lenient definitions of compounds (e.g., Y. Y. Huang, 1991, and Li and

Thompson, 1981, cited in Zhou et al.) enough of the VN compounds from the Bates et al. study are reclassifiable as verb phrases that the constituent-level double dissociation effect disappears.

Responding to these criticisms, Bates et al. (1993) claimed that the issue of what to consider compounds in Chinese is more complicated than the definitions of compounds cited by Zhou et al. (1993). In some VN verb compounds, the noun component functions as an object within the compound, while in others, the noun is an instrument or agent. When this noun constituent is an object, the entire compound verb cannot take an object, but it can when the noun constituent is an instrument or agent. Additionally, in different sentences, the same combinations of words can have both a phrasal reading and an idiomatic compound meaning. These issues in classifying potential compounds as compounds or phrases occur when compounds occur with context, and Bates et al. point out that in their picture-naming task, subjects were simply asked to name the depicted action. In Chinese, even when certain VN constructions are phrases in a syntactic sense, they still function as single words, since the V in these constructions must immediately be followed by an N. Bates et al. acknowledge that more work is needed on VN compounds, particularly on VN noun compounds, which were not included in the original study.

Chen and Bates (1998) replicated the Bates et al. (1991) study with a few important modifications. First, they only examined compounds whose categorization as compounds is uncontroversial. Second, their study included both frequent and infrequent Chinese compound types. For all compounds, Broca's aphasics were more likely to omit or substitute noun constituents, and the same pattern was observed among Wernicke's

aphasics for verb constituents. While the double dissociation may not be observed for some compounds, such as the VN compounds investigated in Bates et al., it is clearly present for others.

Largely ignoring the debate about the status of compounds in Chinese, Lee et al. (2005) compared agrammatic patients' production and comprehension of NN, NV, VN, and VV compounds, all of which, except for NN compounds, can be nouns or verbs. They presented patients with pictures of items that could be named with these compounds and asked them to provide the correct name. In a category judgment task, compounds and disyllabic adverbials (control words) were displayed on a computer screen. In one section of the task, patients had to decide whether the presented word was a noun or not, and in the other had to determine whether or not the presented word was a verb. For multiple reasons, the results of this study are difficult to interpret. In the results section for the category judgment task, the authors do not provide the data they collected. They also state that both groups of aphasics were statistically equivalent in their categorization of compounds, yet they do not compare the aphasics' results to those of the normal subjects. The authors' conclusion that agrammatic patients were best at producing NN noun compounds and worst at VV verb compounds is unsurprising, because we would expect this result regardless of whether the double dissociation applies at the morpheme or compound word level.

While the research reviewed here cannot resolve the issue of whether VN compounds should truly be considered compounds, there is good evidence that the other types are represented compositionally. In order for a sublexical double association to apply, as it did in Chen and Bates (1998), the constituents of compounds must be separate at some

level of processing. Unlike the studies from other languages, there is no evidence for whole-word storage. However, given the unique features of Chinese compounds in comparison with those of other languages, the results from Chinese may be representative of differences in the structure of the compounds themselves. Componential storage may simply reflect the fact that the constituents of Chinese compounds can be separated in a sentence.

Conclusion

Table 1. A summary of the results by language and linguistic features.

	English	**German**	**Italian**	**Finnish**	**Japanese**	**Chinese**
Morphological marking	moderate	rich	rich	rich	rich	minimal
Gender	no	yes	yes	yes	no	no
Orthography of compounds	mixed	alphabetic	alphabetic	alphabetic	logographic	logographic
Headedness	right (usually)	right	variable	variable	variable	variable
Internal inflection	rare	yes	yes	yes	no	no
Constituent or whole-word storage?	*evidence for both*	*evidence for both*	*evidence for both*	*evidence for both*	*evidence for constituent storage*	*evidence for constituent storage*
Sublexical double dissociation?	*no evidence*	*no evidence*	*indirect supporting evidence*	*no evidence*	*no evidence*	*direct supporting evidence*

When the results of studies from all six languages are considered, there appears to be evidence in all languages for componential storage and in some for whole-word storage. The languages for which whole-word processing was not demonstrated are Japanese and Chinese, which both represent compounds orthographically and do not allow internal inflection of compound words. Further research on more languages is necessary to predict whether or not these features actually predict different processing mechanisms in

different languages. The prevalence of both strategies in many languages suggests that future research may reveal whole-word processing in languages where these strategies have not yet been demonstrated.

The patients from Libben's (1993) and Badecker's (2001) case studies tended to use both componential and whole-word strategies when naming and defining compound words. As Libben (1993) suggests, the tendency toward componential processing observed in aphasia may reflect a back-up approach to whole-word storage, and whole-word storage may be the default method among non-aphasics. Now that studies of aphasics have shown both approaches to compound processing—approaches that may not be as readily apparent in studies of normal processing—studies of non-aphasics may reveal whether or not normal speakers use both strategies.

Unfortunately, the issue of whether or not a sublexical double dissociation exists for compounds has been largely ignored outside of Chinese. The reasons for this are unclear, since all the languages in which the effects of aphasia on compound processing have been studied contain compounds with noun and verb components. The only other evidence for a double dissociation comes from Italian. Nasti and Marangolo (2005) reported that their patient had more difficulty with the verb constituent of compounds than with the noun component, but since the patient was not diagnosed with Broca's aphasia, this result does not constitute direct evidence for a double dissociation. The Broca's aphasics in Semenza et al.'s (1997) study demonstrated more difficulty with the verb component of VN compounds, but Wernicke's aphasics did not demonstrate a similar pattern of errors with nouns. Given the unique features of Chinese compounding in comparison with other languages, it would be unwise to draw cross-linguistic conclusions about compounding

based primarily on evidence from this language. At best, we can conclude that a sublexical double dissociation for compounds is not impossible, and the results from Italian suggest that further research on compounds in other languages may reveal evidence of a cross-linguistic double dissociation for Broca's and Wernicke's aphasics.

An issue that merits further study is a possible distinction in lexical access for constituents at different positions in a compound word. Blanken's (2000) research on German compounds and Mäkisalo et al.'s (1999) work in Finnish suggest that the first constituent plays a special role in compound word retrieval. Since Finnish compounds vary in terms of headedness, and German compounds are always right-headed, similar order effects for different constituents may be found in other languages. Other features of compounds that may influence processing are semantic transparency and frequency of constituents, but research in more languages is necessary to conclude that these factors influence compound processing in general.

There are limitations in the extent to which broad conclusions can be drawn from the existing research. In working with aphasic subjects, there is a tradeoff between replicating the complex real-world context in which language is understood and produced and accommodating the limited processing capabilities caused by aphasia, as well as associated factors like advancing age. Although studies of aphasics often include age-matched normal subjects as controls, there are still limits to how well aphasics and non-aphasics can be matched on cognitive factors. Thus, more work is needed to determine how factors like context affect aphasics' processing of compounds. Cross-linguistic studies of compounding in context are especially important because it may influence the interpretation of compounds differently in different languages. Context distinguishes

compounds from phrases in Chinese (Bates et al. 1993) and literal compounds from idiomatic ones in German (Hillert 2004).

In addition to differences in the languages investigated, studies of compounding differ in experimental design. For example, Mäkisalo et al. (1999) presented their subject with written compounds out of context, while Avrutin et al. (1999) used pictures to elicit production of the target compounds. However, the deficits caused by aphasia do not necessarily apply uniformly to comprehension, production, reading, and writing. Thus, an aphasic could lose the ability to name a target word by looking at a picture while still being able to read the same target word. Some of the studies reviewed here did use multiple tasks to elicit compound word comprehension and production, but this practice should be used more frequently.

Since most of these studies are based on very small sample sizes, it is difficult to determine how well we can generalize the results to all aphasics with the same diagnosis and to normal speakers' representations of language. Results from studies such as Mondini et al.'s (2004) study of Italian compounds suggest that individuals may store linguistic knowledge differently. It is also possible that each person has a slightly different neurological representation of language, which would cause different deficits in patients with similar patterns of brain damage. If this is the case, future research must answer the question of why people's representations of language differ. More uniform studies of aphasia across languages may help answer this question. Unfortunately, it is difficult to match patients on both demographic factors and site of brain damage, so large sample sizes may be difficult to obtain.

Rather than classifying patients in studies of aphasia by subtype, it may be more

useful to group them by specific symptoms. The Delazer and Semenza (1998) case study of an uncategorized patient who displayed deficits in processing compound words but not monomorphemic words was particularly informative because it focused on one specific symptom, rather than a collection of symptoms described by a subtype. For organizing aphasic patients into comparison groups for experiments, the neuroassociationist classification may be less useful than other systems. Luria's system of classification sorts aphasics by deficits rather than by relative preservation and degradation of abilities (Basso 2003). Since there are differences in symptoms among patients in the same type, selecting participants according to specific symptoms may make the results of studies of compounding in aphasia more generalizable.

Given the difficulty of finding homogenous groups of aphasics for studies, studies of bilingual subjects may prove beneficial. Testing bilingual subjects in each language spoken and comparing the results eliminates the effects of individual differences present when making between-groups comparisons of speakers of different languages. Furthermore, the effects of aphasia on compounding among bilinguals may be interesting from a theoretical standpoint. These subjects may show different deficits for the compound words contained in each language, or they may show similar patterns of results.

Finally, the findings from this review of the literature on compounding in aphasia reaffirm the need for cross-linguistic studies in aphasia research. Compositional approaches to compound word storage can be observed not only in languages like German, which only allows right-headed compounds, but also in Finnish, which allows for more variable combinations of constituents. The argument for the presence of a

sublexical double dissociation in Chinese is strengthened by the fact that similar effects can be observed in an unrelated language like Italian. Cross-linguistic investigations allow psycholinguists to make broader and more robust claims about the way humans process and organize linguistic knowledge.

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