Default and exceptional stress processing in Spanish as a testing ground for generative versus exemplar-based phonology models: evidence from ERPs

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In this paper we set out to investigate the status of stress as an abstract category and its connection with lexical information concerning differently stressed words. In the course of a neurophysiological experiment measuring event-related potentials (ERPs), we tested the generativist hypothesis concerning lexical storage *vis à vis* its competing usage-based model. As is well-known, generativist models of phonology assume that only unpredictable information that cannot be derived by rules is stored in the UR. Non-contrastive data and phonetic detail redundant for the processing of a given word, including predictable stress markers, are excluded from the lexicon. The competing approach, drawing on the theory of exemplars (Bybee, 2001, 2006), abandons fully abstract, phonemic representations of words or morphemes and focuses on the effects of frequency and other external factors on sound production and perception. Here, gradient, lexically diffuse differences in pronunciation are all stored in the mental lexicon as they are. Consequently, stress cannot be a derived or abstract category. It is a bundle of acoustic and auditory features stored with each word represented in the exemplar cloud.

In our experiment, we wanted to put the two approaches to phonological information storage to the test. For this purpose, we used Spanish – a language with variable stress and a prevalence of one stress pattern over the others (hence partial stress predictability). Importantly, over 64% of all Spanish words are stressed on the penultimate syllable (Morales-Front, 2014; 78.9% according to Quilis 1981), while antepenults constitute merely 8% (or 2.76%) and should be considered exceptional (the rest are words with final stress). As a result, we can assume that there is a default penult pattern derivable by rules in the language with lexical exceptions (final and antepenult) that have to be learned (see e.g. Piñeros, 2016). At the same time, given variable stress and the existence of minimal pairs, we expect that Spanish speakers are sensitive to stress differences in perception as they have to at least partially learn them (they are not 'stress-deaf', Peperkamp et al. 2010). Thus, we want to look at the processing of stress by Spanish speakers and its consequences for the users' grammars. More specifically, we want to establish whether the default penultimate stress pattern is processed differently than the exceptional antepenult and whether the latter but not the former is stored in the mental lexicon to facilitate word retrieval. To achieve this goal, we must gain access not only to pre-lexical processing, but also to semantic activation responsible for linking phonology with meaning. In neurophysiological literature, paradigms evoking the N400 negativity effect (Kutas & Hillyard, 1984) are typically used for this purpose, hence we designed a study focused on auditory identification and subsequent classification of native Spanish words as either correctly or incorrectly pronounced.

32 native speakers of Spanish (19 females) aged 19-32 listened to 240 stimuli including either correctly or incorrectly stressed trisyllabic words. 60 penults and 60 antepenults with a CV.CV.CV structure were chosen and recorded with a female native speaker in both a standard (correct) and a deviant (incorrect) version, then spliced into an invariable carrier sentence. The words from the two patterns were of matching frequencies (based on the log count in *Corpus del español*) and controlled for phonological neighbourhood. Antepenults had a deviant version with penultimate stress and vice versa, i.e. penults had deviant versions with antepenultimate stress. As the participants listened to the stimuli and then judged their correctness, we measured their neurophysiological responses with the Biosemi ActiveTwo EEG system, and reaction times using the Neurobs Presentation software. Incorrect stress was assumed to invoke a more robust negativity in the range of approximately 400 ms from the onset of the stimulus compared to the correctly stressed word. Given the distributional differences between penults and antepenults in the language, it was further assumed that a significant difference would ensue in

the data between the two stress patterns. As N400 is a component that occurs in response to a semantic violation, if information concerning stress is derived in online processing and not stored in the mental lexicon, the change of the stressed syllable should not cause major problems. If, however, the stress information is stored (lexicalised), then a mismatch between the memorised and the perceived word will be detected and more processing steps will be needed to identify the word in question. Thus, if the assumptions of the exemplar-based model are correct, there should be no difference in responses to stress shift between the exceptional antepenult and the default because all types of stress are stored. Difficulty with the antepenults but not penults should be considered evidence supporting generative phonology models.

The results of the study show significant negativity in the range of 350-600 ms from target word onset in the antepenult case only. A repeated measures ANOVA conducted on the data from 27 participants showed a main effect of condition for this word type ($F(1,26) = 20.38$, $p < 0.001$) and no effect in the case of the penults ($F(1,26) = 1.562$, $p = 0.222$). This means that moving the stress from the penultimate to the antepenultimate syllable does not result in an N400 effect, while shifting the stress in the opposite direction evokes a significant negative response. The effect was observed in the range of 350-600 ms from the onset of the target word, which roughly corresponds to the end of the second syllable – the time we suppose is necessary to identify stress in trisyllabic words used as stimuli. ERP difference waves further confirmed the conclusion that the processing of stress is different for the two tested word types, showing a main effect of stress pattern ($F(1,26) = 12.89$, $p = 0.001$).

In the later time window corresponding to correctness judgment (positivity between 600 and 900 ms from word onset), responses to deviants vs. standards were similar in both types of words (significant effect of condition $F(1,26) = 23.05$, $p < 0.001$), but the reaction times following antepenult deviants were longer than following penult deviants. This means that Spanish speakers were able to correctly judge the correctness of both penults and antepenults, but it was more costly for them to process words in which the stress was shifted from the antepenult than in the reverse condition. Such a result further corroborates the hypothesis that antepenults are treated as exceptions and their stress markers have to be underlyingly present as their change causes a semantic violation. At the same time, penults behave as true defaults whose underlying abstract representations are not indexed with stress information. Instead, the stress is inferred (or computed) from grammatical rules concerning default stress assignment.

Thus, the data support the generative phonology framework which assumes that only unpredictable information is stored in the mental lexicon. While frequency effects play a role in speech processing, when they are controlled for, grammar is the decisive factor. Grammatical operations, which translate acoustic detail and auditory cues into abstract features and phonological constituents, are therefore an indispensable element of online language analysis and cannot be limited to mere statistical inference. This conclusion finds support in previous studies on the perception of stress in e.g. Russian or Turkish (Mołczanow et al. 2013, Domahs et al. 2012) in which N400-like negativity effects were observed and interpreted as pointing to problems with the lexical processing of exceptional word types.

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