Journal of Psycholinguistic Research, Vol. 19, No. 6, 1990

Phonological and Form Class Relations in the Lexicon

Joan A. Sereno[1,2] and Allard Jongman[1,2]

Accepted August 7, 1990

Two experiments were conducted to examine the structure of the mental lexicon. A lexical search of American English, using the Brown corpus (Francis and Kucera, 1982), revealed a skewed, frequency-dependent distribution in which the syntactic classes of noun *and* verb *are distinguished in terms of the phonological classification of their vowels. Among high-frequency words, nouns are more likely to have back vowels (57%) rather than front vowels (43%) and verbs more likely to have front vowels (62%) than back vowels (38%). This distribution, however, does not hold for low-frequency nouns and verbs in the language. Noun and verb stimuli containing front and back vowels were examined in both an auditory noun/verb categorization task and an auditory lexical decision task. In general, the phonotactic composition of nouns and verbs in the lexicon was shown to have perceptual consequences. Listeners seem to be differentially sensitive to incoming sound patterns on the basis of distributional properties of the lexicon.*

A fundamental issue of interest in word recognition studies is the structural relations among lexical items. Although many experiments have emphasized the semantic or associative relationship among words, few studies have examined the phonological structure of the lexicon or the way in which this factor interacts with other lexical variables. The present study will investigate systematic phonological relations in the lexicon

These experiments were conducted at the Brown University Phonetics Laboratory. The technical expertise of John Mertus and Andrew Mackie as well as the help of Martha Burton and Annemie Witjes are gratefully acknowledged.

[1] Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands.

[2] Address for correspondence: Joan A. Sereno and Allard Jongman, Max Planck Institute for Psycholinguistics, Wundtlaan 1, 6525 XD Nijmegen, The Netherlands. E mail: Joan @ MPI.NL.

0090-6905/90/1100-0387$06.00/0

using both a lexical search procedure to document their distribution in the language and an experimental approach to test whether these lexical patterns affect word recognition processes.

Statistical properties involving the phonological structure of the English lexicon have been investigated by Shipman and Zue (1982) and Huttenlocher and Zue (1984). They found that there are strong structural constraints at the phonological level in language. For example, simply specifying the consonant–vowel pattern of a given input word will reduce the number of potential word candidates in a 20,000-word vocabulary, on average, to only 20 possible lexical items (Shipman and Zue, 1982). These results indicate that partial specification at the segmental level dramatically reduces the number of possible word candidates since there are powerful constraints on the sound patterns found in the lexicon.

In addition to systematic phonological structure in the lexicon, important phonological differences within the lexicon have also been documented. The early research of Landauer and Streeter (1973) and the more recent verification of their claims by Pisoni, Nusbaum, Luce, and Slowiaczek (1985) and Pisoni and Luce (1986) have shown that high-frequency lexical items seem to be phonologically distinct from low-frequency lexical items. Invoking the notion of a similarity neighborhood (word neighbors differing in only one phoneme), Landauer and Streeter (1973) found both that high-frequency words tend to occur in dense neighborhoods and that the neighbors of high-frequency words tend to be high-frequency words. Thus, there appear to be fundamental structural differences in the distribution of high- and low-frequency words. Landauer and Streeter (1973) further examined the phonemic constituents of high- and low-frequency words and concluded that similarity neighborhood differences seem to be the result of differences in the distribution of phonemes in these items. The phonemes that tend to occur very often in high-frequency words are not the same phonemes that make up low-frequency words.

More recently, Luce (1986) has shown that the nature of the similarity neighborhood, as well as the frequency of the stimulus item per se, affects reaction times in word recognition studies. The density of the neighborhood and the frequency of those neighbors, in addition to stimulus word frequency, are also very good predictors of the speed and accuracy of auditory word recognition in a variety of tasks (word identification in noise, lexical decision, pronunciation). The number and nature of words in the similarity neighborhood—in other words, the phonological structure of the lexicon—have important consequences for models of word recognition.

In linguistic theory, the phonological structural relations in the lexicon and their interactions with other lexical variables have also been considered. Specifically, the correspondence between the set of meaningful forms of a language and the various phonemes which make up these forms falls within the study of *sound symbolism*, a term originally coined by de Saussure. However, de Saussure (1959) claimed that the connection between the signifier (the sound-image) and the signified (the concept) is arbitrary and, in general, many linguists have tended to adopt that doctrine advocated by de Saussure. However, there is far from unanimous agreement with this principle of arbitrariness. A variety of scholars from different disciplines (e.g., Humboldt, Peirce, Bloomfield, Bolinger, and Jakobson) have disputed the claim that the signified is not bound to the sequence of phonemes that serve as its signifier, citing a variety of correspondences of sound and meaning in the languages of the world (see Jakobson, 1965, 1978).

In recent years, two widespread and consistent cases of sound symbolism have been discovered in the work on language universals (see Greenberg, 1978). First, Ultan (1978) found evidence for distance symbolism.[3] In an analysis of 136 languages, Ultan found that 33.1% of the sample exhibited distance symbolism in their demonstrative system. More importantly, those languages that overtly symbolized distance relationships predominantly used front or front-high vowels to represent proximity to the speaker.

Second, Ultan found universal correspondences for size symbolism in language. Some languages overtly mark words expressing diminution by changing the phonological features of the vowel sound in the root. Ultan found that 27.3% of the 136 languages he sampled had diminutive marking. In almost 90% of these languages, the diminutive was symbolized by front-high vowels. The widespread distribution of these consistently recurring patterns of sound symbolism suggests that the relation between sound and meaning in language may not be completely arbitrary.

Taking into account the systematic phonological structure of the lexicon that has been documented and shown to affect word recognition and using the universal semantic–sound correspondences as a model, a different type of phonological structure in the lexicon is suggested here.

---

[3] The notion of distance symbolism must be considered within the broader framework of deixis. *Deixis* refers to those features of the language which reflect the spatio–temporal coordinates of the relative situation of the utterance. Distinctions are made between things that are near in space and/or time vs. things that are far in space and/or time.

Correspondences between phonological content and two clearly delineated and linguistically salient categories of syntactic class are analyzed. Specifically, the syntactic classes of *noun* and *verb* are compared in terms of the phonological classification of their vowels. The present paper will first document the correspondences between specified phonological features of the vowel and different syntactic categories and then test whether this lexical pattern affects word recognition.

Both the syntactic class categorization and the phonological classification of the vowels are basic distinctions in language. No language fails to distinguish the syntactic categories of noun and verb, suggesting the universality of this distinction in the languages of the world (Hockett, 1968; Sapir, 1944). Moreover, the classification of front vowels as distinct from back vowels is acoustically and articulatorily as well as perceptually salient (Ladefoged, 1975; Pickett, 1980). An explanation in terms of formant frequencies, the resonant frequencies of the vocal tract, suggests that front vowels are characterized by a relatively high second formant frequency (F2) due to a tongue constriction close to the front of the oral tract, whereas back vowels are characterized by a relatively low F2 due to a tongue constriction close to the back of the oral tract. Moreover, the perception of front and back vowels has indeed been shown to be dependent on the frequency location of F2 (Carlson, Fant, & Granström, 1975).

A lexical search was undertaken to carefully examine the relationship between syntactic class membership and phonological vowel classification. Using the Brown corpus (Francis and Kucera, 1982), the first 1000 noun and verb lemmata in the rank list were classified according to the phonological category of their stressed vowel (front vowel [i, I, e, ɛ, æ] vs. back vowel [ə, a, ʌ, ɔ, o, ʊ, u, aI, aʊ, ɔI]).[4]

The phonological analysis of the nouns and verbs in the Brown corpus revealed a systematic, skewed distribution. In general, high-frequency stimuli (i.e., greater than 200 per million) pattern differently than low-frequency stimuli (i.e., less than 200 per million). Moreover, the stimuli within each of the two frequency-based groups show a consistent

[4] In the present analysis, the base form of each word is used. Diphthongs are classified on the basis of the more prominent first vowel sound (Ladefoged, 1975) and multisyllabic words are analyzed for the vowel in their stressed syllable. A previous analysis (Sereno, in press), using both the Lorge (1949) frequency word list and the Francis and Kucera (1982) list, had shown that the exclusion of all possible controversial cases (e.g., multisyllabic words, words containing diphthongs, and words that change the categorization of the stressed vowel such as strong verbs with alternative forms) did not affect the categorization results.

pattern.[5] For present purposes, only two sets of 200 stimuli (a high-frequency set and a low-frequency set) are presented and analyzed in terms of vowel quality. For the high-frequency set, the first 200 nouns and verbs in the rank list of the Brown corpus were analyzed. These words have frequencies ranging from approximately 3000 per million to 250 per million. In these high-frequency words, nouns are more likely to have back vowels rather than front vowels in their stressed syllables while high-frequency verbs are more likely to have front vowels than back vowels. Specifically, only 43% of nouns have front vowels while 57% have back vowels. This pattern is reversed for the verbs, with 62% of the verbs having front vowels and only 38% having back vowels. A chi-square test for these high-frequency words showed that there is indeed a significant relationship between the syntactic category of the word and the front/back quality of the stressed vowel of the word ($\chi^2 = 6.23$, $p < .02$).

A similar distribution, however, is not maintained for low-frequency nouns and verbs. For the low-frequency set, the first 200 nouns and verbs in the rank list having a frequency less than 50 per million were analyzed. These words have frequencies ranging from 50 per million to approximately 30 per million. In these low-frequency words, the proportion of front and back vowels for both nouns and verbs is virtually identical. For low-frequency words, 54% of nouns have front vowels and 46% have back vowels; 49% of verbs have front vowels and 51% have back vowels. A chi-square test for these low-frequency words showed that there was no significant relationship between the syntactic category of the word and the vowel quality of the stressed vowel ($\chi^2 = 0.47$, $p > .50$, n.s.). Thus, for high-frequency words, there is a significantly greater number of nouns with back vowels and verbs with front vowels, but this pattern does not hold for low frequency nouns and verbs in English.

To further investigate these syntactic class and vowel quality correspondences, two experiments were conducted to determine whether this relationship is effective in the processing of language. Both experiments were presented in the auditory modality. The first experiment consisted of a noun/verb categorization task while the second experiment was a lexical decision task. If it is the case that a systematic relationship obtains between syntactic class and phonological features of the stressed vowel,

[5] A complete analysis of the Brown University corpus (Francis and Kucera, 1982) in terms of form class membership and vowel classification is presented in Sereno (in press).

it may be expected that nouns with back vowels and verbs with front vowels will be processed faster due to the listener's sensitivity to the distribution of nouns and verbs and front and back vowels. In addition, a comparison of the frequency of the stimuli can clarify whether such an effect is a distributional consequence of the language (response latency differences present only in high-frequency stimuli) or a general processing strategy (response latency differences present in both high- and low-frequency stimuli).

EXPERIMENT 1

The purpose of this experiment was to determine whether the interaction between the vowel category of a word and its form class would be observable in a word recognition task. In this experiment, a noun/verb categorization task was employed in which subjects were to decide whether an auditorily presented stimulus item was a noun or a verb. This task was used in an attempt to maximize, on the one hand, the acoustic-phonetic differences in vowel category by presenting stimuli in the auditory modality and, on the other hand, the contrast between nouns and verbs by using a noun/verb categorization paradigm.

Method

Subjects. Twenty students attending Brown University were paid to participate in the experiment. All were native speakers of American English and reported no history of speech or hearing disorders. No subject participated in more than one of the present experiments.

Stimuli. Sixty-four words (32 nouns and 32 verbs) were selected from the Brown corpus (see the appendix). Each of the noun stimuli is used at least 90% of the time as a noun and each of the verb stimuli is used at least 90% of the time as a verb. Each of the noun and verb groups was equally divided on the basis of vowel quality, with one-half of the stimuli having front vowels and the other half back vowels. Moreover, the stimuli were equally divided into high-frequency words (occurring more than 250 times per million) and low-frequency words (occurring between 50 and 30 times per million). Thus, for the nouns, there were eight high-frequency front-vowel nouns, eight low-frequency front-vowel nouns, eight high-frequency back-vowel nouns, and eight low-frequency back-vowel nouns. Likewise, for the verbs, there were eight high-frequency front-vowel verbs, eight low-frequency front-vowel verbs, eight

high-frequency back-vowel verbs, and eight low-frequency back-vowel verbs.

Within each list of nouns and verbs, all subgroups (front-vowel nouns, back-vowel nouns, front-vowel verbs, and back-vowel verbs) were matched for word frequency (Francis and Kucera, 1982). For the high-frequency stimuli, mean frequency of occurrence for front-vowel nouns, back-vowel nouns, front-vowel verbs, and back-vowel verbs was 452, 443, 442, and 437 per million, respectively, with standard deviations of 179, 164, 153, 133, respectively. Low-frequency words were similarly matched. Mean frequency of occurrence was 42, 41, 39, and 44 per million, respectively, with standard deviations of 5, 4, 10, and 6, respectively.

Only monosyllabic words were used, and all stimuli were matched for mean number of phonemes. All subgroups of stimuli were comparable in duration. For high-frequency stimuli, durations for front-vowel nouns, back-vowel nouns, front-vowel verbs, and back-vowel nouns were 644, 606, 644, and 614 ms, respectively, while for low-frequency stimuli mean durations were 621, 596, 648, and 606 ms, respectively.

Procedure. All subjects were tested in groups of one to three. For the noun/verb classification task, subjects were instructed to identify each stimulus either as a noun or a verb. They were told that the stimuli were all familiar English words and that, although some of the words could occur both as a noun and a verb, each stimulus was to be categorized on the basis of its more frequent usage. Subjects were to respond as quickly and accurately as possible to each stimulus item. Following instructions, subjects were given a set of eight practice items to introduce them to the procedure. These practice items were not used in the experiment.

The stimuli were first recorded by a male speaker on a Sony tape recorder in an anechoic chamber using a Bruel and Kjaer 4179/2660 microphone. The stimuli were then digitized on a microVAXII computer at a sampling rate of 20 kHz with a 9.0-kHz low-pass filter setting and 10-bit quantization. The stimuli were then transferred to an IBM AT personal computer and converted to 12-bit quantization for playout to the subjects. Subjects listened to the stimuli over Sony (MDR-2V) headphones at a comfortable listening level. All responses to the stimuli were made by pressing one of two clearly marked buttons on a response box placed in front of the subjects. Each trial was completed when subjects used the index finger of their preferred hand to press one of the two equidistantly placed response buttons labeled *noun* or *verb*. Position of the response buttons was counterbalanced across subjects.

The stimuli were presented at a fixed rate. Reaction times were measured from the onset of the stimulus until a key press was made. Following a response, there was a 3-s silent interval until the next stimulus was presented. This sequence was repeated for every stimulus item. The entire experiment lasted approximately 15 min.

Results and Discussion

The mean latencies for the noun/verb classifications are given in Table I. No errors were included in these averages. The total number of errors was 55, representing 4.3% of all responses. No further analyses were conducted on the errors.

A three-way ANOVA (Frequency × Syntactic Class × Vowel) revealed a main effect for Syntactic Class [$F(1, 19) = 18.22, p < .001$], for Vowel [$F(1, 19) = 22.75, p < .001$], and for Frequency [$F(1, 19) = 6.07, p < .023$]. In general, nouns (995 ms) had faster reaction times than verbs (1046 ms), back-vowel stimuli (1004 ms) had faster reaction times than front-vowel stimuli (1037 ms), and high-frequency words (1009 ms) had faster reaction times than low-frequency words (1032 ms).

More importantly, however, there was a significant Syntactic Class × Vowel interaction [$F(1, 19) = 9.00, p < .007$]. Reaction times to nouns with front vowels (1025 ms) relative to nouns with back vowels (965 ms) were significantly different from verbs with front vowels (1050 ms) relative to verbs with back vowels (1043 ms). However, this effect was dependent on the frequency of the stimuli. That is, there was a significant Syntactic Class × Vowel × Frequency interaction [$F(1, 19) = 20.06, p < .001$], as shown in Fig. 1. High-frequency stimuli clearly show a difference in noun and verb processing with regard to their vowel categorization while the low-frequency stimuli do not.

There was one additional significant interaction between Syntactic Class and Frequency [$F(1, 19) = 12.70, p < .002$], as shown in Fig. 2. Differences in categorization latencies for nouns and verbs are much more extreme for low-frequency compared to high-frequency stimuli.

Overall, then, a significant interaction between syntactic class and

Table I. Mean Response Latencies (ms) for Nouns and Verbs with Front and Back Vowels in the Noun/Verb Categorization Task (Experiment 1)

	Front	Back
Noun	1025	965
Verb	1050	1043

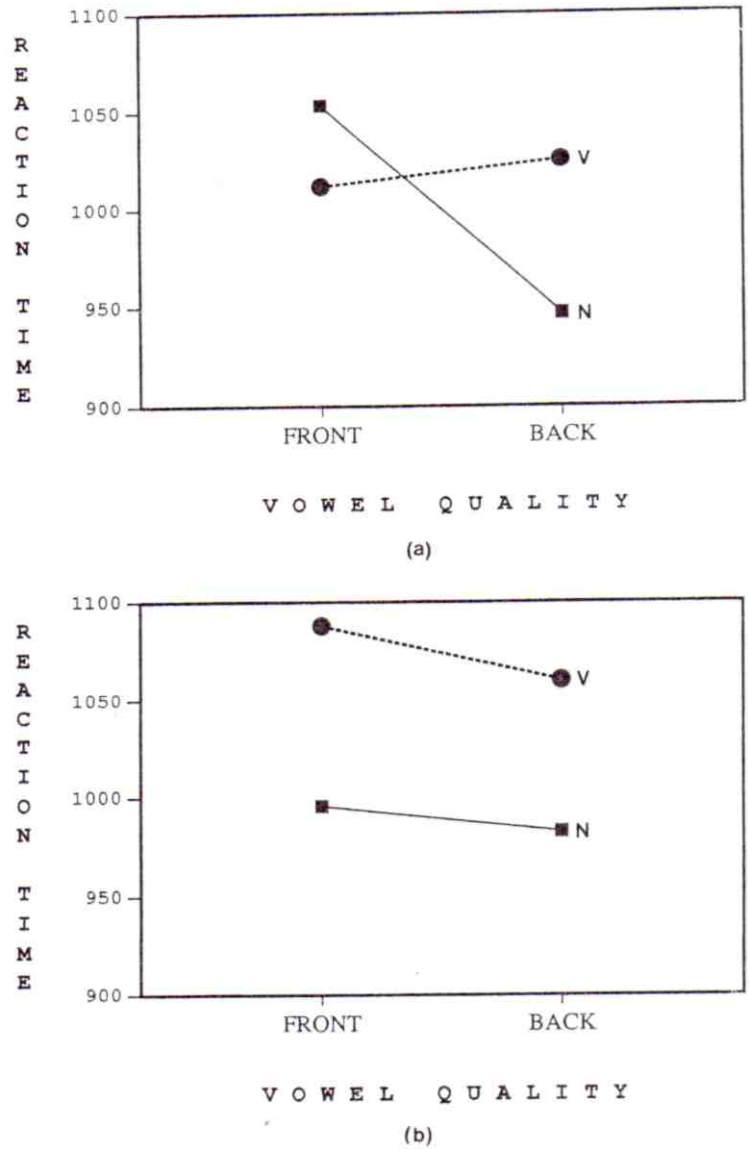

Fig. 1. Response latencies for the classification of nouns and verbs as a function of vowel quality in both high-frequency stimuli (panel a) and low-frequency stimuli (panel b).

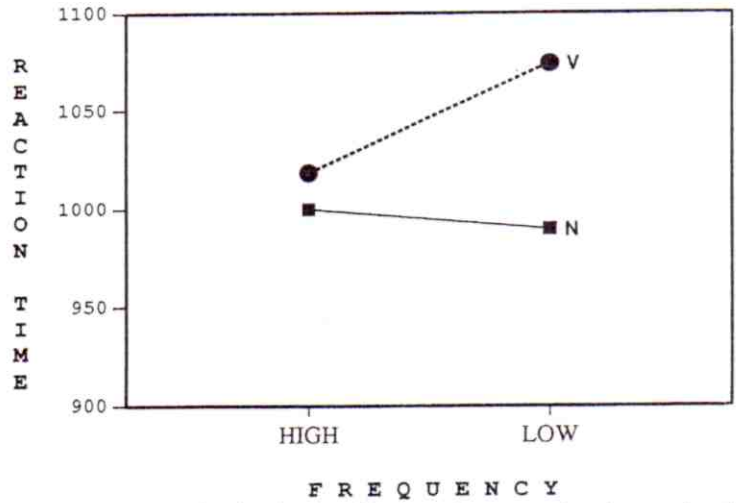

Fig. 2. Response latencies for the classification of nouns and verbs as a function of frequency.

vowel quality was obtained for high-frequency stimuli, such that nouns with back vowels and verbs with front vowels were processed faster.

EXPERIMENT 2

Experiment 2 was conducted to determine whether the interaction between syntactic class and vowel quality would also be obtained when using a task that did not require subjects to make explicit judgments about syntactic form class. We therefore used an auditory lexical decision task in which subjects were only to make a word/nonword decision.

Method

Subjects. Twenty-eight students attending Brown University were paid to participate in the experiment. All were native speakers of American English and reported no history of speech or hearing disorders. None of these subjects had participated in the previous experiment.

Stimuli. The same 32 nouns and 32 verbs used in Experiment 1 were also used in Experiment 2. Additionally, 32 legal nonwords were constructed (see the appendix). One-half of the nonwords had front vowels

and the remaining half had back vowels. All nonwords were monosyllabic and matched to the word stimuli in mean number of phonemes.

Two sets of test stimuli were constructed—a "Noun Test" containing the 32 nouns and the 32 nonwords and a "Verb Test" containing the 32 verbs and the same 32 nonwords.

Procedure. The procedure was similar to that used in Experiment 1. However, subjects were told to identify each stimulus as either a word or a nonword. Fourteen subjects were given the Noun Test and 14 different subjects were given the Verb Test.

Following instructions, subjects were given a set of 10 practice items to introduce them to the procedure. A separate practice session accompanied each test set (Noun Test, Verb Test). Practice items were not used in the experiment. Following practice, the test stimuli were presented.

The experimental procedure and collection of response times are those described in Experiment 1. All responses to the stimuli were made by pressing one of two clearly marked buttons (*word* or *nonword*). The Noun Test and the Verb Test each lasted approximately 15 min.

Results and Discussion

The mean lexical decision latencies for the noun and verb tests are given in Table II. No errors were included in these averages. The total number of errors was 107, representing 6.0% of all responses. No further analyses were conducted on the errors.

For the Noun Test, a one-way ANOVA revealed that nouns (904 ms) were responded to faster than nonwords (1023 ms) [$F(1, 13) = 45.38$, $p < .001$]; likewise, for the Verb Test, a one-way ANOVA

Table II. Mean Response Latencies (ms) in the Noun Test (Top) and the Verb Test (Bottom) for Nouns, Verbs, and Nonwords with Front and Back Vowels Using a Lexical Decision Task (Experiment 2)

	Front	Back
	Noun Test	
Noun	919	889
Nonword	1017	1029
	Verb Test	
Verb	983	978
Nonword	1029	1030

revealed that verbs (981 ms) were responded to faster than nonwords (1030 ms) [$F(1, 13) = 9.04, p < .010$].

Combining the results for the word stimuli contained in the Noun Test and the Verb Test, a three-way ANOVA (Syntactic Class × Frequency × Vowel) revealed a main effect for Syntactic Class [$F(1, 26) = 5.96, p < .022$], with nouns (904 ms) having faster reaction times than verbs (980 ms).

Most importantly, however, there was a significant Syntactic Class × Vowel × Frequency interaction [$F(1, 26) = 5.34, p < .029$]. For high-frequency stimuli, reaction times to nouns with front vowels (924 ms) relative to back vowels (866 ms) and verbs with front vowels (966 ms) relative to verbs with back vowels (988 ms) were significantly different than reaction times for low-frequency stimuli in which nouns with front vowels (914 ms) relative to back vowels (912 ms) and verbs with front vowels (999 ms) relative to verbs with back vowels (968 ms) were compared. As shown in Fig. 3, high-frequency stimuli clearly showed a difference in noun and verb processing with regard to their vowel categorization while the low-frequency stimuli did not.

No other significant main effects or interactions were found. One trend, a main effect of Vowel, was observed [$F(1, 26) = 3.37, p > .078$, n.s.]. In general, there was a tendency for reaction times to back-vowel stimuli (934 ms) to be faster than reaction times to front-vowel stimuli (951 ms).

In summary, the results from the lexical decision task are very similar to those of the noun/verb categorization task employed in Experiment 1, in that both experiments showed a facilitation, dependent on frequency, for nouns with back vowels relative to front vowels and for verbs with front vowels relative to back vowels.

Comparing the two tasks, reaction times in the noun/verb categorization task were on average approximately 80 ms slower than those in the lexical decision task. However, a comparison of number of errors in both tasks revealed that subjects made slightly less errors in the noun/verb categorization task (4.3%) than in the lexical decision task (6.0%). The slower response latencies in the noun/verb categorization task may be attributed to the fact that subjects were required not only to identify the stimulus item but also to make a form class judgment.

GENERAL DISCUSSION AND CONCLUSIONS

A lexical search of American English revealed a pattern involving nouns and verbs and front and back vowels. This pattern was present in

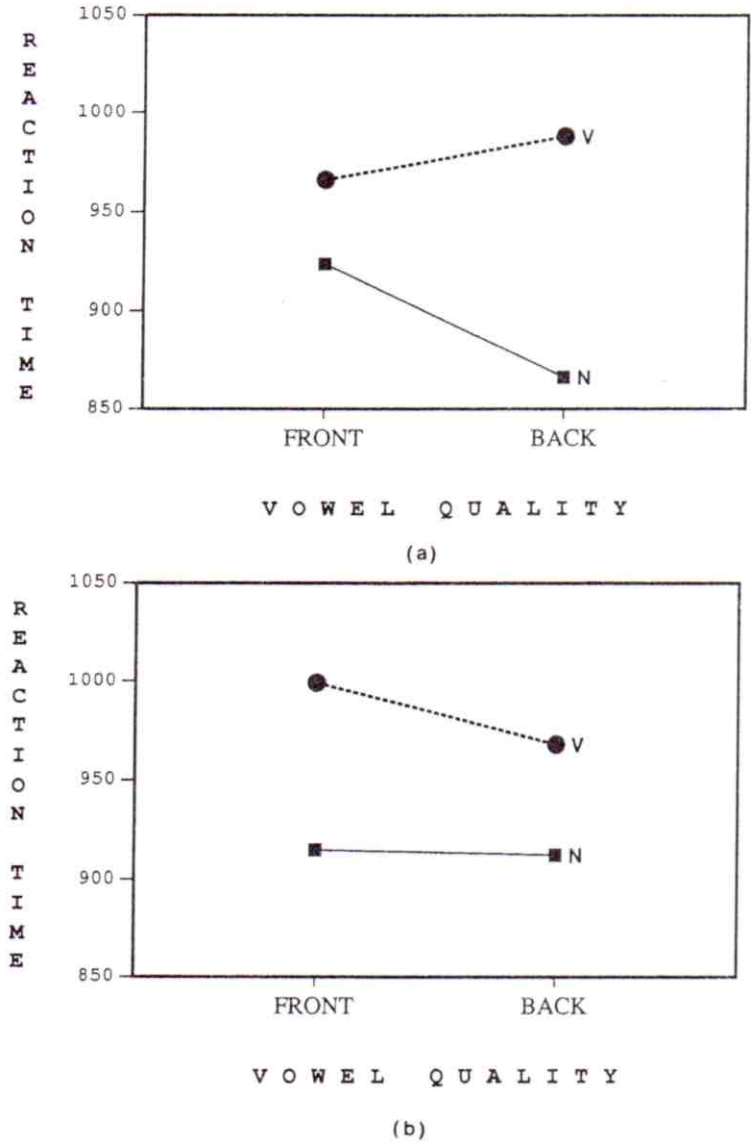

Fig. 3. Response latencies for word stimuli (nouns and verbs) as a function of vowel quality in a lexical decision experiment in both high-frequency (panel a) and low-frequency stimuli (panel b).

high-frequency nouns and verbs but was not observed in low-frequency words. Two psycholinguistic experiments then established that language users are sensitive to this distribution of nouns and verbs with respect to the phonological classification of their vowel. Our results showed that, in both a noun/verb categorization task and a lexical decision task, there do exist systematic processing differences between nouns and verbs depending on the quality of their stressed vowel. Nouns with back vowels were processed faster than nouns with front vowels. Conversely, verbs with front vowels were processed faster than verbs with back vowels. Moreover, in both tasks, this interaction was found only for high-frequency words. The processing effects thus directly mimic the lexical distribution of nouns and verbs with front and back vowels in the language.

It is not surprising that this pattern of results is observed for high-frequency words but is not present in low-frequency stimuli. The extensive research of Landauer and Streeter (1973) and Luce (1986) has shown that there are substantial and systematic differences between high- and low-frequency words in terms of their similarity neighborhoods. Moreover, these neighborhood differences have significant perceptual consequences in that reaction time latencies are influenced not only by frequency of occurrence but also by neighborhood structure (Luce, 1986). These findings suggest that high-frequency items are structurally distinct from low-frequency lexical items.

It is also important to note that the interaction between syntactic form class and phonological vowel classification involves two rather basic parameters in language. Both the noun/verb syntactic distinction and the front/back acoustic distinction are important linguistic categories among the languages of the world. On the one hand, the noun vs. verb distinction is a universal syntactic division. Processing differences based on syntactic form class membership are not uncommon. Specifically, function or closed class words are often contrasted with content or open class words (see, for example, Bradley, 1978) and recognition processes for these two vocabulary classes have been shown to be distinct (Bradley, 1978; Friederici, 1985; but see Gordon & Caramazza, 1982; 1985). Rarely, however, are other vocabulary types, besides the open/closed class categories, distinguished. As a notable exception, Seidenberg, Tanenhaus, Leiman, and Bienkowski (1982) did distinguish noun–noun semantically ambiguous lexical items from noun–verb semantically ambiguous items and found consistently different patterns of behavior, suggesting that some syntactic form class information may be coded in the lexicon. In general, however, the linguistic categories of noun and verb

are often conflated in word recognition, with little attention paid to possible differences in processing.

On the other hand, the acoustic distinction between front and back stressed vowels is also well documented in the area of speech perception (e.g., Jakobson, Fant, & Halle, 1972). Although the front/back distinction in vowel quality is acoustically, articulatorily, and perceptually salient, phonological information contained in the stressed vowel of a lexical item is often not the variable of interest in word recognition studies. Phonological variables have often been bypassed due to the fact that most studies of lexical access processes have contrasted orthographic rather than phonological parameters and those studies that have investigated phonological variables have most often been conducted in the visual rather than the auditory modality. Recently, however, the stressed syllable of a word has been shown to play a dynamic role in speech perception (Cutler & Clifton, 1984; Cutler, Mehler, Norris, & Segui, 1986; Cutler & Norris, 1988; Grosjean & Gee, 1987; Mehler, Dommergues, Frauenfelder, & Segui, 1981). In addition, it has been demonstrated that subjects are sensitive to the phonological consonant–vowel structure of lexical items, with listeners' expectations matching the distributional characteristics of the CV patterns in the language (Cutler, Norris, & Williams, 1987). These data suggest that phonological information contained in the stressed syllable of words may be pivotal to lexical access processes.

The present distributional and psycholinguistic data suggest that syntactic class membership and phonological information regarding the stressed vowel may be important variables in processing since subjects are faster in recognizing nouns with back vowels and verbs with front vowels. This pattern, however, is frequency-dependent, appearing only in high-frequency lexical items. An explanation for these results can be found simply by appealing to lexical statistics. For high-frequency words, there is a greater number of nouns with back vowels and verbs with front vowels and, therefore, listeners, on average, more often hear high-frequency nouns with back vowels and high-frequency verbs with front vowels. However, they do not hear such a skewed distribution of form class and phonological vowel classification in low-frequency lexical items since, for low-frequency words, there is not a greater number of nouns with back vowels and verbs with front vowels. The present research shows that subjects' facilitation in both a noun/verb categorization task and a lexical decision task is based on these lexical distributional characteristics of the language. The greater the number of words with certain charac-

teristics existing in the language, the faster subjects seem to be in recognizing those types of words.

The present data support the claim that syntactic class and vowel quality may be parameters that help structure lexical space. The present findings may also have more general implications for researchers in the field of word recognition, in particular in the area of auditory word recognition. Since there are significant processing interactions between the syntactic categories of noun and verb and the phonological classification of front and back vowels due to distributional factors present in the language, subjects' expectations concerning these variables must be taken into account when analyzing experimental results. Finally, two quite different tasks were used: a noun/verb categorization task and a lexical decision task. One common objection against the use of lexical decision tasks is that word/nonword decisions are unnatural since they are not required in normal communication. On the contrary, noun/verb decisions must be made constantly, and the present data suggest that they are made with little effort. The noun/verb categorization task might therefore provide a more natural way to understand particular aspects of language processing.

APPENDIX

Stimuli used in Experiments 1 and 2

Nouns

High-frequency stimuli		Low-frequency stimuli	
Front-vowel nouns	Back-vowel nouns	Front-vowel nouns	Back-vowel nouns
hand	school	milk	clerk
thing	house	fence	porch
fact	group	gift	dirt
class	church	cat	bus
field	door	bench	bride
street	month	prince	tongue
friend	book	sand	corn
death	wife	leaf	barn

Verbs

High-frequency stimuli		Low-frequency stimuli	
Front-vowel verbs	Back-vowel verbs	Front-vowel verbs	Back-vowel verbs
leave	want	mix	bind
feel	call	swim	shut
keep	put	snap	pour
let	try	beg	quote
pay	move	seize	hunt
reach	grow	tempt	stir
sit	serve	melt	crawl
spend	lose	cease	wipe

Nonwords

Front vowel		Back vowel	
meap	visp	lurp	nart
bist	flink	fon	troz
strig	gep	spont	plark
blent	trep	blun	sprup
smed	spet	hoke	plord
plef	gret	cron	vorg
kade	plave	bolf	lufe
plam	glant	cloot	doot

REFERENCES

Bradley, D. (1978). *Computational distinction of vocabulary type*. Unpublished doctoral dissertation, Massachusetts Institute of Technology.

Carlson, R., Fant, G. & Granström, B. (1975). Two-formant models, pitch, and vowel perception. In G. Fant & M. A. A. Tatham (Eds.), *Auditory analysis and the perception of speech*. London: Academic Press.

Cutler, A., & Clifton, C. E. (1984). The use of prosodic information in word recognition. In H. Bouma and D. Bouwhuis (Eds.), *Attention and performance X: Control of language processes* (pp. 183–196). Hillsdale, NJ: Erlbaum.

Cutler, A., Mehler, J., Norris, D., & Segui, J. (1986). The syllable's differing role in the segmentation of French and English. *Journal of Memory and Language, 25*, 385–400.

Cutler, A., & Norris, D. (1988). The role of strong syllables in segmentation for lexical access. *Journal of Experimental Psychology: Human Perception and Performance, 14*, 113–121.

Cutler, A., Norris, D., & Williams, J. N. (1987). A note on the role of phonological expectations in speech segmentation. *Journal of Memory and Language, 26,* 480–487.

Francis, W. N., & Kucera, H. (1982). *Frequency analysis of English usage: Lexicon and grammar*. Boston: Houghton Mifflin.

Friederici, A. D. (1985). Levels of processing and vocabulary types: Evidence from on-line comprehension in normals and agrammatics. *Cognition, 19*, 133–166.

Gordon, B., & Caramazza, A. (1982). Lexical decision for open and closed class items:

Failure to replicate differential frequency sensitivity. *Brain and Language, 15*, 143–180.

Gordon, B., & Caramazza, A. (1985). Lexical access and frequency sensitivity: Frequency saturation and open/closed class equivalence. *Cognition, 21*, 95–115.

Greenberg, J. (1978). *Universals of human language*. Stanford: Stanford University Press.

Grosjean, F., & Gee, J. P. (1987). Prosodic structure and spoken word recognition. *Cognition, 25*, 135–155.

Hockett, C. F. (1968). *The state of the art*. The Hague: Mouton.

Huttenlocher, D. P., & Zue, V. W. (1984). A model of lexical access from partial phonetic information. In *Proceedings IEEE International Conference on Acoustics, Speech, and Signal Processing, San Diego, California* (pp. 26.4.1–26.4.4).

Jakobson, R. (1965). Quest for the essence of language. *Diogenes, 51*, 21–37.

Jakobson, R. (1978). *Six lectures on sound and meaning*. Cambridge, MA: MIT Press.

Jakobson, R., Fant, G., & Halle, M. (1972). *Preliminaries to speech analysis*. Cambridge, MA: MIT Press.

Ladefoged, P. (1975). *A course in phonetics*. New York: Harcourt Brace Jovanovich.

Landauer, T. K., & Streeter, L. A. (1973). Structural differences between common and rare words: Failure of equivalence assumptions for theories of word recognition. *Journal of Verbal Learning and Verbal Behavior, 12*, 119–131.

Lorge, I. (1949). *The semantic count of the 570 commonest English words*. New York: Bureau of Publications, Teachers College at Columbia University.

Luce, P. A. (1986). *Neighborhoods of words in the mental lexicon*. (Research on Speech Perception, Tech. Rep. 6). Bloomington: Indiana University.

Mehler, J., Dommergues, J. Y., Frauenfelder, U., & Segui, J. (1986). The syllable's role in speech segmentation. *Journal of Verbal Learning and Verbal Behavior, 20*, 298–305.

Pickett, J. M. (1980). *The sounds of speech communication*. Baltimore: University Park Press.

Pisoni, D. B., Nusbaum, H. C., Luce, P. A., & Slowiaczek, L. M. (1985). Speech perception, word recognition, and the structure of the lexicon. *Speech Communication, 4*, 75–95.

Pisoni, D. B., & Luce, P. A. (1986). Speech perception: Research, theory, and the principal issues. In H. C. Nusbaum & E. Schwab (Eds.), *Pattern recognition by humans and machines, Vol. 1: Speech perception*. New York: Academic Press.

Sapir, E. (1944). *Language*. New York: Harcourt, Brace and World.

de Saussure, F. (1959). *Course in general linguistics*. (W. Baskin, Trans.). New York: McGraw-Hill.

Seidenberg, M. S., Tanenhaus, M. K., Leiman, J. M., & Bienkowski, M. (1982). Automatic access of the meanings of ambiguous words in context: Some limitations of knowledge-based processing. *Cognitive Psychology, 14*, 489–537.

Sereno, J. A. (in press). Phonosyntactics. In L. Hinton, J. Nichols, & J. Ohala (Eds.), *Sound symbolism*. Cambridge, England: Cambridge University Press.

Shipman, D. W., & Zue, V. W. (1982). Properties of large lexicons: Implications for advanced isolated word recognition systems. In *Proceedings IEEE International Conference on Acoustics, Speech, and Signal Processing, Paris, France* (pp. 546–549).

Ultan, R. (1978). Size-sound symbolism. In Joseph Greenberg (Ed.), *Universals of human language (Volume 2—Phonology)*. Stanford: Stanford University Press.