Stress in Time

Michael H. Kelly
University of Pennsylvania

J. Kathryn Bock
Michigan State University

The goals of this research were to determine whether speakers adjust the stress patterns of words within sentences to create an alternation between strong and weak beats and to explore whether this rhythmic alternation contributes to the characteristic stress differences between two major lexical categories of English. Two experiments suggested that speakers do alter lexical stress in accordance with rhythmic biases. When speakers produced disyllabic pseudowords in sentence contexts, they were more likely to place stress on the first syllable when the pseudoword was preceded by a weak stress and followed by a strong one than when the strong stress preceded and the weak followed. This occurred both when the pseudowords served as nouns and when they served as verbs. Text analyses further revealed that weakly stressed elements precede nouns more often than verbs, whereas such elements follow verbs more often than nouns. Thus, disyllabic nouns are more likely than disyllabic verbs to occupy contexts biased toward trochaic rhythm, a finding consistent with leftward dominant stress in disyllabic English nouns. The history of stress changes in English nouns and verbs also conforms with the view that rhythmic context may have contributed to the evolution of stress differences. Together, the findings suggest that the citation stress patterns of words may to some degree reflect adaptations of lexical knowledge to conditions of language performance.

In rhythmically organized activities ranging from poetry to military marching, there is a marked tendency toward an alternation of strong and weak beats. In English verse, for example, the most common rhythmic pattern by far is the iamb, a weak beat followed by a strong beat, as in the sea (Shapiro & Beum, 1965). The trochee, a strong beat followed by a weak beat, as in where the, is the next most common. Much rarer are patterns that violate this simple alternating rhythm, such as the anapest (weak-weak-strong, as in on the sea) and other patterns incorporating successive strong or successive weak beats. Indeed, Shapiro and Beum estimated that roughly 90% of English verse from the sixteenth century onward is iambic, testifying to an overwhelming bias toward rhythmic alternation in our poetry. The work to be reported here was designed to explore a similar rhythmic bias that is believed to exist in more prosaic uses of language, and its relation to common lexical stress patterns in English.

Rhythmic alternation forms a basic principle in formal linguistic explanations of the stress patterns of both words and sentences. In explanations of word stress, it is used to account for how stress changes when certain kinds of affixes are added. For example, the word sólid becomes solidity, and compensate becomes compensatory, avoiding the long sequences of weak beats that would result if the stress did not move, as in solidity or compensatory (Schane, 1979). Moving the stress preserves something closer to the optimal alternating pattern.

In phrases and sentences, the tendency toward rhythmic alternation may contribute to timing variations and stress shifts. Timing variations can be seen in the reductions of word durations that accompany increases in the numbers of unstressed syllables separating stressed ones. Fowler (1977) asked speakers to produce sentences such as The fact started the argument, The factor started the argument, The factory started the argument, and so on, progressively adding unstressed syllables to the interval between fact and start. The duration of the vowel in fact was found to decrease as the number of unstressed syllables increased. Similar arguments and evidence about timing have been offered by Fónagy and Magdics (1960) and Huggins (1975). It is as if the speaker tries to preserve a roughly fixed interval between strong beats.

Stress shifts have been argued to occur in words such as unknown and thirteen (as well as fourteen, fifteen, and the rest), as a function of the rhythmic context. It is possible to say unknown (with stress on known) in a phrase such as unknown assailant, but it sounds odd to say unknown in Tomb of the Unknown Soldier (Cutler & Clifton, 1984). Stressing the first syllable (unknown) yields a better rhythmic pattern. Similarly for thirteen: The dictionary entry for thirteen places primary stress on the second syllable, but in a phrase such as thirteen men, primary stress has been argued to shift to the first syllable (Allen, 1975; Liberman & Prince, 1977; Schane, 1979; Selkirk, 1984). As a monosyllabic noun, men receives a strong stress. Shifting primary stress from the second to the first syllable of thirteen removes the possible clash between two successive strong stresses and produces the more euphonious alternating pattern of strong-weak-strong.
Some of the rhythm-based explanations for these and other phenomena go back at least a century. Sweet (1875-1876, 1908), for example, argued that the bias toward alternating beats is not specifically linguistic but operates in other rhythmic activities, such as music and tapping. Sweet was among the first to suggest that rhythmic patterns that deviated from the alternating best preference would be pressured into conformity. He noted that “It is . . . possible to have a rhythm of four beats, thus (a, a, a, a, a, a, a, a). But here the principle of alternation of force comes into play, and to break up the monotony of three weak stresses in succession, a secondary accent is placed on the third beat of each bar” (1875-1876, p. 11).

Although the principle of alternation has played a background role in many accounts of linguistic stress over the past century, it has gained new prominence in phonological theories that draw on metrical constructs from music (G. Cooper & Meyer, 1960) for their explanations of stress and intonation. In some of these phonological theories, the principle of rhythmic alternation is the keystone (Liberman & Prince, 1977; Selkirk, 1984). On it rest detailed accounts of stress patterns in words and phrases.

In Selkirk’s (1984) theory, for example, the syllables of words are aligned with pulses (points in abstract time) represented as the columns of a “metrical grid.” The rows of the grid represent different levels to which beats may be assigned, with rhythm or meter emerging from different patterns of beat assignments. At the first grid level, every syllable is linked to a beat. If a syllable has no beats at higher levels, it will be weak; syllables with additional beats at higher levels are stronger. For instance, the syllables in Mississippi would be aligned on the metrical grid as

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    X X X
Missisipi
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The third syllable of Mississippi has the most beats and receives the most prominent stress. Of the remaining syllables, the first is associated with the next largest number of beats, so it receives secondary stress. The second and fourth syllables have only first level beats (called demibeats) and are not distinguished from each other.

The assignments of syllables to levels in the metrical grid result from the application of two types of rules: text-to-grid alignment rules and grid euphony rules (note that these rules are conceived as functions that link formal representations, with no necessary implications for linguistic performance). The text-to-grid alignment rules are the first to apply. They assign higher level beats on the basis of a syllable’s phonological features, such as the length of its vowel, as well as on the basis of the syllable’s location in a word, compound, phrase, and so on. One example of a text-to-grid alignment rule for English is the heavy syllable basic beat rule, which aligns syllables that have tense vowels (e.g., teen in thirteen) with a beat on the second level of the metrical grid.

After the text-to-grid alignment rules, a variety of grid euphony rules apply. These rules are specifically designed to bring the metrical grid patterns constructed by the text-to-grid alignment rules into conformity with the principle of rhythmic alternation. The grid euphony rules operate by adding, moving, or deleting beats. In constructing the grid for thirteen men, for example, the text-to-grid alignment rules yield a stress clash (two successive strong beats) between the second syllable of thirteen and the first syllable of men. A beat movement rule therefore operates to shift the primary stress from the second syllable of thirteen to the first.

It appears that the principle of rhythmic alternation has played and continues to play a fundamental role in psychological and linguistic theories of stress and timing in speech. Yet this appearance hides a number of vexing problems. These arise from questions and controversies about the facts that the principle is supposed to capture. It has sometimes been argued that there is nothing in the acoustic stream of speech that is well or easily characterized in terms of rhythmic alternation and that what appears to be alternation is no more (or less) than a construction that the perceptual system imposes on the speech stream (Lehiste, 1977). Though the problem may be traceable to the difficulty of isolating the locus of strong beats in speech (Fowler & Tassinary, 1981; Morton, Marcus, & Frankish, 1976), differences have arisen even in experiments employing similar manipulations and measurement criteria. Thus, Fowler (1977; Rakerd & Fowler, 1984) and W. E. Cooper and Eady (1986) report different results and come to correspondingly different conclusions about manifestations of rhythmic alternation in the actual timing of speech. Apparently, a central principle of theories of stress and timing rests on somewhat shaky empirical foundations.

In the present article we will propose an extension of the principle of rhythmic alternation to a broader linguistic domain, developing its implications for phenomena to which it has not traditionally been applied and opening up different methods for evaluating its effects. The phenomenon that we will particularly emphasize is a regularity of lexical stress that is well known but poorly understood. Specifically, disyllabic nouns (e.g., tiger) are much more likely than disyllabic verbs (e.g., convince) to have stress on the first syllable (Chomsky & Halle, 1968; Liberman & Prince, 1977). More generally, multisyllabic nouns often have stress on the antepenultimate syllable, while multisyllabic verbs more commonly have stress on the penultimate syllable (compare the nouns Cánada, América, teléfono, and attribute with the verbs solicitar, enéu, imaginar, and atribuir; Schane, 1979). Even when verb-plus-particle constructions are nominalized, their stress patterns tend to change in a way that moves the main stress from the particle to the open-class component of the compound (compare He failed to follow through on the suggestion with His follow through was weak; Bolinger, 1958). Ross (1973) enunciated the general principle: “Primary stress in English nouns is farther to the left than primary stress in English verbs” (p. 168).

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1 Problems of this sort carry little weight for linguistic theory. Whether the alternation is imposed during perception or production, it may still be regarded as a manifestation of the native speaker’s knowledge.
This regular difference between the stress patterns of nouns and verbs is especially striking for homographic nouns and verbs. There is a large set of nouns and verbs that differ only in their stress patterns, such as *permit* and *permit*, *convert* and *convers*, *compound* and *compounding*, and so on. In these pairs, the noun has a strong-weak or trochaic pattern (as in *permit*), while the verb has a weak-strong or iambic pattern (as in *permitted*). Whenever there is a stress difference between homographic nouns and verbs, it always takes this form.

A slightly weaker version of the same asymmetry can be found in the stress patterns of pure nouns and verbs or nouns and verbs without homographs in other form classes (compare the nouns *ardor*, *aspect*, *corpus*, *tremor*, *fervor*, and *purist* with the verbs *maintain*, *dispel*, *inscribe*, *adore*, *transmit*, and *procure*). We estimated the strength of the asymmetry for these words by recording the dictionary-prescribed stress patterns of all disyllabic nouns and verbs in the Francis and Kučera (1982) word frequency norms, excluding words with homographs occurring in other grammatical categories (such as *yellow*, which may serve as a noun, verb, or adjective). There were 3,002 pure nouns and 1,021 pure verbs. Of the nouns, 94% had strong-weak stress; of the verbs, only 31% showed the same pattern. Though this difference is reduced when the stress patterns of all of the disyllabic nouns and verbs listed in the Francis and Kučera (1982) norms are considered, it remains substantial: The strong-weak pattern is preferred for 89% of the 4,218 nouns compared with 46% of the 1,676 verbs.

Obviously, there is a massive difference between nouns and verbs in their citation stress forms, yet this difference goes largely unexplained in linguistic theory. Grammars of word stress (e.g., Liberman & Prince, 1977) are indifferent to possible nonstructural sources of the variation and explain it by stipulating the relation between form class and canonical stress structure. So, to assign the stress patterns of the homographic forms, a rule applies that says, essentially, if a word has a final Latin stem such as *mit* and the word is a verb, then it gets weak-strong stress. Nonhomographic forms are handled by a wide variety of rules and principles that refer to internal phonological properties of words, to form class, and to the general trochaic bias of English words (Chomsky & Halle, 1968; Schane, 1979; Selkirk, 1984). Ross (1973) acknowledged this problem when he attributed his “leftward-hop” principle to a conspiracy: The rules conspire to produce the outcome, but its motivation remains shrouded.

There may be a partial explanation of this conspiracy that draws on the principle of rhythmic alternation. The hypothesis that we will explore in the remainder of this article is that the stress patterns of nouns and verbs are related to the typical rhythmic contexts in which they occur. For example, if disyllabic nouns are often preceded by unstressed syllables but followed by stressed syllables, as in *The ____ sleeps or A ____ ran*, the pressure for rhythmic alternation would predispose a strong beat in the first syllable. For verbs, on the other hand, the occurrence of contexts such as *The boy ____ the girl or A girl ____ a boy* would predispose a weak beat in the first syllable. Over time, a word that consistently occupied a particular rhythmic context might come to reflect the pressures imposed by that context in its citation stress pattern. If disyllabic nouns are more likely than disyllabic verbs to be preceded by unstressed syllables and followed by stressed syllables, they may as a result be more likely than verbs to manifest strong-weak stress patterns. The next section outlines the strategy we used to test this claim.

**Overview of Studies and Experiments**

The investigation focused on the hypothesis that those stress differences which are correlated with grammatical category differences arise in part as a result of the principle of rhythmic alternation. Specifically, the proposal is that rhythmic biases may have a systematic impact on speech performance that is reflected in variations in the stress patterns of words in different rhythmic contexts. More generally, we will suggest that if a particular type of rhythmic context is a common one for a particular word, the word’s citation stress pattern may come to reflect the rhythm induced by its characteristic context. This constitutes an adaptation of the speaker’s lexical knowledge to the conditions in which that knowledge is customarily used.

Our first step in exploring this hypothesis was to examine the rhythmic environments of nouns and verbs in natural texts, both written and spoken. If the greater dominance of the trochaic pattern for nouns is attributable to the operation of rhythmic alternation in typical nominal and verbal contexts, nouns should be more likely than verbs to be preceded by weak beats and followed by strong beats. From the text analyses we proceeded to an experimental evaluation of the assumption that rhythmic context affects lexical stress in the way predicted by the rhythmic alternation principle. In the first of two experiments we examined the stress patterns that speakers assigned to two-syllable pseudowords occurring in the typical rhythmic and syntactic contexts of nouns and verbs to determine whether pseudowords would reveal the intonational biases found in real nouns and verbs. In the second experiment we then examined the stress patterns assigned to pseudowords in rhythmic contexts that varied while the syntactic context was controlled. If the principle of rhythmic alternation contributes to speakers’ stress assignments in the pronunciation of unfamiliar words, the pseudowords should tend to display trochaic patterns when they are preceded by syllables carrying weak stress but iambic patterns when preceded by syllables carrying strong stress.

**Written Text Counts**

Bartlett’s *Familiar Quotations* (1937) was used for the written text sample. Two advantages of this corpus are that many different individuals and historical periods are represented. As a result, any systematic patterns that emerge from the analysis cannot be readily attributed to the idiosyncracies of a particular author or epoch.

Two samples of nouns and verbs were taken from Bartlett’s. One, the disyllabic sample, consisted of the first disyllabic noun and verb for each individual quoted in Bartlett’s who
that were longer or shorter than two syllables as a result of affixation or its absence (e.g., promise and running were included, but promising and run were not). The second sample, the unrestricted sample, consisted of the first noun and verb for each individual regardless of word length.

The rhythmic contexts for the words in each sample were determined by examining the words preceding and following the sampled nouns and verbs. Sampled words were excluded from the analyses of preceding contexts when they were preceded by (a) a noun whose citation stress was unknown and unlisted in Webster's New Collegiate Dictionary (1977), (b) a comma or other punctuation that would affect rhythm in indeterminate ways, or (c) proper nouns. The analyses of following contexts excluded sampled words that were followed by any of these. The resulting sample sizes for each of the analyses are shown in Table 1.

Subject to these constraints, each of the nouns and verbs in the disyllabic and unrestricted samples was classified as being preceded by a stressed or unstressed syllable and as being followed by a stressed or unstressed syllable. Monosyllabic context words were classified as stressed if they belonged to one of the major lexical categories (noun, verb, adjective, or adverb). All other monosyllabic context words (determiners, pronouns, prepositions, contractile auxiliary verbs) were classified as unstressed. These classifications were motivated by considerations such as the procedures for poetic scansion (Shapiro & Beum, 1965) and the normal encliticization of words from minor categories (e.g., box off/bakso/said as "boxa"/baksa/). Only two deviations from these criteria were permitted. The first concerned the adverb not and the copula is. The frequent encliticization of these words indicates that they are typically unstressed, and they were counted as such. The second concerned the modal verbs might, could, and must and wh words such as who and what. These words were considered stressed for two reasons. First, they are not contractible, a property that is correlated with the presence of stress (Selkirk, 1984). Second, modals are acquired earlier than verbal auxiliaries (Brown, 1973). Because words that children acquire earlier tend to receive more stress in adult speech than words acquired later (Gleitman & Wanner, 1982; Miller & Ervin, 1964), this earlier acquisition suggests that the modals are more prominent in the speech of adults than the auxiliaries.

The stress patterns of disyllabic and polysyllabic context words were determined from their preferred citation forms as given in Webster's New Collegiate Dictionary (1977). Only the primary stress location was counted as a stressed syllable; all secondary and tertiary stresses were considered unstressed.²

The major results of the context analyses are shown in Table 1. In both written samples, verbs were significantly more likely than nouns to appear in iambic-biasing contexts, preceded by a stressed syllable but followed by an unstressed syllable. In the disyllabic sample, verbs were preceded by a stressed syllable 31% of the time, whereas nouns were preceded by a stressed syllable 14% of the time (z = 10.43, p < .001). In the unrestricted sample, 24% of the verbs and 15% of the nouns were preceded by a stressed syllable (z = 6.17, p < .001). The exact reverse of these patterns was found in the analyses that looked at the following context. In the disyllabic sample, verbs were followed by a stressed syllable 20% of the time, whereas nouns were followed by stressed syllables 42% of the time (z = 11.77, p < .001). In the unrestricted sample, verbs were followed by stressed syllables 17% of the time, whereas nouns were followed by such syllables 29% of the time (z = 7.81, p < .001).

It appears, then, that there is a very reliable asymmetry in the rhythmic contexts of nouns and verbs in written English. To check on the generality of this difference, we carried out additional analyses on samples of spoken English.

### The Spoken Text Count

Two samples of spoken nouns and verbs in speech were again obtained, a disyllabic sample and an unrestricted sample. The criteria used to determine the stress levels in the preceding and following contexts were the same as those used for the written samples.

The disyllabic sample was drawn from transcripts representing a wide range of speech situations, including trials, mother–child conversations, and class lectures.³ Table 2 lists the materials used. All of the disyllabic nouns and verbs were taken from the transcripts along with the immediately preceding or following word, subject to the same restrictions used for the written samples. The unrestricted sample was drawn

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2 In any case, only 6% of the nouns and 5% of the verbs were preceded by words containing more than three syllables. In the samples concerned with looking at following context, the values averaged 2% for both nouns and verbs. None of these differences between nouns and verbs were significant.

³ We thank Don Hayes of the Sociology Department at Cornell University for graciously supplying the speech transcripts.

### Table 1

Percentages of Nouns and Verbs Preceded (Pre) and Followed (Fol) by Stressed Syllables in Naturally Produced Texts

<table>
<thead>
<tr>
<th>Corpus</th>
<th>Context type</th>
<th>Pre nouns</th>
<th>Pre verbs</th>
<th>Fol nouns</th>
<th>Fol verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Disyllabic written</td>
<td>14</td>
<td>1,442</td>
<td>31</td>
<td>1,189</td>
<td>42</td>
</tr>
<tr>
<td>Unrestricted written</td>
<td>15</td>
<td>1,446</td>
<td>24</td>
<td>1,442</td>
<td>29</td>
</tr>
<tr>
<td>Disyllabic spoken</td>
<td>15</td>
<td>2,717</td>
<td>18</td>
<td>2,571</td>
<td>24</td>
</tr>
<tr>
<td>Unrestricted spoken</td>
<td>14</td>
<td>2,968</td>
<td>18</td>
<td>2,968</td>
<td>19</td>
</tr>
</tbody>
</table>
Table 2
Composition of the Spoken Corpus for the Text Analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage of words in strong positions</th>
<th>Stress score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nouns</td>
<td>94</td>
<td>5</td>
</tr>
<tr>
<td>Verbs</td>
<td>76</td>
<td>4</td>
</tr>
<tr>
<td>Adverbs</td>
<td>71</td>
<td>4</td>
</tr>
<tr>
<td>Adjectives</td>
<td>61</td>
<td>3</td>
</tr>
<tr>
<td>Modals</td>
<td>41</td>
<td>2</td>
</tr>
<tr>
<td>Auxiliaries/copulas</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>Pronouns</td>
<td>34</td>
<td>2</td>
</tr>
<tr>
<td>Prepositions</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>Conjunctions/complementers</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Articles</td>
<td>11</td>
<td>1</td>
</tr>
</tbody>
</table>

from the transcripts of the Watergate tapes published in The White House Transcripts (Gold, 1974). Because of the immense size of the Watergate transcripts, only the first four nouns and first four verbs on each page of the text were included, again subject to the restrictions established for the written samples. The sample sizes are given in Table 1.

The results replicated the patterns in the written samples, though they were weaker (evidently, everyday speech less often achieved the metrical felicity of the quotations that find their way into Bartlett’s). As Table 1 shows, verbs were again more likely than nouns to be preceded by stressed syllables. In the disyllabic sample, 18% of the verbs and 15% of the nouns were preceded by stressed syllables (z = 2.94, p < .01). In the unrestricted sample, the values were 18% and 14% for verbs and nouns respectively (z = 4.17, p < .01). The opposite patterns were found for the contexts following nouns and verbs. In the disyllabic sample, 24% of the nouns and 17% of the verbs were followed by stressed syllables (z = 5.80, p < .01). In the unrestricted sample, the values were 19% and 16% for nouns and verbs, respectively (z = 2.96, p < .01).

Discussion

The evidence from both the written and spoken texts is reasonably well in line with the hypothesis that the rhythmic contexts of nouns and verbs differ. In general, there is a tendency for strong beats to precede verbs more often than nouns and to follow nouns more often than verbs. If the principle of rhythmic alternation is correct, such a tendency could predispose weak beats to occur on the first syllables of verbs more often than on the first syllables of nouns.

Two weaknesses of this analysis have to be considered. First, the results depend a great deal on which grammatical categories in the preceding and following contexts are considered stressed, because most of the contexts consisted of monosyllabic words of various classes. Second, our analysis treats stress as consisting of only two values, stressed and unstressed. Yet, as many linguists have noted, English listeners can reliably discriminate more than two stress levels (Chomsky & Halle, 1968). We attempted to address both these issues by constructing a more objectively defined ranking of stress levels for different grammatical categories.

The construction of the stress ranking exploited an established method for determining lexical stress patterns in early English (Halle & Keyser, 1971). This method examines the distribution of words or syllables across expected strong positions in verse. For example, the underlying metrical pattern of iambic pentameter consists of 10 syllables alternating between weak and strong beats. One can construct a stress ranking by examining the frequency with which words of different grammatical categories occupy the strong positions in this pattern. The categories can in this way be ranked according to their probability of taking strong stress. Applying the results of such a ranking to the preceding and following contexts in our text samples should yield a more sensitive and objective index of the tendency of verbs and nouns to appear in different rhythmic environments.

A stress ranking was constructed for the 10 grammatical classes shown in Table 3. For each class, the first 150 monosyllabic instances were recorded from Shakespeare’s sonnets (Harbage, 1969) and from Milton’s Paradise Lost (Elledge, 1975), which exhibit clear, regular metrical patterns (Kiparsky, 1977). Each of the 1,500 instances was classified as occurring in a strong or a weak position. Then the percentage of words in each category that occurred in strong positions was calculated, and the categories were ranked. Because the rank order constructed for Shakespeare correlated .88 with the order constructed for Milton, the data for the two poets were collapsed to obtain a single ranking, given in Table 3. The order is intuitively plausible, with nouns on the top, articles on the bottom, and pronouns in between. Finally, the percentages were compared to determine which classes occupied significantly different levels. To be placed at a given level, a category had to be significantly different in binomial tests from all others at the next higher and the next lower levels. Table 3 gives the five levels identified in this way.

This scale was applied to three subsamples from the original text analyses: (a) The unrestricted written sample classified by preceding context (which yielded the strongest results in the original analyses), (b) the unrestricted spoken sample classified by preceding context, and (c) the unrestricted spoken sample classified by following context (the weakest results in the original analyses were found for these latter two classifications). The first 1,000 nouns and 1,000 verbs with monosyllabic contexts were selected from each sample and given context stress scores corresponding to the stress levels of their contexts. The mean context stress scores for nouns and verbs were then compared for each sample. If the results from the original analyses reflected real differences in the distributions
of nouns and verbs across rhythmic contexts, these differences should emerge clearly with this more sensitive metric.

Table 4 presents the results. Despite the reduced sample sizes, the noun-verb difference was confirmed in each case (unrestricted written preceding, $t(1,998) = 18.31$; unrestricted spoken preceding $t(1,998) = 17.56$; and unrestricted spoken following, $t(1,998) = 5.86$, all $p < .01$).

Thus, in analyses relying on an objective scheme of stress-level assignments to a multivalued stress system, as well as in analyses using a simple two-valued system, nouns and verbs were found to occupy different rhythmic contexts. These contexts favor trochaic patterns for nouns more heavily than trochaic patterns for verbs, consistent with a rhythmic-alternation account of the stress difference between these grammatical categories. However, to make the leap from characteristics of rhythmic contexts surrounding nouns and verbs to an explanation of their typical stress patterns requires evidence that rhythmic context can affect lexical stress. In particular, the preference for alternating strong and weak beats must be at least powerful enough to pressure lexical stress patterns into conformity with rhythmic alternation. In the two experiments that follow we explored whether changes in rhythmic context were systematically related to changes in the stress patterns of pseudowords that were produced within otherwise natural sentences.

Experiment 1

The first experiment had two interlocking goals. The first was to determine whether pseudowords produced in sentence contexts would reveal the characteristic stress difference between real nouns and verbs. Just as for real nouns and verbs, the rhythmic contexts as well as the syntax were biased in favor of one or the other stress pattern—strong-weak for nouns and weak-strong for verbs.

The second was to examine the viability of a different method for investigating rhythmic context effects. As noted in the introduction, previous tests by Fowler (1977) and W. E. Cooper and Eady (1986) of predictions related to rhythmic alternation produced conflicting results. Where Fowler found changes in the lengths of words as a function of their rhythmic environments, Cooper and Eady observed no reliable differences in the durations of stressed syllables in different contexts. For example, in contrasts between sentences such as Tom introduced Chris Burn to his sister and Tom introduced Chris Burninski to his sister, Cooper and Eady found no significant changes in the durations of target words (Chris in the example). On the basis of Selkirk's (1984) theory, Cooper and Eady had predicted that when two strong beats occurred consecutively (as in Chris Burn; compare Fowler's fact start), a stress clash might be avoided by lengthening the first word, relative to its length when followed by a weak beat (as in Chris Burninski; compare Fowler's factor start). This did not occur. Likewise, Cooper and Eady failed to find changes in the stress pattern of the word thirteen in different rhythmic environments.

There are several possible explanations for the disparities in the conclusions of these experiments, but most of them come down to this: The duration differences that are at issue are miniscule, in the neighborhood of 20 ms. Minor procedural and behavioral variations could easily tip the results in one direction or another. Though the experimental designs are elegant and the measurements technically sophisticated, their very elegance and sophistication limit the types of materials and the numbers of subjects that can be tested, thereby increasing the probability that minor procedural and behavioral variations will have some impact on the results.

To get around these limitations, our experimental paradigm employed materials for which the rhythmic environments could be easily varied, a manipulation that was very strong, and a measurement procedure that was simple to apply. The target items were pseudowords, allowing identical targets to appear in many different environments, and the rhythmic contexts preceding as well as following the target items were manipulated, increasing the impact of rhythmic context differences.

To assess the changes in stress patterns that accompanied changes in the rhythmic contexts, we relied on the perceptual judgments of two raters naive to the hypotheses in question. The reason for choosing perceptual judgments over acoustic analyses, beyond their simplicity of use, was that they yield similar results: Cooper and Eady (1986, Experiment 4) found that the perceptual judgments of a single rater mirrored objective timing measurements. The price for this ease of assessment is that it becomes difficult to allocate any effects to the speaker's production rather than the hearer's perception. In particular, evidence indicates that hearers lean toward the perception of rhythmic alternation even when there are no acoustic cues for it in the speech stream. For example, Martin (1970) spliced the same two monosyllabic words into different rhythmic contexts, so that the two words themselves did not differ. However, when asked to judge the accents placed on the two words, subjects varied their responses in accord with the prior rhythmic context. If the raters in our study were to hear the pseudowords in their full context, they might hear rhythmic alternation even when it did not exist. To rule this out, the pseudowords were excised from their contexts and then judged for stress by the raters.

| Table 4 |
|---|---|---|
| | Sample | Nouns | Verbs |
| Written, preceding context | 1.64 | 2.51 |
| Spoken, preceding context | 1.57 | 2.24 |
| Spoken, following context | 2.04 | 1.82 |

4 This problem is to some extent irrelevant to the rhythmic context explanation for noun-verb stress differences. Given different rhythmic contexts for nouns and verbs, listeners would hear nouns as trochaic more often than verbs, and such stress differences could become part of the lexical representation. Nonetheless, the historical impact of these contextual influences should be greater if rhythmic alternation occurs in production as well as perception.
In Experiment 1, the subjects were asked to read aloud sentences containing disyllabic pseudowords. The syntactic context indicated whether the pseudoword acted as a noun (e.g., The corlax cured the cow) or a verb (e.g., The drugs corlax the cow). In the noun context, the pseudoword was preceded by an unstressed word, the definite article the. It was followed by a stressed syllable, either a monosyllabic verb or a disyllabic verb with stress on the first syllable (e.g., challenged). Stress on the first syllable of the pseudoword would produce the optimal alternating pattern, while stress on the second syllable would yield two consecutive unstressed syllables followed by two consecutive stressed syllables, violating the principle of rhythmic alternation. In the verb context, the pseudoword was preceded by a monosyllabic stressed noun and followed by the unstressed article the. To conform to the principle of rhythmic alternation, the pseudoword in these contexts required a weak–strong stress pattern. In general, then, if speakers are sensitive to either grammatical class or to rhythmic context in determining stress patterns for novel words, more strong–weak patterns should be assigned to nouns than to verbs.

Method

Subjects. Sixteen members of the Cornell University community were paid for their voluntary participation in the experiment.

Materials. Forty-eight pseudowords were created that conformed to the phonological rules of English but did not correspond to real words. To ensure that they were pronounced with two syllables, all of the pseudowords had at least one, and most had two, medial consonants flanked by vowels. All of them were judged to be acceptable with stress on either the first or the second syllable.

Forty-eight pairs of four-syllable sentence carriers were constructed, and one pseudoword was randomly assigned to each pair of carriers. In one of the carriers in each pair the pseudoword acted as a noun (e.g., The ponvven served the drinks) and in the other it acted as a verb (e.g., The drinks ponvven the guests). All pseudowords serving as nouns were preceded by the and followed by a stressed syllable in a carrier with the form the-pseudoword–verb–(the)–noun (the postverbal the did not occur in the noun carriers when the verb had two syllables). All pseudowords serving as verbs were preceded by a monosyllabic noun and followed by the in a carrier with the form the–noun–pseudoword–the–noun. This procedure established a trochaic-biasing rhythmic context for nouns and an iambic-biasing rhythmic context for verbs. All of the carriers and pseudowords are given in Appendix A.

Two lists of 48 sentences were constructed from the full set of 96. The two sentences from each pair were randomly assigned to the alternate lists, with the constraint that each list contain 24 noun carriers and 24 verb carriers. The sentences in the lists were randomly ordered with the constraints that no more than three carriers of the same type appeared consecutively and that carriers from the same pair occurred in the same position in both lists.

Procedure. The sentences were presented one at a time, typed on separate index cards, and the subjects read them aloud. After a subject read each sentence, the experimenter turned over the index card to reveal the next one. All responses were tape-recorded.

The subjects were tested individually. They were told that the experiment was an investigation of the phonological rules that people use to determine the pronunciation of unfamiliar words. To this end, they were asked to read each sentence from the beginning and not to pronounce the nonsense word before it occurred, the better to mimic the typical situations in which unfamiliar words are encountered in sentence contexts. The subjects found the task easy and required no more than 10 min to go through the entire list.

The pseudowords were excised from the produced sentences by recording each pseudoword token onto a second tape. The recordings were repeated until all traces of prior and subsequent context that were audible under normal listening conditions were eliminated, leaving only the pseudoword. The tapes of the excised pseudowords were given to two naive raters, both of them Michigan State University undergraduates, who were blind to the conditions and purposes of the experiment. They were instructed to listen to all the responses produced by a subject before performing the stress ratings in order to familiarize themselves with individual voice characteristics. The raters then classified each item as having stronger stress on the first or second syllable. When uncertain, they were told to guess. Both raters judged all of the pseudowords produced by all of the subjects.

Design and data analysis. The two lists were presented to 16 subjects, 8 per list. Each subject read 24 of the pseudowords in the noun context condition and a different set of 24 pseudowords in the verb context condition; the stress patterns were evaluated by two different raters. After each of the 48 pseudowords was presented once in the noun context condition to 8 subjects and once in the verb context condition to 8 different subjects, both raters evaluated the pseudowords.

Two within-subjects analyses of variance were performed on the ratings, with one analysis having subjects as the random factor and the other having items as the random factor. Each analysis examined the effects of two factors, context (noun and verb) and rater (A and B). Because the proportions in one of the conditions were close to 1.00, producing a skewed distribution, analyses were performed on the arc-sine transformations of the raw proportions.

Significance levels in this and the subsequent experiment were set at .05. The probabilities associated with the statistics used for simple-effects tests were two-tailed unless noted otherwise.

Results

Averaging over the two raters, 87% of the pseudowords were produced with a strong–weak stress pattern when they occurred in noun contexts, compared with 59% when they occurred in verb contexts. The analysis confirmed the obvious: Noun contexts were far more likely than verb contexts to induce strong–weak patterns, *F*(1,15) = 70.06. This result was replicated in the items analysis, *F*(1,47) = 159.19.

In addition to the main effect of context on stress patterns, the analysis also revealed a significant interaction between context and rater—for subjects, *F*(1,15) = 15.41; for items, *F*(1,47) = 41.45. This was due to a stronger contextual effect for Rater B than for Rater A. Nonetheless, both raters were significantly more likely to hear pseudowords from noun contexts as having stress on the first syllable—for subjects, *F*(1,15) = 40.23 and 50.86 for Raters A and B; for items, *F*(1,47) = 32.14 and 249.84 for Raters A and B. For Rater A, 83% of the pseudonouns and 67% of the pseudoverbs received first-syllable stress. The corresponding values for Rater B were 90% and 51%.

Discussion

The results clearly showed that pseudowords received strong–weak stress patterns more often when they served as nouns than when they served as verbs. This difference reflects...
the one found in natural English rather well: Recall that in the full sample of disyllabic nouns and verbs, 89% of the nouns and 46% of the verbs had strong-weak stress. In this experiment, averaging over the two sets of ratings, 87% of the nouns and 59% of the verbs were judged to have strong-weak stress. Evidently, the stress patterns that the speakers assigned to the pseudowords were reasonably similar to those that would have been expected in a random sample of real nouns and verbs, suggesting that for the purposes of assigning stress, the speakers treated the pseudowords much as they would real words.

Also as in natural English, however, the experiment con-founded the two possible sources of the stress difference between nouns and verbs—the linkages between different stress patterns and different grammatical categories on the one hand and differences between grammatical categories in their rhythmic contexts on the other. All pseudonouns were in trochaic-biasing rhythmic contexts, whereas all pseudverbs were in iambic-biasing rhythmic contexts. The next experiment separated these factors.

**Experiment 2**

This experiment attempted to determine whether rhythmic context and grammatical-category-conditioned stress rules both contribute to the stress patterns of words. The basic method was identical to that of Experiment 1, except that nouns appeared in iambic- as well as trochaic-biasing contexts, and verbs appeared in trochaic- as well as iambic-biasing contexts. The factors of grammatical category and rhythmic context were thus completely crossed. If grammatical category alone controls stress, nouns should be more likely than verbs to receive trochaic patterns, and no effect of rhythmic context should appear. On the other hand, if rhythmic preferences also influenced the results of the first experiment, trochaic-biasing contexts should increase the likelihood of first-syllable stress for both nouns and verbs, relative to iambic-biasing contexts. Of course, both factors may influence stress patterns, implicating category-based knowledge as well as rhythmic performance principles.

**Method**

*Subjects.* The subjects were 32 members of the Cornell University community, paid for their voluntary participation in the study. None had taken part in Experiment 1.

*Materials.* The same 48 pseudowords used in the previous experiment were employed. Each word appeared in four sentence carriers designed to cross the grammatical category factor (noun vs. verb) and the rhythmic context factor (trochaic vs. iambic biasing). All of the sentences contained six syllables, with the pseudoword occurring as the third and fourth. The carriers in the noun/trochaic context condition had the structure verb-article-pseudoword-adverb (e.g., *Save the pernew quickly*). Carriers in the noun/iambic context condition had the structure article-noun-pseudoword-noun (e.g., *The dogs pernew dismay*). Each pseudoword appeared in one set of four carriers such as these. An example of a set is listed in Table 5; the full group is given in Appendix B.

From the 48 quadruplets of sentences constructed in this way, four lists were formed containing 48 sentences each. Every list contained one sentence from each quadruplet, and an equal number of sentences representing each of the four conditions. Together, the four lists contained all four members of every quadruplet. The order within lists was random, with the constraints that (a) no more than three sentences appeared consecutively in which the pseudoword belonged to the same grammatical category or appeared in the same rhythmic context, and (b) sentences from the same set appeared in the same serial position in every list.

*Procedure.* The procedure was the same as in Experiment 1. The same two raters judged the excised pseudowords blindly, following the same instructions.

*Design and data analysis.* Thirty-two subjects received 12 sentences in each of the four cells formed by crossing the grammatical category factor (noun/verb) with the rhythmic context factor (trochaic biasing/iambic biasing). Each of the 48 pseudowords was presented to 8 subjects in every cell of the same design. All items and subjects were scored by both raters.

As in the first experiment, analyses of variance were performed on the design, with subjects as the random factor, and on the design, with items treated as the random factor. Three effects were examined on both analyses: rhythmic context (trochaic biasing and iambic biasing), grammatical category (noun and verb), and rater (A and B). The analyses were again performed on the arc-sine transformations of the raw proportions.

**Results**

Both rhythmic context and grammatical category had a significant impact on stress patterns. Table 6 shows these results in terms of the percentages of pseudowords that received strong-weak stress patterns. Overall, 84% of the pseudowords received strong-weak stress in trochaic-biasing contexts, compared with 77% that received strong-weak stress in iambic-biasing contexts. This difference was reliable for subjects, *F*(1, 31) = 37.40, and for items, *F*(1, 47) = 20.51. In addition, pseudowords serving as nouns were more likely than pseudowords serving as verbs to receive strong-weak stress, 86% to 75%. This difference was likewise reliable both for subjects, *F*(1, 31) = 35.40, and for items, *F*(1, 47) = 29.36.

There were two significant interactions. First, grammatical category interacted with rhythmic context, but only in the subjects analysis, *F*(1, 31) = 6.10. This interaction is attributable to a greater rhythmic effect for nouns than for verbs, *t*(31) = 2.29, even though rhythmic context was reliably differentiated for both nouns and verbs: *F*(1, 31) = 42.66 and 6.70 for nouns and verbs in the subjects analysis; *F*(1, 47) = 15.90 and 5.08 for nouns and verbs in the items analysis. The second significant interaction was between grammatical category and rater, *F*(1, 31) = 23.03 for subjects and *F*(1, 47) = 21.81 for items. This interaction was due to Rater B's higher trochaic scores for nouns relative to Rater A, which led to a

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1. The auxiliary *will* was used because it is contractible, a property associated with weak stress.
greater grammatical category effect for the former rater, $F(1, 31) = 19.57$ for subjects and $F(1, 47) = 9.88$ for items. The grammatical category effect was nonetheless significant for Rater A in the subjects analysis, $F(1, 31) = 4.30$, and nearly significant in the items analysis, $F(1, 47) = 3.64, p = .06$. No other effects reached significance.

**Discussion**

Taken together, the results of Experiments 1 and 2 suggest that speakers use both the rhythmic context and knowledge of grammatical categories to assign stress to words. The subjects in Experiment 2 adjusted stress assignments so as to maintain an alternating sequence of strong and weak beats in utterances, or, at a minimum, to maintain an optimal distance between strong beats. They also used their knowledge of the characteristic stress patterns of nouns and verbs to assign form-class-appropriate stress patterns to novel nouns and verbs.

The tendency for nouns to show stronger rhythmic effects than verbs is probably related to the greater prominence of nouns in the speech stream. Nouns tend to last longer than verbs (Sorenson, Cooper, & Paccia, 1978), and, as our stress ranking revealed, they are more likely than verbs to occupy strong positions in metrical patterns. In line with this, speakers may be likelier to produce, and listeners may be likelier to hear, stress variations in them.

Although the results for the two raters were generally consistent, some minor differences between them did appear. Such differences could be due to a number of factors ranging from response biases through different sensitivities to a focus on different types of acoustic information to determine stress (e.g., duration vs. fundamental frequency). What is more crucial for the rhythmic hypothesis is the overall similarity in the two sets of ratings: Both attributed strong-weak stress to words in trochaic-biasing contexts more often than to words in iambic-biasing contexts.

**Table 6**

<table>
<thead>
<tr>
<th>Grammatical category</th>
<th>Noun</th>
<th>Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhythmic context</td>
<td>Rater A</td>
<td>Rater B</td>
</tr>
<tr>
<td>Trochaic biasing</td>
<td>86</td>
<td>95</td>
</tr>
<tr>
<td>Iambic biasing</td>
<td>77</td>
<td>85</td>
</tr>
</tbody>
</table>

**General Discussion**

The experiments we have reported suggest that speakers use both the grammatical categorization and the rhythmic context of unfamiliar words in generating lexical stress patterns. Pseudowords serving as nouns were more likely than the same pseudowords serving as verbs to receive stress on the first syllable, consistent with the greater preponderance of trochaic patterns for English nouns than for English verbs. The more important finding, from the perspective of the issues that motivated this work, was that pseudowords preceded by unstressed syllables were more likely than pseudowords preceded by stressed syllables to be pronounced with a strong-weak pattern. This result suggests that speakers tend to adjust lexical stress in a way that arrays strong beats over time in a regular way, perhaps creating an alternation between strong and weak beats across full utterances. We will discuss these two findings in turn.

The grammatical category effect reveals that speakers are surprisingly sensitive to the relation between form class category and stress pattern. This is surely a case in which the relevant prosodic knowledge is not consciously available, yet the subjects differentiated the stress patterns of the pseudowords in a way that is consistent with the distribution of the stress patterns across extant nouns and verbs. There are at least two ways in which this might occur. In line with linguistic accounts of lexical stress assignments, English speakers may tacitly know and productively use grammatical-category-conditioned stress rules that, in interaction with phonologically conditioned stress rules, produce strong-weak stress patterns for nouns more often than for verbs. Alternatively, form-class-constrained similarities to the suprasegmental features of known words may affect the generation of the stress patterns of novel words. For example, when the pseudoword *corlax* serves as a noun, the assignment of its stress pattern may be more influenced by its phonological similarity to the proper noun *Ex-Lax* than by its phonological similarity to the verb *relax*, and vice-versa when it serves as a verb.

Although the effect of form class categorization was reasonably clear, it was not the only factor that systematically influenced lexical stress assignments. Whether a pseudoword was used as a noun or as a verb, its stress pattern tended to reflect the rhythmic context in which it occurred. In trochaic-biasing contexts, where weak beats preceded and strong beats followed the pseudowords, strong-weak stress patterns were more common than in iambic-biasing contexts, where strong beats preceded and weak beats followed the pseudowords. This pattern of stress assignments is consistent with the principle of rhythmic alternation (Liberman & Prince, 1977; Selkirk, 1984), because it suggests a preference for a regular alternation between stressed and unstressed syllables in speech production. It is likewise in line with previous evidence for stress-related timing variations in speech (Fowler, 1977; Rakverd & Fowler, 1984), because the observed alternation promotes an equalization of the intervals between the strong stresses in an utterance. So, under conditions in which stress was free to vary, speakers tended to use those stress patterns that produced a regular rhythm.
This evidence for rhythmic context effects on lexical stress serves to answer one of the questions with which we began. That question was whether the stress patterns of words accommodate to the prosodic environment. It appears that they do and that these accommodations occur for words of different form classes. But because there are reliable variations between the rhythmic contexts of nouns and verbs in natural language, they should in fact be pressured to conform in different ways. The extant nouns of English should tend more strongly toward strong-weak stress than verbs do, and that is the case.

It remains to be shown that facets of the historical development of stress differences between nouns and verbs are consistent with the rhythmic context hypothesis. According to Sherman (1975), Old English followed Old Germanic in placing stress rigidly on the first syllables of words, accounting for the overall trochaic bias in the modern English lexicon. The pattern for verbs began to change with the prefixation of weak prepositional adverbs onto the stems of certain verbs (Campbell, 1959). Thus, unstressed prepositional adverbs and monosyllabic stressed verbs merged to create compound verbs with unstressed initial syllables. This established the contrasting distributions of stress patterns over nouns and verbs that have generally persisted to this day.

But there is more to the story. Not all English nouns are trochaic, nor are all English verbs iambic, and the stress patterns of individual lexical items continue to change over time. Sherman (1975) has documented some of the stress changes that have occurred in the noun–verb homographs of English. Relying on dictionaries going back to 1570, Sherman traced the emergence of stress differences and reported that the number of stress-distinct pairs has increased from fewer than 10 to upwards of 150 today. Most of these changes (141 of 150) involved shifts away from a uniform iambic pattern for both members of a pair, rather than shifts from the uniform trochaic pattern that is the most common one for these homographs (of the 1,165 same-stress homographs in modern English, Sherman reports that 950, or 82%, are trochaic). Because nouns have strong–weak stress and verbs have weak–strong stress in all stress-distinct homographic nouns and verbs, there is clearly a strong tendency for the nouns to desert the iambic pattern and become trochaic, leaving the iambic form to the verbs.

The nearly complete restriction of this change to iambic patterns, coupled with its gradualness, is more consistent with an explanation in terms of factors that create probabilistic pressures on stress patterns than in terms of the impact of categorical stress rules. There is no obvious reason to predict from category-based accounts that stress-distinct homographic pairs would emerge almost exclusively from iambic forms: Such accounts would seem to predict that trochaic forms should just as easily yield stress-distinct homographs. That they rarely do points to something else at work.

A plausible candidate is the effect of rhythmic context on lexical stress patterns. We have shown that the contexts of English tend to bias trochaic forms in both nouns and verbs, insofar as there is a strong tendency for both to be preceded by unstressed syllables. The overall pressure for trochaic forms is thus greater than for iambic forms, making it more feasible for trochaic than for iambic noun–verb homographs to survive. At the same time, the pressure for trochaic patterns is reliably stronger for nouns than for verbs, because nouns occur in trochaic-biasing contexts more often than verbs do. The resulting tension between iambic nouns and their rhythmic contexts may erode the iambic pattern and produce a drift toward the trochaic. Our evidence that changes in rhythmic contexts can induce stress changes, coupled with Sherman's (1975) evidence that stress shifts have indeed occurred and have occurred most often for formerly iambic nouns, creates a good case that metrical factors may be in part responsible for the characteristic stress differences between English nouns and verbs.

Still, the rhythmic context hypothesis and category-based explanations of word stress are both challenged by the existence of verbs and nouns with the stress patterns characteristic of the other grammatical category. Even among noun–verb homographs, the most common pattern is for both forms to have the same stress: Sherman's (1975) exhaustive survey revealed that more than 85% of the polysyllabic noun–verb homographs of modern English have duplicate patterns. These same-stress forms appear to emerge as a product of the processes responsible for the creation of deverbal nouns (nouns formed from verbs) and denominal verbs (verbs formed from nouns). Speakers readily change the grammatical categories of words, as in the use of *Nixon* as a denominal verb in the sentence *My research assistant Nixed one of the subject's tapes* (Clark & Clark, 1979). However, these grammatical category changes do not seem to be accompanied by stress variations. Instead, the original stress pattern is transferred to the new usage.

If speakers tend to keep the stress pattern invariant when they extend a word's usage into a new grammatical category, then some verbs with trochaic patterns may have originated as nouns, whereas some nouns with iambic patterns may have originated as verbs. To test this hypothesis, a sample of same-stress noun–verb homographs (e.g., *poison, reserve*) was obtained by perusing the Francis and Kučera (1982) word frequency norms and recording all noun–verb homographs in which the noun and verb had the same stress pattern. A total of 542 homographs composed the corpus—432 with trochaic and 110 with iambic stress patterns. The order in which the members of each pair entered the language was determined by consulting *Webster's New Collegiate Dictionary* (1977), which lists noun and verb homographs in their purported order of entry into English. Consistent with the hypothesis, the noun entered the language before the verb in 80% of the trochaic homographs (*z = 24.95, p < .001*), whereas the verb entered the language before the noun in 59% of the iambic homographs (*z = 1.77, one-tailed p < .05*).

Such results provide a partial explanation for the uniformity of the stress patterns of most noun–verb homographs. They also help to account for the existence of nonhomographic

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6 Though the context differences are small in absolute terms, there is certainly precedent for the belief that small causes can have large effects. In view of the hundreds of years, the millions of English speakers, and the billions of utterances that have gone into the language changes in question, it does not seem implausible that differences in rhythmic context should have an impact on the process.
sian nouns and trochaic verbs: Words borrowed from other languages tend to bring their stress patterns with them (Nessly, 1974). Apparently, there is a strong tendency to maintain the old stress patterns of words in new contexts, suggesting that stress patterns are determined largely by information stored with a word’s lexical entry (Cutler & Isard, 1980). Such information may simply be looked up and used whenever a word is produced.

The picture that emerges is as follows. When a word is borrowed from another language or extended from one grammatical category to a different one, its stress pattern is maintained. The stress pattern may eventually shift (partially if the word is an iambic noun) in part because the extended word now appears repeatedly in the typical rhythmic context for its new grammatical category. As the stress pattern shifts, different pronunciations of a word may alternate. Consider current usages of the iambic homograph recall. Webster’s Ninth New Collegiate Dictionary (1986) lists the weak-strong pattern as the only one for the verb and as the preferred one for the noun, but with the strong-weak pattern secondary. In line with this, the verb recall seems to be uniformly pronounced with stress on the second syllable, but the noun’s stress pattern is much more variable. Our intuitions are that a strong-weak pattern is favored among psychologists and automotive news reporters (who often use recall as a noun, in different senses), though weak-strong patterns are still common elsewhere.

The pressure toward such transformations of lexical stress could be augmented by a predisposition for the pronunciation of a word to be modeled in terms of other members of its new category. However, this explanation by itself has trouble accounting for the asymmetries in the historical record. The predominant trend (changes from iambic to trochaic nouns) goes along with the trochaic pattern of most nouns, but the rarity of shifts from trochaic to iambic verbs is hard to reconcile with the tendency toward iambic dominance among verbs.

Both perception and production may contribute to rhythmic effects on lexical stress. As we have noted, there is good evidence for rhythmic biases in perception (Lehiste, 1977; Martin, 1970), and a perceptual basis for the principle of rhythmic alternation is consistent with the possibility that rhythmic context influenced the evolution of stress differences between nouns and verbs in English. Because nouns frequently occur in trochaic contexts, listeners should be more likely to hear disyllabic nouns as having stress on the first syllable regardless of the pattern in the speech signal. On entering such words into their lexicons, hearers may tend to mark them as having first-syllable stress.

Difficulty in perceiving established words may also promote stress changes. Cutler (in press; Cutler & Norris, 1988) has reported that rhythmic context contributes heavily to lexical segmentation and thereby indirectly influences lexical access. If there are frequent mismatches between a word’s stress pattern and the rhythmic context in which it occurs, and if these commonly trigger perceptual failures, a change in the stress pattern may ensue.

Though the evidence from perception is consistent with the rhythmic context argument, the present research provides evidence to suggest that production makes a further contribution. The results of both experiments were consistent with the view that production processes play a role in rhythmic context effects over and above perceptual processes. More generally, the effects of stress pattern variations on speech timing suggest that speakers continuously modify their speech in response to changes in the arrangement of strong stresses in utterances (Fowler, 1977). These modifications can be facilitated or impeded by the quality of the fit between the stress patterns of the words of the language and the rhythmic environments in which those words occur.

Interactions between sentence structure and rhythmic context may help to explain other phenomena besides lexical stress. One instance is the preference for iambic meter in English verse. Although both trochaic and iambic meter consist of alternating strong beats, trochaic is much less frequent. This may be attributable to the impact of normal sentence organization on the alternation. Because of the syntactic structure of English, the first representative of a major lexical category in a sentence is often a noun, and as we have shown, nouns are often preceded by unstressed syllables such as articles. Thus, the first line of a poem will generally begin with an unstressed syllable (Shapiro & Beam, 1965). A stressed syllable should follow, thereby establishing the iambic pattern.

In conclusion, we have argued that the stress patterns of words in two of the major lexical categories of English—nouns and verbs—are influenced by the rhythmic contexts in which the words appear. The evidence for this claim comes from changes in the stress patterns themselves coupled with differences in the characteristic rhythmic contexts of nouns and verbs, from experimental demonstrations of stress variations induced by rhythmic context variations, and from the historical record of changes in the stress patterns of homographic nouns and verbs. Taken together, the evidence suggests that lexical stress patterns are transiently influenced by the circumstances in which words are customarily used, and that over time, the stress patterns of words may shift in a way that appears to represent an adaptation of lexical knowledge to the conditions of language performance.

References


Appendix A

Pseudowords and Sentences Used in Experiment 1

pernew
The pernew chased the ball.
The dogs pernew the ball.

ponsect
The ponsect scared the crowd.
The birds ponsect the sky.

roncerp
The roncerp climbed the tree.
The bears roncerp the tree.

delvoe
The delvoe hit the ground.
The jets delvoe the sky.

covact
The covact blew away.
The plants covact the sun.

telpez
The telpez stunned the bee.
The bees telpez the hive.

fontrain
The fontrain challenged John.
The clouds fontrain the sky.
pomset
The pomset jammed the stream.
The logs pomset the stream.

ransfoe
The ransfoe flagged the ship.
The flags ransfoe the ship.

merset
The merset times the race.
The clocks merset the time.

formand
The formand captured Troy.
The Greeks formand the town.

lesbect
The lesbect sailed away.
The ships lesbect the sea.

blotest
The blotest flew away.
The bats blotest the cave.

premit
The premit saved the crops.
The rains premit the crops.

corlax
The corlax cured the cow.
The drugs corlax the cow.

sestrow
The sestrow danced on stage.
The horns sestrow the song.
telez
The telez scorched the shirt.
The maids telez the shirt.

rendict
The rendict lost the tape.
The tapes rendict the show.
beldop
The beldop sang along.
The songs beldop the tale.
solray
The solray stressed the law.
The laws solray the crime.

rignaz
The rignaz stole the cash.
The thieves rignaz the cash.
pelcrak
The pelcrak floods the town.
The floods pelcrak the town.
pinjub
The pinjub ate the grain.
The ants pinjub the grain.
delay
The delay reads the books.
The books delay the mind.
brolay
The brolay ate the grapes.
The grapes brolay the pet.
torpes
The torpes soaked the shirts.
The shirts torpes the light.

hispay
The hispay struck the moon.
The stars hispay the eyes.
colvane
The colvane rocked the boat.
The waves colvane the boat.

prevell
The prevell killed the germs.
The germs prevell the cells.
delpeen
The delpeen mined the coal.
The rocks delpeen the mine.

ronvoon
The ronvoon dammed the creek.
The creeks ronvoon the dam.
ponveen
The ponveen served the drinks.
The drinks ponveen the guests.
mernak
The mernak blessed the book.
The psalms mernak the priest.
bontoon
The bontoon stalked the deer.
The deer bontoon the plain.
fonjoob
The fonjoob drank the wine.
The drugs fonjoob the witch.
peltact
The peltact searched the room.
The ropes peltact the bridge.
seldiz
The seldiz prayed to God.
The priests seldiz the monk.

pernor
The pernor ruled the woods.
The woods pernor the trap.
Appendix B

Sentences Used in Experiment 2

The big pernew escaped.
The dogs pernew dismay.
Save the pernew quickly.
Milk will pernew butter.
The red ponsect emergad.
The birds ponsect concern.
Slice the ponsect slowly.
Gold will ponsect kingdoms.
The tall roncerp relaxed.
The bears roncerp Maurice.
Paint the roncerp nicely.
Heat will roncerp water.
The pure delvoe dissolved.
The jets delvoe Japan.
Chase the delvoe swiftly.
Steam will delvoe engines.
The sad covact refused.
The plants covact Joanne.
Slam the covact roughly.
Trees will covact forests.
The old telpez expired.
The pills telpez disease.
Make the telpez shapely.
Salt will telpez oceans.
The white fontrain erupts.
The kings fontrain esteem.
Sing the fontrain loudly.
Tests will fontrain students.
The sick pomset revived.
The costs pomset demand.
Watch the pomset calmly.
Bells will pomset towers.
The hurt ransfoe survived.
The flags ransfoe Peru.
Search the ransfoe boldly.
Ice will ransfoe harbors.
The poor menset confessed.
The clocks menset Diane.
Play the menset softly.
Rain will menset pictures.
The smart formand delayed.
The Greeks formand Brazil.
Storm the formand bravely.

Troy will formand Helen.
The dumb lesbect forgot.
The ships lesbect canoes.
Hold the lesbect loosely.
Toys will lesbect children.
The dead blotest escaped.
The bells blotest Cornell.
Rule the blotest firmly.
Light will blotest flowers.
The blue premit condensed.
The rains premit despair.
Sell the premit cheaply.
Dogs will premit kennels.
The young corlax enrolled.
The drugs corlax raccoons.
Take the corlax flatly.
Loans will corlax bankers.
The glad sestrow rejoiced.
The plains sestrow giraffes.
Eat the sestrow plainly.
Wheat will sestrow farmers.
The full teplez decreased.
The maids teplez Arlene.
Throw the teplez badly.
Sand will teplez beaches.
The brown rendict endured.
The pines rendict Vermont.
Hit the rendict soundly.
Books will rendict scholars.
The lost beldop returned.
The songs beldop guitars.
Cut the beldop thickly.
Meat will beldop muscles.
The mad solray rebelled.
The laws solray assaults.
Trim the solray thinly.
Dust will solray tables.
The large rignaz advanced.
The men rignaz gazelles.
Store the rignaz safely.
Guns will rignaz hunters.
The nice pelcrak agreed.
The boys pelcrak lacrosse.
Keep the pelcrak saintly.
Wind will pelcrak branches.
The small pinjub believed.
The clerks pinjub cigars.
Drop the pinjub quantily.
Tea will pinjub dresses.
The long delray commenced.
The queens delray estates.
Call the delray shortly.
Stars will delray heaven.
The drunk brolay imbibed.
The seas brolay sardines.
Grasp the brolay tightly.
Fleas will brolay poodles.
The strong torpez attacked.
The drinks torpez Annette.
Kiss the torpez nicely.
Wine will torpez parties.
The last hispay prevailed.
The grapes hispay champagne.
Hug the hispay warmly.
Cures will hispay doctors.
The proud colvane refused.
The pins colvane balloons.
Use the colvane proudly.
Planes will colvane pilots.
The new prevell resumed.
The hats prevell Eileen.
Sing the prevell sweetly.
Boats will prevell sailors.
The cool delpeen subscribed.
The girls delpeen ballet.
Push the delpeen weakly.
Coal will delpeen miners.
The fond ronvoon indulged.
The chefs ronvoon dessert.
Pet the ronvoon fondly.
Snow will ronvoon rivers.
The calm ponveen awoke.
The schools ponveen careers.
Solve the ponveen strangely.
Goals will ponveen mountains.
The strange mernak arrived.
The kids mernak cartoons.
Play the mernak poorly.
Psalms will mernak prophets.
The short bontoon convened.
The goats bontoon plateaus.
Press the bontoon flatly.
Cheese will bontoon shepherds.
The blind fonjoob excelled.
The rocks fonjoob ravines.
Score the fonjoob blindly.
Nuts will fonjoob squirrels.
The fat peltact matured.
The beers peltact adults.
Run the peltact strictly.
John will peltact countries.
The thin seldiz obeyed.
The maps seldiz awards.
Pull the seldiz strongly.
Joe will seldiz movies.
The first pernor occurred.
The moths pernor cocoons.
Say the pernor coldly.
George will pernor programs.
The fair dolmak conceived.
The shops dolmak shampoo.
Judge the dolmak fairly.
Sue will dolmak sandals.
The deaf fornay declined.
The banks fornay deceit.
Soold the fornay sternly.
Worms will fornay robins.
The free feslak conformed.
The stores feslak receipts.
Join the feslak freely.
Blood will feslak jackets.
The lone telnate remained.
The states telnate frontiers.
Try the telnate justly.
Golf will telnate athletes.
The sore menlee improved.
The cooks menlee techniques.
Drink the menlee fully.
Cream will menlee coffee.
The ill deltain regressed.
The roads deltain cement.
Speak the deltain truly.
Dirt will deltain sneakers.
The hot derlag ignites.
The maids derlag Denise.
Bang the derlag soundly.
Mud will derlag faces.
The wet conzee complained.
The jars conzee cologne.
State the conzee coldly.
Straw will conzee donkeys.
The true torvoot arrived.
The dukes torvoot conceit.
Read the torvoot simply.
Hens will torvoot roosters.
The false pamdeen defects.
The cars pamdeen Detroit.
Stalk the pamdeen keenly.
Priests will pamdeen chapels.

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