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Verb Retrieval in Aphasia

1. Characterizing Single Word Impairments

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The ability of aphasic patients to produce words from the grammatical classes of nouns and verbs was investigated in tasks that elicited these types of words in isolation. Eleven chronic aphasic patients produced nouns and verbs in picture naming, videotaped scene naming, sentence completion, naming from definition, and oral reading. Comprehension of the meanings of nouns and verbs was tested in word/picture and word/video scene matching, and appreciation of noun/verb grammatical class differences was tested with two metalinguistic tasks. Five patients demonstrated significantly more difficulty producing verbs than nouns, two patients were significantly more impaired producing nouns than verbs, and the remaining four patients showed no difference between the two classes. There was no improvement in verb production when naming actions presented on videotape, suggesting that selective verb impairments are not attributable to conceptual difficulty in identifying actions in static pictures. Selective noun impairments occurred in the context of severe anomia, as reported in previous studies. Selective verb impairments were demonstrated for both agrammatic and fluent (Wernicke) patients, indicating that such deficits are not necessarily associated with the nonfluent and morphologically impoverished production that is characteristic of agrammatism. There was no indication that single word comprehension was affected in these patients in a manner consonant with their production impairments. Results are interpreted in light of current models of lexical organization and processing.

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One of the characteristics of aphasia that has motivated its study by researchers interested in normal language is the apparently selective impairment and sparing of words from different grammatical classes. The most obvious of these selective effects compares production of words from the ''major'' content word classes—nouns, verbs, and adjectives—with those from the classes of grammatical function words—determiners, prepositions, pronouns, and auxiliary verbs. Some aphasic patients (agrammatic Broca's aphasics) show relative preservation of the major classes and disruption of grammatical function words, while others (those with ''semantic dementia,'' see Breedin, Saffran, & Costlett, 1994) show poor content word production and relatively spared abilities with grammatical words.

Evidence for selective lexical impairment based on grammatical class has also been reported *within* the broad category of content words. Agrammatic aphasic patients have long been observed to have particular difficulty producing main verbs, in addition to their problems producing functions words (Fillenbaum, Jones, & Wepman, 1961; Myerson & Goodglass, 1972). There are many reasons to expect verbs as a class to be more difficult than nouns and thus perhaps more susceptible to disruption when the brain is damaged. Verbs are acquired later than nouns by normal children, have a greater range of meanings, are more variable in meaning than nouns across languages (Gentner, 1981), and are more difficult for normal subjects to comprehend under some conditions (Reyna, 1987). Thus, it is not surprising that several studies have reported more difficulty with verb production than noun production across all aphasic patient types tested (Kohn, Lorch, & Pearson, 1989; Williams & Canter, 1987).

Nonetheless, the notion that verbs are inherently more ''complex'' cannot easily explain all of the observations that have been made about the performance of aphasic patients. The magnitude of the noun/verb differences shown for both comprehension and production by a patient tested by McCarthy and Warrington (1985) suggested a very specific deficit for verb knowledge, rather than generally poorer performance with more difficult words. In addition, a severe anomic patient described by Zingeser and Berndt (1988) demonstrated a pattern of impairment that could not arise because verbs are more ''difficult'' than nouns: verb production was *superior* to noun production across a range of tasks (Zingeser & Berndt, 1988). The existence of this pattern of superior verb production essentially precludes any general explanation of selective verb impairment that relies on an argument that verbs are inherently more vulnerable to disruption. Clearly, verbs may also be selectively spared.

The double dissociation between noun and verb production in patients described as ''agrammatic'' (verbs worse than nouns) and ''anomic'' (nouns worse than verbs) has also been reported in a group study of Italian patients (Miceli, Silveri, Villa, & Caramazza, 1984). Using the picture materials from the Italian study, Bates, Chen, Tzeng, Li, and Opie (1991) found depressed

naming of actions vs. objects in six Chinese-speaking Broca's aphasics. These authors did not study anomic aphasics, but found a small (but significant) advantage for verb naming among a group of seven Chinese-speaking Wernicke's aphasics.

The same patterns of noun and verb production for agrammatic and anomic patient types have also been demonstrated for English-speaking patients. Zingeser and Berndt (1990) found noun/verb differences in picture naming, naming from definition, and in two connected speech tasks. Although targets are more difficult to predict when connected speech is elicited, noun/verb ratios produced by the patient groups in story narration, and in situation description, maintained the relative advantage of noun production for agrammatic patients and verb production for anomic patients compared to that seen in normal controls.

These studies indicate that it is indeed possible to find differences among patients in the accessibility of words drawn from the categories of nouns and verbs. A number of important questions remain about these findings, however. The first involves the proper characterization of selective retrieval impairments. All of the clear demonstrations of noun/verb differences have employed words that can be pictured and/or described using a definition. Thus, nouns have been drawn from the semantic category of concrete objects, and verbs from the semantic category of picturable actions. Although analysis of connected speech samples (which could include nouns and verbs from other semantic categories) have also shown differences, it remains possible that the selective impairments identified in the noun/verb studies actually involve a semantic category-specific deficit for actions and objects. Indeed, this is the explanation favored by McCarthy and Warrington (1985) for the severe verb impairment demonstrated by the patient they studied.

A second question raised by the earlier studies involves the extent to which differential accessibility of words in different classes is necessarily linked to a patient's clinical classification, i.e., to other aphasic symptoms. Several recent investigations have described selective verb production impairments in patients who do not demonstrate the characteristics of agrammatism (Caramazza & Hillis, 1991; Kremin & Basso, 1993). The importance of this issue extends beyond an interest in characterizing the impairments of different types of aphasic patients; selective verb impairment could well be an important contributor to the structurally impoverished sentence production typical of agrammatism (Saffran, 1982; Zingeser & Berndt, 1990). It is therefore of considerable interest to determine whether selective verb impairments always occur in patients with poor sentence construction abilities, and noun impairments in patients with relatively good sentence construction abilities, or if other possible combinations can be found.

Finally, there are many unanswered questions about the functional locus of selective grammatical class effects within the cognitive system. The cognitive model adopted here to guide discussion of the possible underlying

sources of grammatical class effects is motivated by analysis of speech errors produced by normal adult speakers (Garrett, 1988; Levelt, 1989). Although this model was formulated to explain normal *sentence* production, the components of the model that deal with the retrieval of words (during sentence production) can be considered in isolation. The lexical aspects of this model share critical elements with existing models of single word processing (e.g., Rapp & Caramazza, 1991) which were developed to account for single word transcoding tasks such as oral reading and writing to dictation.

Three general processing levels have been distinguished in the model of sentence production to be used here, each of which makes contact with specific representational knowledge stores (Levelt, 1989). The ''Conceptualizer'' uses situational, contextual, cognitive, and discourse information to generate a preverbal message to be spoken. The ''Formulator'' retrieves words from the lexicon and encodes them grammatically and phonologically into a surface structure that is realized as a phonetic plan; the ''Articulator'' translates the phonetic plan into the motor commands needed to achieve the spoken utterance.

Most studies of production failure in aphasia have targeted aspects of the Formulator (or its representational knowledge base) as the source of word retrieval impairments, and this study is no exception. In addition, however, we will investigate one possible source of selective grammatical class effects that could arise in the Conceptualizer. When patients are asked to produce isolated words in confrontation naming tasks, the ''message'' produced by the Conceptualizer must isolate the aspect of the stimulus that is to be named. Patients with relative verb impairment may have difficulty indentifying the action component when naming static pictures and may fail to name actions for that reason. Several investigators have suggested that confrontation naming tasks using static pictures favor the production of nouns (Kohn et al., 1989; Williams & Canter, 1987). The use of other elicitation techniques—such as naming from definition—somewhat mitigates this possibility, but these tasks might also involve a greater conceptual burden for actions than objects in the isolation and identification of the element to be named. One possible functional locus of selective verb retrieval impairments is, therefore, placed very early in the conceptualization of the information to be lexicalized, as the action is distinguished from other elements (e.g., actors and objects) of the message.

Several other potential sources of specific grammatical class effects can be identified in the Formulator, i.e., in the processes and representations required to translate a conceptual ''message'' into a phonetic plan. Many of the details hypothesized for this component involve the specifics of coordinating lexical and syntactic elements during *sentence* production (Bock, 1987; Levelt, 1989, Chapter 7); these will be considered in Berndt, Haendiges, Mitchum, and Sandson (this issue). For the purposes of accounting for deficits of isolated word retrieval, however, we can limit discussion to the issue

of lexical selection, i.e., to the retrieval of the intended element from the lexicon.

Virtually all contemporary models of lexical representation postulate two independent levels between the formulated message and the articulatory program for a word (Allport & Funnell, 1981; Butterworth, 1989; Garrett, 1988, 1992; Levelt, 1992; Rapp & Caramazza, 1991), although a variety of different terms are used to characterize them. The first of these levels is an abstract lexical representation (sometimes called a ''lemma'') whose semantic specification matches conceptual elements of the message. The lexical entries at this level are hypothesized to be specified for semantic and syntactic information, but to be unspecified phonologically. That is, these representations are independent of modality of output and can serve to activate phonologically and orthographically specified word forms. In some models, these lemma representations are characterized as entries in a lexical/semantic or ''cognitive'' system that functions in both comprehension and production (e.g., Allport & Funnell, 1981; Butterworth, 1989; Rapp & Caramazza, 1991).

At the second level of lexical representation, the lexical item (''lexeme'' or ''word form'') is specified for its phonologic or orthographic form. This store of word forms is in some models necessarily tied to modality of output; thus, the ''phonological output lexicon'' is distinguished from the ''orthographic output lexicon'' that supports written production (e.g., Rapp & Caramazza, 1991). The model adopted here was developed to account for *spoken* production and thus assumes phonological specification of word forms.

The hypothesized existence of two distinct levels of lexical representation, which is currently uncontroversial, does not necessarily imply that these representations are contacted in temporally distinct, serial processing stages. Nonetheless, most extant models of word retrieval incorporate separate stages for gaining access to lemma (or lexical/semantic) representations and to word forms (phonological representations) (see Levelt, 1992, for review). The requirement of serial access to lexical/semantic and word form representations has been challenged by Dell (1986), whose spreading activation model postulates parallel activation of semantic and phonological information, as well as multiple possibilities for interaction and feedback. Debate concerning the requirement of serial processing continues to focus on a variety of types of data from normal speakers (Dell & Reich, 1981; Dell & O'Seaghdha, 1991; Levelt, Schriefers, Vorberg, Meyer, Pechmann, & Havinga, 1991) and from aphasic patients (Nickels, 1995).

The relevance of these details of normal lexical representation and processing to understanding aphasic impairments is considerable. Of most importance to the issues raised here, the characteristics of distinct levels of lexical representation, along with notions about how (e.g., in what sequence) information flows from one level to another, are necessary for locating the functional source of patients' word retrieval impairments. This is not to imply that the task of attributing grammatical class effects to impairments of

specific components of the model is a straightforward undertaking. Models of lexical processing provide insufficient detail about how information is represented at various levels and especially about how information at one level serves to activate a different type of information at another level. Moreover, the models were formulated to describe *normal* production and say little about what the effects would be of even a minor aberration in the normal course of events, e.g., slowed activation, exacerbated decay of information, etc. (but see Schwartz, Saffran, Bloch, & Dell, 1994). Thus, the attempt to identify the functional locus of a deficit within a model proceeds by analyzing patterns of performance across a range of tasks, while building a logical argument about the expected effects on performance of deficits of various types. This report will adopt such an approach, investigating verb and noun retrieval under a variety of different ''activation'' conditions for a group of patients with various symptoms of aphasia. The effects of a number of variables and outcomes that have previously been used to isolate the locus of production deficits, such as word frequency (Garrett, 1992), elicitation context (Caramazza & Hillis, 1991), and error patterns (Schwartz et al., 1994), will also be considered.

GENERAL METHODS

Subjects

Eleven chronic aphasic patients participated in this study, although some patients did not complete all of the tasks. These patients demonstrated a variety of types of aphasia, both fluent and nonfluent. Patients were entered into this study as they became available to us over a 2-year period. Criteria for selection were that the aphasia was secondary to cerebrovascular accident, that the patient was free of generalized dementia or significant visual/perceptual problems, and that speech production at the single word level was intelligible. The mean age of the group was 54.5 years (range, 35–74); mean educational level was 14 years (range, 9–18), and mean time post onset was 6 years (range, 3 months–12 years). Table 1 provides specific information about each patient, including clinical classification;[1] the patients are ordered in the table (based on the patterns of naming results to be presented) to maintain a consistent order across all tables and figures. Several of these patients have been discussed in other published studies;[2] relevant results from these earlier studies are discussed as appropriate.

[1] Clinical classification was based on the Boston Diagnostic Aphasia Examination (1982). The characterization of patients as ''agrammatic'' was based on the morphological indices obtained from the sentence production analysis described by Saffran, Berndt, and Schwartz (1989).

[2] FM (Badecker, Nathan & Caramazza, 1991; Berndt, 1987; Berndt, Salasoo, Mitchum, & Blumstein, 1988; Saffran, Berndt, & Schwartz, 1989; Schwartz, Linebarger, Saffran, & Pate, 1987), LR (Berndt & Mitchum, 1994; Mitchum & Berndt, 1991), EA (Haendiges, Berndt, & Mitchum, 1996; Mitchum, Haendiges, & Berndt, 1993), ML (Mitchum & Berndt, 1994; Mitchum, Haendiges, & Berndt, 1995), JS (Berndt et al., 1988; Caramazza, Berndt, & Basili, 1983; Martin & Caramazza, 1982), HY (Zingeser & Berndt, 1988, 1990), TM (Zingeser & Berndt, 1990), JD (Berndt, 1987; Saffran et al., 1989).

TABLE 1
Descriptive Information, Patient Subjects

	FM	LR	EA	ML	JS	HF	HY	TM	JD	MB	LK
Age at testing	46	62	58	53	55	50	74	55	45	64	35
Years of education	12	18 1	18 1	18 1	14	16	10	18	12	9	14
Years since onset	8	12	6	6	10	1	8	4	10	.5	.3
Clinical classification	Agrammatic Broca's	Agrammatic Broca's	Agrammatic Broca's	Mild Wernicke's	Wernicke's	Anomic	Anomic	Agrammatic Broca's	Broca's (not agrammatic)	Trans. sensory	Mild anomic

Note. All subjects premorbidly right-handed; etiology left CVA; patients are ordered to reflect relative noun/verb naming performance to be presented.

Ten control subjects were tested during the task development phase of this study to assure that the target words were easily elicited by the stimulus materials. All controls were adults without history of CNS disease, chronic alcoholism, or developmental language disorders, drawn from the ranks of hospital visitors and employees. Mean age of control subjects was 44 (sd 5 12); mean education was 11 years (sd 5 1.9).

Materials

Stimulus words. An operational definition of grammatical class usage for words was adopted for this study based on entries in norms that list word frequencies separately by grammatical class (Francis & Kucera, 1982). ''Unambiguous nouns'' and ''unambiguous verbs'' were defined as those words of each class in which the frequency of occurrence in an alternative class was no greater than 5% of the cumulative frequency of the target class. Words that function easily as either a noun or a verb, i.e., that are ''grammatical class ambiguous,'' were included in some tasks. An operational definition of class ambiguity was based on log transformations of noun and verb cumulative frequencies in Francis and Kucera (1982) to allow more consistent evaluation of differences between frequencies across the entire frequency continuum. ''Class-ambiguous'' words were defined as words for which the log frequencies of noun and verb usages differed by .2 or less.

Stimulus preparation. Picture naming tasks employed black and white line drawings prepared by a graphic artist to depict the target actions and objects. For the video tasks, actions and objects were filmed on videotape and edited to a 7-sec viewing segment. Actions were carried out only once within the segment by one or two actors, as needed. For directional verbs with two participants (e.g., *give*) focus was placed on the agent by portraying only the arm of the (off-screen) recipient.

Procedures

The tasks discussed here were part of a larger battery exploring several aspects of patients' production and comprehension of single words and sentences. This battery was administered to patients in weekly 2-hr sessions over a period of several months. The tasks were presented in one of three predetermined orders such that demands of comprehension and production were staggered. A target word was elicited only once in any test session. The picture naming task was administered first for all patients.

1. PRODUCTION OF NOUNS AND VERBS

Four types of tasks were designed to probe patients' abilities to produce nouns and verbs in response to various stimulus types, including pictures, videotaped scenes, spoken sentences, and written words. The hypothesis tested was that verb production would be enhanced from videotaped stimuli compared to that seen with pictures, to the extent that an impairment in the identification of the action component contributed to patients' deficits. These tasks also allowed some assessment of the extent to which factors such as frequency of occurrence and concreteness influence patients' ability to produce isolated nouns and verbs.

Naming Pictures of Actions and Objects

Materials and procedures. A set of 60 unambiguous, picturable nouns and 30 unambiguous, picturable verbs was selected from frequency norms as described above. Two nouns were chosen for each verb: one noun was matched to the verb's *cumulative* frequency (i.e., combined

frequencies for all inflectional forms), and a second noun was matched to the verb's *base* frequency (i.e., uninflected verb frequency). This dual matching was carried out because there is typically a large discrepancy between cumulative and base frequencies for verbs, and it is not clear which of the two provides the best match to noun frequencies, which do not show this discrepancy. The use of two sets of nouns in this study provided a wide range of noun frequencies matched to the unambiguous verb pool. Members of each triad (one verb and two nouns) were also matched for length (in syllables). See Zingeser and Berndt (1990) for description of norms and picture preparation; see Appendix A for a list of stimulus words.

Blocks eliciting verbs were shown first with instruction to ''tell, in one word, the action taking place''; no attempt was made to elicit a specific form of the verb. If patients responded with the name of an object in the picture, they were told again to name the action. Nouns were elicited with instruction to ''tell the name of the object shown.''

Results. There was no difference in patients' ability to name objects as a function of whether they were matched to verb base or cumulative frequency ($t(10) = 1.40$, $p = .19$),[3] so the two noun sets were combined for the subsequent analyses. Figure 1 (top) shows the proportion of correct responses produced by each patient when naming pictured actions and objects. The patients have been grouped in the figure on the basis of whether they have relatively more difficulty producing verbs (left group), have more difficulty producing nouns (middle group), or show no difference between the two. Significantly better production of nouns than verbs was demonstrated by patient FM (FI = 6.70, $p = .01$), by LR (FI = 29, $p < .0001$), by EA (FI = 4.61, $p = .05$), by ML (FI = 6.22, $p = .01$), and by JS (FI = 5.76, $p = .03$). Two patients showed reliable differences in the opposite direction; that is, verbs were *better* produced than nouns (patient HF, FI = 10.53, $p = .001$; patient HY, FI = 4.95, $p = .04$). The remaining four patients demonstrated little difference in the ability to name pictures of objects and actions, with two of these patients performing near ceiling levels.

Naming Videotaped Scenes of Actions and Objects

Materials and procedures. Twenty-eight unambiguous verbs and 28 unambiguous nouns were selected as described above, with the added requirement that they could be filmed and presented on videotape. It was possible to film 18 of the 30 verbs that had been used in picture naming; others were either difficult to enact for videotaping (e.g., *drown, bleed*) or resulted in a poor depiction of the action (e.g., *add, melt*). Many of the nouns were also difficult to portray unambiguously on videotape (e.g., *deer, thorn*), but were relatively easy to depict in a line drawing. Consequently, an additional 10 verbs and 19 nouns, selected from frequency norms as set out above, were combined with the 18 verbs and 9 nouns from the picture naming task that could be successfully filmed. The videotaped stimuli initially consisted of 28 action/object pairs, only some of which had been presented in the picture naming task. Since the primary purpose of the video presentation was to investigate a possible enhancement of *verb* production using video format, nouns were matched item by item to the *lower* (base) frequen-

[3] *t* Tests are carried out on arcsine transformed proportion correct. Analyses of individual patient data when N is small (< 30) were done with Fisher's Exact Test (FI), with two-tailed test of probability unless otherwise noted. Comparisons with larger N were assessed with χ^2 Test, with two-tailed probability estimate corrected for continuity (Yates correction).

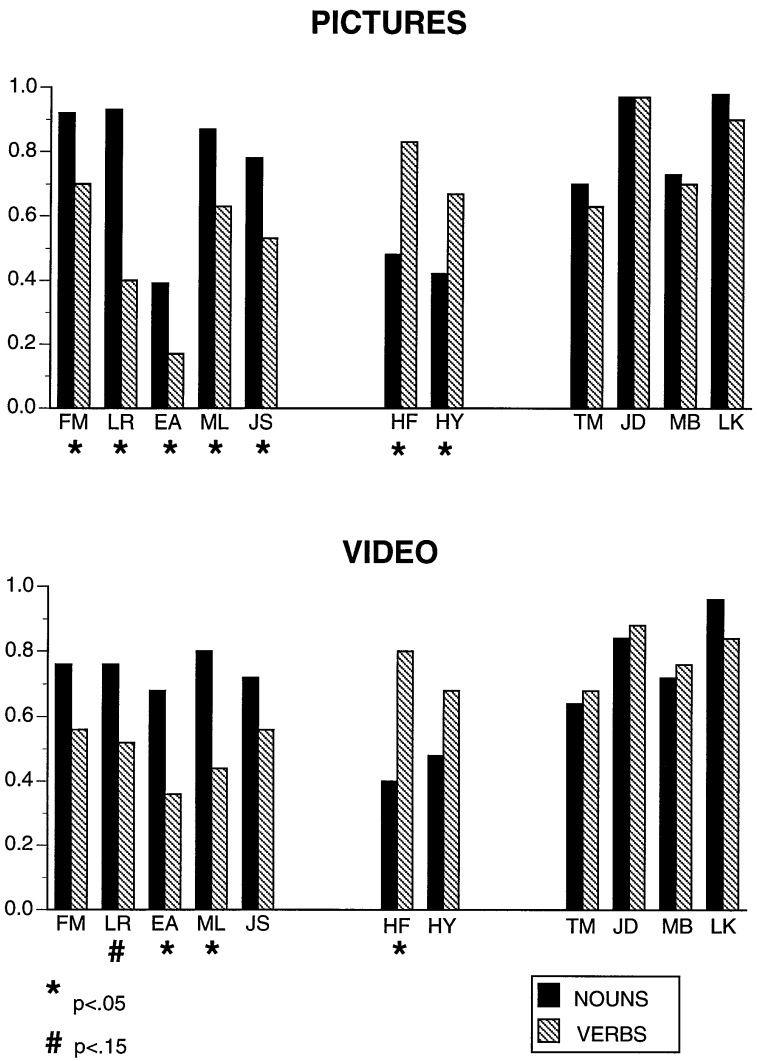

FIG. 1. Proportion correct production of frequency-matched nouns and verbs by 11 aphasic patients naming pictures (top) and video depictions (bottom) of actions and objects. (Number of stimuli: picture task, 30 verbs and 60 nouns; video task, 25 nouns and 25 verbs.)

cies of the verbs. Failure by two or more control subjects to identify the intended verb target resulted in the elimination of three verb/noun pairs. The final set of stimuli thus consisted of action and object video sequences that were easily identifiable as the 25 frequency-matched pairs of target nouns and verbs. (These are listed with their frequencies in Appendix A.) Each noun and verb was represented by a 7-sec video segment, as described above.

Instructions were identical to those employed for the picture naming task. Action naming

was administered first for all patients to avoid the establishment of an object naming response that could interfere with action naming.

Results. As shown in Fig. 1 (bottom), the relative patterns of noun/verb production that had been shown in picture naming were maintained, although only three patients demonstrated a statistically reliable difference when naming the smaller set of videotaped stimuli. EA continued to show a significant advantage for nouns (FI 5 5.04, p 5 .05), as did ML (FI 5 6.79, p 5 .02). HF again produced significantly more verbs than nouns (FI 5 8.27, p 5 .009). Three patients who had shown a significant noun advantage in naming pictures continued to produce nouns better than verbs, but this difference was not statistically reliable when naming from video (FM, FI 5 2.18, p 5 .23; LR, FI 5 3.05, p 5 .14; JS, FI 5 1.37, p 5 .38). Similarly, one of the two patients with significant verb advantage when naming pictures produced only a nonsignificant difference in the same direction when naming from video (HY, FI 5 2.01, p 5 .25).

To determine the source of these modulations in noun/verb differences across tasks, each patient's production of verbs and of nouns was compared across picture and video naming. It was expected that video presentation would lead to *improved* verb production if one source of action naming difficulty involved identifying the action component in a static picture. In fact, no patient showed a significant difference in the ability to name actions as a function of the task. In contrast, the ability to name *objects* in the two tasks differed for several patients: LR was significantly better able to name objects from line drawings than from video (FI 5 4.73, p 5 .03); FM showed a similar but weaker effect (FI 5 3.66, p 5 .06). Thus, for these two patients, the attenuation of the noun/verb difference that was found in video naming compared to that seen in picture naming was attributable not to *better* naming of verbs from video, but to *worse* naming of nouns from video.

The problem that FM and LR experienced when naming objects presented on video does not apparently reflect general difficulties with interpretation of the videotaped segments, since there was no difference in performance of the two tasks for the 11 patients as a group in production of nouns (t(10) 5 1.48, p . .10) or of verbs (t(10) 5 .61, p . .50). Furthermore, patient EA also showed a significant difference in noun production as a function of picture vs. video task (FI 5 6.88, p 5 .009), but his performance was *better* when objects were presented in video format than when pictured in a line drawing. Thus, the fluctuations that occurred in the naming of objects across the two tasks presumably reflect item-specific factors relevant to the noun stimuli, rather than a general problem with the video depictions. When verb production was poor, it was poor in both elicitation formats.

Frequency Analysis

Word stimuli for the video naming task, as well as for the picture naming task, were selected from norms to cover a wide spectrum of frequency of

occurrence. In order to determine whether the differences in noun and verb production uncovered here were limited to some portion of the frequency continuum, patients' peformance on the two tasks was analyzed by frequency. For the picture naming stimuli, verbs and the nouns matched to their base frequencies were each divided into high-frequency and low-frequency items. A similar division was made for the nouns and verbs elicited from video scenes. Table 2 shows the frequency means and standard deviations for the resulting high- and low-frequency stimuli, as well as the mean proportion of high- and low-frequency words produced correctly by each patient. There was an overall effect of frequency on the group's performance ($t(10) = 2.74$, $p = .02$), and as shown in Table 2, there were significant frequency effects for several patients (ML, $\chi^2 = 5.04$, $p = .02$; JS, $\chi^2 = 4.61$, $p = .03$; HF, $\chi^2 = 11.94$, $p = .001$; and HY, $\chi^2 = 6.56$, $p = .01$).

The patients with clear frequency sensitivity demonstrated robust differences in noun and verb naming that cut across the frequency differences. Figure 2 displays the grammatical class by frequency data for each patient. For four of the five verb-impaired patients (leftmost group), the lowest frequency nouns were retrieved as well as or better than the highest frequency verbs; JS showed a very small frequency overlap. An opposite effect is shown for the two patients with relative noun impairment (middle group). For these patients, verbs had an advantage even when they fell in the low frequency range. It appears, then, that the noun/verb differences that have emerged are more powerful than retrieval differences based on frequency of occurrence.

Error Analysis

The responses produced by patients when they failed to name noun and verb targets in the picture and video naming were analyzed using an adaptation of an error classification system developed in earlier work (Mitchum, Ritgert, Sandson, & Berndt, 1990; see also Kohn & Goodglass, 1985). Semantic errors included words related to targets either associatively (e.g., *kitchen* $\rightarrow$ coffee) or categorically (e.g., *shoe* $\rightarrow$ boot). Semantic errors were divided on the basis of their grammatical class to investigate the extent to which patients' responses maintained the grammatical class of the target. Semantic substitutions of words in the alternate grammatical class were necessarily associatively related to the target (e.g., *road* $\rightarrow$ driving; *write* $\rightarrow$ letter). These alternate-class substitutions sometimes named an element of the picture or video stimulus that was not the target, especially noun substitutions when verbs were the targets. Often, however, the alternate-class response was not explicitly pictured but was related only indirectly to the target (e.g., *wait* (elicited with a video of a woman standing at a bus stop) $\rightarrow$ ''bus'').

Phonological errors shared at least half the target's phonemes. Circumlo-

TABLE 2
Proportion of Pictures and Video Segments Named Correctly (Collapsed across Action/Object), as a Function of Word Frequency

Frequency mean (sd)	FM	LR	EA	ML	JS	HF	HY	TM	JD	MB	LK
High, 76 (58) (N 5 52)[a]	.77	.63	.40	.79	.75	.79	.69	.67	.92	.79	.92
Low, 4 (3) (N 5 58)	.72	.67	.43	.57 p 5 .02	.53 p 5 .03	.45 p 5 .001	.43 p 5 .01	.69	.91	.64	.91

[a] Unequal *N*s reflect poor performance of controls on three high frequency verbs in the video condition, resulting in deletion of those items and matched nouns.

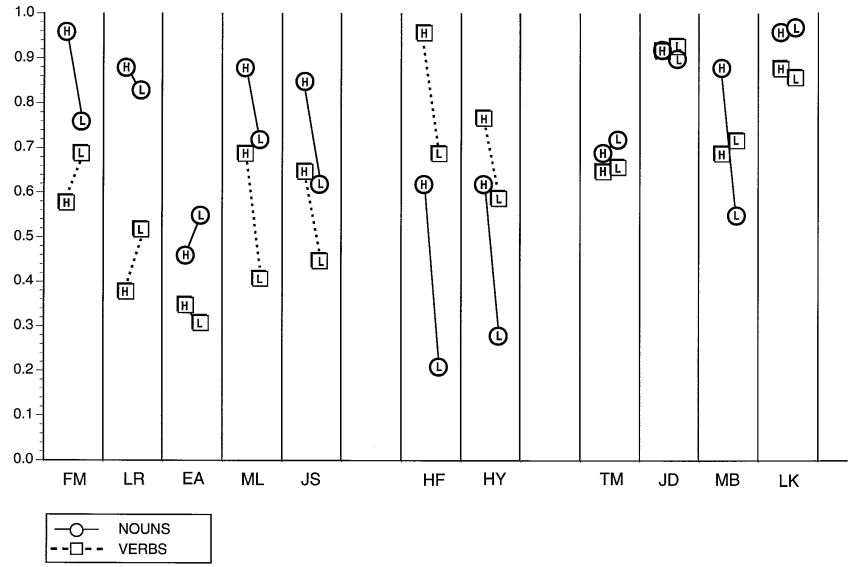

FIG. 2. Proportion correct nouns and verbs produced by 11 aphasic patients naming actions and objects from pictures and video, shown as a function of word frequency (high frequency $N = 26$, low frequency $N = 29$, for each class).

cutions included sentences or phrases with some relevance to the target. For purposes of this analysis, other types of responses (e.g., gestures, neologisms, unrelated words, and failures to respond) were collapsed into a single category labeled ''other.''

Results. Preliminary inspection of error patterns found no obvious differences between errors produced to pictures and video. Table 3 thus presents the proportion of errors of each type produced by the 11 patients collapsed across the two tasks. Several different error patterns can be detected in the responses. For three of the five patients with relative verb impairments (top group of Table 3), the predominant type of error involved semantic substitution. A fourth patient (EA) also produced a considerable number of semantic errors, but more often failed to respond or attempted to gesture in lieu of a verbal response (. 50% errors classed as ''other''). Patient JS produced an error pattern different from all other patients in that his errors tended to be phonologically related to the targets. This pattern suggests that the functional basis of JS's word retrieval impairment may be different from that of the other patients, since it has been argued that error patterns may be one index of the functional source of retrieval impairments (Howard & Orchard-Lisle, 1984; Kay & Ellis, 1987; Nickels, 1995).

The most striking aspect of the error patterns of the verb-impaired patients (JS aside) is their production of nouns instead of verbs when actions were

TABLE 3
Proportion of Errors of Different Types for Nouns (N 5 85) and Verbs (N 5 55) in Picture Video and Naming Tasks

Patient		No. (prop.) of errors	Error Type: Semantic: Same class	Semantic: Alternate class	Phonological	Circumlocution	Other[a]
			Relative verb impairment				
FM	Ns	11 (.13)	.91	.00 p , .05	.09	.00	.00
	Vs	20 (.36)	.35	.55	.05	.00	.05
LR	Ns	10 (.12)	.70	.20 p , .05	.10	.00	.00
	Vs	30 (.55)	.17	.57	.00	.03	.23
EA	Ns	45 (.53)	.38	.06 p 5 .06	.00	.00	.56
	Vs	40 (.73)	.25	.20	.05	.00	.50
ML	Ns	13 (.15)	.46	.08 p , .05	.23	.23	.00
	Vs	25 (.45)	.36	.44	.00	.12	.08
JS	Ns	20 (.23)	.05	.00	.70	.10	.15
	Vs	25 (.45)	.32	.12	.36	.12	.08
			Relative noun impairment				
HF	Ns	46 (.54)	.44	.04	.02	.35	.15
	Vs	10 (.18)	.40	.00	.00	.40	.20
HY	Ns	48 (.56)	.17	.02	.00	.58	.23
	Vs	18 (.33)	.44	.11	.00	.28	.17
			No selective noun or verb impairment				
TM	Ns	27 (.32)	.37	.00	.00	.04	.59
	Vs	19 (.35)	.21	.16	.00	.00	.63
JD	Ns	6 (.07)	.83	.00	.17	.00	.00
	Vs	4 (.07)	.75	.00	.00	.00	.25
MB	Ns	23 (.27)	.64	.00	.05	.18	.13
	Vs	15 (.27)	.63	.06	.00	.00	.31
LK	Ns	2 (.02)	1.00	.00	.00	.00	.00
	Vs	7 (.13)	.71	.14	.00	.00	.15

[a] ''Other'' includes failures to respond, gestures or writing in lieu of verbal response, and errors (words and nonwords) completely unrelated to the target.

the naming target (see Table 3, production of ''alternate class'' semantic errors). This tendency was maintained despite repeated recueing to the need to name the *action.* In addition, patients frequently demonstrated (e.g., through gesture) that they were attempting to name the action, even when they produced a noun instead. Furthermore, there was no attenuation of noun substitution for these patients when naming from video, which might have been expected if they had failed to understand the action-naming task requirements or to identify the action depicted in a static picture.

The two patients with selective noun production impairment (middle group of Table 3) showed little tendency to substitute across grammatical class. These patients tended to produce the kinds of circumlocutions typical in anomic aphasia (Kohn & Goodglass, 1985) when naming both actions and objects.

The remaining patients produced many semantically related errors for both classes of targets, but did not demonstrate a strong tendency to substitute nouns for verbs. It should be mentioned that the large proportion of TM's errors classified as ''other'' are largely ''failures to respond,'' which suggests that TM had adopted a very conservative criterion for responding only when he was relatively certain of success.

Producing Nouns and Verbs in Response to Spoken Sentence Cues

Materials and procedures. Fourteen pairs of base frequency-matched nouns and verbs from the picture naming task (indicated in Appendix A) were selected on the basis that both members of the pair could be embedded predictably into a sentence context, and that simple and transparent definitions could be formulated for each of them. Definitions were slight modifications of those described by Zingeser and Berndt (1990), for which norms were available from a group of 40 undergraduates (Zingeser & Berndt, 1990, p. 17). Definitions for verbs took the form ''What do you call it when you . . . . '', e.g., ''What do you call it when you put words on paper with a pen?'' A sentence completion item was formed from each definition, which for verbs used an infinitive completion such as ''To put words on paper with a pen is to . . . . '' For nouns, the definition format was ''What do you call the . . . '', for example, ''What do you call the tall woody plant with bark and leaves?'' Sentence completion items were generated from noun definitions, for example, ''The tall woody plant with bark and leaves is a . . . . ''

These two tasks were developed later than other tasks and were given toward the end of the administration of the battery. Three patients (JS, HF, and TM) had already completed testing and were not available when these tasks were administered. The definitions and completions formats were presented in separate testing sessions.

Results. As noted above, 8 of the original 11 patients contributed data to this analysis. The number of nouns and verbs produced correctly in these two auditory tasks was compared to the data for the same 14 items that had been elicited through picture naming. A comparison of naming ability for these items across the eight patients indicated that the three tasks were not comparable in difficulty. Naming pictures was significantly easier for the group than was producing the same names in response to definitions ($t(7) = 2.8$, $p = .02$), or as sentence completions ($t(7) = 3.5$, $p = .01$), while

the latter two tasks did not differ for the group ($t(7) = 1.8$, $p > .10$). These differences presumably reflect the demands of auditory comprehension for the definitions and completions paradigms. Restricting the analysis to the four patients demonstrated to have problems retrieving verbs relative to nouns in picture naming uncovered a similar pattern of picture naming easier overall than either completions ($t(3) = 2.9$, $p = .06$) or definitions ($t(3) = 6.44$, $p = .007$), but naming from definitions for this group was more difficult than was completing sentences ($t(3) = 4.48$, $p = .02$). This was true to some extent for all four patients, despite the very close similarity of the two auditory tasks (the major lexical items employed were identical).

Superior performance on sentence completion as compared to picture naming and definitions has been noted in clinical practice without theoretical interpretation (but see Zingeser & Berndt, 1988). Examination of the error patterns of the verb-impaired patients on the tasks administered in this study suggests one possible explanation, at least for the patients described here. As illustrated in Table 3, the verb-impaired subjects frequently produced noun responses to verb targets in the picture and video naming tasks, accounting for 38% of their total action naming errors. This tendency was exacerbated in the definitions task for the four verb-impaired patients who were tested, accounting for 59% of total action naming errors. The completions task, in contrast, did not elicit noun substitutions; only one of the four subjects (ML) produced more than one such error. This pattern suggests that superior sentence completion performance (compared to definitions) may be attributable to the greater syntactic constraints that the completion task places on production of words from specific grammatical classes.

An inspection of the number of items named correctly across the three tasks for the four verb-impaired patients shows two distinct patterns. Patients LR and EA (Fig. 3), who had demonstrated a significant verb retrieval impairment in the full picture naming task ($N = 30$ verbs), produced no difference between the subset of nouns and verbs probed with sentence completions and definitions. EA also showed very little difference between verbs and nouns when naming these selected 14 picture pairs, although floor effects may obscure some actual differences. In contrast, shown in Fig. 4, FM and ML maintained the advantage of nouns over verbs across the three tasks. Analysis of combined responses in the naming to definitions and sentence completion tasks revealed reliably better production of nouns than verbs for both FM (FI = 6.09, $p = .007$, one-tailed) and ML (FI = 2.53, $p = .05$, one-tailed). For these two patients, diminished retrieval of the target nouns in the auditory tasks was accompanied by an exacerbation of their selective difficulty producing verbs. The remaining four patients had not demonstrated noun/verb differences in picture naming and continued to perform equivalently for the two types of words in the auditory tasks.

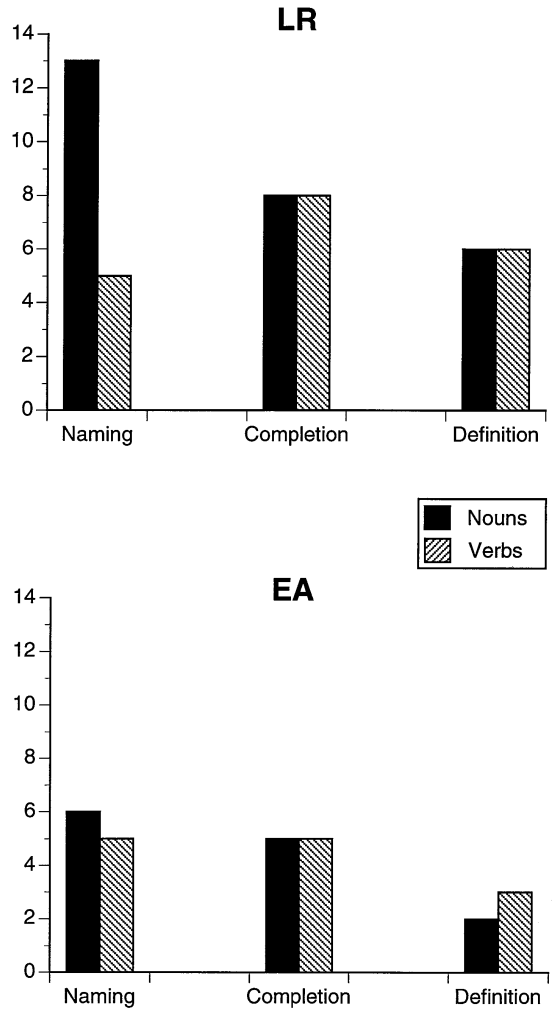

FIG. 3. Number correct productions of nouns and verbs by patients LR and EA in three elicitation conditions.

Oral Reading of Nouns, Verbs, and Ambiguous Words

Materials and procedures. The inclusion of a noun and verb oral reading task allowed the testing of abstract words that could not be depicted in the naming tasks described above. Since it is known that a word's imageability can influence patients' reading independently of grammatical class (Coltheart, 1980), we attempted to control imageability within the grammatical class factor. Twenty-four unambiguous verbs and an equal number of unambiguous nouns were selected from frequency norms. Imageability norms were taken from Paivio, Yuille, and Madigan (1968) for nouns and from Klee and Legge (1976) for verbs. Norms were not available for 12/48 of the unambiguous noun/verb stimuli nor for any of the class-ambiguous

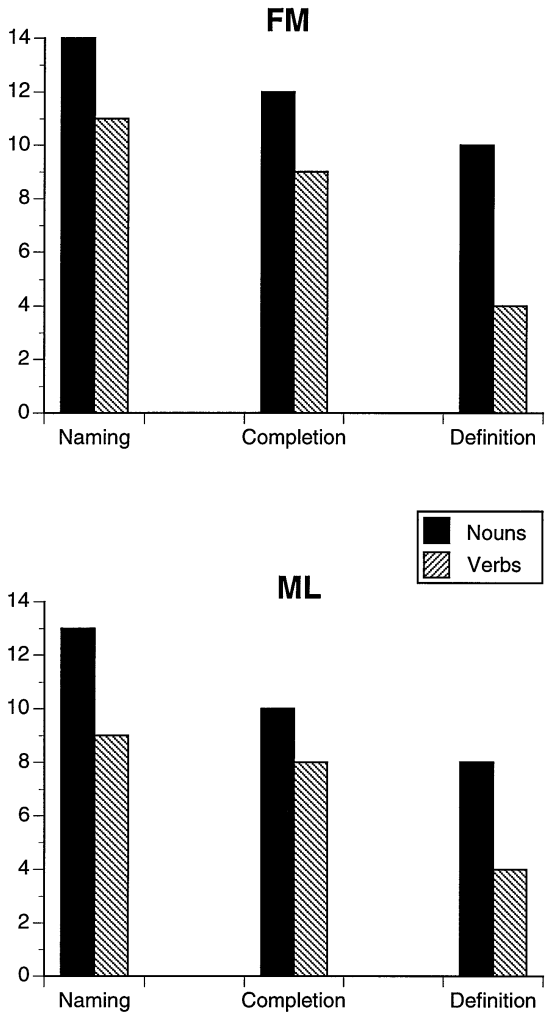

FIG. 4. Number correct productions of nouns and verbs by patients FM and ML in three elicitation conditions.

words. In these cases, an independent judge classified words as imageable or nonimageable based on how easily the word could be pictured. Stimuli were also roughly matched for letter length. Thus, in each grammatical class, four frequency-matched cells of six words were created by crossing the factors of length and imageability. An additional set of 24 grammatical class-ambiguous words was included. These words were also divided into four groups of six based on length and imageability, although frequencies are necessarily higher in general than for unambiguous words (because of dual function as nouns and verbs). The entire set of oral reading stimuli, with frequencies, appears in Appendix B. Words were randomized, printed in large type, and presented in list form.

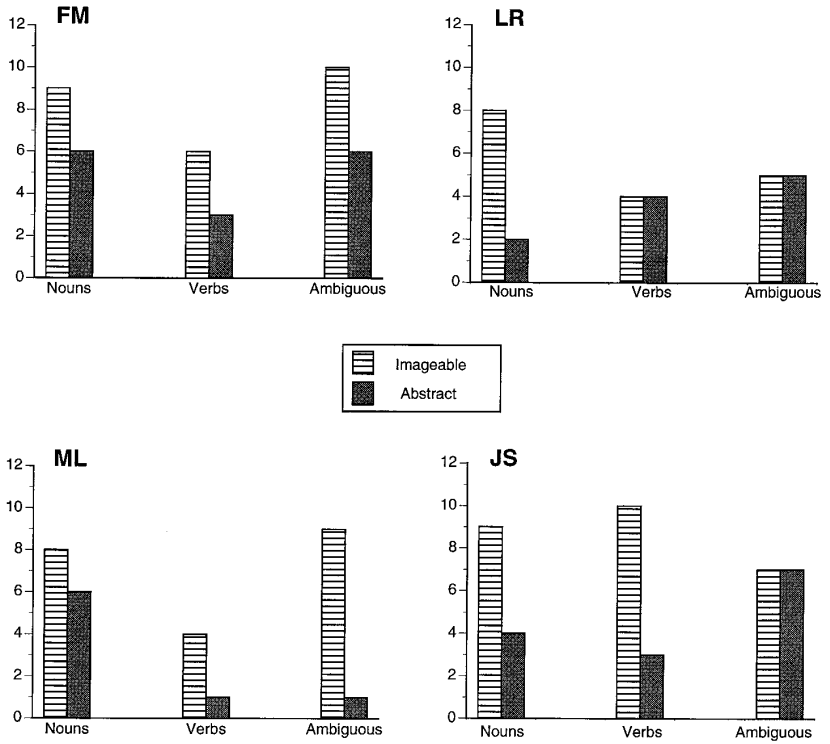

FIG. 5. Number of imageable and abstract words read aloud correctly by four patients with relative verb impairment.

Results. Although all 11 patients completed this task, only 8 patients demonstrated enough variability in performance to support a meaningful analysis. The oral reading abilities of two of the patients (EA and HY) were considerably worse than their ability to produce words in other contexts. Their performance of this task was very poor and will not be considered further. Patient LK, in contrast, completed the reading task without error; her data are also omitted from the analysis.

There was no difference in overall reading performance for the four patients with verb production impairment (M 5 .48) and the four patients without evidence of such impairments (M 5 .67; $t(6)$ 5 1.84, p 5 .12), nor were there group differences in the ability to read nouns ($t(6)$ 5 1.15, p 5 .29) or ambiguous words ($t(6)$ 5 2 1.93, p 5 .10). However, the ''verb impaired'' group read significantly fewer verbs correctly (M 5 .38) than did the patients without verb production impairment (M 5 .77; $t(6)$ 5 2 2.64, p 5 .04).

Figure 5 shows the noun/verb performance of the four ''verb impaired''

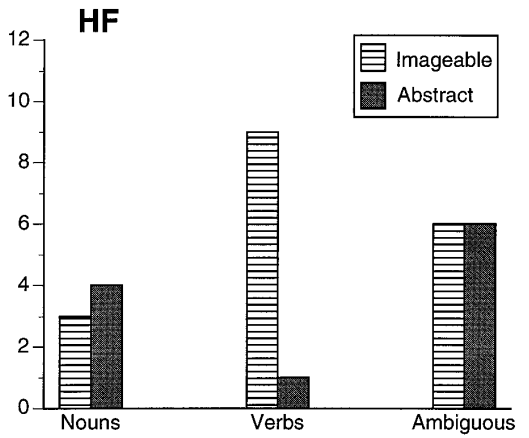

FIG. 6. Number of imageable and abstract words read correctly by patient (HF) with relative noun impairment.

patients separately for the imageable and nonimageable words. FM and ML showed poorer verb than noun reading for both types of words. FM read ambiguous words (regardless of imageability) at a level that corresponded to his reading of nouns. In contrast, ML read imageable, ambiguous words at a level comparable to his reading of imageable nouns, while abstract verbs and abstract ambiguous words were read comparably poorly. LR demonstrated a strong noun/verb difference only for imageable words. The fact that imageable nouns were the only category of word she could read at least reasonably well suggests that LR's noun/verb difference in other tasks could represent preservation of imageable nouns relative to all other words, rather than selective impairment of imageable verbs. JS showed a strong imageability effect for both nouns and verbs with no tendency for better performance on nouns.

Figure 6 presents the same data for HF, who had shown a robust advantage of verbs over nouns in the naming tasks. In reading he showed this advantage only for imageable verbs; ambiguous words (regardless of imageability) were also read better than nouns.

Summary and Discussion, Single-Word Production

Of a group of 11 patients tested, five showed reliably better production of nouns when naming objects than of frequency-matched verbs when naming actions in a picture naming task. Three of these patients (see Table 1) were nonfluent patients who produced the morphological omissions that are characteristic of agrammatism; the other two patients (ML and JS) were fluent

speakers who showed some of the symptoms of Wernicke's aphasia. These results suggest that the selective difficulty in the production of verbs that has been reported for agrammatic patients in previous studies (Miceli et al., 1984; Zingeser & Berndt, 1990) is not limited to patients falling within the clinical group of agrammatic Broca's aphasics. In fact, one of the patients who showed no difference between noun and verb production in this study (TM, see below), is a classically agrammatic patient. Thus, particular difficulties with the retrieval of verbs relative to nouns does not necessarily co-occur with the difficulty producing grammatical morphemes that characterizes agrammatism.

The two patients in this study who showed reliably better production of verbs than of nouns (HF and HY) demonstrated the clinical characteristics of anomia that have been noted previously in patients with superior verb production (Miceli et al., 1984; Zingeser & Berndt, 1990). The occurrence of this pattern of performance (verbs better than nouns) is interesting in its own right (cf. Breen & Warrington, 1994; Zingeser & Berndt, 1988) and is critical to the interpretation of selective verb impairments. The fact that some aphasic patients can be shown to produce verbs consistently *better* than nouns indicates that selective verb impairments do not occur because verbs are inherently more difficult to produce than nouns and thus more sensitive to the effects of brain damage.

This set of experiments on single-word production yielded no evidence to suggest that diminished ability to produce verbs relative to nouns occurs because patients have difficulty extracting the nameable ''action'' component from a picture. Although some individual patient differences emerged in action/object naming as a function of whether stimuli were presented as static line drawings or in dynamic video format, these involved differences in the accessibility of *nouns* rather than of verbs in the two tasks. Although it is possible that other sorts of problems at the ''message'' level could undermine the production of verbs selectively, these results seem to rule out the most obvious candidate for a message-level source of selective verb production impairment, at least for these patients.

Analysis of patients' errors showed a general tendency to produce words that shared some elements of meaning with the targets. Many of the patients produced more semantic errors than other error types, but only patients with relative difficulty producing verbs tended to violate the grammatical class of the target. When the task strongly constrained the patient to produce *verbs* (sentence completion), production of noun-for-verb substitutions decreased although performance relative to noun production remained poor.

One important factor that was found not to influence selective grammatical class effects was frequency of occurrence. Although frequency was a strong general predictor of performance for some patients, it was overwhelmed by grammatical class differences for the patients who showed significant noun/

verb differences when naming pictures. This result supports the claim that grammatical class differences are not an artifact of the difficulty or providing adequate frequency matching between nouns and verbs.

Another factor that *did* appear to affect the emergence of a noun/verb difference for some patients was the ''imageability'' of the words' referents. Although FM and ML showed poor performance reading aloud unambiguous verbs relative to nouns (in an oral reading task), regardless of the words' imageability, other patients (LR, JS, and HF) did not show a noun/verb difference for nonimageable words. The fact that all three of these patients read abstract words very poorly mitigates this finding, as grammatical class differences may have been masked by floor effects. Clearly, more information is needed from other tasks on the production of nouns and verbs that do not name objects and actions.

The data reported here also provide information about two other factors that might be important in the emergence of noun/verb differences: severity of patients' word retrieval impairments and the consistency of patterns across testings. With regard to the first issue, it might be possible that grammatical class differences emerge only when patients' word retrieval symptoms are relatively mild. Because most of the patients with selective grammatical class deficits (ML, FM, LR, and HF) produced one class of unambiguous words at a high level, the difference might be viewed as a selective *preservation* of one class of word. Evidence against such an argument is the fact that grammatical class differences can occur within the context of poor overall naming ability, where neither class seems to have been ''spared.'' For example, EA's production of nouns when naming pictures was quite poor—worse than the noun production of the two patients with selective impairment of noun production! Nonetheless, EA's verb production was still significantly worse than his noun production. Other patients with relatively poor general word retrieval (MB and TM) showed no selective impairment as a function of grammatical class. These patterns suggest that grammatical class differences do not necessarily emerge when word retrieval is poor, although they can do so. Moreover, their occurrence does not require preservation of one class of words.

The issue of consistency of response patterns across testings is an important issue that is frequently ignored in studies of naming. Clearly, interpretation of patterns of performance as indications of specific underlying deficits requires that the pattern be a stable feature of a patient's responses. For this reason, we have emphasized the variations and consistencies across tasks for individual patients. In addition, the grammatical class differences found here can be shown to characterize an individual patient's performance over repeated testings spanning months or even years (see, for example, discussion of ML's performance in Mitchum & Berndt (1994) and of EA's naming in Mitchum, Haendiges, & Berndt (1993)). Two of the patients tested in this study (FM and HY) had shown the same pattern as reported here when tested

with the picture naming materials several years earlier (see Zingeser & Berndt, 1990). Comparison of present results with those of that earlier study[4] uncovered only one inconsistency, which we view as an indication of a changing response criterion.[5] The consistencies shown across tasks in this study, in conjunction with the information available about the consistency of noun/verb differences in patients who have been followed for several years, indicate that grammatical class production differences can be a stable characteristic of chronic aphasia.

2. COMPREHENSION OF NOUNS AND VERBS

The previous section demonstrated the occurrence of selective grammatical class impairments for the production of isolated nouns and verbs across a range of tasks. This section explores the possibility of comparable, co-occurring comprehension impairments in the same patients, a pattern reported for Italian-speaking patients by Miceli, Silveri, Nocentini, and Caramazza (1988). Two separate aspects of comprehension were tested: appreciation of the grammatical class (and semantic category) distinction *between* verbs and nouns (action and object names) and comprehension of subtle distinctions in meaning *within* the classes of nouns and verbs.

Appreciation of Grammatical Class Distinctions

An attempt was made to determine whether or not the patients understood that nouns and verbs are essentially different kinds of words. Two types of metalinguistic judgments were elicited using the same set of unambiguous nouns and verbs.

Materials and procedures. The short nouns and verbs from the oral reading task (see Appendix B) served as the basic stimuli for these tasks.[6] For *noun/verb sorting,* each word was printed on a 3 3 5 card and randomized. Patients were asked to sort the cards into two stacks

[4] Patients LR and JS reported by Zingeser and Berndt (1990) are not the same LR and JS reported in this study. The only patients participating in both studies were FM, TM, and HY, as discussed.

[5] TM had named pictured actions significantly more poorly than he named objects when tested in January of 1987, but he showed no such difference in April of 1989 when tested for this study. This difference cannot be attributed to general recovery of word retrieval abilities: although production of verbs did improve somewhat across the two testings from .50 to .63 correct (FI 5 1.08, p 5 .30), noun production *declined* significantly from .88 to .68 correct (FI 5 7.06, p 5 .008). As noted above, TM's errors on this current testing suggested that he was unwilling to attempt a response unless certain that he was correct. This strategic shift of response criterion may have masked noun retrieval abilities that were uncertain but nonetheless better retained than the data suggest. In any event, TM's change of performance pattern indicates the need for caution in interpreting the results of a single task for an individual patient (see also Berndt, Mitchum, & Haendiges, 1996).

[6] Despite the rather stringent control employed for grammatical class ambiguity, control subjects indicated that two noun stimuli (''bowl'' and ''baby'') were ambiguous for grammatical class. Length and frequency matched words ''lamp'' and ''lake'' were substituted for purposes of this task.

to represent *verbs* (also cued with ''actions,'' ''things you *do*''), and *nouns* (''persons, places, or things''). Each word was read aloud to the patient as the card was presented for sorting. Four practice items preceded the test items and were used for further clarification and instruction.

Since patients' comprehension of the words ''noun'' and ''verb'' (as well as the other cueing words used) may have favored the picturable words, a second metalinguistic judgment task that employed short noun and verb phrases was administered. In this *phrase judgment task*, each of the words was preceded, in separate administrations, by the words ''the'' and ''will.''[7] Patients were asked to judge whether or not each spoken phrase (e.g., ''the bird'') could be used grammatically in a sentence. Again, extensive instruction with the practice items preceded the task. HF and TM did not participate in these metalinguistic tasks.

Results. Table 4 shows the proportion of correct judgments for the two tasks separately for imageable and abstract stimulus words. The imageability manipulation appeared to be an important factor in the performance of the sorting task. Although four of the nine patients could distinguish nouns from verbs when the words were imageable, only two of these patients continued to do so when the words were not picturable. Interestingly, the patient with the poorest verb retrieval ability (EA), who frequently produced nouns instead of verbs when naming, was quite sensitive to grammatical class distinctions in this receptive task.

The instructions for the sorting task, which interspersed discussion of ''actions'' and ''things'' with the grammatical class labels ''verb'' and ''noun,'' might have been expected to contribute to the difference that emerged between imageable and abstract words. However, results of the phrase judgments task, which did not employ instructions favoring action/object interpretations of nouns and verbs, continued to show a strong effect of imageability. Seven of the nine patients were able to perform the judgments above chance when the nouns and verbs were imageable, but only two of them maintained this above-chance performance with abstract words.

There appears to be little relation between appreciation of grammatical class differences and selective impairment of verb or noun *production.* Patient MB, who was unable to distinguish between nouns and verbs in these tasks, produced the two types of words at equivalent levels when naming. More importantly, several of the patients with selective verb production impairment (especially EA) were quite sensitive to grammatical class, indicating that their frequent substitution of nouns for verbs when naming actions did not arise from a basic lack of understanding of grammatical class distinctions.

Comprehension of Meaning

Materials and procedures. Two tests were designed to assess patients' comprehension of isolated, referential words in conditions in which a word's meaning needed to be distinguished

[7] The overall number of stimuli was further reduced for this task because two of the verbs (''owe'' and ''earn'') are homophones of nouns and thus inappropriate for this auditory

from a closely related meaning. In the *photo matching* test, 30 picturable, unambiguous verbs were frequency matched to an equal number of picturable, unambiguous nouns. Half of the noun/verb pairs were relatively high in frequency (base frequency greater than 49/m), and half were low (less than 12/m). Distractors were chosen to be an activity (for verbs) or an object (for nouns) closely related in meaning to its target. (Stimulus words and distractors appear in Appendix C). Black and white photographs, mounted individually on cards, were produced for each action and object and their distractors. Target and distractor pictures were arranged vertically, randomizing the position of the target. Patients were asked to point to the photograph that best depicted the spoken stimulus word, which for verbs used the uninflected form. Nouns and verbs were presented separately, in random order.

The *video verb comprehension test* consisted of 20 pairs of videotaped action scenes presented in split-screen format. Since the goal was to test comprehension of closely related verbs, stimuli were selected to include 10 pairs of verbs in which the members of the pair shared several components of meaning;[8] because of the limited number of available pairs, frequency and ambiguity were not closely controlled. Both actions within a single trial were portrayed by the same actor (e.g., boy, girl, woman, man). After the examiner read the target word to the patient, a target and a distractor scene were presented individually on one-half of the video screen (for 10 sec). Both scenes were then presented simultaneously on the same sides of the screen as they had previously appeared, for 10 sec. The patient responded by pointing to one side of the screen. The target occurred on the left side of the screen in half of the trials and on the right side in half the trials in a counterbalanced design.

Although all patients were available to participate in these tasks, LR could not tolerate the visual/perceptual demands of the split screen video. Her incomplete data were omitted from this analysis.

Results. There was no overall difference in difficulty of noun and verb comprehension on the photo matching test ($t(10) = 1.77$, $p = .11$), and all patients performed in both tasks at better than chance levels (binomial test, $p < .05$). As shown in Table 5, only one patient (HY) was significantly better able to comprehend nouns than verbs (FI = 10.79, $p = .001$). This result represents a pattern opposite to the selective impairment that HY had shown in production, where he was better able to produce *verbs* than nouns. Of the patients with verb production impairment, only EA and JS showed some problems with verb comprehension (in both tasks), but both of these patients performed better in comprehension than did MB, who had shown no selective verb impairment in production.

Summary and Discussion, Comprehension Tasks

The consistent difficulties *producing* verbs or nouns that had characterized the performance of seven patients were not observed in the results of comprehension testing. It is difficult to compare directly the results of comprehension tasks (which provide the patient with a small number of choices) with

task. Further, two control subjects found the phrases ''the dig'' and ''will corn'' to be acceptable, and these items were removed from the analysis.

[8] The pairs included kick/hit, praise/punish, free/capture, shoot/stab, pay/rob, surprise/scare, scratch/tickle, dry/wash, hug/kiss, and help/hinder.

TABLE 4
Proportion Correct Noun and Verb Metalinguistic Judgments in Two Tasks (Chance 5 .5)

	FM	LR	EA	ML	JS	HY	JD	MB	LK
				Sorting nouns and verbs					
Imageable (*N* 5 12)	.67	.33	1.00**	.75	.92*	1.00**	.42	.50	1.00**
Abstract (*N* 5 12)	.42	.42	.83**	.50	.58	.50	.17	.58	1.00**
				Phrase judgments (‘‘the’’/‘‘will’’)					
Imageable (*N* 5 20)	.85**	.95**	.80*	.75*	.60	.86**	.90**	.60	1.00**
Abstract (*N* 5 16)	.69	.88**	.75	.75	.56	.56	.75	.75	1.00**

* Score differs from chance performance, p , .05.
** Score differs from chance performance, p , .005.

TABLE 5
Proportion Correct Word Comprehension in Two Tasks with Semantic Distractors (Chance 5 .5)

	FM	LR	EA	ML	JS	HF	HY	TM	JD	MB	LK
					Word/photo matching						
Nouns (N 5 30)	1.00	.90	.93	.93	1.00	.97	.97	.97	1.00	.80	1.00
Verbs (N 5 30)	.93	.93	.87	.93	.87	.93	.63	1.00	1.00	.70	1.00
							N . V, p 5 .001				
					Word/video enactment matching						
Verbs (N 5 20)	1.00	Could not test	.80	.90	.80	.95	1.00	.95	.95	.75	1.00

Note. All scores differ from chance, p , .05.

actual production of words. Nonetheless, interpretation of the underlying functional basis of the production impairment requires some information about patients' knowledge of noun/verb differences and of word meanings. For example, co-occurring selective impairments in the production and comprehension of words within a grammatical class could be taken as evidence for a central and modality-independent disruption of a particular class of words (McCarthy & Warrington, 1985). In contrast, the *absence* of comprehension impairment has been taken as one piece of evidence that selective grammatical class production impairments can be located in processes or representations that are specific to word production (Caramazza & Hillis, 1991). Our results support the argument that there is no necessary relationship between difficulty producing nouns or verbs and difficulty comprehending their meanings (see also Bates et al., 1991). Further, results of the sorting and judgments tasks indicate that some patients with selective impairment *naming* actions, who frequently produce the names of objects in lieu of action names, nevertheless demonstrate appreciation of the fact that nouns and verbs are different kinds of words that function differently in phrases.

GENERAL DISCUSSION

The results reported here provide further evidence that words from different ''content word'' grammatical classes can be selectively affected in aphasia, and that such effects are unlikely to be artifacts of static depiction of actions, of a failure to match frequency adequately, or of ambiguity of grammatical class usage for target words. Although there may be other confounds undermining our claim of selective impairment of words of different classes, the contribution of the most obvious potential artifacts has been minimized in this study. Furthermore, these results provide evidence that some selective word class differences actually reflect the influence of grammatical class (noun/verb) rather than semantic category (action/object). The two patients whose oral reading data were not subject to floor effects (FM and ML) maintained clear noun/verb differences with abstract stimulus words that were not members of the semantic categories of concrete objects and picturable actions (see also Caramazza & Hillis, 1991). On the basis of these results, we assume that focal brain damage can affect content words selectively as a function of their usage in the grammatical classes of noun and verb. We now turn to a consideration of the functional source of these effects within the model of production outlined in the Introduction.

The results reported here effectively counter the most obvious candidate source of action-naming impairment attributable to problems in the Conceptualizer component of the Levelt (1989) model described in the Introduction—the level at which nonlinguistic aspects of the environment trigger conceptual formulation of a ''message'' to be conveyed. This level of the

model would be the functional source of the impairment if patients found verb production more difficult than noun production simply because they had difficulty interpreting pictured actions. Asking patients to name static pictures of actions caused no more problem than asking them to name dynamic action sequences. Although other types of impairments to the Conceptualizer are possible, the most obvious conceptual difficulty underlying action naming impairment has been shown here to be an unlikely explanation for such impairments.

A number of different possible impairments to the Formulator component of the model could produce grammatical class effects. As noted in the Introduction, this aspect of the model begins with the conceptual message to be conveyed and yields a phonologically specified linear sequence that serves as input to the motor speech apparatus. Contemporary models of word and sentence production distinguish two types of lexical representations for words; an abstract ''lemma'' representation that encodes meaning and grammatical information, and a phonologically specified ''lexeme'' that represents word form. Is it possible to attribute selective grammatical class effects to failure of one of these two types of lexical information stores?

On first consideration, retrieval impairments that are selective for grammatical class would likely be attributed to failure at the first of the two hypothesized levels of lexical representation (the lemma), since grammatical class information is argued to be represented at that level (Bock & Levelt, 1994). However, Caramazza and Hillis (1991) have reported data that appear to contradict this analysis by locating selective grammatical class effects not at the lemma level, but in the word form (the Output Lexicon). These authors described two fluent aphasic patients with apparently selective production impairment for verbs. One patient had difficulty producing verbs only when speaking; the other patient had difficulty only when writing. These facts, in conjunction with the finding for both patients that *comprehension* of verbs was not affected, led the authors to hypothesize that the locus of the impairment was to the store of word forms (the output lexicons)—phonological word forms in one case and orthographic word forms in the other. This finding and interpretation force the conclusion that these elements of the lexical system (the output lexicons) are organized along lines of grammatical class, a proposal with little support from other sources of evidence.

The argument that comprehension results can constrain hypotheses concerning the locus of production impairments is controversial. The general model sketched here is largely silent with regard to comprehension and in fact remains agnostic on the question of whether components of the model are shared in comprehension and production (e.g., Levelt, 1992, p. 18; Bock, 1995). Models based on analyses of neurogenic lexical impairments (e.g., Patterson & Morton, 1985; Rapp & Caramazza, 1991) appear to be more firmly committed to division of components into a lexical/semantic system

that is shared in comprehension and production and word form lexicons that contain independent lexical representations used for production and comprehension (although evidence in favor of this latter distinction is not very compelling; see Allport & Funnell, 1981; Monsell, 1987). Lexical models that emanate from linguistics are more likely to assume that distinct lexical subcomponents serving the needs of phonological, syntactic, orthographic, and semantic analysis are shared in comprehension and production (e.g., Emmorey & Fromkin, 1988).

Furthermore, even if lemma representations *are* shared for comprehension and production, it is not clear that a lemma-level disruption would have equivalent effects on the two functions. It may be that an impairment to lemma representations that is of sufficient magnitude to undermine the retrieval of a specific entry for production does not necessarily abolish semantic information. Such a partial deficit may continue to allow sufficient semantic activation to support a choice between two pictures in a comprehension task. For these reasons, although we believe it is useful to evaluate patients' knowledge of the target word classes in comprehension, it is not clear that *failure* to demonstrate parallel deficits in comprehension and production strongly constrains potential sources of the production impairment. Some sort of disruption of lemma representations, or limitation on the transmission of information from lemma to lexeme, is not ruled out by our failure to demonstrate comprehension deficits that parallel the production deficits.

Other aspects of the data, in fact, appear to support the lemma level as a source of selective grammatical class effects. The high rate of semantic errors produced by the verb-impaired patients might indicate that their retrieval deficits arise as conceptually driven (lemma) representations are selected on the basis of meaning and grammatical class. The large number of substitutions of semantically related nouns for verbs among these patients suggests a possible failure of both sources of activation at this level. In this regard, it is interesting that the sentence completion task—the only condition that provided explicit syntactic structure as a constraint on word retrieval—severely reduced the number of substitutions of nouns for verbs by the verb-impaired patients. This finding suggests that the completion paradigm succeeded in constraining lemma activation to the correct grammatical class, even though patients continued to have difficulty retrieving the target item.

Another aspect of the data that might contribute to an interpretation of selective verb impairment involves the effect of word frequency on patient performance. Garrett (1992) argues that responses demonstrating sensitivity to word frequency would suggest an impairment locus in the word form system, since there is no evidence that frequency has a strong impact on message-driven lemma retrieval (see also Jescheniak & Levelt, 1994). Our findings related to frequency were complex, and they highlight some differences among the patients. Of the five patients with relative verb impairment, the three who produced ''agrammatic'' sentences in clinical testing (FM,

LR, and EA) showed no effect of frequency on their naming. In fact, two of these patients produced more low- than high-frequency verbs. The absence of a frequency effect for these agrammatic patients also characterized the naming pattern of the other agrammatic aphasic included in this study (TM), who did not demonstrate selective verb impairment. The lack of a frequency effect in noun and verb production for these patients is consistent with other aspects of their production: one of the defining features of ''agrammatism'' is omission of words that are among the most frequent in the language (grammatical function words), with sparing of words with much lower frequency of occurrence (e.g., concrete nouns). Thus, frequency does *not* appear to be a major determinant of word retrieval for these patients, suggesting in Garrett's analysis a possible locus of naming impairment at the level of lemma retrieval.

The situation is quite different for the remaining two patients with selective verb impairment (ML and JS), as well as for the two anomic patients with selective difficulty retrieving nouns relative to verbs (HF and HY). All four of these patients were strongly influenced by frequency in general, consistent with their generally facile production of high-frequency grammatical words relative to lower-frequency content words. Nonetheless, frequency was overcome by grammatical class as a predictor of naming success for all four patients, even though they continued to demonstrate a strong effect of frequency *within* each grammatical class. In Garrett's analysis, this pervasive influence of frequency suggests a locus of impairment at the level of the word forms, and other data from these patients are consistent with this interpretation. JS (and to a lesser extent ML) produced phonemic paraphasias in their fluent speech that suggest a failure of phonological encoding (cf. Kay & Ellis, 1987).

The effect of word frequency on performance thus indicates potentially different sources of selective grammatical class effects in the patients tested. It is possible that these effects indeed arise from different sources, and if the frequency data had *coincided* with grammatical class effects we would have had a neat story to tell. However, the four fluent patients with strong frequency effects diverge sharply in the relative accessibility of nouns and verbs, with ML and JS having difficulty with verb production, and HF and HY showing more problems with the production of nouns. Moreover, the two patients with the *most* similar general profiles with regard to grammatical class effects are agrammatic patient FM and fluent patient ML, who showed different sensitivity to word frequency. Both patients demonstrated consistent findings favoring noun production across a range of tasks, including the reading of abstract words. The argument that their verb production impairments arise from different functional deficits (on the basis of the frequency analysis) is weakened by the striking similarity of other aspects of their performance patterns across the range of tasks discussed here.

Another way to distinguish among these possible sources of impairment

is to investigate sentence production in patients with relative verb retrieval impairment. Lemma-level and word-form sources of word retrieval impairment might be expected to have different effects on sentence production. A lemma-level word retrieval impairment, if specific to verbs, would be predicted to have clear detrimental impact on patients' ability to produce well-structured sentences, while failure at a later point would not be expected to have the same structural consequences at the sentence level (Levelt, 1989; Roelofs, 1993). These predictions are motivated and explored in the companion paper in this issue.

Without recourse to investigations of sentence production, however, the results reported here cannot easily be interpreted (for any patient) as indicating a clear and selective impairment of one of the lexical levels within the Formulator component of Levelt's (1989) model. A primary problem yet to be overcome is gross underspecification of the model, especially in the details about how lemma information activated during lexical retrieval triggers the selection (or construction) of a word form during phonological encoding. Current state of knowledge about the details of this interface is sparse even for normal speakers; of more relevance to aphasia will be information about how such a system would deal with partial activation, degraded representations, or both.

APPENDIX A

Unambiguous nouns and verbs elicited in picture naming (organized by verb frequency)						Unambiguous nouns and verbs elicited in video naming task (organized by verb frequency)			
Verb	Frequency (Cum/Base)	Noun (cum matched)	Frequency	Noun (base matched)	Frequency	Verb	Frequency (base)	Noun (base matched)	Frequency
WRITE[a]	561/106	eye	524	mouth[a]	103	give	387	**DOOR**	312
FOLLOW	540/97	city	521	doctor	87	**WRITE**	106	**BALL**	103
SIT	314/66	**DOOR**	348	desk	65	**FOLLOW**	97	**GLASS**	96
CARRY	304/88	office	301	bridge	79	**READ**	89	**DOCTOR**	87
add	291/88	book	292	knife	72	**CARRY**	88	kitchen	90
READ[a]	274/89	road	262	glass[a]	96	wait	82	building	94
sell	128/39	yard	100	bread	41	**SIT**	66	rifle	61
TEACH[a]	153/41	dog	147	moon[a]	46	**EAT**	58	hat	54
hang	131/26	bed	139	cow	28	**LISTEN**	50	**WAGON**	52
LISTEN	123/50	radio	126	wagon	52	draw	46	cup	43
EAT[a]	122/58	leg	126	tree[a]	56	**TEACH**	41	bag	41
sing	120/27	**BALL**	123	fence	30	**PRAY**	12	**EGG**	12
shoot[a]	117/26	sun	117	bird[a]	25	**DIG**	9	**MOUSE**	9
swim[a]	55/10	shoe	58	fox[a]	9	pour	7	jug	6
beg	34/11	belt	36	bee	10	**SHAVE**	6	axe	6
DIG	32/9	leaf	33	**MOUSE**	9	**RIP**	5	pear	6
melt[a]	32/4	tail	31	badge[a]	5	kneel	5	bicycle	5
PRAY[a]	30/12	shirt	29	**EGG**[a]	12	weigh	4	leash	3
SHAVE[a]	23/6	bell	23	ant	6	**SEW**	4	cannon	3
bleed[a]	18/2	rope	19	broom[a]	2	**LICK**	3	pizza	3
SEW[a]	18/4	pie	19	thorn[a]	3	**DECORATE**	2	ruler	3
bake[a]	15/3	vase	15	clown[a]	3	**ERASE**	1	kite	1
rob	15/2	ghost	16	owl	2	mow	1	ketchup	1
RIP	14/5	deer	13	witch[a]	5	**SHARPEN**	1	**CARROT**	1
drown[a]	14/3	cane	13	raft[a]	3	**SPILL**	1	**CRUTCH**	1
LICK	14/3	globe	14	skull	3				
DECORATE	12/2	violin	13	butterfly	2				
SPILL	9/1	crib	8	**CRUTCH**	1				
SHARPEN	7/1	oven	8	**CARROT**	1				
ERASE[a]	5/1	robot	4	camel[a]	1				

Note. Items shared across static and video naming tasks appear in boldface capital letters.

[a] Items used in sentence completion and definition tasks.

APPENDIX B

Noun and Verb Oral Reading Stimuli

Imageable			Abstract		
	Base F	Cum F		Base F	Cum F
Verbs					
Short					
fill	49	184	deny	47	109
eat	61	122	fail	37	142
hang	26	131	owe	10	
shut	46	50	warn	11	62
wipe	10	35	earn	16	45
dig	9	32	tend	43	104
	(33.7)	(92)		(27.3)	(82.6)
Long					
announce	18	116	confirm	16	41
deliver	18	71	respond	21	54
destroy	48	104	deserve	12	40
prepare	35	163	promote	32	61
combine	15	72	achieve	51	133
collect	16	78	improve	39	121
	(25.0)	(100.6)		(28.5)	(75)
Nouns					
Short					
bird	25	83	ego	13	14
corn	32	38	fate	29	36
gift	32	45	fun	43	44
bowl	20	26	joy	40	47
baby	57	80	odor	14	22
doll	10	22	mood	35	45
	(29.3)	(49.0)		(29)	(34.6)
Long					
elephant	7	18	affection	18	22
magazine	33	65	welfare	46	53
mountain	26	98	tribute	23	25
library	48	90	democracy	22	25
physician	15	22	miracle	15	26
boulder	11	6	emergency	33	46
	(23.3)	(49)		(26.1)	(33)
Ambiguous					
Short					
note	126	165	gain	69	77
file	59	87	vow	8	6
vote	66	79	cure	19	20
claw	3	4	hope	136	164
fish	30	33	love	179	145
press	107	82	lack	97	70
	(65.1)	(75)		(84.6)	(80.3)
Long					
measure	107	128	promise	46	68
approach	125	95	venture	11	17
surprise	49	76	dispatch	12	9
blister	3	4	attempt	102	87
fracture	2		support	144	132
purchase	48	50	estimate	53	79
	(55.6)	(59.2)		(61.3)	(65.3)

APPENDIX C

Verb and Noun Target Stimuli with Semantic Distractors: Photo Matching Test

Verb target	Semantic distractor	Noun target (matched to verb base frequency)	Semantic distractor
	High frequency (base frequency . 49/million)		
1. add	divide	chair	table
2. eat	drink	shoe	boot
3. give	share	car	bus
4. write	paint	newspaper	magazine
5. sit	stand	ear	eyes
6. carry	lift	knife	fork
7. buy	steal	dress	shirt
8. listen	look	gate	door
9. serve	cook	finger	foot
10. wait	leave	box	bag
11. feel	hug	paper	pen
12. save	waste	check	money
13. take	pull	house	church
14. read	think	rifle	cannon
15. enter	leave	coffee	tea
Mean frequency 5 141.7		5 145.7	
	Low frequency (base frequency , 12/million)		
1. lick	bite	bookcase	desk
2. mend	knit	saucer	cup
3. pour	spill	crutch	cane
4. stir	shuffle	nozzle	sprinkler
5. wipe	wash	perfume	soap
6. weigh	measure	mushroom	onion
7. melt	drip	leash	rope
8. arrange	set	robe	pajamas
9. rip	squeeze	banana	orange
10. applaud	snap	mailbox	stamp
11. zip	tie	ashtray	pipe
12. celebrate	dance	notebook	clipboard
13. erase	draw	hotdog	hamburger
14. calculate	type	telescope	binoculars
15. carve	chop	mitten	scarf
Mean frequency 5 4.7		5 4.7	

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