

# Origins and development of the Speech Learning Model

James E. Flege

*Univ. of Alabama at Birmingham*

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# Outline

1. Purpose of the Speech Learning Model (SLM)
2. Historical background
3. Core aspects of the SLM
4. Some testable predictions generated by the SLM
5. How to falsify the SLM
6. What is most needed now?

# Outline

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# SLM Purpose

- To account for how individuals learn – or fail to learn – to produce and perceive phonetic segments (vowels, consonants) in a second language

# SLM Purpose

- Focus on question such as:
  - Are certain L2 speech sounds not learnable?
  - learnable just by children?
  - What about the perception of speech sounds?

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# Zeitgeist: 1979-1984

- Critical Period hypothesis
- Contrastive Analysis hypothesis
- Focus on abstract linguistic units, not phonetic substance
- Categorical Perception/filtering via the phonological “grid”
- Unidirectional L1 → L2 interference

# Critical Period Hypothesis (CPH)

- **Lenneberg (1969)** proposed that as humans mature neurologically, ability to learn the L1 diminishes
- Lenneberg casually observed that it is difficult to learn to pronounce an L2 w/o foreign accent after the age of 12 years
- This remark triggered extension of CPH from L1 to L2

# Doubts re: CPH

- Certainly true that “earlier is better”
- However, no objective evidence existed for
  - A sharp drop in L2 learning success at a particular age (say, 12 years)
  - Success for all children
  - Failure for all adults

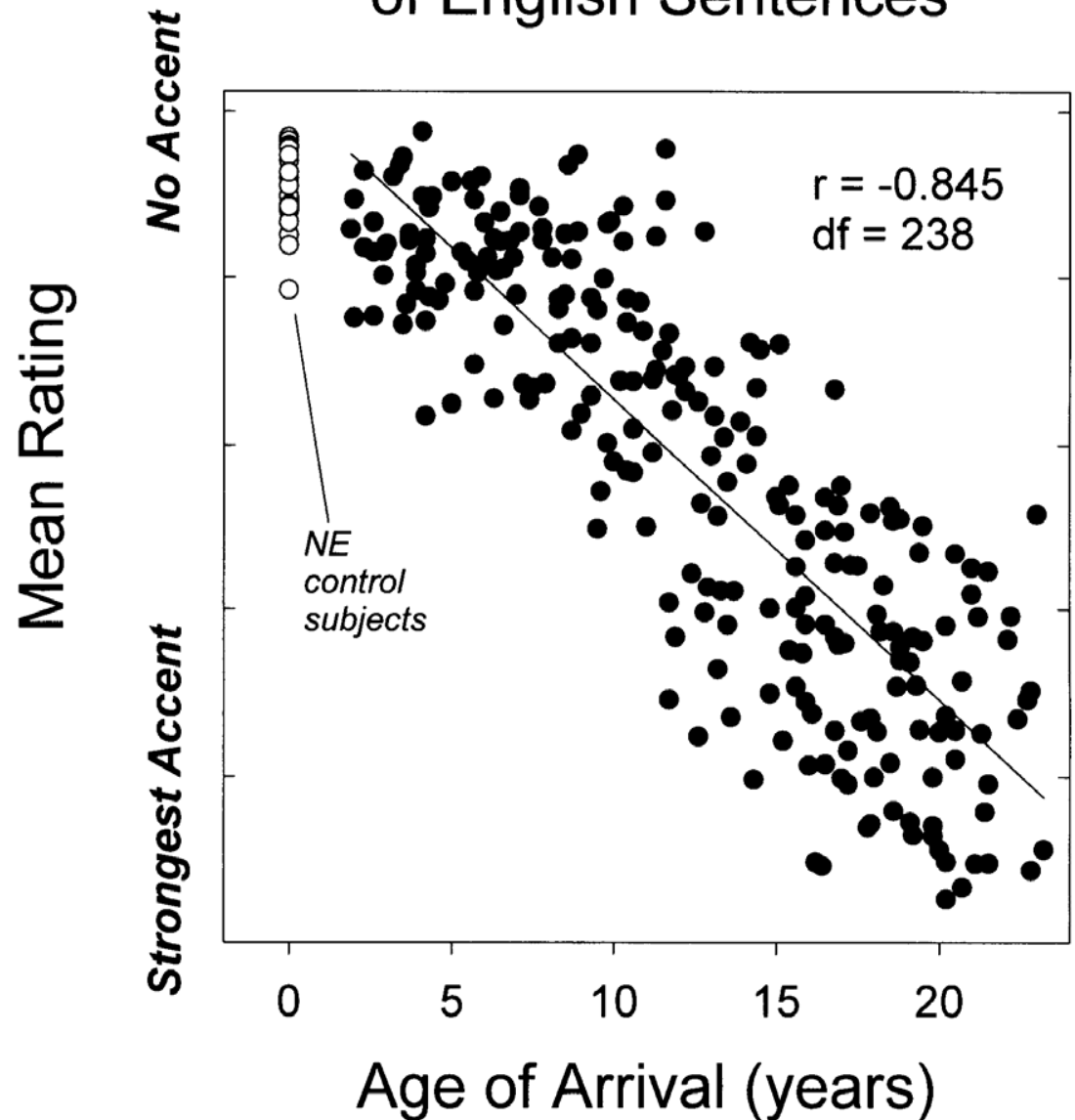
# Doubts re: CPH

## **Subsequent empirical research failed to sustain CPH predictions**

- Two studies examined large ( $n = 240$ ) groups of immigrants to North America
- Adults stratified by AOA
- Sentences rated for foreign accent by native English listeners

Flege et al. (1995)

## 240 Native Italian Ss' Production of English Sentences



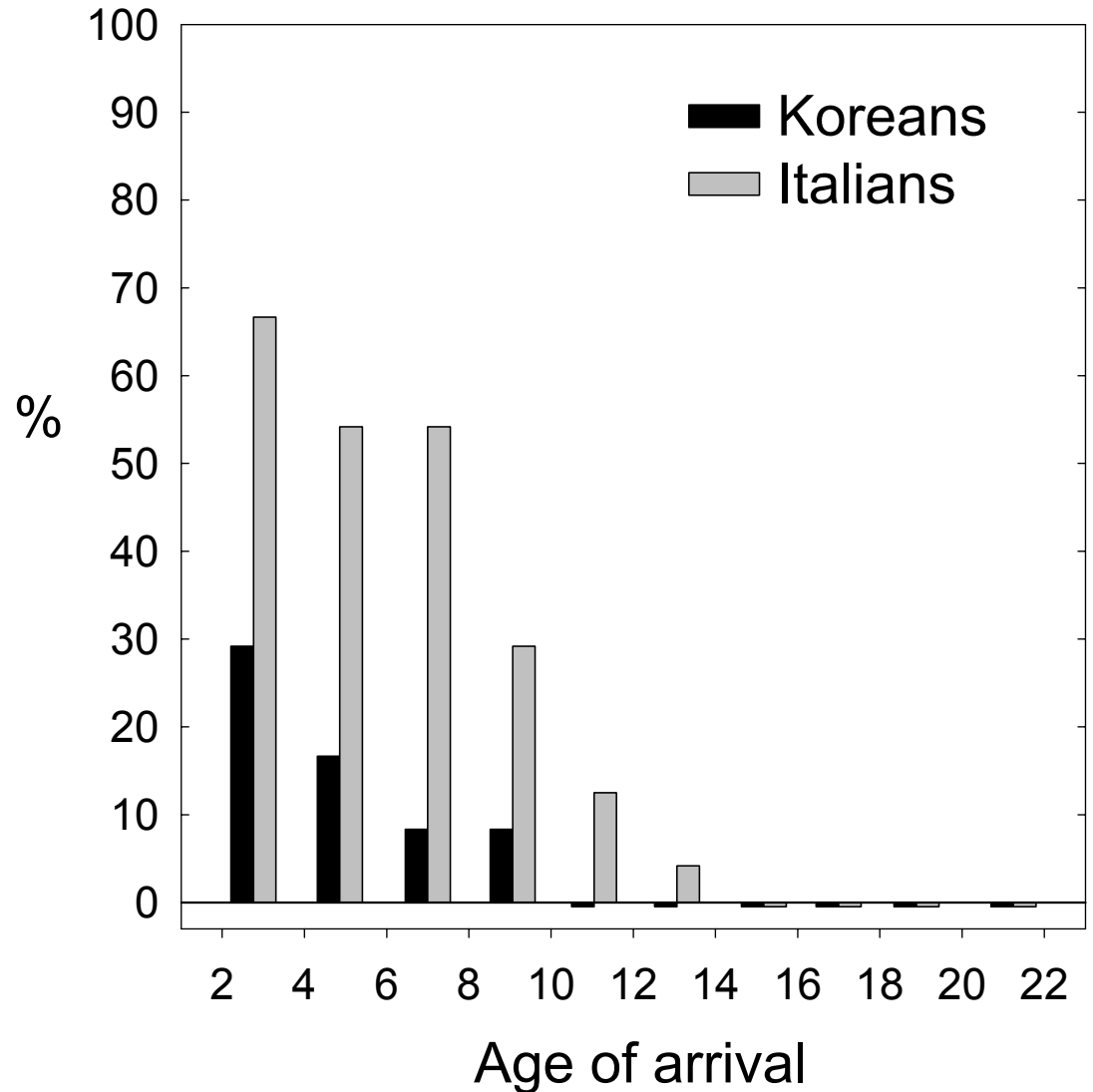


## Index of “accent free”

- Did individual nonnative speaker obtain a rating within 2 SDs of mean rating obtained for NE group

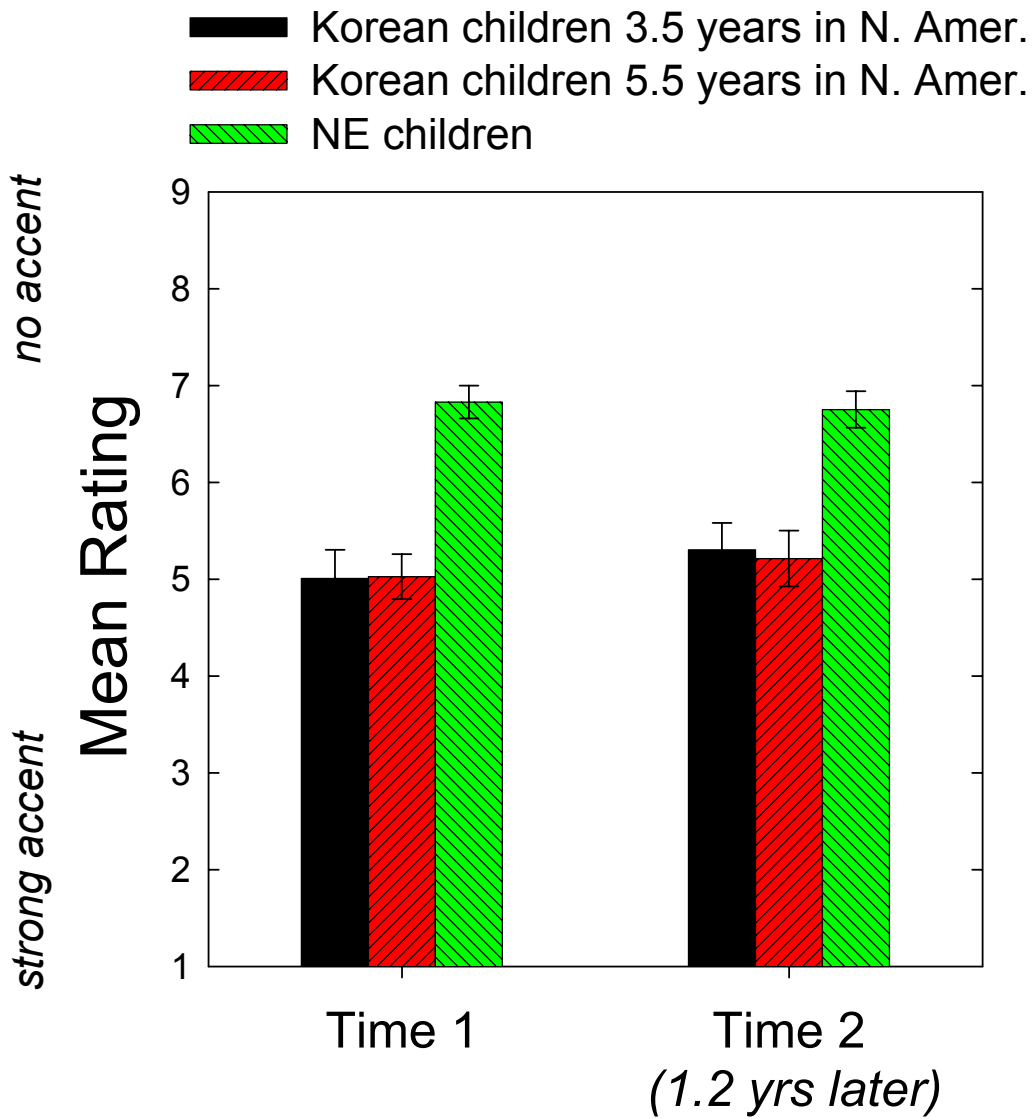
Flege et al.  
(1995, 1999)

% of immigrants (n = 24 per AOA group)  
who spoke English w/o foreign accent



# Doubts re: CPH

- Flege et al. (in press)
- Evidence of foreign accent in children currently learning an L2



Flege et al. (in press)

Analysis of subgroups

- 10-year-old Koreans who arrived at the age of 6 received significantly lower ratings than NE 10-year-olds

## Conclusions re: CPH

- Many (most?) children speak their L2 with a FA, even after long-term immersion
  - inconsistent with CPH
- Most adult L2 learners speak with a FA
  - consistent with CPH
- However, work by [Bongaerts et al.](#) has demonstrated that some adult L2 learners manage to speak without FA

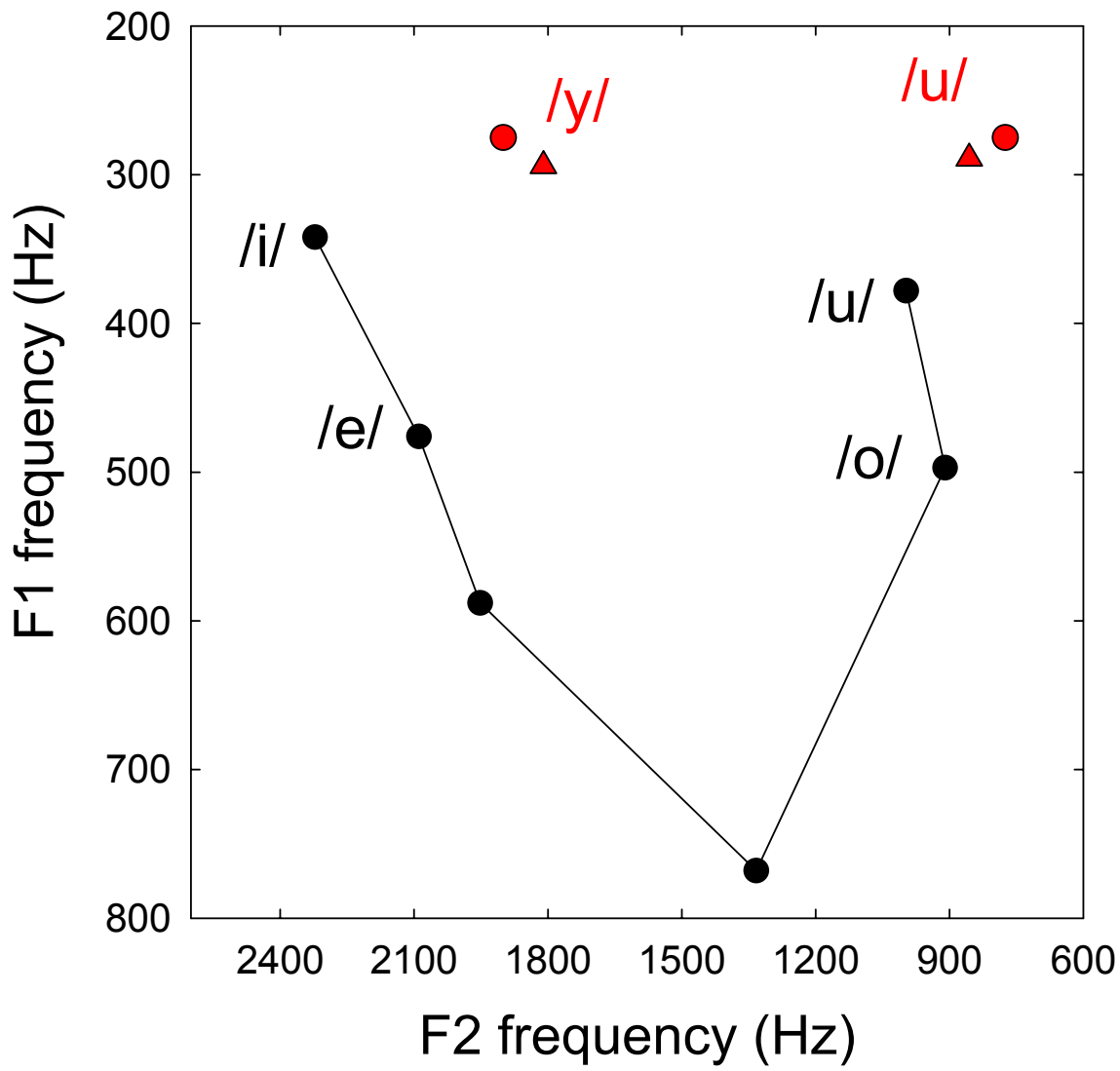
# Contrastive Analysis (CA) hypothesis

- In 1979-1984, most L2 research framed in terms of CAH, which claimed that
  - L2 phonemes that are similar to L1 phonemes will be “easy”,
  - L2 phonemes that are different from L1 phonemes will be “hard”
- Interference: what you already know in L1 will hurt you (when learning L2)

# Doubts re: CAH

- Flege (1987) examined English speakers' production of French /y/ and /u/
- Both vowels heard as English /u/ (Rochet) even though
  - English /u/ is more fronted than French /u/ (higher F2)
  - French /y/ is “radically different” from any English vowel, and so “new” (Delattre, 1964, p. 83)

- French values (Delattre)
- ▲ French values (Debrock & Forrez)
- English vowels (Hillenbrand et al. (1995))



## Flege (1987)

Tested 3 groups of native English women

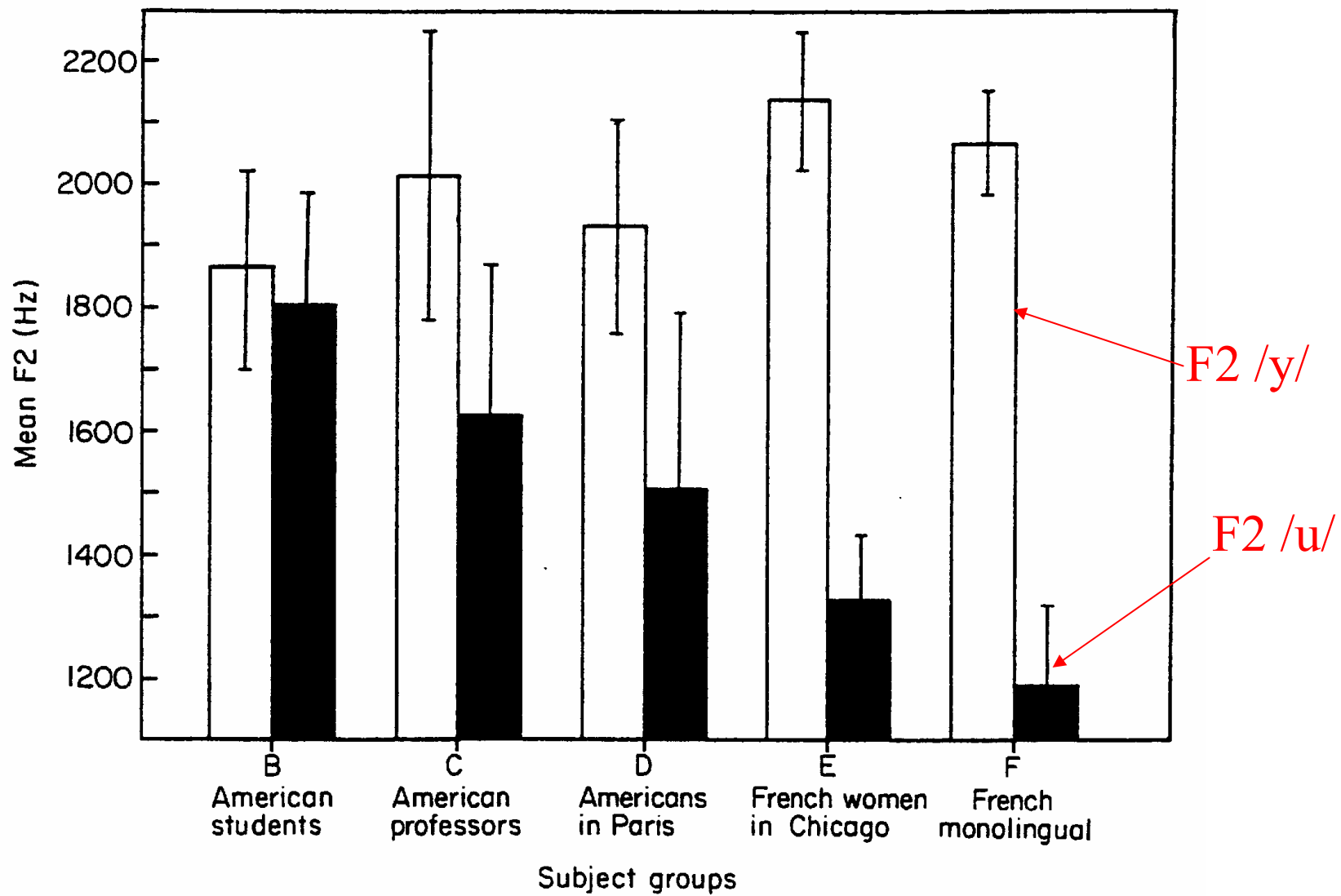
**Group B:** American college students, just returned from 9 months in Paris

**Group C:** Americans with advanced degrees in French, taught French at American university

**Group D:** Americans who lived in Paris for  $M = 10$  years

... and 2 groups of native French women

- Group B:
- Group C:
- Group D:
- Group E: lived in Chicago for  $M = 10$  years
- Group F: French monolinguals in France



## Flege (1987)

- All three NE groups (B, C, D) produced French /u/ with significantly higher (“fronted”) F2 values than French monolinguals
- No NE group differed significantly for the “new” French vowel, /y/

## Conclusions re: CAH

- dissimilar “new” French vowel produced better than a French vowels that differed from an English counterpart
- Opposite of the CA

# Abstract linguistic analyses

- In 1979-1984, widely believed that learners perceive L2 sounds through the grid of the L1 “phonology” (Trubetzkoy)
- Hear/produce L2 phonemes as if they were L1 phonemes (“new wine in old bottles”)

# **Abstract linguistic analyses**

- Phonemes described as bundles of commutable, distinctive features
- Not possible to learn to use “new” features not employed in L1

# Doubts re: abstract analyses

Production of English /p/ by native speakers of Arabic (Flege & Port, 1981)

## Flege & Port (1981)

- Arabic has /b/, /d/-/t/ and /k/ phonemes  
(no /p/ or /g/)
- Logically, Arabic must have [voicing] and [place] features for stops
- Should be able to produce English /p/ by re-combining L1 [voicing] and [place] features

## Flege & Port (1981)

- However, Arabic adults at Indiana University produced /p/ with glottal pulsing
- Result: their /p/s heard as /b/
- **Conclusion:**
  - Didn't re-combine abstract features
  - Their problem seemed to be learning new phonetic segments
  - a phonetic problem, not a phonological one

# Doubts re: abstract analyses

- McAllister, Flege & Piske (2002) examined production & perception of a new feature needed to distinguish Swedish vowels, [length]
- Native English and Spanish Ss (> 10 years in Stockholm)
- [length] not used to distinguish vowel phonemes in their L1

## McAllister, Flege & Piske (2002)

examined 4 Swedish long-short vowel contrasts examined

- mid vowels – almost exclusively duration
- High/low vowels – duration and spectral quality differences

## McAllister, Flege & Piske (2002)

### Participants:

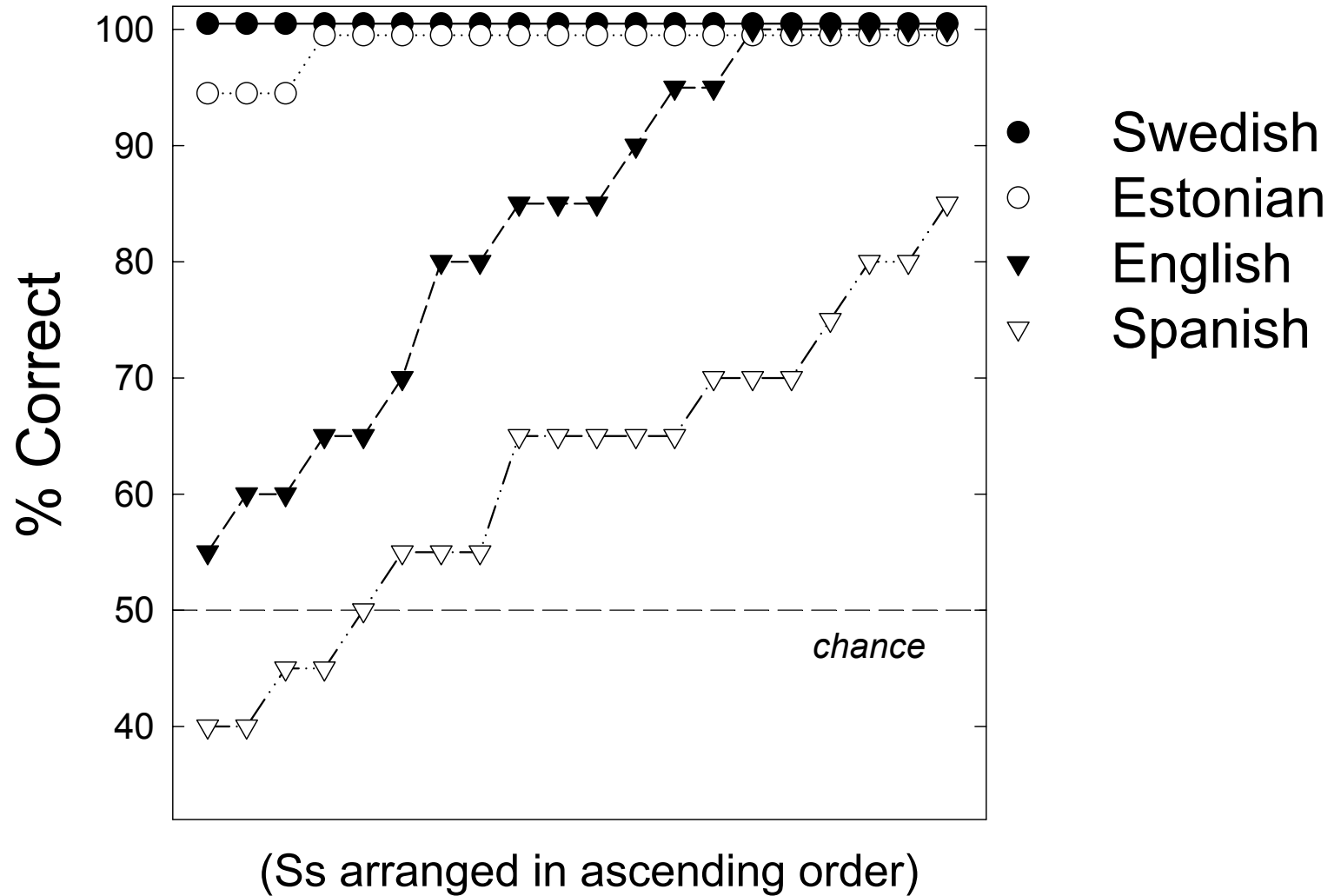
- 20 native speakers each of Swedish, English and Spanish
- 20 Estonians included as control because [length] used to distinguish Estonian vowels

# McAllister, Flege & Piske (2002)

## Stimuli:

- naturally produced Swedish words containing long or short vowels
- Productions of same stimuli in which quantity was modified (long → short, short → long), making non-words
- Task: decide if each stimulus was produced “correctly”

# Contrast between /ø/-/ø:/'

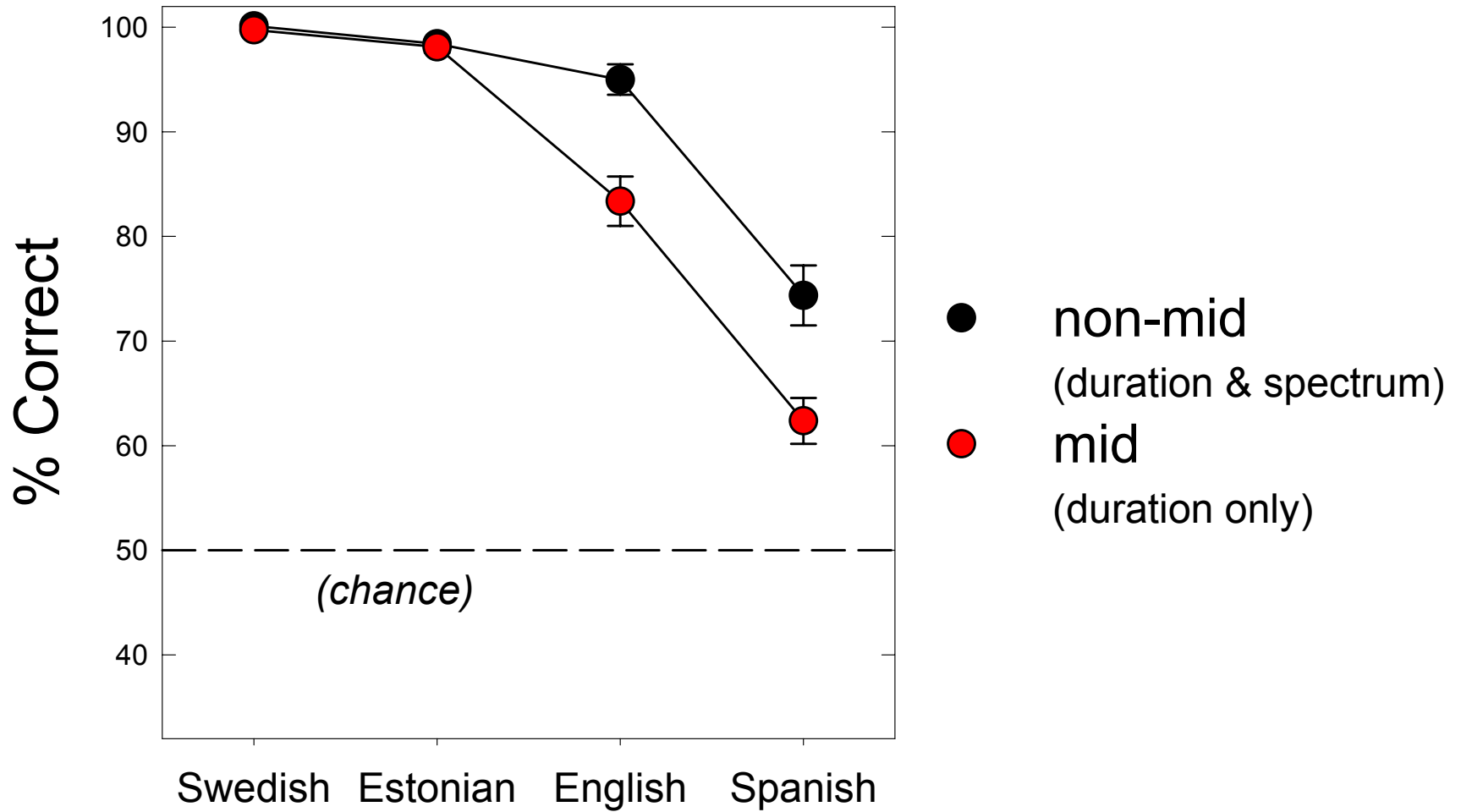


# McAllister, Flege & Piske (2002)

## Separate analyses for

- **mid vowel pairs** (contrasts based almost entirely on duration)
- **high and low vowel pairs** (contrasts based on duration & spectral quality)

# McAllister, Flege & Piske (2002)



## McAllister et al. (2002) **conclusions**

- Estonians benefited from the presence of a [length] feature in their L1
- Native English & Spanish Ss did better for Swedish long-short contrasts when a feature exploited by L1 (vowel spectrum) could be used
- Evidence for difficulty of a new feature

## McAllister et al. (2002) **conclusions**

However

- Above-chance performance of most native English & Spanish Ss
- Excellent performance of some native English

# Doubts re: abstract analyses

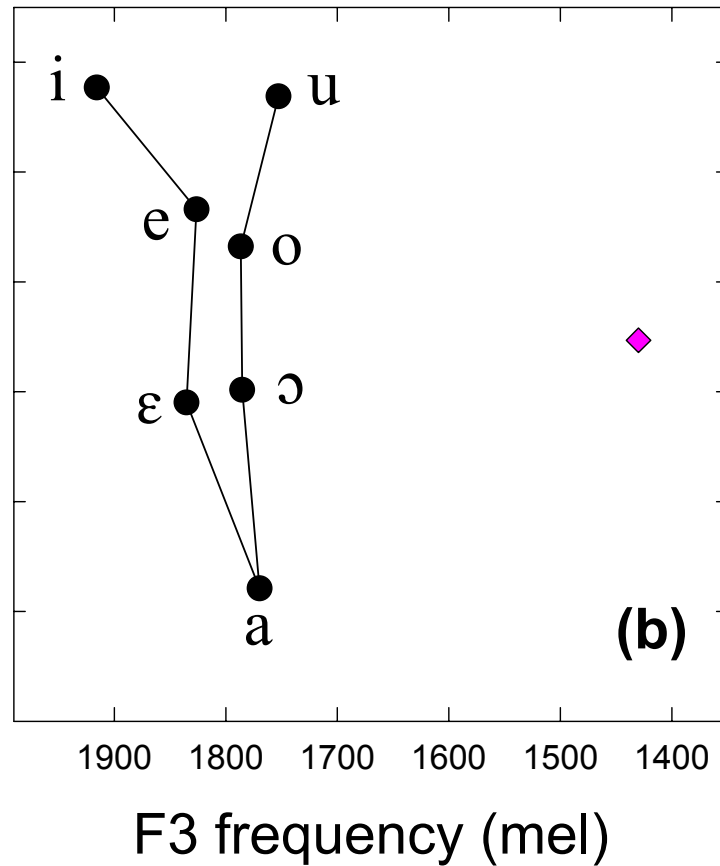
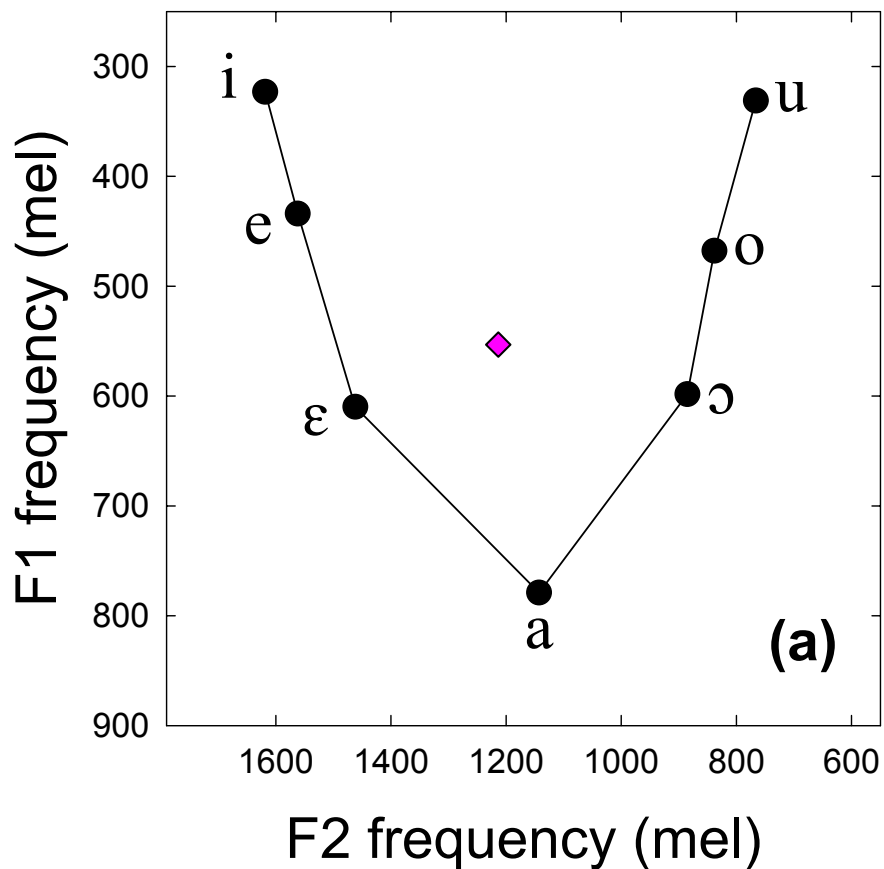
Research examining native Italian speakers' production of English /ə<sup>v</sup>/

- Munro, Flege & MacKay (1996)
- Flege, Schirru & MacKay (2003)
- Flege & MacKay (2004)

# Doubts re: abstract analyses

- English /ɚ/ very dissimilar from any Italian vowel
- Perceptual assimilation (Flege & MacKay, 2004)
- Also shown by acoustic analysis

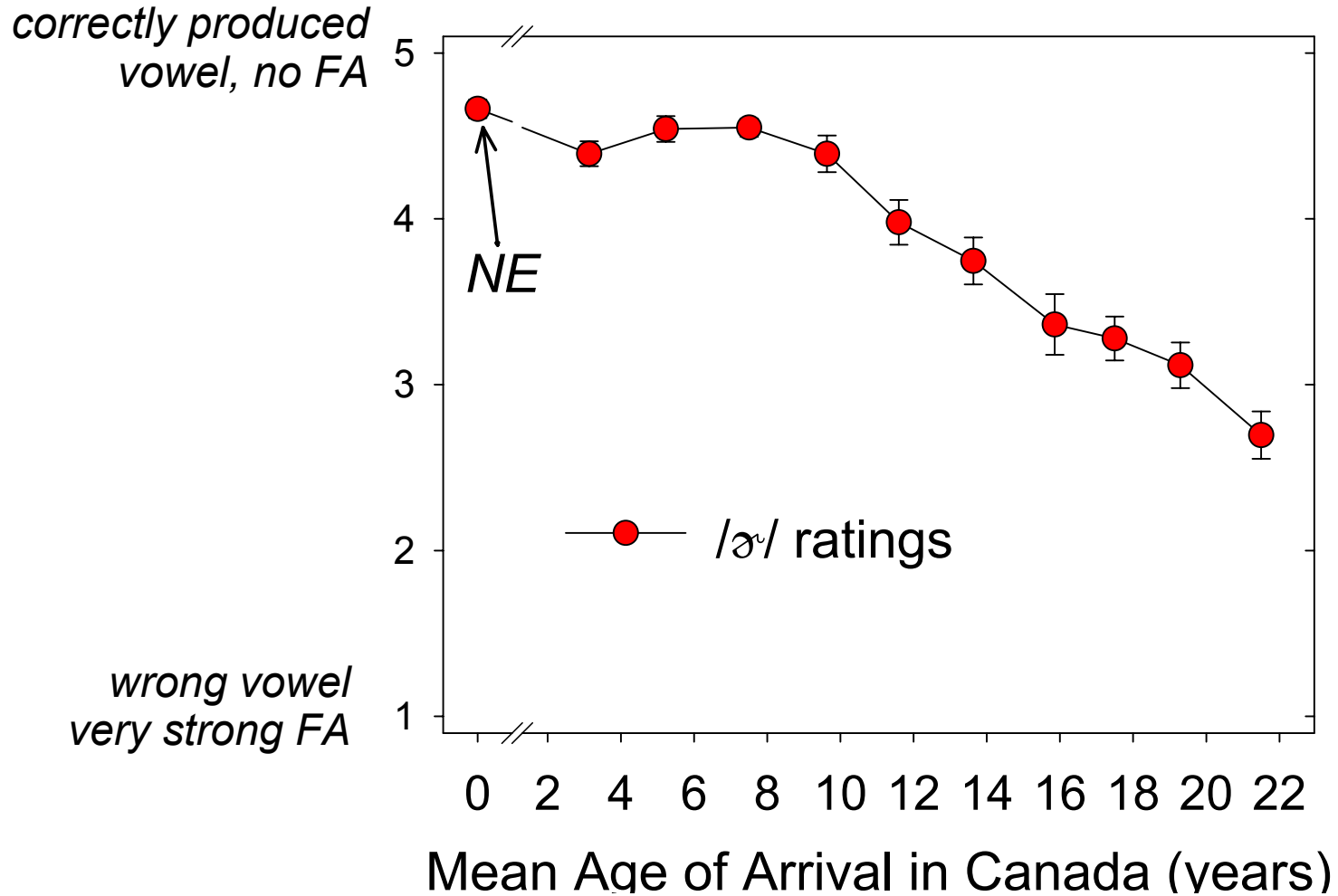
● Italian vowels  
◆ English /ə/



## Munro, Flege & MacKay (1996)

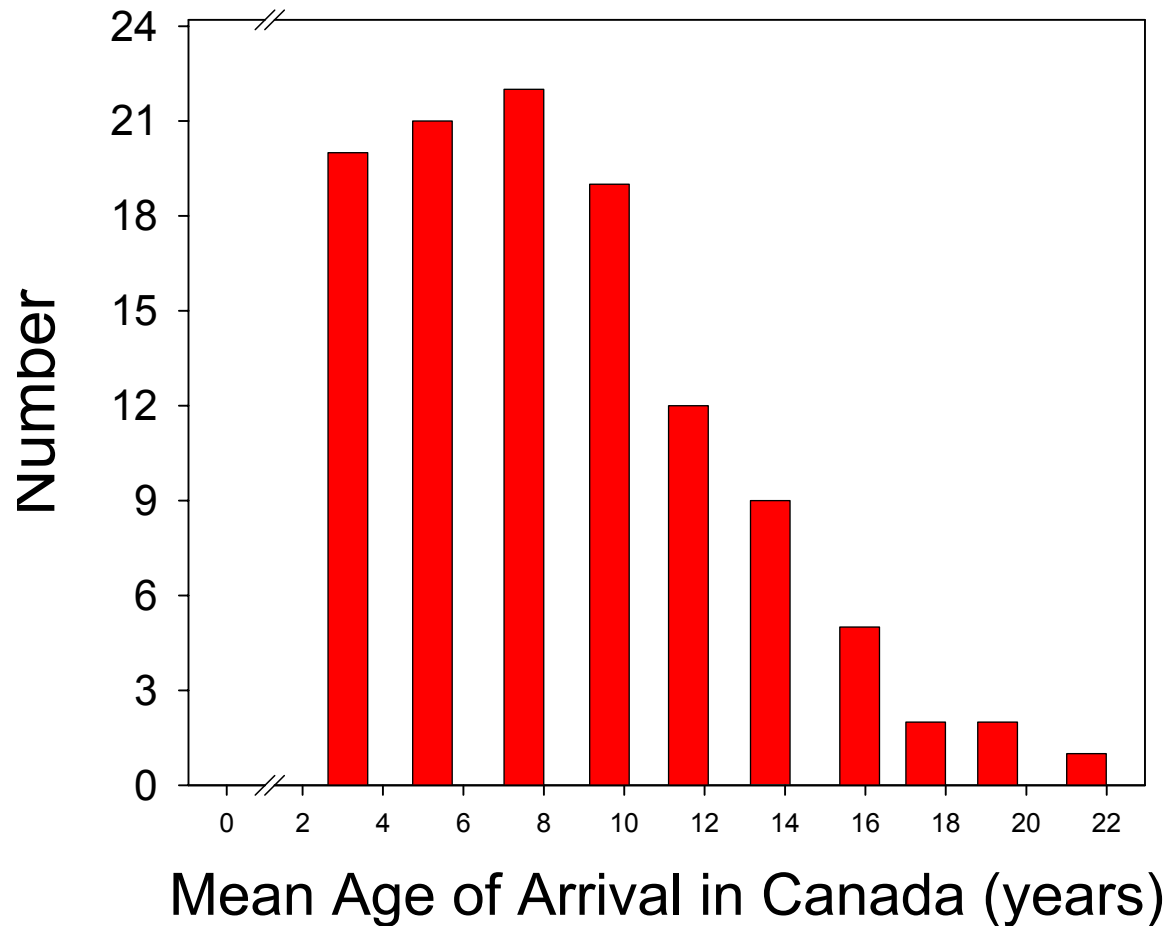
- 240 Italian immigrants
  - Differed in age of arrival
  - Many years of residence in Canada
- Delayed repetition of English words
- Vowels rated by listeners, 5-point scale

# Munro et al. (1996)



# Munro et al. (1996)

N per group (max = 24) whose /æ/ received a rating within 2 SD of NE mean



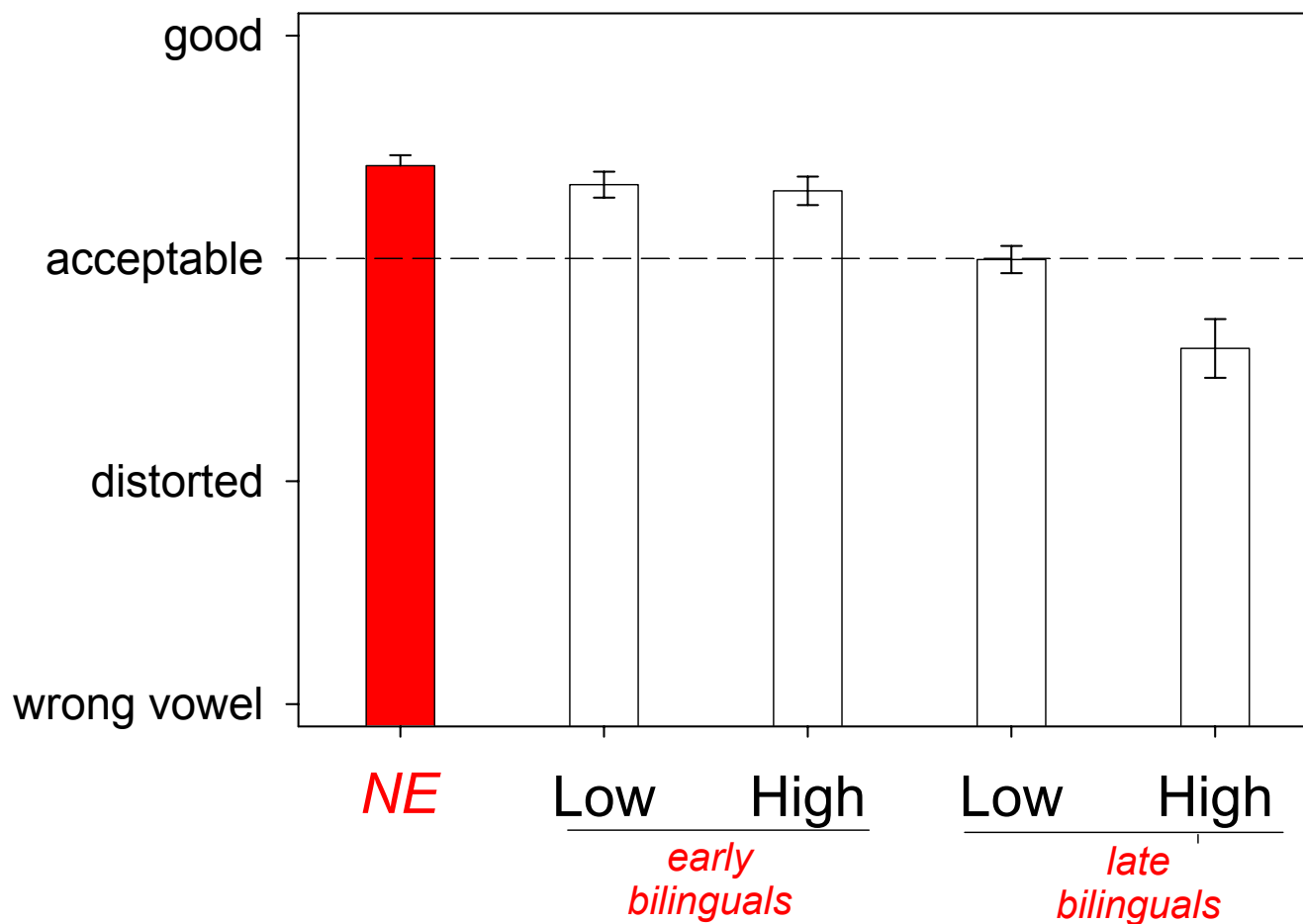
## Flege, Schirru & MacKay (2003)

Examined /ə̃/ produced by 5 groups (n=18 each)

- Native English
- 2 group of Italian early learners (differed in amount of Italian use, 7% vs. 43%)
- 2 groups of late learners (10% vs. 53%)

# Flege et al. (2003)

## Mean ratings of /æ/ production



## Flege, Schirru & MacKay (2003)

- In both parametric, non-parametric analyses

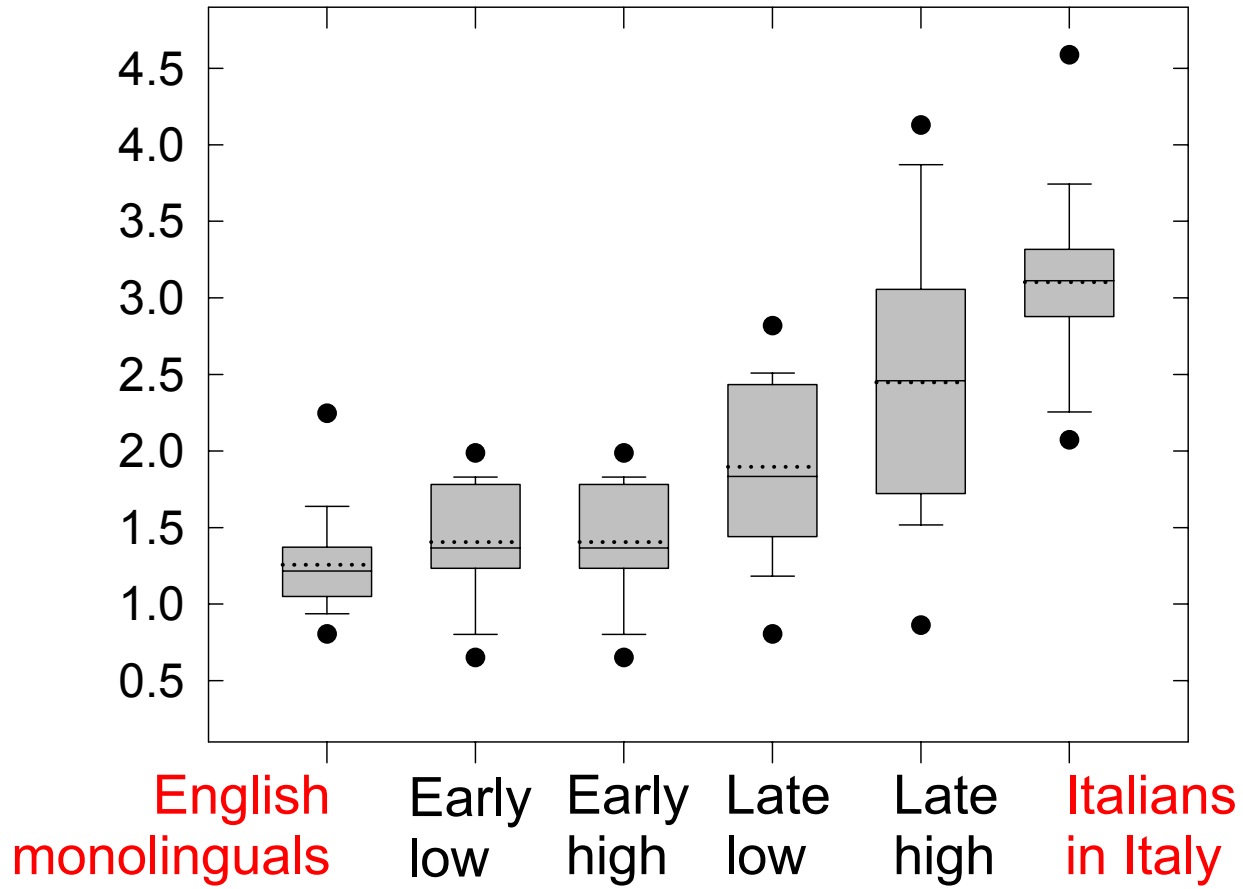
NE > late but not early learners

- Perhaps “no new feature” ([rhotic]) applies just to late learners

## Flege, Schirru & MacKay (2003)

- Acoustic analysis, however, suggested that late learners do acquire sensitivity to [rhotic] feature
- Examined Bark-transformed  
F3-F2 differences: index of [rhotic]

# F3-F2, Barks (index of rhotic dimension)



## Flege, Schirru & MacKay (2003)

- Late bilinguals produced significantly larger F3-F2 differences (less “rhotic” vowels) than early bilinguals

## Flege, Schirru & MacKay (2003)

However ...

- Late bilinguals produced significantly smaller F3-F2 differences (more “rhotic” vowels) than Italian monolinguals
- Indicated that late bilinguals acquired sensitivity to [rhotic] feature
- Some individual late learners native-like

# Conclusions re: abstract analyses

Both early and late learners can gain access to features not used to contrast L1 phonemes

# Categorical perception

- a) Used in most cross-language perception research in 1979-1984
- b) Physically different tokens of a single phoneme in the L1 not discriminated (e.g., English [t] tokens having VOT values of 25 and 65 ms)

# Categorical perception

- c) If L2 sound heard as an instance of an L1 phoneme, despite physical differences, then detectable acoustic-phonetic differences might be perceptually “filtered out”

# Categorical perception

If L1-L2 differences filtered out, and if L2 production limited by perceptual accuracy, then L2 sounds differing from L1 sounds can never be produced accurately

The “doom” scenario

# Doubts re: applying tenets of categorical perception to L2 speech learning

Evidence has long existed that, for monolinguals hearing stimuli drawn from their L1, within-category phonetic information is

“...available to listeners, although the retrieval of this information ... will depend on the level of processing ...” (Pisoni & Tash, 1974)

# Doubts re: Categorical Perception

Research suggests that application of the L1 phonological “grid” to L2 speech via categorical perception does not cause L2 learners to filter out cross-language phonetic differences

*Flege (1984)*

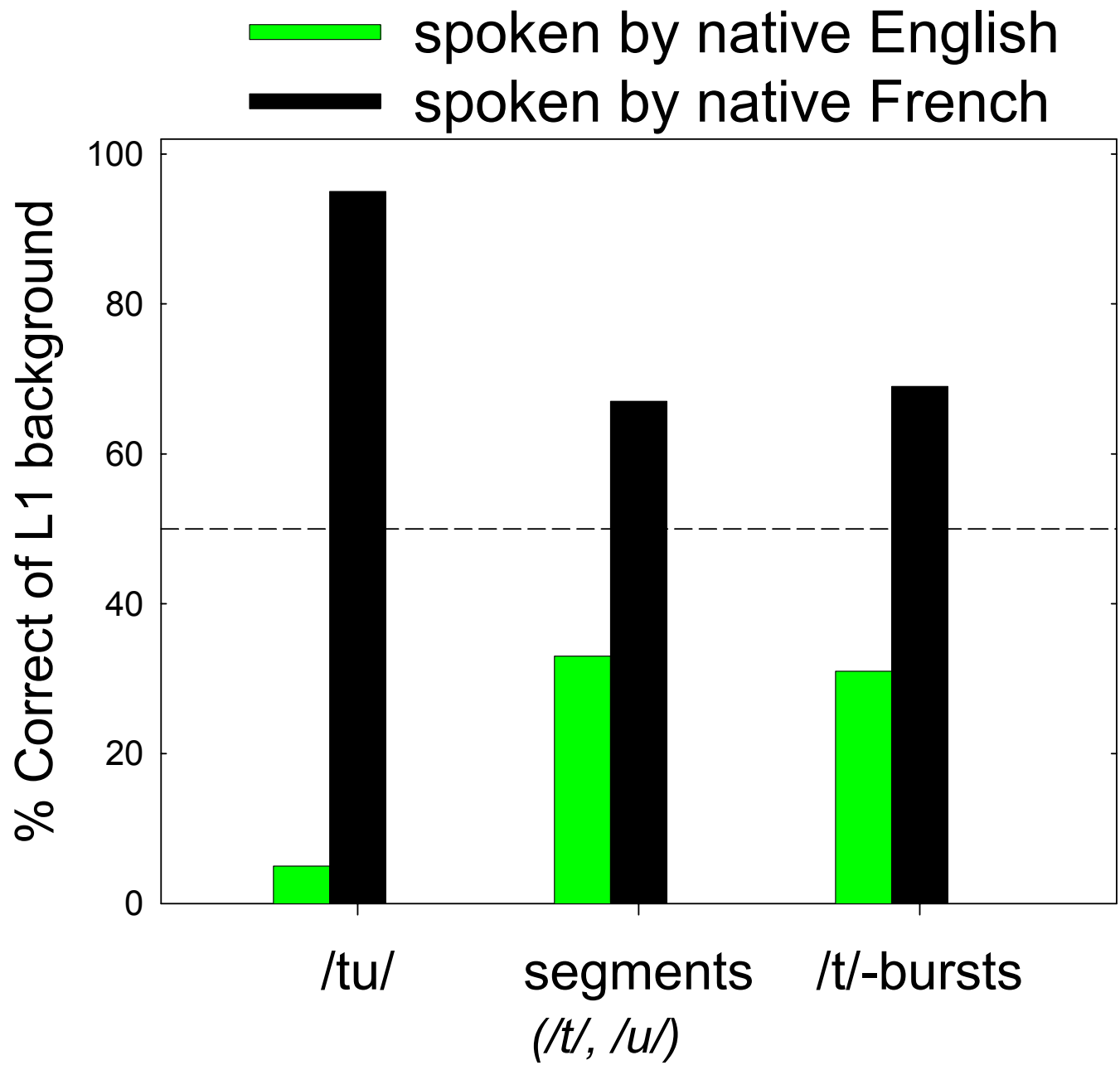
*Flege & Hammond (1982)*

## Flege (1984)

- Examined English speech samples produced by native English and French adults in Chicago
- Stimuli:
  - Original /tu/ syllables
  - Hybrid /tu/ syllables - single segments (/t/ or /u/) edited from syllables then cross-spliced to a native English-produced segment (/u/ or /t/)
  - First 30-ms of /t/ (release bursts)

## Flege (1984)

- English stimuli presented in pairs
  - One produced by native English speaker, the other by a native French speaker*
- Listeners' task: decide which of 2 stimuli was "foreign"
- Listeners given no training or feedback



# Flege (1984)

- NE listeners could detect
  - “backness” (non-fronting) of French-accented /u/
  - Too-short VOT values in French-accented /t/
  - Dental rather than alveolar place of articulation in French-accented /t/

## Flege (1984)

- Paired-comparison task demonstrated English monolinguals' ability to detect “within” category variation arising from cross-language phonetic interference
- Possible in “real world” where listeners pay attention to meaning?

Yes

## Flege & Hammond (1982)

- Tested 50 native English students at U of Florida
- Familiar with Spanish-accented English
- Enrolled in 1<sup>st</sup> year Spanish classes taught (in English!) by native Spanish adults who spoke English with strong Spanish accents

**Task:** Try to produce English words inserted into a carrier phrase (*The\_\_is on the\_\_*) with a “Spanish accent”

Lexical Items	Substitute	Frequency
nose, cheese, hose	s/z	141 (47%)
vice, veil, vase	b/v	129 (43%)
fig, pig, wig	i/I	127 (42%)
book, hook, crook	u/U	61 (20%)
shell, sheet, sheep	č/š	49 (16%)
bean, phone, bone	ŋ/n	1 (0.3%)
tape,tube, toad	d/t	0 (0.0%)

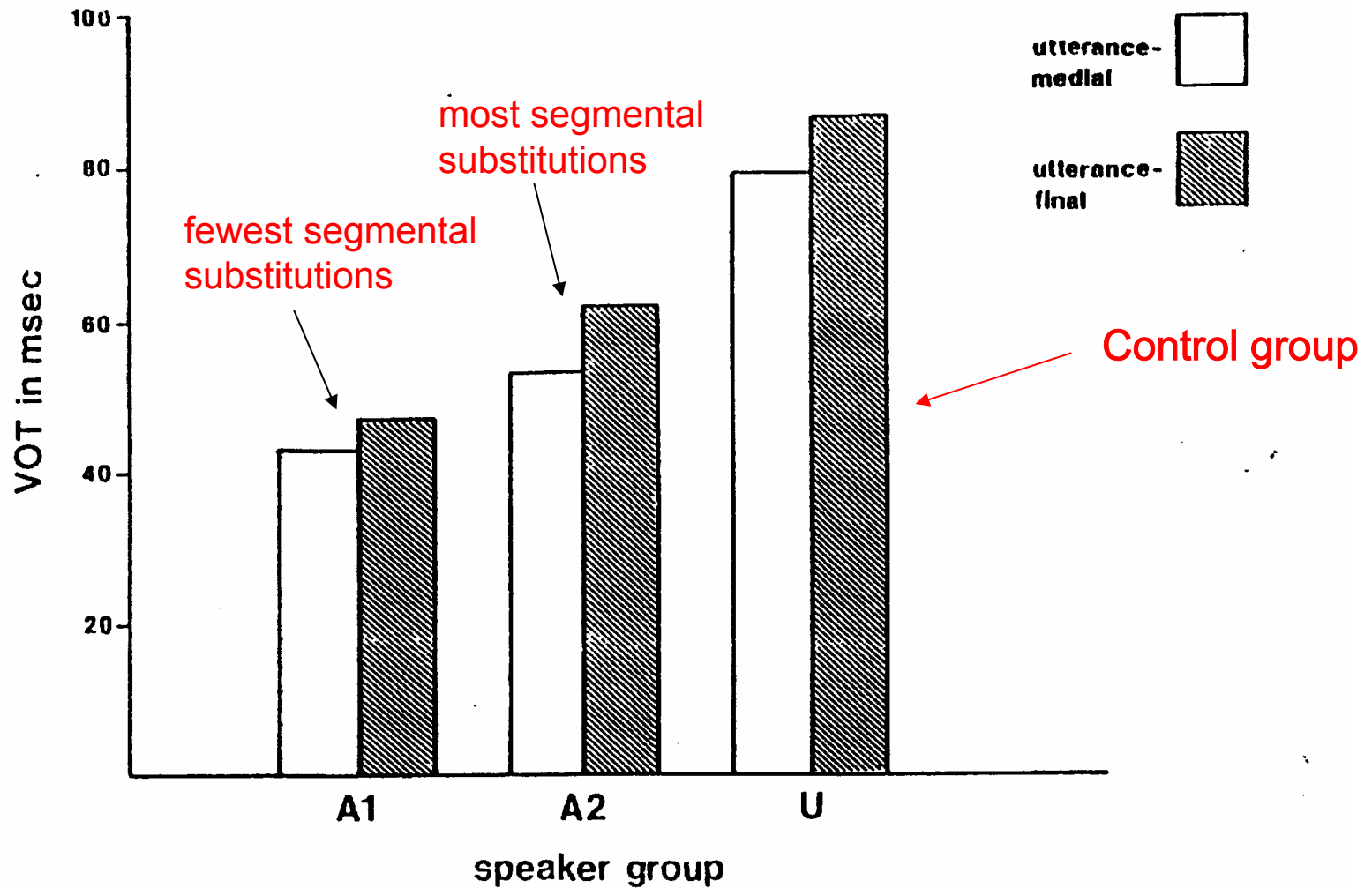
## Flege & Hammond (1982)

- In Spanish-accented English, VOT of /t/ is often midway between short-lag and long-lag values typical for Spanish & English
- This sometimes causes Spanish speakers' /t/ to be heard as /d/

## Flege & Hammond (1982)

- The students never realized /t/ as /d/ when imitating a Spanish accent
- Fail to detect VOT shortening in Spanish-accented /t/?

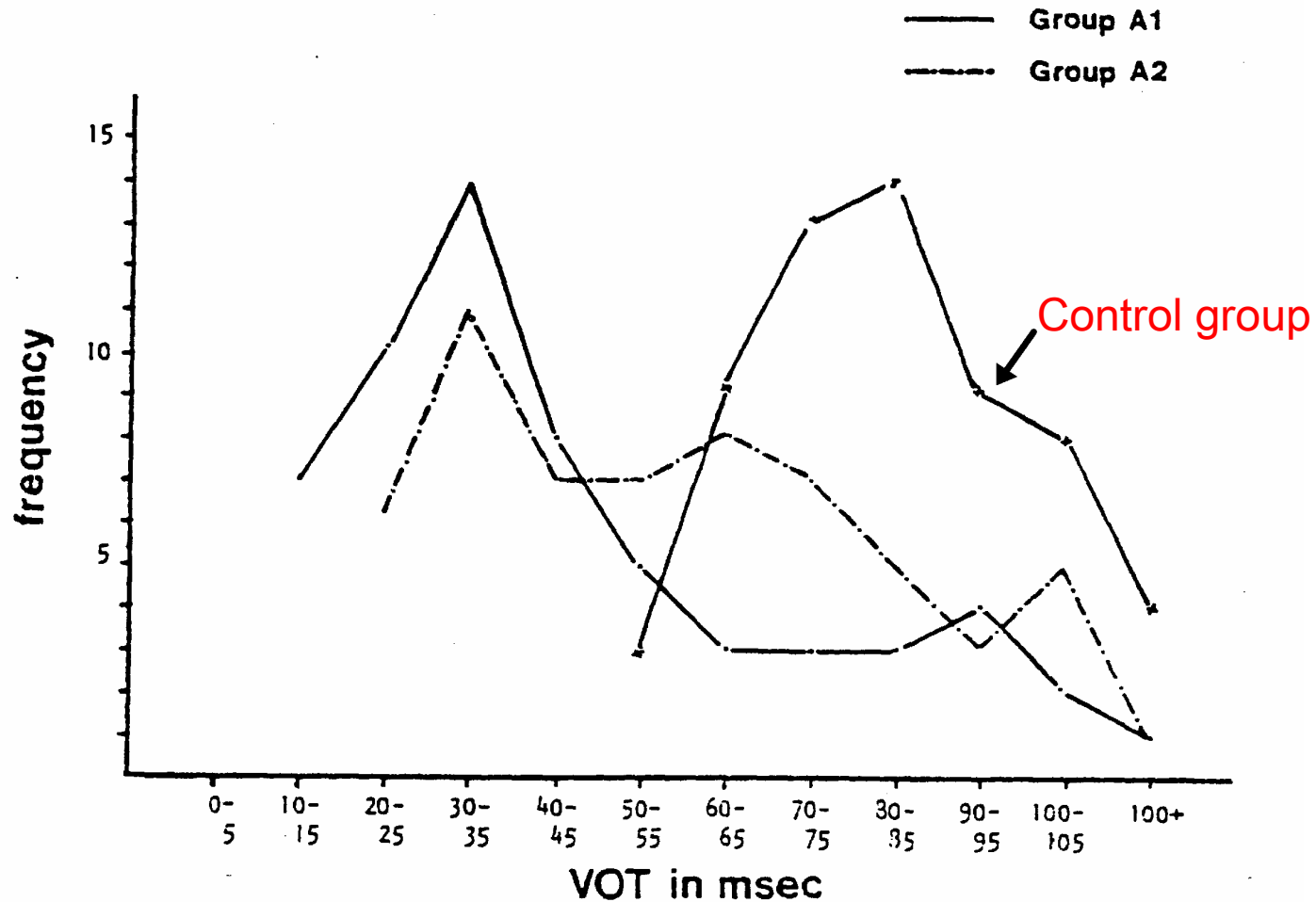
# Flege & Hammond (1982)



## Flege & Hammond (1982)

- **Conclusion:** as knowledge of Spanish-accented English developed, within-category phonetic variation was detected and stored in LT memory
- VOT finding not an artifact of combining Spanish short-lag + English long-lag values (frequency histogram)

# Flege & Hammond (1982)



**Figure 1.** Frequency of VOT values measured in stops produced by three groups of speakers.

# Conclusions re: Categorical perception

- Adults can (eventually) detect cross-language phonetic differences, and store this information in long-term memory representations

# Unidirectional L1→L2 interference

- In 1979-1984, no interest/discussion of L2→L1 interference

Why not?

# Unidirectional L1→L2 interference

Implicit belief that ...

- Bilinguals “switch” between separate self-contained L1 & L2 systems
- Errors occur because L2 not properly learned
- What is learned early in the L1 “stays learned” (Jakobson)

# Doubts re: unidirectional interference

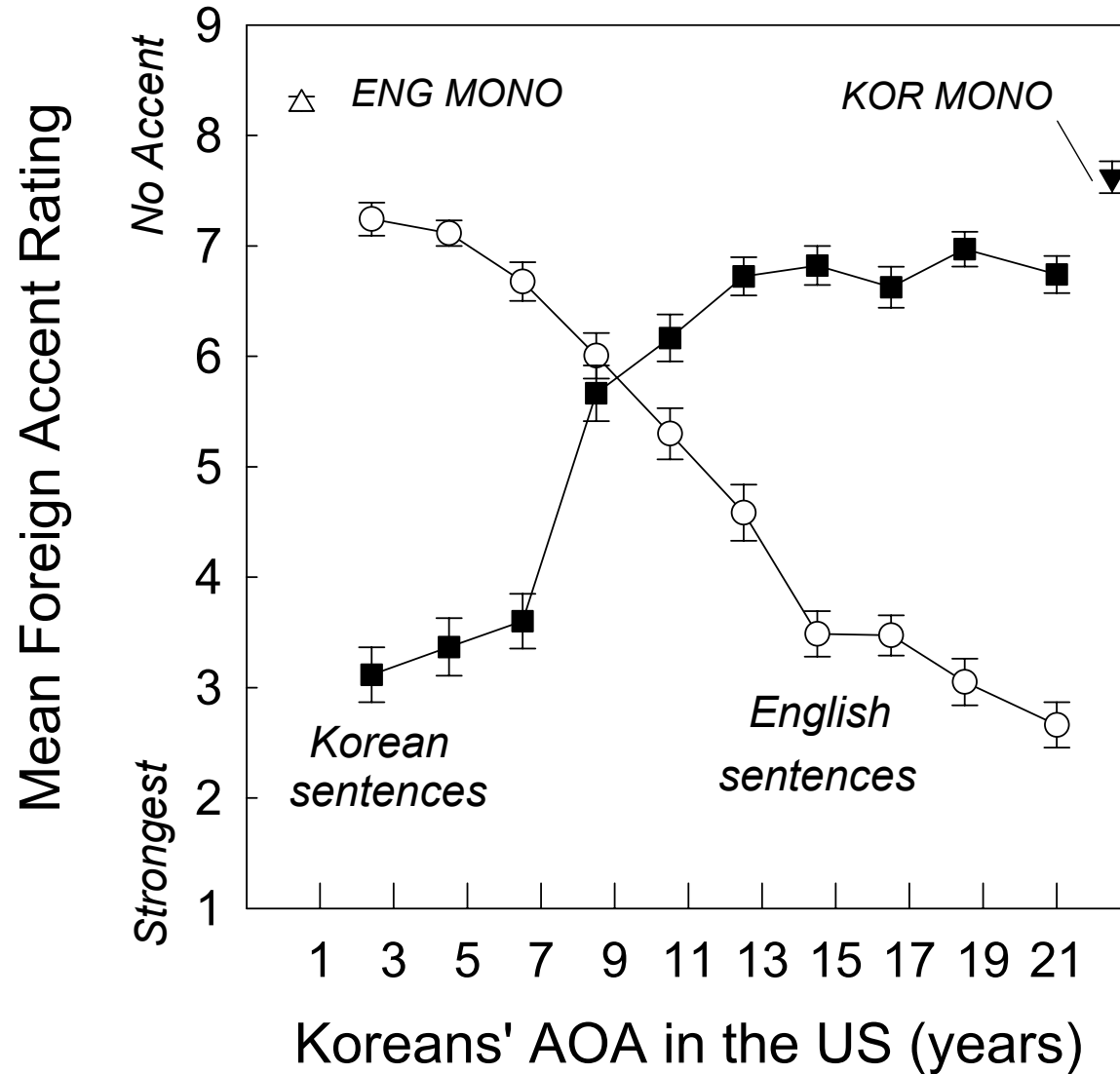
- Recent research shows effect of L2 learning on L1 production
  - Yeni-Komshian et al. (2000)
  - Yeni-Komshian & Flege (unpubl.)

# Doubts re: unidirectional interference

Yeni-Komshian et al. (2000) elicited Korean and English sentences from 240 Koreans living in US

- Rated by native Korean and English listeners, respectively

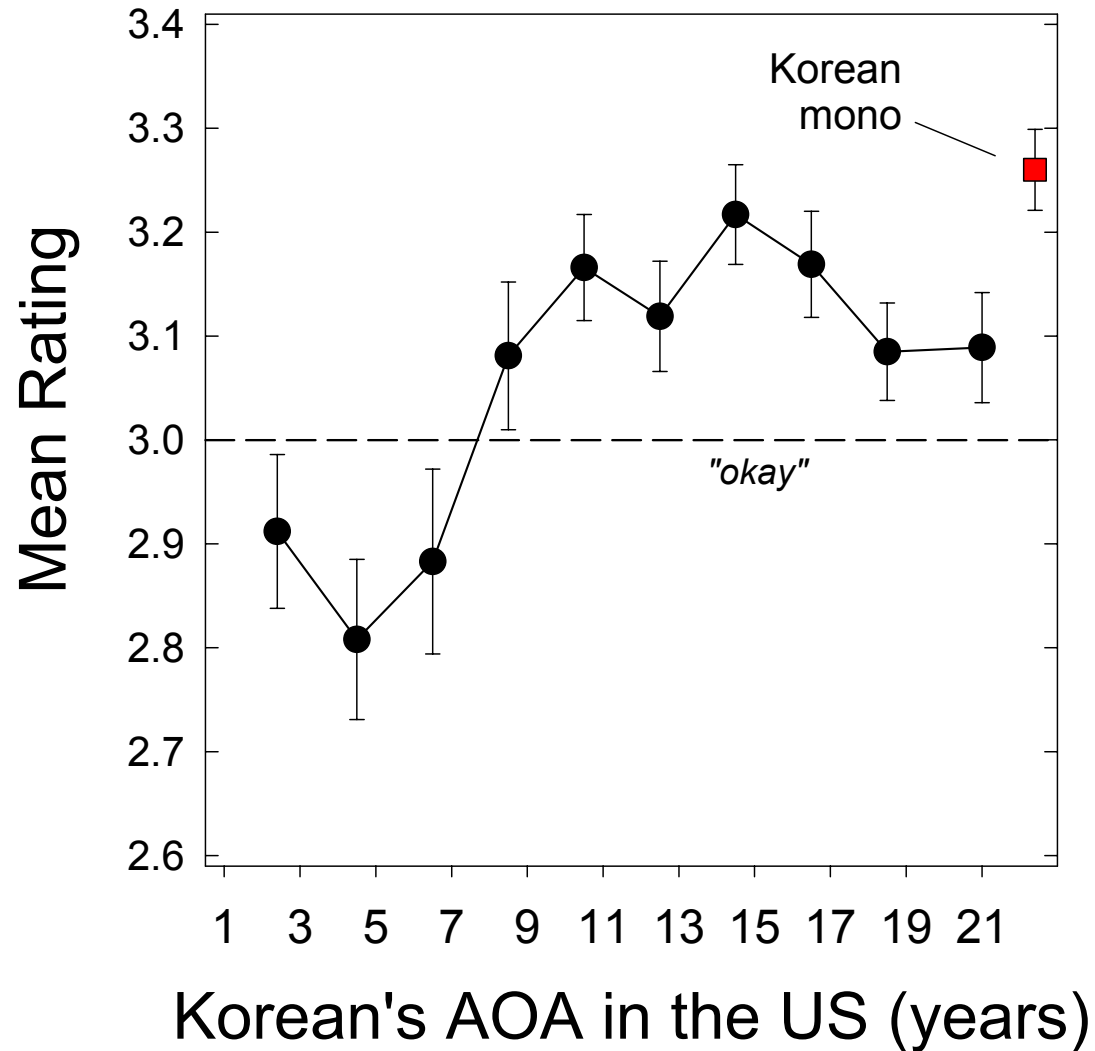
# Yeni-Komshian et al. (2000)



# Doubts re: unidirectional interference

- Yeni-Komshian & Flege (unpubl.) elicited isolated Korean words beginning in /s/, /s'/, /t<sup>h</sup>/, /t'/
- Initial consonants rated by Korean listeners
  - 4 very good
  - 3 okay
  - 2 distorted
  - 1 wrong consonant

# Yeni-Komshian & Flege (unpubl.)

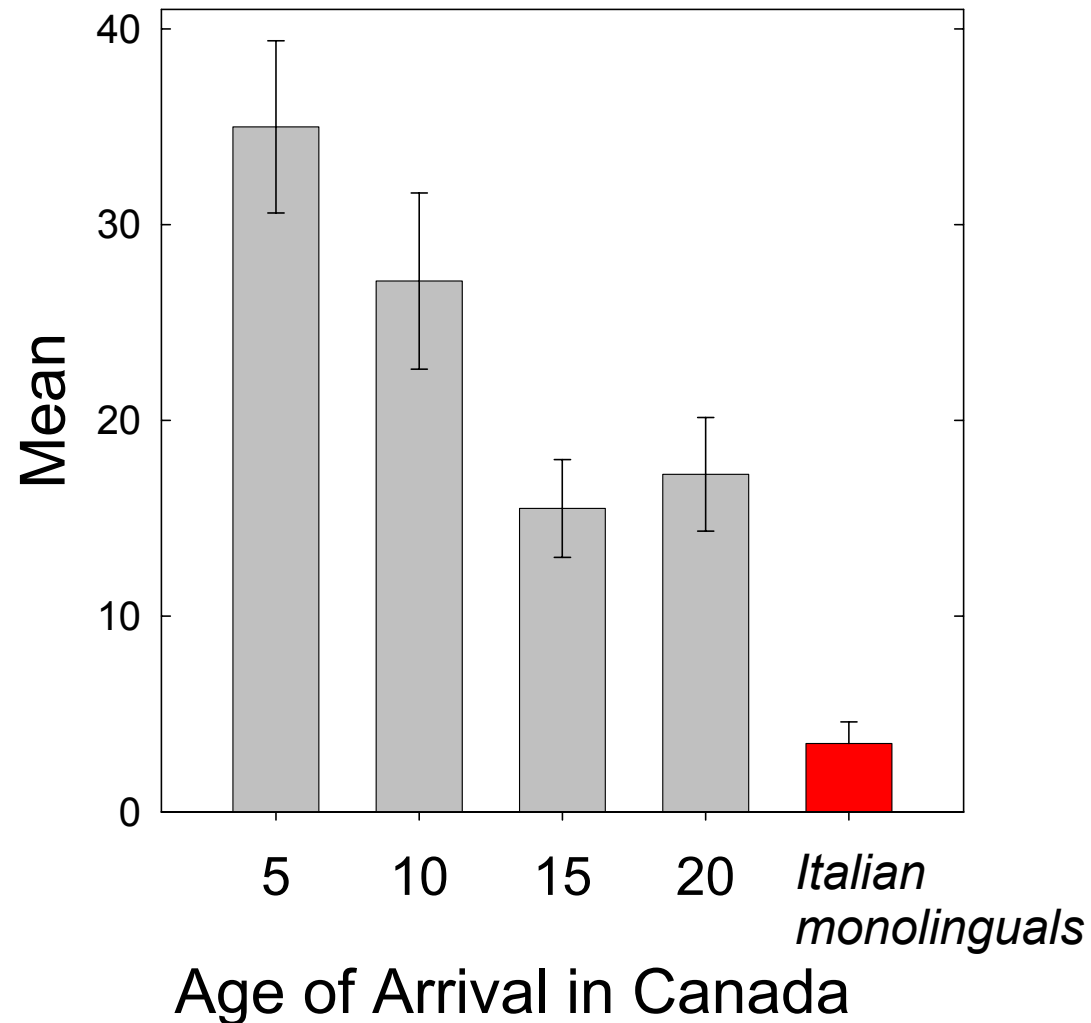


# Doubts re: unidirectional interference

Flege et al. (unpubl) examined Italians' production of Italian /b d g/

- Italian /b d g/ lead VOT
- English /b d g/ usually short-lag VOT

Mean % of Italian /b d g/ tokens (n = 20)  
realized as short-lag stops



# Conclusions

## re: unidirectional interference

- Learning L2 affect L1 segmental production
- Perhaps stronger for early than late bilinguals
- L1 and L2 not isolated systems

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4. Some predictions generated by the SLM
5. How to falsify the SLM
6. Future directions

# SLM proposes that ...

- L2 learners can, in time, veridically perceive the phonetic properties of L2 speech sounds
- As in L1 speech learning, L2 speech learning
  - takes time
  - is influenced importantly by the nature of input received
- As in L1, production is guided by perceptual representations stored in LTM

## SLM proposes that ...

- The processes and mechanisms that guide successful L1 speech acquisition—including the ability to form new phonetic categories—remain intact and accessible across the life span
- Phonetic elements making up the L1 and L2 phonetic subsystems exist in a “common phonological space”, and so mutually influence one another

# SLM hypotheses

**Hypothesis:** The greater the perceived dissimilarity of an L2 sound from the closest L1 sound, the more likely a new category will be formed for the L2 sound

# SLM hypotheses

**Hypothesis:** Category formation for an L2 sound becomes less likely through childhood as representations for neighboring L1 sounds develop

# SLM hypotheses

**Hypothesis:** When a category is not formed for an L2 sound because it is too similar to an L1 counterpart, the L1 and L2 categories will assimilate, leading to a “merged” L1-L2

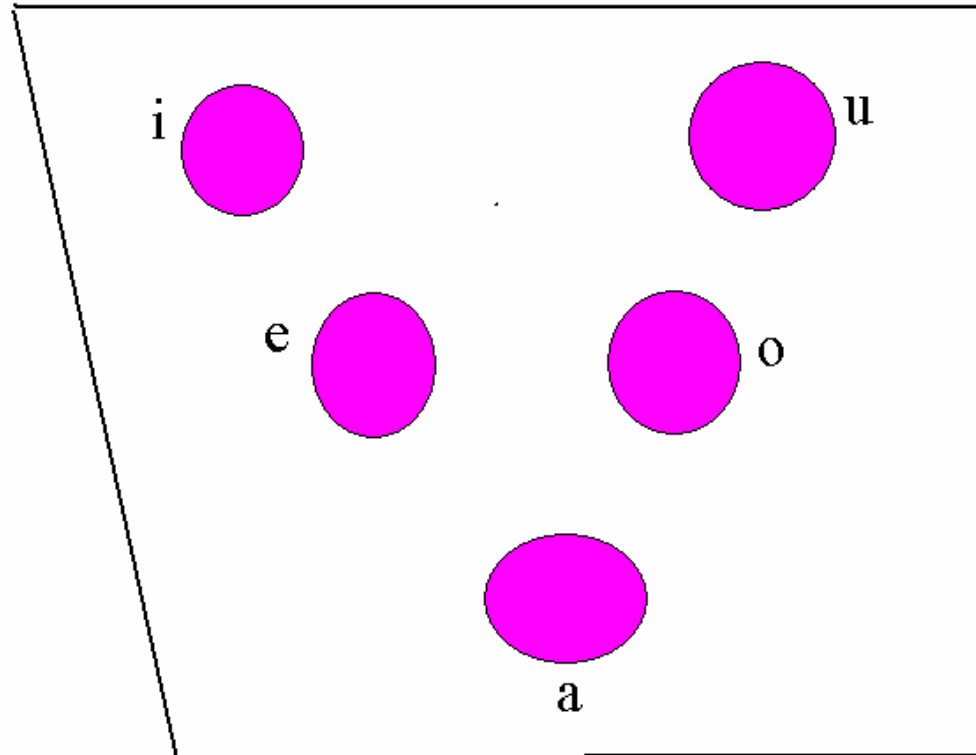
(illustrations/examples to follow)

# SLM hypotheses

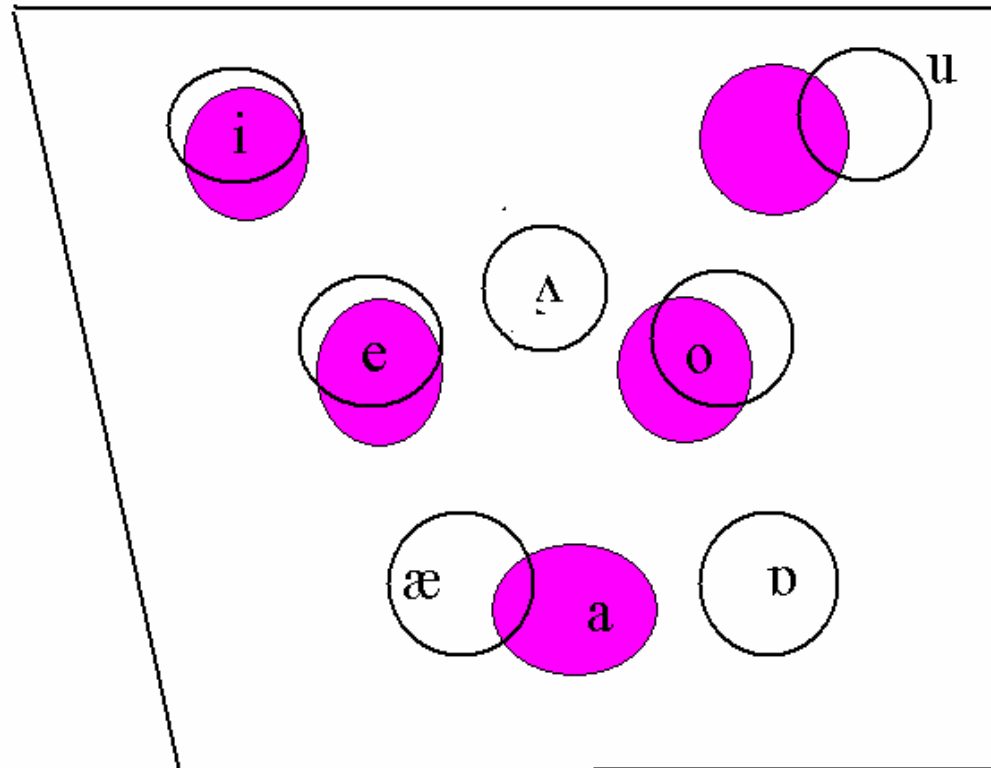
**Hypothesis:** When a new category IS established for L2 sound, it may dissimilate from neighboring L1 and/or L2 sound – and vice versa – to preserve phonetic contrast

(illustrations/examples to follow)

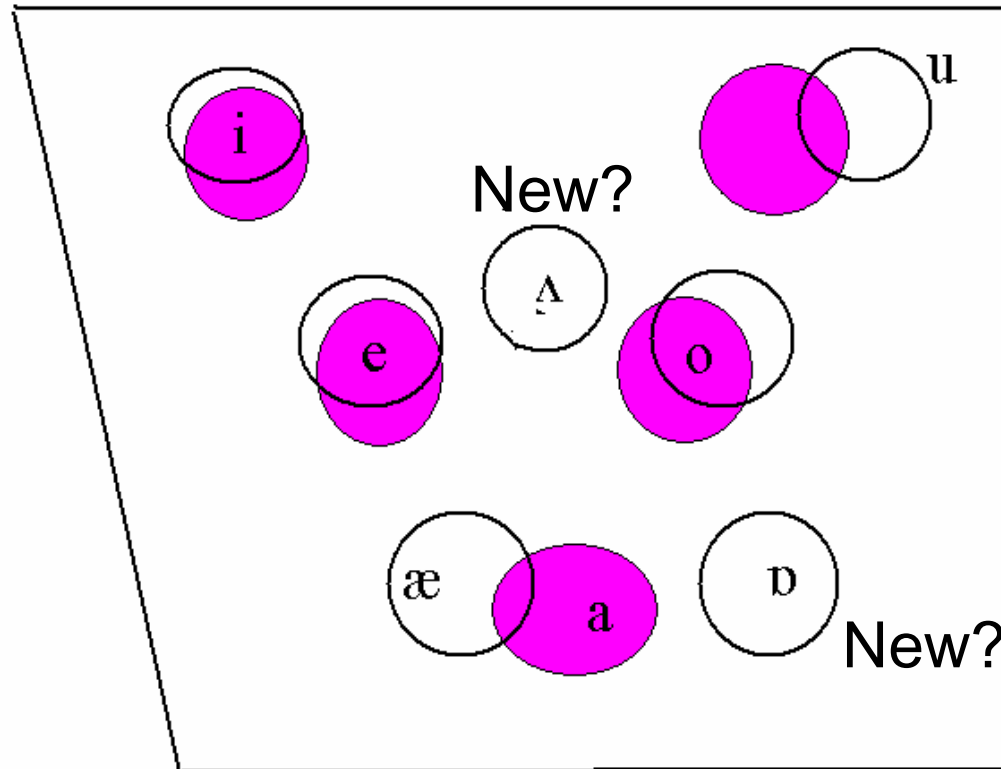
# Illustration: perceived dissimilarity



# Illustration: perceived dissimilarity



# Illustration: perceived dissimilarity



# L1-L2 distance

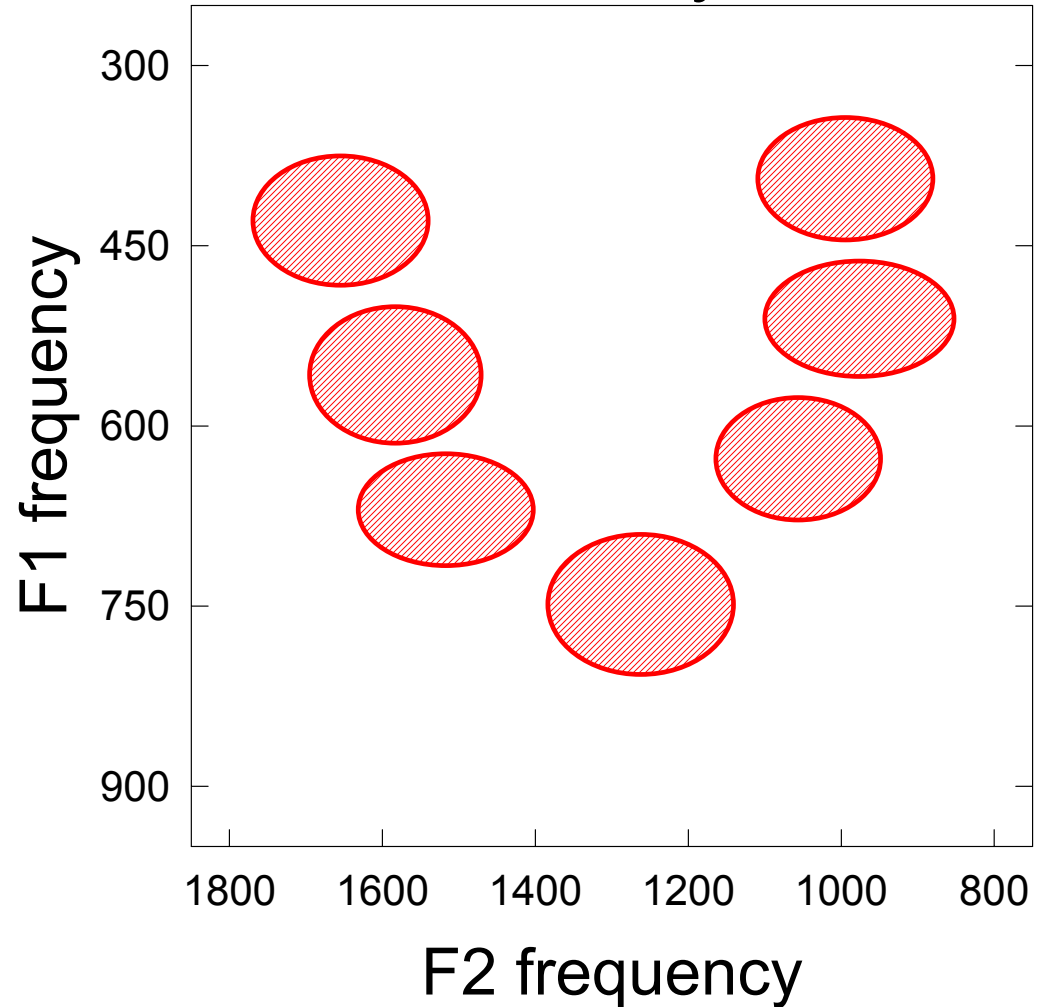
Perceived L1 –L2 phonetic dissimilarity regarded as a continuum (since 1994)

(not a tripartite identical-similar-new division, as specified in the 1984-1993 version of the SLM)

Must be measured empirically; cannot be predicted *a priori*

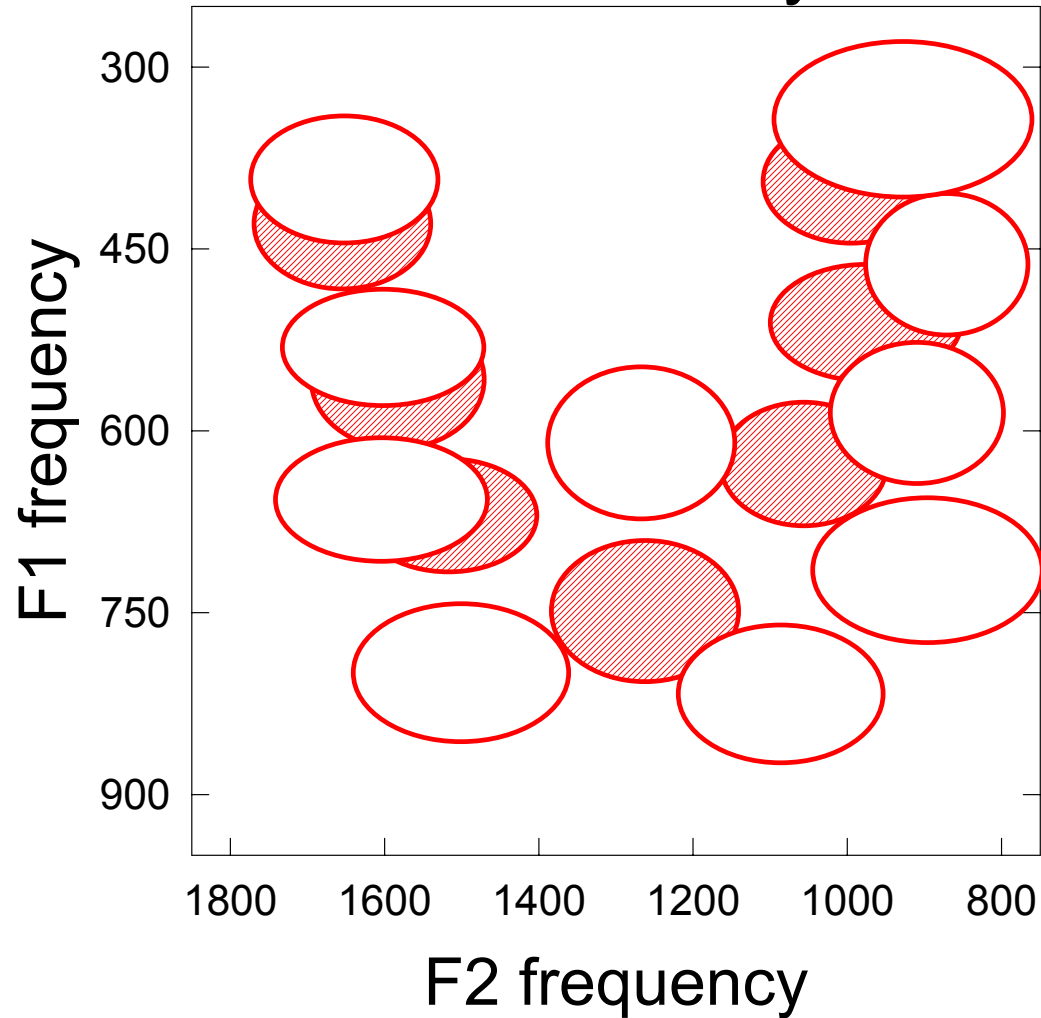
# Assimilation, dissimilation (7 vs. 10 vowel systems)

## L1 Vowel System



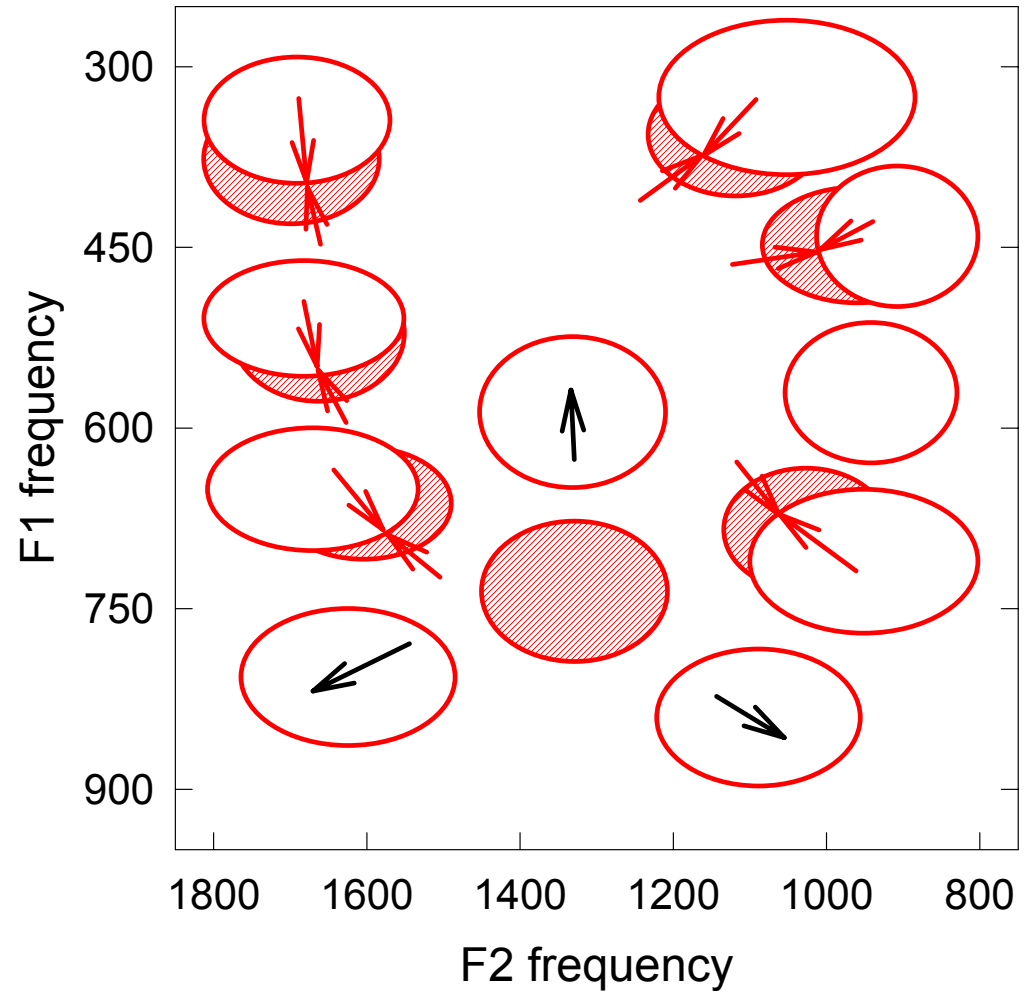
# Assimilation, dissimilation

## L1 & L2 Vowel Systems



# Assimilation, dissimilation

## L1-L2 Interaction



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# SLM predictions

When category formation is blocked, L1 and L2 categories assimilate

L2 sound will continue to resemble L1 sound

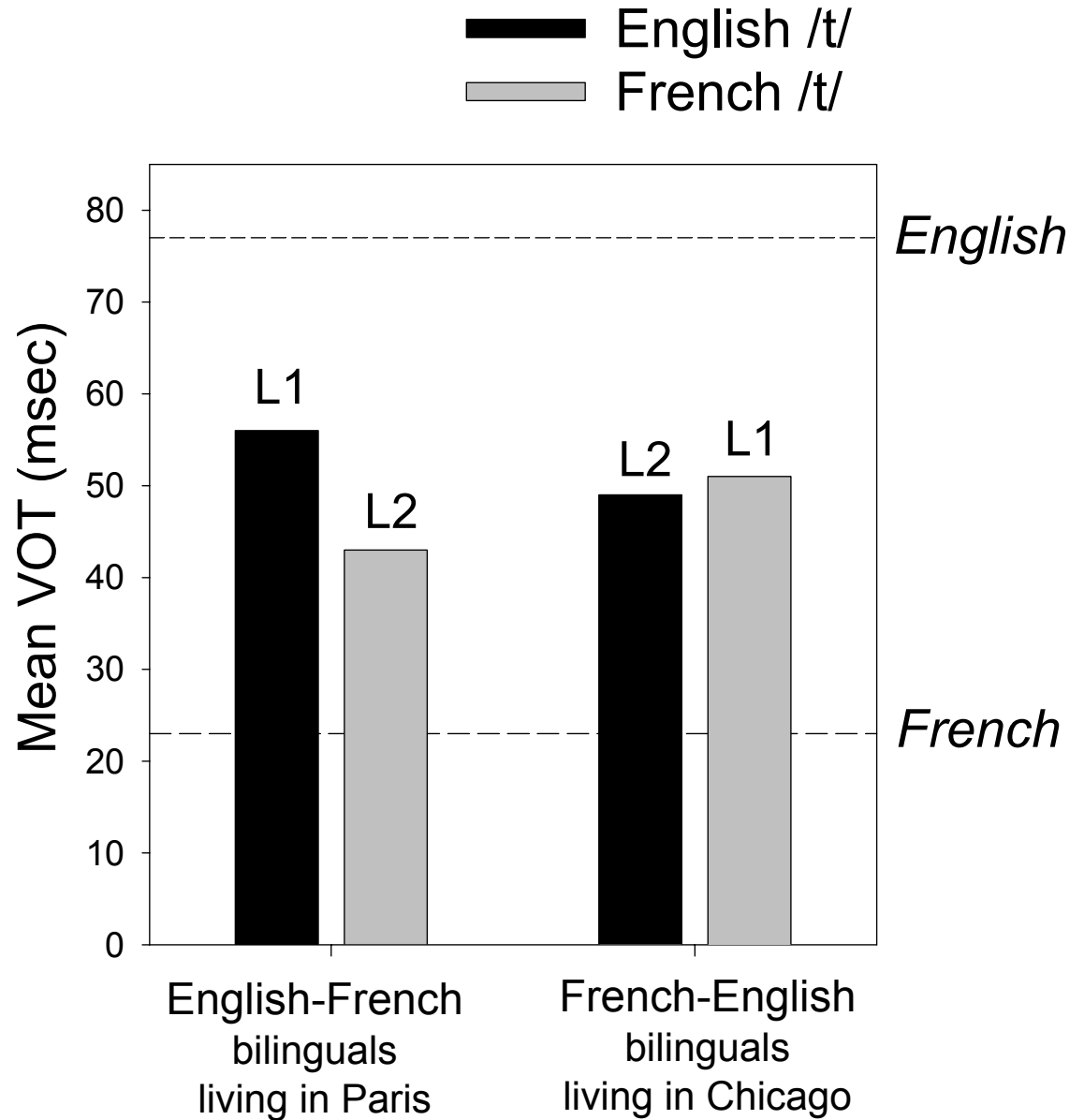
L1 sound will begin to resemble L2 sound

# SLM predictions

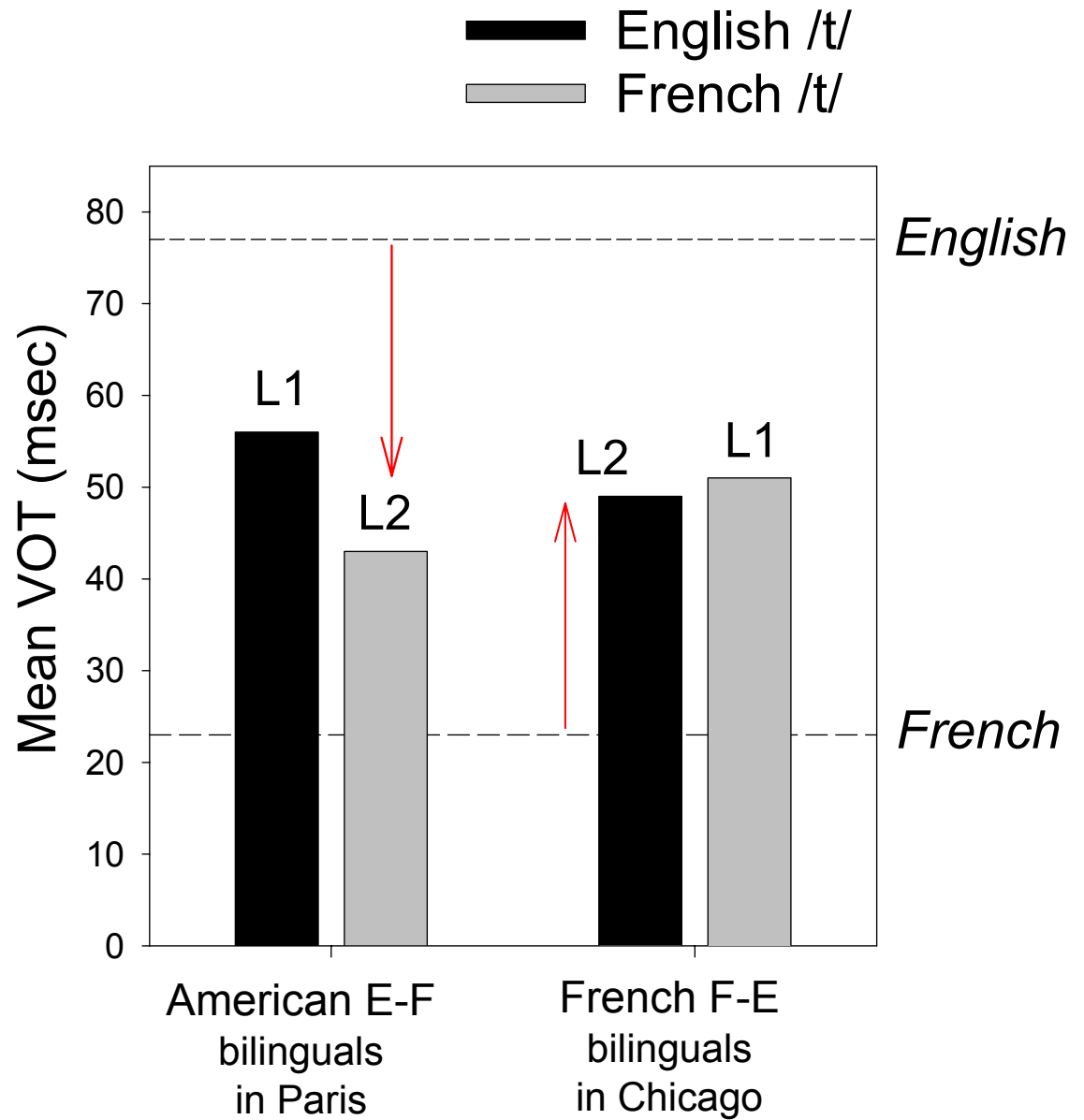
Flege (1987) examined the production of French and English /t/ by

- American women who had lived in Paris for  $M = 10$  years
- French women who had lived in Chicago for  $M = 10$  years

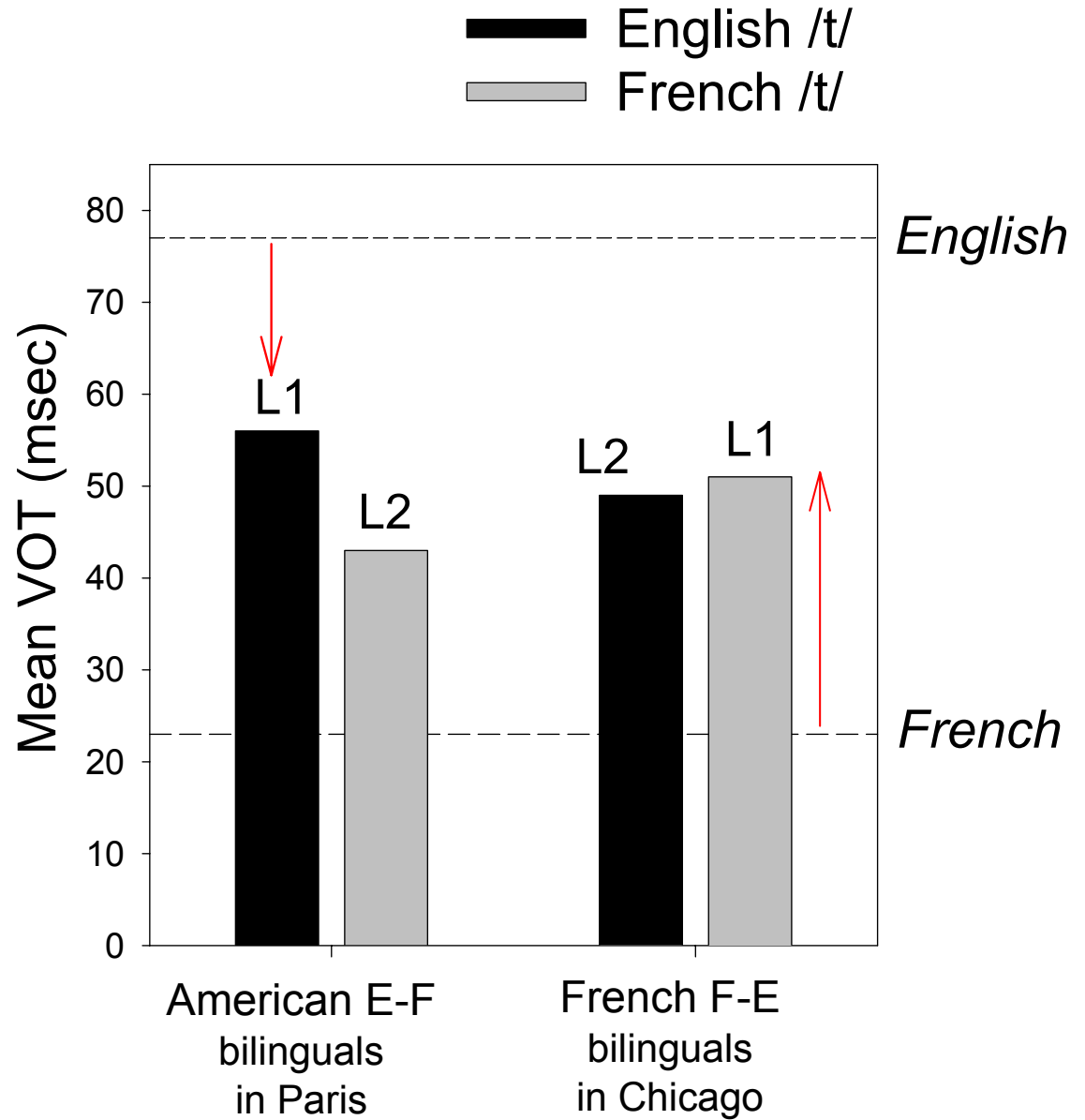
# Flege (1987)



# Flege (1987)



# Flege (1987)



# SLM predictions

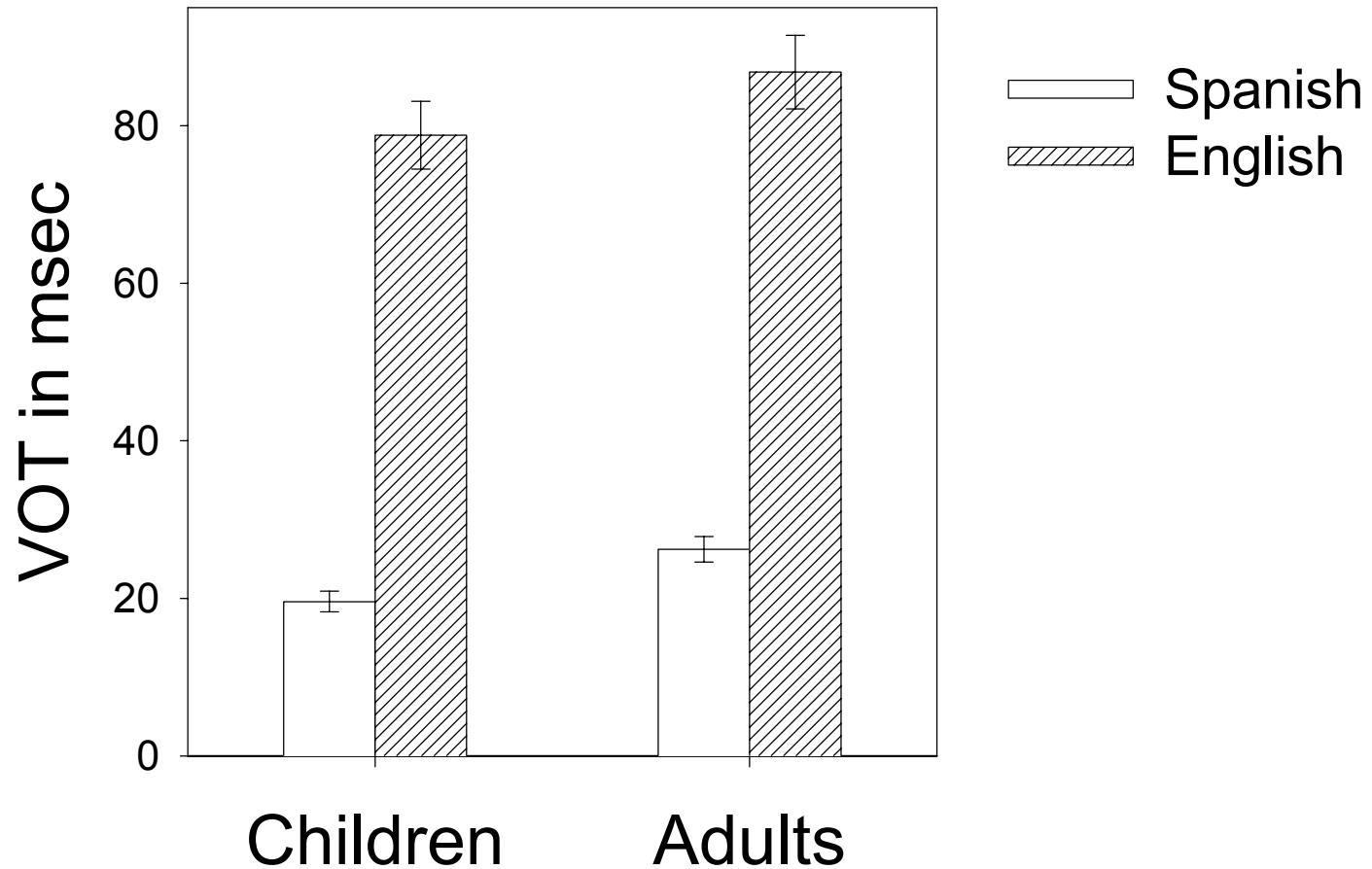
**Prediction:** When a new category is formed for an L2 sound, it and/or nearest L1 sound may dissimilate

# SLM predictions

Flege and Eefting (1986, 1987) examined production of /p t k/ in Spanish and English words by

- Spanish monolinguals: adults & children in Puerto Rico
- English monolinguals: adults & children in Alabama

# Flege and Eefting (1986, 1987)

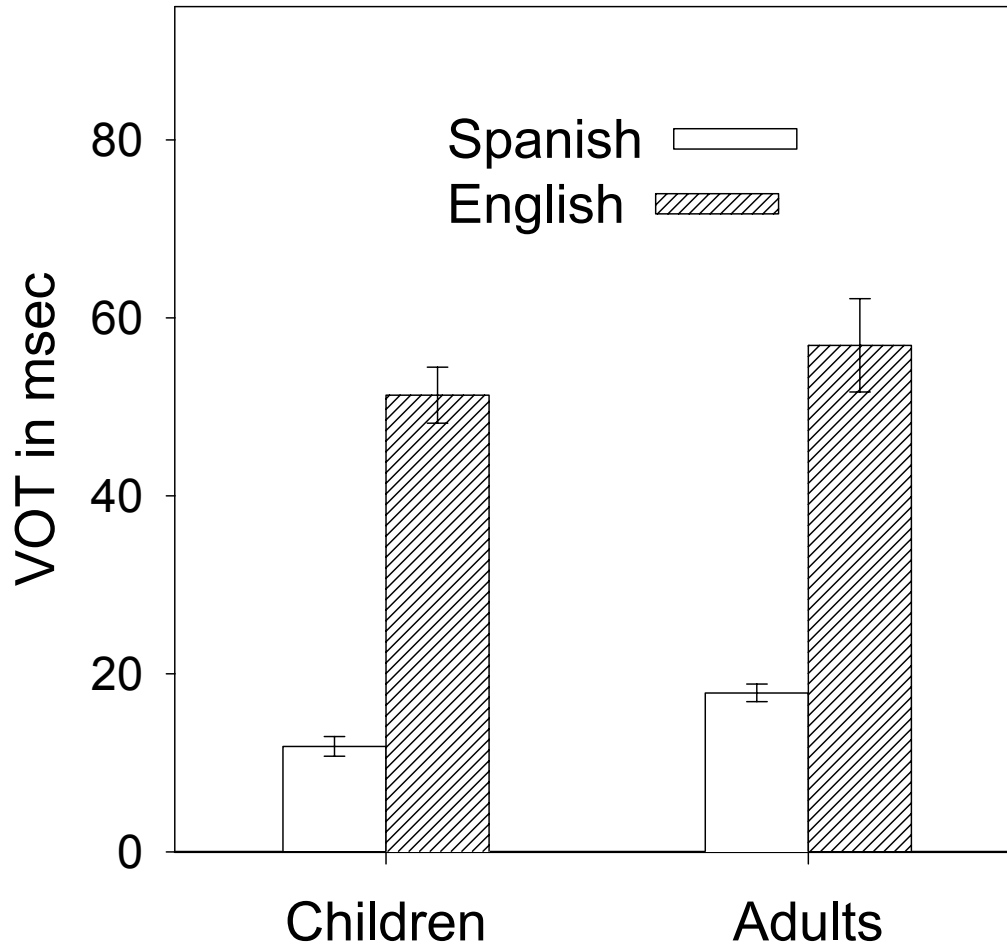


# SLM predictions

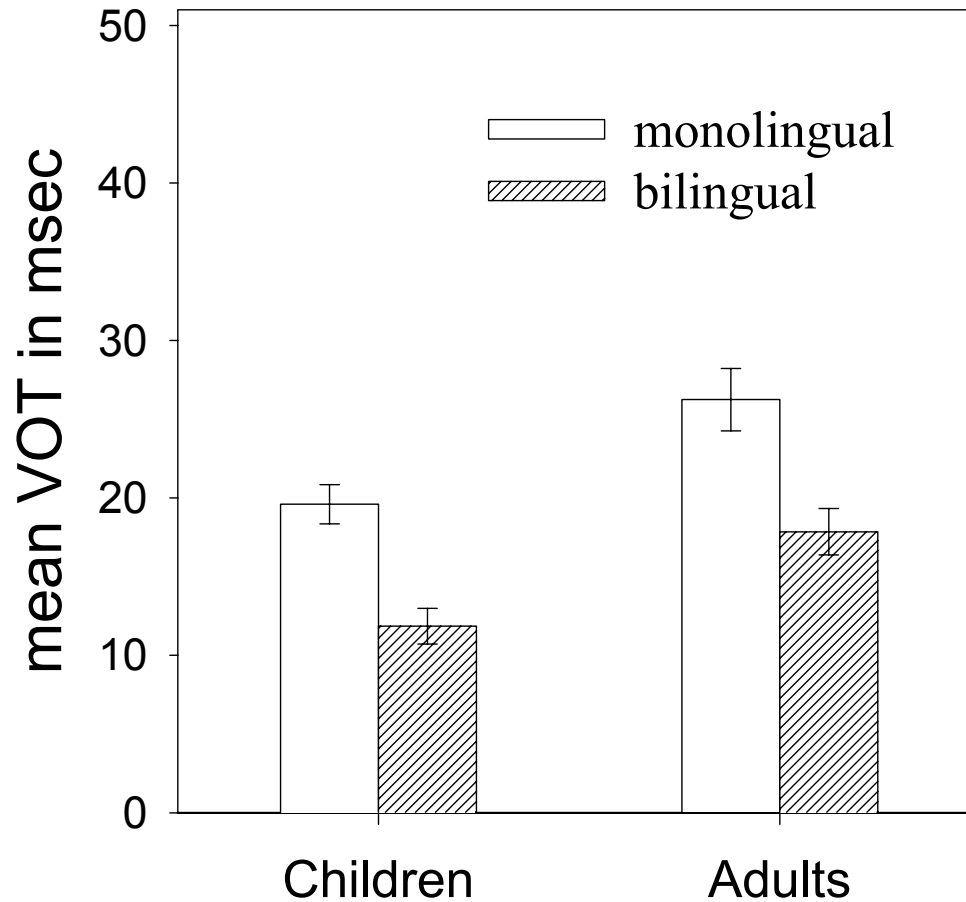
Flege and Eefting (1986, 1987) tested 2 groups of early Spanish-English bilinguals

- Adults: learned English in a bilingual school as children
- Children: currently enrolled in the same bilingual school in Puerto Rico

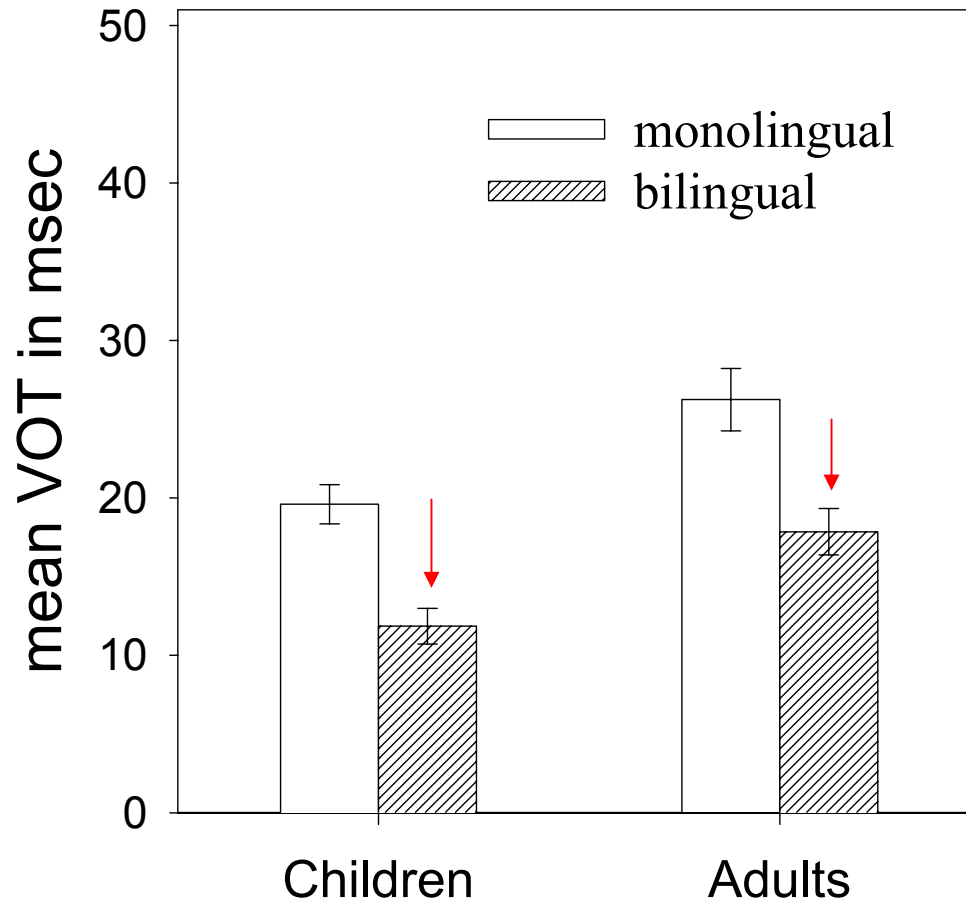
# Early bilinguals' Spanish, English /p t k/



# VOT in Spanish /p t k/ spoken by Spanish monolinguals, early bilinguals



# Significant shortening of VOT in Spanish /p t k/ by bilinguals



# SLM predictions

**Prediction:** Children more likely to form phonetic categories for L2 sounds than adults

However, even adults retain the capacity to form new categories

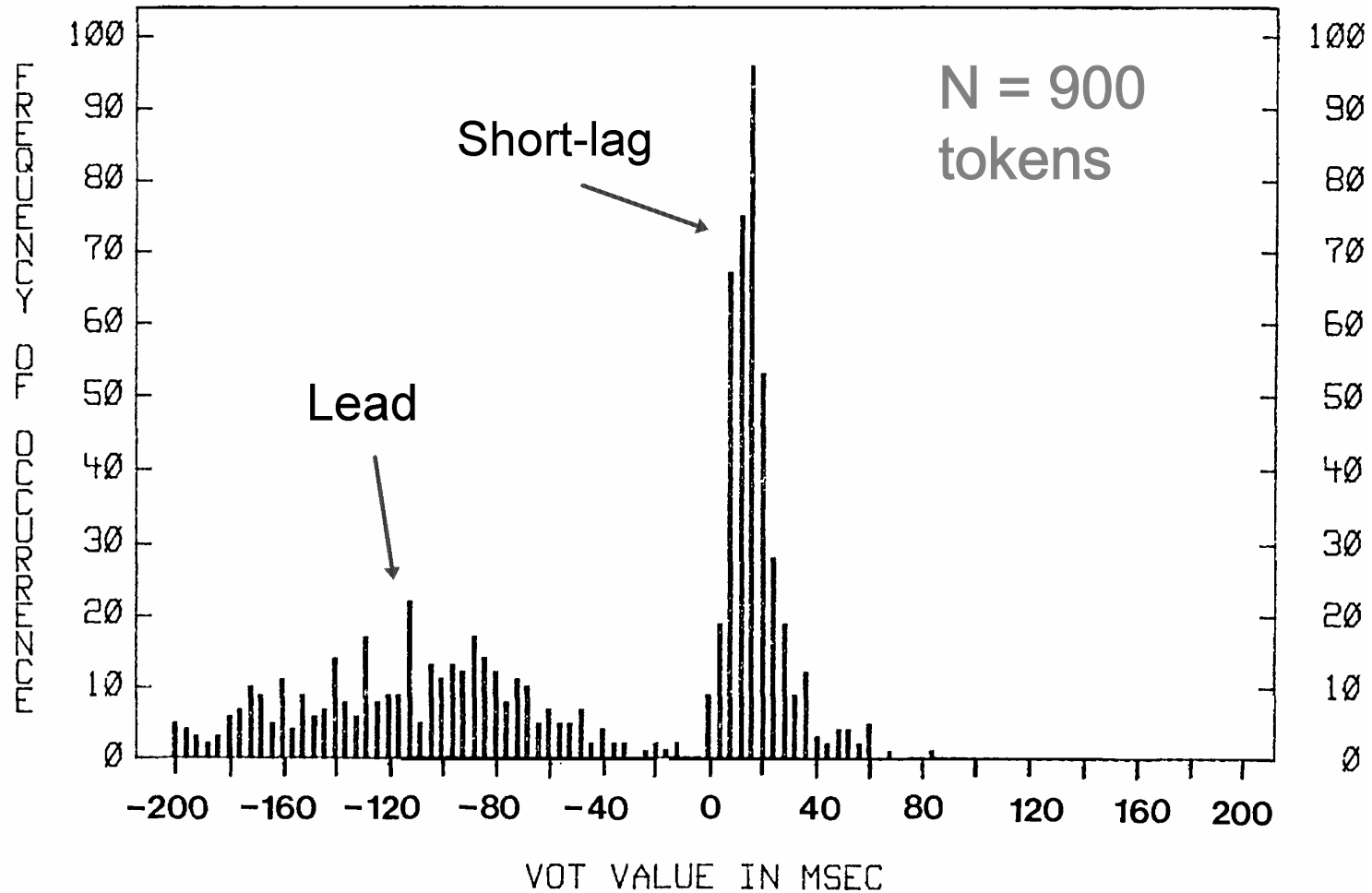
# SLM predictions

Flege & Eefting (1988) provided evidence of category formation for /p t k/ by early Spanish-English bilinguals

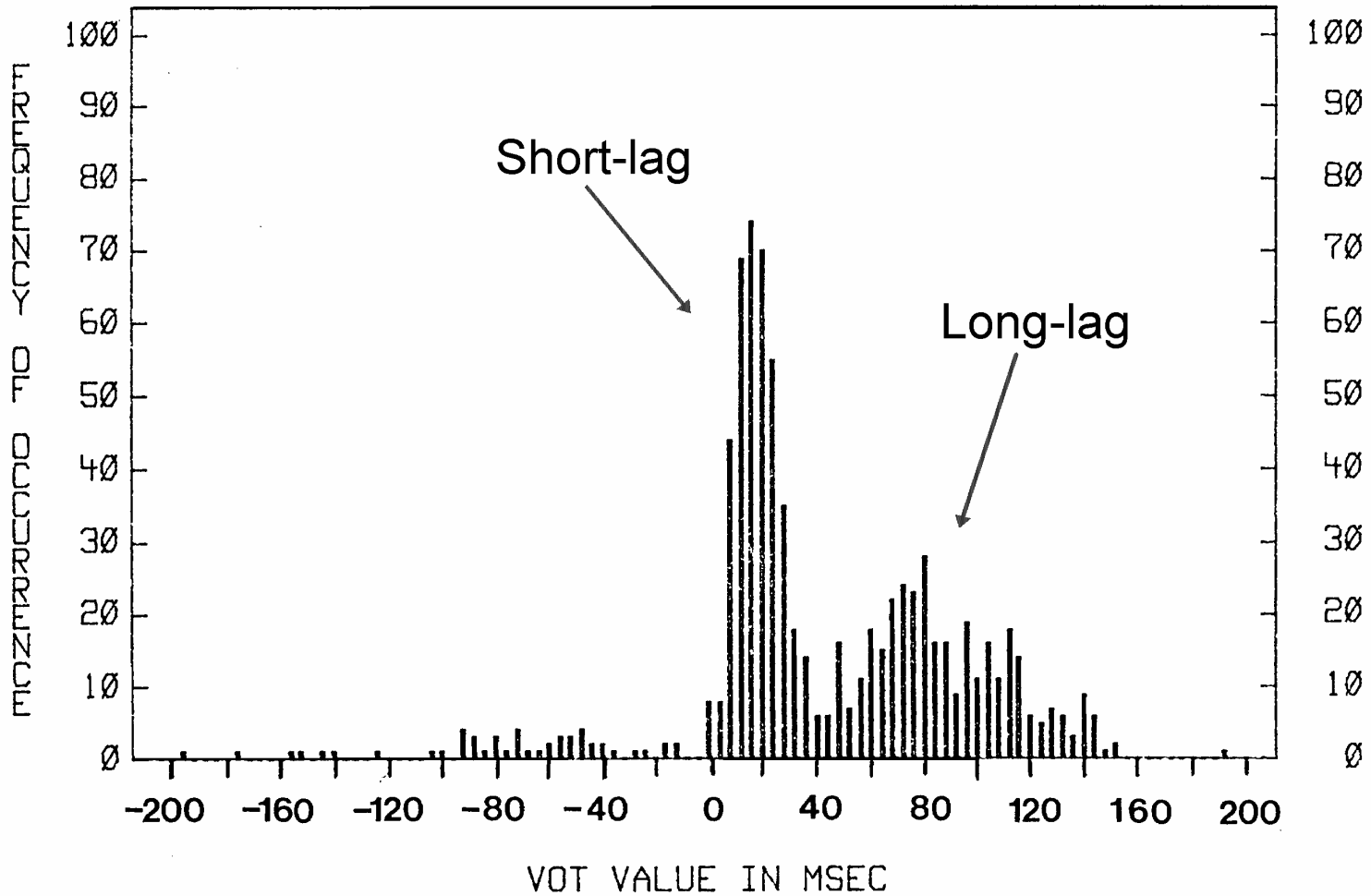
# SLM predictions

- Flege & Eefting (1988) tested
  - Spanish-English bilinguals
  - Spanish & English monolinguals
- imitated members of a synthetic VOT continuum (lead [d] to long-lag [t<sup>h</sup>])

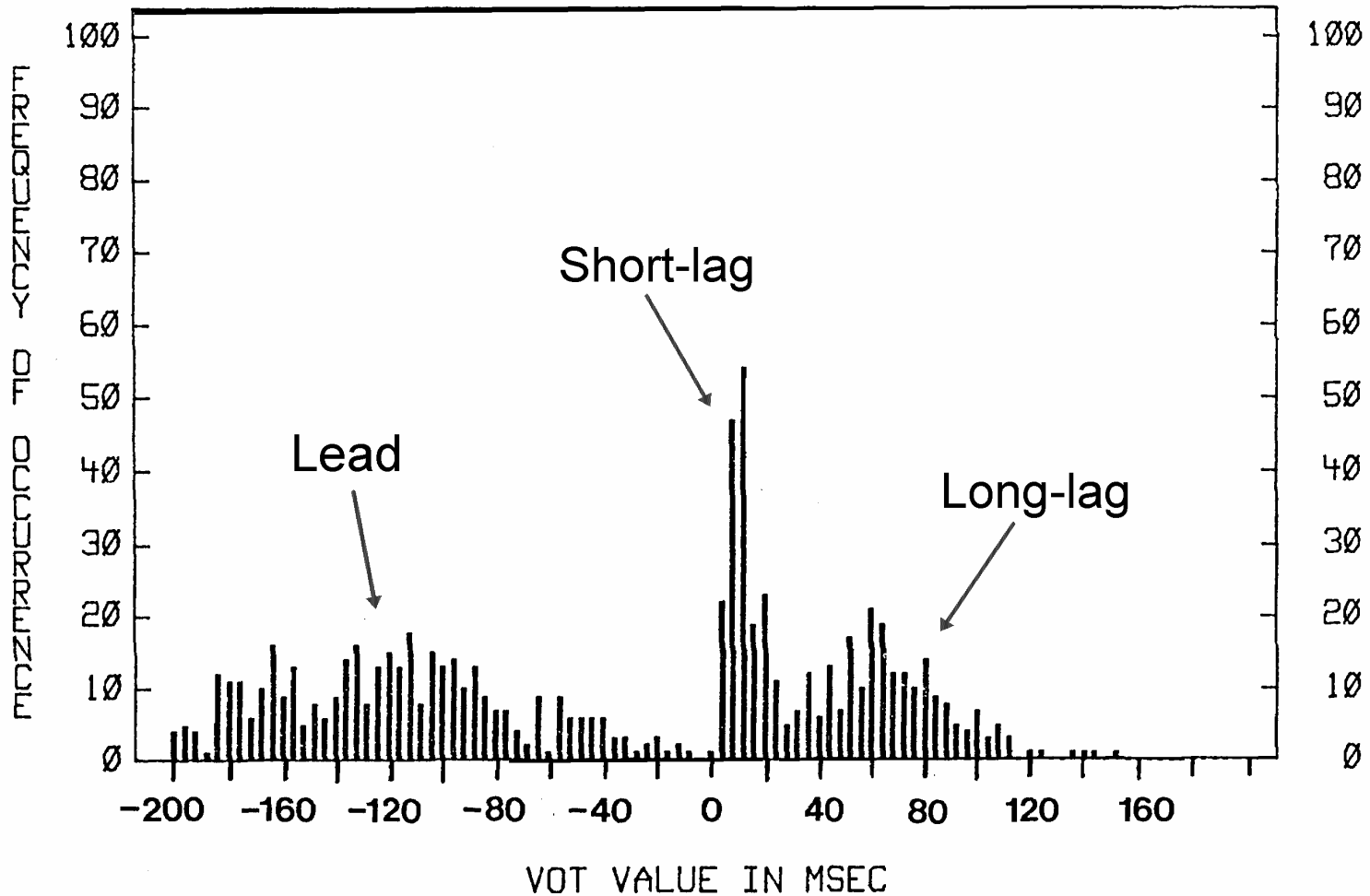
# Monolingual Spanish children



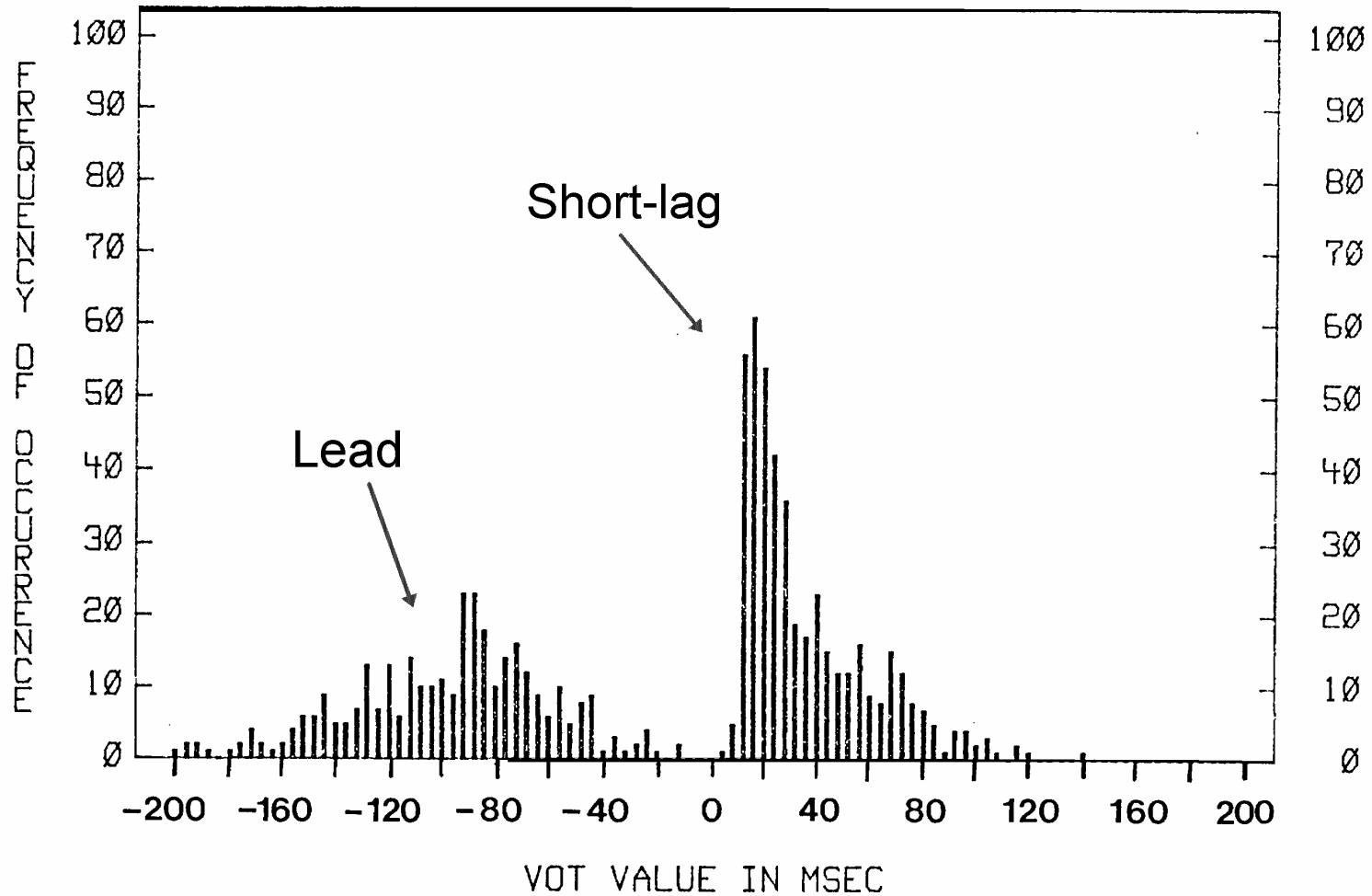
# Monolingual English Children



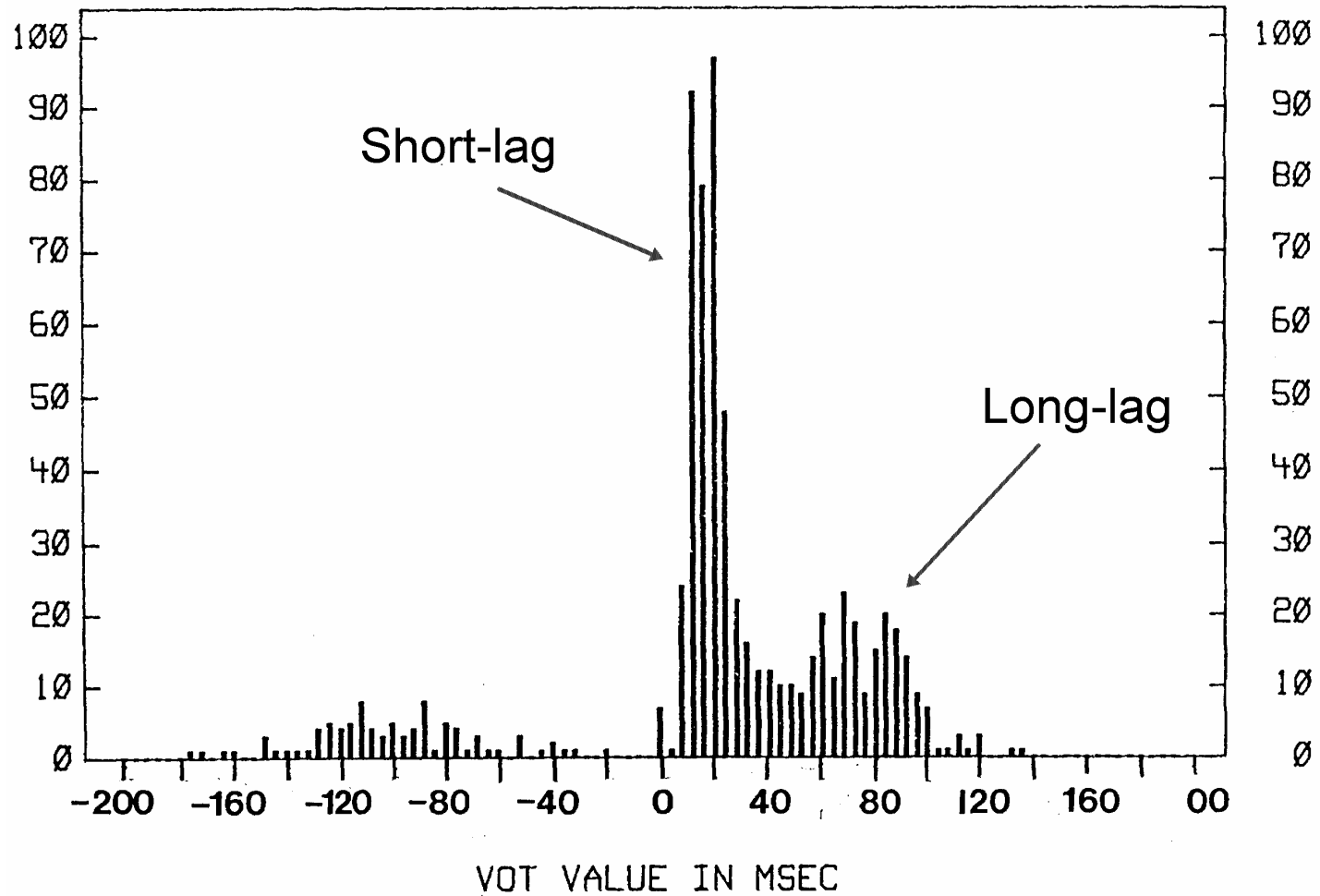
# Spanish-English bilingual children



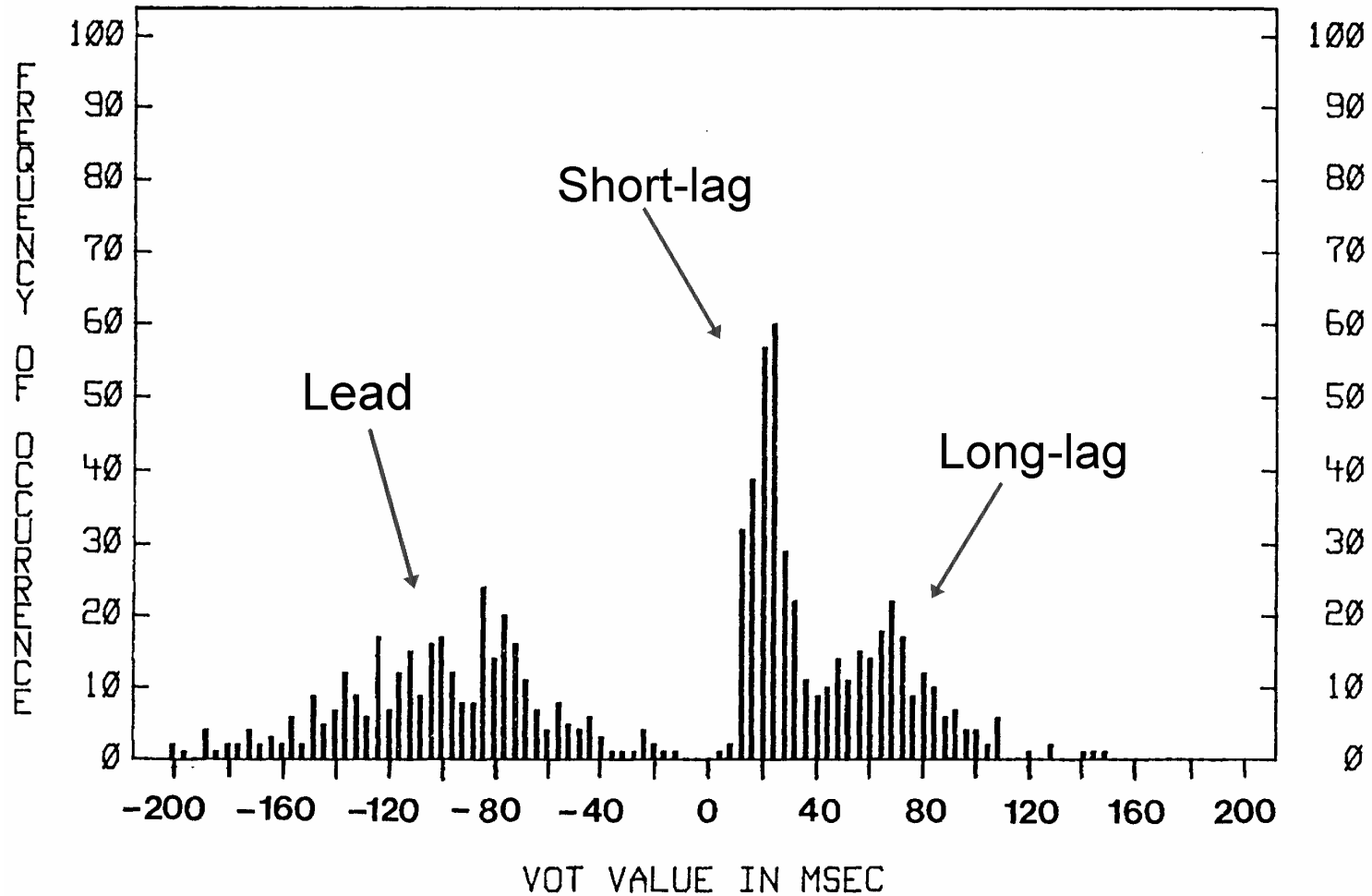
# Monolingual Spanish adults



# Monolingual English adults



# Spanish-English bilingual adults



# SLM predictions

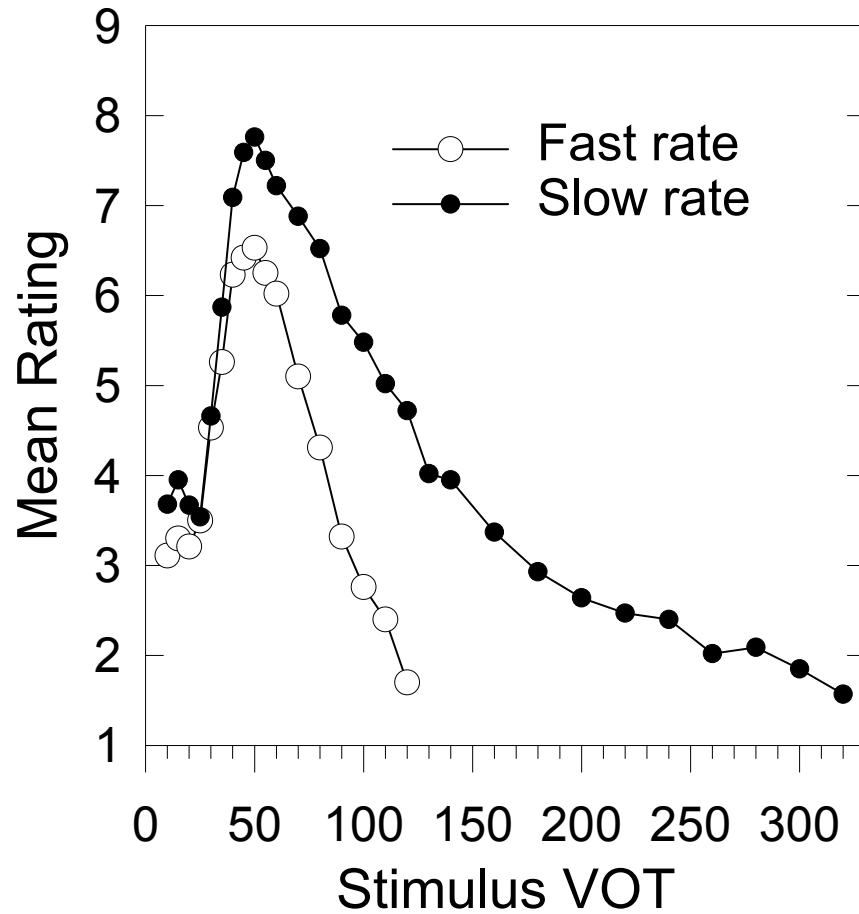
## Flege & Eefting (1988)

- Early bilinguals could rapidly produce short-lag vs. long-lag distinction
- Demonstrated they perceptually differentiated short-lag (Spanish) vs. long-lag (English) realizations of /t/
- Suggested they had distinct categories for English and Spanish /t/

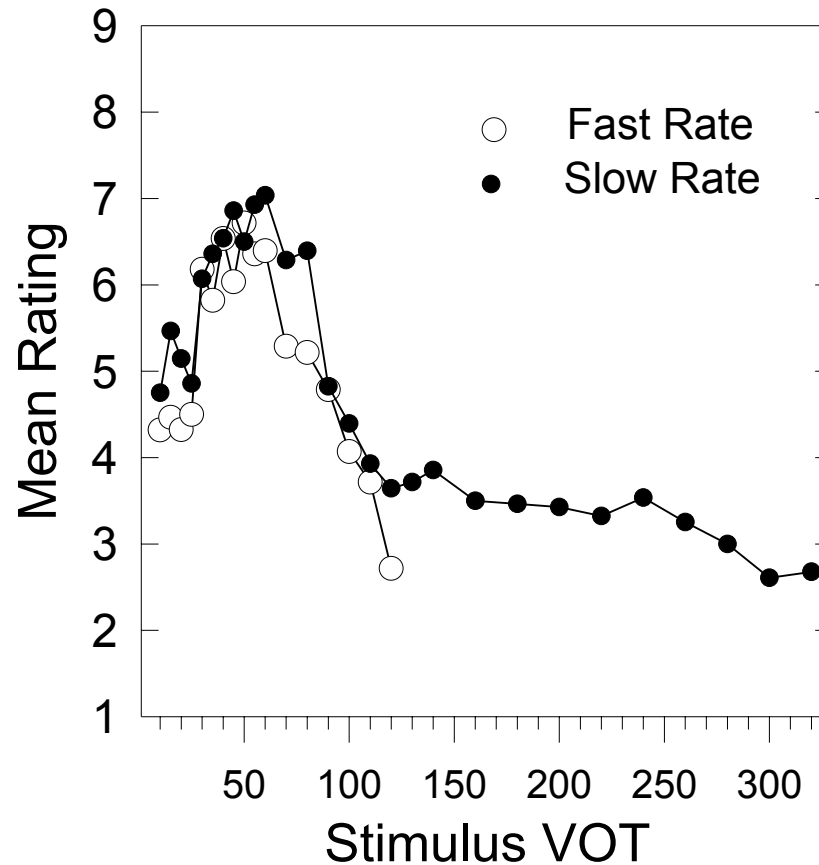
# SLM predictions

Flege, Schmidt & Wharton (1996) and Schmidt & Flege (1995) provided evidence of category formation for English /p/ by a few late Spanish-English bilinguals

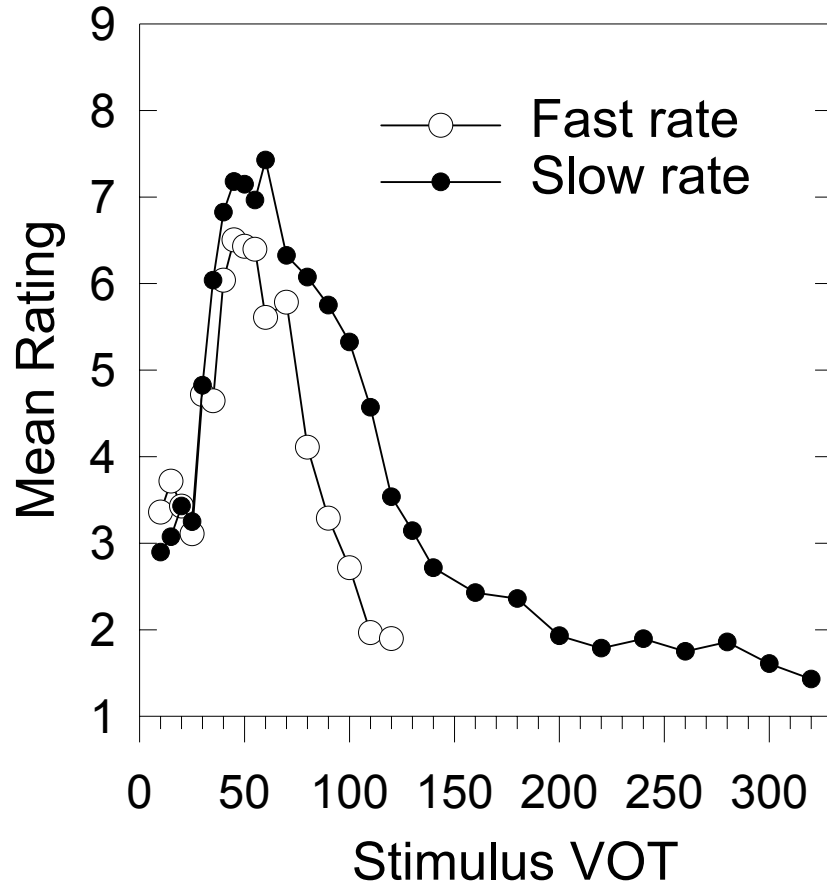
Native speakers of English  
show rate-dependent processing of  
stops differing in VOT



4 (of 15) late bilinguals who produced English /p/ with Spanish-like VOT values of 13-18 ms



# 4 (of 15) late bilinguals who produced English /p/ with English-like long-lag VOT values



# Outline

1. Purpose of the Speech Learning Model (SLM)
2. Historical background
3. Core aspects of the SLM
4. Some predictions generated by the SLM
5. **How to falsify the SLM**
6. What is most needed now?

# Adequate measurement of L2 speech needed!

- *L2 segmental production*
  - Do L2 native speakers hear it as intended?
  - If so, do they judge it to be “foreign accented”?
  - When measured acoustically, does it closely resemble native speaker productions?

# Adequate measurement

- *L2 segmental perception*
  - Do L2 learners correctly identify the segment?
  - If so, do they do so as rapidly as native speakers?
  - Do they show a greater influence of semantic/lexical context than native speakers?

# Appropriate participants must be tested!

- L2 input from native speakers, not foreign-accented input
- Experienced L2 speakers, not beginners
  - In beginners, differences from native speakers may reflect learning in progress, not inability to learn

# Appropriate participants

Find Ss with low/little use of the L1

- Many studies have shown better L2 performance by individuals who seldom use L1 than by those who often use L1
- If participants use L1 frequently, differences from native speakers may reflect difficulty separating L1-L2 system (psycholinguistic), not inability to learn phonetically

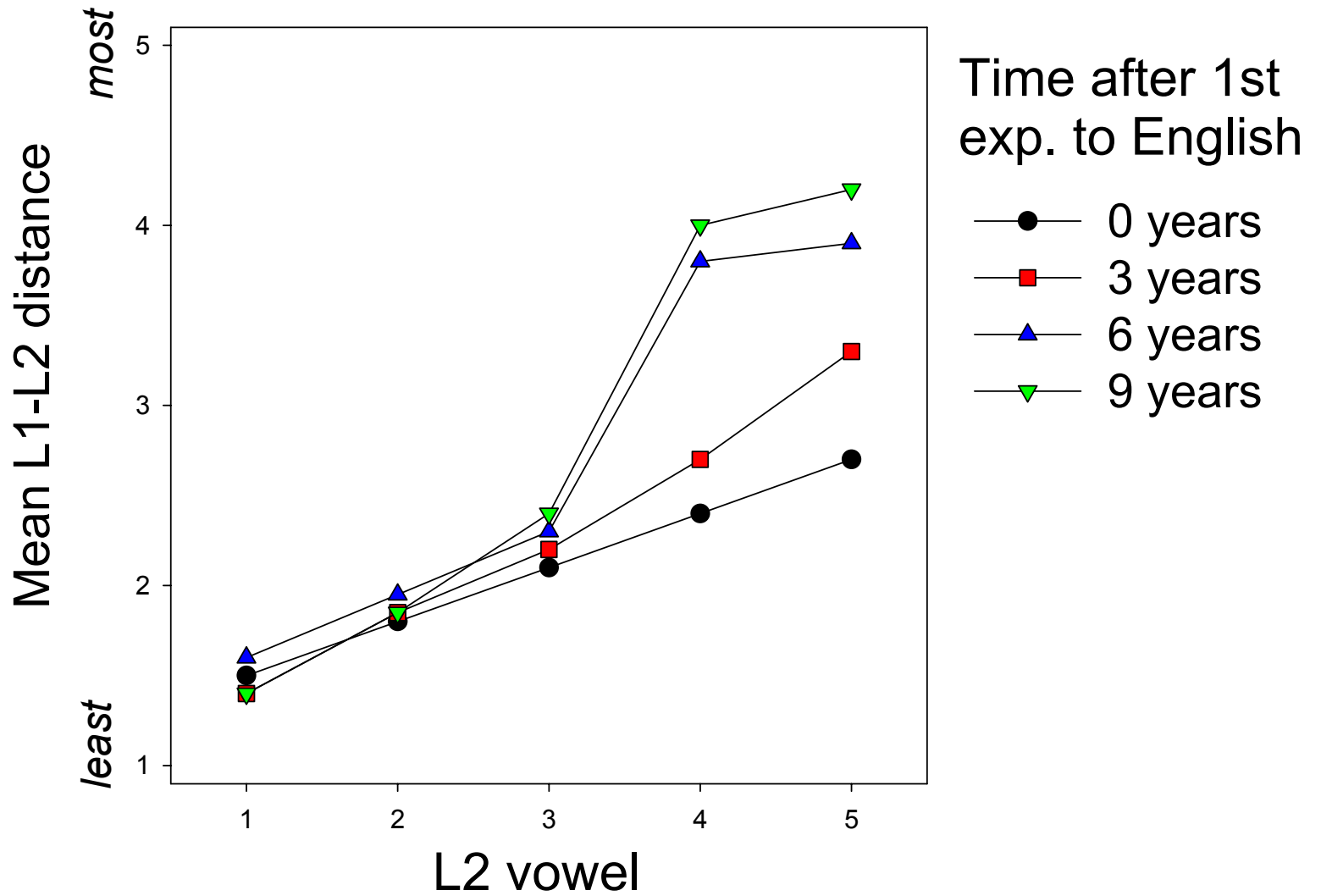
# Assessing perceived L1-L2 dissimilarity

- **Current procedures inadequate**
  - Ss hear a specific L2 phone
  - classify it in terms of abstract (imagined) L1 category
  - Rate it's goodness of fit to the (imagined) L1 category

Is participants really “thinking” about an L1 phoneme?

# How to measure perceived L1-L2 dissimilarity

- Obtain samples of L1 and L2 phones (many contexts) produced by representative L1, L2 monolinguals
- Present all pairings of L1-L2 sounds



# SLM falsified in absence of these findings

1. Category formation (CF) will result in increased perceived L1-L2 distances for certain L2 vowels
2. Greater improvement in the production of vowels showing an augmentation of perceived L1-L2 distance than for vowels not showing evidence of CF

# Category formation

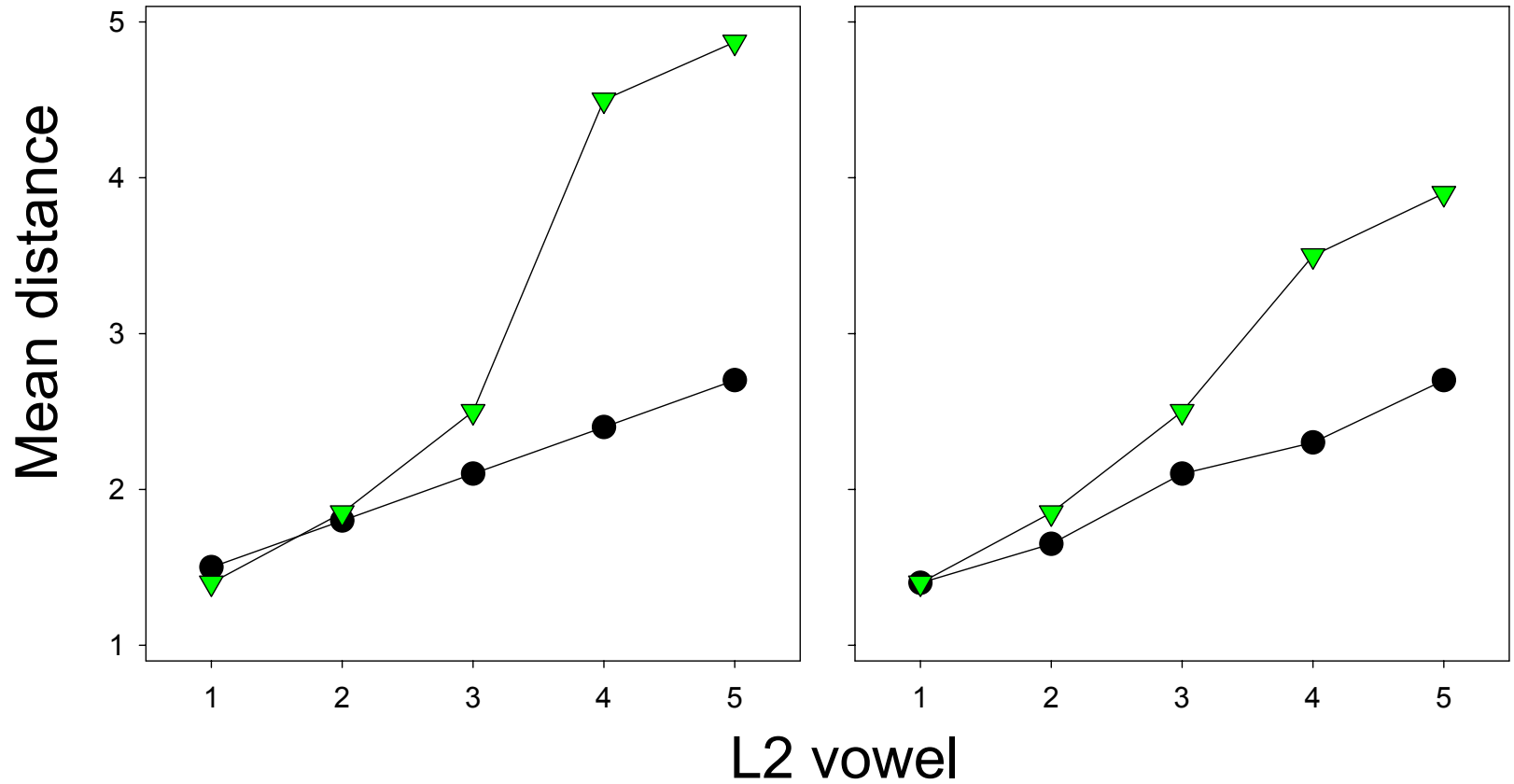
- According to the SLM, category formation (CF) becomes less likely as L1 categories develop
- **Hypothesis:** as L1 categories become more robust through childhood, they “more powerful attractors” for L2 speech sounds (see [Baker, Trofimovich, Mack & Flege, 2002](#))

*Time after 1st Exposure*

- 0 years
- ▼ 9 years

*Children (age 9 at  $T = 0$ )*

*Adults (age 21 at  $T = 0$ )*



# Falsification ...

- Evidence of CF (augmentation in perceived L1-L2 distances) for more early than late learners

(may occur after less L2 input for early than late learners, or for more L2 vowels)

- More improvement in L2 production for children than adults

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6. **What is most needed now?**

# What is needed most?

1. More adequate methods of participant selection
2. Standardized measure of perceived L1-L2 phonetic distance
3. More precise measures of L2 input
4. Quantitative methods to model L2 input-L2 performance link

# What is needed most?

5. Explanation/prediction of individual differences (especially among late learners)
6. Quickly administered test of category formation using non-overt responses (MMN, imaging)
7. Large scale studies examining multiple measures of production & perception specifically designed to falsify the SLM

# What is needed most?

8. Patience
9. Hard work
10. Imagination
11. Luck

# Thanks

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