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The voicing contrast in stops and affricates in the Western Armenian of Lebanon

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Abstract

Research on Western Armenian has described it as having a contrast between voiceless aspirated stops and affricates, and voiced stops and affricates [1, 2]. The variety of Western Armenian spoken by a large population in Lebanon has not yet been examined phonetically, to determine the acoustic correlates of this contrast. The current study examines the alveolar and postalveolar affricates and alveolar stops (voiceless aspirated and voiced) in both word-initial and word-medial position, using nonsense words written in the Armenian script. The results indicate that voiced sounds have prevoicing, voiceless affricates have some aspiration, but voiceless stops have very short VOT, which aligns better with an analysis of them being classified as unaspirated. It was also found that position in the word does not affect VOT, duration of the closure or frication.
Index Terms: affricates, aspiration, VOT, Western Armenian, Lebanon, diaspora

1. Introduction

Stops, or plosives, are made up of a closure and release, which is sometimes followed by aspiration. [3] define aspiration as "a period after the release of a stricture and before the start of regular voicing (or the start of another segment, or the completion of an utterance) in which the vocal folds are markedly further apart than they are in modally voiced sounds" (p.70). To study such features, [4] introduced the concept of Voice Onset Time (VOT), which refers to the time lapse that occurs between the release of closure and the onset of vocal fold vibration. Accordingly, voiced stops are produced with vibration of the vocal folds beginning during the closure (- VOT). Voiceless stops have no voicing during the closure, and whether it begins immediately after the release or after a period of aspiration is the difference between voiceless unaspirated (0 VOT) and voiceless aspirated (+ VOT) stops [4, 5]. Beyond duration contrasts, the voicing effect can also influence f0 and intensity of the following vowel. For example, it is widely attested that voiceless (aspirated) stops induce higher f0 on the following vowel [6]. Some languages, such as English, have a two-way contrast between voiceless aspirated and voiceless unaspirated stops (e.g., /t^{h}/ vs /t/), while others, such as Portuguese, contrast between voiceless unaspirated and voiced (e.g., /t/ vs /d/). Some languages, such as Thai, have a three-way contrast, /t^{h}, t, d/ [7].

Affricates are a single segment made up of a combination of a stop and a fricative. Research has found that affricates are processed by speakers as a single segment, as shown, for example, in patterns of reduplication [8]. [8] also notes that some researchers consider affricates to be a type of stop. Research into Athabaskan languages analyzes aspirated stops as phonemic affricates [9]. Affricates, like stops, can also be voiced, voiceless, and aspirated.

Typologically, a contrast between only voiceless aspirated and voiced affricates is uncommon. In the UPSID database, 78 languages, or 18% of the languages in UPSID, have voiceless aspirated affricates [10]. Table 1 shows the number of languages with alveolar and postalveolar affricates, and their voicing distribution. It could be argued that a contrast between voiceless aspirated and voiced consonants is not ideal because it leaves a gap (voiceless unaspirated) in the continuum of VOT.

Table 1: *UPSID numbers of languages with alveolar and postalveolar voiceless aspirated and voiced affricates, and contrasts between these.*

Sound(s)	Lgs.	Sound(s)	Lgs.
/tʃ^{h}/	51	/ts^{h}/	25
/tʃ/	188	/ts/	45
/dʒ/	113	/dz/	20
/tʃ^{h}, tʃ, dʒ/	13	/ts^{h}, ts, dz/	3
Only /tʃ^{h}/ & /dʒ/	9	Only /ts^{h}/ & /dz/	5

1.1. Western Armenian

Armenian is a distinct branch in the Indo-European language family, spoken by six million people. There are two main varieties of Armenian: Western Armenian and Eastern Armenian. Even though they are mutually intelligible, the former is based on the dialect spoken in modern-day Istanbul, the latter has stemmed from the one spoken in Ararat valley and Yerevan. Eastern Armenian (henceforth, EA) is the official language in the Republic of Armenia today, and it is the language spoken by Armenians living in Iran, India, and the former Soviet Union [11]. Western Armenian (henceforth, WA) is spoken across the Middle East as well as in Europe, South America and the US [1, 12]. Within these groups, there are also sub-dialects. Armenians have been present in Lebanon for over two centuries. The most recent group, which included a larger number of Armenians, were refugees from Western Armenia, who were deported from their country during World War I. Accordingly, Armenians originally settled in different refugee camps across Lebanon (Bourj Hammoud, Marash, Sanjak, etc.) [13]. This has resulted in a substantial Armenian community in Lebanon, estimated at 150,000 people [14]. The Armenian community in Beirut operates two 24-hour radio stations, 3 daily newspapers, 27 schools, 1 university, 29 churches (16 Orthodox, 7 Catholic, and 6 Protestant), and 2 patriarchates with global jurisdictions (Orthodox and Catholic) [15].

Armenian is described as having alveolar and postalveolar affricates, and alveolar stops (as well as bilabial and velar stops, not focused on in the current investigation), with a voicing contrast. According to [2]: "Classical Armenian used a three-way voicing contrast between voiceless aspirates, plain voiceless,

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and plain voiced consonants. [Eastern Armenian] has essentially the same system as Classical, while [Western Armenian] has plain voiced consonants for the second series and voiceless aspirates for the third series, thus neutralizing the system to a two-way contrast" (p.11). (For further details on consonants in Armenian, see [16, 17, 18, 19, 20].)

Interestingly, WA maintained the voiceless aspirates of Classical Armenian, but changed the voiced into voiceless aspirates, while also turning the plain voiceless into voiced. As such, it has flipped the voicing of the latter two, and ended up with a two-way contrast.

1.1.1. Phonetic studies of stops in Armenian

One study on EA examined the effect of prosody on VOT of the three-way bilabial stop contrast [19]. Three speakers of Tehran EA living in Los Angeles were recorded. The distinction in the voicing contrast was found to be maintained in various prosodic conditions, and the averages of VOT in word-internal position for aspirated sounds was 66-92 msec, for unaspirated 7-31, and voiced -7 to -82. In a recent study on the acoustics of the three-way stop contrast in EA, [20] found voicing strength, VOT and aspiration were significantly different among all three groups. To the authors' knowledge, no research has examined the acoustic realization of this contrast in WA or in affricates.

1.2. Acoustic Correlates of Aspirated Affricates

Phonetic research on other languages with aspirated affricates has measured it in terms of closure duration, burst, frication and aspiration [21, 22]. [21] also mention "superimposed aspiration", where aspiration continues into the beginning of the vowel. Some work has also found an effect of where the aspirated sound occurs in the word, for example, [21] examined aspirated affricates in Nepali also using nonsense words, and found that aspirated affricates lost their aspiration in word-medial position. They also found that aspiration induced breathy-voice in the following vowel, correlated with reduced amplitude. Average f0 over the first one-fifth of the vowel was found to be lower in aspirated sounds, and also lower after word-initial than word-medial affricates. However, the authors mention that the former finding was unexpected, since lowered f0 is in fact the opposite of what is usually found after aspiration.

In the Oto-Manguean language Ixcatec, the full duration of the consonant (including closure, burst, frication, VOT) was found to be longer in word-initial than word-medial position [22]. For word-initial affricates, aspirated ones had longer frication than non-aspirated ones, and non-aspirated ones (by definition) had zero VOT. For word-medial affricates, non-aspirated ones had a longer burst and shorter frication than aspirated ones. In comparing plain stops to aspirated stops, word-initial aspirated stops had much longer VOT than unaspirated stops, and that this difference remained in word-medial position but was very reduced.

In the current study, we examine the acoustic correlates of voiced and voiceless aspirated stops and affricates in word-initial and word-medial position among speakers of WA in Lebanon.

1.3. Hypotheses

The following hypotheses will be tested:
Voiceless sounds have aspiration, that is, have positive VOT.
Voiced sounds are prevoiced, that is, have negative VOT.
Affricates have frication after the release.
Affricates have a shorter closure duration than stops.
Stops and affricates in word-medial position have shorter duration of all relevant measures (closure/frication/aspiration) than in word-initial position.
F0 is higher in the vowel following voiceless sounds.
Intensity is lower in the vowel following voiceless sounds, due to aspiration.

2. Method

2.1. Participants

Participants were eight (four females, four males) native speakers of Armenian, who grew up in Beirut. Six participants (three females, three males) were aged 24-32, and the other two were aged 53 and 59. Due to being brought up in Lebanon, all were also native speakers of Lebanese Arabic, and fluent in English.

2.2. Stimuli

Stimuli were nonsense words contrasting voiced and voiceless affricates and stops, in alveolar and postalveolar position, in word-initial and word-medial position:

/t^hat^ha, dada, ts^{h}a ts^{h}a, ʧ^{h}a ʧ^{h}a, dzadza, ʤaʤa/

Each speaker produced each word four times, each time in a carrier sentence. This led to a total of 384 segments for analysis (8 speakers * 4 repetitions * 6 sounds * 2 words positions). Eight were disregarded due to noise or speech errors leaving 376. The carrier sentence was the Armenian translation of "I say X again", where X is the target word. In Armenian this is [nuˈɾɛn X ɡəˌsɛm]. This ensured that the target word was always sentence-medial.

2.3. Procedure

Participants were recorded with a Zoom H5 recorder in a quiet room (.wav file, 44.1kHz). The sentences were presented in the Armenian script on paper, in a block together, but after a block with other sentences for a separate experiment.

2.4. Measurements

As noted above, target words were labelled in Praat [23] for whatever was present among the following: closure, burst, frication, aspiration, superimposed aspiration, and vowel (Figure 1). Superimposed aspiration is defined by [21] as "the portion of the vowel realized with simultaneous aspiration" (p.2), which is shown by noise excitation in the spectrogram. This was still counted as part of the vowel duration. VOT was calculated for voiced sounds as the duration of voicing during the closure until release, and for voiceless sounds as release burst plus aspiration. Average f0 (in semitones) and intensity (dB) over the first one-fifth of the vowel were also measured.

The independent variables were:
Voicing (Voiced vs voiceless)
Consonant type (stop vs affricate)
Word position (initial vs medial)

The measures were subjected to a linear mixed effects regression analysis (*lmer* function in R [24]) to determine if they were affected by the independent variables.

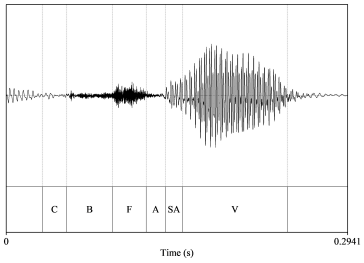

Figure 1: *Target word showing labels for one token of word-initial /tʃʰ/. (C = Closure, B = Burst, F = Frication, A = Aspiration, SA = Superimposed Aspiration, V = Vowel.)*

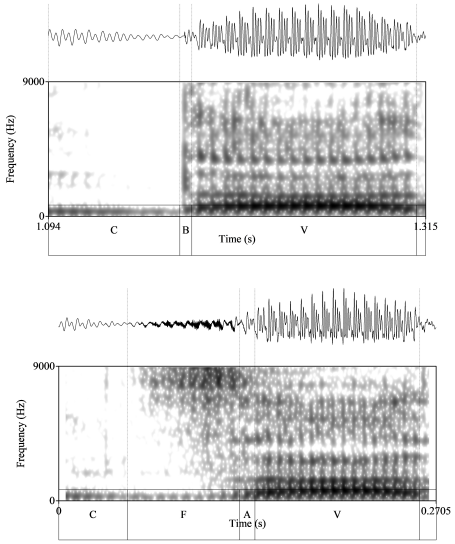

Figure 2: *Example tokens: /d/ and /ʤ/ showing voicing during the closure in voiced stops and affricates.*

3. Results

3.1. Descriptive results

As expected, voiced stops and affricates were pre-voiced, that is, had voicing during the closure, as shown in Figure 2. Voiceless stops and affricates had no voicing during the closure, and had aspiration (Figure 3). This meant that voiced stops had negative VOT and voiceless stops had positive VOT (burst + aspiration) (Figure 4, left panel). However, the +VOT was quite short, average 20msec.

Affricates had frication after the closure, whereas stops did not, as in Figure 3. 60% of voiceless sounds had superimposed aspiration. Frication was slightly longer for voiceless affricates (Figure 4, right panel). Stops appeared to have a longer closure than affricates, as shown in Figures 3 & 5 (left panel). Word-initial closure did not appear to be longer than word-medial closure (Figure 5 right panel), and the same pattern was found with frication and aspiration (Figure 6). F0 in semitones was slightly higher for voiceless sounds, and intensity was lower for voiceless sounds (Figure 7).

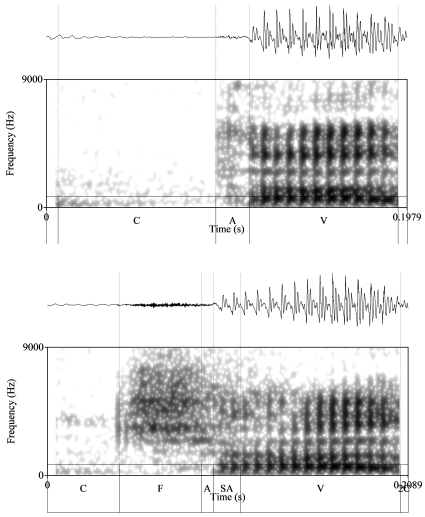

Figure 3: *Example tokens: /tʰ/ & /tʃʰ/ showing (1) lack of voicing during the closure, (2) frication in the affricate, and (3) aspiration in both.*

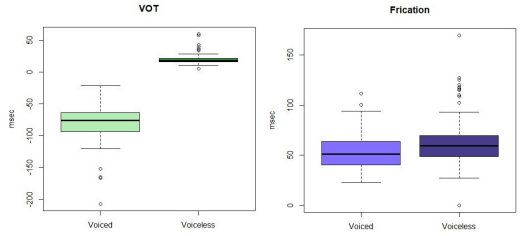

Figure 4: *Left: VOT of voiced and voiceless stops. Right: Frication duration of affricates based on voicing.*

3.2. Statistical results

The results of the linear regressions for each hypothesis are shown in Table 2. The alpha level of 0.001 was chosen. Speaker was included as a random factor. (This was chosen through model comparison, with the *anova* function, comparing models with possible random factors of Speaker and/or Sex and/or Token.) For each measure, the alphabetically first one was the reference level, so for the voicing contrast, the reference level was voiced, for word position, it was word-initial, and for consonant type, it was affricate. The statistical results supported most of the descriptions above, but not all:

- VOT was significantly higher for voiceless stops than voiced stops.
- Frication was significantly affected by consonant type, but also by voicing, whereby voiceless affricates had significantly longer frication than voiced (Figure 4, right panel). Interestingly, it was also subsequently found that there was an effect of place on frication, such that alveolar affricates had longer frication than postalveolar affricates ($p<0.001$).
- Closure duration was longer for stops than affricates.
- Word Position was found not to have any significant effect on any duration measures.
- F0 was found to be higher after voiceless sounds than voiced sounds.

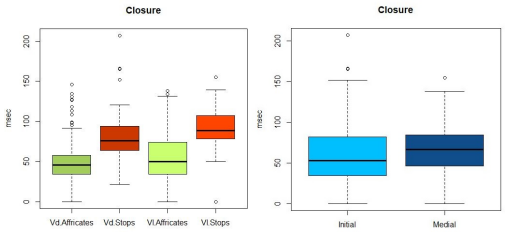

Figure 5: *Left: Closure duration of affricates and stops, by voicing. Right: Closure duration based on word position (affricates and stops are pooled).*

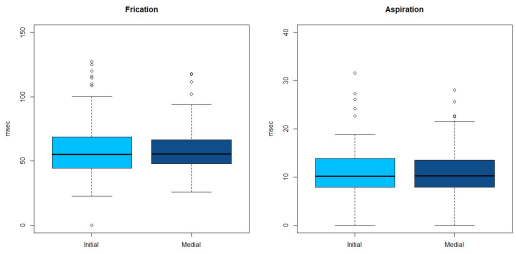

Figure 6: *Duration of frication and aspiration based on word position. Frication is only for affricates; Aspiration is only for voiceless sounds.*

- Intensity was found to be lower after voiceless sounds than voiced sounds.

4. Discussion

In accordance with previous work on VOT, in this study, voiced stops had -VOT while voiceless stops had +VOT. Similarly, voiced affricates were prevoiced while voiceless affricates had (short) aspiration [4, 5]. Average aspiration in affricates was 10msec and stops was 14msec. As mentioned above, the values for VOT for the voiceless stops was short, with an average of 20msec. In the context of crosslinguistic research, the values for stops in fact appear to line up better with voiceless unaspirated stops than voiceless aspirated stops [4]. For example, [7] note that voiceless aspirated (denti-) alveolar sounds usually have VOT of 57-97msec, and unaspirated 1.4-21msec. Research on EA stops mentioned above found voiceless aspirated stops to have an average of 72 msec VOT and voiceless unaspirated 21 msec VOT [19]. While that investigation examined bilabial stops, coronal stops tend to have even longer VOT than bilabial stops [25, 26, 27]. [20] show aspiration duration of word-initial voiceless aspirated stops in EA of around 75msec, and voiceless unaspirated of around 15msec. Thus, both VOT and aspiration (see Figure 6, right panel) values found for WA here align better with unaspirated stops. Since WA has a two-way contrast, it is possible that the voiceless aspirated sounds have gradually reduced aspiration to reframe the two-way contrast by removing the wide gap between voiceless aspirated and voiced stops. It is also possible that this characteristic is an effect of Lebanese Arabic, which has been found to have a contrast between voiceless unaspirated and voiced stops [28]. Some work has examined heritage speakers of WA in the US, finding that vowel production is influenced by English [12]. There is less research showing values for aspiration in affricates, but [21] have values of 31-32 msec for aspirated affricates in Nepali.

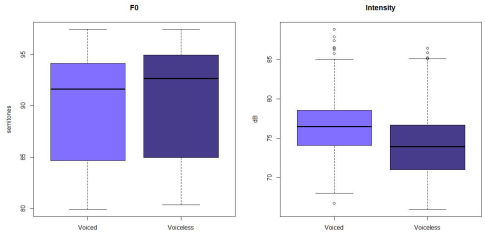

Figure 7: *F0 and intensity by voicing.*

Table 2: *Statistical results for all measures.*

Measure	Coef.	SE	t	*p*
VOT				
Voicing	103	5.3	19.5	<0.001*
Word Position	0.12	5.3	0.023	0.98
Frication Duration				
Voicing	15.8	2.7	5.8	<0.001*
Consonant Type	-51.7	3.2	-16.1	<0.001*
Word Position	4.2	2.6	1.6	0.102
Closure Duration				
Consonant Type	25.1	5.1	4.9	<0.001*
Voicing	-13.7	4.3	-3.2	0.002
Word Position	-9.3	4.2	-2.2	0.03
F0				
Voicing	0.797	0.14	5.5	<0.001*
Consonant Type	-0.4	0.17	-2.35	0.019
Intensity				
Voicing	-2.2	0.3	-6.6	<0.001*
Consonant Type	1	0.39	2.6	0.011

Stops and affricates were otherwise characteristic of their sound type, with a longer closure for stops, and frication in affricates. The results for f0 and intensity were as expected, with voiceless sounds inducing a higher f0 and lower intensity on the beginning of the vowel.

Unlike the studies conducted on affricates in Nepali [21] and Ixcatec [22], where word-initial affricates had longer duration of closure, frication, and aspiration than word-medial ones, this study showed that word position did not have a significant effect on any measures, in relation to both affricates and stops.

5. Conclusions

The current study indicates that WA in Lebanon has voiced and voiceless affricates and stops, with affricates having shorter aspiration than stops. Voiced sounds are pre-voiced. Voiceless stops have been described as aspirated, but the current measures suggest that they may be more accurately described as unaspirated, since VOT was found to be short.

Future directions include examining natural words to determine whether the same patterns are found, and to examine the effects of lexical stress on the patterns found here. In order to determine whether the short VOT found in voiceless stops may be an effect of Lebanese Arabic, it would be insightful to examine heritage speakers of WA in English speaking countries, since English has long VOT in voiceless sounds.

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