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Phonetic factors contributing to the inception of sound change

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More attention has been paid to how sound changes spread through the lexicon and the linguistic community (Labov, 1994; Wang, 1969; Phillips, 2006) than to the phonetic factors which contribute to the origin of sound change.

The present study deals with the latter research topic by looking into the following aspects :

(a) ***whether sound changes have an articulatory and/or an acoustic origin,***

(b) ***whether sound change implementation follows a single or a multiple pathway,***

(c) ***the contribution of articulatory/acoustic prominence to sound change,***

(d) ***how sound change originates in the individual.***

1. ***Articulation- vs acoustic-based sound changes***

Articulation-based approach

Linguists and philologists from about 1875 to 1975 believed that sound shifts were essentially articulation-based.

General principle:
Listeners may mistake one phoneme for another whenever prominent articulatory changes in phonemic realization occur in specific contextual, positional and/or prosodic conditions.

Proponents of the articulation-based approach:

Rousselot, Jean-Pierre (1897-1901) Principes de phonétiques expérimentale, Welter, Paris, 2 vols.

Millardet, Georges (1910) Études de dialectologie landaise: le développement des phonèmes additionnels, Privat, Toulouse.

Grammont, Maurice (1933) Traité de phonétique, Delagrave, Paris.

Assimilatory processes are a byproduct of coarticulatory effects.

(Example) Productions of [a] involving tongue body fronting and raising next to an (alveolo)palatal consonant may be taken to be realizations of a mid front vowel by the listener.

Cat.	[ˈ**e**(j)ʃ]	< *[ˈ**a**jse]	< [ˈakse] AXE “axis”
Cat.	[ˈf**e**(j)t]	< *[ˈf**a**jto]	< [ˈfakto] FACTU “done”

Acoustico-perceptual based approach

A considerable number of sound changes originates from the failure on the part of the listener to compensate for coarticulation.

Sound changes may be triggered by acoustic equivalence rather than by articulatory variation (Ohala, 1981).

Ohala, J.J. (1981) The listener as a source of sound change, Papers from the Parasession on Language and Behaviour, C.S. Masek, R.A. Hendricks & M.F. Miller (eds.), 178-203, Chicago Linguistic Society, Chicago.

IE*_e**kw**os_ > Classical Greek _hi**pp**os_
Lat. _sa_[**pj**]_a_ SAPIAM > Fr. _sa_[**(t)ʃ**]_e_

Similar burst spectrum and formant transitions

Lat. _amp_[**l**]_o_ AMPLU > *_amp_[**j**]_o_ AMPLU > Sp. _an_[tʃ]_o_
Cat. _a_[**ɫ**]_ba_ > dial. Cat. _a_[**w**]_ba_

Similar steady-state spectral characteristics and formant transitions

Old Eng. [**k**in] > Modern Eng. [**tʃ**ɪn]

Spectral similarity between the stop burst for front [k] and the frication noise for [tʃ]

Problems with the two approaches

[In support of the acoustic origin of sound change]

There are sound changes which are presumably acoustically driven and thus not triggered by articulatory variation

Cat. *coï*[**t**]/[**k**] “mosquito”, *fi*[**t**]/[**k**] “wart”, *préss*e[**k**]/[**t**] “peach”
Exchanges between syllable-final stops exhibiting a weak burst in favorable vowel contexts (Gauchat, 1925).

dial. Sp. *a*[**l**]*to* > *a*[**ɾ**]*to*
Manner changes between acoustically similar sounds (e.g., clear /l/ and [ɾ] share a short duration and a relatively high F2).

Fr. [**ỹ**] >[**œ̃**] *un*, [**ĩ**]>[**ɛ̃**] *vin*
In disagreement with articulatory explanations (Grammont, 1933), Beddor (1983) has argued convincingly for a spectrally-based explanation of vowel quality changes that may occur when nasal formants are added to oral vowels.

[In support of the articulatory origin of sound change]

A considerable number of changes which have been attributed to acoustic equivalence may have an articulatory basis

[**kw**]> [**p**]	[kw] > [kɸ] > [(k)p] > [p]	Rom. *patru* QUATTUOR
[**pj**] > [**tʃ**]	[pj] > [pç] > [(p)tʃ] > [(t)ʃ]	Port. *cheo* PLENU
	Increase in constriction degree for [w] and [j]	
[**C*l***] > [**Cj**]	[l] > [ʎ] > [j]	It. *amp*[j]*o*
[**Cɫ**] > [**Cw**]	[ɫ]> [w] through apical contact loss	Cat. *a*[ɫ]*ba* > *a*[w]*ba*
front [**k**] > [**tʃ**]	[k] > [c] > [tʃ]	Eng. *chin*

2. ***Single vs multiple evolutionary pathways of sound change implementation***

Sound changes may be implemented through ***more than one evolutionary pathway***, which is in line with vowel and consonant phonemes being cued by several cooccurring acoustic characteristics as a general rule (Lisker, 1986).

(Example) Among other combination of acoustic cues, the voiced/voiceless stop distinction may be signaled by vocal fold vibration ***alone*** or ***in conjunction with*** segmental duration.

[ɫ] *elision*

(Sp. <u>otro</u> ALTERU, Cat. <u>cop</u> COLAPHU)

(1) [aɫ] > [aw] > [ɔw] (Port. *outro*) > [ɔ]

(2) [aɫ] > [ɔɫ] (Lombard *molta* MALTHA) > [ɔ]

(a) C-to-V anticipatory effects exerted by [ɫ] on [a] cause the vowel postdorsal constriction to move from the lower pharynx to the upper pharynx ([a] > [ɔ]).
(b) Articulatory and acoustic similarity between [ɔ] and [ɫ] accounts for the elision of the alveolar lateral at a later date.

3. ***Research program***

Given that sound changes may be **articulation- and/or acoustic-based** and implemented through **several perceptual identification mechanisms**, the following issues need to be looked into in order to account for sound change inception:

(a) whether sound change has been triggered by articulatory and/or acoustic variation,

(b) which acoustic cues bring out the replacement of one phoneme by another.

Experiment 1

[ɫ] > [w]

(Old Fr. *haut* ALTU)

Articulatory and/or acoustic origin of sound change

Whether [ɫ] > [w] may be triggered by

(a) ***Acoustic equivalence***
Tongue dorsum retraction and/or predorsum lowering may cause the steady-state F2 for [ɫ] to sound [w]-like.

(b) ***Apical contact loss***
Apical contact loss may give rise to [w]-like articulatory and spectral characteristics (Lin et al., 2014).

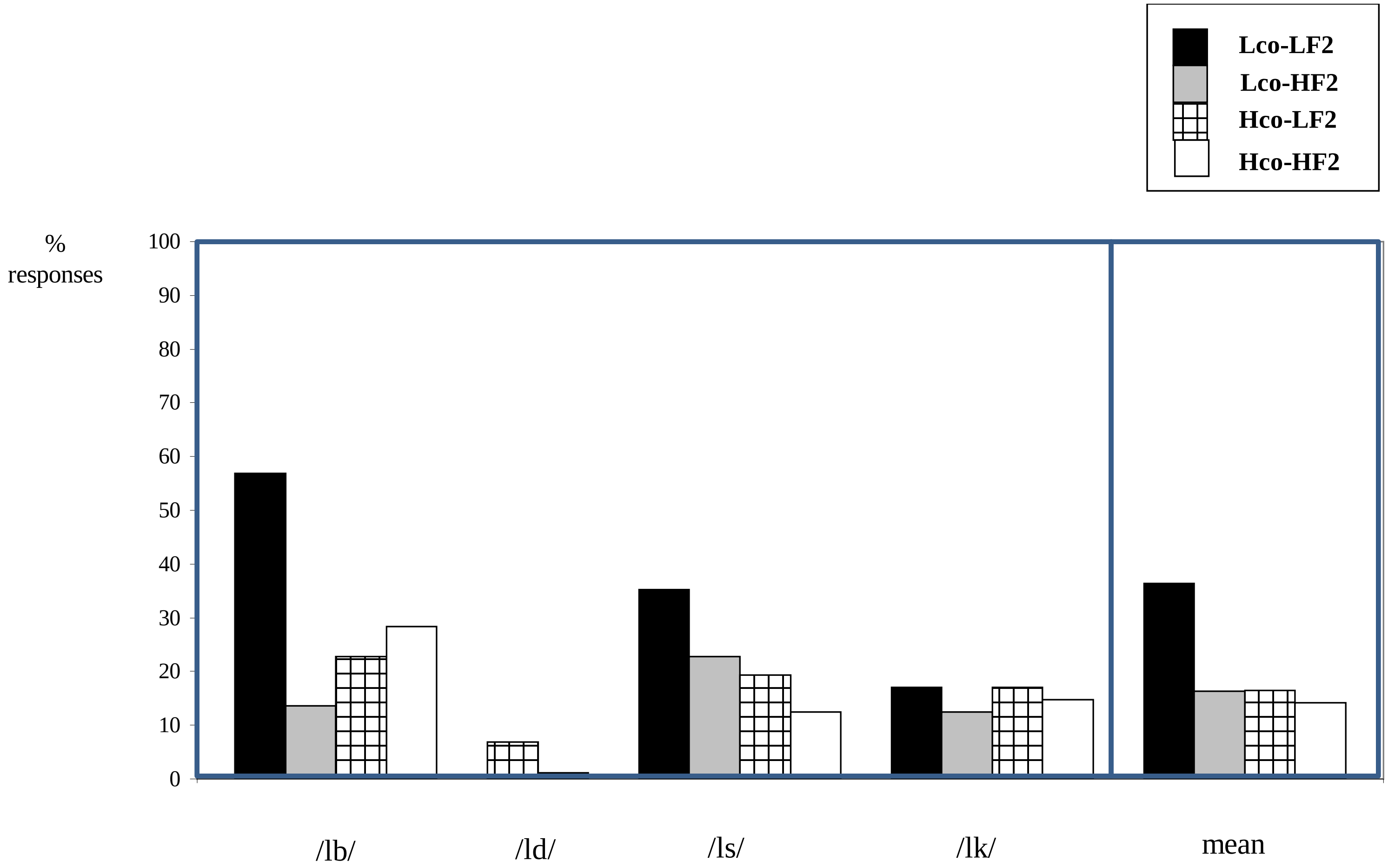
Dimensions: *tongue contact degree at closure location (EPG)-F2 height*

Conditions: LoCo-LoF2, LoCo-HiF2, HiCo-LoF2, HiCo-HiF2

4 clusters; 4 speakers

		tongue contact		**F2**	
cluster	**speaker**	**condition**	**number "on" electrodes**	**condition**	**frequency values (Hz)**
lb	BM	low	0	low	657
	MJ		0		666
	CA	low	1	high	882
	BM		0		824
	ND	high	8	low	755
	ND		8		762
	CA	high	8	high	898
	ND		7		827
ls	MJ	low	0	low	828
	MJ		0		875
	CA	low	0	high	1144
	CA		0		1070
	ND	high	8	low	862
	BM		7		861
	BM	high	6	high	1048
	ND		6		1019
ld	MJ	high	8	low	642
	MJ		8		678
	BM	high	8	high	1168
	BM		8		1121
lk	MJ	low	1	low	920
	MJ		2		928
	MJ	low	1	high	1082
	MJ		3		1037
	MJ	high	8	low	799
	CA		8		879
	BM	high	8	high	1052
	BM		7		1047

Articulatory and acoustic characteristics of the 28 tokens included in the perception test



Highest /w/ responses for the ***Lco-LF2 condition***, mostly so for /lb/, which is in agreement with labials causing /l/ to exhibit alveolar contact loss and much F2 lowering.

Results support an ***articulation-based*** explanation of [ɫ] vocalization without excluding completely an ***acoustic-based*** account of this sound change.

Which acoustic cues are responsible for [ɫ] *vocalization?*

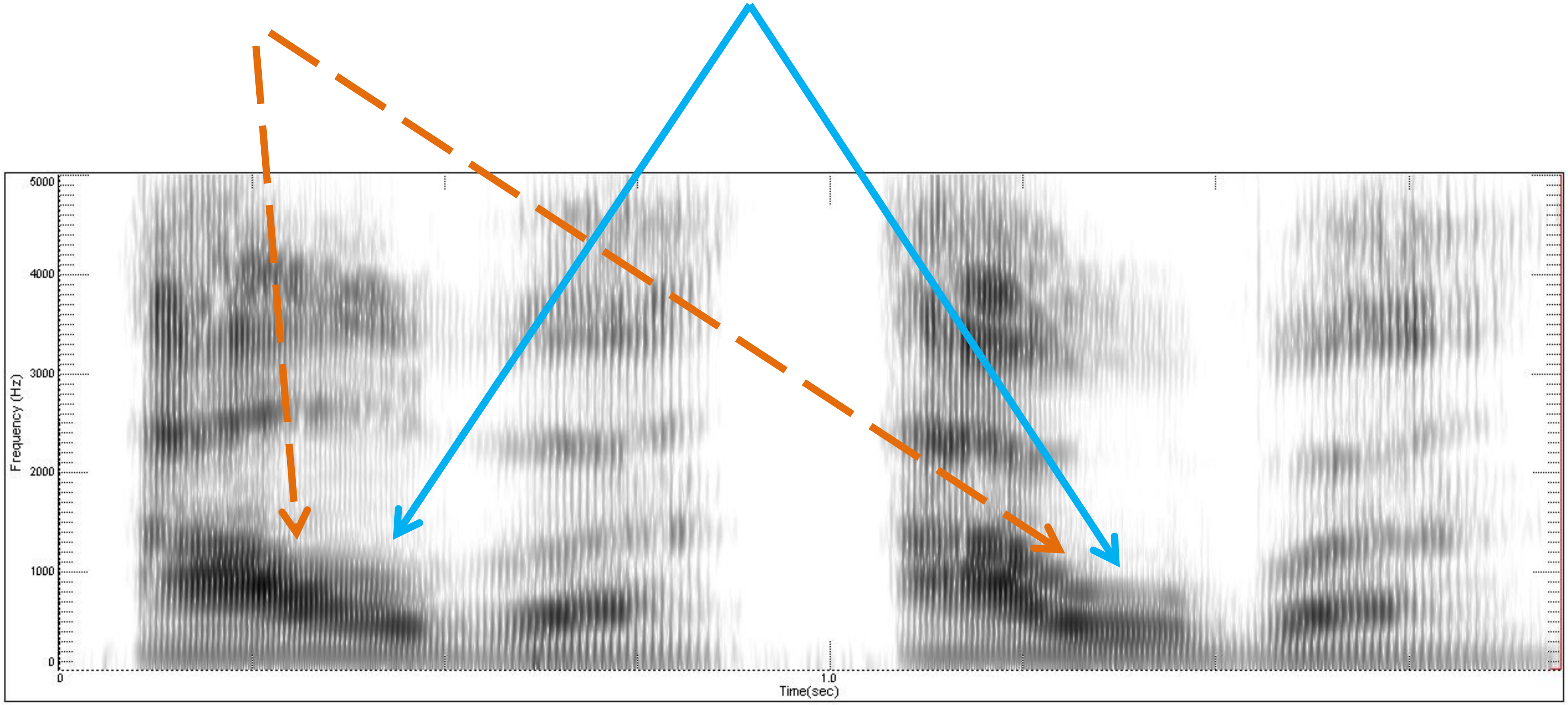
The change [ɫ] > [w] may be triggered by

(1) Misperception of the ***grave steady-state spectrum*** for [ɫ] ([aɫ] > [aw])

(2) Integration of the ***VC transitions*** as /w/: [aɫ] >[awɫ] (Romansh [awɫt] ALTU), followed by [ɫ] ***elision*** whenever the apical closure is severely reduced or occurs after voicing offset: [awɫ] > [aw] (Recasens & Farnetani, 1994).

F2 VC transitions

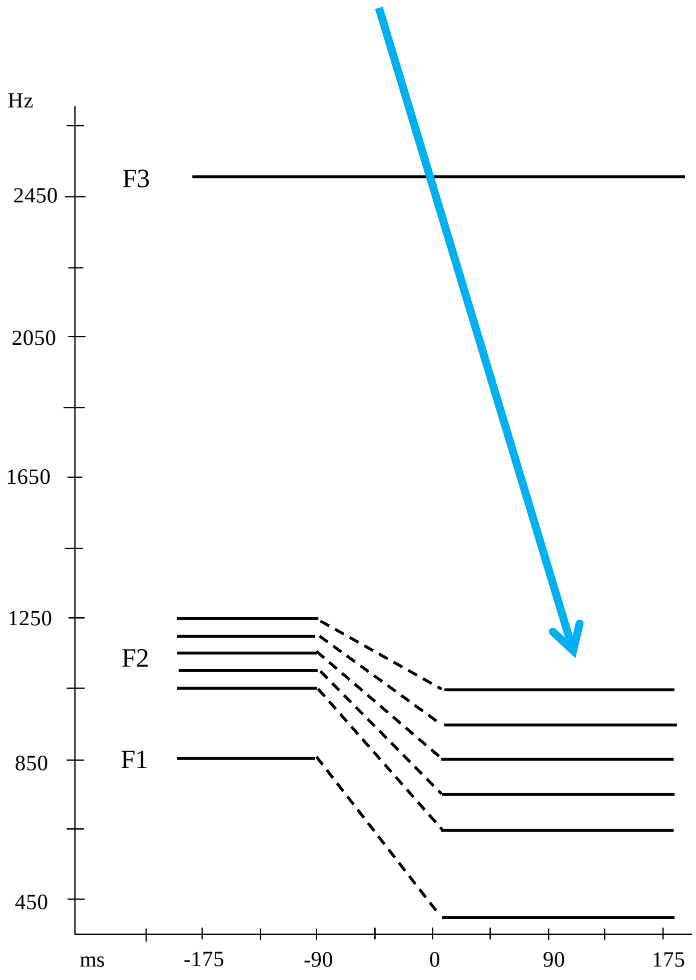
F2 steady-state



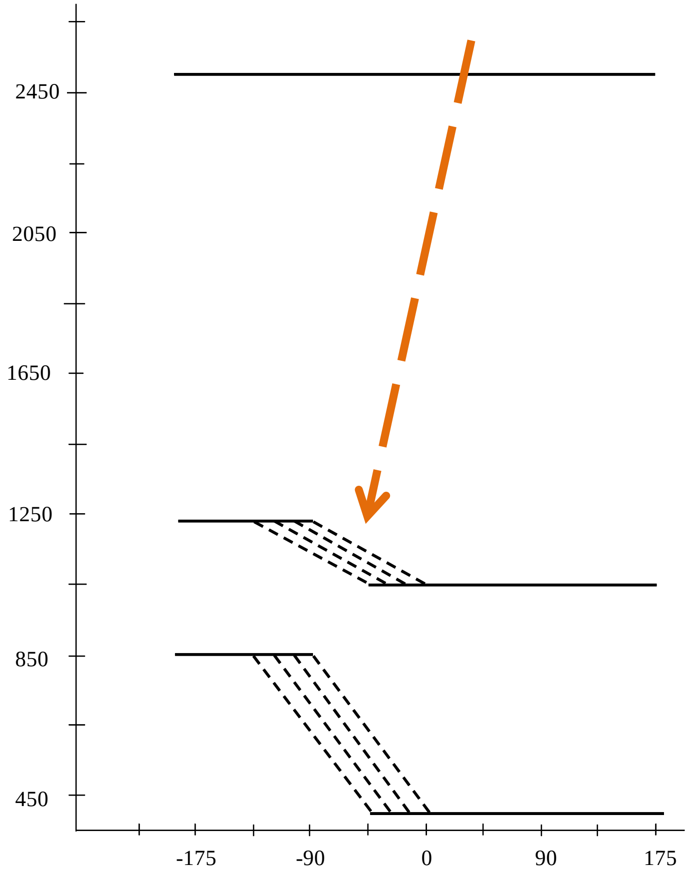
aɫßə

awßə

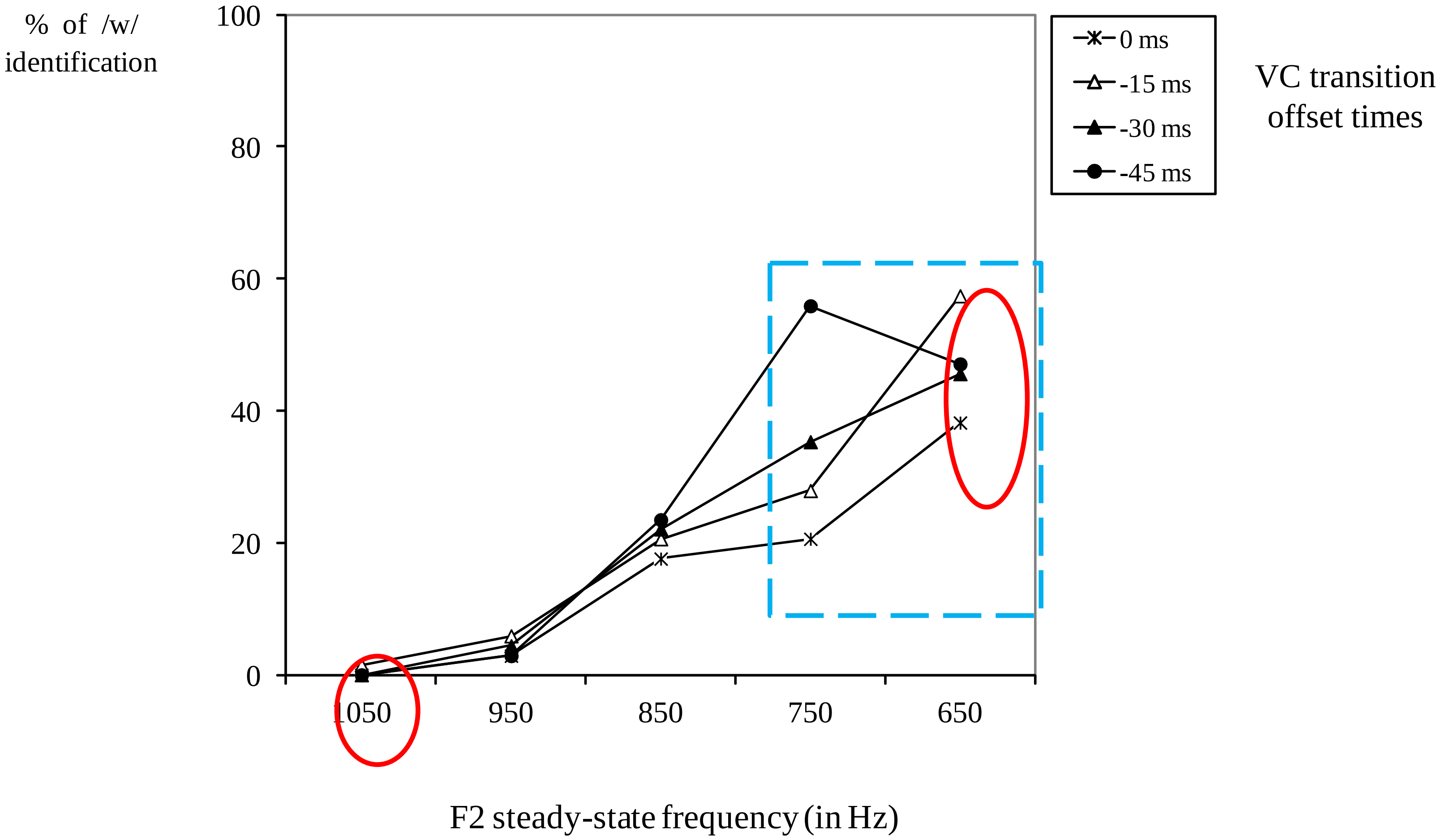
5 /ɫ/ steady-state values ranging from 650 Hz to 1050 Hz



4 VC transition offset times ranging from -45 ms to 0 ms



20 perception stimuli



The /w/ identification percentages increase by lowering F2 at the [**ɫ**] ***steady-state period*** (by 5-45%) rather than by anticipating the ***VC transition*** (by 15-35% only when F2 is lowest)

These /w/ identification results are consistent with [ɫ] vocalization in the world’s languages yielding [w] rather than [wɫ].

Experiment 2

[Vɲ] > [VjN]

(Majorcan Cat. /aɲ#bɔ/ > [ajm ˈbɔ])

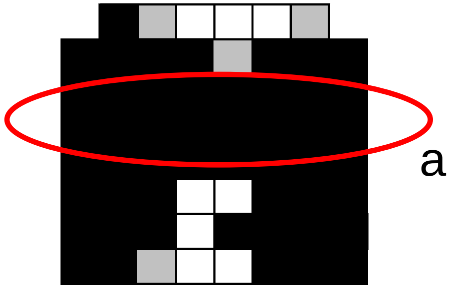
Origin of sound change

In principle, the change [ɲ] > [jn], may be triggered by

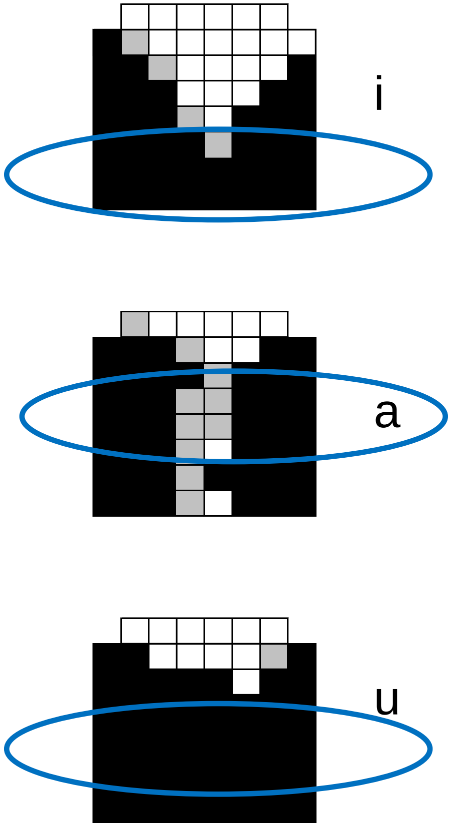
(1) ***A decrease in dorsopalatal contact*** associated with the syllable-final position ([ɲ] > [n], *which leaves unexplained the presence of the on-glide*)

(2) ***An increase in dorsopalatal contact*** which is in line with [j] having a higher F2 than [ɲ] ([ɲ] > [jɲ] > [jn]).

EPG patterns at closure midpoint for intervocalic [ɲ] in Majorcan Catalan suggest that the latter account is more plausible than the former.



Eastern Catalan



Majorcan Catalan

Which acoustic cues are responsible for the change **[ɲ] > [jn]?**

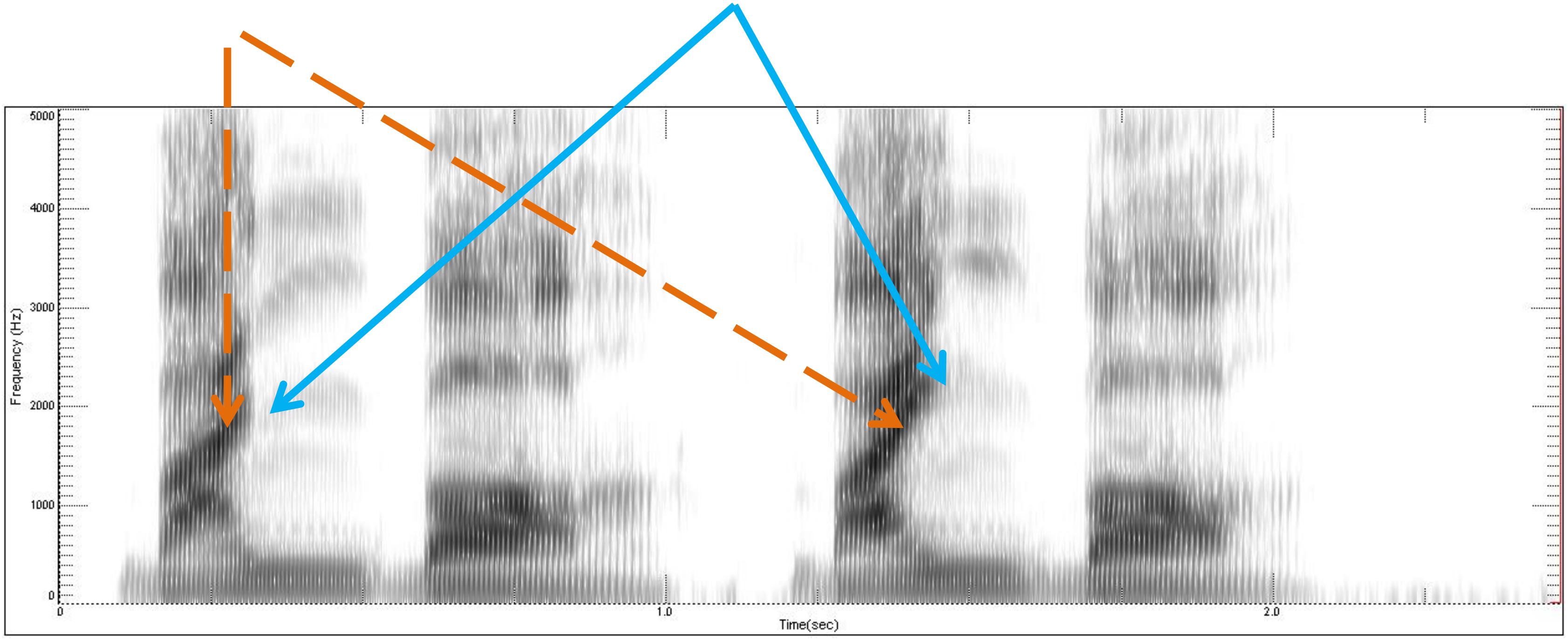
The [j] percept in the sound change [ɲ] > [jn] may be triggered by

(a) ***The duration of the VC transitions***,

which ought to be greater for [jN] than for [ɲ] and in principle could be associated both with [ɲ] reduction and with an increase in dorsopalatal contact for [ɲ].

(b) ***The VC transitions endpoint frequency***,

which should be higher for [jN] than for [ɲ] and ought to be positively related to an increase in dorsopalatal contact (i.e., the larger the dorsopalatal contact size, the higher the F2 frequency).



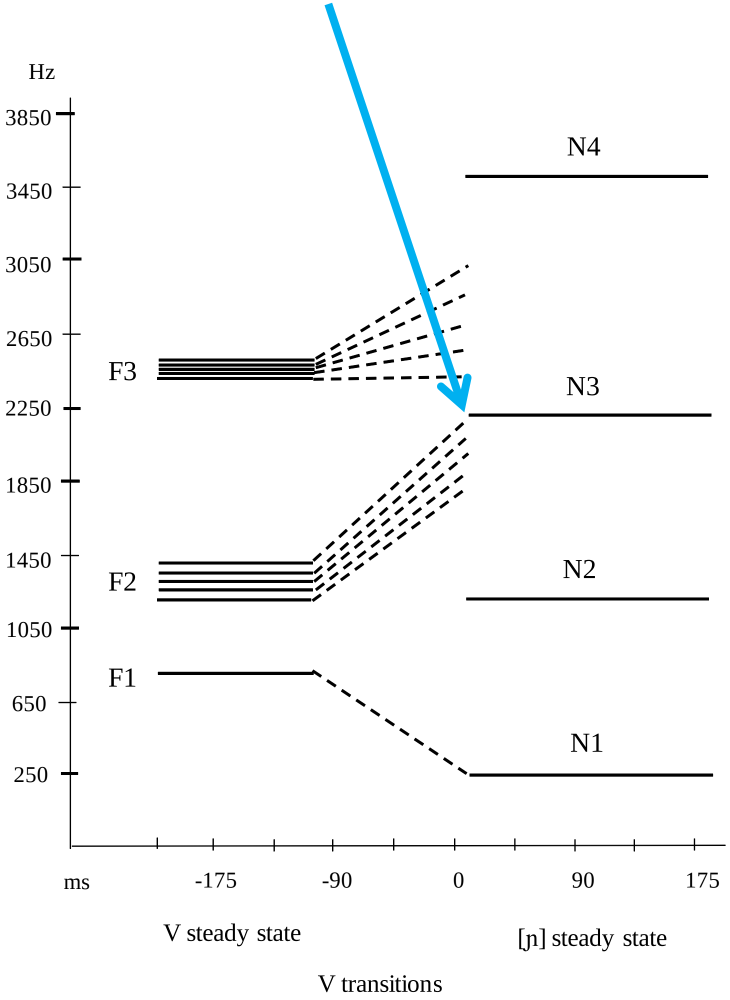
F2 vowel transition

F2 vowel transition endpoints

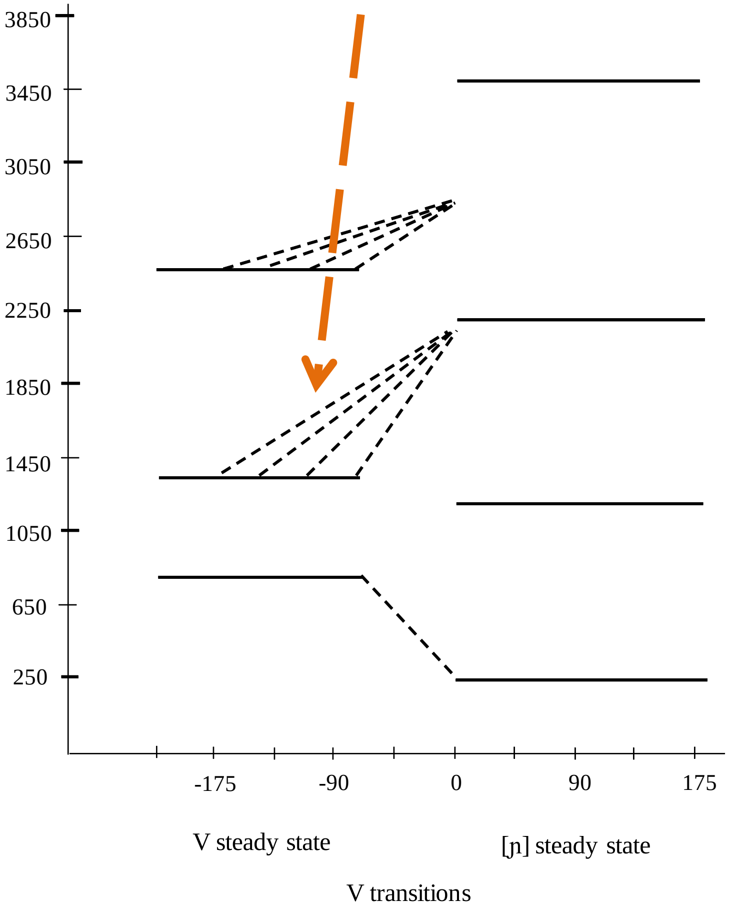
baɲ bɔ

bajn bɔ

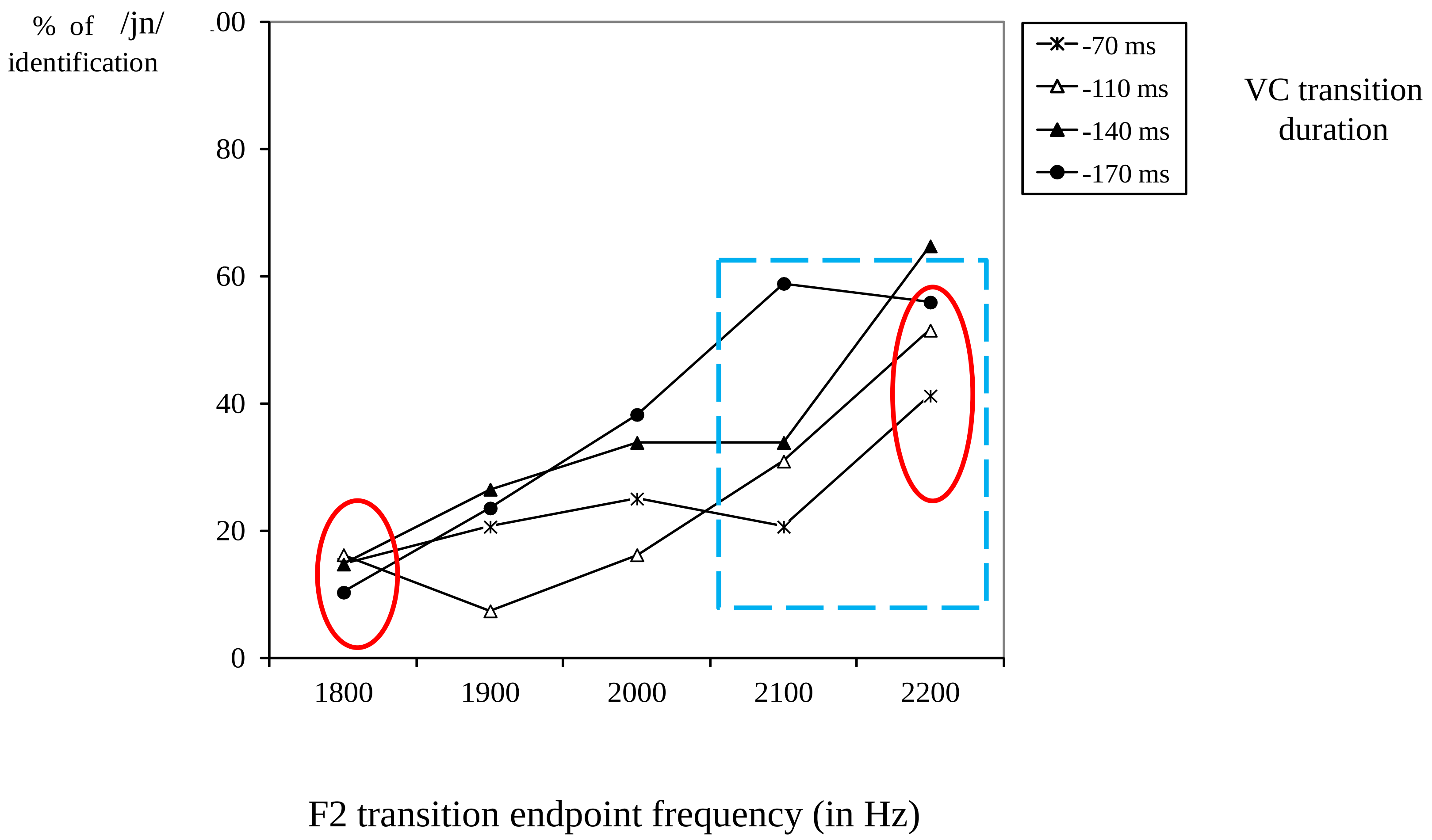
5 transition endpoints ranging from 1800 Hz to 2200 Hz



4 transition onset times ranging from -170 ms to -70 ms



20 perception stimuli



/jn/ identification percentages increase with the ***F2 transition endpoint*** frequency (by 10%-50%) rather than with the ***duration of the VC transitions*** (by 20%- 40% only when F2 is highest)

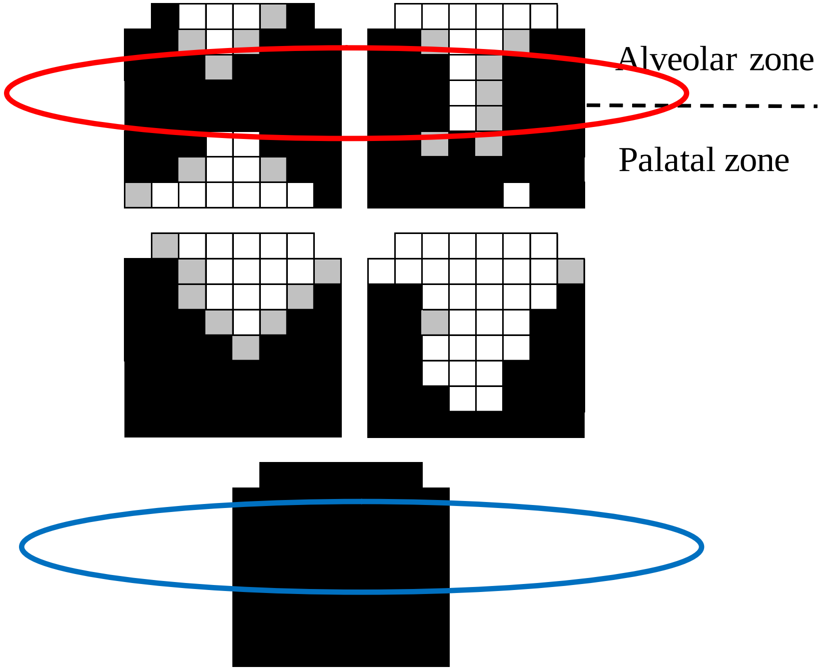
These results appear to be in support of the hypothesis that ***an increase in dorsopalatal contact may cause [ɲ] to be heard as /jn/:*** more dorsopalatal contact > higher F2 transition endpoint frequency, longer VC transitions.

Experiment 3

Front /k / > [tʃ]

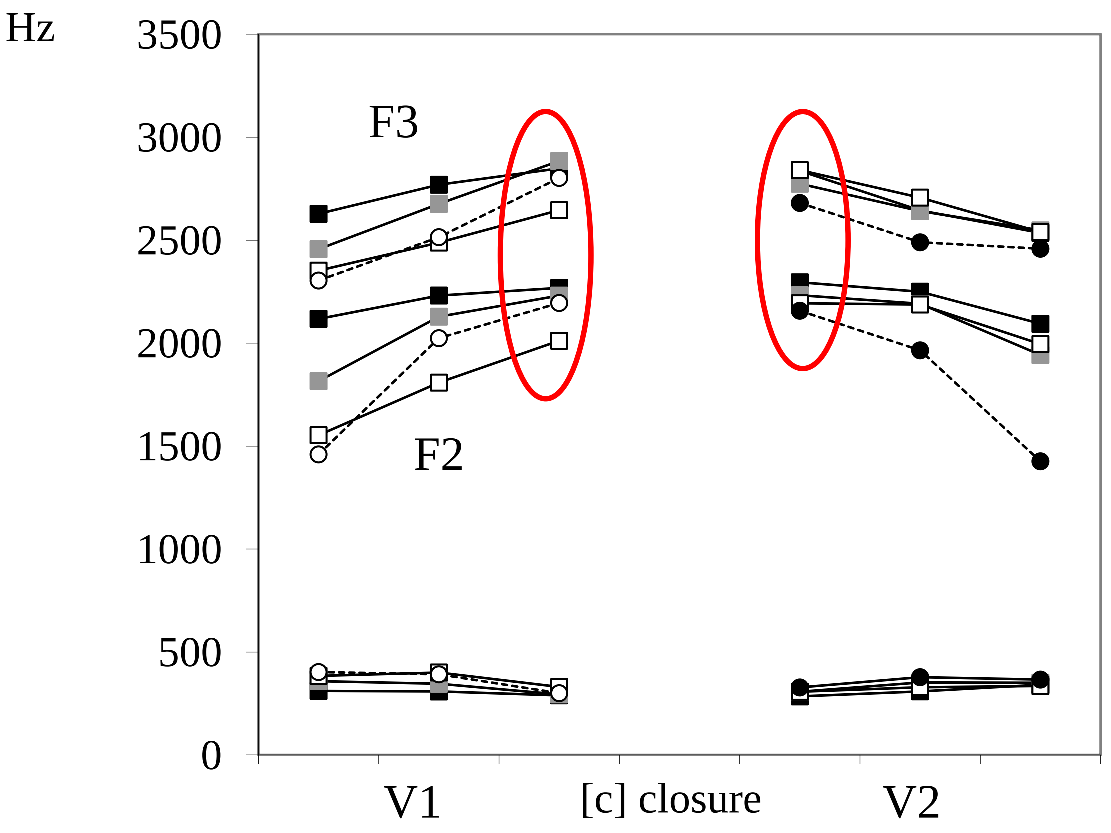
(It. *cento* < Lat. [ˈkɛnto] CENTU)

Articulatory and/or acoustic origin of sound change



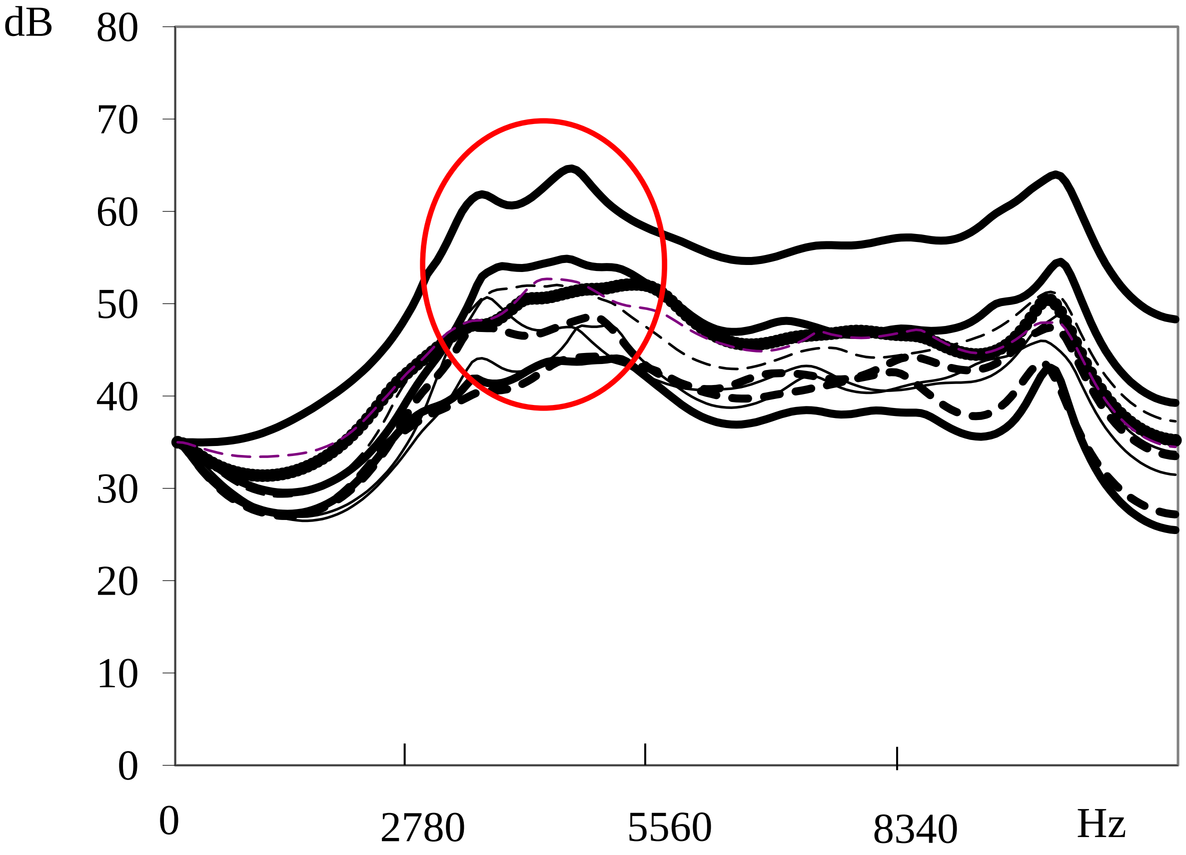
EPG contact patterns at the midpoint of [c] for 5 speakers of Majorcan Catalan, where the (alveolo)palatal stop is an allophone of /k/, show that the ***stop closure*** location may approach the articulatory configuration for [tʃ] in several cases.

Vowel transitions for VCV sequences with [c]



The ***vowel transition characteristics*** for [c] are also similar to those for [tʃ] across vowel context conditions.

[c] bust spectral configuration



Similar ***spectral characteristics*** for the [c] burst and the [tʃ] frication noise in the [i] and [a] contexts.

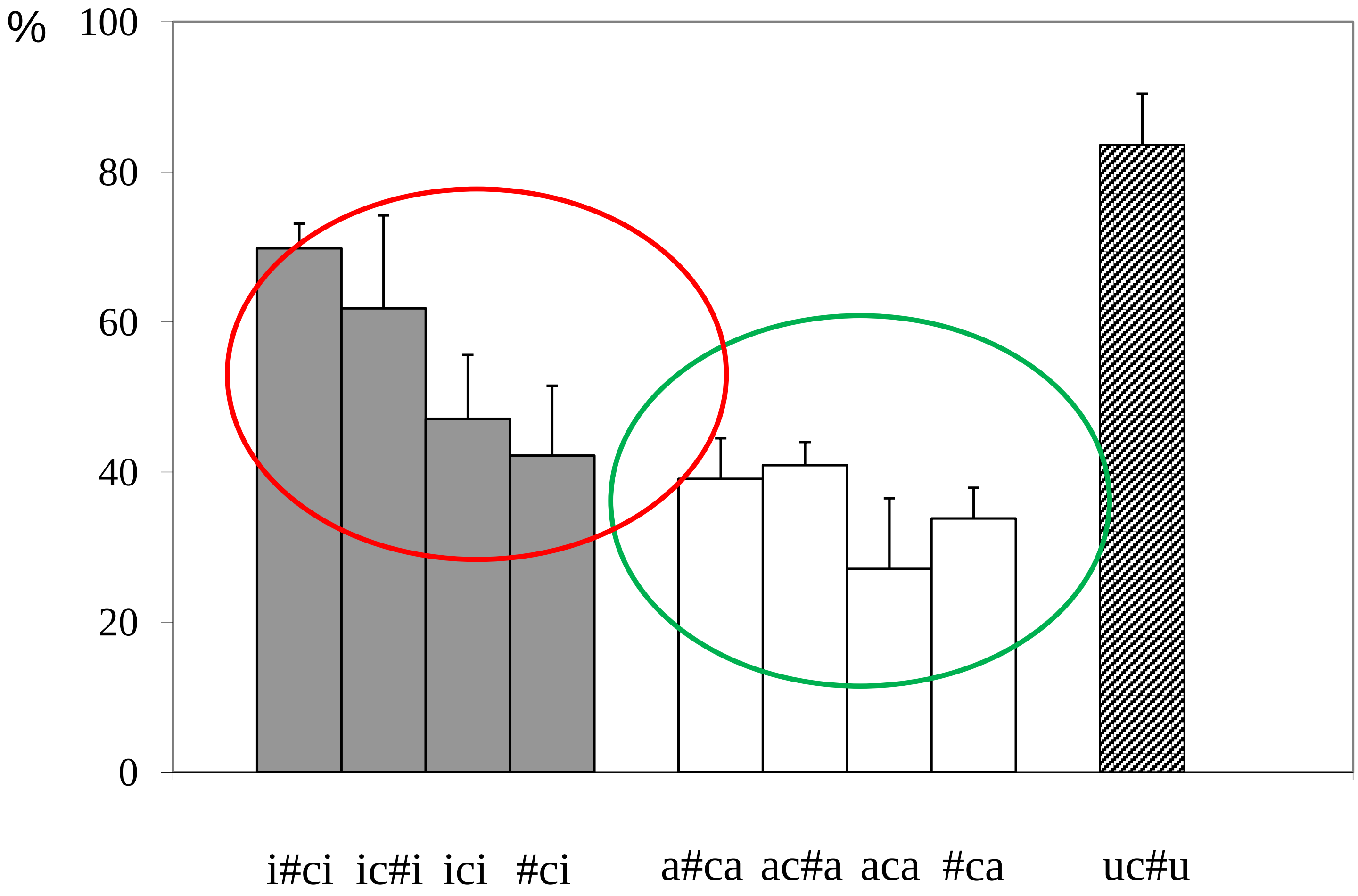
Perception test

CV excerpts with [c] excised from a subset of [V#cV], [Vc#V], [VcV] and [#cV] sequences with vowels [i] and [a] (also from [uc#u]) produced by Majorcan Catalan speakers.

In Majorcan Catalan, [c] is an allophone of /k/ occurring before [i, e, j, a] and word finally.

The [cV] excerpts contained the stop burst and the vowel following the consonant.

/tʃ/ identification percentages for [c]



[c] may be perceived as /tʃ/ ***next to /i/ rather than to next to /a/*** which is in line with velar softening occurring mostly before front vowels in the world’s languages. (The sequence [u#cu] is a special case).

Which acoustic cues are responsible for the change /k/>[tʃ]?

While the spectral characteristics of [c] are quite invariant across vowel contexts and positions, listeners may categorize [c] as /tʃ/ mostly before [i].

This appears to be so since the ***stop bust*** has a ***higher intensity and/or a longer duration*** in this vowel context than in other vowel contexts due to articulatory and aerodynamic factors.

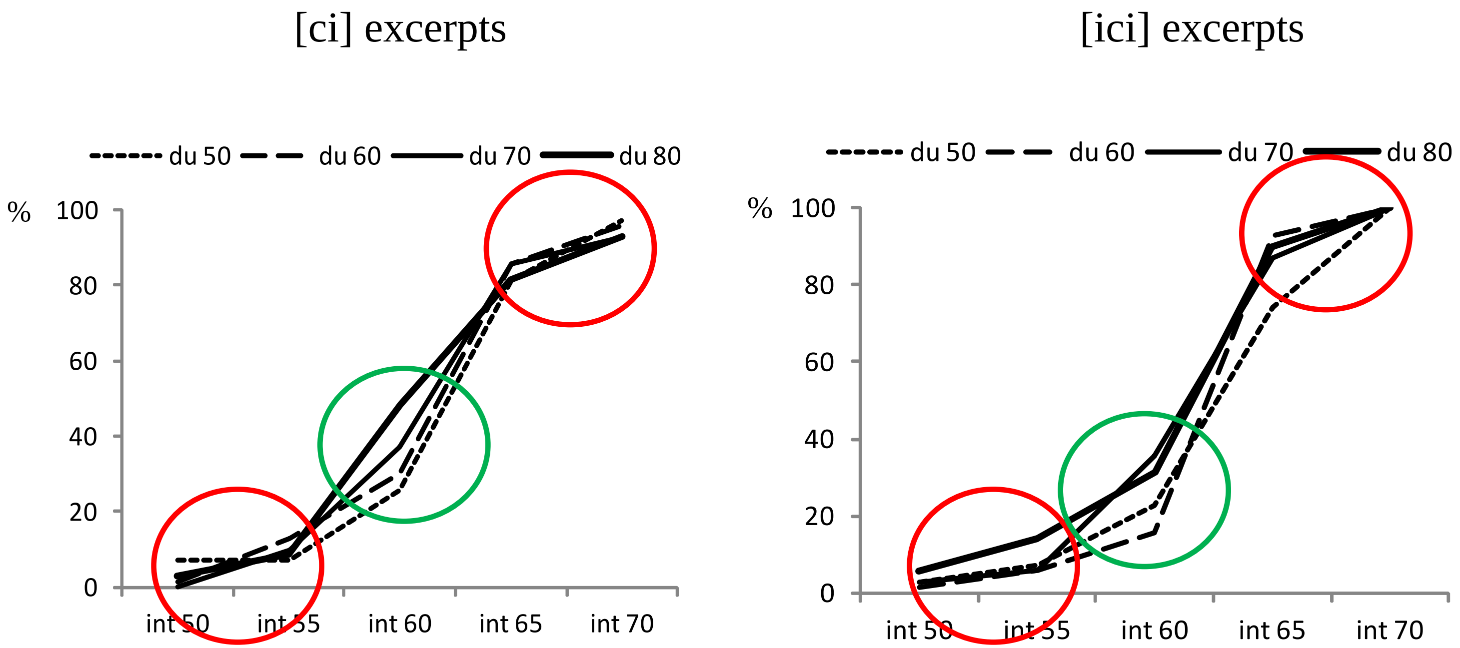
Another perception test with synthetic stimuli was carried out in order to find out whether changes in ***burst intensity level*** and/or ***duration*** for [c] before [i] (sequences [ci], [ici]) could yield an affricate percept.

Stimulus number	Duration (ms) /Intensity(dB)
1.	50/50
2	50/55
3.	50/60
4.	50/65
5.	50/70
6.	60/50
7.	60/55
8.	60/60
9.	60/65
10.	60/70
11.	70/50
12.	70/55
13.	70/60
14.	70/65
15.	70/70
16.	80/50
17.	80/55
18.	80/60
19.	80/65
20.	80/70

[c]-like stimuli

[tʃ]-like stimuli

Percentage of /tʃ/ responses



[ci] excerpts

[ici] excerpts

Intensity is the most prominent acoustic cue for the identification of [c] as /tʃ/. (The affricate is heard about 80%-100% when burst intensity is 65-70 dB).

Duration only plays a role when the intensity level is somewhere between the intensity levels for [c] and for [tʃ].

Summary

Results for the perception tests reported so far show that

(a) sound changes are prone to operate in ***positional and contextual conditions favoring a given acoustic characteristic***,

(b) one or more ***secondary acoustic characteristics*** may be used in order to enhance the perceptual effectiveness of the ***primary acoustic cue***.

(4) ***Articulatory/acoustic prominence.***

Cognitive aspects

Sound changes affecting Catalan unstressed vowels **(Recasens, 2014)**

The ***frequency of occurrence of contextual consonants and vowels*** was calculated for several V-to-C and V-to-V assimilatory processes affecting unstressed vowels. This data analysis was carried out using lexical material from modern Catalan dialects .

(a) Progressive vowel-to-consonant assimilations are triggered by ***word-initial consonants*** 70.5% of the time.

Process	*Triggering segment*	*Examples*
[o] > [u]	preceding labial consonant	**bo**_rró_, **po**_llí_
[e] > [i]	preceding palatal consonant	[**ʎ**]**_e_**_stó_, [**dʒ**]**_e_**_rmà_
[e] > [a]	preceding alveolar trill	**re**_cer_, **re**_sina_.

(b) Regressive vowel-to-vowel assimilations occur most often when the triggering vowel is ***stressed*** and the target vowel is situated in ***word-initial*** position.

Process	*Triggering segment*	*Examples*
[o] > [u]	following high vowel	*c**o**m**ú**, p**o**ll**í***
[e] > [i]	following high vowel	*r**e**s**i**na, v**e**g**í**lia*
[e] > [a]	following lower vowel	*t**e**rr**a**t*, [dʒ]***e**rm**à***.

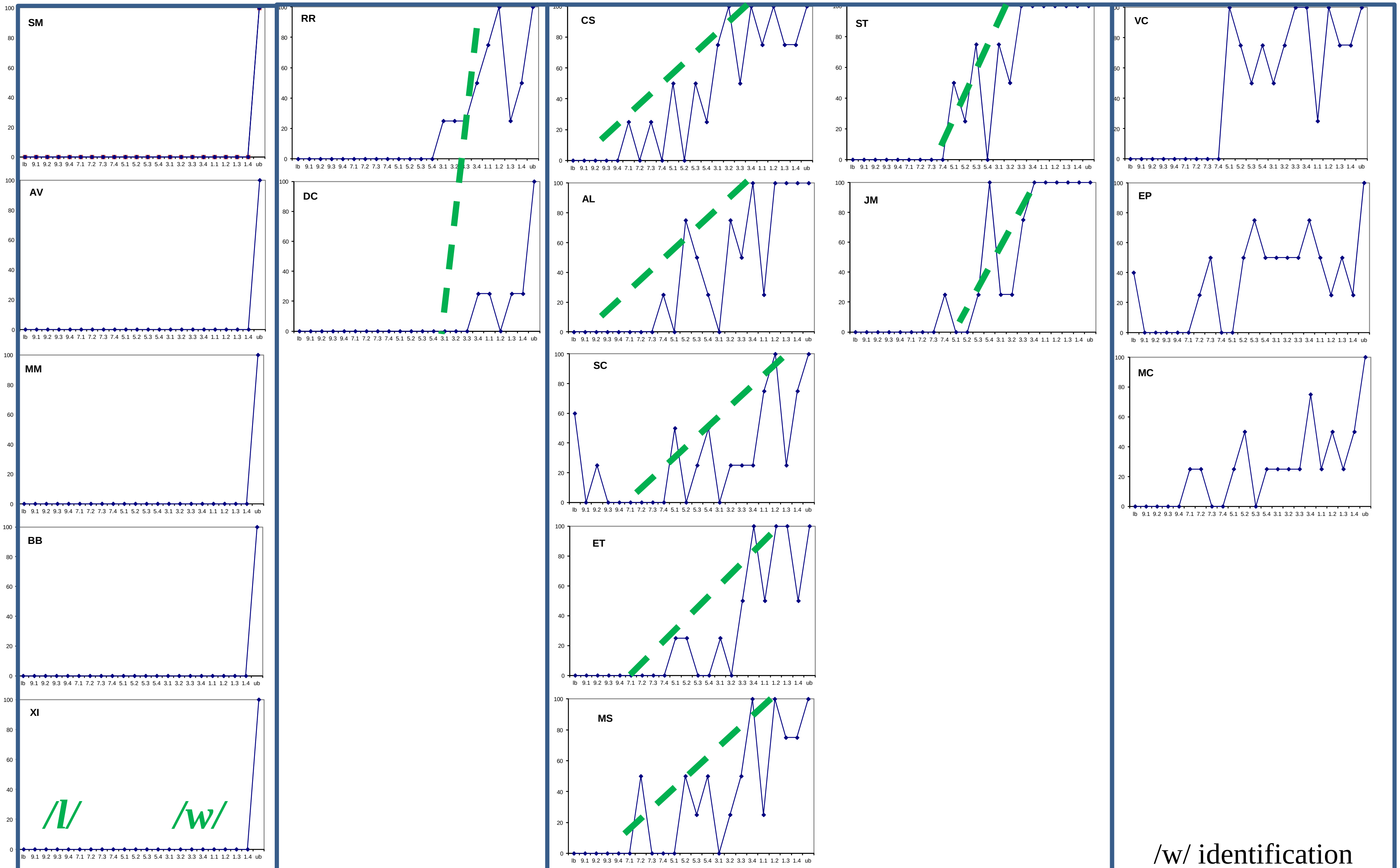
(c) ***Cooccurrence*** of

- progressive and/or regressive vowel-to-consonant assimilatory effects,
- regressive vowel-to-vowel assimilatory effects.

Process	*Triggering segment(s)*	*Examples*
[o] > [u]	preceding labial or velar consonant,	
	following palatal or labial consonant,	
	following high vowel	***po**ll**í***, ***co**m**ú***
[e] > [i]	preceding or following palatal consonant,	
	following high vowel	[ʎ]***e**g**u**m*, *d**e***[ʒ]***ú***.

5. ***How does sound change originate in the individual?***

/w/ identification percentages for [ɫ] in the word [ˈaɫβə]



no /w/ identification cases

few /w/ identification cases

/w/ identification function increases progressively

/w/ identification function does not increase progressively

Listeners may exhibit ***different degrees of perceptual sensitivity*** to changes performed in the acoustic realization of vowel and consonant phonemes (Grosvald, 2010).

Innovative listeners are highly sensitive to small variations in the acoustic signal and lead sound changes.

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