Prominence Contrasts in Czech English as a Predictor of Learner's Proficiency

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Abstract

The study investigates prominence patterns in Czech-accented English comparing the production of non-native speakers of English at two distinct stages of phonological acquisition (beginners and intermediates) with a native performance. Word stress in Czech is entirely different from English, it has a fixed position, a delimitative function and rather impalpable acoustic manifestations. Alternations in the realization of word stress were analyzed by measuring the ratios or differences of acoustic correlates of prominence: duration, fundamental frequency, sound pressure level and spectral slope. Since word stress is a relational phenomenon, these characteristics were measured in two adjacent syllables one of which was a canonical stress bearer. The results reveal a clear difference between native and non-native treatment of word stress in all parameters examined. In the non-native sample distinct interferences of L1 across the two groups were detected: the subjects displayed different exploitation of duration, spectral slope and sound pressure level (SPL) with relation to their proficiency in L2 English. Out of these, duration ratio proves to be the most significant correlate. Furthermore, our findings indicate a strong effect of prosodic context coinciding with the prominence features, particularly in intonation declination and phrase-final lengthening.

Index Terms: Czech English, word stress, prominence, duration, F0, SPL, spectral slope

1. Introduction

Non-native accents of English have gradually ceased to be frowned upon, firstly due to the vast interconnectedness of today's world requiring the ability to understand a wide range of interlocutors and secondly thanks to the continuous research offering valuable insights into the nature of foreign-accentedness and its impact on human communication. One such groundbreaking study revealed that even heavily accented speech may be objectively intelligible [1], however the authors in the same breath warn of subjectively perceived difficulty to comprehend strongly accented productions which may consequently trigger negative attitudes or result in prejudiced judgments [2], [3]. In the field of second language pedagogy it has been repeatedly argued that appropriate prosodic features may contribute greatly to successful communication, increase intelligibility e.g., [4], [5], [6] and weaken the degree of foreignness [7]. Nevertheless, phonological transfer from the mother tongue places many constraints on the acquisition of the target sound system, especially in the area of rhythm and intonation [8].

The present study aims at mapping the relationship between L1 (Czech) and L2 (English) at different stages of phonological acquisition in the area of prominence patterning. One of the main functions of stress in English is to maintain the natural rhythm in connected speech [9], [10]. Stress misplacement may therefore bring about momentary confusion on the listeners' part as the deviated surface form does not immediately match the expected prominence scheme. Stress is a relational phenomenon and its degree of prominence cannot be determined within monosyllabic isolated words. The juxtaposition of stressed and unstressed syllables makes stressed parts stand out clearly which leads to their smoother identification and processing. The decreased degree or even absence of prominence in unstressed syllables corresponds perceptually to relative shortness, lower pitch, quietness and vowel reduction involving a centralization of peripheral vowel qualities, which is most frequently materialized as *schwa* [11]. The stress systems of English and Czech do not coincide, the former being completely unpredictable for a Czech speaker with the experience of a fixed stress mother tongue and a very limited space for reductions in standard pronunciation.

In general, word stress is not a one-dimensional phenomenon as it manifests itself in different ways in the speech signal. Several reliable acoustic correlates of word stress have been identified: F0, duration, intensity and spectral slope, e.g., [12, 13, 14, 15, 16, 17, 18, 19]. However, the way these parameters are manipulated by the speakers in order to create prominence contrasts can be highly language-specific, see e.g., [20].

In Czech, word stress remains somewhat impalpable and its comprehensive description is yet to be completed. Contrary to English, its position is fixed to the first syllable and its acoustic manifestations do not usually include an increase of F0, intensity or duration. Furthermore, unstressed syllables contain predominantly full vowel qualities. Duration is mainly used for marking phonologically long and short vowels and the stressed syllables can be shorter than the unstressed ones [21]. Also, F0 of stressed syllables is often lower due to a post-stress rise (i.e., L*+H accent) typical of Czech stress-groups [22]. The results concerning intensity and spectral slope are still preliminary and these acoustic attributes are an object of ongoing research.

The issue of prominence in Czech English has enjoyed an increased interest among researchers in both perception and production domains in the past decade. In the former, Czech listeners demonstrate a weakened perceptual sensitivity to English vowel reductions [23] and experience greater difficulties identifying strong beats when individual acoustic attributes indicating syllable prominence are in conflict [24]. As far as production is concerned, Czech-accented English can be generally characterised as lacking clear temporal contrasts, that is to say stressed syllables tend to be shorter and unstressed syllables longer than in native speech, which may, however, in certain contexts give rise to positive L1 transfer [25]. The strong inclination of Czech speakers to equalize the duration of vowels with a different degree of prominence seems to be a straightforward fact, although at a closer inspection, various strategies for signalling prominence have been detected. These largely depend on a number of factors, such as phonological structure of words, their textual frequency and resemblance to Czech counterparts [26]. Turning to weak vowels, the measurement of their spectral slope yielded quite reliable results in discriminating Czech and

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British speakers of English [27]. Prominence investigation was also opted for in the assessment of strength of foreign accentedness under adverse listening conditions [28].

The current study follows and further develops the previously mentioned research in two respects. First, it compares the ratios or differences of acoustic parameters in stressed and adjacent unstressed vowels instead of comparing the values of duration, F0, intensity and spectral slope in grand means. We believe that this method better reflects the relational character of the explored phenomenon and is consistent with the idea of the speakers' effort to create local contrasts between prominent and non-prominent elements. Second, Czech respondents were subdivided into two groups according to the achieved language competence (beginners A1/A2 × intermediates B2/C1), which allows us to monitor the development of interlanguage at two distinct stages of phonological acquisition. Native speakers' prominence patterns served as an important reference point. Since a single corpus on Czech-accented speech involving various language levels is not available to the best of our knowledge, we drew the data from two different corpora with a high degree of compatibility [29], [30]. Although we may hypothesize that the more proficient speakers will exploit prominence features in a more native-like manner, we do not know which of the investigated prosodic dimensions will be most amenable to the acquisition process. Thus, the results should be generally informative with respect to prosodic pattern acquisition.

2. Method

2.1. Czech beginners

Czech beginners, 34 pupils of a lower-secondary school in Prague were asked to read aloud a list of 12 words, 8 short sentences and a limerick. The choice of lexicon corresponded to the respondents' language level or was lower. 18 boys and 16 girls at the age of 12 or 13 were recorded individually with a portable professional device Edirol HR-09, sampling frequency of 48 kHz and 16-bit resolution. The subjects reported no or rather limited contact with native English outside the classroom setting. All respondents were perceptually assessed as having a heavy foreign accent.

2.2. Czech intermediate and native British speakers

As for the Czech intermediate and British native speakers, their recordings were taken from the Prague Phonetic Corpus [29]. The subjects were 16 (8 Czech, 8 British) female non-professional speakers ranging in age from 20 to 25 years. They were instructed to read a news bulletin from the BBC in the length of about 500 words. The British subjects were speaking with a Southern Standard British accent, whereas the Czech subjects were selected as having a clear Czech accent, which was afterwards verified by naive listeners in a perception test (see [31]). Nevertheless the speakers were advanced enough to read a relatively complex text without substantial dysfluencies.

The recordings of the Czech intermediate speakers were made in a sound-treated studio with an electret microphone IMG ECM 2000, soundcard SB Audigy 2 ZS, 32-kHz sampling frequency and 16-bit resolution. The English speakers were recorded in the same way as the group of Czech beginners. All the recordings obtained with the Edirol HR-09 were afterwards downsampled to 32 kHz. Word and phone boundaries in both corpora were manually labelled in *Praat* [32] by experienced phoneticians.

2.3. Data selection

For this study, we selected comparable material from both corpora – pairs of vowels in adjacent syllables within a word, where one carries primary stress and the other is unstressed according to the lexical rules [33]. This resulted in two possible patterns – an unstressed vowel following a stressed vowel (S-U pattern, constituting 67.6 % of all pairs) and vice versa (U-S pattern, constituting the remaining 32.4 %).

Tokens containing dysfluencies, external noise or mispronounced elements were discarded. In total, we analyzed 1913 words: 884 uttered by beginners, 493 by intermediates and 536 by native speakers. The following parameters were extracted from or determined for each vowel:

- identity of the vowel (similar vowels clustered into six resulting types: /i/, /e/, /a/, /o/, /u/, /ə/)
- canonical prominence status (stressed, S × unstressed, U)
- position within a prosodic phrase (non-final × final)
- duration (in milliseconds)
- sound pressure level (in dB)
- F0 (in semitones relative to 100 Hz)
- spectral slope quantified with the α measure (difference between spectral energy above and below 1000 Hz, the highest boundary being the Nyquist frequency, that is 16 kHz; expressed in dB)

The last three characteristics were taken in the middle third of each vowel's duration to reduce the effects of consonantal transitions and potential labelling inaccuracies. F0 was not extracted from the beginners' word-list task, since it could be confounded by specific melodies of isolated word reading.

In the analyses, we compared the neighbouring vowels in the selected acoustic parameters. Our variables were:

- duration ratio (U/S)
- F0 difference (S-U)
- SPL difference (S-U)
- α difference (S-U)

The duration variable was expressed as a ratio in order to neutralize the effects of speaking tempo and differences in number of syllables in the examined words. The statistical significance of the results was verified by one- or two-way ANOVAs for independent measures with Tukey HSD post-hoc tests.

3. Results

3.1. Duration

The ratio of duration (unstressed/stressed vowel) in phrase non-final words decreases as the proficiency of the speaker group increases. The BrE speakers exhibit an average ratio of 0.7 (i.e., the unstressed vowel duration constitutes seven tenths of the stressed vowel duration), regardless of the stress pattern type. The CzE speakers differed according to their proficiency level and the investigated stress pattern.

Figure 1 shows how the duration ratio changes in the three speaker groups and in S-U vs. U-S patterns. The interaction of LEVEL*PATTERN is statistically significant (two-way ANOVA: $F(2, 892) = 6.5$, $p = 0.002$). Unlike BrE speakers, the two Czech groups yield different results in their temporal treatment of stress patterns. In U-S, they are more native-like – the difference between the CzE intermediate group and the native speakers is not even significant, whereas in S-U, they treat the temporal ratio quite differently: the beginners prolong the

second, unstressed syllable (the ratio is higher than 1) and the intermediates display roughly the same duration of both.

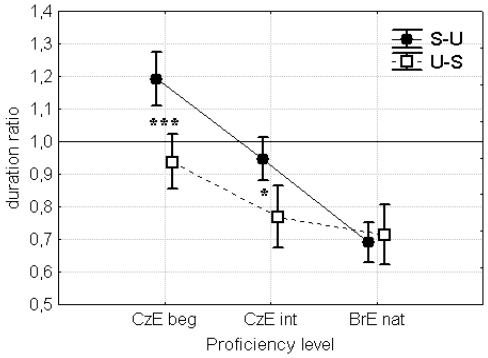

Figure 1: *Average duration ratio of adjacent stressed (S) and unstressed (U) vowels in non-final words of two patterns: S-U and U-S. Whiskers indicate 0.95 conf. intervals. Tukey post-hoc tests: *** → $p < 0.001$, * →$0.01 < p < 0.05$.*

The durations in phrase final words are not easy to interpret, since final lengthening influences the situation in a more arbitrary manner. Nevertheless, our data suggest that phrase-final lengthening may intensify the differences stemming from the stress pattern. This tendency applies to all three groups. In the case of U-S sequence, the effects of both lengthenings combine, resulting in lower ratios than in non-final words. In S-U cases it works in the opposite direction and equalizes the duration values making the ratio around one or higher.

3.2. Sound Pressure Level

In the case of sound pressure level differences, we discovered that Czech speakers of both proficiency levels behave identically – the difference between stressed and unstressed vowels was around 0.7 dB. Conversely, native speakers mark the stressed vowels substantially – the stressed elements have on average 3.3 dB higher sound pressure level than the neighbouring unstressed ones (see Figure 2); one-way ANOVA: $F(2, 1910) = 70.6$, $p < 0.001$.

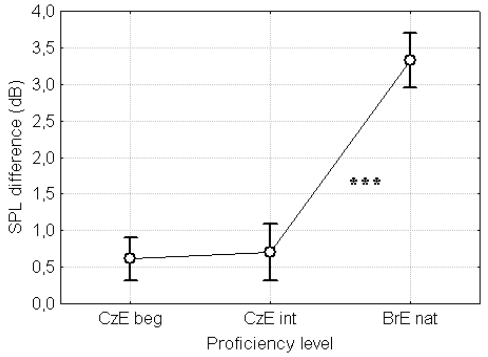

Figure 2: *Average SPL difference between adjacent stressed and unstressed vowels.*

The differences in SPL between words in final and non-final prosodic positions were negligible in all groups. However, when we examined the two stress patterns individually, we discovered a significant difference in the beginners group's final words. In U-S the SPL of the first vowel is 1.5 dB higher, whereas in S-U it is the other way round (the average difference is -1.9 dB). Thus the first syllable of phrase-final words of CzE beginners has always higher SPL regardless of its canonical stress status.

On the other hand, both BrE and CzE intermediate speakers maintain a constant SPL difference between the stressed vowel and its unstressed neighbour, regardless of the position or stress pattern. The former group has an average difference of 3.3 dB and the latter of 0.7 dB.

3.3. F0

Taking into consideration the typical Czech pattern of post-stress pitch rise, it seemed necessary to analyze both S-U and U-S groups separately to avoid its possible influence.

Generally, it is possible to infer from our data that Czech speakers do not use F0 difference to mark the stressed vowel, irrespective of the proficiency level, while the British speakers do, albeit only in the S-U pattern (see Figure 3). The stressed syllable of the native speakers is on average about 1.7 ST higher than the adjacent unstressed one and a Tukey post-hoc test reveals a highly significant difference between S-U and U-S of the British speakers: $p < 0.001$. Both Czech groups in both stress patterns fluctuate around zero and none of the differences between beginners and intermediates is significant.

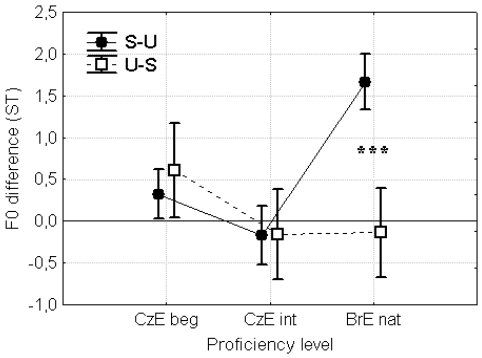

Figure 3: *Average F0 difference between adjacent stressed (S) and unstressed (U) vowels in two orders: S-U and U-S.*

We also investigated prosodically final words on their own as the phrase-final lowering (enhanced declination) could have an effect on the F0 stress pattern. Particularly, it could interact differently with S-U or U-S positions in the same way as in the durational domain.

Due to the exclusion of the word list reading task from F0 measurements, there were not enough U-S final cases in CzE beginners, therefore only CzE intermediates and BrE natives underwent the analysis. Both groups show a similar distinction in their treatment of S-U F0 difference in final words, which coincides with phrase-final declination. In the U-S pattern, the difference is reversed in both groups, i.e., unstressed syllable is higher that the stressed one. In the S-U sequence it is vice versa, the declination and the F0 difference caused by the stress pattern reinforce each other, resulting in higher F0 differences in both groups (Tukey post-hoc: $p \leq 0.01$).

3.4. Spectral slope

The results concerning spectral slope have to be interpreted with caution. As far as we know, all metrics of short-term spectral slope are sensitive to vowel identity (see e.g., [34]), so

the difference in spectral slope between two adjacent vowels can occur due to their different qualities and not due to prominence or vocal effort. Nevertheless, with all vowels pooled, we still found a highly significant dissimilarity between the speaker groups – CzE speakers of both proficiency levels showed α difference around zero, while BrE ranged around 3 dB (one-way ANOVA: $F(2, 1910) = 27.4$; $p < 0.001$). This means that the stressed syllables of the native speakers demonstrate in general a flatter spectral slope than the neighbouring unstressed syllables.

This tendency was confirmed by inspecting vowels with identical qualities – the pairs /i/-/ə/, /e/-/ə/, /a/-/ə/ and /u/-/ə/ (other pairs were not represented sufficiently). The pair /e/-/ə/ with the highest occurrence in our data is shown in Figure 5.

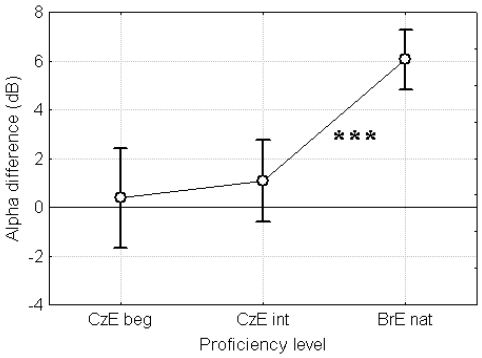

Figure 4: *Average α-measure difference between adjacent stressed /e/ and unstressed /ə/.*

If the vowel quality were the decisive factor, then we would expect no differences across individual groups. However, in this case, the BrE speaker group differs significantly (one-way ANOVA: $F(2, 249) = 16.8$, $p < 0.001$). The same applies to the /u/-/ə/ couple (one-way ANOVA: $F(2, 106) = 7.2$, $p = 0.001$). In the case of /i/-/ə/, the CzE intermediates coincide with the BrE natives, whereas the CzE beginners differ significantly (one-way ANOVA: $F(2, 227) = 8.2$, $p < 0.001$). With /a/-/ə/ the same trend emerges but it was not found significant.

4. Discussion

Addressing our research questions, British native speakers display different behaviour from Czech respondents with regard to all investigated parameters: duration, SPL, F0 and spectral slope of two adjacent vowels. The acoustic characteristics of the BrE native group correspond to the prototypical prominence scheme documented in literature: i.e., the stressed vowels exhibited longer duration, higher SPL, higher F0 and flatter spectral slope than the unstressed ones. On the other hand, Czech speakers fail to create prominence contrasts as systematically and comprehensively as their native counterparts.

Nevertheless, certain variability was detected within the Czech sample. The beginners differ substantially from the intermediates in duration and to a lesser degree in SPL and spectral slope. The character of these findings corroborates the initial hypothesis: more advanced speakers employ the examined features in the direction of native-like realizations.

In the temporal area the results accord with the previous studies exploring Czech English [25], [26], [30]. Moreover, the duration ratio turned out to be the most reliable predictor of the level of L2 phonological acquisition. The ability of Czech speakers to alter the duration of stressed and unstressed vowels seems to improve proportionately to the amount of their linguistic competence in L2. Interestingly, Trofimovich and Baker's data confirmed a similar tendency in English [35], despite differences in their respondents' language background and learning setting (Korean immigrants).

With regard to the SPL, an interesting contrast occurred across the group of CzE speakers. In the phrase-final words the beginners produced the first syllable with a higher SPL consistently regardless of its canonical stress status. This led to a native-like difference in the S-U items and a reversed pattern in the U-S sequences. Since higher SPL does not function as a consistent marker of Czech stress, we may also attribute this outcome to the influence of prosody in the reading task rather than to the mother tongue transfer.

F0 differences showed a notable distinction within the native speaker group. The U-S pattern was treated differently from the S-U, the former exhibiting no change between the two adjacent vowels. This phenomenon could be explained by anticipation: the speakers raise their F0 before the target vowel, so that it manifests itself on the preceding one, too. It has also been shown by [36] that if two subsequent syllables have the same pitch, the second one is perceived as more prominent, because of the expected F0 declination pattern. Examinations of the F0 differences in phrase-final words revealed that phrasal prosody plays a greater role than the F0 stress patterning and tends to override it in both native and CzE intermediate speakers. It would be interesting to see if the F0 measurements in the middle third of the vowels conceal any finer F0 dynamics occurring throughout the whole vowel.

The spectral slope results also suggest that CzE speakers treat the stressed-unstressed contrast differently from the native speakers. The measured contrast is smaller, which implies that Czech speakers articulate both vowels with a similar vocal effort and do not reduce the unstressed elements sufficiently. This finding is in accordance with [27] which found that Czech speakers articulate schwa with a flatter spectral slope than natives.

In conclusion, our results have shed some light on the nature of phonological acquisition of stress by Czech speakers of English. The acquisition process could be viewed as gradual clustering of fragmented acoustic parameters for signalling prominence. While Czech speakers' production illustrates low interconnectedness of the discussed features due to L1 interference, native speakers exploit them in a more cohesive way. Furthermore, SPL, spectral slope and F0 seem to be more compliant with the L1 constraints than duration: the temporal contrast proved to be in stronger relation to learners' L2 experience. How exactly and in which order the remaining aspects develop and interact to create natural prominence patterns poses a question for the future research. In addition, fuller understanding of Czech prominence scheme may help determine the extent of mother tongue transfer.

5. Acknowledgements

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