Perception of vowel quantity by English learners of Czech and native listeners

Kateřina Chládková – Václav Jonáš Podlipský – Karel Janíček – Eva Boudová

1 Introduction

Vowels in both English and Czech are realized with varying duration. Vowel duration is a feature that is important in both languages. However, in each language, it has some different functions. We can sum up the basic differences and similarities concerning length in the two vowel systems in the four following points. First, Czech distinguishes long and short vowels. These differ mainly in quantity, e.g. [a, aː], [ɛ, ɛː], while in English vowels differ primarily in quality. English vowels differ in quantity, too, but the qualitative differences, i.e. formant frequencies, are the main tool helping to distinguish perceptually between lax and tense English vowels. That is to say, the difference between the vowels such as [u] and [ʊ] is based primarily on the variation in formant frequencies rather than in duration. (Palková 1995, Ladefoged 2001, Keating 1985). Second, this either qualitatively or quantitatively based difference goes hand in hand with the function vowel duration has in a given language. Czech vowel length has a phonological function. We are able to contrast the meaning of a word only on the basis of different duration of vowels not differing in quality, e.g. [pas] 'a pass' vs. [paːs] 'a belt' (Hála 1962). English vowel length is not contrastive. It undergoes a number of phonological processes and it depends to a high extent on the phonetic and phonological environment of a particular segment. Among other things, the placement of stress has an effect on duration of vowels in English. Stressed vowels are much longer that unstressed vowels. For instance, in the word *fantastic* the first and the second vowel both have the low front quality of [æ] but the first one is unstressed and thus much shorter than the second, stressed one (Klatt 1976, Gimson 1996). Vowel duration can actually serve as a perceptual cue to stress in English. Third, English vowel length is influenced by stress but Czech vowel length is not – stressed vowels are not consistently longer than the same vowels when unstressed (e.g. Lehiste 1970). In Czech, stress is fixed on the first syllable of a word (Palková 1995) so no cue for stress in the form of variations in vowel duration is necessary. Finally, in both English (Klatt 1976) and Czech (Hála 1962) vowels are lengthened in final, pre-pausal position.

We based the present study on the study by Nenonen et. al (2003) which tested the perception of Finnish vowel quantity by native listeners and by Russian L2 (second language) listeners. They assumed that Russians would transfer their native-language expectations

that stressed vowels are longer than unstressed vowels to their L2 Finnish. The results reported by Nenonen et. al indicated that experienced non-native listeners perform in a native-like manner in stressed but not in unstressed syllables. We chose their study as the basis for our study because Czech is similar to Finnish and English to Russian in the way stress and vowel length interact.

We supposed that English learners of Czech would have troubles with identifying short and long vowels, especially when stress and vowel quantity conflict with each other, i.e. when short vowels are in stressed syllables and long vowels in unstressed syllables. The aim was to (1) find out whether L2 listeners perceive the difference between Czech short and long vowels as categorically as L1 (native) listeners do, and (2) state the maximum duration of a vowel that will still be identified as short and the minimum duration of a vowel that will already be identified as long by both groups of listeners; i.e. we asked whether the boundary between long and short is the same in English listeners as in native listeners and whether its location is affected by stress.

2 Methods

2.1 Stimuli

We created two 8-member continua with vowel durations varying from short to long in the first (i.e. stressed) syllable (continuum 1) and in the second (i.e. unstressed) syllable (continuum 2). The nonsense word katap was naturally produced by a female Czech speaker and then edited by concatenating fundamental cycles to create the stimuli. In the first continuum, the first vowel was edited and the durations of this vowel ranged from 61ms to 158ms, with a constant step of 13.9ms between neighboring members of the continuum. In continuum 2, second vowel was edited and the durations ranged from 83ms to 230ms, the step between neighboring members being 20.8ms.

member no.	1	2	3	4	5	6	7	8	step
continuum 1 /ka:tap/	61 ms	74 ms	88 ms	102 ms	115 ms	130 ms	143 ms	158 ms	13.9 ms
continuum 2 /kata:p/	83 ms	104 ms	126 ms	145 ms	166 ms	188 ms	208 ms	230 ms	20.8 ms

Table 1: First and second vowel duration in continuum1 and continuum 2 respectively.

2.2 Subjects

Three groups of participants took part in the experiment: (1) American learners of Czech who had spent more than 1 year in the Czech Republic and had been learning Czech for at least one year at the time of the experiment, (2) monolingual Czechs who did not speak any language other than Czech, and (3) Czechs speaking other language(s) fluently (one of them necessarily being English) who had spent at least six months abroad in an English speaking country. In each group, eight subjects were tested.

Prior to the testing, the subjects were not familiar with the aim of the experiment. They reported to have no hearing or language dysfunction. The subjects were all over the age of 30 and younger than 45.

2.3 Procedure

Vowel quantity categorization in the first and second syllable was tested separately by two two-alternative forced-choice categorization tests using Alvin (Hillenbrand 2005). Stimuli were presented via headphones in a silent room. Prior to actual testing, subjects conducted a short practice test. In the main test that followed, each stimulus was presented 10 times in random order (within each set). The subjects heard a stimulus, decided whether they heard a long or short vowel in the syllable under focus, and then they used a mouse to click on one of the buttons that appeared on the screen marked as *katap* and *kátap* for continuum 1, *katap* and *katák* for continuum 2 (á indicating a long vowel in Czech orthography). The subjects were allowed to return to a previous trial by clicking on a back-up button.

According to the responses, for each subject we computed the short/long boundary (duration that would have an equal-likelihood [50:50] labeling, or P50. We assumed that the identification probability y of a stimulus of length x follows a step-like function $y \sim 1/(1+\exp(a-bx))$. To estimate the duration of stimuli that would receive 25%, 50%, and 75% identifications by each subject (or P25, P50, and P75 respectively), we used standard log-link transformation of the probabilities before applying linear regression. (Only the longest stimulus receiving 100% *short* identification and the shortest stimulus receiving 0% short identification were kept for each person; identifications of 0% and 100% were treated as 1% and 99% respectively.) The steepness of each function was expressed as one number, (P25-P75)/P50. Category boundary (P50) scores and the steepness scores were then submitted to ANOVA (ANalysis Of VAriance).

3 Results

Three Americans were excluded from the results as they showed they had not established the two vowel length categories strongly enough, i.e. their responses never reached 100% or 0% levels. We decided to treat monolingual and polylingual Czechs as one group as their results did not significantly differ ($p>.05$).

The category boundary, i.e. the boundary between a long and a short vowel was located as follows. In the first syllable, for Czech listeners the boundary was 103ms and for American listeners it was 108ms. In the second syllable, the boundary was 146ms for Czechs and 140ms for Americans. The location of the boundary between a long and short vowel was not significantly different ($p>.05$) for American and Czech listeners in either syllable, i.e. no significant effect of language background was found. In reverse, the steepness scores did significantly differ ($p<.01$) between groups. The Czech categorization curves were steeper than those of the Americans in both syllables. Figure 1 shows categorization curves pooled across subjects in each group for both conditions.

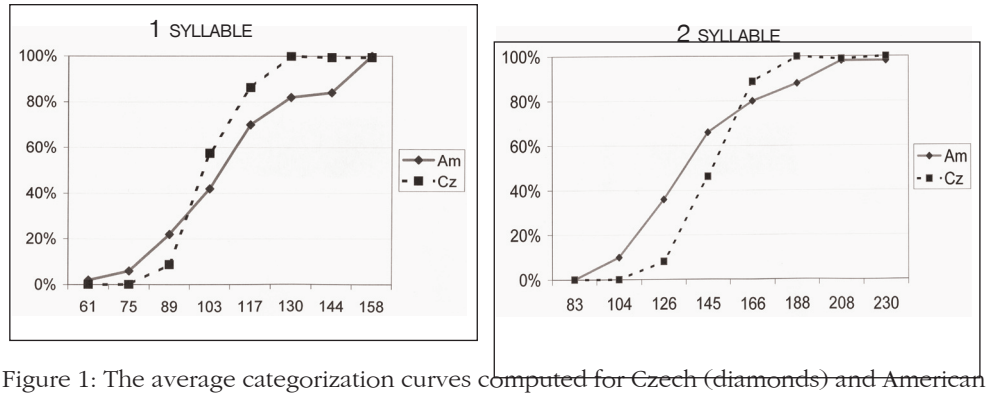

Figure 1: The average categorization curves computed for Czech (diamonds) and American (squares) subjects from the mean responses of each subject. Notice that the location of the boundary between the short and long vowel is more or less the same for Czechs and Americans in both the first and the second syllable. However, in both syllables, the American categorization curve is less steep than the Czech curve.

4 Conclusions

As indicated by the steepness scores mentioned in the previous section, perception of vowel quantity in L1 listeners is relatively categorical, whereas in L2 listeners it seems to be more continuous. This may be due to several factors. Most probably, the L2 listeners' categories are not established strongly enough. It is possible that the American listeners had not been exposed to Czech enough to be able to perceive and categorize the phonemes as categorically as native listeners do.

Importantly, our hypothesis that English learners of Czech would perform differently than natives because of stress does not seem to be confirmed. Our results suggest that the location of the boundary between long and short did not differ in native and non-native listeners in either of the syllables. The L2 listeners performed similarly to Czechs in the first, stressed syllable as well as in the second, unstressed syllable. Either the L2 listeners successfully acquired Czech quantity in terms of perception in spite of the fact that stress is marked by vowel duration in their L1, or L1-English stress recognition strategies do not interfere with the L2-Czech quantity perceptual distinction at all. This remains to be decided in future research.

5 Acknowledgements

The authors would like to express their thanks to Dr. David Boukal (Institute of Marine Research, Bergen, Norway) for his help with processing the data. We further thank our colleagues B. Majstrík, M. Čujanová and J. Fröhlichová for their help with collecting the data.

6 References

Gimson, A. C.: *Gimson's Pronunciation of English.* 5th ed. London 1996.

Hála, B.: *Uvedení do fonetiky češtiny na obecně fonetickém základě.* Praha 1962.

Hillenbrand, J. M., a R. T. Gayvert.: *Open-Source Software For Experiment Design and Control.* Journal of Speech, Language, and Hearing Research, 48, 2005, s. 45–60.

Keating, P.: *Linguistic and nonlinguistic effects on the perception of vowel duration*. UCLA Working Papers in Phonetics, 60, 1985, s. 20–39.
Klatt, D. H.: *Linguistic uses of segnemtal duration in English: Acoustic and Perceptual evidence*. J. Acoust. Soc. Am., 59, 1976, s. 1208–1221.
Ladefoged, P.: A *Course in Phonetics*. 4th ed. Boston 2001.
Lehiste, I.: *Suprasegmentals*. Cambridge, MA 1970.
Nenonen, S. et al.: *Perception of vowel length in native speakers and second-language users of a quantity language*. Helsinki 2003.
Palková, Z.: *Fonetika a fonologie češtiny*. Praha 1994.