**Fronting of the voiceless velar plosive in Persian**

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**Overview**

The fronting of the voiceless velar plosive /k/ in Persian 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 [ʃ], 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 “palatalized in final position and before ̀ [probably a mistake for the central vowel /a/, in Boyle’s transcription represented with ā, ČJ], e, i, and ı” 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. 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 +/- 50Hz 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.

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.
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.

Orientalia Suecana LVII (2008)
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 /ka/ in Appendix (A).

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

<table>
<thead>
<tr>
<th>Vowel Type</th>
<th>Total Average</th>
<th>Male Avg</th>
<th>Female Avg</th>
<th>Word</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Front</strong></td>
<td>2800</td>
<td>2600</td>
<td>3300</td>
<td>ki</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kif</td>
<td>2900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kej</td>
<td>2900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kard</td>
<td>2800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kedar</td>
<td>2700</td>
</tr>
<tr>
<td><strong>Back</strong></td>
<td>1100</td>
<td>1000</td>
<td>1200</td>
<td>kac</td>
<td>1300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kumjab</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kofr</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>koed</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kujeʃ</td>
<td>800</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Vowel Type</th>
<th>Total Average</th>
<th>Male Avg</th>
<th>Female Avg</th>
<th>Word</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_B</td>
<td>1100</td>
<td>1100</td>
<td>1100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>barakot</td>
<td>1300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jekar</td>
<td>1300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>niku</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tafakkoo</td>
<td>900</td>
</tr>
<tr>
<td>B_F</td>
<td>2600</td>
<td>2600</td>
<td>–</td>
<td>puki</td>
<td>2700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jakc</td>
<td>2500</td>
</tr>
</tbody>
</table>

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)

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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/  

<table>
<thead>
<tr>
<th>Vowel Type</th>
<th>Total Average</th>
<th>Male Avg</th>
<th>Female Avg</th>
<th>Word</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>BackV_</td>
<td>2700</td>
<td>2400</td>
<td>3200</td>
<td>tok</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>rok</td>
<td>2800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>puk</td>
<td>2500</td>
</tr>
<tr>
<td>FrontV_</td>
<td>2900</td>
<td>2600</td>
<td>3300</td>
<td>tak</td>
<td>2900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>jek</td>
<td>2900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>jik</td>
<td>2800</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Position</th>
<th>Total Average</th>
<th>Male Avg</th>
<th>Female Avg</th>
<th>Word</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>_C</td>
<td>2400</td>
<td>2300</td>
<td>3000</td>
<td>hokm</td>
<td>2900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>makr</td>
<td>2600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>jek</td>
<td>2200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>jokr</td>
<td>2100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>sabk</td>
<td>2700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>jekk</td>
<td>2700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>potk</td>
<td>2700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>susk</td>
<td>2300</td>
</tr>
</tbody>
</table>

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 /fekē/ (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 /u, 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 /bēnk/, /tēnke/ and /mēnkān/. 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

<table>
<thead>
<tr>
<th>Position</th>
<th>Total Average</th>
<th>Male Avg</th>
<th>Female Avg</th>
<th>Word</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>BN₃₀₀₀</td>
<td>3000</td>
<td>2900</td>
<td>3100</td>
<td>bank</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tankē</td>
<td>3100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mēnkān</td>
<td>2900</td>
</tr>
</tbody>
</table>

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.

References


Orientalia Suecana LVII (2008)
Appendix A: Palatographic Analysis
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’
kamjub  successful, prosperous
kar  work
kard  he/she/it did
keerdar  act, deed, manner
kej  when
ki  who
kif  purse, bag, briefcase
kof  blasphemy
kord  Kurd
kuje  effort, attempt, struggle
monkan  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
fuker  thankful
fokar  hunting, prey, game
fark  polytheism
jik  stylish, fashionable
fokr  gratitude, thanks (to God)
tak  vine
tanker  tanker
tafakkor  thought, reflection
tak  single, unique
jek  one