Contents lists available at ScienceDirect

International Journal of Psychophysiology

Lexical influence on stress processing in a fixed-stress language

Linda Garami [a,b,*], Anett Ragó [a,c], Ferenc Honbolygó [a,c], Valéria Csépe [a,d,e]

[a] MTA RCNS Brain Imaging Centre, 1519 Budapest, P.O. Box 286, Hungary
[b] ELTE FEP, Doctoral School of Psychology, 1064 Budapest, Izabella u. 64, Hungary
[c] ELTE FEP, Institute of Psychology, 1064 Budapest, Izabella u. 64., Hungary
[d] BME FNS, Department of Cognitive Science, 1111 Budapest, Egry József utca 1. T. épület, V. emelet 506., Hungary
[e] PU FMPSS, Institute of Hungarian and Applied Linguistics, 8201 Veszprém, Pf. 158., Hungary

ARTICLE INFO

ABSTRACT

In the present study, we investigate how lexicality affects the processing of suprasegmental features at the word level. In contrast to earlier studies which analyzed the role of either segmental or suprasegmental feature in language processing our aim was to investigate the effect of the lexical status on the processing of violated stress pattern defined by linguistic rules. We have conducted a passive oddball ERP experiment, presenting a frequent CVCV word with legal (familiar) and illegal (unfamiliar) stress patterns. Former results obtained with pseudo-words in a similar paradigm enabled to assess the influence of lexical information on stress processing.

The presence of lexically relevant information resulted in different ERP patterns compared to those obtained with pseudo-words. We obtained two consecutive MMN responses to the illegally stressed words while violating the illegal stress pattern with a legal one the deviant stimulus elicited two consecutive MMN responses as well. In the latter condition lexicality clearly enhanced the comparison of prosodic information between standard and deviant stimuli, as these components very completely missing when presenting pseudo-words.

We interpret the results that lexicality acts as a filter since in the absence of lexical familiarity unfamiliar stress patterns are discriminated better.

Our results highlight that even when stress is fully predictable, it is taken into account during pre-attentive processing of linguistic input.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

Speech comprehension, particularly the activation of lexical representations of spoken words, relies on both segmental and suprasegmental information. The long-term representation of segmental elements such as phonemes has an extensive literature. According to recent data, adults also use suprasegmental information, i.e. word level prosodic features, relying on long-term prelexical representations when processing linguistic input. In the present study, we investigate how lexicality affects the processing of suprasegmentals at word level.

Word level stress pattern is defined by the order of stressed and unstressed syllables. Languages determine the sequential order and the instantiation of stress itself, individually. In French, for example (cf. Dupoux et al., 2008) F0, duration and intensity are together responsible for the realization of stress pattern. However, the contribution of duration in defining the stressed segment of words varies to a large extent.

In Hungarian, duration is a segmental cue itself that implies a constraint on how much it can contribute to syllabic stress. Earlier results demonstrated no contribution at all (Fónagy, 1958), while more recent, yet controversial phonetic data are suggesting a certain amount of contribution (for more details about Hungarian vowel lengths see Mády and Reichel, 2007). Vowel length does not play any role in stress expression in Polish (Domahs et al., 2012). The other two aspects of forming a language-specific acoustic complex associated with the stress pattern are related to the location and emergence of regular stress. There is a broad range of variations in languages from strictly fixed-stress languages to free stressed ones. In fixed-stress languages, word-internal position for stress is assigned according to a common rule. It is always on the first syllable in Finnish and in Hungarian (Siptár and Törkenczy, 2007), and is always on the last in French words (Dupoux et al., 2010). Moreover, there are languages with a predominant pattern supplemented with numerous exceptions. Polish words bear stress mostly on the penultimate syllable with a well-defined group of exceptions (Domahs et al., 2012). On the contrary, contrastive languages use lexical stress to convey differences in meaning. Although both Spanish and English have a predominant stress pattern, stress is also a lexical feature in contrast with the aforementioned languages. In contrastive languages, stress contributes to lexical comprehension while in fixed-

* Corresponding author at: MTA RCNS Brain Imaging Centre, 1519 Budapest, P.O. Box 286, Hungary.
E-mail addresses: garami.linda@ttk.mta.hu (L. Garami), rago.anett@ppk.elte.hu (A. Ragó), honbolygo.ferenc@ttk.mta.hu (F. Honbolygó), csepe.valeria@ttk.mta.hu (V. Csépe).

stress languages word level stress correlates well with word boundaries (Cutler et al., 1997). These different functions seem to impact both developing and mature prosodic processing.

Locating word boundaries in fluent speech is not an obvious task since there are no pauses between words like there are clear spaces in written text. In optimal conditions, adults use lexical segmentation strategy relying on known word forms (Norris, 1994). However, suprasegmental features become important when conditions are suboptimal, for instance when lexical cues are not clearly available (Mattys et al., 2005). The period of early language acquisition is also characterized by the unavailability of lexical cues. According to the literature on early segmentation, prosody helps infants to find word boundaries. However, there are differences between fixed vs. contrastive languages (Friederici et al., 2007; Höhle et al., 2009; Skoruppa et al., 2009) in regard of the predominant pattern of native language (trochaic, iambic, penultimate, ultimate, etc.).

In contrast to infants, segmentation for adults is based mostly on lexical segmentation, which gives rise to the question: what happens to the exploitation of word level stress? Does independent prosodic analysis operates further as it does in infants, or do prosodically rich lexical representations take over by suppressing the importance of word-stress pattern as a segmentational cue? Or, as Cutler et al. (1997) also puts it: if stress is fully predictable and segmentation is solved, what benefit could be gained from word level stress information?

Irrespective of the rich lexical representation, phrase level prosody overlaps with word level stress and holds syntactic structural information that speeds up speech comprehension (Christophe et al., 2004). Jacobsen argues that both segmental and suprasegmental features are constantly monitored (Jacobsen et al., 2004) in order to identify relevant information in the auditory environment. Evidence for separate processing of phonemes and prosody, the domain to which stress belongs, comes from neurocognitive research. Separable neural mechanisms devoted to aspects of the input that vary over longer or shorter timescales have been identified for the processing of complex auditory signals in general (e.g., Boemio et al., 2005), as well as for the processing of speech in particular (e.g., Luo and Poeppel, 2007). These findings integrate into a neurocognitive model of different temporal integration windows according to which speech is analyzed at intervals of approximately 20 to 50 ms appropriate for identifying phonemes, and at intervals of approximately 150–300 ms appropriate for identifying prosody (for review see Hickok and Poeppel, 2007; Poeppel, 2003, 2014) Indeed, electrophysiological studies have demonstrated that stress patterns at word level are processed in adults even in Finnish, Polish and also in Hungarian (Domahs et al., 2012; Honbolygó and Csépe, 2013; Peperkamp et al., 2010).

When investigating prosody, analyzing the Mismatch Negativity (MMN) component of event-related brain potentials (ERPs) is a plausible tool, as it is a robust electrophysiological correlate of stimulus discrimination elicited by infrequent stimuli among frequently presented ones. In addition, MMN is independent of attention, and its features, amplitude, latency and scalp distribution depend on the discriminability of the stimuli used. The MMN component is also influenced by permanent language-specific memory traces. It was shown for speech-sounds (Näätänen et al., 2007), and also consistent with earlier results (Winkler et al., 1999) that the MMN component is sensitive to between and within category distinctions. The long-term traces of the categories serve as recognition patterns (equivalent of templates, see Honbolygó and Csépe, 2013) parallel to the short-term trace established by the actual standard stimulus in oddball paradigms. This is also confirmed by magnetoencephalography (MEG) measurements showing that auditory and phonological mismatch components stem from somewhat different locations (Winkler et al., 1999). Pulvermüller and colleagues extended this notion to the word level (Pulvermüller et al., 2001). They obtained differences in MMNs for words and nonsense words confirming that the familiarity with a word form also results in different responses. This supports the idea that linguistic information can be assessed preattentively connected to different linguistic representations (e.g. phonemes, words).

Beside the familiarity of word form, the familiarity of the word level stress pattern was also investigated. Ylinen and colleagues used a legally stressed CVCV pseudo-word as frequent standard stimulus violating it along the dimension of stress legality (illegal pattern) and/or lexicality (word vs. pseudo-word). Two consecutive MMNs were elicited by the stress violations. Presenting word in an oddball paradigm as a deviant was also accompanied by an MMN that was expected to be delayed when it also violated the legal stress pattern of the standard stimulus. Unfortunately, using the same legally stressed pseudo-word as standard does not allow for a precise distinction between the suprasegmental and lexical processes responsible for the MMNs, and the EEG is lacking the sufficient spatial resolution for testing generators' location in this experiment. Honbolygó and Csépe (2013) tested different standards along the stress legality dimension by using pseudo-words to control for word familiarity, and found different ERP patterns discriminating language-specific (legal) and violated (illegal) stress patterns, regardless of word familiarity. This means that Hungarian adults are able to discriminate illegal stress pattern as it was shown by the occurrence of two consecutive MMNs for bi-syllabic pseudo-words, while no mismatch response was elicited by the infrequent legal pattern delivered among frequent illegal standards. This strengthens the argument for an existing long-term representation of stress pattern in adults as the ERP responses resulted from processing the complex stress patterns and not just the simple salient acoustic features.

Along the same logic, we tested words with legal and illegal stress patterns using them both in standard and in deviant roles across conditions. Our aim was to examine whether the illegal stress pattern delays the MMN when it plays a deviant role as it did in the study of Ylinen and whether the template-based processing takes place at all when lexical information is easily accessed. We tested Hungarian adults, because Hungarian has a fully predictable stress pattern without exceptions; therefore the results would underpin Jacobsen's proposal of the continuous monitoring of the environment while exploiting full predictability of patterns rather than neglecting them as it was raised by Cutler.

Our recent investigation aimed at monitoring the interplay between word meaning and stress pattern. It seems that using words instead of pseudo-words for following the effect of prosodic violation invites several expectations regarding the mismatch component. According to the lexical trace hypothesis of Pulvermüller et al. (2001) MMN component is more pronounced in case of words than pseudo-words as deviants. This suggests that we might observe larger MMN amplitudes than there was shown in the study of Honbolygó and Csépe (2013). Although in our experiment we presented words in both standard and deviant roles, the lexical trace hypothesis (Jacobsen et al., 2004) proposes that activated lexical representations in addition to acoustic ones affect the change detection. The familiar context hypothesis proposes more elaborate processing of the standard stimulus when it is a familiar one; therefore we can expect higher amplitude responses for words than for pseudo-words in the same paradigm. We also expected that when the standard stimulus is the legally stressed form, the MMN amplitude would be higher compared to the standard stimulus with an illegal stress pattern.

2. Material and methods

2.1. Participants

Twenty-eight Hungarian native speakers (3 left-handed) participated in the experiment. They have reported no hearing, language and neurological disorders, were recruited from a university course (mean age = 21) and got course credit for participation. Participants provided written informed consent before taking part in the study. The Ethical Review Committee for Research in Psychology (Hungarian Research