Examining the Role of Prosody in Fluent Reading

Lesly Wade-Woolley & Eric Akaoka
Queen's University at Kingston, Ontario, Canada

"...I can never escape the inner pronunciation that forms a part of all my reading..." (Edmund Huey, 1908/1968 pp.122).

Abstract

Phonological effects in visual word recognition have been demonstrated using many different paradigms, and despite the many controversies around the precise location and time course of these effects, there is little argument that phonology is involved at some early stage in the process of word reading (Frost, 1998). Demonstration of such phonological effects, however, have largely been restricted to segmental phonology. Little attention has been paid to investigation of activation of stress information in skilled reading. We report a study that uses a visual priming paradigm to test whether linguistic stress is activated in the word reading of adult native speakers of English. We also demonstrate that individual differences in the magnitude of the priming effect are related to standardized measures of reading achievement.

Introduction

Linguistic stress in English

Like Spanish and Dutch, English is a stress-timed language. However, English differs from Spanish and Dutch in the prevalence of vowel reduction in unstressed syllables. Vowel reduction does not occur in Spanish and occurs to a lesser degree in Dutch, relative to English. Unstressed vowels often reduce to schwa in the natural alternation of strong and weak syllables typical of English speech. This means that, along with the suprasegmental cues to stress (i.e., marked by duration, pitch, intensity), segmental information in the form of vowel quality is an additional marker for stress.

Stress is not marked in English orthography, as it is in Spanish, yet it is a crucial part of the phonological system. In some cases, stress placement distinguishes minimal pairs (e.g., *DEsert* vs. *desSERT*; here and throughout, stressed syllables are indicated by upper case letters). Since any vowel may be realized as a schwa in a given word (e.g., *ANimal, WOman, LEmon, sugGEST, reSULT*), readers must either know the word by sight, or be sensitive to the statistical probabilities that govern stress assignment (syllable weight, grammatical category, morphological makeup) in order to achieve correct pronunciation.

One place where we have seen an emphasis on stress has been in the area of spoken word processing. Recent years have seen a number of studies showing that suprasegmental information, specifically lexical stress, is used in lexical access. Many of these studies have used cross-modal priming to demonstrate that stress information presented auditorily influences the decision time on visual presentation of word targets. Despite the involvement of written targets, these studies are largely seen as contributing to the literature on "the processing of spoken words" (van Donselaar, Koster & Cutler, 2005, p. 251), and discussion of the phonemena observed in these papers generally does not extend to implications for models of word reading.

Soto-Faraco, Sebastien-Galles and Cutler (2001) showed that suprasegmental information (i.e., stress) was as effective at constraining lexical access as was segmental information. They conducted a series of lexical decision experiments in Spanish in which a nonconstraining sentence (e.g., [translated] *Nobody knew how to read the word…*) which ended with a word fragment (e.g., *sardi, prinCI*)was presented auditorily. Participants judged whether the letter strings that appeared immediately afterwards were Spanish words. Results showed that targets that matched primes in segmental information (*sardi – SARDINA*) or stress placement (*prinCI – PRINCIPIO*) were accepted more quickly than in cases with a control prime. Similarly, when targets followed primes with mismatched segmental or stress information (*sardi – SARDANA; prinCI – PRINCIPE*), they were accepted more slowly than after control primes.

Similar findings were reported by Van Donselaar, Koster and Cutler (2005, exp. 1) in Dutch. These authors presented auditory primes that had been excised from spoken words, differing in the placement of stress (e.g., *OKto, okTO*). In a lexical decision paradigm, responses of Dutch native speakers were facilitated when the written target shared the same first two syllables of the prime, but only when they shared stress placement. That is, participants responded more quickly to *OCTOPUS* when it was preceded by *OKto*, but were inhibited when the stress placement of the prime and target were mismatched (e.g., *OKTOBER* preceded by *OKto*). The naming latency results of this experiment are summarized in Figure 1; similar results were observed for accuracy.

The nature of stress in English makes these studies difficult to replicate (but see Cooper, Cutler & Wales, 2002), because vowel reduction in natural speech creates a confound; how are we to know whether participants are paying attention to stress or to the accompanying change in vowel quality of the weak syllable? Furthermore, although the cross-modal studies involve written word recognition, the auditory presentation of the prime invokes a modality that is not used in typical word reading. We seek, therefore, evidence that stress is involved in word reading beyond that provided by auditory priming.

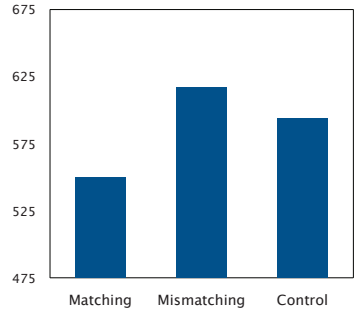

Figure 1. *Results from Van Donselaar, Koster & Cutler (2005, exp. 1)*

There is limited research investigating lexical stress in word reading, although prosodic factors have been the focus of greater attention in reading sentences and connected text (e.g., Bader, 1998; Slowiaczek & Clifton, 1980). Some evidence of lexical stress influencing word reading, however, has come from eye movement studies. Ashby and Clifton (2005) reported a study where participants silently read sentences containing target words that differed in the number of stressed syllables (see Table 1). They showed that words with two stressed syllables took longer to read and received more refixations than did frequency-matched words with one stressed syllable when these conditions controlled for the number of morphologically derived words, familiarity ratings and sentence-context goodness of fit indices. The authors concluded that, since orthography does not supply overt markers of stress, readers were constructing phonological representations that included assignment of stress to the appropriate syllables within words. They further concluded that computation of stress assignment occurs at a relatively late stage in lexical access, since effects that are typically prelexical (e.g., interaction with frequency and duration of first fixation) were not observed.

	one stressed syllable	*two stressed syllables*
High Frequency	Poverty is the most *sigNIficant* problem in our society today.	Poverty is the most *FUNdaMENtal* problem in our society today.
Low Frequency	Ken dressed for Halloween in his *prePOsterous* bird costume.	Ken dressed for Halloween in his *OStenTAtious* bird costume.

Table 1. *Stimuli from Ashby & Clifton (2005).*

It should be noted, however, that Ashby and Clifton (2005) examined the effect of lexical stress in sentence context. Rhythmic alternation of strong and weak syllables may lead to expectancy effects that are consistent with word order and grammatical class (Kelly & Bock, 1988). What is required to support the notion that readers construct phonological representations that include stress information is a measure of lexical stress activation in isolated word reading where there is no context to bias stress assignment.

The current study: Predictions

A design feature of the study is the orthographic overlap between primes and targets; each letter of the prime is contained in the target. Therefore, if stress is not communicated through the prime, no difference should be seen between congruent and incongruent conditions, and both should be faster than the control condition. But if readers construct on-line phonological representations as they encounter words, and if lexical stress information is part of that representation, then we predict that the congruent prime should facilitate target naming relative to both the incongruent condition and the control condition. Also: if computation of stress assignment is part of the operating routine of skilled readers, we predict that individual differences in the size of the priming effect will be related to overall indices of reading ability.

Method

Participants

Participants, mostly undergraduate students, were recruited through word-of mouth and internet advertising. Participants who reported a language other than English as their most fluent language were not included in the current study. Thirty-two participants contributed data to this study.

Materials

Priming Task. 20 English word pairs were devised; each pair consisted of three-syllable words which shared the same orthographic segments in the first two syllables, but differed in the stress placement in those syllables, such that each pair contained a word with stress on the first syllable (e.g., *communist*) and a word with stress on the second syllable (e.g. *communion*). Half the word pairs contained high frequency words (mean frequency 49.55, sd 31.26) and half the pairs contained low frequency words (mean frequency 1.12, sd 1.33). Frequency statistics were determined from Kucera and Francis (1967). The item pairs are given in Table 2.

Primes were then created for each item; the prime for a given word was one of three conditions: 1) *congruent prime*: the first two syllables of the target word, with its primary stress in capital letters (*PEtu* for *PETULANT*); 2) *incongruent*: the first two syllables of the target word, with the unstressed syllable in capitals (*peTU* for *PETULANT*); or 3) *control*: the prime consisted of two syllables presented in lower case which did not share any orthographic segments with the target (*mazi* for *PETUNIA*). An example is shown in Table 3.

Each word was paired with each of the three priming conditions, forming a randomized list of 120 items, broken up into three sections; each target ap-

albania	albatross
appliance	applicant
communion	communist
compendium	compensate
continue	continent
correction	correlate
escaping	escapade
exception	excellent
harmonic	harmony
illusion	illustrate
internal	interim
manila	manicure
opponent	opposite
patina	patio
petunia	petulant
policeman	politics
position	positive
recital	recipe
relation	relative
solicit	solitude

Table 2. *Item pairs used in masked priming task.*

	PETULANT	PETUNIA
Congruent	PEtu	peTU
Incongruent	peTU	PEtu
Control	mazi	mazi

Table 3. *Example of primes for a given target pair.*

peared once in each section. Two such item lists were created.

Reading Tasks. The Word Identification subtest and the Word Attack subtest of the Woodcock Reading Mastery Test (Woodcock, 1998) were used to assess general levels of reading achievement.

Procedure

The items were presented in 20 pt Times font on a Dell Inspiron laptop using DMDX software, along with a Sony microphone for voice input. Each stimulus consisted of a plus sign in the center of the screen as a fixation point, followed by a 39 ms prime, which was then masked by hash-marks. The target word was then displayed in uppercase letters, at which point the participant named the target aloud. A voice key recorded the time of voice onset; accuracy was recorded manually by the experimenter. Four practice stimuli were presented before the main task, after which the participant could ask questions about the procedure. After the experiment had been run, participants were shown a list of the 40 words and asked to circle any words with which they were unfamiliar. Because 26 out of the 32 participants were unfamiliar with *PATINA*, this item and its mate, *PATIO*, were excluded from further analyses.

Results

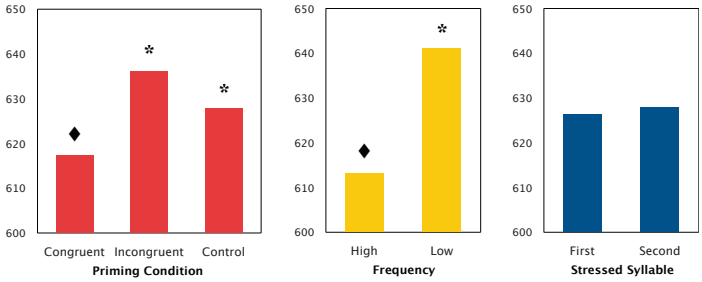

Figure 2. *Naming latency (ms) for priming condition, word frequency and stress position. Asterisks indicate significant difference from diamond.*

A 2 (Frequency) x 3 (Prime Condition) x 2 (Stress Placement) repeated measures ANOVA was run on the RT data. Results showed significant main effects for Frequency, $F(1,31) = 38.723$, $p < .001$, $\eta^2 = .555$, and Prime Condition, $F(2,30) = 9.566$, $p < .01$, $\eta^2 = .389$. Neither the main effect of Stress Placement nor any of the possible interactions reached significance. The main effects are displayed in Figure 2. Follow-up tests showed that the congruent prime condition resulted in significantly faster naming latencies than the incongruent condition or the control condition; the incongruent prime condition was not significantly different from the control prime condition. Targets were named on average 18 ms faster when preceded by a congruent prime than an incongruent prime. Facilitation was observed for 26 out of the 32 participants. Error data were not analyzed because of the high level of accuracy (97%). Our second research question asked whether individual differences in the ability to make use of stress information made overt by the case manipulation carried by the prime were related to overall levels of reading achievement. To address this question, a measure of the stress effect was computed for each participant by means of a difference score between the incongruent and congruent conditions. Correlations between the stress effect score and the reading measures are shown in Table 4; these correlations indicate that higher reading scores are associated with greater ability to benefit from the stress information in the congruent priming condition.

	Stress Effect	Word ID	Word Attack
Stress Effect	1.00		
Word ID	.401*	1.00	
Word Attack	.345^{+}	.699**	1.00

$^{+}p = .05$, *$p < .05$; **$p < .001$

Table 4. *Correlations between stress effect and reading skills.*

Discussion

When naming multisyllabic English words, readers must assign stress to the correct syllable in order to achieve the correct pronunciation. This study investigated whether orthographic manipulation representing lexical stress could influence written word recognition. We aimed to test whether the effect of lexical stress shown in the cross-modal studies in the spoken word processing literature (e.g., Soto-Faraco, et al., 2001; van Donselaar, et al., 2005) could be captured in an orthographic priming paradigm.

Our results demonstrate that when stress information is made overt through the use of uppercase letters, skilled readers are faster at recognizing targets that share the same stress placement. No inhibition relative to control primes was observed with the incongruent prime condition; when the stress information between the prime and target is mismatched, naming is no slower than the case where the prime shares no overlapping letters with the target. This suggests that the orthographic identity carried by the incongruent prime compensates for the misleading stress information.

No interactions involving word frequency were observed; the effect of prime condition affected high and low frequency words equally. This result is similar to that found by Ashby and Clifton (2005), where the eye movement record was influenced by number of stressed syllables in the word, regardless of word frequency. Similarly, no effect or interaction was observed for stress placement; participants were equally sensitive to stress congruence information in both first and second syllable. At least one study (Carreiras, Ferrand, Grainger & Perea, 2005) has suggested that phonological codes are computed sequentially during reading aloud, because of findings that overlap of first-syllable but not second-syllable priming speeds naming latencies. Our results suggest that stress may be a different kind of phonological information than is typically considered in word reading studies. Perhaps this is because English stress assignment often results in reduced vowels which affect vowel quality of adjacent syllables.

We also sought to determine whether individual differences in the ability to benefit from stress information in the congruent prime condition relative to the incongruent condition were related to general reading skills. The finding of significant correlations between the stress effect and standardized measures of word reading and decoding suggest that speed of accurate stress assignment is an integral process in becoming a skilled reader. Given the importance of stress in the phonological system of English and other stress-timed languages, further research into this relationship is warranted.

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Please direct comments or questions to Lesly Wade-Woolley at:
wadewool@educ.queensu.ca

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