Valéria Krepsz, Anna Huszár & Viktória Horváth

Acoustic realization of prosodic cues in boundary and non-boundary functions in Hungarian

Abstract

In addition to meaning-modifying functions, prosodic parameters also serve as boundary markers. However, their actual purpose depends on the position they occupy, along with their influence and behaviour on other features. The current study displays results on the co-occurrence of different prosodic features focusing on left-headed Hungarian, where the position of focus is defined syntactically, in boundary and non-boundary functions. Reading, along with spontaneous three-party conversation of 10 young women speakers, were analysed. The changes of f0, attendance of final lengthening, appearance of creaky voice and silent pauses were examined. Statistical difference was found between the absolute final and non-final positions based on the analyzed features' phonetic realizations. In terms of timing, a slowing down of the articulation tempo and an elongation of the last syllable, a greater change in the f0, and a more frequent appearance of the creaky voice were found in final positions compared to the non-final positions.

1. Introduction

The relationship between syntactic structure and prosodic phrasing has been explored by some previous studies (cf., e.g. Soderstrom et al. 2003; Peters 2005). Prosodic boundaries are marked by diverse phonetic and phonological cues, such as various timing patterns, e.g. final lengthening (FL) or pre-boundary lengthening, slowing tempo towards the end of the phrase, appearance of silent pause (SP), alteration in the f0 values (e.g. upstep, edge tones), decreasing intensity, glottalization or change of amplitude (e.g. Turk & Shattuck-Hufnagel 2007; Petrone et al. 2017). As Petrone et al. (2017) stated, the most dominant phonetic parameter of the intonational phrase is the SP, while FL and f0, the other two boundary markers considered to be fundamental (cf. Gee & Grosjean 1983), are primarily valid at other levels of the prosodic hierarchy.

Pitch changes have been shown to be relevant in the segmentation of speech in many languages, such as in English (cf. e.g. Ladd 1986) and in Dutch (Van den Berg, Gussenhoven & Rietveld 1992). Other studies have emphasized the effect of FL as a boundary marker: Kohler (1983) based on the examination of German language found that, the duration of the last syllable of the IP showed greater elongation, than the stressed syllable of the given speech unit.

Petrone et al. (2017) investigated the variation in f0, FL and pauses in speech production and how these cues affect boundary perception. The prosodic phrasing was explored based on bracketed lists in German. In line with the literature, they found that the boundaries of the intonation phrases are often signalled by pauses, while FL and f0 are used on other, different levels of the prosodic hierarchy. It is important to emphasize that although there are some trends at the group level in the segmentation of communication and the indication of boundaries, several studies have shown that there are often significant individual differences in the application and realization of prosodic characteristics (cf. Huttenlauch et al. 2021).

1.1 Research questions and hypothesis

Each prosodic feature is thus a central element of communication, serving different purposes in different positions of revelation. A previous study showed differences in reading by type and length of compound sentences (Krepsz, Huszár & Mády 2022). In addition, several studies, including some early ones, have corroborated that there can be significant differences in the use of prosodic features as a function of speech type between spontaneous speech (SpS) and reading (cf. Howell-Kadi-Hanifi 1991). Due to differences in speech planning and speech production, differences have been found in temporal features and pausing (Jacewicz, Fox & Wei 2014), f0 values (Abu-Al-Makarem & Petrosino 2007; Skarnitzl & Vanková 2017), segmentation (White et al. 2010), etc. However, it is still questionable what difference might be revealed in these patterns in the case of the comparison of these two speech types. Although the examination of prosodic features in the boundary function has been carried out earlier in English and German by some studies (e.g. Ladd 1986; Petrone et al. 2017), we have relatively little knowledge of the Hungarian language. The relevance of the comparison is given by following reasons, namely:

The word order conveys fundamentally information about the information structure in Hungarian, while the focus position is determined by the syntactic structure of the text, so the impact of the prosodic prominence marking is less pronounced (Mády 2015).

According to our hypotheses, we assumed that: (1) the coexistence of the prosodic boundary marker cues will have different combinations and strengths in reading and SpS; (2) the pattern of prosodic boundary markers will be different for IPUs and IPs; (3) there will be different individual prosodic patterns for the boundary sign per speaker.

2. Methodology

Readings and spontaneous three-party conversations of 10 young female speakers, hereinafter referred to as S (Subject), were selected from the Hungarian Spontaneous Speech Database (cf. Neuberger et al. 2014). In the reading task, participants were asked to read a 234-word long educational text consisting of 5 simple and 8 complex sentences. The average duration of the read sound sample is 138±27 sec. Adapted to the duration of the reading, a part from each speaker's three-party conversations were selected from the middle of the recordings, so that the speaking time of S was 2 minutes. The three-party conversation's protocol is as follows: 3 participants (Fieldworkers l and 2 (Fwl, Fw2), who are colleagues and S participated in a quasi-spontaneous conversation. An everyday, but debatable topic of conversation was provided at the beginning of the conversation by the Fwl. Here, the speakers do not have time to prepare for the conversation either.

2.1 Participants

The recordings of 10 female speakers were selected for the current study. S were different speakers in each conversation. The Fwl and Fw2 both were the constant people on all recordings selected for the present study: two monolingual, Hungarian female speakers of the same age. S, Fw1 and Fw2 were between 20 and 40 years of age. The fact that 2 of the 3 speakers were the same in all recordings increased the homogeneity of the recordings.

2.2 Method

Sound samples were signal-text aligned using the web service webMAUS (BAS, LMU; Kisler, Reichel & Schiel 2017) for a multi-level annotation. Thus, the annotation included the utterances of the speakers on IPU (interpausal units), intonation phrase (based on the f0 contour; cf. Heeman & James 1999), word and syllable level and which was supplemented by the labelling of SPs. Syllables are marked with the "Mark syllables by syllables" function in the Vocal Toolkit program (R. Corretge 2017). Automatic annotation was manually corrected in the Praat (Boersma & Weenink 2020). Because no prosodic unified notation method (like ToBi) is available for Hungarian, to obtain systematic and reliable data, two trained phoneticians labelled the prosodic structure on the basis of a jointly developed, systematic marking system. Firstly, the examined prosodic features were labelled in those points of the utterances that took place directly before the pauses. Within these IPU units, the possible intonation phrase boundaries were also marked using grammatical and syntactic structures, as well as prosodic structure (see Reed 2009).

The occurrence and duration of SP, the attendance of FL, the alteration in fundamental frequency (f0) were examined given that these parameters are considered to be the most commonly used boundary features (cf. Gee & Grosjean 1983). Later, the list of potential prosodic boundary markers was extended; among others we analyzed the frequency of creaky voice (CV; cf. González, Weissglass & Bates 2022). In each case, the given parameter's position (final, non-final) in the IPU and the intonation phrase were considered, and the values in the two types of speech were compared.

Word and syllable durations were considered for the analysis of the FL. Three methods were used for the analyses:

(1) The duration of the last syllable of the phrase was compared with the duration of the other syllables of that phrase.

(2) The phenomenon of FL was also examined through word durations: the duration of the last word of the phrases was compared with the duration of other words with the same number of syllables occurring in a non-end-of phrase position (cf. Dankovicová et al. 2014).

(3) We calculated the average syllable length for the given intonation phrase and IPU, and then the actual realized syllable durations were divided by this value. Then, we compared the proportions of syllables that were realized in the final and non-final positions, and compared the values reported in reading and SpS, as well as the values measured in the IPUs and intonation phrases.

To examine the change in f0, the "Mark regions by pitch" (R. Corretge 2017) function of the Vocal Toolkit was used. This function gradually measured the value of f0 in Hz from the given utterances. We calculated the fundamental frequency values for the penultimate and final syllables of the given IPU, and then divided the two values with each other. The difference in f0 values was converted to semitone, which enabled us to determine the extent and direction of the change in the f0 values of the speech segments at each position.

The appearance of the CV in each syllable-level annotation, based on the visual signal (spectrogram) and the audio, was manually marked.

Finally, the duration of the pauses was automatically extracted using a Praat script. A minimum time limit for pauses was not applied; however, data were manually checked, e.g. voiceless plosives stops were eliminated.

2.3 Statistics

The occurrence and duration of SPs and CV, the attendance of FL, the alteration in f0 were analyzed by linear mixed models in the R program (R Core Team 2020 with the lme4 package (Bates et al. 2015), *p*-values were obtained using Satterthwaite approximation (lmerTest package, ANOVA function; Kuznetsova, Brockhoff & Christensen 2017). Fixed effects (intercept) were the position (final and non-final position), speech type (SpS or reading task) and the number of syllables in the case of FL. Random effects were given to speakers, and the dependent variables were the duration of the syllables and words, ratio of the f0 compared to the average value. For each parameter, we also constructed a random intercept and a random slope model (with the speaker as a random factor for each variable) and compared the two models (with the ANOVA function available in the lmerTest package; Kuznetsova, Brockhoff & Christensen 2017). There was no significant difference between the models, so in the results' section that follows, we present the random slope values giving a lower AlC number (Akaike 1973). Mann-Whitney test was used for statistical analysis of frequency (McKnight & Najab 2010). Tukey post hoc test was used to compare each group. Correlation analysis was performed using Pearson's correlation calculation (Benesty et al. 2009).

3. Results

3.1 Final lengthening

Based on the results of methodology (1), the duration of the last syllable was twice (201%) as long as on average that of the other previous syllables. The difference between the two types of speech is minimal: the duration of the last syllables were found to be longer with 198% than of those occurring in other, non-final positions in SpS, while with 206% in reading. The ratio of phrase FL was significantly higher for IPUs (243% on average) than for IPs (174% on average): $F_{1,\ 10,965}$=63.145, p<.001. Statistical analysis corroborated the occurrence of the FL based on a comparison of the duration of syllables appearing at non-final and final position ($F_{1,\ 10,965}$=24.108, p<.001). However, there was no significant difference between the two speech types.

Based on the examination of word durations, method (2), the following tendency was observed: the duration of the words occurring as the last word of the current IPUs – regardless of the number of syllables – was realized on average 31% longer than those appearing in the non-final situation. The same portion was 16% on average for IPs. For IPUs, the largest difference in duration was observed for 1-syllable words (mean 47%), for 2–5 syllables this value ranged from 29–39%. In the case of IPs the difference was smaller: the largest difference in the case of final and non-final position was measured in the case of single-syllable words (12%), in the other cases this value ranged between 9 and 11%. The statistical analysis showed a significant difference ($F_{1,\ 4760}$=59.234, p=.007) between the two positions in terms of the words' duration in the IPUs, but not for the IPs. However, with regard to the syllable numbers, only the duration of monosyllabic words differed significantly from the others in the IPUs (1–2-syll: p=.011, 1–3-syll: p=.004, 1–4-syll: p=.023, 1–5-syll: p=.018. Regarding the speech types, no statistical difference has been observed.

The FL based on method (3) was detectable in both types of speech: in reading, the fraction of the elongation was higher (mean=40±21%), than in SpS (mean=24%±5%). The difference between the two speech types – based on this method – was significant ($F_{1,\ 4760}$=33.795, p=.013). In addition, in reading the more syllables the word contained, the greater the degree of the elongation was. There was no such tendency in SpS.

In the third part, the following trend was observed in relation to the proportion of the real syllable durations to the average syllable durations. Regarding IPUs, syllables appearing in the non-final position in the sentences were realized in 84% of the average duration, and syllables in the final position were realized in 176% of the average duration. In the intonation phrases, this ratio was 95% and 134%. Data corroborated a significant difference ($F_{1, 7950}$=19.675, p=.003) depending on whether the IPU or the intonation phrase was considered the basis of the analysis. According to this, the degree of elongation measured at the end of the IPUs was significantly higher than the values measured at the end of the intonation phrases. In reading, the proportion of syllables appearing in the non-final position compared to the average was 91%, 180% in the final position, 78% in the non-final position and 166% in the final position in the SpS. The same proportions in intonation phrases were 92 and 158% and 95 and 143% in spontaneous conversations. The difference in speech types was significant ($F_{1, 4760}$=17.314, p=.005).

3.2 Fundamental frequency

The change in f0 in the final positions showed an average semitone increase of 9.7 compared to the average f0 value in each IPUs. The rate of f0-alteration between the final syllable to the average was lower in SpS (8.7 semitones on average) than in reading (11.38 semitones on average). F0 showed a notably smaller change at the end of intonation phrases than for IPUs.

According to the LM model, the rate of increase was significantly higher in the final position than in the non-final position both in reading: $F_{1, 4385}$=26.164, p<.001, and in SpS as well: $F_{1, 4197}$=14.504, p<.001, just as the rate of decrease was higher in the final position in both cases.

There was no significant difference between the two types of speech at the group level. The results showed a notable individual difference both in terms of which type of speech showed higher values and according to the degree of the difference, as well.

3.3 Creaky voice

CV was found in 6.46% (in non-final position) and 17.83% (in final position) in reading, and 9.05% and 13.08% in SpS. The observed trend between the positions was evident in everyone except for one speaker. Statistical analysis did not show a significant difference in the frequency of CV between speech types, but by position: $F_{1, 575}$=24.151, p=.001. According to whether the unit represents an IPU or an intonation phrase boundary, the findings indicated that there is no difference in the frequency of CV occurring in the final position.

However, individual differences in the frequency of CV are dominant: while reading in the non-final position ranged from an average of 0.3–10%, this fraction averaged 1.01–25.09% in the final position. In the SpS, the lowest incidence for the non-final position was 0% (there was not any occurrence of the given speaker's utterance within the speech units) and the highest was 32%. In contrast, in the final position, the frequency ratios ranged from 2.27% to 36.11%.

3.4 Relationships between boundary marking features

The interplay between prosodic features and different positions and speech types were analyzed (Figure 1).

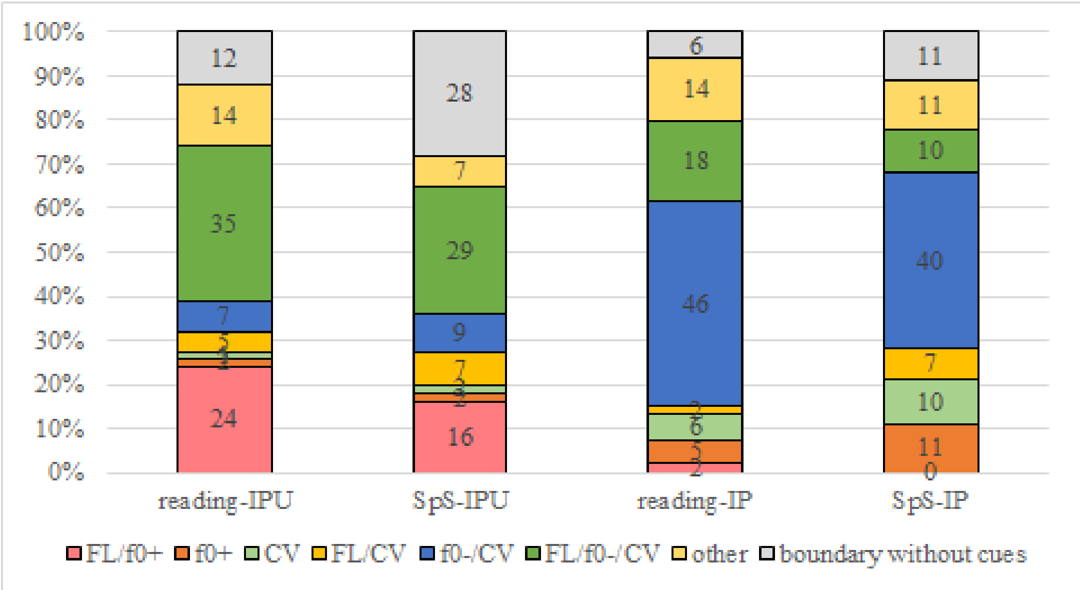

Figure 1: Coexistence of prosodic features by speech type IPUs and intonation phrases (the IPU boundary marking always includes the pause)

In reading's IPUs, the most common combination of boundary markers for IPUs was FL / rising f0 (the '/' sign means co-occurrence in all cases) without producing CV (35% of all the cases). However, looking at the results in an individual breakdown, it is apparent that this type of boundary marking was found to be the most common in only 2 out of 10 speakers. The appearance of FL / decreasing f0 / CV was the second most frequent prosodic combination (24%). Although, this was also the only most common occurrence in two speakers. The appearance of CV (i.e., without FL and with a floating f0 value) as a standalone boundary marker was very common. Its occurrence also demonstrated huge individual differences: there were speakers for whom it appeared to be the most common boundary marker; occurrence was reported for 14% of all cases.

Furthermore, it was also investigated whether the duration of the pauses correlated with other prosodic features at the given boundary. The results showed that the pauses were significantly longer ($F_{1, 1324}$=123.582, p=.011) with an interplay of decreasing f0, decreasing articulation rate as well as the appearance of the CV, and it was shorter with increasing f0 and articulation rate, as well as without any CV.

The boundary-marking strategies of reading and SpS were compared. The results showed that the interplay of the prosodic parameters displayed huge variance in the SpS, although the trends were very similar to those found in the reading. In SpS the most common boundary markers were FL / increasing value, and FL/CV (29–28%), and several other occurrences were reported: in some positions only the rise or fall of f0, the relationship between the SP and the CV or the SP and the FL was realized as a boundary marker. There was also a difference between the signalling of IPUs and intonation phrases: while the FL dominated for IPUs, the rising f0 value was dominant for intonation phrases.

The appearance of the co-occurence with the position occupied in the text was compared in the speech styles with respect to the speakers. We found that the co-occurrence of these prosodic features in the reading was 96% consistent with IPU boundaries and 93% with the boundaries of the IPs. In SpS, these values are somewhat smaller, the coincidence of the interaction of prosodic features and IPU boundaries being 86%, and that of intonation phrases 81%.

4. Discussion and conclusions

The combined results from the experiment presented here form a consistent picture, showing that prosodic boundary cues reveal a coherent pattern at different points in the utterances. Results show that in all prosodic parameters there was a statistical difference in the absolute final and non-final positions based on their realizations. In terms of timing, a slowing down of the articulation tempo and an elongation of the last syllable, a greater change in the f0, and a more frequent appearance of the CV were found in these positions compared to the non-final positions.

Similarly to the previous results of the literature (e.g. Petrone et al. 2017), differences in the prosodic notation of IPUs and intonation phrases were found in two major factors: a difference was found in the patterns of the prosodic parameters, while incidence of these factors showed considerable individual differences, corroborating the results of Huttenlauch et al. (2021).

Our first hypothesis was partly corroborated: the frequency trend of prosodic cues interaction was nearly the same for the two types of speech. At the same time, the data showed that the appearance of the boundary markers in reading is much stronger than in the case of SpS, in line with previous research on prosody in other languages (Millotte et al. 2008, a.o.), the appearance of tempo deceleration and FL is more significant than in SpS. In addition, it is important to emphasize that the smaller coincidence of IPU and intonation phrases in SpS, together with the delimitation of parameters, may indicate that conversation, and especially in a three-person conversation, is not only signalled in the last unit of the utterance. Rather, the speaker can sign partners earlier that they want to take over to someone the right of speaking. In addition, a number of other communication parameters may contribute to the specific implementation: overlapping speech, backchannelling, nonverbal communication features may all be determinants of the specific linguistic implementation. Furthermore, the difference between the two types of speech can be explained by differences in planning and construction processes of the speech production: while in reading the boundaries are marked by the punctuation, in the SpS planning and construction took place simultaneously, and the construction of the conversation (within the occurrence of the boundary markers) is affected by many parameters, such as the phenomenon of turn-taking, the occurrence of backchannels and overlapping speech, or the possible transition relevant places.

Our results partially corroborated the second hypothesis as well. For example, results suggest that speakers whose speech production was characterized by the implementation of CV often used it in both positions, while others rarely produced CV in both final and non-final positions. Data showed that while the realization of certain characteristics is nearly uniform for all speakers (e.g. the appearance of pauses or a slowing of the pace of articulation) other characteristics often show significant individual differences (e.g. the frequency of CV), which can be explained by different communication strategies of the speakers. It is also important to highlight that in each speech situation, speakers also use several non-verbal features to indicate communication intentions, such as turn-taking; so eye movement, facial expressions, and body language can also function as boundary markers besides the prosodic features.

Based on the results, it is likely that although Hungarian differs in many prosodic features from the languages studied earlier, English and German, although it is a left-headed/edge-prominence language unlike these two languages, the process of boundary-marking is used similarly to that in English and German. Based on this, it can be assumed that the boundary marking relies more on the physiological needs of the speaker than on the type of the given language. However, in order to support this, it is necessary to examine, among other things, the characteristics of the respiratory patterns of the speakers parallel to prosodic boundary markers. Consequently, we plan to further expand our research with the results of objective examination of respiration.

References

Abu-Al-makarem, A. & Petrosino L. 2007. "Reading and spontaneous speaking fundamental frequency of young Arabic men for Arabic and English languages: A comparative study", *Perceptual and Motor Skills* 105(2), 572–580.

Akaike, H. 1973. "Information Theory and an extension of the Maximum Likelihood Principle", in B. N. Petrov & F. Csáki (eds), *2nd International Symposium on Information Theory (Tsahkadsor, Armenia, USSR, September 2–8, 1973)* (Breakthroughs in Statistics I), 610–624. Springer.

Bates, D., M. Miichler, B. Bolker & S. Walker. 2015. "Fitting linear mixed-effects models using lme4", *Journal of Statistical Software* 67(1), 1–48.

Benesty, J., J. Chen, Y. Huang & I. Cohen. 2009. "Pearson correlation coefficient", in *Noise Reduction in Speech Processing*, 37–40. Springer.

Boersma, P. & D. Weenink 2020. "Praat: Doing phonetics by computer". http://www. praat. org/

Dankovicová, J., K. Pigott, B. Wells & S. Peppé. 2014. "Temporal markers of prosodic boundaries in children's speech production", *Journal of the International Phonetic Association* 34(1), 17–36.

Gee, J. P. & F. Grosjean. 1983. "Performance structures: A psycholinguistic and linguistic appraisal", *Cognitive Psychology* 15(4), 411–458.

González, C., C. Weissglass & D. Bates. 2022. "Creaky voice and prosodic boundaries in Spanish: An acoustic study", *Studies in Hispanic and Lusophone Linguistics* 15(1), 33–65.

Heeman, P. A. & F. A. James. 1999. "Speech repairs, intonational phrases and discourse markers: Modeling speakers' utterances in spoken dialog", *Computational Linguistics* 25(1), 527–571.

Howell, P. & K. Kadi-Hanifi. 1991. "Comparison of prosodic properties between read and spontaneous speech material", *Speech Communication* 10(2), 163–169.

Huttenlauch, C., C. de Beer, S. Hanne & I. Wattenburger. 2021. "Production of prosodic cues in coordinate name sequences addressing varying interlocutors", *Laboratory Phonology* 12(1), 1.

Jacewicz, E., R. Fox & L. Wei. 2010. "Between-speaker and within-speaker variation in speech tempo of American English", *The Journal of the Acoustical Society of America* 128(1), 839–850.

Kisler, T., U. D. Reichel & F. Schiel. 2017. "Multilingual processing of speech via web services", *Computer Speech & Language* 45(1), 326–347.

Kohler, K. J. 1983. "Prosodic boundary signals in German", *Phonetica* 40, 89–134.

Krepsz, V., A. Huszár & K. Mády. 2021. "The relationship between boundary markers and audible inhalation in Hungarian read speech", *Proceeding of 1st International Conference on Tone and Intonation (TAI)*, 254–258.

Kuznetsova, A., P. B. Brockhoff & R. H. B. Christensen. 2017. "lmerTest package: Tests in linear mixed effects models", *Journal of Statistical Software* 82(13), 1–26.

Ladd, D. R. 1986. "Intonational phrasing: The case for recursive prosodic structure", *Phonology Yearbook* 3(1), 311–340.

Mády, K. 2015. "Prosodic (non-realisation of broad, narrow and contrastive focus in Hungarian: A production and a perception study", in *Proceedings of Interspeech 2015,* 948–952. Dresden.

McKnight, P. E. & J. Najab. 2010. "Mann-Whitney U Test", in I. B. Weiner & W. E. Craighead (eds), *The Corsini Encyclopedia of Psychology*. New York: John Wiley.

Millotte, S., A. René, R. Wales & A. Christophe. 2008. "Phonological phrase boundaries constrain on-line syntactic analysis", *Journal of Experimental Psychology: Learning, Memory, and Cognition* 34, 874–885.

Neuberger, T., D. Gyaimathy, T. E. Gráczi, V. Horváth, M. Gósy & A. Beke. 2014. "Development of a large spontaneous speech database of agglutinative Hungarian language", in P. Sojka, A. Horák, I. Kopecek & K. Pala (eds), *Text, Speech and Dialogue: TSD 2014, Lecture Notes in Computer Science*, 8655. Chain: Springer.

Peters, B. 2005. "Weiterführende Untersuchungen zu prosodischen Grenzen in deutscher Spontansprache", in K. J. Kohler, F. Kleber & B. Peters (eds), *AIPUK. Prosodic Structures in German Spontaneous Speech (AIPUK 35a)*, 203–345.Kiel: IPDS.

Peters, B., K. J. Kohler & T. Wesener. 2005. "Phonetische Merkmale prosodischer Phrasierung in deutscher Spontansprache," in K. J. Kohler, F. Kleber & B. Peters (eds), *Prosodic Structures in German Spontaneous Speech (AIPUK 35a)*, 143–184. Kiel: IPDS.

Petrone, C., H. Tmckenbrodt, C. Wellmann, J. Holzgrefe, I. Waitenburger & B. Hoehle. 2017. "Prosodic boundary cues in German: Evidence from the production and perception of bracketed lists", *Journal of Phonetics* 61(1), 71–92.

R Core Team. 2020. "A language and environment for statistical computing". R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org

R. Corretge. 2017. Praat Vocal Toolkit. http://www.praatvocaltoolkit.com

Reed, B. S. 2009. "Units of interaction: 'Intonation phrases' or tum constructional phrases?", *Actes d'IDP (Inteɪface Discourse & Prosodie).*

Skarnitzl, R. & J. Vaňková. 2017. "Fundamental frequency statistics for male speakers of Common Czech", *AUC Philologica* 2017, 7–17.

Soderstrom, M., A. Seidl, D. G. Kemler Nelson & P. W. Jusczyk. 2003. "The prosodic bootstrapping of phrases: Evidence from prelinguistic infants", *Journal of Memory and Language* 49(2), 249–267.

—. 2005. "Six-month-olds recognize clauses embedded in different passages of fluent speech", *Infant Behavior and Development* 28, 87–94.

Turk, A. & S. Shattuck-Hufnagel. 2007. "Phrase-final lengthening in American English", *Journal of Phonetics* 35, 445–472.

Van den Berg, R., C. Gussenhoven & T. Rietveld. 1992. "Downstep in Dutch: Implications for a model", in G. J. Docherty & D. R. Ladd (eds), *Papers in Laboratory Phonology II: Gesture, Segment, Prosody*, 335–367. Cambridge: Cambridge University Press.

White, L., L. Wiget, O. Rauch & S. Mattys. 2010. "Segmentation cues in spontaneous and read speech", *Speech Prosody 2010*, 1–4.

Keywords: boundary marking, prosodic cues, left -headed language, spontaneous conversation, reading