Laryngeal adjustments in the production of consonant clusters and geminates in Moroccan Arabic

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Abstract

The laryngeal adjustments in voiceless consonant clusters and geminates in Moroccan Arabic were examined by means of photoglottography. Findings indicate that speech rate and word boundary have an effect not only on the shape of laryngeal abduction-adduction gestures but also on laryngeal-oral coordination.

1. Introduction

The phenomenon of laryngeal coarticulation has previously been investigated in various sequences of voiceless consonants for languages such as Dutch, Arabic, Japanese and Swedish [5, 6, 7, 8, 9; cf. ar review, 12]. Recently, the phenomenon has been studied in German [3, 4], Berber [10] and Arabic [13]. The common method used in these studies was transillumination and fiberoptic videodensitometry. One conclusion that comes out from these studies is that glottal opening and closing gestures are produced with a one-, two-, or more-than-two-peaked shape depending on the phonetic nature of the consonant sequence. In English, Dutch, and Swedish, cluster s is voiceless fricative + voiceless plosive gestures that correspond underly to two separate glottal closures. Geminates and reduced vowels are produced more than two-peaked shape depending on the phonetic nature of the consonant sequence. In English, Dutch, and Arabic, clusters of voiceless fricatives + voiceless plosives are produced with a one-, two-, or more-than-two-peaked shape depending on the phonetic nature of the consonant sequence. In English, Dutch, and Swedish, clusters of voiceless fricatives + voiceless plosives are produced with a one-, two-, or more-than-two-peaked shape depending on the phonetic nature of the consonant sequence.
with the fricative and the stop r respectively. A closer comparison of these two laryngeal movements reveals that the amplitude of the fricative movement was higher than the second (as indicated by the measurement given in Figure 2). Also, the initial glottal abduction is rapid, while the following adduction-abduction movements are rather slow. These facts seem to indicate two important tendencies: attaining maximal glottal opening during the fricative rather than the plosive and skewing the opening peak to the laryngeal y movement. An explanation for this given in [3, 6] suggests that the fricatives the onset of the abductor movement is illy equires rapid and generates glottal closure so that airflow can generate the frication source. Hence, this equilibrium is satisfied, it is not icical to maintain this pattern if the following voiceless consonant.

The timing of the peak glottal opening (PGO) also seems to vary as a function of the word boundary. When the word boundary intervenes within the voiceless sequences /s/t/, /sk/ and /t/, PGO occurs during the fricative and just before the release of the stop (cf. 3.3. for quantitative data). On the other hand, when /s/t/, /sk/ and /t/ are produced medially, one laryngeal gesture occurs. The peak timing of this gesture tends to occur not during the stop period but during the frication noise. It is interesting to note that plosives in MA are aspirated although they are preceded by fricatives. The tendency to have a two-peak pattern if fricative + aspirated stop combinations in Swedish[11] and English[6] does not apply to MA (cf. a similar result for Berber, [10]). Similar patterns like those for voiceless clusters are also found in geminated sequences /ss/ and /s/s/, where the presence of the word boundary varies. Hence /ss/ and /s/s/ are produced medially only one single glottal gesture is found. However, when a word boundary occurs between /s/ and /s/ or between /s/ and /s/, two consecutive gestures are seen (Figure 1).

3.2. Effect of speech rate

Before we investigate the effect of speech rate on the laryngeal adjustments of the sequences of voiceless segments, we present in Figure 3 the temporal interval between two successive peaks of glottal opening as a function of speaking rate. Speaking rate was indexed by the duration of the interval between the offset of the vowel preceding the first consonant in a sequence and the onset of the vowel following the second consonant in that sequence as in [8].

Figure 3 shows that glottal opening and closing gestures are produced with a one- or two-peaked pattern depending on speech rate. The occurrence of single peak movements is indicated by a single duration of the first consonant in a sequence and the onset of the vowel allowing the second consonant in that sequence as in [8].

Figure 1: Production of sequences of voiceless consonants with two laryngeal gestures for /\r\r\k/ and /\s\s/ (top); and with a single laryngeal gesture for /\r/ and /\s/ (bottom).

Figure 2: The amplitude of peak glottal opening in arbitrary units during the initial consonant in the sequence of voiceless consonants across word boundary.
3.3. Laryngeal-oral coordination

We have already noted in § 3.1 the effect of word boundary on the coordination between laryngeal and oral articulation. Figure 4 compares the location of peak glottal opening (PGO) for the different sequences of voiceless consonants produced at a slow rate. PGO location was calculated in % as follows: 100 x position of PGO relative to fricative onset / duration of fricative. For the geminated sequences /ss/ and /s\#s/, PGO generally occurs in the first half of the frication phase indicating that these geminates are articulated with an early devoicing gesture. On the other hand, for singleton /s/ and /s\#s/, PGO is attained just before the consonant mid-point. As for the clusters /s\#t/, /sk/ and /st/, the location of PGO varies as a function of the word boundary. When these sequences span a word boundary, PGO is just before mid-frication, similar to singleton /s/ and /s\#s/. The absence of the boundary, however, produces a delaying of PGO, which occurs later than mid-frication. A similar peak delay, which is probably due to the triggering of the adjacent plosive, was reported in English by Saltzman & Munhall (1989) cited in [12]. [2] also notes that PGO may be delayed in fricative-stop sequences compared to single fricatives. Other researchers [3, 10] have also indicated that the location of PGO is not systematically aligned with the midpoint of the fricative. The peak of glottal opening is delayed even more when the sequence of fricative and plosive is produced at a faster rate as illustrated by Figure 5. The peak occurs in the second half of the frication phase and sometimes towards the frication end. This result is in agreement with the finding reported in [3]. So it seems that the location of PGO is not systematically aligned with the midpoint of the fricative and this contradicts with a rule thatformulates laryngeal-oral coordination as follows: "if a fricative gesture is present, coordinate the PGO with the mid-point of the fricative... [2: 446]"

Another interesting aspect of laryngeal adjustment concerns the production of the schwa /a/ between voiceless obstruents. It was observed in most productions of consonant clusters that the glottis tended to begin opening while the vocal folds were still vibrating for the schwa /a/ preceding fricatives. However, a single laryngeal gesture is produced for both the fricative and the plosive, PGO occurs dur ing frication noise and the glottis is closing before the release of the stop. In this case, it is not possible to identify a specific opening gesture for the plosive, the laryngeal articulation of which is a continuation of the adduction phase of the adjacent fricative. On the other hand, when two consecutive gestures are produced for the fricative and the stop, respectively, a delaying of PGO occurs. The glottis is open at the stop release and PGO is attained around that release. To be more specific, in 3 cases, PGO was synchronized with the stop release, while in the remaining cases, PGO is achieved a little before the release. On average PGO leads by 10 ms in /\#t/, 20.6 ms in /s\#t/, and 27 ms in /s\#k/.

Figure 3: Peak to peak interval as a function of vowel-offset-to-vowel-onset.

Figure 4: Location of peak glottal opening in % relative to the duration of the fricative (slow rate production).

Figure 5: Location of peak glottal opening in % relative to the duration of the fricative (fast rate production).
Generally abduction for the fricatives was found to be synchronized with the onset of this vowel. An explanation for this devoicing gesture is that since the two consonants in the cluster are voiceless, the presence of the schwa would require a rapid change from a very abducted glottis to a brief moment of voicing for the vowel to, again an abducted glottis for the voiceless stop.

4. Conclusion

The overall patterns of laryngeal adjustment in sequences of voiceless consonants reported in the present paper are in general agreement with previous studies. Speech rate and word boundary have an effect not only on the shape of laryngeal abduction-adduction gestures but also on laryngeal consonant coarticulation. An explanation for such effects would be that the airflow during voiceless fricatives and stops is mainly controlled by the oral constriction. The requirement for the glottis control is to maintain the glottis area greater than the oral constriction area so that the frication noise generated at the oral constriction becomes dominant over aspiration noise at the glottis. This is why the glottal gesture can be ely vary in function of the esence-absence of the bound gr and of speaking rate as the equr ement for the glottis is relatively weak. For voiceless stops, however, to generate the dominant aspiration noise, the glottis rath the vocal folds must be controlled after release so that the glottal area is smaller than the al consonant.

5. Bibliography


Figure 6: Productions of sequences of voiceless consonants with (a) two laryngeal gestures at slow rate and (b) a single laryngeal gesture at fast rate for /s#k/, /s#t/ and /s#s/, respectively. The small lines on the glottal movements for the plosives correspond to the release.