EGG Study of Czech Phoneme /ř/

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1. INTRODUCTION

1.1. Background

In a previous study investigating the conflicting descriptions of the distinction between the two Czech trills /r̝/ and /r/ in the literature, Howson, Komova & Gick (2011) concluded that tongue height is not the distinguishing factor between the two sounds, despite it being the most commonly-cited feature (Hála 1923, Dankovičová 1999). Tongue height was shown to be subject to systematic variation by individual and word position, and to be unaffected by region and age differences. Previous work has not provided an alternative feature by which to phonetically distinguish /r̝/ and /r/.

1.2. Present Study

The current study utilizes electroglottography (EGG) to test for a difference in laryngeal setting as the potential source of acoustic distinction inexplicable by tongue height, such as the higher airflow and prolonged trilling that has been reported for /r̝/ (Dankovičová 1999). Acoustic analysis is also utilized to obtain the difference between H1 and H2 which has been shown to correspond to the open quotient of the vocal folds (Holmberg, Hillman, Perkell, Guiod and Goldman 1995).

Due to the spectrographic evidence which shows that /r̝/ becomes more fricated towards the end of the sound, particularly in word-initial and word-final positions, we give special attention to monitoring this time-course variation in laryngeal setting over the duration of the sound.

1.3. Predictions

In terms of the laryngeal setting, we predict to see regular modal voicing for contrasting /r/. For /r̝/, however, previous descriptions lead us to expect a more open glottis, possibly with indications of breathiness. Moreover, to reflect the temporal transition in /r̝/ seen in spectrograms, we expect to find evidence of a spread glottis during the latter portion of the sound, as well as higher H1-H2 values in the vowels preceding and following /r̝/, consistent with a longer open quotient. We expect this to hold for all word-initial, word-medial and word-final positions.

2. METHODS

Six native speakers of Czech, two male and four female, participated in the study. Their mean age was 42 years (SD: 21 years, range 20-75 years) at the time of the study. As the speakers originated from a variety of regions within the territory of the Czech Republic, the data presented is representative of a wide range of dialects.

Stimuli words were selected in order to place /r̝/ and /r/ in contrasting environments, #rv, vrv, and vr#, covering word-initial, intervocalic and word-final positions. The words used were *rád*, *řád*, *paráda*, *pařát*, *tvar*, and *tvář*, which were delivered using PowerPoint.

The primary tool of investigation was a Kay Model 6103 electroglottograph. Audio was recorded with a Sennheiser MK66 short shotgun microphone. EGG and audio were recorded using Praat. EGG waveforms were inverted and smoothed using EGGWorks. Wavesurfer was used to produce a 512-point FFT spectrum from which H1 and H2 were measured at 5% and 50% into the vowel preceding and following /r/ and /r̝/. Results were compared statistically using ANOVA, with average values from each subject for each condition being treated as a single data point.

3. RESULTS

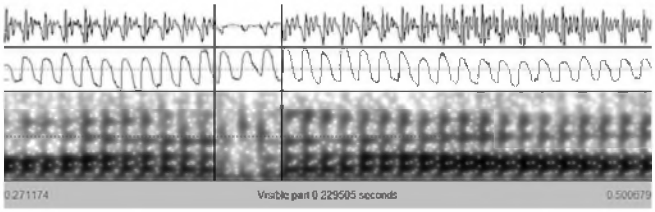

Figure 1: Waveform, EGG and Spectrogram for the token *paráda*, respectively. Image shows only [ará].

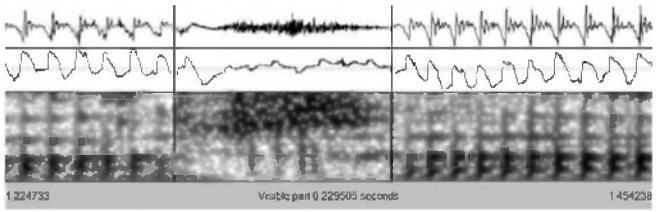

Figure 2: Waveform, EGG and Spectrogram for the token *pařát*, respectively. Image shows only [ařá].

The figures above show the canonical EGG patterns for /r/ and /r̝/. The EGG for /r/ exhibits the typical modal voicing pattern with a slightly larger open period, as compared to the rest of the token. However, the EGG pattern for /r̝/ differs substantially from typical modal voicing. The EGG demonstrates a wide open glottis with little to no glottal closure during the duration of articulation. We also note a substantially longer duration for /r̝/ as compared to /r/, which holds across all word positions.

The EGG results further indicate that the EGG patterns for /r/ and /r̝/ exhibit variation. While the EGG patterns for /r/ do exhibit a more open glottis in some tokens, the EGG pattern for /r̝/ always exhibits a more open glottis. The patterns for /r̝/ vary from a wide open glottis to more typical patterns for breathy voice.

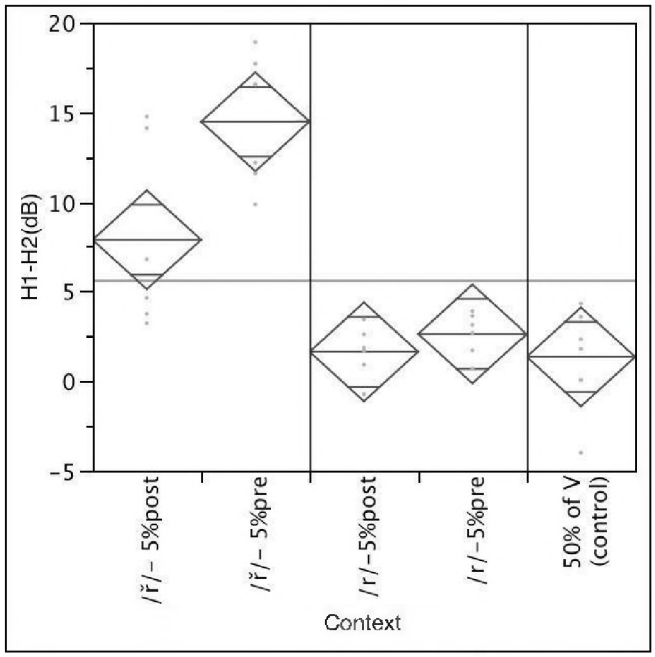

Figure 3: Student's T-test comparing H1-H2 /r̝/, /r/ and 50% of participants vowel (control).

In the acoustic test for glottal open quotient, overall ANOVA results show significant variation in the data [$F(4,25)=17.64$; $p < .0001$]. Post-hoc comparisons (Student's t-test) indicate significant differences in spectral tilt (H1-H2) between the control measure (at 50% of vowel) and 5% before and after /r̝/ ($p < .0001$ and $p = .0020$, respectively). No difference was observed between /r/ and control ($p > .05$).

4. DISCUSSION AND CONCLUSION

In line with our predictions, the EGG for /r̝/ reveals a more open glottis than the EGG for /r/. It also maintains a distinction in duration, with /r̝/ being substantially longer in duration than the contrasting phoneme /r/. In the tokens where /r̝/ demonstrated a temporal transition, the glottis was the most open for the later portion of the sound. This suggests that the first portion of this sound is simply the glottis transitioning from modal voice to a more open glottis, setting up the conditions necessary for trilling and breathiness to co-occur; the fact that the trilling happens during the second portion, as well as the high H1-H2 of the portion before frication, supports this claim.

The canonical EGG pattern seen during /r̝/ closely mimics the EGG pattern seen during speakers' regular breathing and breathy speech, which additionally provides evidence for a degree of breathiness in /r̝/. This is most evident in the word-initial and word-final positions but also obtains intervocalically for many speakers. This is different from the vocal fold action of the voiceless allophone because intervocalic position ensures that the tokens are voiced so that the pattern seen in /r̝/ could not be simply explained as a result of voicelessness.

The acoustic analysis further confirms an increase in breathiness associated with /r̝/ compared to /r/, indicated by higher H1-H2 values. The considerable spike in H1-H2 for /r̝/ in contrast to the values found at 50% of the vowel and /r/ suggests that a more widely open glottis is necessary for producing a trill-fricative. The notable difference in glottal openness and distinction in duration constitutes the most prominent contrast between /r/ and /r̝/.

The distinction in glottal opening suggests that there should be the addition of the feature [+spread glottis] to the feature set which describes this sound.

At present, the Czech trill /r̝/ is represented in the IPA as [r̝], stressing the tongue height as the distinctive feature between /r̝/ and /r/. However, in view of the findings refuting this in Howson, Komova & Gick (2011), as well as the strong evidence for a difference in the laryngeal setting presented here, we propose that a breathy [r̥] would constitute a more accurate transcription for this sound.

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