Stress Assignment on Non-Words: A Lexical Approach

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ABSTRACT

Seventeen native English speakers participated in an investigation of language users' knowledge of stress patterns. Forty two-syllable non-words of varying syllabic structure were produced as nouns and verbs. Preference for first or second syllable stress of the same words was determined in a perception task. In addition, lexical neighbors of the non-words were collected. Both syllabic structure and lexical class (noun or verb) had independent effects on stress assignment. The effects of syllabic structure and lexical class were not always in agreement with predictions made by traditional stress rules. In logistic regression analyses, predictions of stress placement made by (1) traditional stress rules, (2) lexical class, and (3) stress patterns of lexical neighbors all contributed independently to the prediction of stress assignment. The results support the hypothesis that words are stored with stress information and that stress is assigned to novel words based on similarity to stored lexical items as well as statistical knowledge about the patterning of stress placement across the lexicon.

1. INTRODUCTION

Traditional views hold that stress is applied to lexical representations devoid of stress by a set of rules. Alternatively, stress may be a property of individual lexical items and knowledge of stress patterns may emerge from distributional regularities across the lexicon. With the goal of investigating predictions made by these views, English speakers' stress assignment on two syllable non-words is examined. Evidence from both production and perception is considered. The roles of syllabic structure, lexical class (noun vs. verb) and stress pattern of phonologically similar words in stress assignment are investigated. Predictions made by a rule-based view are compared with predictions made by a view in which stress is assigned to novel words on the basis of similarity to stored lexical items as well as patterns emergent from those lexical items.

Traditional approaches to English stress assignment propose that regular words stored in the lexicon without stress and undergo rules, while irregular forms are thought to be stored with stress and not undergo rules [1, 2]. Researchers have conducted behavioral tests to determine whether or not the proposed rules are active in stress placement. Typically, these tests have involved investigation into the stress assignment of novel words. The assumption is that if stress rules are productively assigning stress during the course of the derivation, then they should also apply to novel forms. Despite the many studies, no firm conclusions can yet be drawn on this issue. Experiments have found effects of English stress rules in some cases [3, 4] and not in others [5, 6]. Experiments in which rules and other potential factors make different predictions are still needed (but see [7]). In addition, many previous studies did not control for prosodic context and orthographic effects.

An alternative approach to stress placement proposes that stress is stored as part of the lexical representation of each word. When new words are encountered, stress placement will be influenced by the stress patterns of existing lexical items. The influence may be from a single, similar word or from patterns abstracted across the lexicon.

Evidence that lexical representations contain detailed information and are not simple, abstract forms has been provided by experimental studies. Results from behavioral research suggest that detailed episodes of word usage (i.e., productions and perceptions) constitute the basic representations in the mental lexicon [see, e.g. 8]. In addition, our ability to detect and exploit probabilistic information suggests that more abstract patterns can also play a role in stress assignment. Distributional patterns of stress across the lexicon may be learned and then applied to novel forms. This proposal must necessarily admit the learning and application of multiple types of probabilistic information. There is good evidence that animals and humans are sensitive to probabilities in many domains, including language [9] and, specifically prosody [10].

The research reported here was designed to test the prediction of two competing hypotheses. The first hypothesis is that words are stored without stress, except for lexically marked exceptions, and assigned stress by rule. This hypothesis predicts that only rules will have an effect on stress placement. The rule effects to be tested are agreed upon by theoreticians [1, 11]. The second hypothesis is that stress is assigned to novel words on the basis of similarity to stored lexical items and statistical knowledge about the patterning of stress placement. This hypothesis predicts that any regularity can be learned and probabilistically applied to the stress assignment of non-words.

The two-syllable non-words used as stimuli in the current study have four different types of syllabic structure. The

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same words appear in noun and verb conditions. Table 1 presents the stress assignment predicted by rule-based accounts. Note that nouns and verbs have different stress treatments for Types 1 and 2 but not 3 and 4. The rules predict that if the ultimate syllable is heavy, it will be stressed. If it is not heavy, the penultimate syllable will be stressed. What counts as a heavy ultimate syllable differs for nouns and verbs. For nouns, only a long vowel makes a syllable heavy. For verbs, a long vowel or a consonant cluster makes a syllable heavy.

Type	Noun	Verb
1	'CVVCVCC	CVV'CVCC
2	'CVCVCC	CV'CVCC
3	'CVCVC	'CVCVC
4	CV'CVVC	CV'CVVC

Note: C=Single consonant, CC=Consonant cluster, V=Short or lax vowel, VV=Long, tense or diphthong vowel.

Table 1. Predicted stress for the non-words based on rule-based accounts.

A lexical approach to stress assignment makes different predictions for stress placement of these word types. Stress patterns of phonologically similar lexical items are predicted to influence stress placement. In addition, it is predicted that distributional stress patterns may be learned and then applied to novel forms. Any type of statistical regularity could be chosen. Here, the distribution of stress across the lexical classes of nouns and verbs is primarily considered. This distributional characteristic was chosen because stress predicted by lexical class makes competing predictions to the stress rules in some cases. Corpus-based studies have found that bisyllabic nouns are up to three times more likely to be stressed on the first syllable than verbs are [12]. Thus, the hypothesis that statistical tendencies in stress distribution can be learned and then applied to novel forms makes the prediction that nouns will have more first syllable stress than verbs, regardless of the stress predicted by rule. If an effect for lexical class on stress placement is found in the data investigated here, a rule-based approach will not be able to explain it.

2. METHOD

The same 17 American English speakers (7 males, 10 females) were paid to participate in all three tasks. Participants ranged in age from 18 to 54 years with a mean of 24 years. None reported being diagnosed with any language or reading disorders and all passed a pure tone hearing screening.

2.1 PRODUCTION TASK

The purpose of this task was to investigate the factors contributing to stress assignment in the production of non-words. Four two-syllable word types, each predicted to have different stress patterns by traditional stress rules (see Table 1), were used. There were 10 tokens of each syllabic type (e.g., Type 1 [beɪ bɛkt], Type 2 [dɛ kɪps], Type 3 [nɪ lɛt], Type 4 [bɪ teɪs]). Participants were asked to concatenate two syllables presented in isolation into a single word and say it in a carrier phrase. Each of the words was said twice, once in the noun frame (*I'd like a__*) and once in the verb frame (*I'd like to__*). Two pseudo-randomized, counterbalanced blocks were used, making a total of 80 trials. Each word was presented only once in each block. Half of the productions in each block were nouns, half verbs.

2.2 PERCEPTION TASK

The purpose of this experiment was to investigate the factors contributing to stress preference in the perception of non-words. The same 40 words used in the Production Task were presented with stress on the first and second syllable in each of the carrier frames *I'd like a__* and *I'd like to__* making a total of 160 sentences. Participants were asked to listen to the prerecorded phrases in pairs. They were instructed to listen to the two sentences and indicate which one sounded the most like a real English sentence to them. In a given trial the same sentence frame (noun or verb) was presented. The stress of the target word was all that varied. Each target word was presented in two trials, once as a noun and once as a verb. Two pseudo-randomized, counterbalanced blocks were used, making a total of 80 trials. Each word was presented only once in each block. Half of the productions in each block were nouns, half verbs.

2.3 NEIGHBORS TASK

The purpose of this experiment was to gather information on the stress patterns of lexical neighbors of the non-words used in the study. Participants heard the same non-words presented as isolated syllables. A 10 second interval followed the presentation in which time the participants listed any words that were brought to mind. The words were presented in 40 trials in a single randomized block.

3. RESULTS

The results of the study indicate that stress placement in the production and perception of non-words is affected by several factors. Nouns were more likely to receive first stress than verbs, even in cases for which the stress rules did not make that prediction. Another factor found to affect stress placement in non-words was the stress pattern of similar words. The stress patterns of lexical neighbors acted as a predictor of stress independently of the predictions made by stress rules and the predictions made by the distribution of stress across the lexical classes of noun and verb. The stress predicted by rules was realized in some cases but not in others. In addition, syllable structure effects not predicted by rule were found.

3.1 PRODUCTION TASK

For each non-word in each sentence frame, the number of first syllable stress responses was divided by the total number of responses for the 17 subjects, resulting in a proportion of first syllable stress responses for each word. The proportions were arcsine transformed and then submitted to an analysis of variance (ANOVA) with two

factors, Word Type (4) and Lexical Class (noun, verb).

Consider the mean proportion of first syllable stress for the four syllable types and two lexical classes displayed in Figure 1. Note that, in general, nouns were more often produced with first syllable stress than verbs. Also note that a long vowel in the first syllable (Type 1) conditioned more first syllable stress, whereas a long vowel in the final syllable (Type 4) conditioned more final stress.

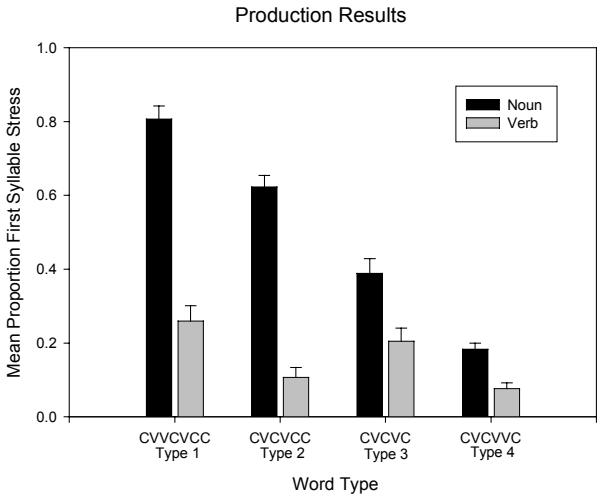

Figure 1. Mean proportion and standard error of first syllable stress productions for 17 native English speakers. Four non-word types with different syllabic structures were produced in noun (black bar) and verb (gray bar) sentence frames.

The interaction of Word Type and Lexical Class was significant [$F(3,72) = 27.06$, $p < .001$]. The effect of Word Type was significant for nouns [$F(3,36) = 58.62$, $p < .001$] ($1 > 2 > 3 > 4$, $p < .01$). The effect of Word Type was also significant for verbs [$F(3,36) = 7.049$, $p = .001$] ($1 > 2, 4$; $3 > 4$, $p < .01$). The effect of Lexical class was significant ($p < .01$) for *all four* of the word types [$F(1,18) = 83.19$, $F(1,18) = 132.95$, $F(1,18) = 11.47$, and $F(1,18) = 11.75$, respectively], with nouns receiving more first syllable stress productions than verbs.

3.2 PERCEPTION TASK

For each non-word in each sentence frame, the number of responses preferring first syllable stress was divided by the total number of responses, resulting in a proportion of first syllable responses for each word. The proportions were arcsine transformed and then submitted to an ANOVA with two factors, Word Type (4) and Lexical Class (noun, verb).

Consider the mean proportion of first syllable stress preference for the four syllable types and two lexical classes displayed in Figure 2. Note that, in general, nouns were more often preferred with initial stress than verbs were. Also note that Word Type 1, which has a long vowel in the first syllable, conditioned more first syllable stress preference for both nouns and verbs.

The main effects of Word Type and Lexical Class were both significant [$F(3,72) = 12.13$, $p < .001$ and $F(1,72) = 35.90$, $p < .001$ respectively]. The interaction was not significant [$F(3,72) = 1.17$]. Nouns were found to have a larger ratio of first syllable stress preference (.51) than verbs (.31). The lack of a significant interaction indicates that the effect of Lexical Class was similar across the four word types. The main effect of Word Type revealed that Word Type 1 had significantly more first syllable stress preferences than any of the other three types ($p < .01$). In addition, Type 3 had a marginally higher ratio of first syllable stress preference than Type 4 ($p = .08$).

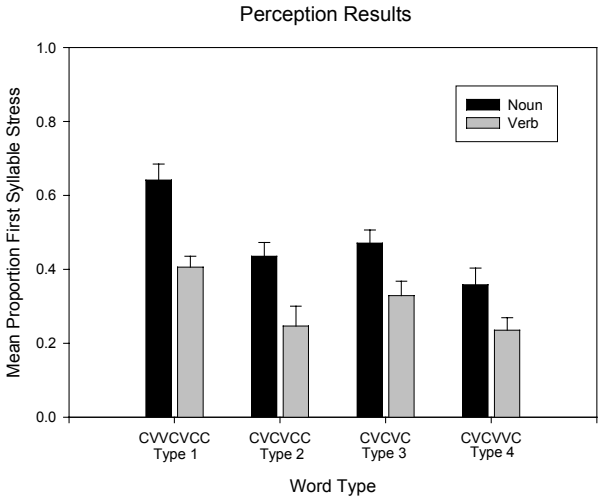

Figure 2. Mean proportion and standard error of first syllable stress preference for 17 native English listeners. Four non-word types with different syllabic structures were heard in noun (black bar) and verb (gray bar) sentence frames.

3.3 NEIGHBORS TASK

Out of the 680 trials (40 words X 17 participants), responses were collected for 358. Most words were disyllabic but a few (around 5% of the cases) were longer. In these cases, the stress was coded as first syllable stress for stress on the first syllable and as second syllable stress for stress on the second syllable. No words with primary stress after the first two syllables were produced. On average, responses for 21 out of 40 trials were recorded per participant.

3.4 LOGISTIC REGRESSION

The statistical tests presented here were designed to determine what sort of effects three predictor variables had on the assignment of stress in non-words. The first variable, 'Rules', was stress predicted by rule application (see Table 1). Of course, this potential effect could either be based on knowledge of rules or on statistical knowledge about stress distributions in the lexicon based on syllabic structure. The next independent variable, 'Lexical Class', predicted that nouns would have initial stress and verbs would have final stress. The third predictor variable, 'Neighbors' was made up of the results from the Neighbors Task. The stress pattern of a similar word to a given stimulus item for a given participant was used to predict the stress of that item. Only those cases for which a neighbor response was recorded are included in the analysis presented here (53% of the trials presented received responses). A total of 716 trials were analyzed in each of the production and perception analyses.

The results of the regression analyses indicate that the

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stress assignments predicted by the variables of Rules, Lexical Class and Neighbors were *all* significantly associated with the behavioral results from both the Production and Perception Tasks. The stress patterns predicted by these three variables each independently contributed to the prediction of stress placement in the stress Production Task and to the preference of stress placement in the Perception Task. The results of the regression analyses are given in Table 2. Note that the estimated odds ratio, *Exp(B)*, gives the change in odds for the case in which the value of an independent variable increases by one. For example, if *Exp(B)*= 2, then the non-words are two times more likely to be preferred with initial stress if the variable predicts initial stress placement than if it predicts final stress placement.

	Variables Entered	*B*	Wald (df=1)	Sig.	*Exp (B)*
Production					
Step 1	Rules	1.48	71.1	.001	4.40
Step 2	Rules	1.06	30.0	.001	2.88
	Lexical Class	0.99	27.8	.001	2.69
Step 3	Rules	1.06	29.45	.001	2.88
	Lexical Class	1.00	28.04	.001	2.73
	Neighbors	.51	8.63	.003	1.66
Perception					
Step 1	Lexical Class	0.67	18.39	.001	1.96
Step 2	Lexical Class	0.68	18.54	.001	1.98
	Neighbors	0.34	6.33	.012	1.49
Step 3	Lexical Class	0.49	7.64	.006	1.64
	Neighbors	0.39	6.20	.013	1.49
	Rules	0.40	4.89	.027	1.49

Table 2. Results from the stepwise logistic regression with the results from the Production and Perception Task as dependent variables.

4. CONCLUSIONS

The results reported here support the hypothesis that stress is assigned to novel words on the basis of similarity to stored lexical items and statistical knowledge about the patterning of stress placement. Knowledge of distributional patterns was shown to affect stress assignment in both production and perception. First, the statistical patterning of stress by lexical class affected stress assignment. Nouns were more likely to be assigned first syllable stress than verbs, echoing the distributional characteristics of these two lexical classes. Second, stress assignment was affected by the vowels of the non-words. Long vowels were assigned stress more often than short vowels, reflecting the tendency for more stress on long vowels in real words. Both of these distributional effects, the lexical class effect and the long vowel effect, were partially independent of the stress predicted by traditional stress rules. Thus, probabilistic distributions of stress assignment have an effect on the placement of stress in novel word production as well as on the preference of stress placement in novel word perception. This indicates that patterns of stress can be abstracted across stored lexical items and then applied to novel forms in a probabilistic fashion.

Interestingly, distributional patterns are not the only factors affecting stress placement. The location of stress on a phonologically similar lexical neighbor also influences the placement of stress. Importantly, the stress pattern of a lexical neighbor predicts stress independently of the predictions made by traditional stress rules and the distribution of stress across lexical class. This was found to be the case in regression analyses on both the production and perception data.

The hypothesis that words are stored without stress, except for lexically marked exceptions, and assigned stress by rule was not supported. The rule hypothesis, even if amended to reflect the effects of syllable structure found here, cannot explain the independent effects of lexical class and neighbors on the assignment of stress in novel words.

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