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CONTRASTING PATTERNS OF LARYNGEAL ACTIVITY FOR STOPS IN NEO-ARAMAIC

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The lingua franca dialect of Neo-Aramaic as spoken by the Assyrians in Iraq has a rich consonantal system. It includes a three-way contrast for homorganic stops: fully voiced, voiceless unaspirated and voiceless aspirated. First attempts to investigate the production of the stops and to relate this to the requirements of the three-way system of acoustic contrasts are described here for a single speaker of the dialect, the first author.

The phonological system (1) contains a syllabic feature of emphasis. Plain and emphatic contrasts are shown in Figure 1, which illustrates the sound patterns for the denti-alveolar stops: / tina / 'because they are' ; /-tina / (emphatic) 'clay' ; /t^hina / 'fig' and / dina / 'religion'. The carrier sentence /$c^h t^h$u ---- t^hreʒa / ('write ---- twice') was used. Five tokens of each utterance were recorded in a studio. All the spectrograms, for words / pida / 'in hand' ; / p^hida / a girl's name ; / bina / 'breath', as well as for the denti-alveolar set, showed the same main distinguishing acoustic patterns, as seen on Figure 1.

Voice continues all the way through the acoustic 'closure' for /b/ and /d/; voice persists into the 'closure' for the other stops but ends before the release transient. Voice onset time (VOT) is much longer for /p^h/ and /t^h/ than for /p/ and /t/ and is near zero for /b/ and /d/. /p^h/ and /t^h/ have strong frication noise in the 'open interval' following the release. Average values for 4 or 5 tokens are shown in Table 1. VOT was measured from the transient to voice visible near 500 Hz at the top of the F_1 band; acoustic 'closure' was measured from the offset of F_3 and F_4 to the transient.

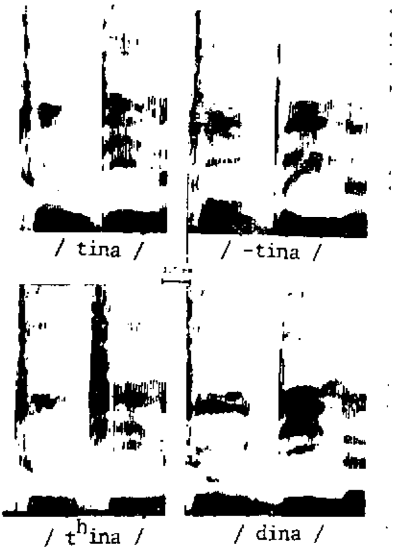

Figure 1. Spectrograms for / tina /, /-tina /, / t^hina / and / dina /.

The voiceless aspirated stops have significantly higher airflow at the release than do the voiceless unaspirated and the fully voiced stops. The voiced stops have significantly lower oral pressure than the other two types of stop. Typical aerodynamic traces are shown in Figure 2. The airflow data suggest that there is a relatively wide glottal slit at the moment of release for the aspirated stops but not for the others. How is the high oral pressure associated with the voiceless unaspirated stops to be explained?

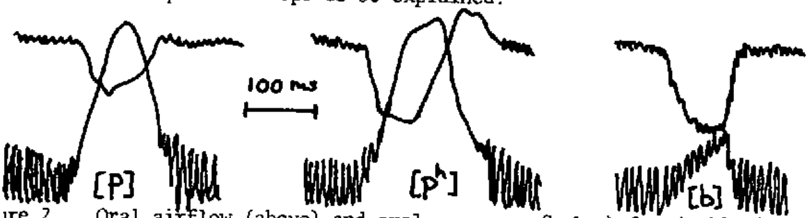

Figure 2. Oral airflow (above) and oral pressure (below) for / pida / , / p^hida / and / bina / .

	p^h	p	b	t^h	t	d
acoustic 'closure' duration ms	115	135	95	90	120	105
voice onset time (VOT) ms	55	10	5	70	20	5
peak oral pressure in closure cm H_2O	7.3	7.3	3.4	9.9	9.1	3.9
peak oral airflow at release l/min	91	39	35	78	32	35

Table 1. Some acoustic and aerodynamic measures for the stops. Mean values for 4 or 5 tokens are shown.

There has been much discussion about possible mechanisms to keep voicing going during the myodynamic closure phase of a stop consonant, but, as Lisker (2) points out: "one is entitled to ask whether it is the voicing or the devoicing of a closure interval that forces us to invoke a maneuver or maneuvers over and above the aerodynamic effects of the unaided closure." (p. 306).

In a computer simulation of simple /vowel-stop-vowel/ sequences different degrees of airflow absorption were modelled. The mechanisms could be enlargement of the supraglottal cavity, lowering of the larynx, nasal escape, or a combination of these. The results suggested that, with very little absorption of airflow, oral pressure builds up to near the level of subglottal pressure, regardless of the state of the glottis during the closure. With larger amounts of airflow absorption, however, pressure rise increases markedly as the vocal folds are abducted more. Thus, voiceless unaspirated plosives could probably be created by deliberately reducing airflow absorption to a small level. Passive wall compliance may well vary from one vocal tract to another; for some, deliberate reduction of wall compliance might be necessary to achieve high pressure without widening the glottal slit (3).

Some aspects of laryngeal behaviour for the three types of Neo-Aramaic stops were investigated, using the carrier sentence in each case. Figure 3 shows typical data from optical glottography (4) for /p/, /p^h/ and /b/. All the glottograms indicated that the vocal folds are abducted for the aspirated stops but not for the others. Laryngograph traces (5) were consistent with the optical evidence. Vertical movements of the larynx were investigated, using the thyrometer technique designed by Kakita and Hiki (6). Kakita and Hiki calibrated this optical system, which employs a small mirror stuck onto the

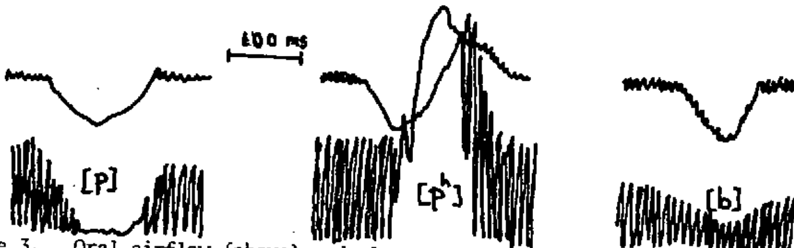

Figure 3. Oral airflow (above) and glottograms (below) for the three stop types.

speaker's skin at the level of the thyroid notch, against cineradiography of the larynx, but that was not done in these experiments. Only a few tokens were recorded, but the results were consistent. Typical examples are shown in Figure 4. The data seem to indicate that the speaker's larynx remained at the same level as for the surrounding vowels in the case of /pʰ/ and /b/ but that his larynx rose during the closure for /p/.

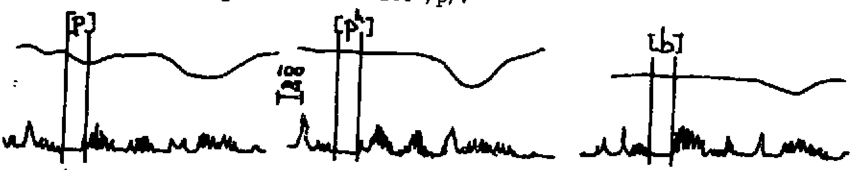

Figure 4. Thyometer traces (above) and duplex oscillograms (below) for the 3 stop types. Acoustic 'closures' are enclosed by vertical lines.

All the data, taken together, suggest that the speaker does not employ a special voice-maintaining mechanism at the larynx: the vocal folds remain adducted for the fully voiced stops but the larynx is not lowered. For the voiceless aspirated stops the vocal folds are abducted, with maximum glottal area timed close to the moment of supraglottal release. The rather short acoustic 'closure' of about 90 ms for /tʰ/ and its VOT value of 70 ms, with voice persisting through much of the acoustic 'closure' and with long and strong frication noise during the 'open interval' are all consistent with predictions made from modelling vowel-plosive-vowel sequences (3), (7). For the voiceless unaspirated stops the data suggest a pressure-raising mechanism similar to but not as extreme as that used in ejectives: during the closure the vocal folds remain adducted and the larynx is raised. These stops do not sound like ejectives, which is not surprising, since the oral pressure achieved is no higher than that for the aspirated plosives. A continuum, ranging from 'normal' to 'ejective' stops seems to be available.

Supraglottal actions were not investigated here, except that the nasal airflow trace showed that nasal escape was not used as a voice-maintaining mechanism. Respiratory activity could be used to influence the aerodynamic conditions throughout the vocal tract also.

It is inappropriate to specify a unique articulatory mechanism for a particular acoustic category such as voiceless unaspirated stop. Many methods seem to be available; different languages, with different systems of contrast, and different individual speakers, may well select different options. Individually simple gestures interact to create many varieties of acoustic patterning. More sophisticated modelling of speech production processes should help to increase our understanding of the varieties of acoustic detail associated with broadly similar acoustic patterns which are categorised together.

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