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ERP evidence for implicit L2 word stress knowledge in listeners of a fixed-stress language

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ABSTRACT

Languages with contrastive stress, such as English or German, distinguish some words only via the stress status of their syllables, such as "CONtent" and "conTENT" (capitals indicate a stressed syllable). Listeners with a fixed-stress native language, such as Hungarian, have difficulties in explicitly discriminating variation of the stress position in a second language (L2). However, Event-Related Potentials (ERPs) indicate that Hungarian listeners implicitly notice variation from their native fixed-stress pattern. Here we used ERPs to investigate Hungarian listeners' implicit L2 processing. In a cross-modal word fragment priming experiment, we presented spoken stressed and unstressed German word onsets (primes) followed by printed versions of initially stressed and initially unstressed German words (targets). ERPs reflected stress priming exerted by both prime types. This indicates that Hungarian listeners implicitly linked German words with the stress status of the primes. Thus, the formerly described explicit stress discrimination difficulty associated with a fixed-stress native language does not generalize to implicit aspects of L2 word stress processing.

1. Introduction

In many languages, a single syllable of a multisyllabic word or phrase is acoustically more salient (i.e., stressed) compared to the other syllable (or the other syllables) of that word or phrase. The stressed syllable typically is longer and louder and shows characteristic pitch and formant frequencies (Sluijter and van Heuven, 1996; Sluijter et al., 1997). However, languages differ in the actual phonetic realization of stress: For example, in Hungarian, stress is realized mainly by changes of f0 (pitch) and intensity (Fónagy, 1958) with syllable duration playing a minor role (White and Mády, 2008), while in German, all three acoustic cues are crucially involved (Jessen et al., 1995). Across languages that use stressed syllables, more or less restrictive rules govern their position within words or phrases. In fixed-stress languages, a single restrictive rule determines stress assignment. Hungarian and Finish, for example, mandatorily assign stress to the initial syllable of a word, while French assigns stress to the final syllable of a phrase. In other languages, such as English and German, rules govern stress assignment for many but not for all words. Stress can even become contrastive in those languages, differentiating, for example, the English words "CONtent" vs. "conTENT" or the German words "AUGust" (male name) vs. "auGUST" (name of the month August; here and in the following examples capital letters indicate a stressed syllable). In the present study, we investigate listeners with a fixed-stress native language (L1, Hungarian) processing a second language with more variable stress (L2, German).

Listeners with a fixed-stress L1 implicitly detect deviation from the mandatory stress pattern of their native language. This was attested by Event-Related Potentials (ERPs) recorded for correctly and incorrectly stressed words: Across several studies, spoken strings deviating from the mandatory stress position elicited different ERPs than strings following the mandatory stress position in Hungarian listeners (Honbolygó and Csépe, 2013; Honbolygó et al., 2004), in Polish listeners (Domahs et al., 2013; Domahs et al., 2012), and in French listeners (Astésano et al., 2004; Magne et al., 2007; Schön et al., 2004). Furthermore, incorrect stress hampered word recognition in listeners with a fixed-stress L1. Finish listeners detected the word "HYmy" [smile] faster in "pyHYmy" than in "PYhymy" (Vroomen et al., 1998).

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The latter finding might imply that Finish listeners store the mandatory word-initial stress position together with each word and have difficulties in accessing a word with incorrect stress. This would be in accordance with the characteristic ERP responses for stress deviation obtained for native listeners from other fixed-stress languages (see above). In addition, or alternatively, as Vroomen et al. (1998) argue, Finish listeners might selectively exploit stressed syllables (which obligatorily are word onsets in their L1) for lexical search. According to this interpretation, Finish listeners would take every stressed syllable to access a new word.

Across two studies, listeners with a fixed-stress L1 (French) were restricted in their ability to use syllable stress for explicit word identification in an L2 with variable word stress: In a study by Tremblay (2008), French learners of English heard either a stressed English word onset, such as “MYS-”, or an unstressed English word onset, such as “mis-”. Their ability to complete those word onsets correctly (“MYStery” and “misTAKE”, respectively), was only slightly above chance level. In a study by Dupoux et al. (2008), French leaners of Spanish had difficulties in distinguishing correctly stressed Spanish words, such as “ROpa” [clothing], from incorrectly stressed versions, such as “roPA”. Also in that study, accuracy rates were only slightly above chance level. Together, both studies suggested that listeners with fixed-stressed L1 do not store different stress patterns of L2 words or that they cannot exploit their implicit knowledge about syllable stress for explicit judgements on the stress pattern of L2 words.

Stress discrimination difficulties that listeners with a fixed-stress L1 showed for L2 words found a parallel in stress discrimination difficulties for meaningless strings. In one type of respective tasks, participants listened to sequences of nonsense words differing only in the position of the stressed syllable, such as “BOpelo – boPElo – BOpelo”. Participants judged which strings had the same stress pattern, for example by determining whether the third nonsense word was equal to the first nonsense word or to the second nonsense word. Listeners with an L1 that allows stress variation (Dutch, German, Japanese, and Spanish), performed better in those explicit stress discrimination tasks than listeners with a fixed-stress L1 (Finish, French, Hungarian, and Polish, see Dupoux et al., 1997; Dupoux et al., 2008; Honbolygó et al., 2017b; Rahmani et al., 2015). Superior performance of listeners with an L1 that allows the stress position to vary (compared to listeners with a fixed-stress L1) were also obtained for sequence recall tasks, in which nonsense words varying only in stress had to be recalled (Dupoux et al., 2001; Peperkamp et al., 2010). Together, these findings are captured by the stress “deafness” hypothesis, which holds that the processing of varying stress positions poses a problem for listeners with a fixed-stress L1 (Dupoux et al., 2001).

In contrast to previous work investigating explicit L2 word identification and stress discrimination, the present study focuses on the implicit aspects of L2 word recognition, namely, on phonologically mediated mechanisms of lexical access. Since the first conceptualization of parallel processing in the Cohort model of spoken word recognition (Marslen-Wilson and Welsh, 1978), empirical findings indicated that listeners implicitly handle multiple lexical hypotheses simultaneously. As soon as the unfolding speech stream provides some information about word identity, listeners not only consider all word completions that are fully overlapping with the temporary input but also canditates that are only partially overlapping (for a review, see Weber and Scharenborg, 2012). The first connectionist model of speech recognition (TRACE, see McClelland and Elman, 1986) added the assumption that simulteanously considered candidates compete for recognition. Models of spoken word recognition resolve this competition either via lateral inhibition (as in TRACE), via mechanisms that select the candidate that fits the input best (as in revised versions of the Cohort model: Marslen-Wilson, 1990; Marslen-Wilson and Warren, 1994), or via selection mechanisms that consider the evidence from the signal and the probability of a given word (as in instances of the neighboorhood acitvation model [NAM]: Luce, 1986; Luce and Pisoni, 1998). Together, parallel consideration of lexical hypotheses and competition processes are considered to be universal, i.e., those implict ascpects of processing are also involved when L2 words are recognized (for review, see Weber and Broersma, 2012).

Word onset priming allows identifying neurocognitive correlates of phonologically mediated mechanims of lexical access. In cross-modal versions of this paradigm, participants listen to spoken word onsets and make lexical decisions to immediately following printed words (or pseudowords). ERPs for phonologically overlapping target words (e.g., “Ano - Anorak” [anorak]), start to differ from ERPs for unrelated targets (e.g., “Idi – Anorak”), around 300 ms after target word onset (Friedrich, 2005; Friedrich et al., 2013; Friedrich et al., 2004a; Friedrich et al., 2008). ERP difference waves (related-unrelated) substantiated left-anterior positive amplitudes that led to the label “P350” effect. In addition, enhanced posterior central negativity for phonologically unrelated targets (between 400 and 600 ms) shows parallels with the phonological N400 effect (Praamstra et al., 1994) and with the phonological mapping negativity (Connolly and Phillips, 1994; Steinhauer and Connolly, 2009). We related the P350 and the N400-like negativity to the systems' consideration of lexical hypotheses and respective predictions about upcoming words (e.g., Friedrich et al., 2013).

ERPs reflect slightly different aspects of word onset priming than lexical decision latencies recorded in word onset priming. P350 and central negativity effects consistently reflected that candidate words with some overlap with the input (e.g., “Ana - Anorak”) modulate target word processing (Friedrich, 2005; Friedrich et al., 2013; Friedrich et al., 2008). Following a gradual pattern, ERP amplitudes elicited by partially overlapping target words were in-between ERP amplitudes for completely overlapping target words and unrelated target words. This gradual pattern was even found when lexical decision latencies for partially overlapping target words did not differ from those for unrelated words (Friedrich et al., 2008) or when lexical decision latencies for partially overlapping words were slower than those for unrelated words (Friedrich et al., 2013). We concluded that lexical decision latencies are more prone to competition effects or selection strategies than ERP effects are (for further discussion, see Friedrich et al., 2013). Together our results substantiate models assuming several mechanisms considering different aspects during lexical access (e.g., revised version of the Cohort model or NAM, Luce, 1986; Luce and Pisoni, 1998; Marslen-Wilson, 1990; Marslen-Wilson and Warren, 1994). Mechanisms that focus on bottom-up evidence in favor of a lexical hypothesis (as reflected in the ERPs) are separable from mechanisms that, in addition, consider evidence against a given hypothesis (as reflected in lexical decision latencies).

Although not considered in classical models of speech recognition, syllable stress appears to constrain the evidence in favor of or against a given candidate word. This was attested, for example, by eye-tracking data obtained from Dutch, English, and Italian listeners (Jesse et al., 2015; Reinisch et al., 2010; Sulpizio and McQueen, 2012). Participants listened to words with similar phonemic but different stress onset (e.g., “MUsic” and “muSEum”) in their respective L1. Across these three studies, listeners directed their eye gazes more frequently to printed versions of the stress-matching candidate than to the stress-mismatching candidate well before the offset of the spoken target word. Syllable stress also modulated behavioral responses in word onset priming. Dutch, English, German, Italian, and Spanish listeners responded faster to targets in prime-target pairs with stress overlap, such as “MUs - MUsic”, than to targets that differed in their onsets from the stress status of their preceding primes, such as “MUs - muSEUM” (e.g., Cooper et al., 2002; Soto-Faraco et al., 2001; Spinelli et al., 2001; Tagliapietra and Tabossi, 2005; van Donselaar et al., 2005).

ERPs recorded in word onset priming revealed independent processing of phoneme-relevant information and syllable stress in native listeners (Friedrich et al., 2004a). In the design of that study, phoneme overlap and stress overlap within prime-target-pairs varied independently (for illustration, see Table 1). Phoneme overlap elicited