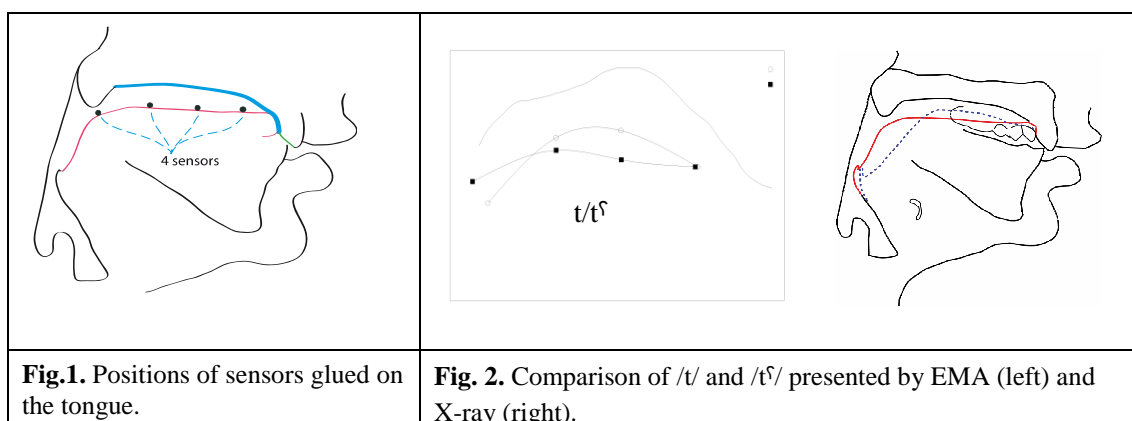


Studying pharyngealisation using an articulograph

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In this talk, we present an articulatory study of pharyngeals and pharyngealised phonemes in Arabic and their coarticulatory effects using an electromagnetic articulograph. Previous studies of pharyngealised phonemes and pharyngeals were based on a very limited number of x-ray images, but this technique is no longer practiced due to its danger to health. Our aim here is to revisit this kind of studies by using electromagnetic articulography (EMA) which is a current non-invasive technique to record articulatory data. This technique allows the acquisition of larger sets of articulatory data. More importantly, however, it is possible to study the movement of the tongue, even the back phonemes (produced at the pharynx) at a sampling rate of 200Hz which gives very good temporal resolution. This allows the capturing of very fine speech movements. The 3D articulograph (AG500, Carstens Medizinelektronik) was used to track the movement of tongue, jaw, lips and head. Three sensors were used for head positions, four for lips, one for the jaw and four sensors were glued on the tongue. It is very difficult to glue more sensors on the tongue, because in this case uttering speech becomes difficult and the acoustics will be adversely affected. The sensors were located at distances of approximately 1.6, 3.6, 5.2 and 7cm from the tongue tip respectively in the midsagittal plane (Fig. 1). A weak point of this layout is that we did not put one sensor on the tip of the tongue (the nearest sensor to the tip is at about 1.6 cm). However, our purpose is to observe back phonemes and thus we privileged, as much as possible, the coverage of the movement of the back of the tongue. The palate shape was "drawn" by one sensor approximately at the midsagittal plane, at the end of the recording session. This covers all the hard and soft palate up to the velum.



A list of Arabic words that covered a variety of phonemes in several contexts was recorded. Fig. 2 shows an example of presentation of two phonemes /t/ and /tʕ/ as observed by EMA, in comparison with the same pair of sounds as observed by X-ray images¹.

One main finding of this study regarding pharyngealised phonemes /tʕ/ and /ðʕ/ is that while the main articulation of the tongue is actually moving towards a dental position, the secondary articulation of backing of the tongue can be observed. The dynamics observation shows that in pharyngealised context a backing of the tongue starts earlier than the production of the pharyngealised phoneme (Fig.3). This anticipatory coarticulation is in accordance with several earlier studies.

¹ Ghazeli, Salem. 1977. Back Consonants and Backing Coarticulation in Arabic. Ph.D. Dissertation, University of Texas at Austin, Austin, USA.

EMA data confirms that back consonants (/X/, /h/, /ʃ/, /ʒ/ and /q/), which we consider as pharyngeals, are produced by backing the tongue toward the pharynx (Fig.4). This study investigates also the influence of phoneme context on backing of the tongue during the articulation of pharyngealized phonemes and the mutual influence with pharyngeals. In addition, the pharyngealization of the surrounding vowels was also studied.

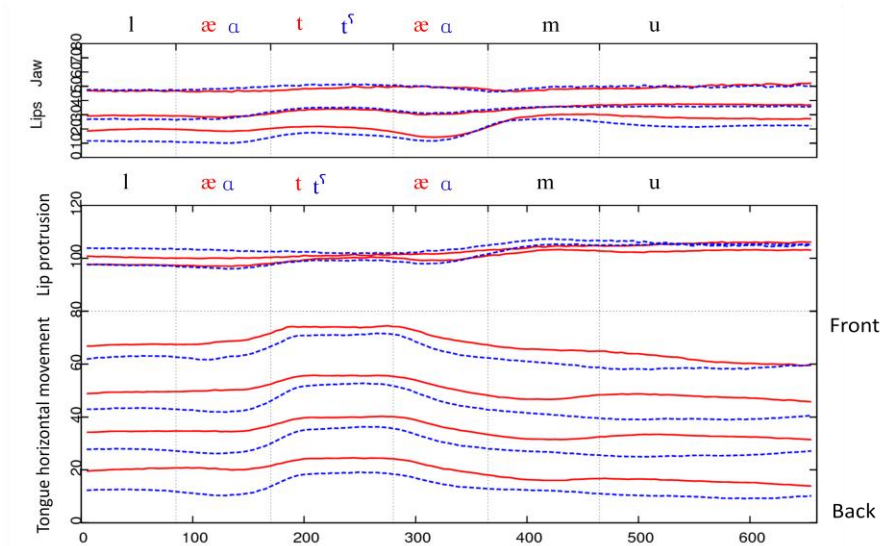


Fig.3. Comparison between the articulation dynamics of /t/ and /tʰ/ in two words different by one phoneme. The anticipatory articulation can be observed during the production of /tʰ/. The pharyngealisation affects the previous and following vowel.

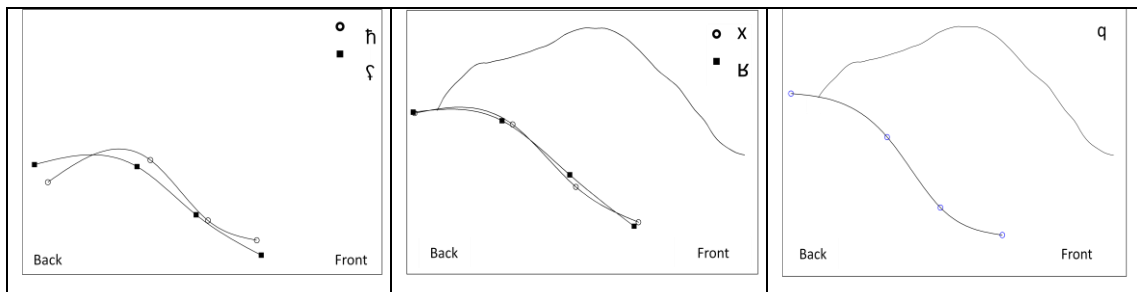


Fig.4. Place of articulation of different pharyngeals