Phonetic structures of Turkish Kabardian

Matthew Gordon & Ayla Applebaum

Department of Linguistics
University of California, Santa Barbara
mgordon@linguistics.ucsb.edu
ayla1@umail.ucsb.edu

This paper reports results of a quantitative phonetic study of Kabardian, a Northwest Caucasian language that is of typological interest from a phonetic standpoint. A number of cross-linguistically rare properties are examined. These features include the phonetic realization of Kabardian's small vowel inventory, which contains only three contrastive vowel qualities (two short vowels and one long vowel), spectral characteristics of the ten supralaryngeal voiceless fricatives of Kabardian, as well as the acoustic, palatographic, and aerodynamic characteristics of ejective fricatives, an extremely rare type of segment cross-linguistically. In addition, basic properties of the consonant stop series are explored, including closure duration and voice onset time, in order to test postulated universals linking these properties to place of articulation and laryngeal setting.

1 Introduction

Kabardian is a Northwest Caucasian language spoken by approximately 647,000 people (SIL online *Ethnologue*, www.sil.org) primarily in Russia and Turkey, and also in smaller communities in various countries, including Syria, Lebanon, Jordan, Germany, and the United States. Kabardian belongs to the Circassian branch of the Northwest Caucasian language family, which also includes three other languages: Ubykh, a moribund language of Turkey, and the two very closely related languages/dialects of Abkhaz and Abaza. The Circassian languages are commonly divided into two branches: East Circassian, including Kabardian and closely related Besleney, and West Circassian, including Adyghe and its associated dialects.

Kabardian dialects can be further divided into three groups (Smeets 1984): West Kabardian, including Kuban and Kuban-Zelenchuk, Central Kabardian, which includes Baksan and Malka, and East Kabardian, comprising the Terek and Mozdok varieties. The Baksan dialect serves as the basis for the literary language arising in the 19th century (Colarusso 1992a: 3). Most speakers of Kabardian living outside of Russia do not read Kabardian, which has been written using the Cyrillic script since 1937 (Kuipers 1960: 9). Nevertheless, Kabardian (along with other Northwest Caucasian languages) has a rich tradition of oral tales, the best known of which are the Nart sagas (Colarusso 2002).

The largest concentration of Kabardian speakers resides in the Kabardino-Balkar republic of Russia. However, a substantial minority of speakers now reside in Turkey after a long struggle between the Northwest Caucasians and the Russians culminated in a mass exodus from Russia in the 19th century. The *Ethnologue* cites a figure of 202,000 Kabardian speakers in Turkey, though it is quite likely that the actual number of speakers exceeds this figure (John Colarusso, p.c). Smaller groups of Kabardian speakers are scattered throughout various

Journal of the International Phonetic Association (2006) 36/2
doi:10.1017/S0025100306002532

countries, including Syria (about 40,000 total speakers of Circassian languages as of the early 1960s according to Smeets 1984: 53), Jordan (30,000 Circassian speakers according to Smeets), and the United States.

Most previous descriptions of Kabardian focus on the variety of Kabardian spoken in Russia, in particular, the Baksan dialect upon which the literary standard language is based (Colarusso 1992a). The literature on Kabardian is largely published in Russian sources, which include several grammars (Turchaninov & Tsagov 1940, Yakovlev 1948, Abitov et al. 1957, Bagov et al. 1970) and dictionaries (Kardanov & Bichoev 1955, Apazhev et al. 1957). Nevertheless, at least one grammar (Colarusso 1992a), two dictionaries (Jaimoukha 1997, Alhas 2005), and a handful of phonetic and phonological descriptions (Yakovlev 1930, Catford 1942, 1984, Kuipers 1960) have been published in other languages. Quantitative phonetic studies of Kabardian and/or related Northwest Caucasian languages include studies by Henderson (1970), Colarusso (1988, 1992b, 1994), Catford (1984), Choi (1991), and Wood (1994).

This paper presents results of a phonetic study of Kabardian as spoken by the diaspora community, focusing in particular on the variety of Kabardian used in Turkey. Despite comprising up to one-third of the Kabardian speaking population, Turkish Kabardian has not been systematically described in the literature. Thus, this study helps to fill a salient lacuna in the literature on Kabardian linguistics, and more specifically, Kabardian phonetics. Moreover, the present work describes a number of phonetic features in Kabardian that are typologically unusual. These properties include the vowel system, which is remarkable in possessing only one to three (depending on the analysis) contrastive vowel qualities, and the fricative inventory, which contains at least nine contrastive places of articulation as well as both ejective and non-ejective voiceless fricatives. Examination of these properties provides insight into the phonetic realization of small vowel inventories and complex consonant systems. In addition, the paper provides a basic description of consonant closure duration and voice onset time for the stop consonants in order to test hypothesized universals linking voicing and place of articulation to these acoustic parameters.

2 Methodology

This paper is based on an analysis of a word list illustrating the principle phonetic properties of Kabardian as spoken by the Kabardian diaspora. Data from eleven speakers, six female and five male, were analyzed. Nine of the eleven speakers spent their formative years in Turkey (five of the six still live in Turkey), while a tenth speaker, one of the males, grew up in Jordan and currently lives in the United States. The speech of the speaker from Jordan was found to closely resemble that of the other speakers, except for some minor differences discussed in the section on fricatives (section 3.2). In addition to the ten speakers belonging to the Kabardian diaspora, the speech of a Kabardian from Russia was also considered for purposes of comparing Kabardian spoken outside of Russia with the Russian variety described in most published literature.

The word list was recorded in Turkey, except for the speakers from Jordan and Russia, and one of the speakers from Turkey, whose recordings were made in Southern California. The targeted words were elicited in Turkish for the nine speakers from Turkey and in English for the speaker from Russia and the speaker from Jordan. Data were recorded using a head-mounted unidirectional microphone connected to a Sony DAT recorder. Recordings were then converted to .wav files in preparation for acoustic analysis using Praat (www.praat.org) and MacQuirer (www.sciconrd.com).

Several analyses were performed in the current study. First, section 3 focuses on the consonants of Kabardian, providing an overview of the consonant inventory, a qualitative description of some of the typologically less common consonants, as well as quantitative

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

Table 1 The consonant phonemes of speakers examined in this paper.

	Labial	Denti-alveolar	Palato-alveolar	Palatal	Palatalized velar	Velar	Uvular	Pharyngeal	Laryngeal
Stops	pʰ p' b	tʰ t' d			kʲ' gʲ	kʷʰ kʷ'	qʰ q' qʷʰ qʷ'		ʔ ʔʷ
Affricates		ts ts' dz							
Fricatives	f f' v[w]	s z	ʃ ʃ' ʒ	ç ʝ		xʷ ɣʷ [gʷ]	χ ʁ χʷ ʁʷ	ħ	h
Nasals	m	n							
Laterals		ɬ ɬ' l							
Tap		ɾ							
Glides				j					

analysis of stops and fricatives. Section 4 examines the vowel system. Finally, section 5 summarizes the results of the current study.

3 Consonants

The speakers in our study from outside of Russia were found to possess the 46 consonants presented in table 1.

The 46 consonants in Kabardian far exceed the modal number of 21 consonants found in Maddieson's (1984) survey of 317 languages. Particularly unusual from a typological perspective is the 13-way contrast among voiceless fricatives. Eight distinct places of articulation are represented, one of which (uvular) has a rounding contrast. In addition, there are both lateral and central fricatives produced in the denti-alveolar region as well as a contrast between ejective and non-ejective fricatives at three places of articulation (labiodental, alveolar lateral, and palato-alveolar). Ejective fricatives are very rare cross-linguistically: Maddieson reports them for only 10 of the 317 languages in his survey (Kabardian being one of the surveyed languages). The nature of the fricative contrast is discussed further in section 3.2.

The rounded velar fricative /ɣʷ/ is characteristically produced as a voiced stop [gʷ] word-initially. The labiodental fricative /v/ may be realized either as a fricative or as a labial-velar glide [w] depending on context and speaker. In addition, the lateral approximant /l/ is often realized with some frication noise, i.e. as [ɮ], as reported in other works on Kabardian.

The contrast between voiced and voiceless stops is realized as a contrast between voiced and voiceless aspirated stops intervocalically. Word-initially, however, the voiced stops are typically realized as voiceless unaspirated, making the contrast one of aspiration in this position. In final position, the voiceless aspirated consonants lack the aspiration, though the voiced consonants are voiced throughout most if not all of their closure. The aspiration associated with the voiceless uvular [qʰ] is often realized as a uvular fricative, i.e. [qᵡ]. Ejective stops are distinguished from non-ejective stops by the increased intensity of their burst releases, in addition to differences in voice onset time. Consonant voicing patterns are discussed further in section 3.

The inventory in table 1 differs from the literary dialect of Russian Kabardian described in published works on Kabardian. Speakers from Turkey have a single set of palato-alveolar fricatives unlike speakers of literary Kabardian from Russia, who have both the palato-alveolars /ʃ, ʒ/ and the alveolopalatals /ɕ, ɕ', ʑ/. This difference between Turkish Kabardian

Table 2 Words containing the targeted stops for closure duration and voice-onset-time measures.

Stop	Initial position		Intervocalic position	
b	'baːdzɐ	'fly'	'saːbɐ	'dust'
pʰ	'pʰaːsɐ	'early'	'naːpʰɐ	'face'
p'	'p'aːɬɐ	'date, time'	'gʷaːp'ɐ (siːp'ɐ)	'pleasant' ('my bed')
d	'daːmɐ	'wing'	'faːdɐ	'drink'
tʰ	'tʰaːnɐ	'young bull'	'ʃaːtɐ	'cream'
t'	't'aːt'ɐ	'soft'	'jaːt'ɐ	'dirt'
gʲ	'gʲaːnɐ	'shirt'	'bzaːgʲɐ	'evil'
gʷ	'gʷaːp'ɐ	'pleasant'	not realized as stop	
kʲ'	kʲ'aːpsɐ	'rope'	no example in data	
kʷʰ	'kʷʰɐ	'core'	'siːkʷʰɐ	'my core'
kʷ'	'kʷ'aːsɐ	'fugitive'	'maːkʷ'ɐ	'he goes'
qʰ	'qʰɐʔɐ	'please'	'siːqʰɐ	'my cemetery'
q'	'q'aːlɐ	'city'	'vaːq'ɐ	'shoe'
qʷʰ	'qʷʰah	'boat'	'ʃ'aːqʷʰɐ	'bread'
qʷ'	'qʷ'aːʒɐ	'village'	'ɬaːqʷ'ɐ	'foot'

and literary Kabardian is discussed further in section 3.2. In addition, the palatal fricative /ç/ employed by the speakers examined in this paper corresponds to a more posterior /x/ for certain speakers of Kabardian in Russia (including the speaker from Russia analyzed in this paper). Speakers of Kabardian from Russia generally also have a voiced palato-alveolar affricate /dʒ/ instead of the more conservative (Kuipers 1960: 21) voiced palatalized velar stop /gʲ/ consistently employed by the speakers recorded for this project.

3.1 Stop consonants

In order to investigate the phonetic realization of the place and laryngeal contrasts in the plosive series, both closure duration and voice-onset-time were measured for a subset of the recorded data. Data from nine speakers (five female and four male) were analyzed for phases of the study involving consonants. Measurements were taken from a waveform with the assistance of an accompanying spectrogram using Praat (www.praat.org). Voice-onset time for most stops was measured in two contexts: in word-initial position before a stressed low vowel and in word-medial position between two low vowels, the first of which was stressed. Closure duration was measured for the intervocalic stops. The words containing the consonants targeted for measurement appear in table 2.

3.1.2 Closure duration

Closure duration values for intervocalic stops appear in table 3. Results for individual speakers as well as averages across speakers are given. The five female speakers are labelled F1–F5, while the male speakers are labelled M1–M4. Gaps occur where speakers either failed to produce the consonants as expected or altered the context in which the targeted consonant was expected to appear. For example, some speakers produced the word /gʷaːp'ɐ/ 'pleasant' with a voiceless bilabial plosive rather than an ejective. Interestingly, one speaker (M2) realized the uvular ejective /q'/ as an ejective fricative [χ'] rather than a stop (see section 3.2 for further discussion of fricatives).

Overall, voiced stops had slightly shorter closure durations (93 ms on average) than either voiceless aspirated stops (102 ms) or ejective stops (110 ms). An analysis of variance performed using SPSS version 11.0 (www.spss.com) revealed a significant effect of manner on closure duration: $F(2,182) = 5.808$, $p = .004$. However, Scheffe's *post hoc* tests showed only the difference between voiced and ejective closure durations to be statistically robust,

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

Table 3 Closure duration values (in milliseconds) by speaker for stops in intervocalic position.

	Stop												
	Voiced			Aspirated					Ejective				
Speaker	b	d	g^j	p^h	t^h	k^{wh}	q^h	q^{wh}	p’	t’	k^{w}’	q’	q^{w}’
F1	88	107	75	103	101	78	—	94	113	89	92	101	38
F2	105	138	100	124	121	90	—	111	—	127	103	174	156
F3	67	87	97	104	83	75	—	88	—	112	80	125	140
F4	85	116	—	130	128	86	—	119	134	128	89	117	100
F5	92	108	98	131	118	154	—	158	164	110	126	128	154
M1	106	91	61	119	93	76	—	—	—	143	99	97	113
M2	121	86	—	95	111	—	—	73	86	95	69	—	98
M3	74	76	68	107	70	114	65	—	98	93	73	70	68
M4	94	97	—	125	101	—	30	73	—	117	110	113	115
Mean	**93**	**100**	**82**	**115**	**103**	**95**	**53**	**102**	**116**	**114**	**97**	**116**	**110**

$p = .004$. The greater length of aspirated consonants relative to voiced consonants was most robust in the bilabial series for which 8 of 9 speakers (all except speaker M2) had longer aspirated plosives.

The shorter closure duration of voiced stops relative to voiceless ones is a common pattern cross-linguistically (Lehiste 1970, Maddieson 1997) and has an aerodynamic basis. The length of a voiced closure is constrained by the requirement that there be a sufficient pressure drop across the glottis to allow vocal fold vibration. This pressure differential cannot be maintained indefinitely because of the occlusion in the vocal tract, which induces a rise in intraoral pressure.

Aerodynamic factors also predict that more posterior voiced stops should have shorter closure durations than their anterior counterparts, since intraoral air pressure will reach levels at which voicing is no longer possible faster for a more posterior constriction than for a more anterior one. This prediction appears to be robustly confirmed cross-linguistically (see Lehiste 1970, Maddieson 1997). However, the inverse correlation between backness of constriction and length of closure is not consistently seen in the data examined here. Voiced bilabial stops have longer closures than denti-alveolars for only two of the nine speakers, though five of the six speakers for whom data for the palatalized velar series were available have longer dental than velar closures as predicted.

Differences in closure duration between aspirated and ejective stops showed considerable variation dependent on speaker and place of articulation with the most consistent pattern found in the rounded velar series, where ejective closures were longer for five of seven speakers with available data. In the bilabial and rounded uvular series, there was considerable interspeaker variation in the relative length of the aspirated and ejective closure durations. The two speakers for whom the non-rounded uvulars could be compared had longer closures for the ejectives, though this difference was quite small for speaker M3.

3.1.2 Voice onset time

Voice onset time was examined in two environments in order to determine the nature of the three way laryngeal contrast in the plosive series. Of particular interest is the phonetic realization of the voiced series, which has typically been described as voiced, although Kuipers (1960: 19) mentions a voiceless unaspirated realization as a variant. Henderson (1970: 93) states that his consultants sometimes pronounced the /d/ and the /dʒ/ (historically equivalent to the palatalized velar /g^j/ produced by speakers in the current study) as voiceless obstruents. In the data we collected, the stops were consistently voiced in intervocalic position and final position but varied considerably from speaker to speaker in their voicing patterns

Table 4 Voice-onset-time values (in milliseconds) by speaker for 'voiced' stops in initial position.

	Stop			
Speaker	b	d	g^j	g^w
F1	0	0	–	20
F2	−61	8	−117	−40
F3	13	21	24	–
F4	−11	19	43	30
F5	8	17	28	0
M1	−71	−55	−34	0
M2	−141	−124	–	−127
M3	−78	−63	−89	–
M4	0	−14	−94	–
Mean	**−38**	**−18**	**−34**	**−16**

Table 5 Voice-onset-time values (in milliseconds) for the three stop series in intial and intervocalic position (averaged across 9 speakers).

	Voiced	Aspirated	Ejective
Initial	−6	62	37
Intervocalic	(−93)	48	28

word-initially. Individual voice-onset-time results for the phonemic voiced stops in initial position appear in table 4.

The four male speakers produced voiced stops word-initially with the exception of the labialialized velar for speaker M1 and the bilabial for speaker M4, both of which were realized as voiceless unaspirated stops. Female speaker F3 realized the stops with slightly positive voice-onset-times word-initially. Speaker F1 initiated voicing exactly at release for the bilabials and denti-alveolar stops, while speakers F2 and F4 varied in their voicing patterns depending on place of articulation with bilabials having negative voice-onset times for both speakers and denti-alveolars being characterized by slightly positive voice-onset-times. The two velars were voiced for speaker F2 but had positive voice-onset-times for speaker F4. Individuals were generally consistent in their pronunciation of a stop produced at a given place of articulation. In the bilabial and palatalized velar series, however, speaker M1 produced one token as a voiceless unaspirated stop and the other as a heavily voiced stop (>80 ms of prevoicing).

Overall, the results suggest that the stops labelled as voiced in table 1 are indeed phonemically voiced but can become phonetically devoiced due to the reduced subglottal pressure characteristic of absolute initial position. This accords with a common cross-linguistic pattern found, for example, in English (Keating 1984). Averaged across nine speakers, VOT values were shorter for the bilabials than for the other three plosives. However, because of the considerable interspeaker variation, none of the pairwise comparisons between different plosives reached significance according to unpaired t-tests. Furthermore, an analysis of variance did not reveal any reliable effect of place of articulation on VOT values in initial position.

Table 5 summarizes VOT results across places of articulation for the different series of stops in initial and intervocalic position.

Voice onset time values for the aspirated and ejective stops were considerably longer than those for the phonemic voiced stops. An analysis of variance for the three series of stops in initial position indicated a significant effect of laryngeal setting on voice onset time: $F(2,223) = 97.821$, $p < .001$. VOT values were shortest for the phonemic voiced, but phonetically often unvoiced, stops (–6 ms on average), longest for the voiceless aspirated stops (62 ms) and intermediate in duration for the ejective stops (37 ms). Scheffe's *post hoc*

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

Table 6 Voice-onset-time values (in milliseconds) by speaker for voiceless aspirated and ejective stops in initial position.

	Stop										
	Aspirated					Ejective					
Speaker	p^h	t^h	k^{wh}	q^h	q^{wh}	p’	t’	k^{w}’	k^{j}’	q’	q^{w}’
F1	29	—	72	79	111	51	—	41	65	33	19
F2	48	—	72	58	21	—	—	—	114	18	29
F3	37	—	75	84	111	28	—	—	24	34	14
F4	38	—	80	93	87	45	—	29	27	25	93
F5	44	—	87	67	55	93	115	—	102	35	36
M1	30	—	57	82	77	27	—	—	26	25	0
M2	53	—	101	74	58	36	38	26	53	20	0
M3	25	46	70	53	37	16	—	42	55	22	41
M4	23	55	55	45	57	37	—	38	30	16	14
Mean	**36**	**51**	**75**	**67**	**73**	**42**	**77**	**34**	**55**	**25**	**19**

tests revealed all of the pairwise comparisons to be highly significant: voiced vs. aspirated, $p < .001$; voiced vs. ejective, $p < .001$; aspirated vs. ejective, $p < .001$. T-tests conducted using balanced places of articulation confirmed the robustness of this result: voiced vs. ejective, $t(1,146) = 8.837$, $p < .001$; voiced vs. aspirated, $t(1,105) = 10.339$, $p < .001$; aspirated vs. ejective, $t(1,161) = 5.966$, $p < .001$. Overall voice-onset-time values were slightly longer in initial position than in intervocalic position for the aspirated series but not for the ejectives.

In medial position, aspirated stops had longer voice onset times than ejectives also (48 ms vs. 28 ms): $t(1,138) = 4.518$, $p < .001$. Voice onset time for voiced stops in intervocalic position was not compared to the other two series of plosives, since the voiced stops are typically voiced intervocalically making their voice onset times equivalent to their closure durations. An analysis of variance determined that position had a significant effect on VOT values: $F(1,301) = 13.556$, $p < .001$. VOT values were longer in initial position than medial position for both the aspirated and ejective stops: 62 ms vs. 48 ms for the aspirated series and 37 ms vs. 28 ms for the ejectives. Another analysis of variance using places of articulation represented in both positions in both the aspirated and ejective series (i.e. labial, rounded velar, and rounded uvular) produced similar statistical outcomes. The effect of position on voice onset time would be even greater were it not for the bilabial series, for which initial position was not associated with longer VOT values than intervocalic position in either the aspirated or the ejective series.

VOT values for the aspirated stops were consistent with those found for phonemic aspirated stops in most of the languages with contrastively aspirated stops (including Gaelic, Hupa, Jalapa Mazatec, Khonoma Angami, Western Apache) in Cho & Ladefoged’s (1999) cross-linguistic study of voice-onset times with the exception of Navajo and Tlingit, which had longer VOT values than Kabardian. The shorter VOT values for the ejective stops relative to the aspirated stops in Kabardian is also consistent with the languages in Cho & Ladefoged’s survey that contrast ejective and aspirated stops (Hupa, Navajo, Tlingit, Western Apache). VOT values from the present study are similar to those reported for Kabardian in Catford’s (1984) survey of VOT values in Caucasian languages (see also Catford 1977). Catford’s results indicate substantial differences between languages in VOT. In particular, VOT values differ significantly for ejective stops, ranging from a low of 12 ms (averaged across places of articulation) in Abkhaz to a high of 116 ms in Adyghe, both of which are Northwest Caucasian languages like Kabardian.

Individual results for the aspirated and ejective stops in initial position and intervocalic position appear in tables 6 and 7, respectively.

Table 7 Voice-onset-time values (in milliseconds) by speaker for voiceless aspirated and ejective stops in intervocalic position.

	Stop									
	Aspirated					Ejective				
Speaker	p^h	t^h	k^{wh}	q^h	q^{wh}	p’	t’	k^{w}’	q’	q^{w}’
F1	35	66	75	—	87	53	35	35	21	32
F2	42	37	61	—	81	27	44	36	13	24
F3	55	72	32	—	—	—	27	17	15	18
F4	41	44	22	—	14	62	66	23	—	14
F5	43	65	80	—	30	104	89	8	25	21
M1	28	65	37	—	45	10	13	−69	29	—
M2	43	33	78	—	105	—	40	26	10	0
M3	0	35	110	39	—	17	28	17	37	35
M4	18	41	—	37	36	—	27	41	13	12
Mean	**34**	**46**	**59**	**39**	**57**	**43**	**39**	**25**	**21**	**20**

It is interesting to note that the ejective release in Kabardian stops is often less salient for the rounded ejectives than for the non-rounded ones. In fact, the rounded ejectives appear to have been replaced by either voiceless unaspirated stops or voiced stops for certain speakers, an observation which is supported by the very short VOT values characteristic of the rounded ejectives for some speakers. Male speakers M1 and M2 have zero voice onset time values for the rounded uvular series in initial position and speaker M1 produced a voiced rounded velar in intervocalic position. This realization does not jeopardize any phonemic contrasts, since the phonemic voiced rounded velar stop is realized as a fricative or an approximant intervocalically (see section 3). The realization of the phonemic ejective /q^{w}’/ with zero voice onset time for a male speaker is depicted in figure 1 along with its voiceless aspirated counterpart, which has a fricated release. It may be noted that the first two voicing periods after the release of the underlying ejective (on the right) suggest slightly creaky phonation, consistent with the ejective identity of the preceding stop.

3.2 Fricatives

One of the typologically unusual features of Kabardian is its large number of fricatives: thirteen voiceless ones in the variety studied here, /f, f’, s, ɬ, ɬ’, ʃ, ʃ’, ç, x^w, χ, $χ^w$, ħ, h/, and five voiced ones, /v, z, ʒ, ɣ, $ɣ^w$/, three of which, /v, ɣ, $ɣ^w$/, often have approximant realizations. (Speakers of literary Kabardian in Russia have an additional alveolopalatal series /ɕ, ɕ’, ʑ/.) Two features of the fricative system are of particular interest. First, there are a large number of place contrasts in the voiceless series, including lateral and two rounded fricatives. Second, three of the voiceless fricatives have contrasting ejective fricatives. Ejective fricatives are exceedingly rare and there is very little phonetic data on their realization cross-linguistically. Section 3.2.1 examines the spectral attributes of the place and secondary articulation contrasts among the non-ejective voiceless fricatives, section 3.2.2 presents center of gravity measures for the fricatives, and section 3.2.3 explores the acoustic, articulatory, and aerodynamic characteristics of the ejective fricatives.

3.2.1 Spectral characteristics of the voiceless fricatives

The spectral attributes of the voiceless supralaryngeal fricatives were investigated in a set of words containing the fricatives in word-initial position before a low vowel. The words containing the target fricatives are in table 8.

A 512-point window (approximately 23 ms) was centered around the middle of each fricative and an FFT spectrum of this window was calculated using MacQuirer

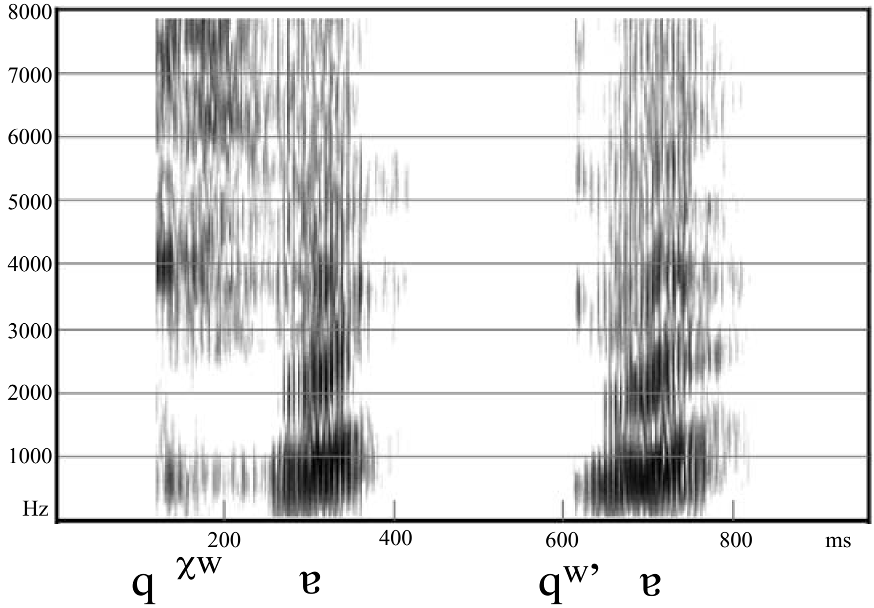

Figure 1 Phonetic realization of the phonemic aspirated uvular stop /q^{wh}/ and the phonemic ejective uvular stop /q^{w}'/ in the words /q^{wh}ɐ/ 'pig' and /q^{w}'ɐ/ 'son' as produced by male speaker M1.

Table 8 Words containing the targeted voiceless fricatives for the spectral measurements.

Fricative	Word	Gloss
f	fa:dɐ	'drink'
s	sa:bɐ	'dust'
ɬ	ɬa:q^{w}'ɐ	'foot'
ʃ	ʃa:tɐ	'cream'
ç	ça:mɐ	'foreign'
x^{w}	x^{w}a:bɐ	'warm'
χ	χa:rzənɐ	'good, useful'
$χ^{w}$	$χ^{w}$a:psɐ	'envy'
ħ	ħɐ:dɐ	'corpse'

(www.sciconrd.com). Numerical spectra were then averaged together over the two tokens of each fricative appearing in the same environment for a given speaker. Because visual inspection revealed consistency across speakers in the spectral properties characterizing each fricative, the spectra for all speakers of the same gender were averaged together for each fricative with the exception of /ʃ/ and /ç/ for the male speakers. In the case of /ʃ/ and /ç/, three of the male speakers (M1, M3, M4) pattern together with respect to spectral characteristics, while speaker M2 showed different patterns. The averaged spectra appear in figure 2 (fricatives articulated anterior to the velar region) and figure 3 (posterior fricatives). Spectra for the female speakers appear on the left and those for the male speakers on the right in each figure.

The spectral characteristics are generally similar for the male and female speakers. The labiodental /f/ has a relatively flat spectrum compared to the other fricatives. Fricatives other than the labiodental have one or more energy peaks that vary in frequency and acuity between the different fricatives. Fricatives produced with more anterior articulations characteristically

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

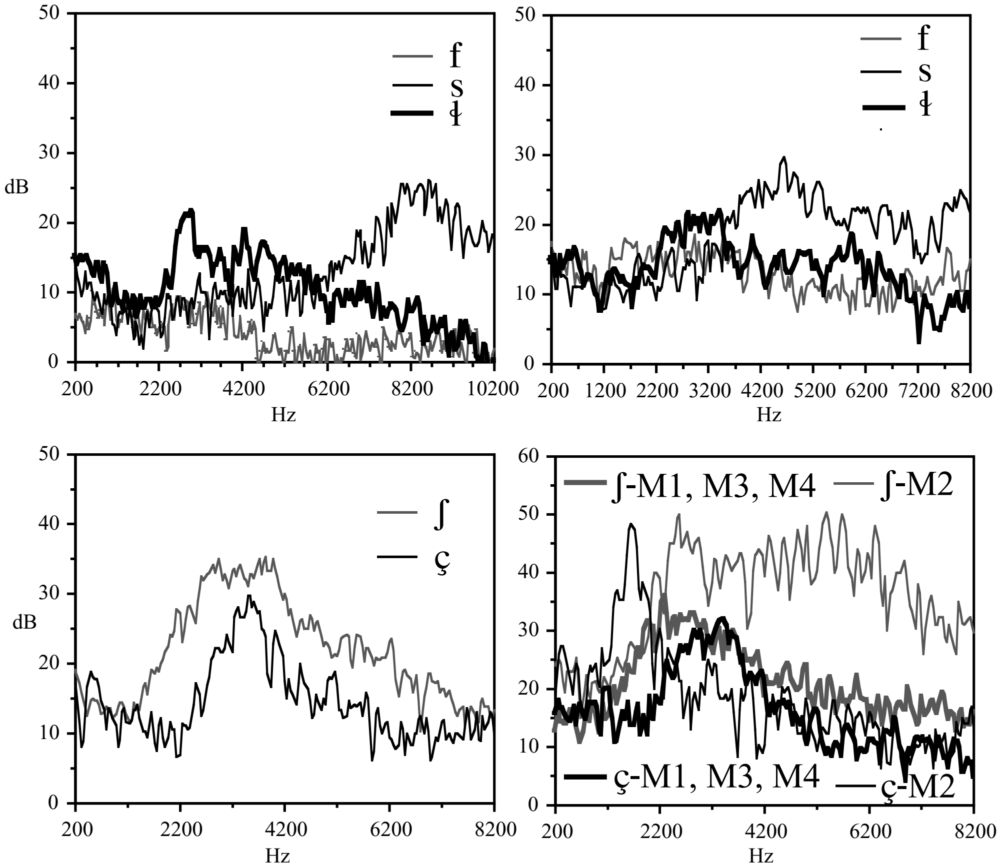

Figure 2 FFT power spectra of labial and coronal fricatives (females on left, males on right).

have their primary spectral peaks at higher frequencies while more posterior fricatives have more energy lower in the frequency domain. This correlation between anteriority of the constriction and frequency of the most intense noise band is attributed to the decreased length of the cavity in front of anterior constrictions.

The noise associated with the denti-alveolar /s/ is weighted toward higher frequencies relative to other fricatives, with the bulk of energy occurring between 3500 and 6000 Hz for the male speakers and between 7000 and 9000 Hz for the female speakers. The lateral fricative's primary concentration of energy is lower than that of /s/ and less intense, occurring between 2000 and 5000 Hz. For the female speakers, it is possible to discern two spectral peaks in this range, the first one being more intense and falling between 2000 and 3000 Hz and the second one occurring at slightly higher frequencies. These two peaks correspond to a single broader peak for the male speakers. The palato-alveolar /ʃ/ is characterized for the female speakers by a single spectral peak which is both broader and more intense than those associated with the lateral though they occur at similar frequencies. The male speakers diverge somewhat in their realization of the /ʃ/. All speakers have a relatively narrow peak at roughly 2500 Hz, but three speakers (M1, M3, M4) have a spectrum that drops off steadily throughout the higher frequency range, whereas speaker M2's spectrum has a second broader peak between 5000 and 6500 Hz. The male speakers in the current study also differ greatly in their realization of the palatal fricative /ç/. The spectrum for speakers M1, M3, and M4 is

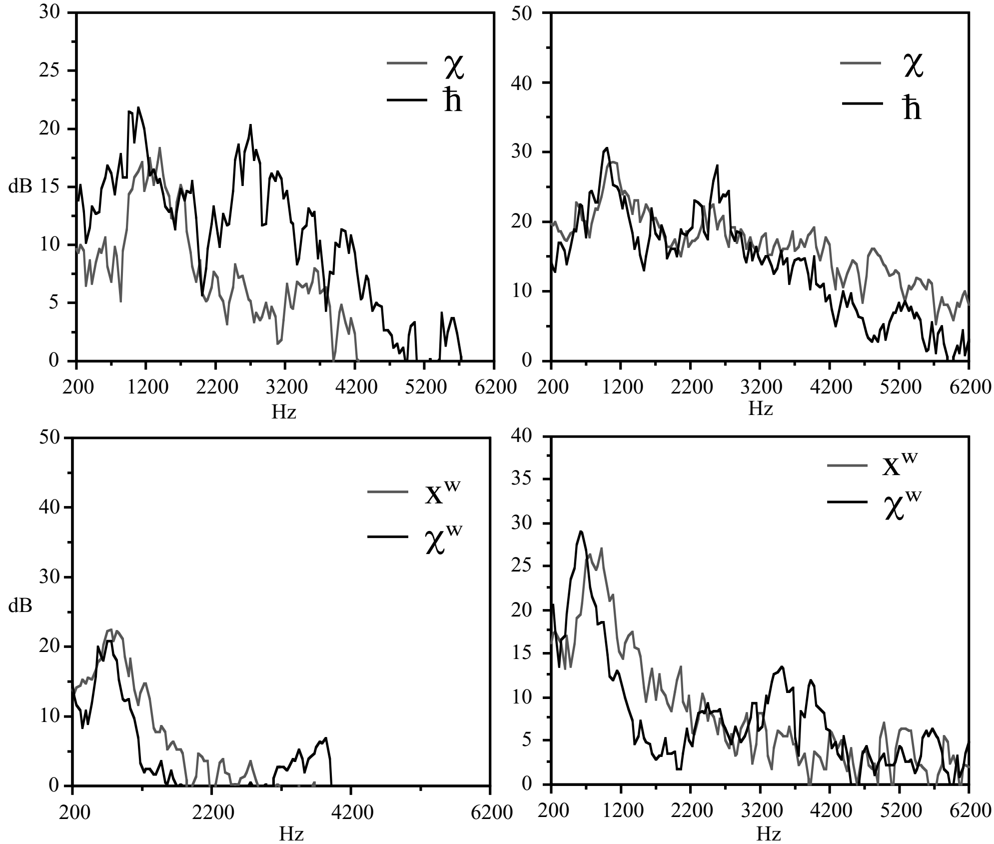

Figure 3 FFT power spectra of posterior fricatives (females on left, males on right).

quite similar to that of the female speakers with an energy peak between 2000 and 4000 Hz. This spectral peak is much narrower than that of the palato-alveolar for the female speakers and is slightly higher in frequency than that of the palato-alveolar for male speakers M1, M3, and M4. Speaker M2's palatal fricative has a single narrow peak centered at approximately 1700 Hz. The lower frequency energy characteristic of this sound as produced by speaker M2 is consistent with the auditory impression of a more posterior constriction, probably more accurately described as a fronted velar, relative to other speakers. This finding is interesting since the palatal fricative of Turkish Kabardian corresponds to a more posterior velar fricative for some speakers of Kabardian from Russia. It is also interesting to note that speaker M2 spent his formative years in Jordan rather than Turkey unlike the other speakers in the study.

The four posterior fricatives /xʷ, χ, χʷ, ħ/ all display a prominent low frequency spectral peak with one or more other lower intensity peaks at higher frequencies. The prominent low frequency peak occurs at lower frequencies for the two rounded fricatives than for the non-rounded uvular or the pharyngeal fricatives. The lowest frequency peak falls at roughly 1000 Hz for the rounded velar and uvular, slightly lower for the uvular than for the velar at least for the male speakers. The lowering effect of rounding on this spectral peak is attributed to the lengthening of the cavity in front of the constriction. Rounding also has the effect of reducing the overall intensity of the fricative noise, particularly at higher frequencies. The rounded velar and rounded uvular are distinguished for the female speakers primarily through a second peak between 3000–4000 Hz which is present for the rounded uvular but not for the rounded velar. The presence of at least two energy peaks is a characteristic of both the rounded and non-rounded uvulars for both the male and female speakers. The pharyngeal has two prominent spectral peaks, one at approximately 1200 Hz and a second centered at roughly 2700 Hz. The lower frequency peak associated with the pharyngeal falls at a frequency between that of the lowest frequency peaks of the rounded and non-rounded uvulars.

The results of the current study correspond fairly closely to findings from other languages (see Colarusso 1994 for spectral attributes of consonants in the Northwest Caucasian languages Ubykh and Bzhedukh) and corroborate predicted relationships between acoustic and articulatory properties of fricatives. The flat spectrum characterizing the labiodental in Kabardian is also found for labiodentals in other languages (see Gordon, Barthmaier & Sands 2002 for typological discussion). Furthermore, the overall correlation in Kabardian between frontness of the constriction and the frequency at which energy is strongest matches findings from other studies, including Colarusso (1994) and Gordon et al. (2002). Energy is concentrated at the highest frequencies for /s/, followed by /ʃ/, followed by the posterior fricatives. The palato-alveolar fricative in this study shows more energy at lower frequency, however, than certain of the languages analyzed in Gordon et al. (2002), e.g. Chickasaw, Toda, and Western Apache. This acoustic difference coupled with the lowering of the third formant in adjacent vowels might suggest a slightly more posterior articulation for the Kabardian palato-alveolar fricative coupled with a sizable sublingual cavity (see below also).

The double spectral peak associated with the lateral has analogs in other languages examined in Gordon et al.'s (2002) study, e.g. Hupa, Montana Salish, Western Apache, and certain speakers of Chickasaw and Toda. Gordon et al. also found that the lowest frequency energy peak in posterior fricatives fell at lower frequencies for rounded fricatives than for their unrounded counterparts in Montana Salish, /χ^w/ vs. /χ/, and Hupa, /x^w/ vs. /x/, and that uvulars were associated with a second higher frequency spectral peak in Montana Salish. Colarusso's (1994) acoustic study of Kabardian's relatives Ubykh and Bzhedukh indicates that rounding triggers lowering of energy in the frequency domain for both fricatives and stop bursts. The low frequency energy peak and the second higher frequency peak associated with the pharyngeal are also found in spectra for the voiceless pharyngeal fricative in Cairene Arabic (Norlin 1983). (None of the languages in Gordon et al.'s study had pharyngeal fricatives.)

As mentioned earlier, a salient area of divergence between Turkish Kabardian and many speakers of Kabardian from Russia is the neutralization of the literary Kabardian contrast between palato-alveolars and alveolopalatals by the speakers analyzed in this paper. For purposes of comparison, figure 4 contains spectrograms illustrating this contrast as produced by a speaker of Kabardian from Russia.

As figure 4 shows, energy for the palato-alveolar extends lower in the frequency domain (to 2000 Hz) than that associated with the alveolopalatal, whose lower edge of noise is just under 3000 Hz. Another interesting aspect of the contrast is the effect that each fricative has on the following vowel. The second formant is higher and the third formant is lower following the palato-alveolar than following the alveolopalatal. The raising of the second formant following the palato-alveolar suggests a higher tongue body position behind the constriction (Recasens 1984; Dart 1991, 1998). The slight lowering of the third formant is likely attributed to an increase in size of the sublingual cavity associated with a relatively posterior constriction, which is also consistent with the distribution of noise during the fricative itself. It may be noted that lowering of the third formant transitions is a recurring trait of consonants commonly termed 'retroflex' (Stevens & Blumstein 1975, Jongman, Blumstein & Lahiri 1985, Dart 1991, Hamann 2003, 2004). The third formant transitions in Kabardian are not as low, however, as those found for prototypical apical or subapical retroflexes in other languages (Stevens & Blumstein 1975, Jongman et al. 1985, Dart 1991, Hamann 2003, 2004).

Of the speakers recorded in the present study, all but one clearly neutralized the distinction between the palato-alveolar and alveolopalatal fricatives in favor of the palato-alveolars. However, the male speaker (M2) who grew up in Jordan has preserved some vestiges of the distinction. The most salient difference, however, now resides in the vowel immediately

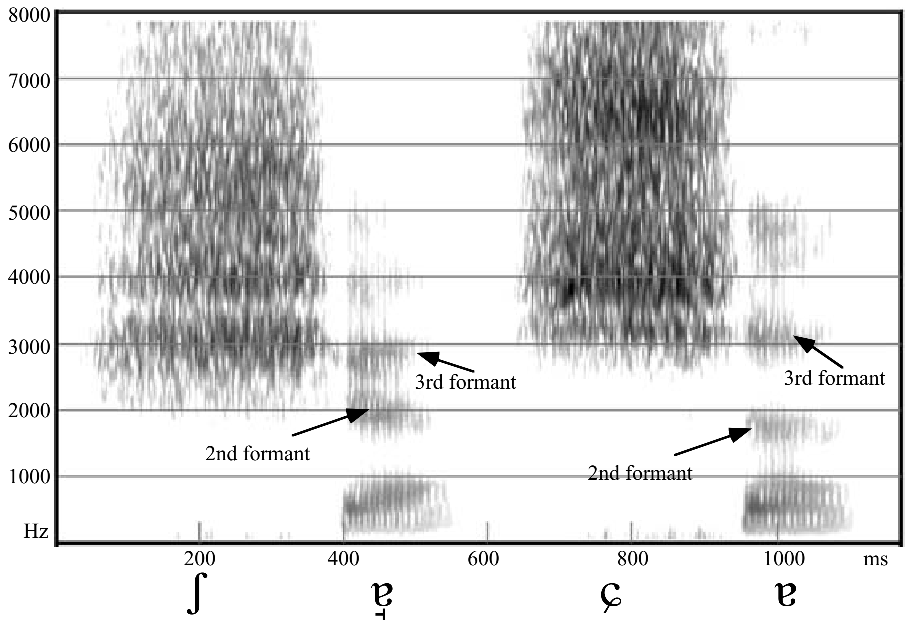

Figure 4 The contrast between palato-alveolar /ʃ/ and alveolopalatal /ɕ/ in the words /ʃɐ/ 'milk' and /ɕɐ/ 'hundred' as produced by a female Kabardian speaker from Russia.

following the fricative. The second formant for /ə/ is lower in the vowel following the sound corresponding to the alveolopalatal in literary Kabardian, as shown in figure 5. This variation was not observed, though, for the lower central vowel /ɐ/. Furthermore, the third formant is not lower following the palato-alveolar unlike for the speaker of Russian Kabardian discussed earlier, indicating that the articulatory basis of the contrast is clearly different between the two speakers.

Figure 5 also suggests a slight difference in the spectral characteristics of the fricative itself. While the frequency range characterized by noise is quite similar for the two fricatives, the postalveolar on the left has noticeably more energy at lower frequencies, in a band just above 2000 Hz. Figure 6 contains spectra of the two types of palato-alveolars (the original palato-alveolar and the one corresponding to an alveolopalatal in literary Kabardian). Spectra are averaged over four tokens of each fricative in a low vowel context in the following words (two token from each word): /ʃɐ/ 'milk', /ʃaːtɐ/ 'cream', /ɕɐ/ 'hundred', /ɕaːbɐ/ 'soft'.

As figure 6 shows, the spectra for the two fricatives overlap nearly completely in their distribution of noise, the biggest difference being the greater intensity of the low frequency peak at 2500 Hz for the palato-alveolar fricative. This difference essentially mirrors that seen in the spectrogram in figure 5. We are unable to say for certain how robust this difference between the two fricatives is, though it is consistent with the weighting toward higher frequency energy characteristic of the alveolopalatal as produced by the speaker from Russia.

3.2.2 Centers of gravity for the fricatives

Centers of gravity were also computed over the frequency range 0–10 kHz for the non-laryngeal fricatives in order to determine the gross weighting of noise for each fricative. The center of gravity for each fricative was calculated by multiplying each frequency value in the

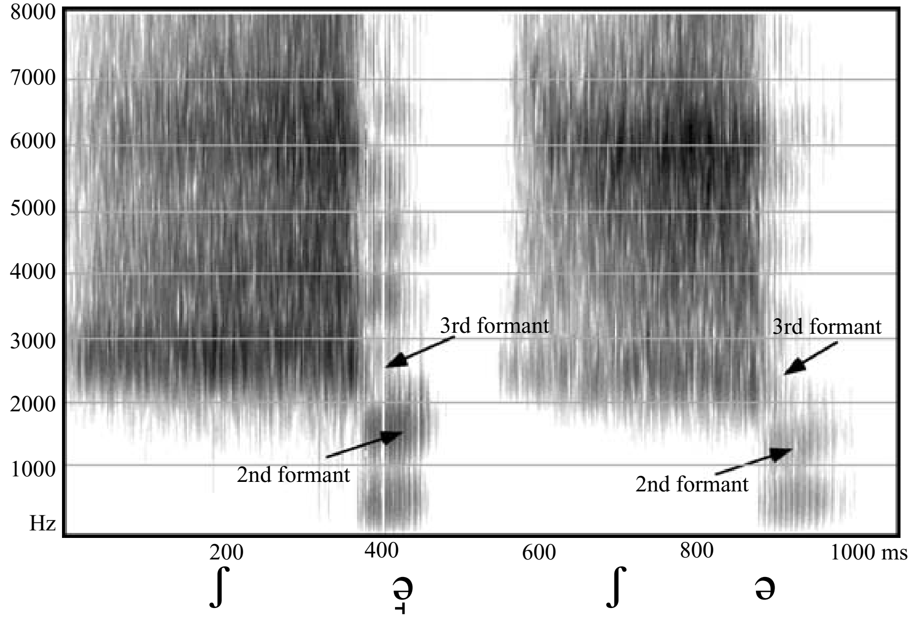

Figure 5 The difference in the backness of /ə/ in /ʃə/ 'horse' vs. /ʃə/ 'three' (corresponding to /ɕə/ in literary Kabardian) as produced by a male Kabardian speaker from Jordan.

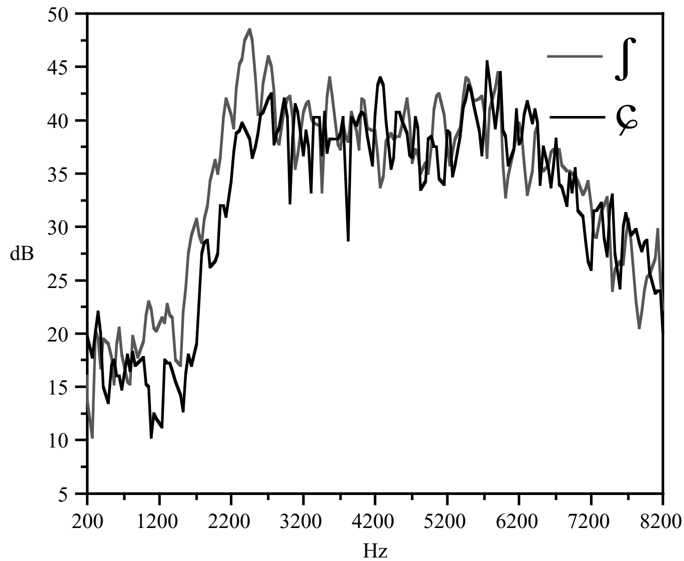

Figure 6 FFT power spectra of the two 'palato-alveolar' fricatives (one corresponding to an alveolopalatal fricative in literary Kabardian) as produced by a male speaker from Jordan.

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

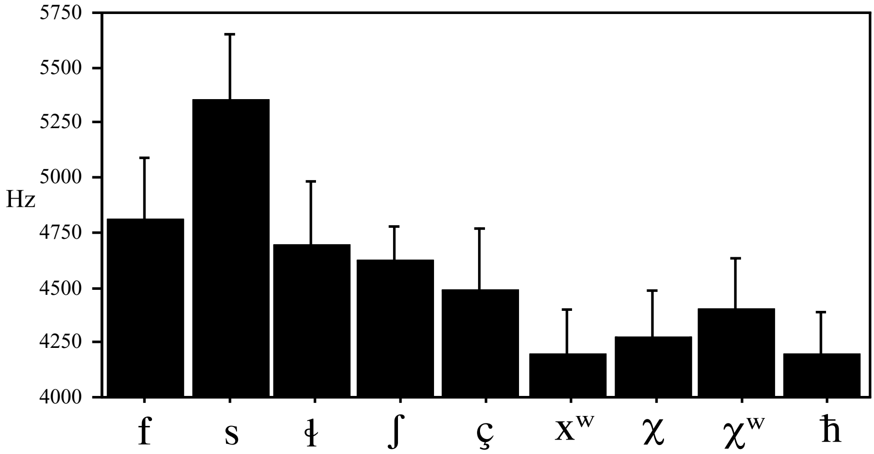

Figure 7 Centers of gravity for Kabardian fricatives (averaged over nine speakers).

Table 9 Centers of gravity for Kabardian fricatives (individual speakers).

	f	s	ɬ	ʃ	ç	xʷ	χ	χʷ	ħ
F1	4458	4776	4458	4502	4460	4173	4125	4647	4215
F2	4639	5362	4639	4636	4270	3990	4214	4327	4325
F3	4635	5465	4635	4756	4871	3916	4246	4138	4337
F4	5104	5738	5104	4762	4578	4270	4152	4302	4058
F5	4850	5725	4850	4437	4966	4187	4246	4517	4071
M1	5062	5155	4384	4578	4482	4355	4201	4308	4363
M2	4996	5517	4670	4846	(4022)	4402	4678	4693	3968
M3	4496	5180	4830	4756	4506	4121	4250	4594	4068
M4	4985	5286	4616	4437	4396	4319	4337	4025	4331
Mean	**4802**	**5349**	**4691**	**4619**	**4484**	**4193**	**4272**	**4395**	**4193**

numerical spectrum by its corresponding intensity value and then dividing the sum of these products by the sum of all the intensity values of the spectrum (Forrest et al. 1988, Zsiga 1993, Jongman, Wayland & Wong 2000, Gordon et al. 2002). Results are shown graphically in figure 7 and then separated by speaker in table 9. Note that the value in the palatal column for speaker M2 appears in parentheses since this speaker produces a more retracted fricative (see section 3.2.1).

An analysis of variance indicated that fricative location affected center of gravity values: $F(1,151) = 39.399$, $p < .001$. The center of gravity measure differentiated many of the fricatives. Among the most robust findings were that the denti-alveolar /s/ has the highest center of gravity, while the posterior fricatives /xʷ, χ, χʷ, ħ/ have the lowest values for center of gravity. These patterns follow findings of other studies investigating different languages (see Gordon et al. 2002 for an overview). Many pairs of fricatives were distinguished in Scheffe's *post hoc* tests, as shown in table 10, which contains check marks for all pairwise comparisons showing significance levels of $p < .01$ or better. The denti-alveolar /s/ was distinguished from all other fricatives, while the labiodental was distinguished from the four posterior fricatives /xʷ, χ, χʷ, ħ/. Three of the four posterior fricatives, all except the rounded uvular, were also differentiated from the anterior fricatives /ʃ, ɬ/. None of the four posterior fricatives were distinguished from each other and the palatal fricative was only reliably different from /s/.

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

Table 10 Summary of *post hoc* comparisons of centers of gravity (averaged over 9 speakers).

	f	s	ɬ	ʃ	ç	xʷ	χ	χʷ	ħ
f		√	n.s.	n.s.	n.s.	√	√	√	√
s			√	√	√	√	√	√	√
ɬ				n.s.	n.s.	√	√	n.s.	√
ʃ					n.s.	√	√	n.s.	√
ç						n.s.	n.s.	n.s.	n.s.
xʷ							n.s.	n.s.	n.s.
χ								n.s.	n.s.
χʷ									n.s.
ħ									

The male speaker from Jordan who potentially distinguished between palato-alveolar and alveolopalatal fricatives did not use center of gravity to differentiate the two. The inherited palato-alveolar had an average center of gravity of 5270 Hz, while the other fricative had a nearly identical mean center of gravity of 5333 Hz, a non-significant difference.

3.2.3 Ejective fricatives

The ejective fricatives of Kabardian are distinguished in several ways from their non-ejective counterparts depending on the fricative, the speaker, and the context in which the fricative occurs. Typically, the ejectives are characterized by relatively short phases of fricative noise compared to their voiceless counterparts. Maddieson et al. (2001) make a similar finding in their study of ejective fricatives in Tlingit, suggesting that the shorter duration of the ejective fricatives is due to the relatively small volume of air available between the glottal and supralaryngeal constrictions.

In addition, there is often a gap between the release of the constriction and the start of voicing in a following voiced sound, parallel to the positive VOT times found for ejective stop consonants. This positive VOT lag is most apparent in the palato-alveolar and lateral ejective fricatives and can be seen by comparing the palato-alveolar ejective in figure 8 with its non-ejective counterpart in figure 9, both of which were produced by a female speaker (F1). The shorter duration of the ejective is also apparent in the comparison of the fricatives in the two figures. It may also be noted in these spectra that the noise associated with the fricative (particularly the plain voiceless one) dips well below 2000 Hz parallel to the apical retroflex fricative in Ubykh (termed 'laminal flat post-alveolar' by Ladefoged & Maddieson 1996: 164), which appears in a spectrogram in Colarusso (1994: 141). The lower frequency limit for the Kabardian postalveolar fricative is shared with postalveolar fricatives in many languages whether or not they are truly retroflex in Ladefoged & Maddieson's classification, i.e. involve subapical contact (see Dart 1991 on O'odham; Svantesson 1986 on Mandarin Chinese; and Shalev, Ladefoged & Bhaskararao 1994 and Gordon et al. 2002 on Toda). It should be noted, however, that non-anterior coronal fricatives in many languages have a slightly higher frequency distribution of noise (Gordon et al. 2002), e.g. English palato-alveolars, which are produced with a domed tongue position (Ladefoged & Maddieson 1996).

In order to quantify the shorter constriction durations characteristic of the ejective fricatives, measurements were taken of the duration of the fricative phase of both the plain voiceless and the ejective fricatives. For each speaker, pairs of ejective and non-ejective fricatives occurring in identical immediate environments were compared. The words targeted for examination appear in table 11.

Across speakers, the ejective fricatives were found to have significantly shorter frication duration (130 ms averaged over speakers) than their non-ejective counterparts (191 ms)

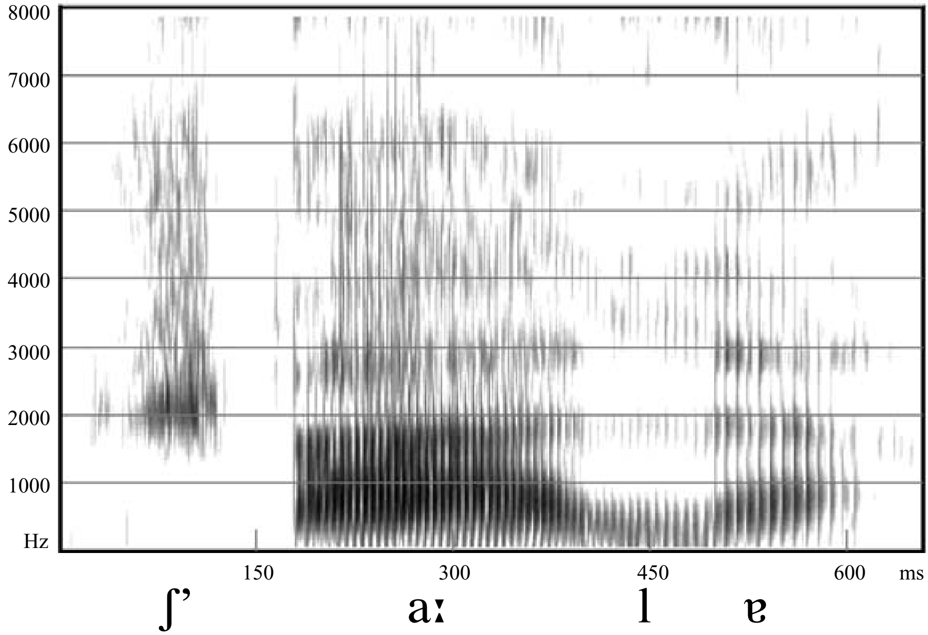

Figure 8 The palato-alveolar ejective fricative /ʃ'/ in the word /ʃ'aːlɐ/ 'young' as produced by speaker F1.

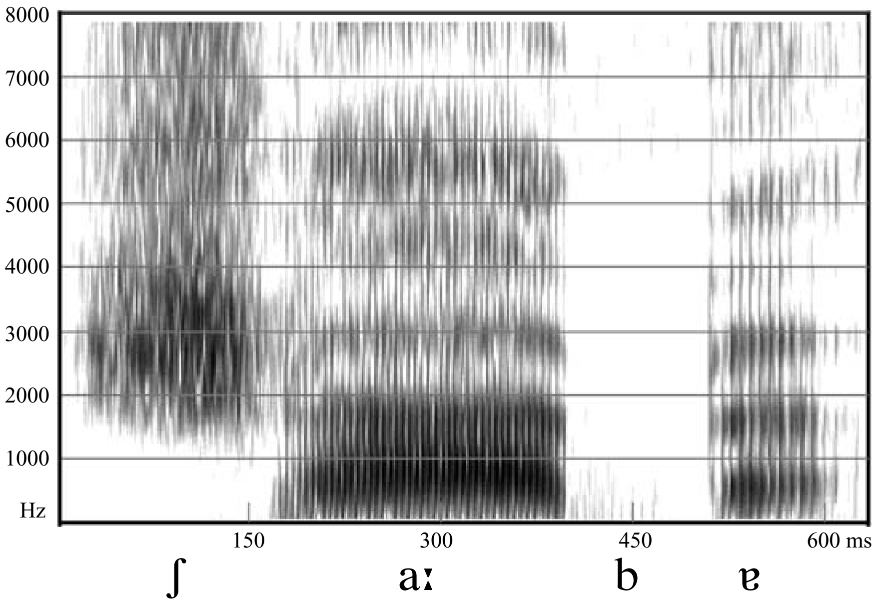

Figure 9 The palato-alveolar voiceless fricative /ʃ/ in the word /ʃaːbɐ/ 'soft' as produced by speaker F1.

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

Table 11 Words containing the targeted plain voiceless and ejective fricatives for the constriction duration measurements.

Fricative	Plain voiceless		Ejective	
Labiodental	haːfɐ	'rubber'	maːf'ɐ	'fire'
	fəz	'woman'	f'ə	'good'
Lateral	ɬə	'blood'	ɬ'ə	'man'
	faːɬɐ	'hoof'	maːɬ'ɐ	'It is dying'
Palato-alveolar	ʃaːbɐ	'soft'	ʃ'aːlɐ	'young'
	maːʃɐ	'tongs'	maːʃ'ɐ	'few, small amount'

Table 12 Fricative duration (in milliseconds) by speaker for plain voiceless and ejective fricatives.

	Fricative					
Speaker	f	f'	ʃ	ʃ'	ɬ	ɬ'
F1	141	111	161	152	215	106
F2	208	177	195	106	209	129
F3	175	166	170	92	204	138
F4	—	—	154	142	213	166
F5	232	75	202	108	203	102
M1	—	—	138	113	121	107
M2	162	137	176	101	312	181
M3	—	—	169	106	126	125
M4	—	—	208	136	296	206
Mean	**172**	**134**	**178**	**120**	**203**	**136**

according to a t-test: $t(1,150) = 6.411$, $p < .001$. Results for individual speakers appear in table 12.

As table 12 shows, the ejective fricative is shorter than its non-ejective counterparts for individual speakers in virtually all cases (with the exception of the lateral fricative for speaker M3), though this difference is fairly small in certain cases, e.g. for the labiodentals for speaker F3 and the palato-alveolar pair for speaker F4.

Another distinguishing characteristic of the ejectives is their reduced intensity relative to their plain voiceless counterparts. This difference was quantified by measuring the intensity of the frication noise relative to the immediately following vowel in order to control for token-to-token fluctuations in overall speaking level. Comparisons were only made for fricative pairs occurring in identical environments, i.e. both occurring before the same vowel in the same position (intervocalically or word-initially). An unpaired t-test pooled over all the data indicated that ejective fricatives were significantly less intense relative to the following vowel (fricative intensity minus vowel intensity $= -16.61$ dB) than non-ejective fricatives (fricative intensity minus vowel intensity $= -12.25$ dB): $t(1,80) = 3.205$, $p = .002$. Results for individual speakers appear in table 13, where a larger difference in intensity between the fricative and the following vowel (which invariably had greater intensity than both ejective and non-ejective fricatives) means that the fricative has relatively less intensity. In virtually all cases, the difference in intensity between the vowel and the targeted fricative is greater for the ejectives, the only exceptions being for the lateral pair for speakers F1, F3, and M3.

Palatography data collected from one of the female speakers suggest that the ejective fricatives are produced with a narrower constriction than their non-ejective counterparts. Figure 10 shows palatograms depicting contact patterns for a representative token of the non-ejective palato-alveolar fricative (on top) in the word /ʃɐ/ 'hundred' and two tokens of the ejective (on bottom) palato-alveolar fricative in the word /ʃ'ɐ/ 'new'.

Table 13 Relative fricative intensity in decibels (fricative minus following vowel) by speaker for plain voiceless and ejective fricatives.

	Fricative					
Speaker	f	f’	ʃ	ʃ’	ɬ	ɬ’
F1	–8.89	–12.89	–12.19	–17.57	–10.03	–9.95
F2	—	—	–14.72	–26.02	–15.23	–17.72
F3	–12.37	–20.37	–4.54	–9.04	–11.38	–9.09
F4	—	—	–15.78	–24.29	–12.29	–17.57
F5	—	—	–9.23	–15.01	–20.25	–28.72
M1	—	—	–13.51	–19.60	–6.02	–6.44
M2	—	—	–8.93	–18.86	–16.73	–17.42
M3	—	—	–17.22	–22.74	–7.54	–4.21
M4	—	—	–12.90	–18.44	–21.49	–23.10
Mean	**–10.63**	**–16.63**	**–11.46**	**–17.76**	**–13.44**	**–15.25**

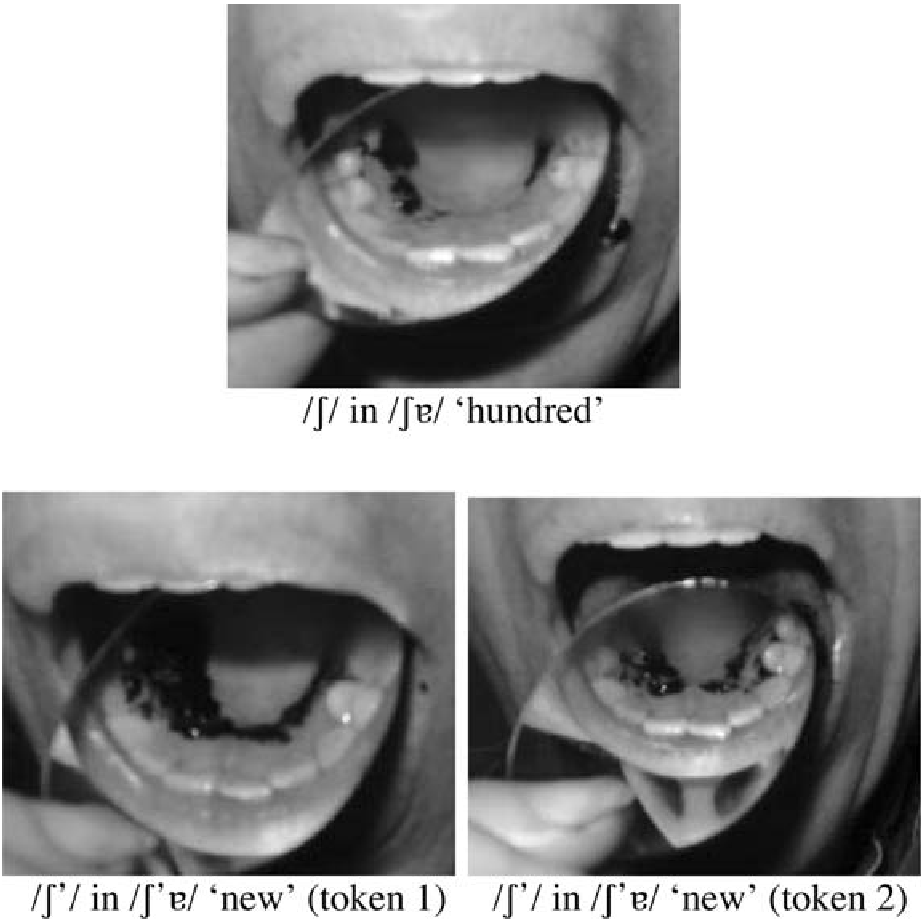

Figure 10 Palatograms of the non-ejective (top) and ejective (bottom) palato-alveolar fricatives in the words /ʃɐ/ ‘hundred’ and /ʃ’ɐ/ ‘new’ as produced by a female speaker (F5).

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

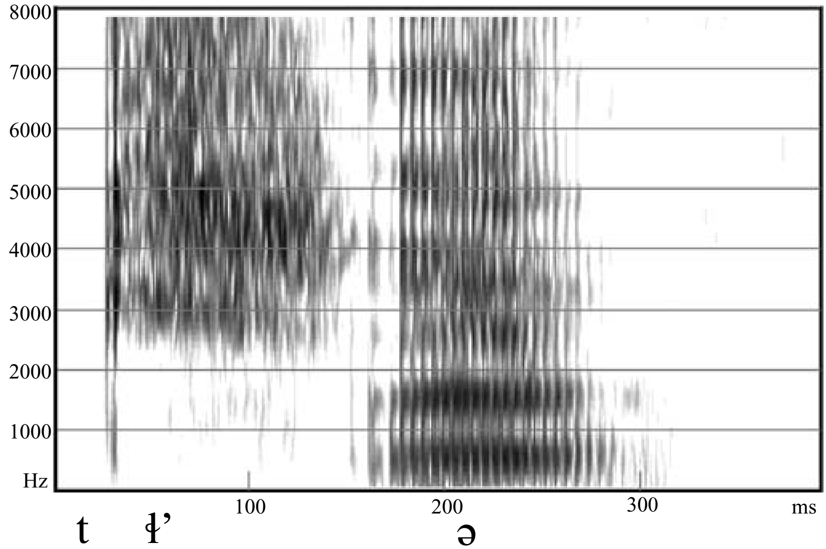

Figure 11 A prestopped realization of the lateral ejective fricative in the word /ɬ’ə/ [tɬ’ə] ‘man’ as produced by speaker F3.

The non-ejective fricative has a much smaller area of contact along the sides of the palate and a much wider opening in the anterior portion of the mouth relative to both exemplars of the ejective fricative. Both the ejective and the non-ejective have asymmetrical contact patterns with greater contact on the right side of the mouth (the left side of the figure). Interestingly, the two tokens of the ejective differ in their contact patterns. The palatogram on the right has a narrow channel just behind the alveolar ridge through which air can escape while the one on the left lacks this opening, indicating the presence of a complete closure prior to the fricative phase. This closure and, more generally, the increased narrowing of the constriction for the ejective fricative in both tokens have the effect of increasing the pressure behind the occlusion while reducing the airflow through the constriction and thus the amount of noise generated. In addition, the glottal constriction associated with the ejective fricative could potentially further reduce the airflow through the constriction in the oral cavity, thereby decreasing the intensity of the fricative noise.

The introduction of a closure before an ejective fricative is even more common for the lateral ejective, an observation previously reported by Kuipers (1960: 46) and apparent in a spectrogram contained in Henderson (1970: 97). A prestopped realization of the lateral ejective is shown in figure 11 as produced by speaker F3. The glottal constriction associated with the ejective fricative is also apparent in this figure: the beginning of the following vowel is produced with creaky voicing, as evidenced by the irregularly spaced glottal pulses (at about 150–175 ms) before modal voicing is initiated.

Another distinguishing characteristic of many realizations of the ejective fricatives, particularly the lateral ejective, is a scraping or pulsing sound during the constriction. This property is also reported for the ejective fricatives in Tlingit described by Maddieson et al. (2001). This realization of ejective fricatives in Kabardian can be seen in the spectrogram in figure 12, which shows the lateral ejective in final position in the word /çɐməɬ’/ ‘foreigner’ as produced by speaker M2. The scraping sound is manifested in the spectrogram as dark vertical striations during the fricative. This ejective also has a brief closure phase prior to the fricative constriction. Maddieson et al. (2001) suggest that the scraping sound is attributed to a narrowing of the constriction associated with ejective fricatives relative to their non-ejective

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

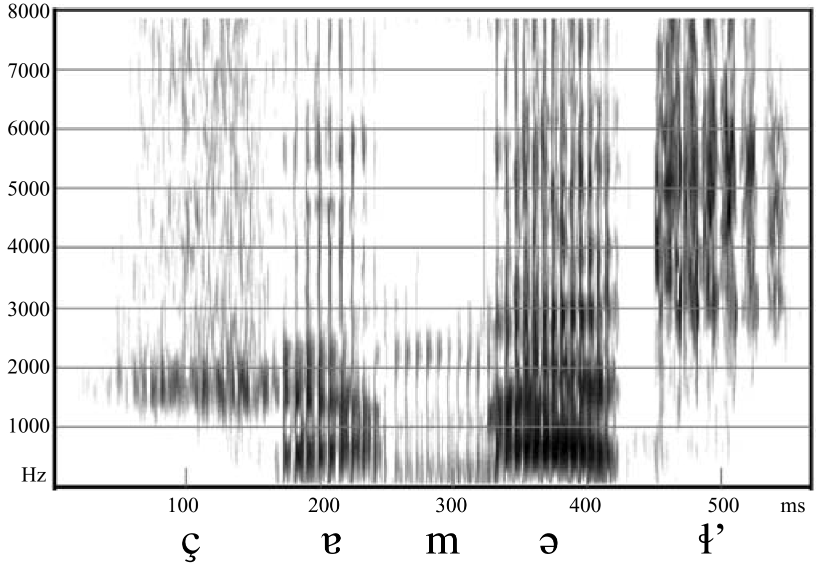

Figure 12 A pre-stopped lateral ejective fricative produced with scraping in the word /çɐməɬ’/ ‘foreign man’ as produced by speaker M2.

counterparts. This tighter constriction potentially leads to intermittent complete obstructions of the vocal tract by either the articulators themselves or by saliva trapped between the articulators. The narrowing of the constriction could also explain the reduced intensity of the ejective fricatives, since the volume of air passing through the narrowed fricative channel would be decreased. For the sake of comparison, a non-ejective lateral fricative produced by the same speaker is illustrated in figure 13.

Aerodynamic data were collected for the ejective and non-ejective fricative pairs from one of the female speakers (F5). Data were collected using the MacQuirer hardware, which allows for collection of both pressure and flow data using a mask worn over the mouth. Intraoral pressure is monitored using a small plastic tube that is inserted in the mouth behind the constriction. Intraoral pressure data are potentially useful in distinguishing the ejective and non-ejective fricatives, since the raising of the glottis during the constriction for an ejective should trigger a rise in air pressure behind the constriction. Maddieson et al. (2001) found that ejective fricatives in Tlingit are associated with much higher intraoral air pressure than their plain voiceless counterparts. In our data, the ejective fricatives also had considerably higher intraoral pressure than the plain voiceless fricatives. In fact, the pressure during the ejectives was typically so great that it produced clipping in the pressure traces.

Figure 14 shows intraoral air pressure along with airflow through the mouth and the audio signal for the plain voiceless /f/ and ejective /f’/ in the words /fəz/ ‘woman’ and /f’ə/ ‘good’, respectively. The gain was set very low in order to avoid clipping during the ejective; a consequence of this was that the pressure for the plain voiceless fricative is negligible in the figure. Figure 14 also shows that the ejective and plain voiceless fricatives have different transoral airflow profiles. Airflow reaches a peak near the middle of the plain voiceless fricative and only slightly declines at release. In the case of the ejective, however, pressure abruptly rises during the labiodental constriction reaching a peak at the release as the air compressed behind the constriction is rapidly released.

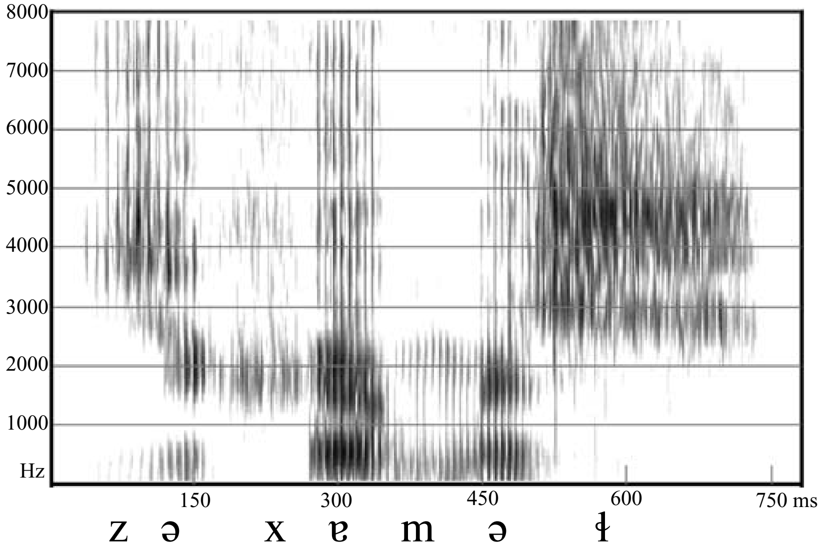

Figure 13 A voiceless lateral fricative in final position in the word /zəçɐməɬ/ 'someone who is inept, unlucky' as produced by speaker M2.

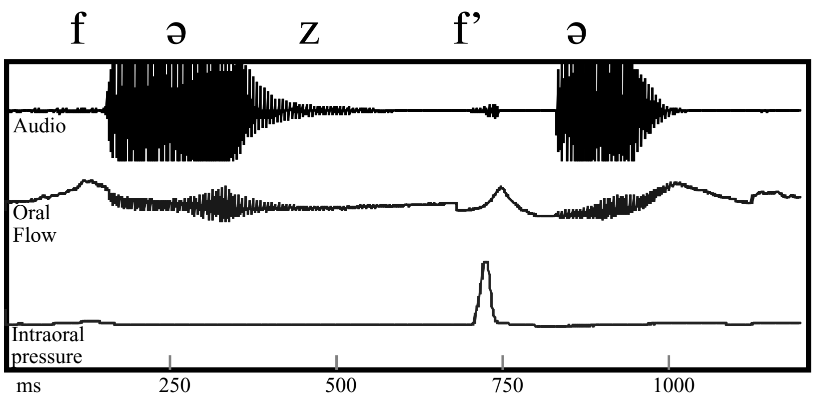

Figure 14 Waveform and oral flow and intraoral pressure traces for the plain voiceless fricative in the word /fəz/ 'woman' and the ejective fricative in the word /f'ə/ 'good' as produced by speaker F5.

4 Vowels

Kabardian possesses a so-called 'vertical vowel system' in which only vowel height and not backness is contrastive. Other languages reported to contain vertical vowel systems are Marshallese (Choi 1991; see discussion below), the Ndu languages of Papua New Guinea (Laycock 1965), and others mentioned by Choi (1991: 5). Accounts differ on the number of vowel phonemes in Kabardian with most sources assuming two short central vowels /ə, ɐ/ as well as a third central but lower vowel /a/ that has either been regarded as a third short vowel (Catford 1984) or as a long vowel (Choi 1991, Wood 1994). Duration measurements by Choi (1991) suggest that the lowest vowel is indeed a long vowel, since it is nearly twice as long as

https://doi.org/10.1017/S0025100306002532 Published online by Cambridge University Press

Table 14 Words containing the vowels targeted for formant analysis.

Vowel	Word	Gloss
ə	psə	'water'
ɐ	psɐ	'life'
aː	psaːɬɐ	'word'
iː	daːriː	'fabric type'
uː	bzuː	'bird'
eː	səseːs	'mine'
oː	psoːrij	'all, whole'

the next lowest vowel quality /ɐ/. In fact, the duration of /a/ was found by Choi to exceed that of the surface long vowels resulting from underlying vowel plus glide sequences (see below).

Many instances of the long low vowel occur in morphophonemic alternation with the slightly higher short vowel /ɐ/, a fact which has led Colarusso (1988, 1992a) to posit only two underlying vowels and derive the long /aː/ by rule. However, as Colarusso points out, there are some instances in which the occurrence of the long /aː/ is not predictable. A more radical approach is adopted by Kuipers (1960), who argues that the occurrence of not only /aː/ but also the higher central vowel /ə/ is predictable. Although this vowel is predictably inserted in certain contexts (see Kuipers for discussion), there are instances in which it is not, as argued by Catford (1984) and Colarusso (1992a). For this reason, we will adopt the maximally conservative approach and assume two phonemic short vowels /ə, ɐ/ and one phonemic long vowel /aː/.

On the surface, there are many additional vowel qualities triggered by surrounding consonants. For example, rounded allophones occur next to rounded consonants and retracted allophones occur next to velar and uvular consonants (see Catford 1984, Choi 1991, and Wood 1994 for phonetic data on these allophones). In addition, long vowels occur on the surface when a short vowel combines with a following glide. Thus, the sequence /ɐw/ yields [oː] on the surface, the sequence /ɐj/ yields [eː], the sequence /əw/ produces [uː] and the sequence /əj/ produces [iː].

In order to examine the phonetic realization of the vowel contrasts in Kabardian, formant structure was examined for the two underlying short vowels and the five long vowels (conservatively, one underlying and four derived through vowel plus glide combinations). Data were examined for ten speakers (five female and five male speakers). The frequencies of the first three formants were measured in Praat using a 25-millisecond window centered in the middle of the vowel. Values were extracted using the get formant function in Praat and results were visually checked against a wideband spectrogram. All vowels were stressed and appeared in a denti-alveolar context. The words containing the target vowels appear in table 14.

The first two formants were plotted against each other for all the speakers using the PlotFormants software developed by Peter Ladefoged at UCLA. Results were then combined for the female speakers and appear in figure 15. The same is done for the male speakers in figure 16. In both figures, both the x-axis (corresponding to the second formant) and the y-axes (corresponding to the first formant) are scaled non-linearly on a Bark scale (Zwicker & Feldtkeller 1967) to correspond more closely to the frequency domain in the auditory dimension. Ellipses indicate two standard deviations from the mean. Results for individual speakers are presented in table 15.

The formant plots for both the female and male speakers show a fairly well differentiated vowel space. The two short vowels sit on top of each other in the center of the vowel space with some overlap between the two vowels in the case of the female speakers' plot. For the female speakers, mean values for the first and second formant for /ə/ were 527 and 1654 and

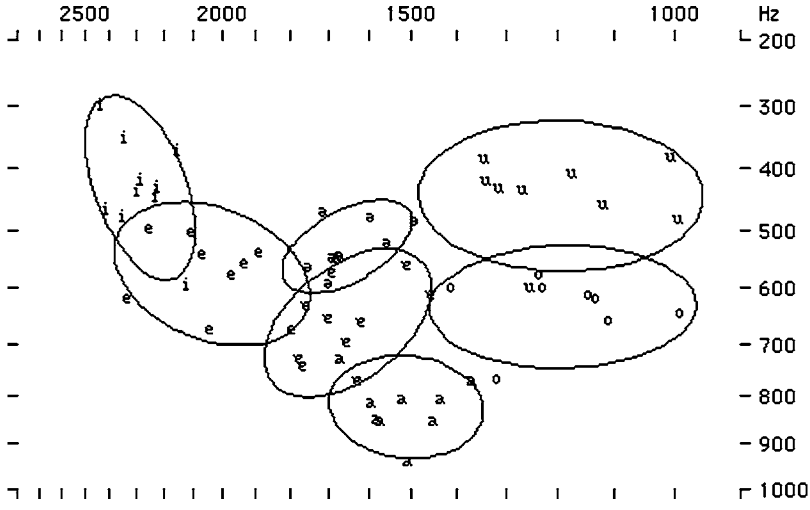

Figure 15 Plots of the first two formants for the five female speakers.

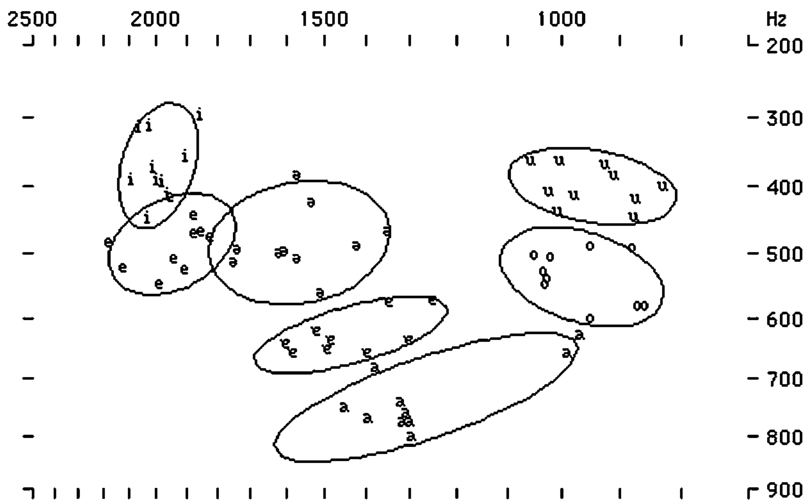

Figure 16 Plots of the first two formants for the five male speakers.

for /ɐ/ were 663 and 1654. For the male speakers, mean values for the first and second formant for /ə/ were 483 Hz and 1571 Hz and for /ɐ/ were 627 Hz and 1440 Hz. The slightly higher second formant values for the higher short central vowel suggest a slightly advanced tongue position relative to its lower short counterpart. The two back long vowels are differentiated primarily in the first formant dimension, corresponding to height, while the two front long vowels differ in both the first formant and second formant values, suggesting both a height and backness difference. The long low vowel is generally also a central vowel, although one of the male speakers (M1) produced a more retracted variant of this vowel than the other male speakers.

The formant values for the two short vowels in the present study are similar to those reported in Wood (1994) and compatible with the transcription of the two vowels as /ə/ and /ɐ/. However, Catford's (1984) and Choi's (1991) studies show slightly lower first formant

Table 15 Formant values for individual speakers.

Speaker F1	F1	F2	F3	Speaker F2	F1	F2	F3	Speaker F3	F1	F2	F3
ə	513	1640	3081	ə	531	1711	2868	ə	503	1528	2668
ɐ	586	1481	3008	ɐ	681	1765	3016	ɐ	614	1696	2885
aː	813	1557	2960	aː	853	1512	2863	aː	791	1627	2756
iː	402	2188	2980	iː	474	2385	3069	iː	521	2175	3141
uː	432	1002	2632	uː	422	1220	2786	uː	516	1284	2841
eː	521	1997	2854	eː	558	2290	2965	eː	540	2067	3090
oː	628	1069	2733	oː	683	1365	2600	oː	657	1109	2568
Speaker F4	F1	F2	F3	Speaker F5	F1	F2	F3	**Female Means**	**F1**	**F2**	**F3**
ə	544	1677	2314	ə	556	1727	2818	ə	**527**	**1654**	**2798**
ɐ	757	1696	2959	ɐ	680	1634	2805	ɐ	**663**	**1654**	**2935**
aː	873	1470	2756	aː	791	1402	2583	aː	**824**	**1514**	**2784**
iː	327	2394	3118	iː	429	2289	3014	iː	**430**	**2286**	**3064**
uː	458	1120	2498	uː	401	1342	2526	uː	**444**	**1201**	**2674**
eː	674	1921	2769	eː	567	1956	2780	eː	**575**	**2043**	**2869**
oː	619	1134	2539	oː	586	1232	2380	oː	**634**	**1197**	**2567**
Speaker M1	F1	F2	F3	Speaker M2	F1	F2	F3	Speaker M3	F1	F2	F3
ə	477	1389	2447	ə	529	1562	2360	ə	503	1600	2343
ɐ	573	1297	2454	ɐ	636	1504	2548	ɐ	647	1347	2487
aː	642	980	2152	aː	729	1338	2230	aː	745	1384	2326
iː	419	2066	3000	iː	316	2048	2584	iː	401	1983	2729
uː	409	958	1957	uː	405	900	2403	uː	410	1001	2247
eː	428	1912	2316	eː	506	1920	2765	eː	503	2150	2489
oː	542	959	2170	oː	569	988	1891	oː	537	1029	2260
Speaker M4	F1	F2	F3	Speaker M5	F1	F2	F3	**Male Means**	**F1**	**F2**	**F3**
ə	502	1748	2717	ə	404	1555	2518	ə	**483**	**1571**	**2477**
ɐ	637	1482	2555	ɐ	650	1591	2589	ɐ	**627**	**1440**	**2523**
aː	788	1305	2787	aː	765	1351	2240	aː	**734**	**1271**	**2347**
iː	365	1962	2871	iː	346	1920	2718	iː	**369**	**1996**	**2780**
uː	409	850	2117	uː	362	1028	2221	uː	**399**	**947**	**2189**
eː	516	1922	2723	eː	472	1847	2221	eː	**485**	**1950**	**2503**
oː	535	870	2235	oː	495	984	1945	oː	**535**	**966**	**2100**

values for these vowels (between 300 and 400 Hz for /ə/ and roughly 500 Hz for /ɐ/), suggesting a higher tongue body position for these vowels; hence their transcription of /ə/ and /ɐ/ as /ɨ/ and /ə/, respectively. Results for the low vowels are more comparable across studies.

It is possible that the difference between Wood's results and those reported by Catford and Choi may be related to a dialect difference between speakers in the studies. Wood's work is based on a male speaker of the Kuban dialect of Russian Kabardian, whereas the results of Choi and Catford are based on speakers of the Terek dialect of Russian Kabardian.

It is instructive to compare the results for Kabardian with phonetic data from another language possessing a vertical vowel system, Marshallese, an Austronesian language whose vowel system has been studied by Choi (1992). Marshallese is similar to Kabardian in possessing three underlying vowel qualities differing in height whose surface realization is dependent on consonantal context. In the case of Marshallese, all consonants can be analyzed as velarized, palatalized, or labialized. Velarization triggers back allophones in adjacent vowels, palatalization induces front allophones and labialization is associated with rounded allophones. Marshallese differs from Kabardian in having contrastive vowel length for all three vowel qualities; the distinction between the two lowest vowels in Marshallese is thus primarily qualitative unlike in Kabardian, where the difference is also one of duration.

Averaged across contexts, Choi (1992: 38) found that the high vowel pooled over two male and two female speakers had a mean first formant value slightly less than 400 Hz, while the first formant for the mid vowel had a mean value of roughly 500 Hz. The mean for the first formant of the low vowel was slightly greater than 600 Hz. The Marshallese vowel space for the three phonemic vowels is thus shifted upward relative to the Kabardian space, though the range of first formant values covered by the three vowel qualities is similar in the two languages. The Marshallese data thus correspond relatively closely to those reported by Catford (1984) and Choi (1991) in their studies of Kabardian. The difference between the results of the present paper and those of the other Kabardian studies and the Marshallese study indicate that there is cross-linguistic variation in the height of vowels comprising vertical vowel systems. Catford's and Choi's results for Kabardian suggest a more dispersed set of vowels consisting of one high, one mid and one low vowel. The Marshallese and the present data, on the other hand, both display smaller differences in tongue height between the highest and lowest vowels with the Marshallese vowel space being shifted upward relative to the Kabardian data in our study.

5 Conclusions

This paper has explored several phonetic characteristics of Kabardian as spoken by speakers outside of Russia. The principal results are as follows. The stops previously classified either as voiced or as voiceless unaspirated were found to be voiced intervocalically and word-finally, but often voiceless in initial position. Voice onset time and closure duration values were shortest for this series of stops. Voice onset time was longer for the voiceless aspirated stops than for the ejectives. Supralaryngeal voiceless fricatives were distinguished by differences in the frequency distribution of their noise. The ejective fricatives were shorter and less intense than their plain voiceless counterparts and were also characterized by higher intraoral pressure due to a broader contact area between the tongue and the roof of the mouth. Finally, formant measurements confirmed that the two phonemic short vowels are phonetically central vowels contrasting only in height and not backness.

Acknowledgements

The authors wish to express a great debt of gratitude to the speakers who so generously taught us about Kabardian phonetics: Hacı Aslan Azmi, Janak Barina, Mike Chek, Janeta Dakhtamisheva, Hacı Aslan Gönül, Hacı Aslan Mehmet, Hacı Aslan Melahat, Hacı Aslan Metin, Şıd Nedret, Koj Nermin, Aslan Pınar, Hacı Aslan Rauf, Şıd Remziye, Hacı Aslan Servet, Hacı Aslan Şeyda, Hacı Aslan Süheyla, and Şıd Tahsin. Thanks to John Colarusso, Michael Dobrovolsky, and John Esling for their very helpful comments on an earlier draft of this paper.

References

Abitov, M. L., Balkarov, B. X., Desheriev, J. D., Rogava, G. B., El'berdov, X. U., Kardanov, B. M. & Kuasheva, T. X. (1957). *Grammatika kabardino-cherkesskogo literaturnogo jazyka*. Moscow: Izdatel'stvo Akademii Nauk.

Alhas, Abaze Ibrahim (2005). *Turkce/Adigece sözlük*. Ankara: Kafdav Yayincilik.

Apazhev, M. L., Bagov, N. A., Bagov, P. M., Balkarov, B. X., Kokov, J. N., Zhakamyxov, X. X. & Urusov, X. Sh. (1975). *Kabardinsko–russkij slovar'*. Moscow: Gosydarstvennoe Izdatel'stvo Inostrannyx i Natsional'nyx Slovarej.

Bagov, P. M., Balkarov, B. X., Kuasheva, T. X., Kumaxov, M. A. & Rogova, G. B. (eds.) (1970). *Grammatika kabardino-cherkesskogo literaturnogo jazyka: 1 fonetika i morfologija*. Moscow: Nauka.

CATFORD, J. C. (1942). The Kabardian language. *Le Maître Phonétique* **78**, 15–18.
CATFORD, J. C. (1977). *Fundamental Problems in Phonetics*. Bloomington, IN: Indiana University Press.
CATFORD, J. C. (1984). Instrumental data and linguistic phonetics. In Higgs, Jo-Ann W. & Thelwall, Robin (eds.), *Topics in Linguistic Phonetics: In Honour of E. T. Uldall*, 23–48. Coleraine, N. Ireland: New University of Ulster.
CHO, TAEHONG & LADEFOGED, PETER (1999). Variations and universals in VOT: evidence from 18 endangered languages. *Journal of Phonetics* **27**, 207–229.
CHOI, JOHN (1991). An acoustic study of Kabardian vowels. *Journal of the International Phonetic Association* **21**, 4–12.
CHOI, JOHN (1992). Phonetic underspecification and target-interpolation: an acoustic study of Marshallese vowel allophony. Ph.D. dissertation, UCLA. [*UCLA Working Papers in Phonetics* **82**.]
COLARUSSO, JOHN (1988). *The Northwest Caucasian Languages: A Phonological Survey*. New York: Garland.
COLARUSSO, JOHN (1992a). *The Kabardian Language*. Calgary: University of Calgary Press.
COLARUSSO, JOHN (1992b). How many consonants does Ubykh have? In Hewitt, B. George (ed.), *Caucasian Perspectives*, 145–156. Munich: Lincom Europa.
COLARUSSO, JOHN (1994). How to describe the sounds of the Northwest Caucasian languages. In Aronson, Howard (ed.), *Non-Slavic Languages of the USSR: Papers from the Fourth Conference*, 61–113. Columbus, OH: Slavica Publishers.
COLARUSSO, JOHN (2002). *Nart Sagas from the Caucasus*. Princeton: Princeton University Press.
DART, SARAH (1991). Articulatory and acoustic properties of apical and laminal articulations. Ph.D. dissertation, UCLA. [*UCLA Working Papers in Phonetics* **79**.]
DART, SARAH (1998). Comparing French and English coronal consonant articulation. *Journal of Phonetics* **26**, 71–94.
FORREST, KAREN, WEISMER, GARY, MILENKOVIC, PAUL & DOUGALL, RONALD N. (1988). Statistical analysis of word-initial voiceless obstruents: preliminary data. *Journal of the Acoustical Society of America* **84**, 115–124.
GORDON, MATTHEW, BARTHMAIER, PAUL & SANDS, KATHY (2002). A cross-linguistic acoustic study of fricatives. *Journal of the International Phonetic Association* **32**, 141–174.
HAMANN, SILKE (2003). *The Phonetics and Phonology of Retroflexes*. Utrecht: Netherlands Graduate School of Linguistics.
HAMANN, SILKE (2004). Retroflex fricatives in Slavic languages. *Journal of the International Phonetic Association* **34**, 53–67.
HENDERSON, EUGÉNIE J. A. (1970). Acoustic features of certain consonants and consonant clusters in Kabardian. *Bulletin of the School of Oriental and African Studies* **33**, 92–106.
JAIMOUKHA, AMJAD (1997). *Kabardian–English Dictionary*. Amman: Sanjalay Press.
JONGMAN, ALLARD, BLUMSTEIN, SHEILA & LAHIRI, ADITI (1985). Acoustic properties for dental and alveolar stop consonants: a cross-language study. *Journal of Phonetics* **13**, 235–251.
JONGMAN, ALLARD, WAYLAND, RATREE & WONG, SERENA (2000). Acoustic characteristics of English fricatives. *Journal of the Acoustical Society of America* **108**, 1252–1263.
KARDANOV, B. M. & BICHOEV, A. T. (1955). *Russko–kabardinsko–cherkesskij slovar'*. Moscow: Gosydarstvennoe Izdatel'stvo Inostrannyx i Natsional'nyx Slovarej.
KEATING, PATRICIA (1984). Phonetic and phonological representations of stop consonant voicing. *Language* **60**, 286–319.
KUIPERS, AERT (1960). *Phoneme and Morpheme in Kabardian (Eastern Adyghe)*. The Hague: Mouton & Co.
LADEFOGED, PETER & MADDIESON, IAN (1996). *Sounds of the World's Languages*. Oxford: Blackwell.
LAYCOCK, DONALD C. (1965). *The Ndu Language Family (Sepik District), New Guinea*. Canberra: Australian National University.
LEHISTE, ILSE (1970). *Suprasegmentals*. Cambridge, MA: MIT Press.
MADDIESON, IAN (1984). *Patterns of Sounds*. Cambridge: Cambridge University Press.
MADDIESON, IAN (1997). Phonetic universals. In Hardcastle, William J. & Laver, John (eds.), *Handbook of Phonetic Sciences*, 619–639. Oxford: Blackwell.

MADDIESON, IAN, SMITH, CAROLINE L. & BESSELL, NICOLA (2001). Aspects of the phonetics of Tlingit. *Anthropological Linguistics* **43**, 135–172.
NORLIN, KJELL (1983). Acoustic analysis of fricatives in Cairo Arabic. *Working Papers* **25**, 113–137. Lund: Lund University Department of Linguistics.
RECASENS, DANIEL (1984). Vowel to vowel coarticulation in Catalan VCV sequences. *Journal of the Acoustical Society of America* **76**, 1624–1635.
SHALEV, MICHAEL, LADEFOGED, PETER & BHASKARARAO, PERI (1994). Phonetics of Toda. *PILC Journal of Dravidic Studies* **4**, 21–56.
SMEETS, RIEKS (1984). *Studies in West Circassian Phonology and Morphology*. Leiden: The Hakuchi Press.
STEVENS, KENNETH & BLUMSTEIN, SHEILA (1975). Quantal aspects of consonant production and perception: a study of retroflex stop consonants. *Journal of Phonetics* **3**, 215–233.
SVANTESSON, JAN-OLOF (1986). Acoustic analysis of Chinese fricatives and affricates. *Journal of Chinese Linguistics* **14**, 53–70.
TURCHANINOV, G. & TSAGOV, M. (1940). *Grammatika kabardinoskogo jazyka*. Moscow: Izdatel'stvo Akademii Nauk.
WOOD, SIDNEY (1994). A spectrographic analysis of vowel allophones in Kabardian. *Working Papers* **42**, 241–250. Lund: Lund University Department of Linguistics.
YAKOVLEV, N. F. (1930). Kurze Übersicht über die Tscherkessischen (Adygheischen) Dialekte und Sprachen. *Caucasica* **6**, 1–19.
YAKOVLEV, N. F. (1948). *Grammatika literaturnogo kabardino-cherkesskogo jazyka*. Moscow: Izdatel'stvo Akademii Nauk.
ZSIGA, ELIZABETH (1993). Features, gestures, and the temporal aspects of phonological organization. Ph.D. dissertation, Yale University.
ZWICKER, EBERHARD & FELDTKELLER, RICHARD (1967). *Das Ohr als Nachrichtenempfänger*. Stuttgart: S. Hirzel Verlag.