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Research report

Prefixes repel stress in reading aloud: Evidence from surface dyslexia☆

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ABSTRACT

This study examined the importance of prefixes as sublexical cues for stress assignment during reading aloud English disyllabic words. In particular, we tested the hypothesis that prefixes repel stress (Rastle & Coltheart, 2000) by investigating the likelihood with which patients with surface dyslexia assign second-syllable stress to prefixed words. Five such patients were presented with three types of disyllabic words for reading aloud: 'regular' prefixed words with weak-strong stress pattern (e.g., remind); 'irregular' prefixed words with strong-weak stress pattern (e.g., reflex); and non-prefixed words with strong-weak stress pattern (e.g., scandal). Results showed that all five patients frequently regularized the strong-weak prefixed words by pronouncing them with second syllable stress. These regularization errors provide strong evidence for the functional role of prefixes in stress assignment during reading. Additional computational simulations using the rule-based algorithm for pronouncing disyllables developed by Rastle and Coltheart (2000) and the CDP++ model of reading aloud (Perry et al., 2010) allowed us to evaluate how these two opponent approaches to reading aloud fare in respect of the patient data.

1. Introduction

Over the past couple of decades, research into the generation of sound from print has begun to move away from a focus on simple monosyllabic words, to consider the special problems posed by multisyllabic words (e.g., Arciuli, Monaghan, & Ševa, 2010; Rastle & Coltheart, 2000). Reading aloud a multisyllabic word requires more than the translation of an orthographic string to its phonological equivalent; it also requires the assignment of stress, which involves the phonetic accentuation of one of the syllables, along with the possible reduction of an unstressed vowel in the word. A clear illustration of these phonetic modulations can be seen in the case of noun/

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verb minimal pairs. For example, the disyllabic English word "suspect" is pronounced/'sVspEkt/[1] when used as a noun (e.g., the usual suspect) and/s@spEkt'/when used as a verb (e.g., to suspect foul play). While the pronunciation of the former is characterised by a first-syllable stress and two phonetically full vowels, the pronunciation of the latter is characterized by a second-syllable stress and the phonetic reduction (schwa) of the vowel in the first syllable.

Several recent studies have investigated the mental processes that underpin stress assignment during reading aloud. These studies have focused on languages characterised by a free-stress system such as English (e.g., Arciuli & Cupples, 2006; 2007; Guion, Clark, Harada, & Wayland, 2003), Italian (see Sulpizio, Burani, & Colombo, 2015 for a review), and Russian (Jouravlev & Lupker, 2014), where stress has neither a fixed position within the word nor is marked by the use of diacritics. These investigations have mainly sought to examine the extent to which stress is determined by word specific stored information (lexical) or statistical-distributional regularities of a given language (sublexical). In respect of this latter dimension, several factors have been identified as potential predictors of stress assignment. These include the distribution of stress patterns in the language (e.g., Arciuli & Cupples, 2006; Colombo, 1992; Kelly & Bock, 1988; Monsell, Doyle, & Haggard, 1989); orthographic sequences, in particular word beginnings and/or endings (e.g., Burani, Paizi, & Sulpizio, 2014; Cappa, Nespor, Ielasi, & Miozzo, 1997; Colombo, 1992; Ševa, Monaghan, & Arciuli, 2009); syllabic weight both at the orthographic (Kelly, 2004; Kelly, Morris, & Verrekia, 1998) and phonological level (Guion et al., 2003); and vowel length (Baker & Smith, 1976; Guion et al., 2003). Of particular importance to the present study is the claim that the morphological structure of a word (i.e., the presence of affixes) also provides important information in determining stress assignment in reading aloud (Rastle & Coltheart, 2000).

Rastle and Coltheart (2000) were among the first researchers to explore the computational processes of stress assignment during the spelling-to-sound translation of a disyllabic stimulus, and to demonstrate how these mechanisms could be implemented within an existing theoretical framework of reading, namely the DRC model (Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart & Rastle, 1994; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Rastle & Coltheart, 1999). The DRC model is a computational instantiation of the dual-route theory of reading, the central tenet of which is that the translation of spelling to sound involves two procedures, a lexical procedure whereby item-specific stored knowledge about the relationship between orthography and phonology is retrieved, and a sublexical procedure whereby phonological information is computed from an orthographic string by a set of rules (Coltheart, 1978; Forster & Chambers, 1973; Marshall & Newcombe, 1973). Rastle and Coltheart (2000) suggested that stress information could be stored in the lexical route of the model as a property of item-specific phonological representations, and thus retrieved during the reading aloud of known words. They concentrated instead on the more challenging task of implementing a stress assignment procedure along the sublexical route of the model that could be applied to the reading of disyllabic letter strings without a lexical representation (i.e., unfamiliar words and nonwords).

The rule-based process developed by Rastle and Coltheart (2000) was designed to execute both the mapping between sublexical orthographic and phonological representations (segmental information) and the assignment of stress along with the appropriate vowel reduction (suprasegmental information). Morphological structure plays an important role in the system of rules that Rastle and Coltheart (2000) implemented, particularly in relation to the assignment of stress (for an illustration of the stress rules refer to Figure 2, p. 349 in Rastle & Coltheart, 2000). Specifically, the identification of a prefix (e.g., pre-, de-, dis-. re-, mis-) results in the assignment of second-syllable stress, while the identification of a suffix results in the assignment of first-syllable stress (except in the case of a small group of stress-taking suffixes identified by Fudge (1984) such as −een, −ique, -oo). In the absence of an identifiable affix, first-syllable stress is assigned, which is the dominant stress pattern for disyllables in the English language. Rastle and Coltheart (2000) reported that the algorithm successfully predicted stress assignment on 89.7% of all disyllabic English words present in the CELEX database (Baayen, Piepenbrock, & van Rijn, 1993), and it also predicted the modal stress given to 84% of a large set of disyllabic nonwords read aloud by human subjects. This work thus provides evidence supporting the notion that prefixes can serve as important cues for stress assignment, and more generally, that sublexical cues for assigning stress to disyllables can be expressed within a system of rules relating spelling to sound.

The present study introduces a new approach to ascertaining the sublexical cues to stress assignment. Specifically, we denote prefixed words as 'regular' if they take second-syllable stress (e.g. remind) and 'irregular' if they take first-syllable stress (e.g. reflex). We then test whether patients with acquired surface dyslexia, an acquired disorder of reading in which the reading aloud of irregular words is impaired while the reading aloud of nonwords is spared (Marshall & Newcombe, 1973), are likely to assign second-syllable stress to prefixed irregular words. Typically, these patients produce regularization errors in pronunciation when reading aloud irregular monosyllabic words (e.g., reading *pint* as if it rhymed with *mint*). Thus, while these patients demonstrate an impairment in utilising lexical information during reading, their ability to translate orthography to phonology via sublexical operations appears to be intact. Accordingly, we hypothesized that these patients would commit stress regularisation errors when reading aloud irregularly-stressed disyllabic words (e.g., read 'reflex' with second-syllable stress).

While patients with surface dyslexia have typically been examined in respect of the segmental errors produced during reading aloud, it has long been known that they also produce errors with respect to suprasegmental information (Marshall & Newcombe, 1973). Stress regularization errors in acquired, as well as developmental, surface dyslexia have been

[1] For consistency reasons we chose to report transcriptions throughout the article using the phonemic vocabulary of the dual-route cascaded model. The glossary of the DRC phonemic vocabulary is provided in Appendix A.