Aerodynamics of [r] in tonogenesis
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It has been noted by several scholars that dialects of Khmer (Cambodian) have developed a falling tonal contour in words containing an apical trilled [r] in the onset [1,2,3,4,5]. The goal of the proposed paper is to investigate a possible phonetic motivation for this tonal development conditioned by the loss of [r] in onset clusters. It is proposed that the aerodynamic requirements of the apical trill condition a falling fundamental frequency (F0) contour at syllable onset. Specifically, it is hypothesized that the pressure build-up needed to initiate and maintain trilling increases airflow across the glottis, which has the effect of increasing the Bernoulli effect and raising the rate of vocal fold vibration. Evidence from two studies supports this hypothesis.

Much of the literature on tonogenesis has focused on the development of high and low tones after voiceless and voiced onset clusters respectively [6,7,8]. An early explanation of these changes was aerodynamic. Problems with this view [9] led to an alternative hypothesis, namely that F0 differences are due to greater tension on the vocal folds during voiceless than voiced stop productions [10]. We return to an aerodynamic view to explain tonogenesis following the loss of an apical trill. This move is motivated by the stringent aerodynamic requirements of trill production [11] and their potential effect on transglottal airflow. Data from Thai and from non-language trill production are considered.

In the first study, we measured the effect of apical trilling on airflow and F0. Five native Thai speakers were asked to produce nine groups of four monosyllabic words having the same rime and tone but varying in onset from Th to Thr to T to Tr (T = voiceless stop consonant) in a carrier phrase. Results from an analysis of variance indicated that the onset type significantly affected the amount of F0 fall at the beginning of the syllable. Further tests revealed, consistent with the hypothesis, that the Thr onset type had a greater fall than the Th onset type and that the Tr onset type had a greater F0 fall than the T onset type. In the case of the airflow data, we found that [r] had a higher airflow than the vowel onset of the ThV or TV syllable types and that [r] in the Thr context had a greater airflow than in the Tr context. Thus, the greater F0 fall in onsets containing [r] is associated with greater airflow in trill than trill-less onsets.

In the second study, the effect of venting oral air pressure during trill production on F0 was investigated. The hypothesis was that venting air pressure would cause a rise in the volume of air moving across the glottis, and thus raise F0, because additional air in the oral cavity would be needed to maintain the pressure at the apical closure to initiate and maintain trilling. Auditory and airflow recordings of trill produced in [a_a] context with flat intonation by two phonetically trained speakers were made. Vented and non-vented productions were recorded in counterbalanced blocks. The venting was accomplished by introducing a plastic catheter into the post-palatal region of the oral cavity via the buccal sulcus. All trill productions were made with the catheter in place, which allowed venting in one condition, and was pinched to close venting in the other. In the analysis, to normalize for any F0 drift caused by intonational changes, the F0 of the midpoint of the preceding vowel was subtracted from F0 of each of the trill pulses measured. Results from an analysis of variance indicated, consistent with the hypothesis, that the vented trills had a significantly higher F0 than the non-vented trills.

The results from these studies indicate that a high rate of airflow across the glottis during apical trill production produces a falling F0 contour into the following vowel. This falling
contour can be maintained during and after the loss of a trill, potentially creating a new tonal contour in a language. Thus, the results of the studies reported here reopen the possibility of explaining certain types of tonogenesis in terms of aerodynamic forces.

References