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1. Modern Greek

The segments [k] and [kʲ] are allophones of a single phoneme. The data include neither minimal pairs nor near-minimal pairs that would demonstrate contrast between these segments. So we can infer that these are allophones of the same phoneme. The distribution among environments (Table 1b) confirm that the choice of allophone is rule-based; specifically, the palatalized [kʲ] consistently manifests preceding front of high and mid-high front vowels ([i, e]) only, while the regular velar stop manifests in other environments. The analysis proves that the palatalized and non-palatalized velar stops are in complementary distribution.

The same can be said for the velar fricative: the palatalized velar fricative [xʲ] precedes high- and mid-high front vowels only. As with the velar stop, we see neither minimal nor near-minimal pairs that show contrast between the palatalized and non-palatalized (normal) velar fricatives ([x], [xʲ]), so the conclusion is that these are allophones of the same phoneme. Plotting the distribution of these segments shows that they are in complementary distribution, and that adhere to the same patterning as the velar stop, that is, palatalized when preceding a high or mid-high front vowel (Table 1c).

Given that the palatalized form in each case is implemented in very specific cases only, I'd argue that the base consonants are the non-palatalized form, and the rules would look like this:

/k/ → [kʲ] / ____ [i,e]
 → [k] /elsewhere
 /x/ → [xʲ] / ____ [i,e]
 → [x] /elsewhere

When a voiceless velar stop or fricative precedes the vowels [i] or [e], palatalize the consonant.

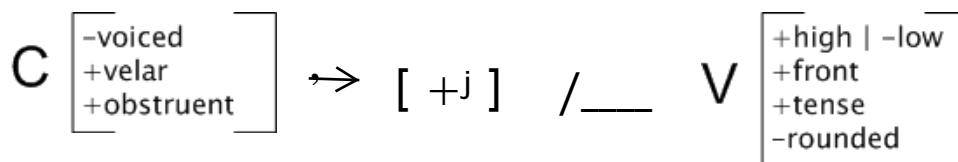
Assuming the converse is true--that the palatalized form is the base, and the non-palatalized form is the allophonic alternation--would require a rule that removes palatalization from the majority of environments, and retains the palatalization in only two instances. This approach would lead to a

clumsily stated rule, at best, and seems like it would require a lot more processing work on the part of speakers to keep track of things (albeit, subconsciously, but it does seem counterintuitive to not use the "elsewhere" allophone as the base.)

There's simply much more surface evidence demonstrating the non-palatalized form; that is, non-palatalized manifests in many more environments than the palatalized, so it makes sense to choose this as the base.

Here's another, more general take on the rule:

Palatalization rule



Applying this rule to some of the data shows how the surface forms derive from the base forms.

Derivations

'do'	'hand'	'move'	'candle'	'no'	
/kano/	/keri/	/kino/	/xeri/	/oxi/	Base forms
----	k ^j	k ^j	x ^j	x ^j	Palatalization rule
[kano]	[k ^j eri]	[k ^j ino]	[x ^j eri]	[oxi]	Surface forms

2. Kikuria

The consonants [β, r, γ] and [b, d, g] are in complementary distribution. As shown in Table 2b, Table 2c, and Table 2d, the stop form of each of these pairs is implemented only when it precedes a nasal at the same place of articulation. That is, the bilabial stop [b] is manifested (instead of the bilabial fricative, [β]), when it follows the bilabial nasal [m]. The same pattern applies to the alveolar tap and velar fricative.


The other general statement that can be made about these two segment series is that the stops never start or end any of the words, but the fricatives start words, appear between vowels, and between vowels and glides ([j]). The fricatives never appear after nasals.

The tones do not seem to have any particular involvement in this question (tones do not seem to be contrastive in this example). Every vowel has a high-tone version, and the low front unrounded vowel has rising version. However, with the exception of the open-mid back rounded vowel ([ɔ]), which appears only in the alveolar stop environment, the plain and toned vowels are spread amongst the data without any obvious pattern.

The pattern that emerges for these allophone sets (documented in Table 2b, Table 2c, and Table 2d) clearly shows the influence of a nasal on whether a given speech sound manifests as a stop or a fricative or tap. Given the wide array of environments in which the fricatives and the tap occur it makes sense to identify these as the base allophone in each pair:

/ β / → [b] /m____
 → [β] /elsewhere
 / r / → [d] /n____
 → [r] /elsewhere
 / ɣ / → [g] /η ____
 → [ɣ] /elsewhere

In more general terms, the rule could be a "**nasalization-stop rule**," stated as:

When a nasal precedes a voiced fricative or tap, change the fricative or tap to a stop at the same place of articulation. 

Derivations

'fox'	'to count me'	'to bewitch me'	'leopard'	
/ekeβwe/	/okoomβara/	/okoondɔɣa/	/eeŋɣwe/	Base forms
--	b	d	g	Nasalization-stop rule
[ekeβwe]	[okoombara]	[okoodɔɣa]	[eeŋgwe]	Surface forms

3. Thai

Aspiration in the voiceless stops and fricatives of Thai seems to be a contrastive feature, but the unreleased stop is not. The data seem to have only one near-minimal pair demonstrating contrast between non-aspirated/aspirated, in particular:

tʃaan  tʃʰan

The distinction between these two words would seem to be very difficult to hear if aspiration were not a language feature to which Thai speakers/listeners pay attention. That said, a single near-minimal pair is probably flimsy evidence, and I'm not even certain the example is a true near-minimal pair, since the /aa/ combination likely represents a long a, and since we see that characteristic throughout the other sample data, long and short vowel combinations may well be contrastive in Thai. So a better argument would be that the overlapping and arbitrary distribution of the aspirated/non-aspirated allophones (and the fact that no discernible pattern emerges to explain the distribution) makes the case for separate phonemes [p], [pʰ] [t], [tʰ], [k], [kʰ].

As shown in Table 3b, whether aspirated or not, the voiceless stops are always word-initial, followed by a vowel or approximant. The environments of the voiced stops ([b] and [d]) also show the same non-predictability, #__r, for example, is common for [p], [pʰ] [t], [tʰ], [k], [kʰ], [b], and [d].

Similarly, the data in Table 3c demonstrate that aspiration is contrastive with respect to the affricates, [tʃ] and [tʃʰ]. The distribution of both plain (non-aspirated) and aspirated affricates is word initial, preceding various vowels; these environments are the same in many instances, and are not predictable based on any particular rule or pattern. In other words, the aspirated/non-aspirated affricates are two separate phonemes.

On the other hand, the unreleased stops, [], [], [] do follow a specific pattern, that is, they manifest only at the end of words, so each of these represents an allophone of one of the other phonemes. However, this base form is not obvious in this case (unlike questions 1 and 2). I cannot decide if it makes more sense that the aspirated phoneme would be affected by its placement at the end of a word, or if the non-aspirated phoneme would be abruptly shortened at the end of the word.

I have a hunch that it would be easier to distinguish an unreleased stop from the non-aspirated stop: If the aspirated phoneme were chosen as the base, then the resulting unreleased stop might be mistaken for a plain [p], and since [p] and [p^h] are different phonemes, that would result in a different word meaning. But then again, the same could be said for the alternative approach. The rule might be:

When a voiceless aspirated stop occurs at the end of a word, do not release the aspirated

I'm not sure at this point how to frame any further argument. In reviewing phonetics, I'm reminded that one of the distinctions between voiced and voiceless [p] is more a matter of aspiration--"a period of voicelessness after the stop articulation and before the voicing of the vowel"¹. This means that the so-called voiceless phonemes in this example set are also aspirated (even though I've been calling them non-aspirated), and as we've seen, the aspiration is contrastive.

As was pointed out in this example's data, the voiceless velar stops ([k, k^h] have no voiced counterpart but I'm not sure what the implications are of this, if any, other than that the language relies heavily on aspiration rather than voicing to distinguish among stop consonants? The note about lack of voiced velar stop could be just a red herring.

Here's one proposed rule statement:

$$\begin{aligned} /p^h/ &\rightarrow [] /V_]_{word} \\ &\rightarrow [p^h] / [word_] V \\ /t^h/ &\rightarrow [] /V_]_{word} \\ &\rightarrow [t^h] / [word_] V \\ /k^h/ &\rightarrow [] /V_]_{word} \\ &\rightarrow [k^h] / [word_] V \end{aligned}$$

These rules could be combined into the following general statement:

De-aspirated word-ending Rule

$$C \left[\begin{array}{l} -voiced \\ +stop \\ +aspirated \end{array} \right] \rightarrow [-aspiration] /V_]_{word}$$

I'm doubtful that I've sufficiently proven this, however, but I'll leave it here.

¹ A Course in Phonetics, Fifth edition, 2006; Peter Ladefoged



1. Modern Greek

1) kano	'do'	9) kori	'daughter'
2) xano	'lose'	10) xori	'dances'
3) x ^l ino	'pour'	11) k ^l ino	'move'
4) kr ^l ima	'shame'	12) xr ^l ima	'money'
5) xu ^l fta	'handful'	13) ku ^l feta	'bonbons'
6) ka ^l i	'charms'	14) xa ^l i	'plight'
7) x ^l eli	'eel'	15) k ^l eri	'candle'
8) x ^l eri	'hand'	16) ox ^l i	'no'

VOWEL CHART

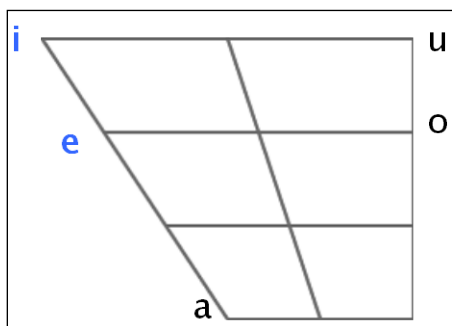


TABLE 1A: CONSONANTS

	Bilabial	Labio-Dental	Dental	Alveolar	Palato-alveolar	Palatal	Velar	Labial-Velar	Glottal
Plosive							k		
Nasal									
Trill									
Tap or Flap									
Fricative							x		
Lateral Fricative									
Approximant									
Lateral Approximant									

TABLE 1B: PALATALIZED AND NON-PALATALIZED VELAR STOP ENVIRONMENTS

[k]			[kʲ]		
/	[word _____ a	1,6	/	[word _____ i	11
/	[word _____ r	4	/	[word _____ e	15
/	[word _____ o	9			
/	[word _____ u	13			

TABLE 1C: PALATALIZED AND NON-PALATALIZED VELAR FRICATIVE ENVIRONMENTS

[x]			[xj]		
/	[word _____ a	2,14	/	[word _____ i	3
/	[word _____ u	5	/	[word _____ e	7,8
/	[word _____ r	12	/	o _____ i	16
/	[word _____ o	10			

2. Kikuria

- | | | | |
|------------------|-------------------|------------------|------------------|
| 1) aβaánton | 'people' | 18) aβamúra | 'young men' |
| 2) amahíindi | 'corn cobs' | 19) amakééndon | 'date fruits' |
| 3) eβǎ | 'forget!' | 20) eengwé | 'leopard' |
| 4) eyǎ | 'learn!' | 21) ekeβwé | 'fox' |
| 5) hoorá | 'thresh!' | 22) iβiyúruβe | 'small pigs' |
| 6) iβirúungúuri | 'soft porridges' | 23) uyusíri | 'huge rope' |
| 7) βáinu | 'you (pl)' | 24) βorjón | 'on the right' |
| 8) itʃiingéna | 'grinding stones' | 25) itʃiingúruβe | 'pig' |
| 9) γaβǎ | 'share!' | 26) itʃiingúta | 'walls' |
| 10) βereká | 'carry a child!' | 27) iyitúumbe | 'stool' |
| 11) γúúká | 'ancestor' | 28) remǎ | 'weed!' |
| 12) reentá | 'bring!' | 29) oβoyááká | 'male adulthood' |
| 13) oβotééndéeru | 'smoothness' | 30) okoyéembá | 'to cause rain' |
| 14) okoómbára | 'to count me' | 31) okoβára | 'to count' |
| 15) okoóndóya | 'to bewitch me' | 32) okoróya | 'to bewitch' |
| 16) romǎ | 'bite!' | 33) teyeta | 'be late!' |
| 17) ukuúmbuurjá | 'to ask me' | 34) uruyúta | 'wall' |

VOWEL CHART

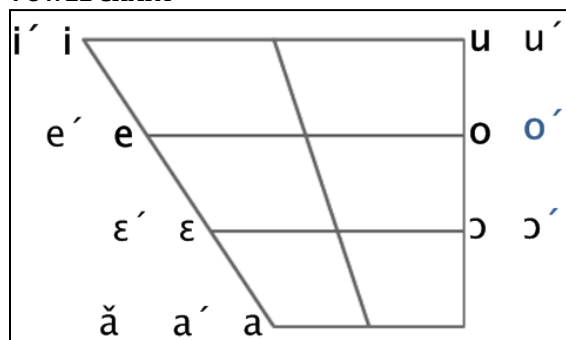


TABLE 2A. CONSONANTS

	Bilabial	Labio-Dental	Dental	Alveolar	Palato-alveolar	Palatal	Velar	Labial-Velar	Glottal
Plosive	b			d			g		
Nasal	m			n			ŋ		
Trill									
Tap or Flap				r					

Fricative	β						ɣ		
Lateral Fricative									
Approximant									
Lateral Approximant									

TABLE 2B. BILABIAL SEGMENT ENVIRONMENTS

[b]				[β]			
/	m	_____	14, 30	/	[word	_____	7
/	m	_____ e	27	/	[word	_____ ε	10
/	m	_____ u	17	/	[word	_____ o	24
				/	a	_____ a	1, 18
				/	e	_____ ä	3
				/	i	_____ i	6, 22
				/	a	_____ ä	9
				/	o	_____ o	13, 29
				/	e	_____ w	21
				/		_____ e	22, 25
				/	o	_____	31

TABLE 2C. ALVEOLAR SEGMENT ENVIRONMENTS

[d]				[r]			
/	n	_____ i	2	/	[word	_____ ε	12
/	n	_____	13	/	[word	_____ o	16
/	n	_____ ɔ	15	/	[word	_____ e	28
/	n	_____ ɔ	19	/	o	_____	5
				/	i	_____	6
				/	u	_____ l	6
				/	ε	_____ ε	10
				/		_____ u	13
				/		_____ a	14
				/		_____ a	18
				/		_____	22, 25
				/		_____ i	23
				/	o	_____ j	24
				/	u	_____ j	17
				/	u	_____ u	34

TABLE 2D. VELAR SEGMENT ENVIRONMENTS

[g]				[ɣ]			
/	ŋ	_____	6	/	[word	_____ a	9
/	ŋ	_____ ε	8	/	[word	_____ o	12
/	ŋ	_____ w	20	/	[word	_____ e	4
/	ŋ	_____	25, 26	/	o	_____	15, 32
				/	i	_____	22

	/ u	_____	l	23
	/ ε	_____	ε	27
	/	_____	u	29
	/	_____	a	30
	/	_____	a	33
	/	_____		34
	/	_____	i	23
	/ o	_____	j	24
	/ u	_____	j	17
	/ u	_____	u	34

3. Thai

- | | | | |
|-------------------------------------|----------------|----------------------------|------------------|
| 1) bil | 'Bill' | 21) myy | 'hand' |
| 2) rak ⁷ | 'love' | 22) baa | 'crazy' |
| 3) loŋ | 'go down' | 23) bryy | 'extremely fast' |
| 4) haa | 'five' | 24) plaa | 'fish' |
| 5) dii | 'good' | 25) tfaan | 'dish' |
| 6) t ^h ee | 'pour' | 26) t ^h ruumεen | 'Truman' |
| 7) k ^h εŋ | 'hard' | 27) panjaa | 'brains' |
| 8) ləəj | 'pass' | 28) p ^h jaa | [title] |
| 9) lyak ⁷ | 'choose' | 29) klaaŋ | 'middle' |
| 10) tʃ ^h at ⁷ | 'clear' | 30) traa | 'stamp' |
| 11) riip ⁷ | 'hurry' | 31) ɔk ⁷ | 'exit' |
| 12) p ^h rεε | 'silk cloth' | 32) kiə | 'wooden shoes' |
| 13) k ^h waa | 'right side' | 33) kεε | 'old' |
| 14) draj | 'drive (golf)' | 34) dyŋ | 'pull' |
| 15) kan | 'ward off' | 35) tʃuək ⁷ | 'pure white' |
| 16) p ^h leen | 'song' | 36) tʃ ^h an | 'me' |
| 17) jiisip ⁷ | 'twenty' | 37) p ^h aa | 'cloth' |
| 18) k ^h aa | 'kill' | 38) dam | 'black' |
| 19) raaj | 'case' | 39) tit ⁷ | 'get stuck' |
| 20) sip ⁷ | 'ten' | 40) pen | 'alive' |

VOWEL CHART

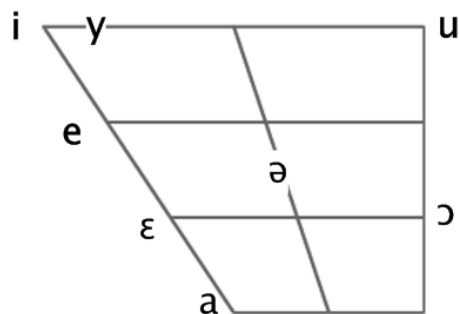


TABLE 3A. CONSONANTS

	Bilabial	Labio-Dental	Dental	Alveolar	Palato-alveolar	Palatal	Velar	Labial-Velar	Glottal
Plosive	p p ^h b			t t ^h d			k k ^h		

Nasal							
Trill							
Tap or Flap							
Fricative							
Affricate				tʃ	tʃʰ		
Lateral Fricative							
Approximant							
Lateral Approximant							

TABLE 3B. OBSTRUENT ENVIRONMENTS

<p>[p]</p> <p>/ [word _____] l 24</p> <p>/ [word _____] a 27</p> <p>/ [word _____] e 40</p>	<p>[pʰ]</p> <p>/ [word _____] r 12</p> <p>/ [word _____] l 16</p> <p>/ [word _____] j 28</p> <p>/ [word _____] a 37</p>	<p>[]</p> <p>/ i _____]word 11,17,20</p>	<p>[b]</p> <p>/ [word _____] i 1</p> <p>/ [word _____] a 22</p> <p>/ [word _____] r 23</p>
<p>[t]</p> <p>/ [word _____] r 30</p> <p>/ [word _____] i 39</p>	<p>[tʰ]</p> <p>/ [word _____] e 6</p> <p>/ [word _____] r 26</p>	<p>[]</p> <p>/ a _____]word 10</p> <p>/ i _____]word 39</p>	<p>[d]</p> <p>/ [word _____] i 5</p> <p>/ [word _____] r 14</p> <p>/ [word _____] y 24</p> <p>/ [word _____] a 38</p>
<p>[k]</p> <p>/ [word _____] a 15</p> <p>/ [word _____] l 29</p> <p>/ [word _____] i 32</p> <p>/ [word _____] ε 33</p>	<p>[kʰ]</p> <p>/ [word _____] ε 7</p> <p>/ [word _____] w 13</p> <p>/ [word _____] a 18</p>	<p>[]</p> <p>/ a _____]word 2,9</p> <p>/ ɔ _____]word 31</p> <p>/ ə _____]word 35</p>	<p>[-]</p>

TABLE 3C. AFFRICATE ENVIRONMENTS

<p>[tʃ]</p> <p>/ [word _____] a 25</p> <p>/ [word _____] u 35</p>	<p>[tʃʰ]</p> <p>/ [word _____] a 36, 10</p> <p>_____</p>
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