

24.962

Consonant duration contrasts

# Readings

For Thursday:  
Steriade (1997)

## Consonant length contrasts

- Explore some issues in the typology of consonant length contrasts.
- Focus on consonant length contrasts in Italian (McCrary 2004).
- Two main points:
  - Distinctiveness plays a central role in accounting for the phonology of consonant length.
  - In Italian, the realization of singleton consonants depends on their contrastive status. Non-contrastive singletons are realized with intermediate duration.
    - duration of short consonants is reduced to enhance the contrast with geminates.

## Consonant length contrasts in Italian: McCrary (2004)

- Short and long consonants contrast in Italian  
e.g. papo - pappo, sete - sette

Distribution of length contrasts:

- All length contrasts appear between vowels.
- Stop and [f] length contrasts are also permitted between a vowel and a liquid:

fabbro          applicato          soffrire

- But not in other contexts, e.g. between a liquid and a vowel:

\*farbbo          \*alppicato          \*sorffire

## McCrary (2004)

- Measured duration of singleton stops in the following environments:

V_V contrast	pápa, páta, páka
V_LV contrast	pápra, pápla, etc.
VL_V no contrast	párpa, pálpa, etc.
- Note: all target consonants are in onset according to standard analyses of Italian syllabification.

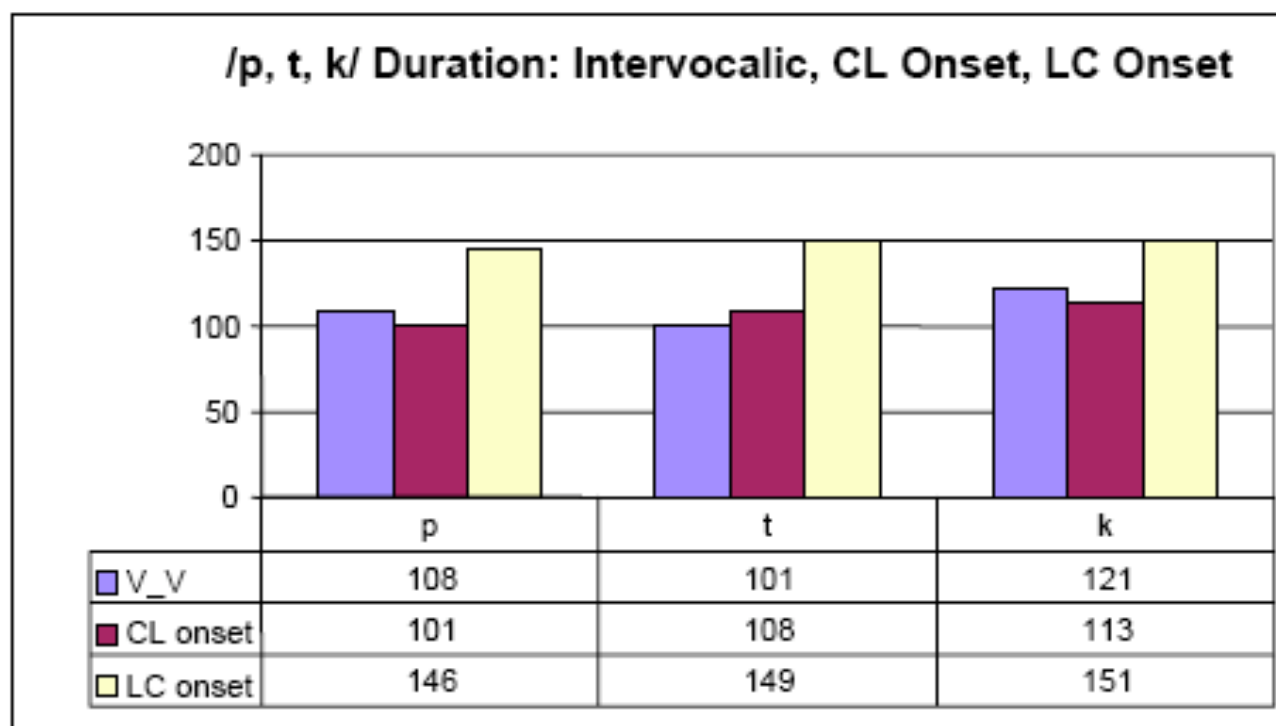
### Method:

- 15 subjects, speakers of Pisan Standard Italian.
- Nonce words spoken in the frame ‘Non trovo la parola \_\_\_ nel dizionario’.
- 6 repetitions of each word.

# Consonant length contrasts in Italian: McCrary (2004)

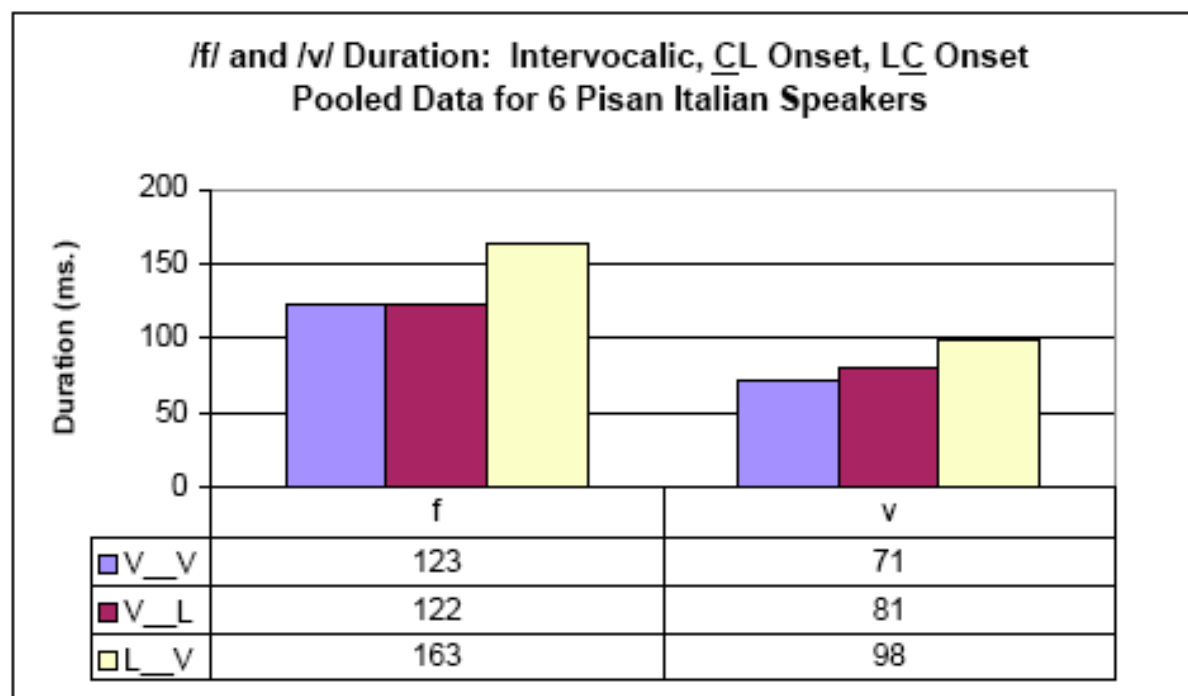
## Results:

- Singleton stops are shorter in the environments where they contrast with geminates (V\_V, V\_L) than in the environment where the contrast is neutralized (L\_V).
- Neutralization of the length contrast yields stops of an intermediate duration (voiceless geminate stop duration between low vowels is ~200 ms (Esposito and Di Benedetto 1999)).



# Consonant length contrasts in Italian: McCrary (2004)

- This interpretation is supported by distinct behaviour of [f] and [v].
  - f-ff and v-vv contrast between vowels
  - f-ff contrast in V\_L (like stops), v-vv do not contrast in this environment.
- [f] patterns like the stops: shorter in V\_V, V\_L, i.e. environments of contrast.
- [v] is shorter in V\_V (environment of contrast) than in V\_L, L\_V.
  - why is [v] shorter in V\_L than in L\_V? Possibly duration is an important cue to [f]-[v] contrast - [v] must be shorter than [f].



# Consonant length in Italian

Two issues:

- Why are length contrasts neutralized in L\_V?
- Why are neutralized consonants intermediate between contrastively long and short consonants?



## Analysis of Italian duration patterns

- The intermediate duration observed in L\_V is the preferred stop duration.
- Where there are length contrasts, consonants deviate from this preferred duration in order to realize a distinct contrast (dispersion).

## Analysis of Italian duration patterns

Inventory:

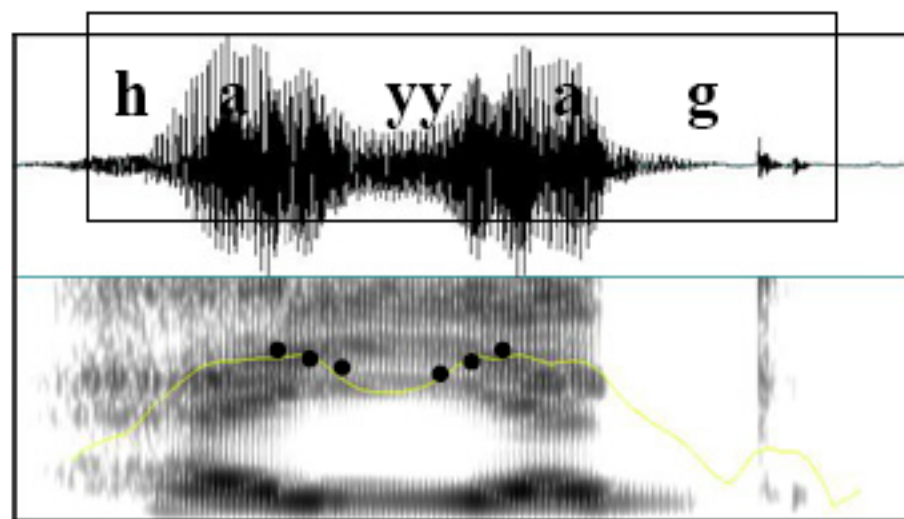
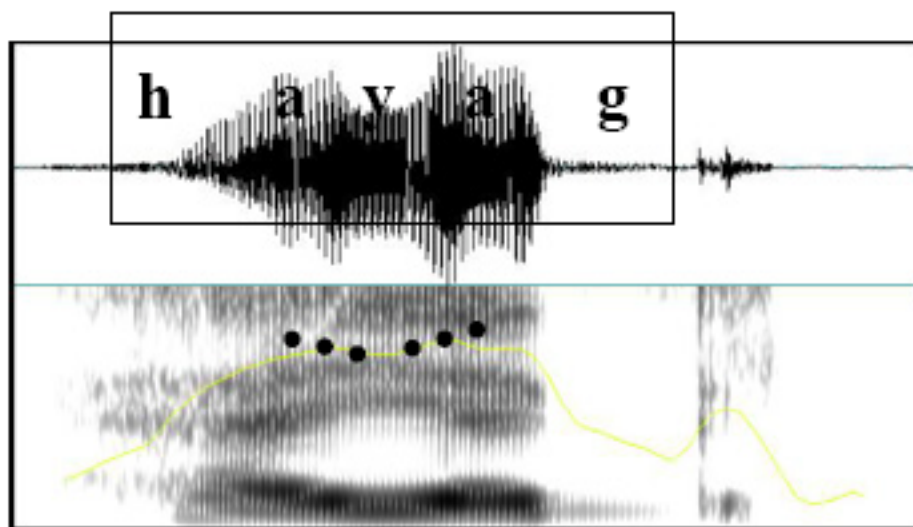
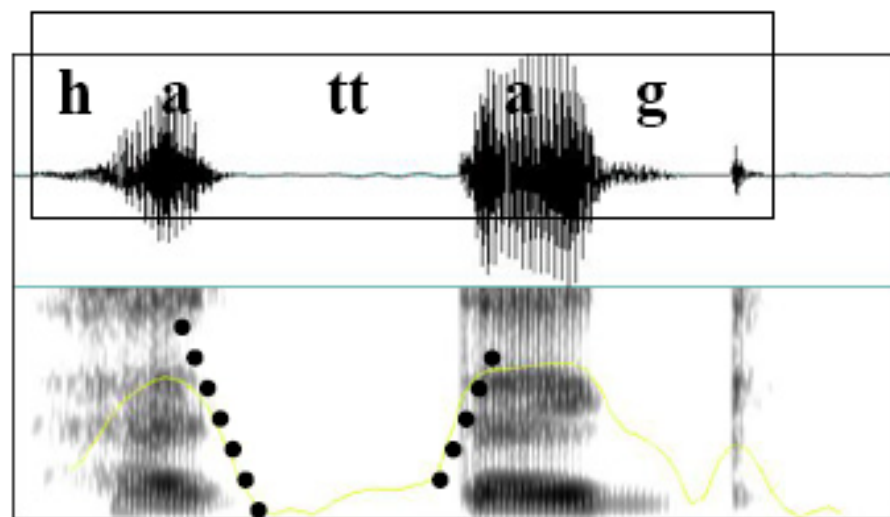
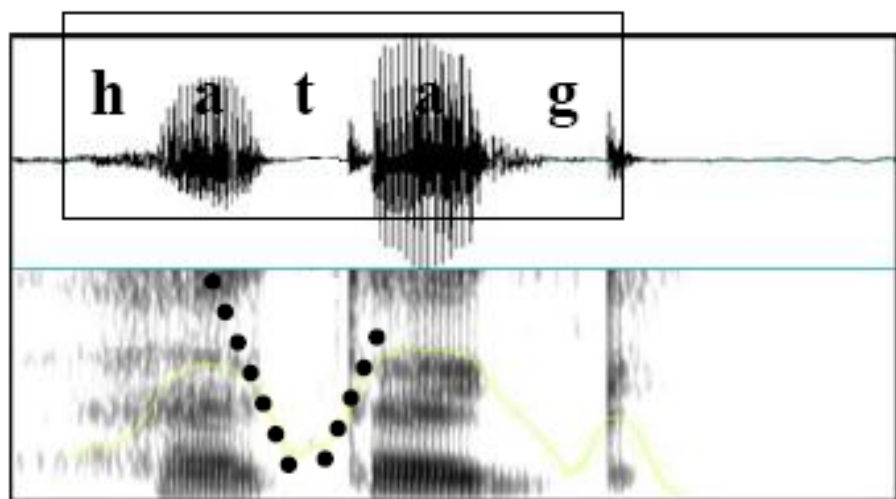
		Dur $\leq$ 200 ms	Dur $\geq$ 100 ms	Mindist = 100 ms	Max Contrasts	Dur = 150 ms
a.	150				✓!	
b.	50-150		*!		✓✓	
c.	☞ 100-200				✓✓	*
d.	150-200			*!	✓✓	

- Where length contrast is neutralized, consonants lack duration targets, so Dur=150 ms is unopposed.
- Why are length contrasts neutralized in L\_V?

## Constraints on C length contrasts

- The central factor in the occurrence and distribution of length contrasts seems to be the discriminability of duration differences.
- Determining the duration of a consonant entails locating its onset and offset in time.
- This is hypothesized to be easier where these events are marked by larger, more abrupt changes in loudness (Podesva 2000, McCrary 2004, Kawahara 2005).
  - Change within frequency bands?

# Constraints on C length contrasts



## Distinctiveness of C length contrasts

- Kato et al (1997) found that modifications of segment duration were easier to discriminate where the change moved a boundary between segments that differed more in loudness.
- So, between vowels, quieter ( $\approx$ less sonorous) consonants should yield more distinct length contrasts.
- The predicted relationship between sonority and geminate markedness is supported by Podesva's (2000, 2002) survey of 52 languages (cf. Kawahara 2005):

## Typology of C length contrasts

- Implicational hierarchy for geminates:  
glides → laterals → nasals → stops

Example languages	Nasals	Liquids		Glides
		Lateral s	Rhotics	
Finnish, Hindi, Icelandic, etc	✓	✓	✓	*
Biblical Hebrew, Wolof	✓	✓	*	✓
Selkup, Yakut, Fula	✓	✓	*	*
Chaha, Japanese, Luganda	✓	*	*	*
!Xoo	*	*	*	*

## Typology of C length contrasts

- Implicational hierarchy for geminates:  
glides → laterals → nasals → stops
- Approximately: more sonorous geminates imply less sonorous geminates
- Rhotics do not fit neatly in this hierarchy.
  - Rhotics are diverse in their intensity characteristics.
  - The geminate counterpart of tap [R] is generally a trill [r], which is not simply a lengthened tap, and so may be subject to independent constraints (cf. Kawahara 2005).
- \*GG >> \*LL >> \*NN >> \*ObsGem

## Distinctiveness of C length contrasts

- There is no implicational relationship between geminate fricatives and nasals although fricatives are lower in sonority.
  - Fricative has less abrupt onset/offset ?
  - Kirchner (1998) argues that geminate fricatives are high effort segments.
- There are also processes eliminating sonorous geminates and blocking their creation (Podesva 2000, Kawahara 2005).



## Distinctiveness of C length contrasts

- Luganda - class 5 augmentative prefix causes gemination

/μ+kubo/	→	[ <u>kk</u> kubo]	‘path’
/μ+tabi/	→	[ <u>tt</u> abi]	‘branch’
/μ+bala/	→	[ <u>bb</u> ala]	‘spot’
/μ+daala/	→	[ <u>dd</u> aala]	‘step’
/μ+sajja/	→	[ <u>ss</u> ajja]	‘man’
/μ+fumu/	→	[ <u>ff</u> umu]	‘spear’
/μ+zike/	→	[ <u>zz</u> ike]	‘chimpanzee’

(2) Occlusivization of geminate approximants in LuGanda

a. *ll* → *dd*

/μ-langa/ → [ddaanga] 'lily'

/μ-lenzi/ → [ddenzi] 'boy'

b. *yy* → *ʃʃ*

/μ-yinga/ → [ʃʃinga] 'stone'

/μ-yembe/ → [ʃʃembe] 'mango'

c. *ww* → *gg<sup>w</sup>*

/μ-wanga/ → [gg<sup>w</sup>aanga] 'nation'

/μ-wala/ → [gg<sup>w</sup>awla] 'girl'

(3) LuGanda occlusivization

/μ+langa/	*GG	*LL	IDENT(CONT)	*OBSGEM
a. [llaanga]		*!		
b. [ddaanga]			*	*

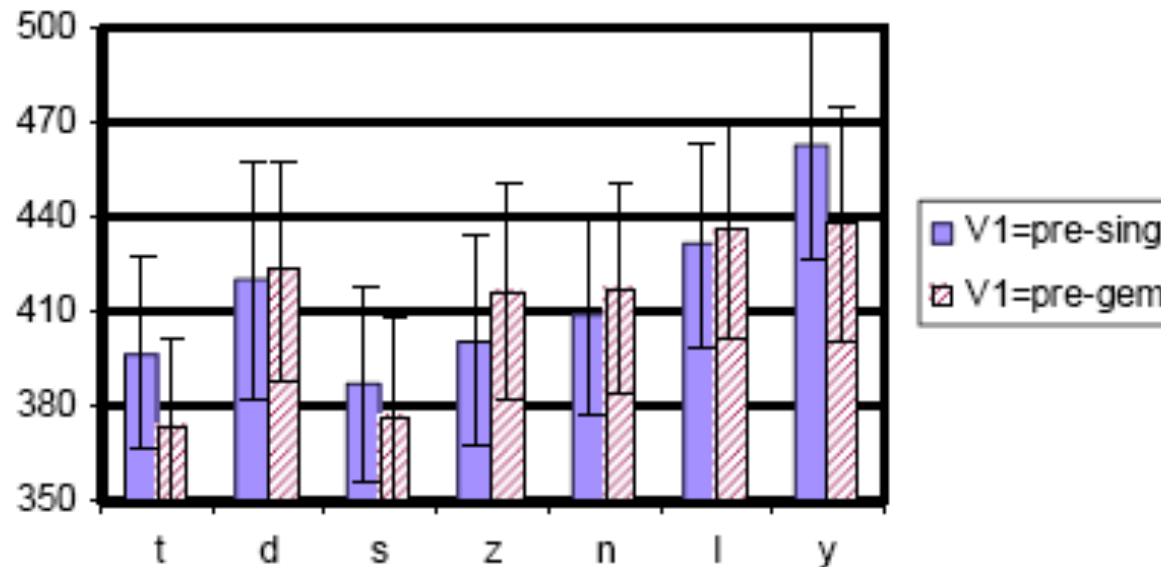
# Distinctiveness of C length contrasts

- Kawahara (2005) provides experimental evidence that the distinctiveness of duration contrasts does depend on consonant manner.
  - Identification task: singleton vs. geminate.
  - 17 Arabic-speaking subjects.
  - Stimuli based on Arabic geminates [tt, dd, ss, zz, nn, ll, jj] in a [ha\_ag] frame.
  - For each consonant type, initial [ha-] taken from one of two utterances, one pre-geminate, one pre-singleton (minimal differences in duration of the vowels).
  - Remainder of word extracted from representative geminate of each consonant type, close to mean duration observed in production study.
  - Duration continuum constructed by deleting 12 ms increments from steady state of geminate constriction.
  - 10 step continuum
  - Production study indicated that all types of geminates are ~120ms longer than contrasting singleton, so the continuum spanned the range from mean singleton duration to mean geminate duration.

# Kawahara (2005) - perception of length contrasts

## Results: Reaction times

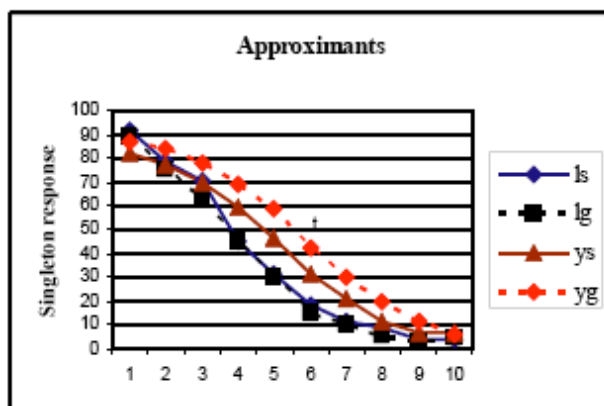
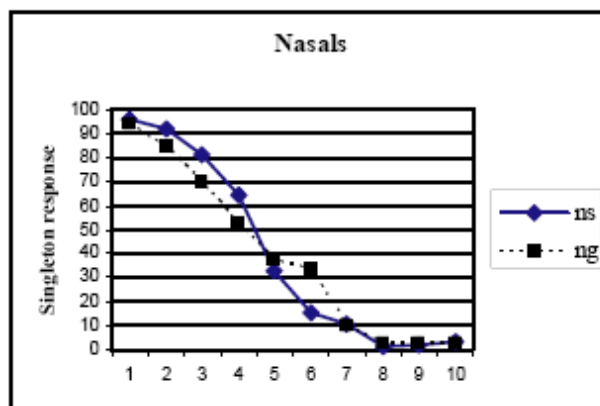
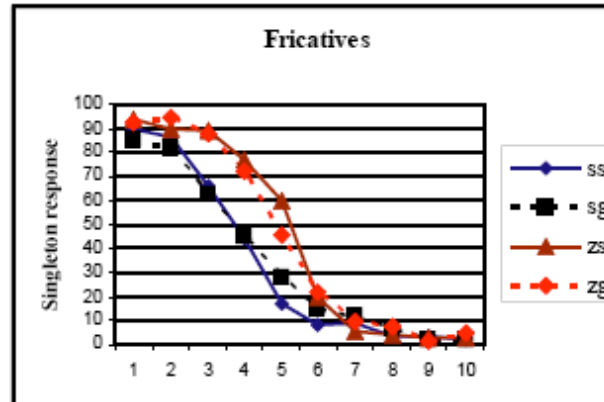
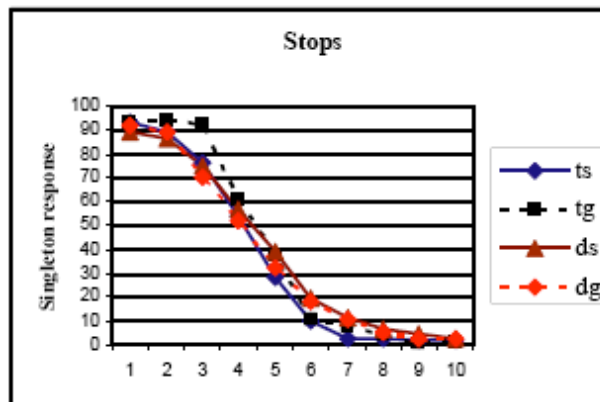
- Previous studies have shown that reaction times in identification and discrimination tasks are generally slower where the perceptual distance between stimuli (or between stimulus and category boundary) is smaller (Pisoni and Tash 1974, Ashby, Boynton & Lee 1994).
- Judgments were generally slower for higher sonority consonants, but voiced obstruents were comparable to nasals:  $y > l > n, d, z > t, s$



# Kawahara (2005) - perception of length contrasts

## Results: Identification functions

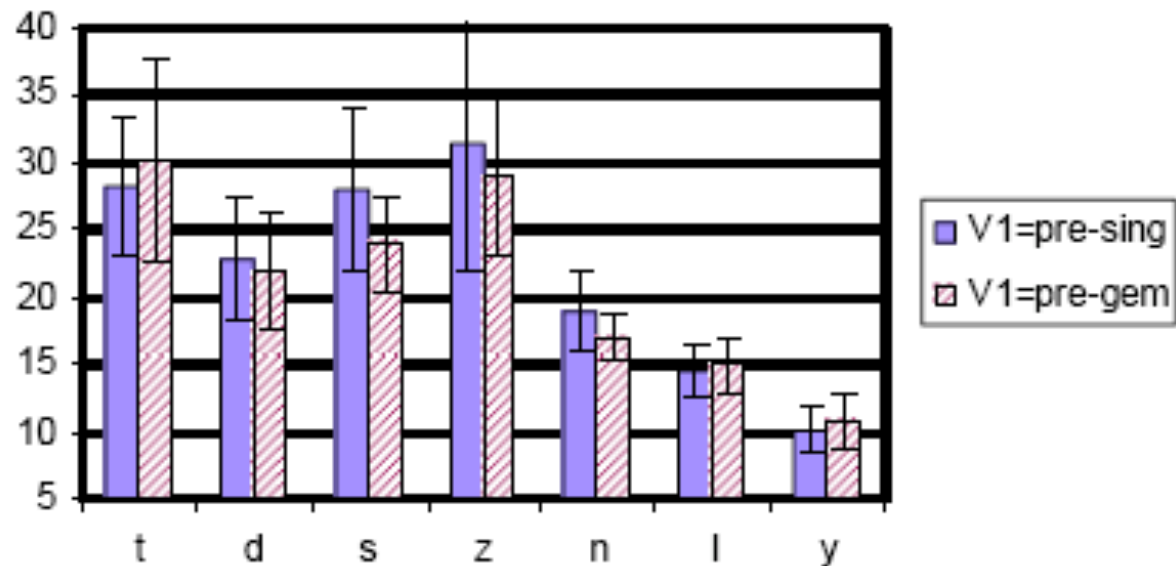
- If length contrast is more perceptually distinct then more of the duration continuum should be consistently categorized as singleton or geminate. I.e. transition in identification function should be steep.



# Kawahara (2005) - perception of length contrasts

## Results: Identification functions

- If length contrast is more perceptually distinct then more of the duration continuum should be consistently categorized as singleton or geminate. I.e. transition in identification function should be steep.
- Quantified as slope joining last point above 80% and last point above 10%.
- Slopes are generally shallower for more sonorous consonants, but now [z] patterns with voiceless obstruents ( $d > n > l > y$ ).



## The distribution of length contrasts

- Preference for clear ‘landmarks’ at segment edges implies constraints on the distribution of length contrasts. Transitions to neighbouring segments should yield abrupt changes in loudness.
  - Vowels should provide the best environment for perception of consonant duration.
  - Stop offset is optimally marked where a clear release burst is realized (generally before vowels, liquids).

## The distribution of length contrasts

- Ancient Greek, Latin, Hindi and Malayalam restrict geminates to intervocalic position
  - the first two allow singleton stop-liquid clusters (McCrary 2004).
- Hungarian: Length contrasts are permitted intervocalically and word-finally (Siptár and Törkenczy 2000). ('fake' geminates below).
- Finnish allows length contrasts between [+son]\_V (C[+son] onset clusters are not permitted).
- Thurgovian Swiss German: Stop length contrasts permitted between sonorants (Kraehenmann 2001).



## The distribution of length contrasts

Hungarian ‘fake’ geminates (Siptár and Törkenczy 2000):

- Mainly obstruents.
- Likelihood of degemination increases as sonority of adjacent consonant decreases (see Côté 2000 for related discussion).

### DEGEMINATION OF FAKE LEFT-FLANKED GEMINATES:

a. In compounds:

O-	<i>direkttermő</i>	[direkt(:)ɛrmø:]	‘a type of wine’	degemination
N-	<i>csonttányér</i>	[tʃont(:)a:nle:r]	‘bone plate’	less
L-	<i>talppont</i>	[tɒlp(:)ont]	‘foot-end’	↓ likely

### DEGEMINATION OF FAKE RIGHT-FLANKED GEMINATES:

a. In compounds:

-O	<i>kisstíllő</i>	[kiʃ(:)ti:ly:]	‘petty’	degemination
-N	<i>őssminő</i>	[öʃ(:)minj]	‘proto-make-up’	less
-L	<i>széppróza</i>	[sɛ:p(:)ro:zɔ]	‘prose fiction’	↓ likely

## The distribution of length contrasts

- Most Italian length contrasts are restricted to V\_V, but the lowest intensity geminates, stops and [f] are permitted in V\_L.
- Liquids allow for more abrupt loudness change than less sonorous consonants. Clear stop burst can be realized with following liquid.
- Asymmetry between L\_V and V\_L:
  - Stops: clear release burst is possible with following liquid. A preceding liquid results in a less abrupt decline in intensity than a preceding vowel.
  - Source of asymmetry with [f] is less obvious.
  - McCrary suggests that V\_L may provide the advantage of pre-vocalic duration as an additional cue (cf. Esposito and Di Benedetto 1999).

## The distribution of length contrasts

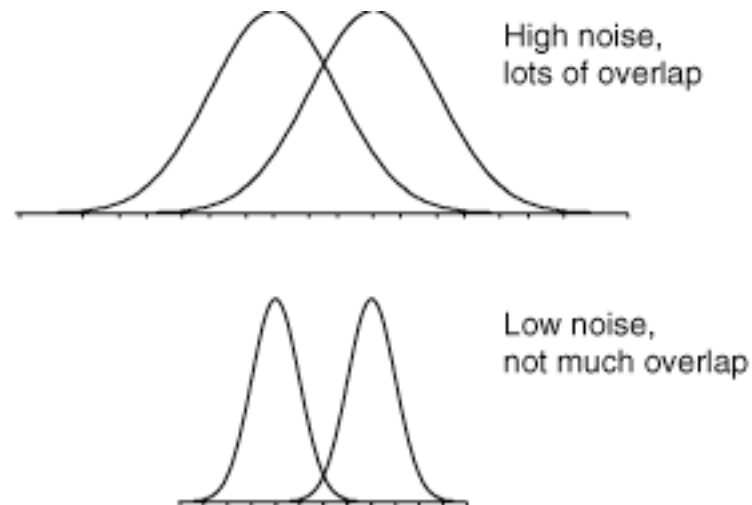
- The distribution of geminates is unlikely to be explained via constraints on syllabification.
- E.g. geminates must be parsed into coda and onset positions, so:
  - $C_1:C_2$  is acceptable only if  $C_1C_2$  is an acceptable onset:  $-C_1.C_1C_2-$
  - $C_1C:2$  is acceptable only if  $C_1C_2$  is an acceptable coda:  $-C_1C_2.C_2-$
- Approximately correct for Italian: according to standard analyses, TL is a good onset, but LT is not a good coda.

But:

- In Italian, TN is also a good onset, but  $*-VTTNV-$  (McCrary 2002).
- Will not generalize to Latin, Greek, where TL is a good onset, but geminates are restricted to intervocalic position.
- Will not generalize to Hungarian word-final geminates.

## Distinctiveness of length contrasts

- Restriction of length contrasts to V\_V, V\_L reflects greater distinctiveness of duration differences in these contexts.
- The distinctiveness of two categories depends not only on the perceptual distance between their central values, but also the range of variation in each category (due to production or perception).
- In signal detection theory, variability plays a central role in the measure of perceptual distance (or sensitivity),  $d' = \text{separation} / \text{spread}$ .
- Uncertainty about segment edges results in variable estimates of duration.




# Formalizing distinctiveness of length contrasts


- A simple interpretation of the Podesva/McCrary/Kawahara account of the distinctiveness of length contrasts:
  - The level of noise in the perception of onset and offset time depends on the rapidity of the change in loudness.
  - The variance in the percept of duration is the sum of the variances (due to noise) in the perception of the edges.
  - The distinctiveness of a duration contrast is the duration difference divided by the variance of noise in duration perception.
- In effect, perceived duration differences are divided by a variance factor that depends on the manner of the segment and the context.
  - e.g. T/V\_V 1, T/V\_L 1, T/L\_V 1.2
- Mindist constraints refer to effective duration difference.

# Formalizing distinctiveness of length contrasts

- Realization: /alpa/ -> 100ms  
               /alppa/ -> 200 ms  
               /alPa/ -> 150 ms

	/alPa/	Dur $\leq$ 200 ms	Dur $\geq$ 100 ms	Dur = 150 ms
a.	 150			
b.	100			*!

evaluation  
of surface  
contrasts

	/alpa, alppa/	Mindist = 100	Maximize Contrasts
a.	100-200	100/1.2*!	
b.	 150		*

## Analysis of Italian

- A constraint against geminates in L\_V is not sufficient, because the shortest consonants do not occur in this environment either - we find medium length consonants.
- Without distinctiveness constraints:
  - \*T/L\_V
  - \*T:/L\_V
  - \* T>/V\_[+son, +cont]
- No broader motivation for these constraints
- Predicts that lengthening of stops in L\_V (compared to V\_V, V\_L) is independent of length contrasts.

# Components of a stop

