

Fronting of the voiceless velar plosive in Persian

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*Overview**

The fronting of the voiceless velar plosive /k/¹ in Persian² has been described in several grammars. However, no complete study has been made of this phenomenon in different phonological environments. This article is an attempt to make a complete survey of the /k/ phoneme in Persian in different environments in order to establish allophonic rules for its pronunciation.

Previous studies

By ‘velar fronting’ we mean the phenomenon whereby a velar plosive is articulated further forward in the mouth (typically on the postpalate or rear of the hard palate) than is the case for a non-fronted velar (generally articulated on the soft palate). In many languages this may also involve palatalization, whereby the velar becomes a coronal consonant with a sibilant component, such as [tʃ], or acquires a secondary palatalization, such as [kʲ] (Guion 1996: 4).

The phenomenon of velar fronting before front vowels is noted in several descriptions of Persian. Salemann and Shukovski (1925: 5) note that both /k/ and /g/ are “schwach palatal”. Fouchecour (1957: 19) writes that /g/ and /k/ “ont un point d’articulation variable, sensible à l’antériorité ou à la postériorité de l’entourage vocalique”.

A slightly fuller description is found in Boyle (1966: 6) who writes that /k/ is “[p]alatalized in final position and before \bar{a} [probably a mistake for the central vowel /a/, in Boyle’s transcription represented with a , CJ], e , i , and e_i ” and that “/g/ is palatalized according to the same rule as /k/” (Boyle’s transcription; see also Lambton 1953: xvii for a similar statement; she specifies that final position may mean syllable-final or word-final). Meanwhile, Poljakov (1988: 87) states that so called ‘palatal consonants’ are pronounced as velar before the back vowels /a, o, u/,

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¹ All the voiceless plosives, including /k/, are aspirated in Persian.

² The term “Persian” is here used for Modern New Persian. The dialect variant investigated here is that spoken in Iran (sometimes called Farsi, as opposed to Dari and Tajiki spoken in Afghanistan and Tajikistan respectively). The phonetic symbols here are those suggested by the International Phonetic Association (*Handbook* 1999: ix). Note that the words are represented the way they are pronounced in Persian, not necessarily the way they are written. A list of all Persian words cited, together with their English translations, is provided in Appendix B.

but that these consonants before the front and central /e/ and /a/ and especially before the close front vowel /i/ become palatalized. Windfuhr (1997: 681) makes the same observation, and adds that “[f]ronting is part of a major cross-linguistic isogloss that begins in central Iran and stretches across Azerbaijan and the Caucasus.”

Our analysis below seeks to develop the common generalization that velars tend to be fronted before front vowels (e.g. Guion 1996: 37) into a coherent set of principles for the fronting of /k/ in Persian, based on acoustic phonetic evidence from burst frequency and palatography data.

Methodology

Consultants and elicitation

The two main language consultants were male, mother-tongue Persian speakers: C1, aged 55, born in Esfahan but educated and brought up in Tehran; and C2, aged 36, born and brought up in Tehran. A list of 38 Persian words containing the phoneme /k/ in different phonological environments was elicited from each consultant in May 2006. Two tokens of each word were recorded using a condenser microphone, laptop computer and Audacity (v1.2.6) recording software.

Data from a number of other consultants was also elicited during February 2006 and October 2007 from students in their twenties at the University of Sistan and Baluchestan, Zahedan. Data from two main consultants was recorded (C3 and C4), both mother-tongue Persian speakers, along with some data from consultants who spoke local languages in addition to Persian. The data of one of these latter consultants (C5) is also provided below, along with the data from the four mother-tongue Persian speakers (C1 to C4). This data was recorded using a condenser microphone and Sony recording Walkman, then converted into digital format using Audacity recording software.

Acoustic analysis

Acoustic analysis (using Praat v4.6.15 software) was carried out in order to ascertain the burst frequency at the moment of the articulation of /k/ in each token. When the point of articulation of a velar moves further forward in the oral cavity, the size of the resonating chamber is reduced, resulting in a higher frequency. A comparison of the burst frequencies for the articulation of /k/ in different environments can thus be used to identify in which environments the plosive is fronted.³ For each token, approximately 5 milliseconds of the burst frequency was selected (Figure 1).

The spectral slice for this selection was then viewed, and the peak frequency noted in Hertz. A margin of error of ± 50 Hz was assumed, and data was rounded to the nearest 100Hz.

The researchers also noted their own auditory impressions of whether the /k/ in each token was fronted or not.

³ See Guion (1996: 39-47) for an overview of studies investigating the predominant spectral peaks of burst frequencies as a means to establishing degree of velar fronting.

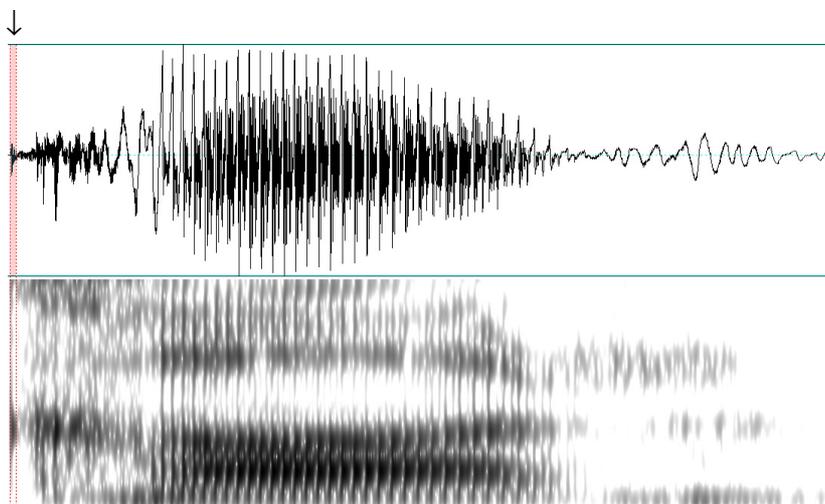


Figure 1: Waveform and spectrogram of /kat/ with 5ms of the burst frequency of /k/ indicated by the arrow.

Palatography

Palatographic analysis was conducted with consultant C1 on some Persian words containing /k/, in order to provide further physical confirmation of the range of fronting involved. A black contrast medium consisting of powdered charcoal and olive oil was painted onto the top surface of the speaker's tongue. He then pronounced the token once only. A flash photograph of the speaker's palate was taken using a Sony DSC P150 digital camera and a small mirror, which was inserted into the mouth.

Each picture resulted in an image showing the mark left on the upper palate through contact with the tongue. Lines were drawn on the picture connecting the anterior edges of the 2nd premolar and 2nd molar to delineate the boundaries of the front-palatal/mid-palatal and back-palatal/front-velar zones, following Butcher and Tabain (2004: 29) (see also Firth 1957: 151). These pictures are shown in Appendix A.

Results

The results confirmed that there is a significant contrast between fronted and non-fronted /k/ in different environments. /k/ is not fronted when immediately followed by a back vowel (u, o, a); but some fronting occurs in every other environment (word-finally, and before any consonant and the vowels i, e, a).

Word-initial position before front and back vowels

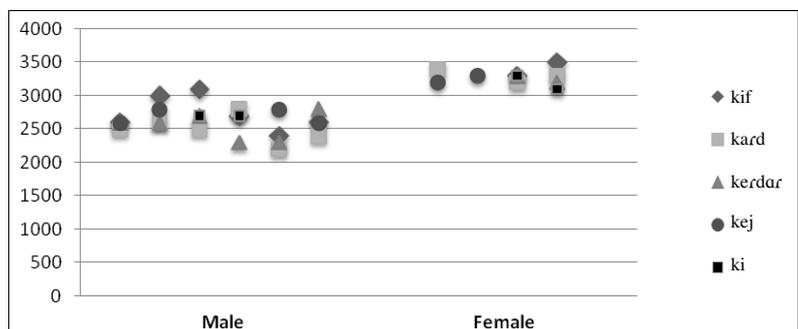
Table (1) below shows the average burst frequencies for word-initial /k/ before front and back vowels respectively, together with average frequencies by gender and by individual word.

The difference in burst frequency between /k/ before front and back vowels respectively is marked. The average frequency before a front vowel ranges from 2700 to 3000 Hz, while before a back vowel the range is 800 to 1300 Hz. This corresponds to the researchers' auditory impressions, and also to the literature. Further confirmation is provided by palatal images, shown for the words /kif/ and /kaf/ in in Appendix (A).

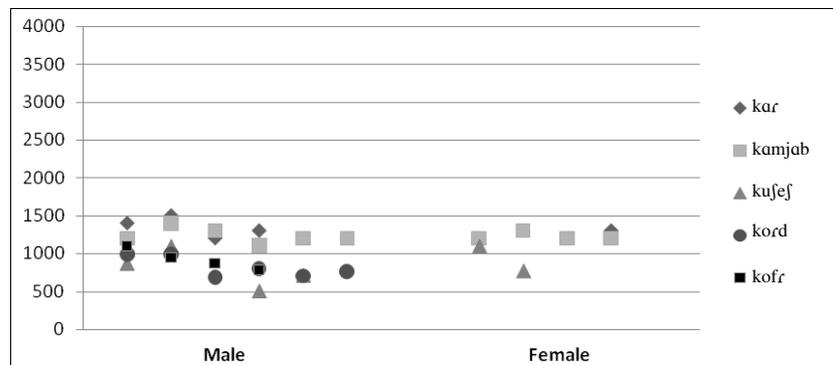
Table (1) Frequencies in Hz for word-initial /k/ before front and back vowels

Vowel Type	Total Average	Male Avg	Female Avg	Word	Average
_Front	2800	2600	3300	ki	3000
				kif	2900
				kej	2900
				kard	2800
				kerdar	2700
_Back	1100	1000	1200	kar	1300
				kamjab	1200
				kofr	900
				kord	800
				kufeʃ	800

Graphs (1) and (2) provide a more detailed, visual breakdown of the data.



Graph (1) Burst frequencies in Hz for word-initial /k/ before front vowels



Graph (2) Burst frequencies in Hz for word-initial /k/ before back vowels

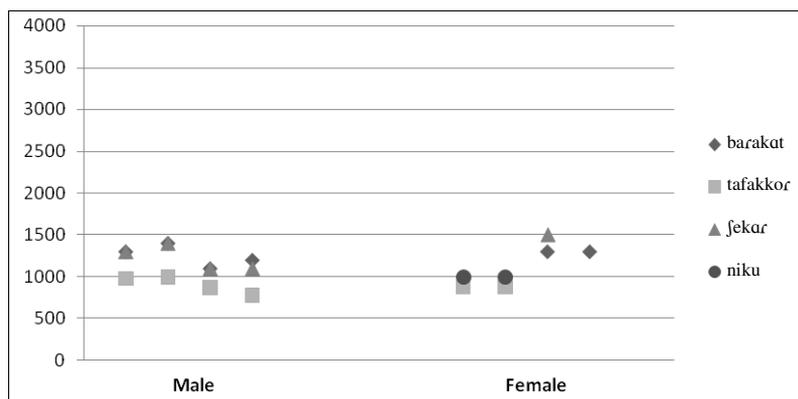
Word-medial position between vowels of contrasting place

Table (2) below shows the average burst frequencies for word-medial /k/ between vowels which contrast in each word for front and back placement, together with average frequencies by gender and by individual word.

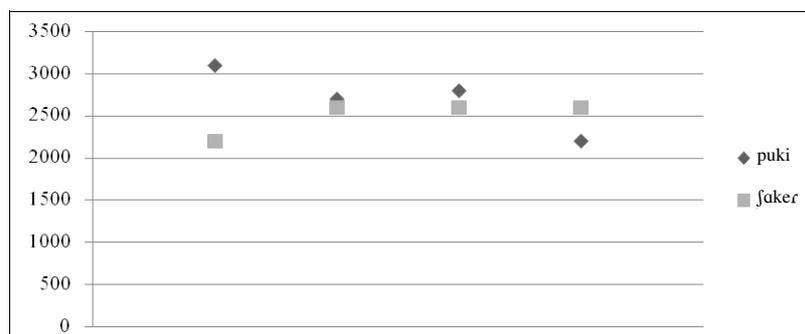
Table (2) Frequencies in Hz for word-medial /k/ between vowels contrasting for front/back placement

Vowel Type	Total Average	Male Avg	Female Avg	Word	Average
F_B	1100	1100	1100	barakat	1300
				ʃekar	1300
				niku	1000
				tafakkor	900
B_F	2600	2600	-	puki	2700
				ʃaker	2500

Graphs (3) and (4) present the full range of data:



Graph (3) Burst frequencies in Hz for word-medial /k/ between front and back vowels



Graph (4) Burst frequencies in Hz for word-medial /k/ between back and front vowels (male only)

Again differences between burst frequencies are significant, ranging from 900 to 1300 before back vowels and 2500 to 2700 before front vowels. Given that the respective ranges for /k/ in word-initial position before front and back vowels mirror these ranges extremely closely, it may be concluded that the fronting of /k/ in word-medial, inter-vocalic position is entirely dependent on the vowel that follows it, as is the case word-initially. The front-ness of the preceding vowel is immaterial.

Palatal images of the words /niku/ and /puki/ are provided in Appendix (A). The place of articulation of /k/ in the second word, where the following vowel is +front, is significantly further forward than in the first word (with a succeeding -front vowel).

Word-finally and in word-final consonant clusters

Tables (3) and (4) below show the average burst frequencies for /k/ word-finally after +front and -front vowels; and in word-final consonant clusters, as the first and as the second consonant in the cluster respectively:

Table (3) Frequencies in Hz for word-final /k/

Vowel Type	Total Average	Male Avg	Female Avg	Word	Average
BackV_	2700	2400	3200	tak	3000
				rok	2800
				puk	2500
FrontV_	2900	2600	3300	tak	2900
				jek	2900
				ʃik	2800

Table (4) Frequencies in Hz for /k/ in word-final consonant clusters as the first or second segment

Position	Total Average	Male Avg	Female Avg	Word	Average
_C	2400	2300	3000	hokm	2900
				makr	2600
				aks	2200
				ʃokr	2100
C_	2600	2400	3200	sabk	2700
				ʃerk	2700
				potk	2700
				susk	2300

The similar burst frequencies for /k/ in all of these positions in the mid to high 2000 Hz range suggests that there is a similar degree of fronting in each case. For /k/ word-finally this conclusion is supported by both the literature and the researchers' own auditory impressions. For /k/ as the first element in a word-final consonant cluster the literature is more ambiguous; a fact explained by the greater difficulty in

hearing fronting of the first element in a cluster. However, the burst frequencies for /k/ in this position are only slightly lower than for fronted /k/ word-finally, and much higher – at an average of 2400 Hz – than the range we would expect were it not fronted at all (800–1300 Hz). The palatal images for the words /sabk/ and /fekr/ (Appendix A) also suggest that /k/ is fronted to an equal degree whether it is the first or second segment in a word-final consonantal cluster.

Finally, it was necessary to investigate Poljakov's (1988: 128) claim that if the consonant cluster /nk/ follows the front and central vowels /i, e, a/, the whole cluster becomes palatal in pronunciation, whereas after the back vowels /a, o, u/ the consonants are pronounced as velar. In this case we would expect to see a velar /k/ with no fronting in words such as /bank/, /tanker/ and /mankan/. However, table (5) below shows that in fact the burst frequencies of /k/ in these words is consistent with the same degree of fronting as the fronted /k/ discussed above in other environments.

Table (5) Frequencies in Hz for /k/ after back vowel and nasal

Position	Total Average	Male Avg	Female Avg	Word	Average
BN_	3000	2900	3100	bank	3000
				tanker	3100
				mankan	2900

Conclusions

This investigation shows that the fronting of /k/ in Persian occurs word-finally, and when preceding a front vowel or a consonant. When followed by a back vowel /k/ is not fronted.

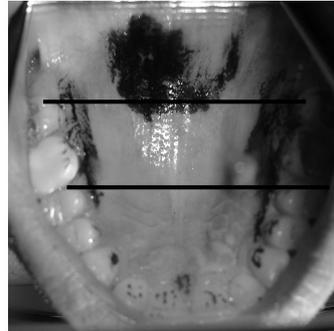
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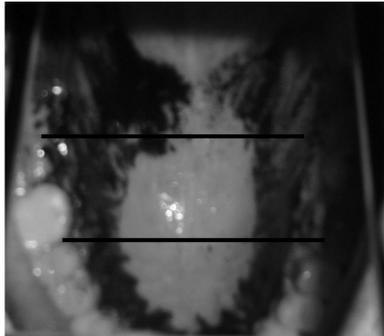
Appendix A: Palatographic Analysis



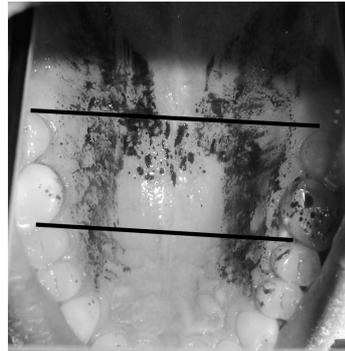
kif



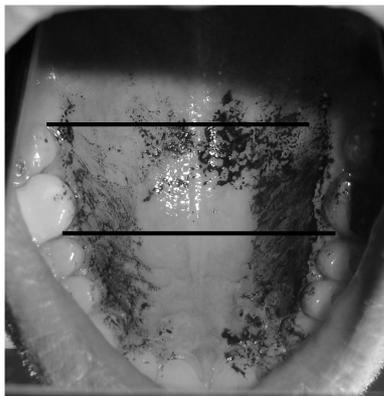
kaf



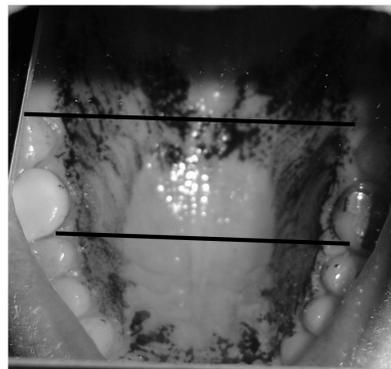
niku



puki



sabk



fekr

Appendix B: List of Persian words cited

In all words cited, stress falls on the final syllable.

aks	picture, photograph, image
bank	bank
barakat	blessings
hokm	command, sentence, verdict
kaf	name of the letter 'k'
kamjab	successful, prosperous
kar	work
kard	he/she/it did
kerdar	act, deed, manner
kej	when
ki	who
kif	purse, bag, briefcase
kofr	blasphemy
kord	Kurd
kuſeſ	effort, attempt, struggle
mankan	mannequin, fashion model
makr	trick, deceit
niku	good
potk	sledge, smith's hammer
puk	hollow, empty
puki	hollowness, emptiness
rok	frank, straightforward, sincere
sabk	method, style, manner
susk	cockroach
ſaker	thankful
ſekar	hunting, prey, game
ſek	polytheism
ſik	stylish, fashionable
ſokr	gratitude, thanks (to God)
tak	vine
tanker	tanker
tafakkor	thought, reflection
tak	single, unique
jek	one