

# **Workshop on Linguistic Convergence**

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The Pennsylvania State  
University**

# What is the cause of “age” effects on second language (L2) learning?

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## Abstract

Earlier is almost always better than later with respect to performance in a second language (L2). This much is clear. However, the basis for age effects remains controversial.

The first aim of this talk is to provide examples of age effects that have been reported in the literature for the acquisition of L2 pronunciation and morphosyntax. In this kind of research, immigrants' age of first exposure to an L2 is indexed by their age of arrival (AOA) in a predominantly L2-speaking country. The effect of AOA research is generally robust, with more native-like performance by individuals with an early than late AOA.

The second aim of the talk will be to describe a serious problem for interpreting AOA effects, namely, the confounding with AOA of variables likely to influence L2 proficiency. For example, a relatively late AOA is typically associated with a relatively short length of residence (LOR) in the L2-speaking country, infrequent use of the L2 and correspondingly frequent continued use of the L1, much education in the home country prior to emigration and little education in L2-medium schools in the host country. Given these confounds, it is more reasonable to speak of “age-related” than of “age” effects on L2 performance.

The final aim of the talk is to outline four broad types of explanations that have been offered in the literature to account for age-related effects. Although strong claims have been made about what causes age-related effects, it is not possible at this time to choose from among the competing hypotheses. More—and better controlled—research will be needed to identify the basis (or bases) of age-related effects on L2 learning.

# Aims

1. Provide examples of age-related effects in second language (L2) acquisition
2. Outline four hypothesized causes of age effects on ultimate proficiency in an L2
3. Discuss arguments for/against the four hypotheses
4. Summary

# Aim #1

Provide examples of age-related effects in second language (L2) acquisition

# Age-related effects: Examples

## How “age of L2 learning” is indexed

- Much (not all) research has used immigrants' age of arrival (AOA) in a country where L2 must be learned
- Examples: native Spanish and Korean immigrants to the United States

# Age-related effects: Examples

All (?) research which has directly compared L2 learners differing in AOA has shown more native-like performance by individuals with relatively early than late AOA. Examples:

- Morphosyntax
- Speech production

## Johnson & Newport (1989)

Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language, *Cognitive Psychology*, 21, 60-99

Most often cited article in literature?

## Johnson & Newport (1989)

- Chinese and Korean adults ( $n = 46$ ) differing in AOA in the United States
- All students/faculty members at U of Illinois (min 3 years of residence in US)
- Evaluated knowledge of 12 types of grammatical structures representing “the most basic aspects of English sentence structure” (1989, p. 72)

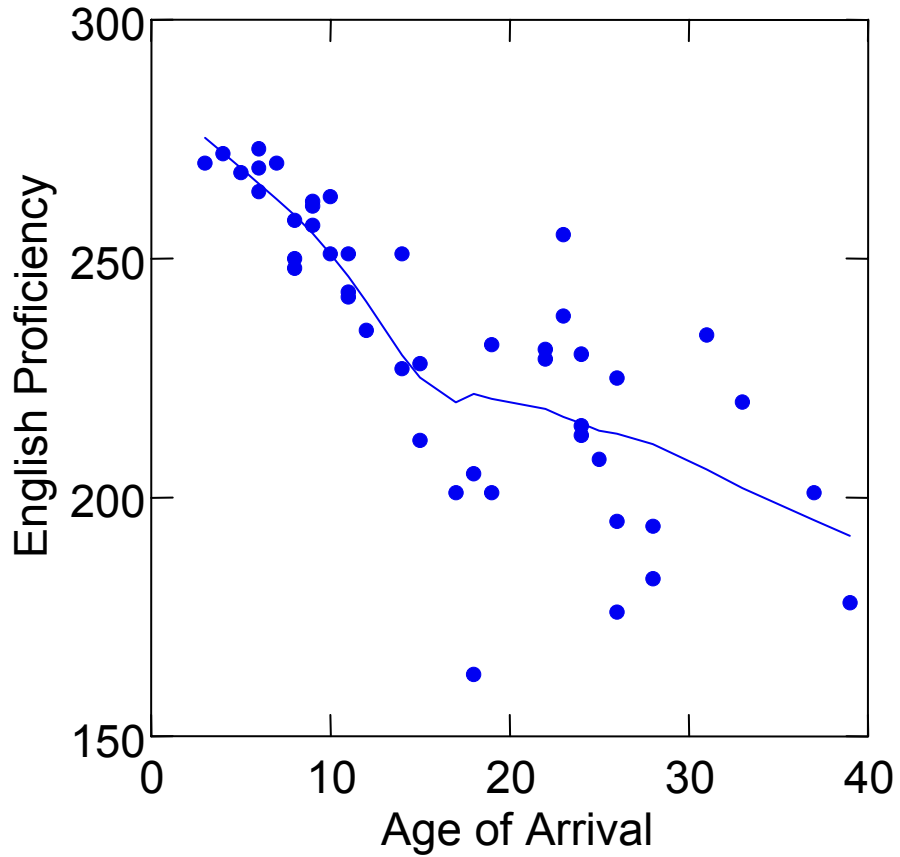
# Johnson & Newport (1989)

Grammatical & ungrammatical versions of 138 sentences such as:

*Last night the old lady died in her sleep*

*\*Last night the old lady die in her sleep*

# Johnson & Newport (1989)



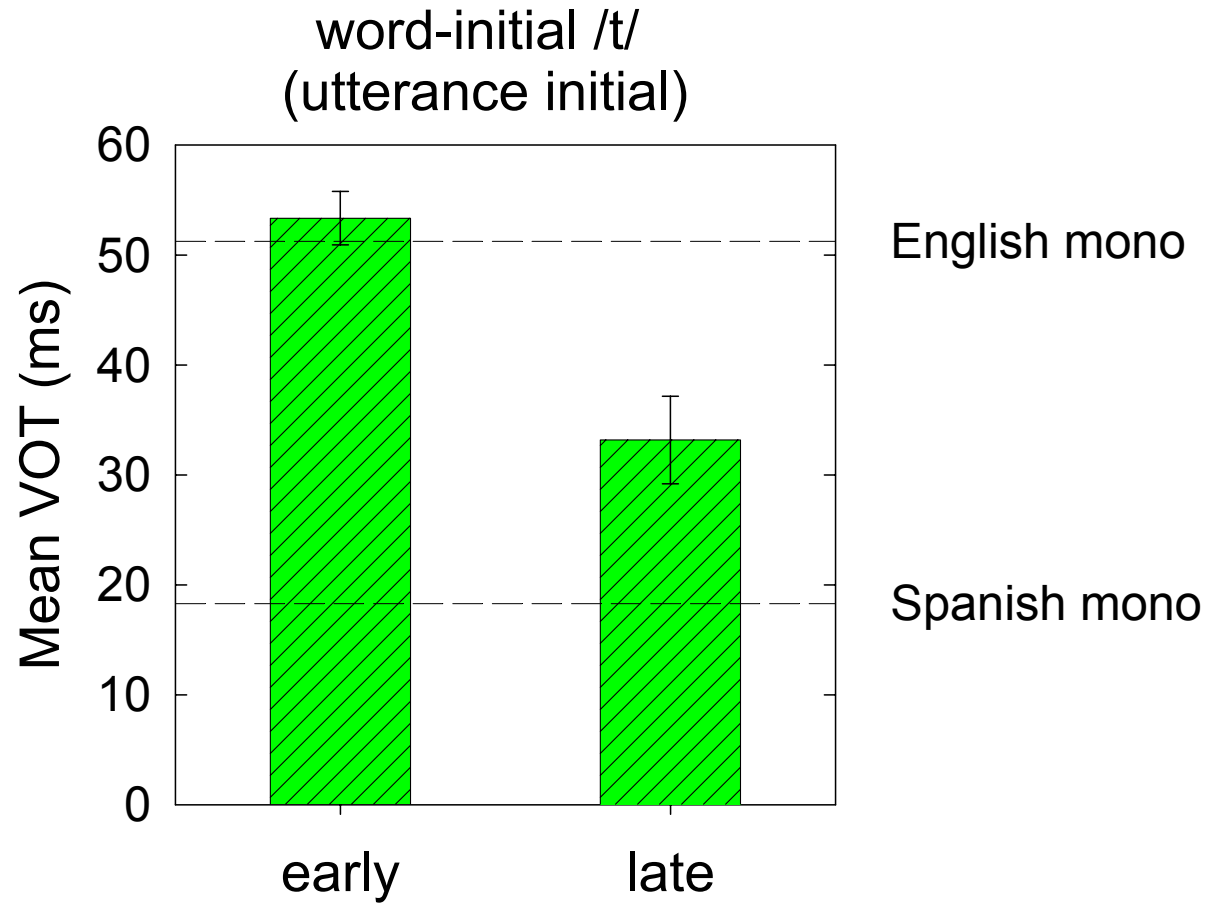
# Flege (1991)

- Measured acoustic phonetic dimension in speech production
- VOT (voice onset time) in word-initial stop consonant, /t/

# Participants tested by Flege (1991)

	<b>N</b>	<b>Age</b>	<b>AOA</b>	<b>Length of Residence</b>	<b>English Use</b>
<b>Spanish monolingual</b>	10	30	--	--	--
<b>English monolinguals</b>	10	26	--	--	--
<b>Early S-E bilinguals</b>	10	23	2	21	82%
<b>Late S-E bilinguals</b>	10	34	20	14	66%

# Flege (1991)



# Age-related effects: Examples

- AOA effect on L2 performance is robust
- However, the best explanation for this effect is uncertain

## Aim #2

Briefly outline four hypothesized causes of age effects on ultimate L2 proficiency

# Age effect hypotheses

1. Maturation constraints
2. Cognitive changes across the life span
3. Age-related changes in how the L1 and L2 systems interact
4. Age-related differences in L2 input

# H1: Maturation constraints

As humans develop normally, some aspect(s) of development reduces the capacity for language learning that enables children to learn their native language well and rapidly

*best known example: “Critical Period” hypothesis*

# H1: Maturation constraints

Regarding the effect of age of learning on grammaticality judgment test scores, [DeKeyser \(2000\)](#) concluded:

*“Somewhere between the ages of 6-7 and 16-17, everybody loses the mental equipment required for the abstract patterns underlying a human language” (pp. 518-519)*

# H1: Maturation constraints

## DeKeyser (2000)

*“...the severe decline of the ability to induce abstract patterns implicitly is an inevitable consequence of fairly general aspects of neurological maturation.”*

(pp. 518-519)

# H1: Maturation constraints

According to [Scovel \(2000\)](#), the critical period for L2 speech learning has a “neuromotor etiology”, i.e., a loss of cerebral “plasticity”

# H1: Maturation constraints

## No convergence of views as to

- The neurological basis of the CP
- When the critical period ends
  - 5-6 years?
  - 12-15 years?
  - somewhere in between?
  - different ages for different aspects of L2 learning?

# H1: Maturation constraints

## Agreement that

- CP ends at the same time for everyone (because CP triggered by normal maturation)
- Less proficiency for those who began learning L2 after than before the CP
- No systematic decline in L2 proficiency as a function of AOA after the CP

## H2: Cognitive changes

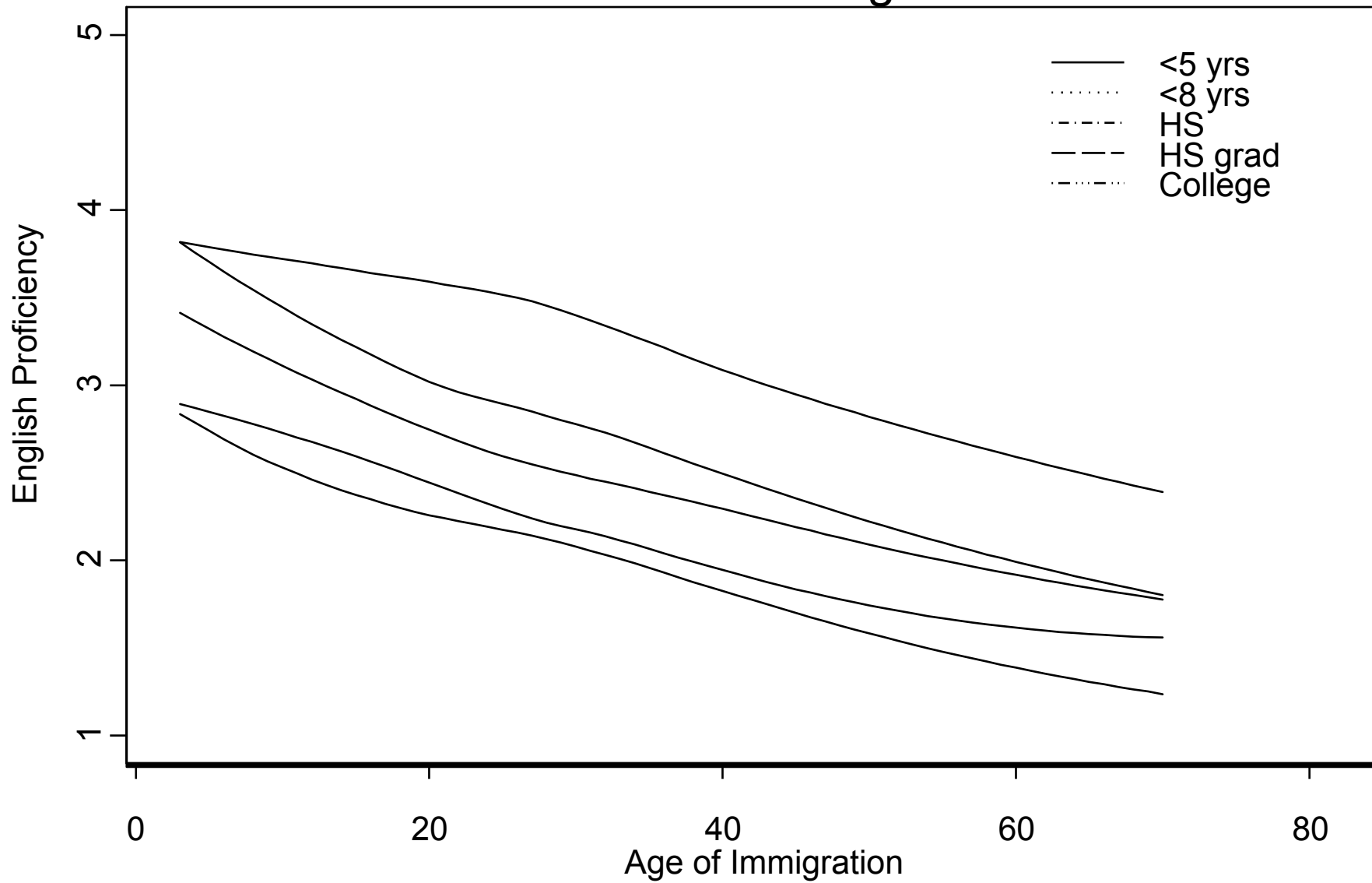
Cognitive abilities needed to learn speech and language diminish slowly across the life span

## H2: Cognitive changes

### Hakuta, Bialystok & Wiley (2003)

- Analysis of census data (self-evaluations of English proficiency) provided by large numbers of Chinese & Spanish-speaking immigrants to the United States
- Similar results for both groups

# English Proficiency on Age of Immigration Chinese Immigrants

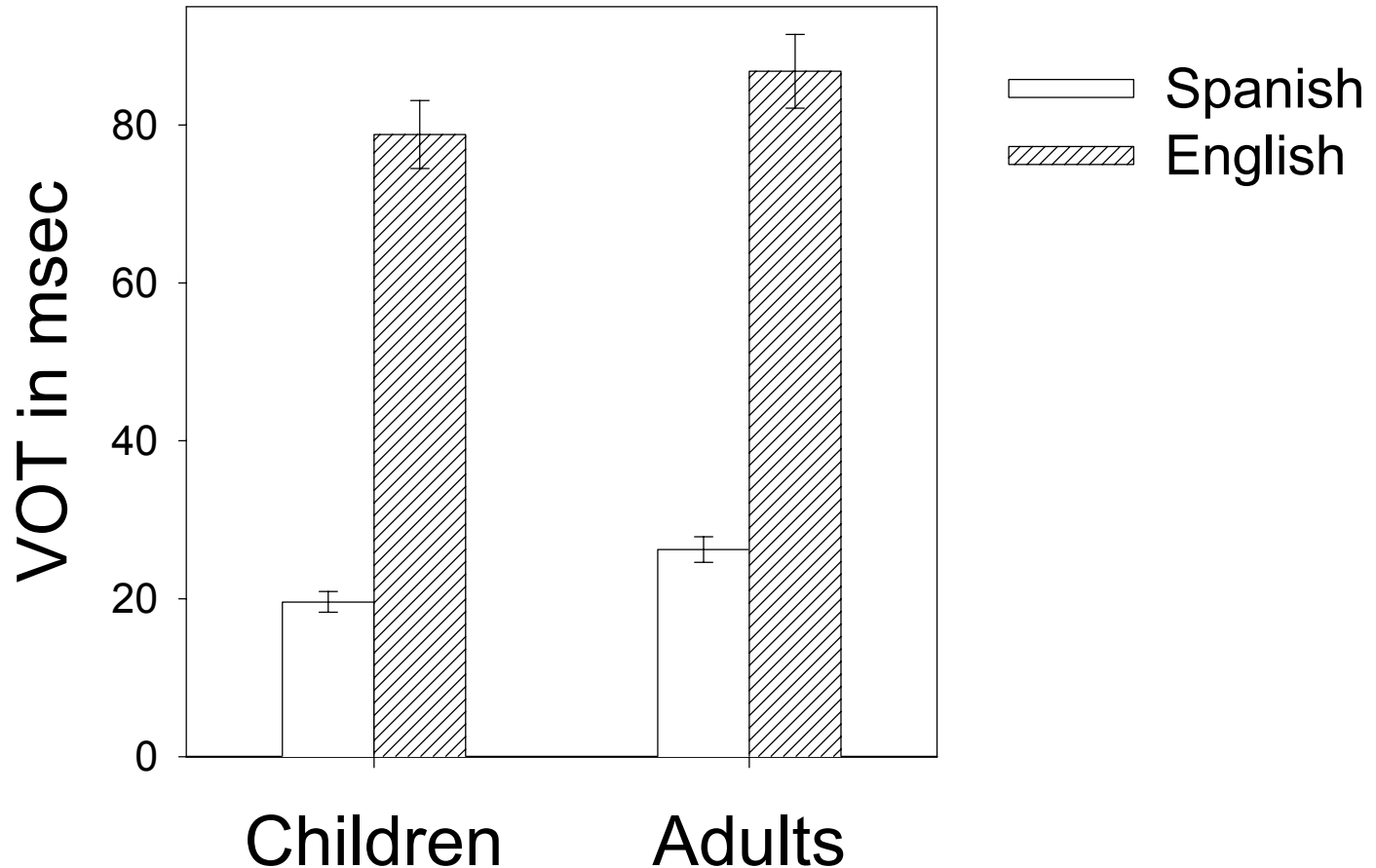


### H3: Changes in L1-L2 interactions

The L1 inevitably influences the L2, but the *nature* of L1-L2 interactions may change with age as an indirect consequence of the development of L1 representations

example from L2 speech

# Flege & Eefting (1987) VOT in /p t k/ produced by Spanish and English monolinguals



## H3: Changes in L1-L2 interactions

### Specifically:

As L1 categories develop, they become stronger “attractors” of L2 vowels and consonants

### H3: Changes in L1-L2 interactions

#### Example:

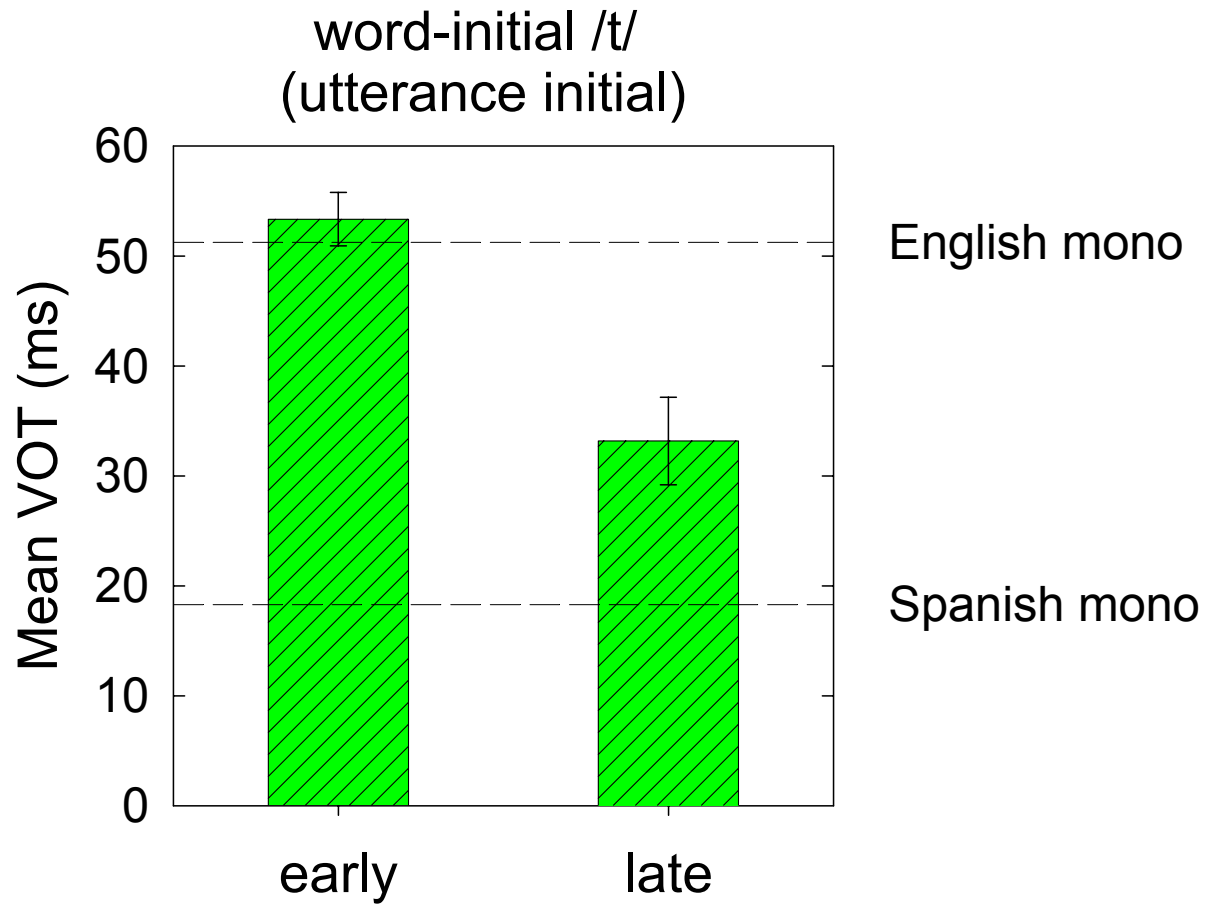
- As Spanish monolinguals get older, English [t<sup>h</sup>] token will sound increasingly more similar to Spanish [t] tokens (even though the difference can be detected auditorily)
- Reduce the likelihood that Spanish speakers who learn English as an L2 will establish a new phonetic category for long-lag English /t/ category

### H3: Changes in L1-L2 interactions

#### Consequence:

- If Spanish learners of English fail to establish a new category for English /t/, they will use a single “merged” category in both Spanish and English
- It will reflect the phonetic properties of both Spanish, English /t/ (in proportion to the input received)

# Flege (1991)



### H3: Changes in L1-L2 interactions

#### Prediction:

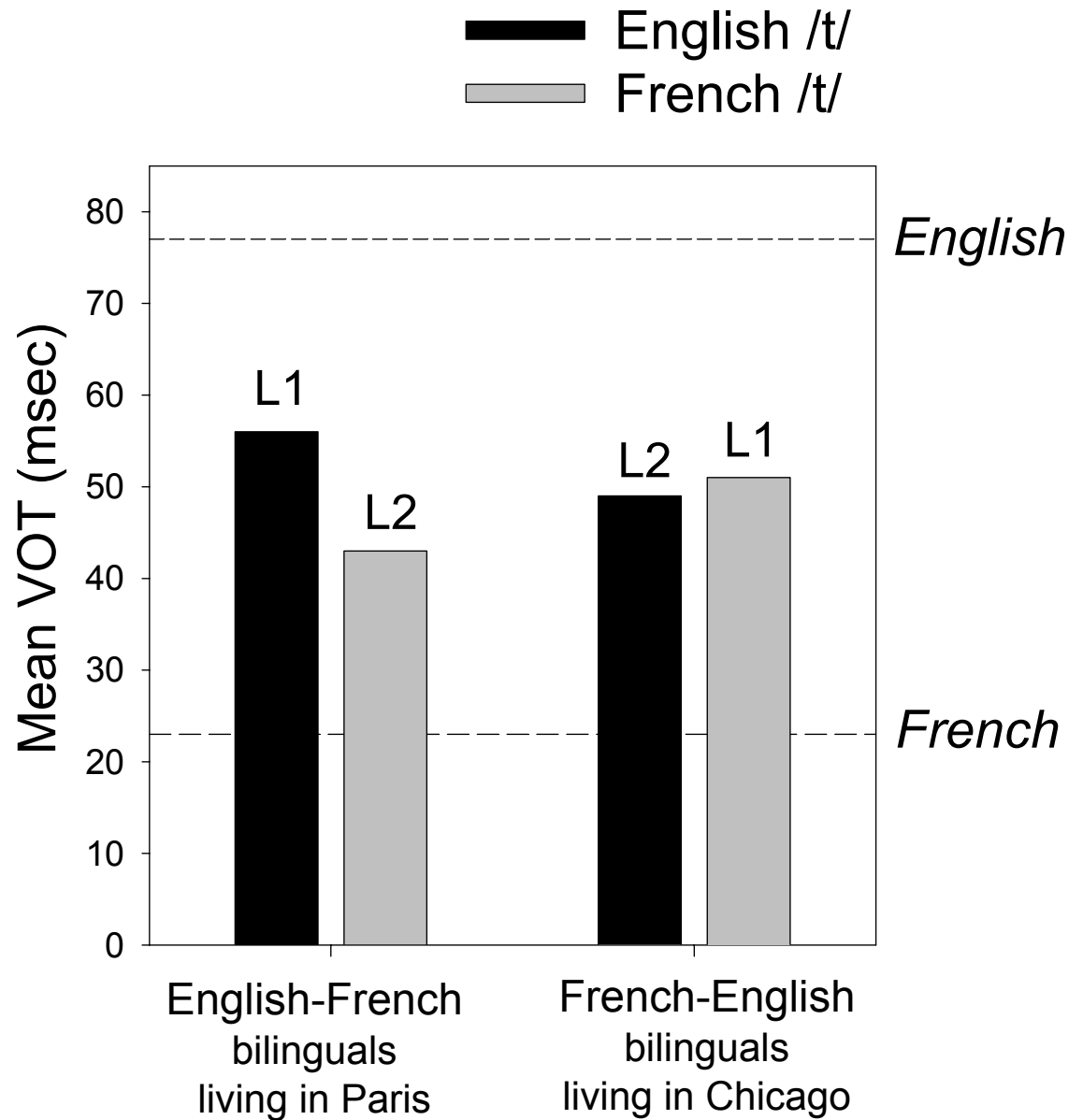
- If Spanish learners of English develop a merged category, VOT should remain too short (Spanish-like) in English but become too long (English-like) in Spanish
- No evidence for Spanish-English bilinguals, but relevant data for French-English (Flege, 1987)

### H3: Changes in L1-L2 interactions

Flege (1987) tested

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

# Flege (1987)



## H4: Differences in L2 input

“Early is better than later” because early learners get more/better L2 input than late learners do

## H4: Differences in L2 input

- Known that the later an L2 is learned, the less the L2 is used and the more the L1 continues to be used
- Likely that late learners receive more foreign-accented L2 input than early learners (however, no hard evidence)

## Aim #3

Discuss arguments for/against the four hypotheses

## Aim #3

- Necessarily selective and brief due to time limits
- To look ahead: Problems can be identified for all four hypotheses

# H1: Maturation constraints

## Correctly predicts

- Earlier is better than later
- Very few individuals who began learning their L2 after the age of 15 years are completely native-like even after years of L2 use (assume: CP ends at 15 years)

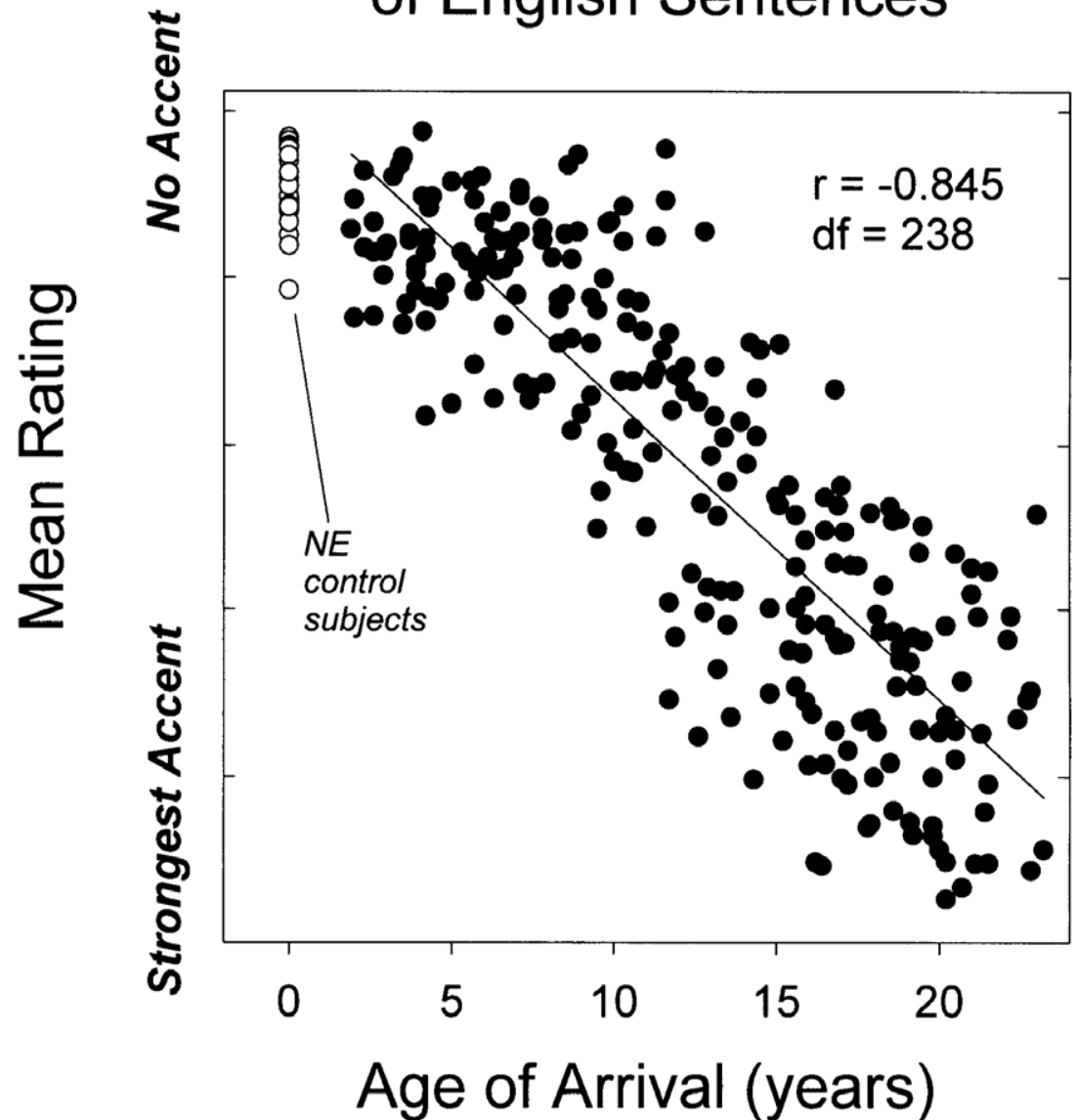
# H1: Maturation constraints

## Illustrate

- Two studies examined large ( $n = 240$ ) groups of immigrants to North America who differed in AOA
- Repeated English sentences following a model
- Sentence rated for foreign accent by native English listeners

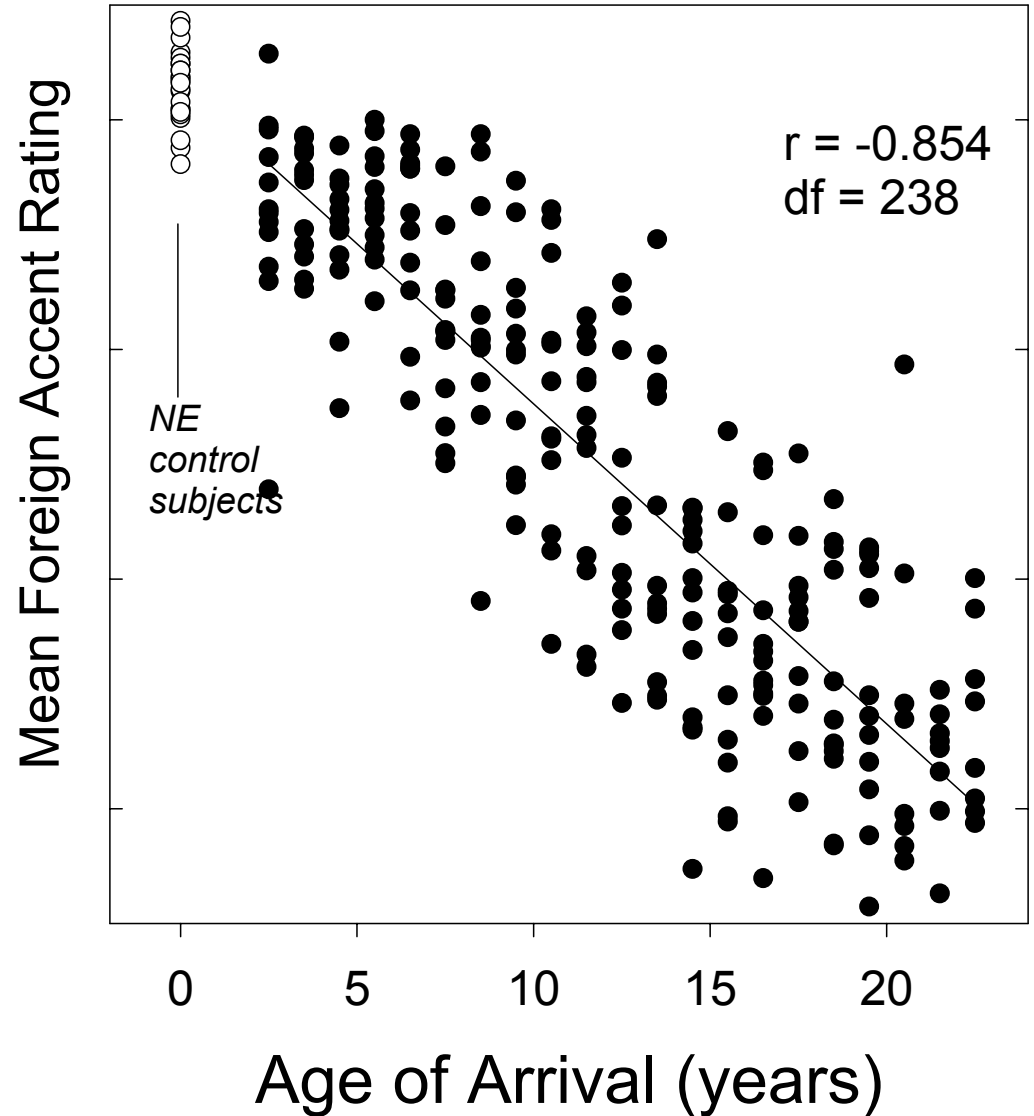
Flege et al.  
(1995)

## 240 Native Italian Ss' Production of English Sentences



# 240 Native Korean Ss' Production of English Sentences

Flege et al.  
(1999)

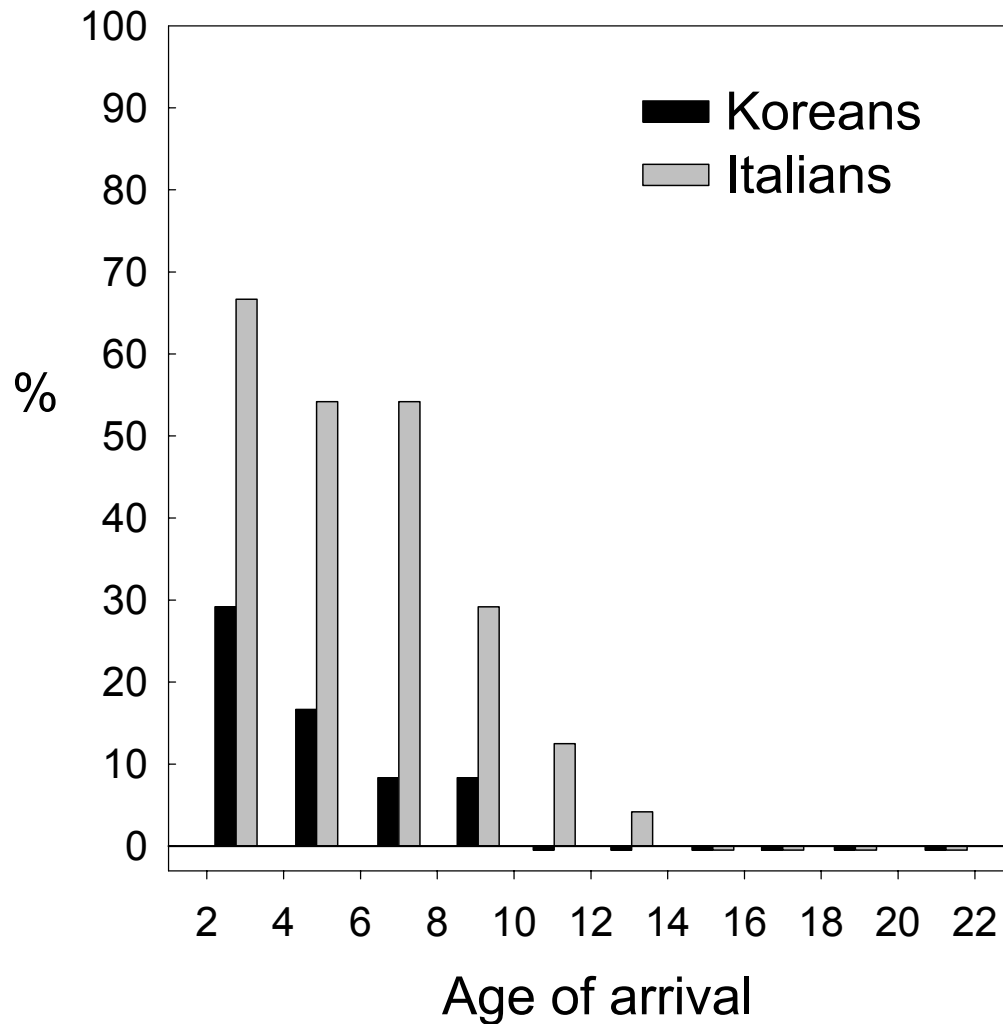


# H1: Maturation constraints

## Index of “accent-free” L2 pronunciation

- Determine if each individual nonnative did/did not produce English sentences receiving a rating within 2 SDs of mean rating obtained for NE group
- Determine % of “accent free” participants in each AOA-defined group of 24 nonnatives

# % of Korean, Italian participants who received a rating within 2 SDs of native English mean



# H1: Maturation constraints

## Problem 1

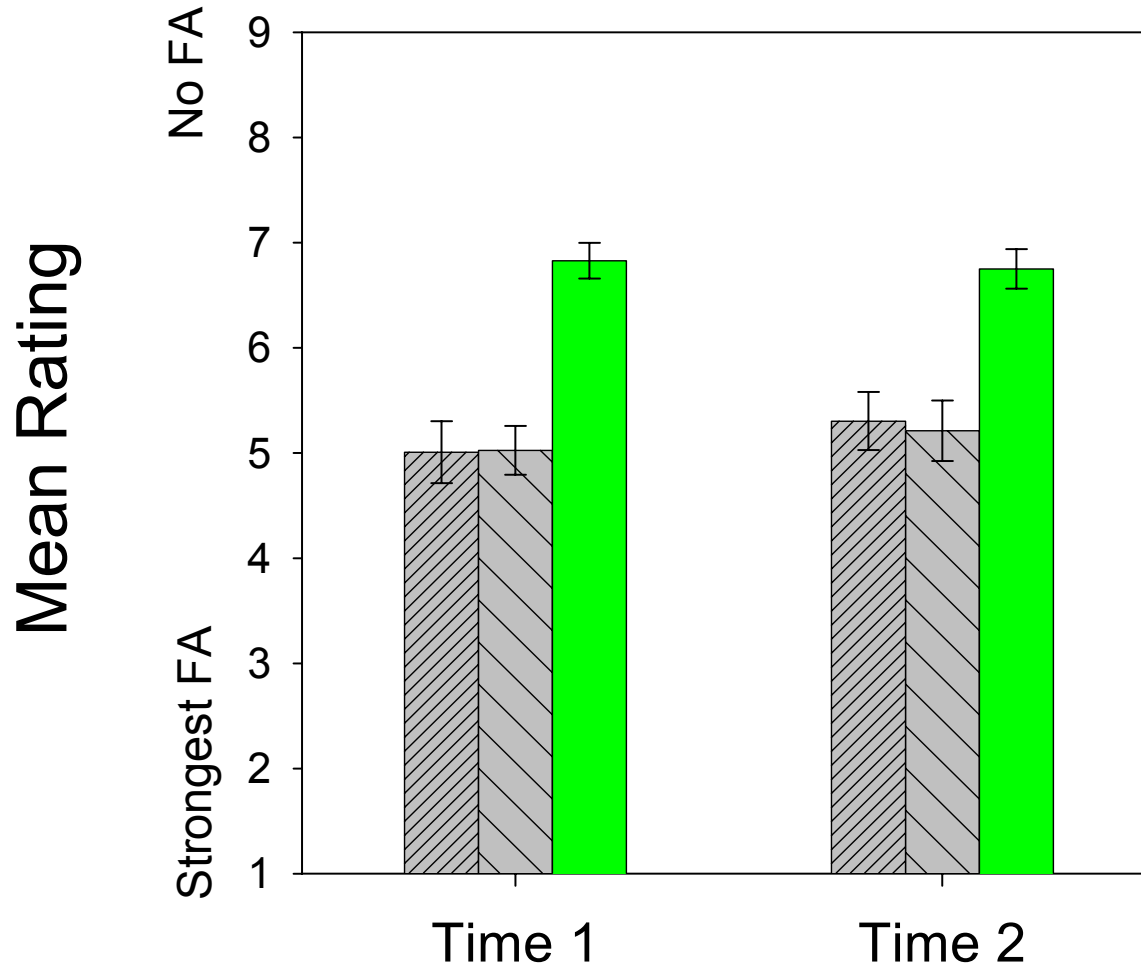
CP hypothesis fails to predict that many individuals who began learning the L2 as young children will continue to speak L2 with a foreign accent, even after many years of L2 use

# H1: Maturation constraints

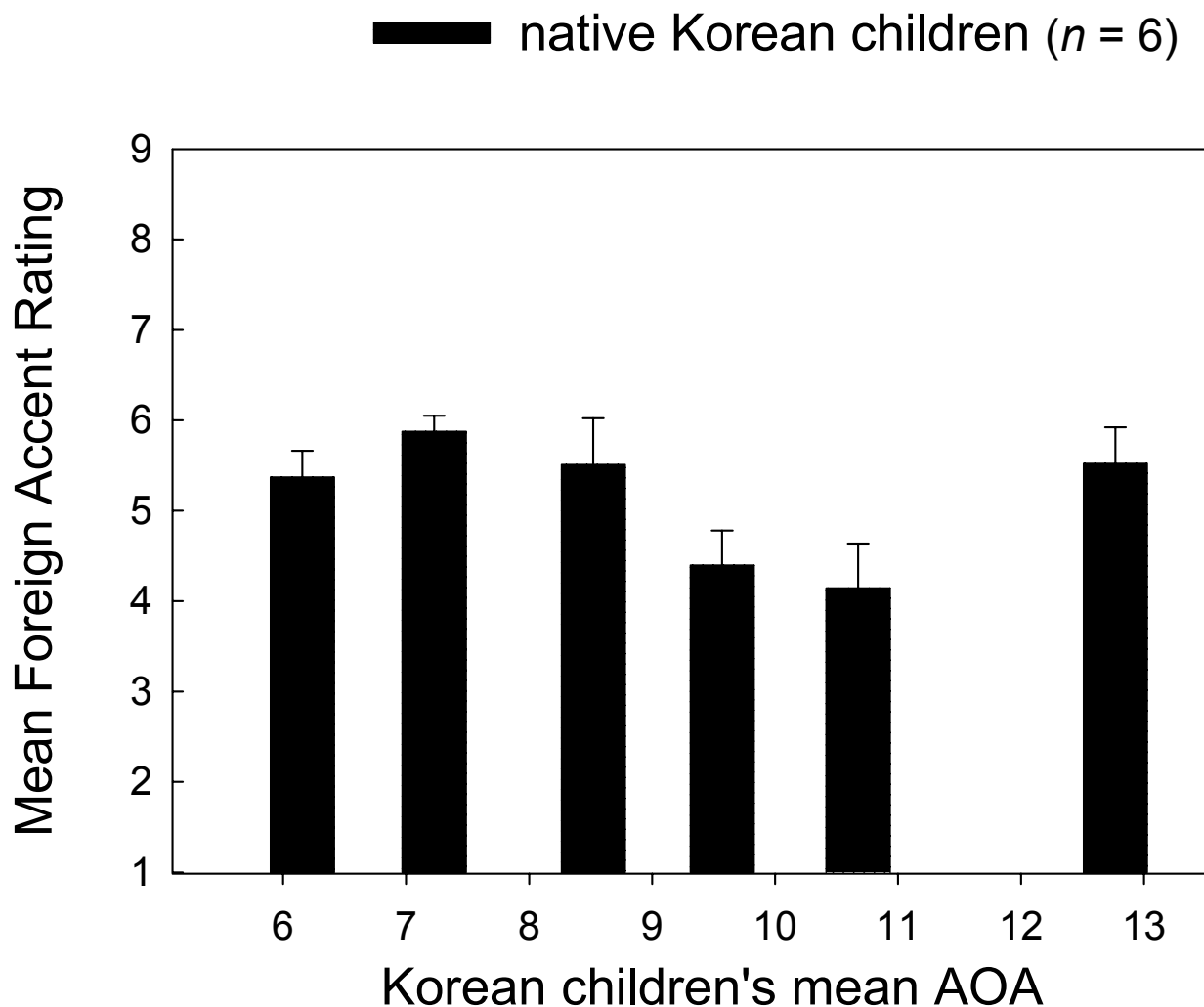
## Illustrate

- [Flege et al. \(in press\)](#) examined Korean children who had lived in North America for either 3 or 5 years
- Both groups tested twice, 1 year apart
- DV: Foreign accent ratings of English sentences

- ▨ Korean Children with LOR = 3 at T1
- ▨ Korean Children with LOR = 5 at T1
- █ age-matched Native English children



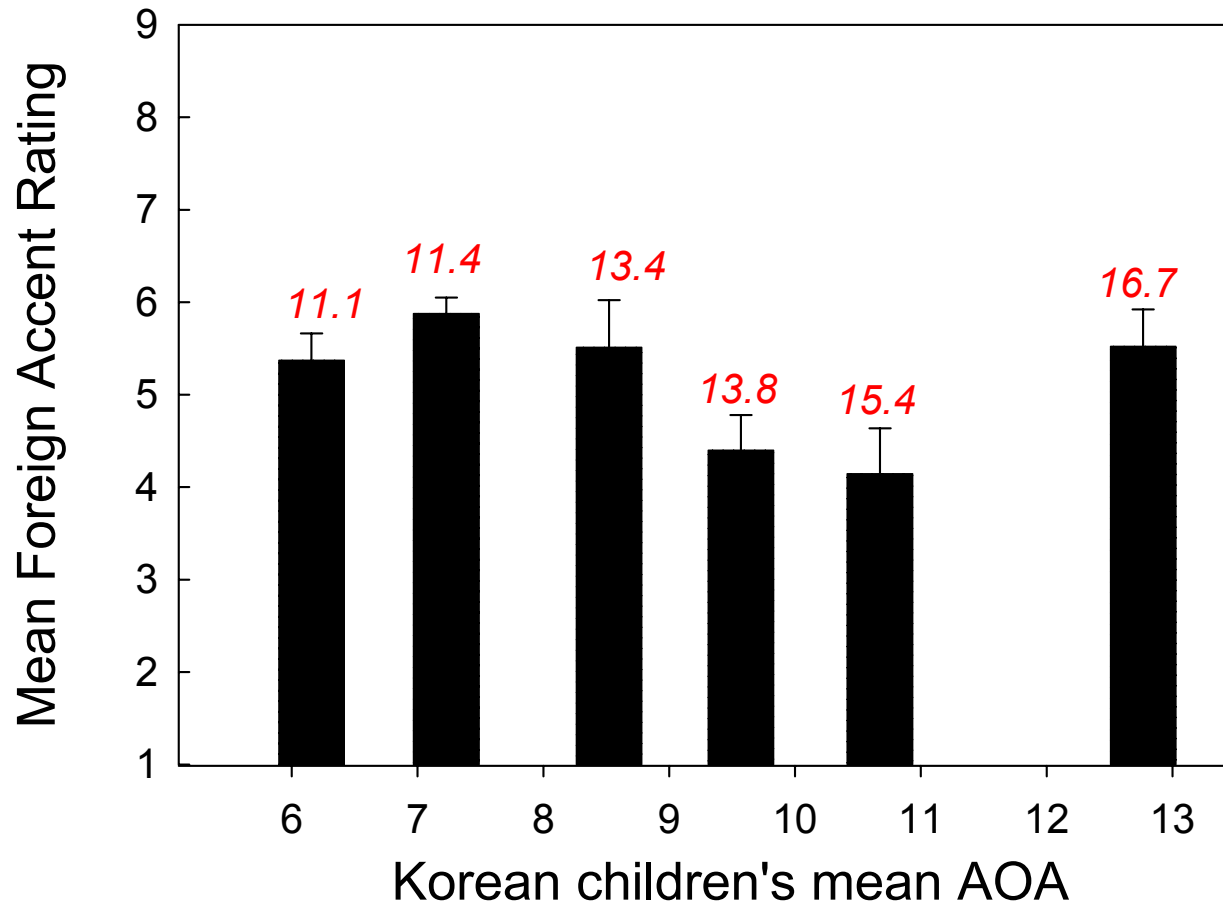
assign Korean children to subgroups of 6 each based on AOA (ratings averaged over T1, T2)



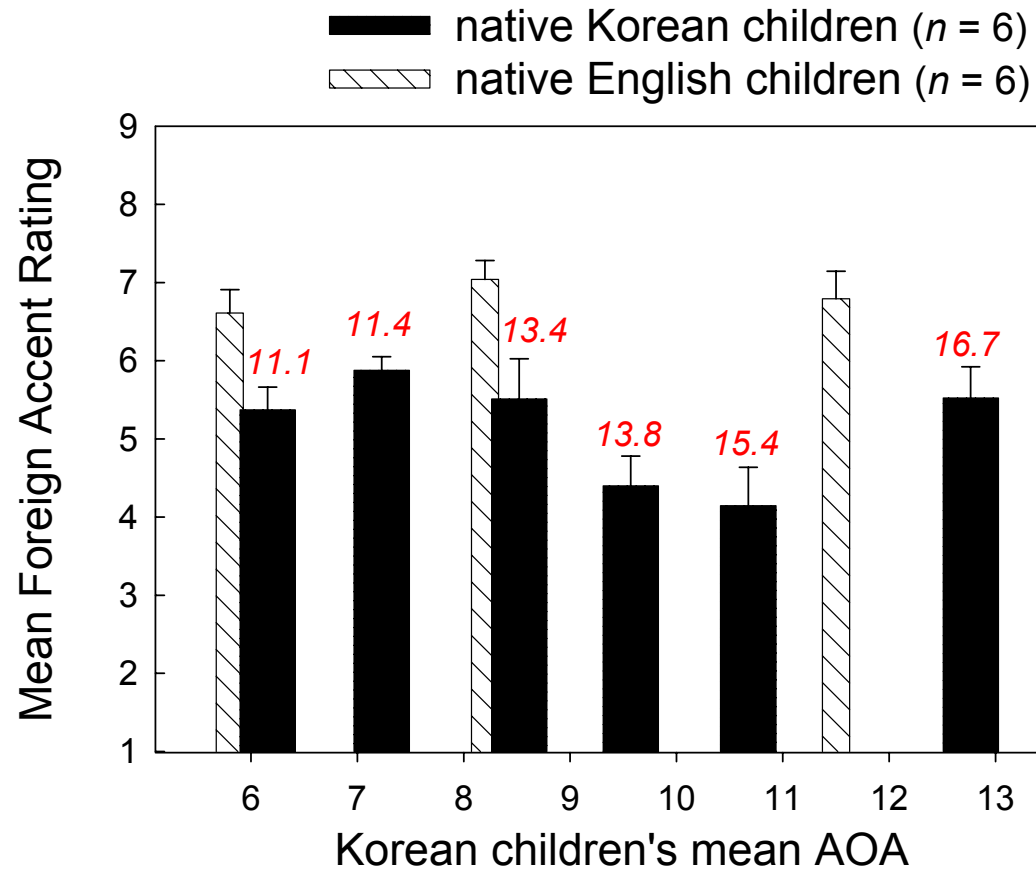
Average over Time 1, Time 2

## Chronological Age

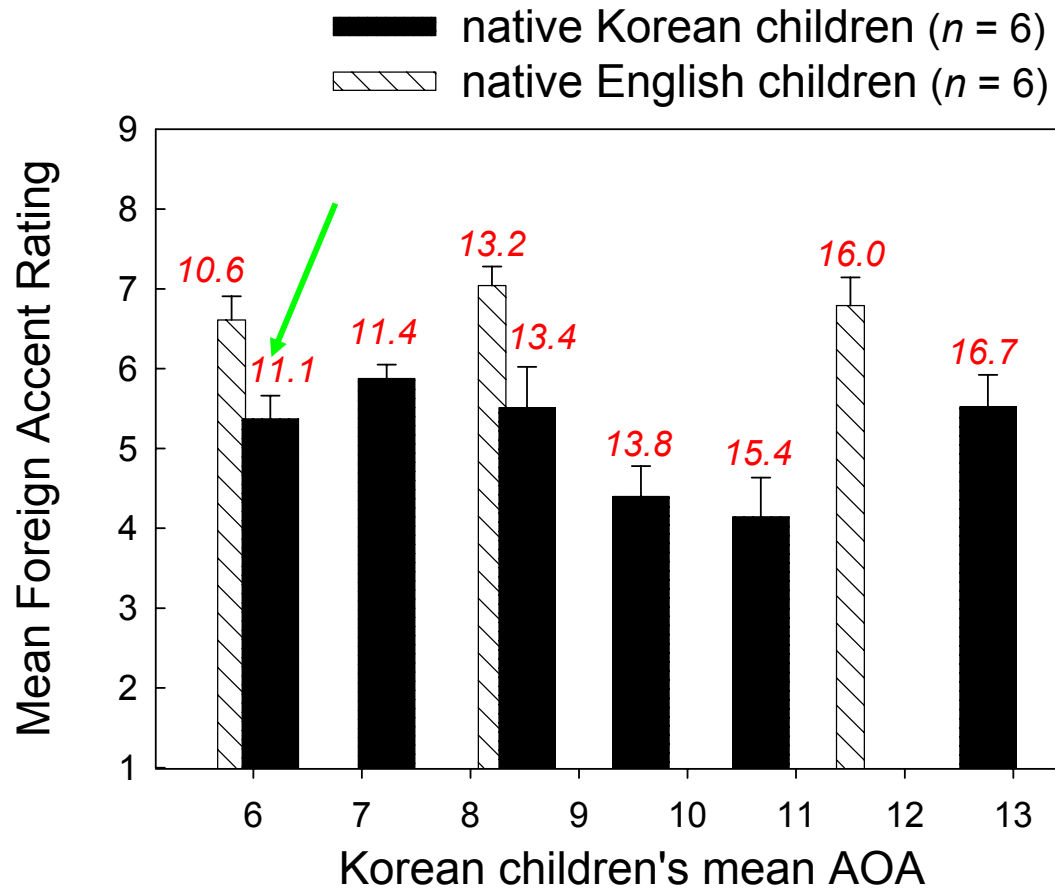
■ native Korean children ( $n = 6$ )



# Assign native English children to subgroups of 6 each (based on chronological age)



# Korean children who arrived at age 6 have a detectable foreign accent after 5 years of immersion



# H1: Maturation constraints

## Problem 2

- Prediction that L2 proficiency will continue to decline as the CP is neared, but not after the CP
- Why? All “post-critical period” learners suffer equally the ill effects attributed to having passed the critical period

# H1: Maturation constraints

## Problem 2

- However, L2 proficiency does decline systematically after the supposed end of a CP
- Example: foreign accent data obtained for 240 Italians and 240 Koreans

## **Flege et al. (1995) Correlation between Italians' AOA–foreign accent ratings**

AOA range	n	correlation	p-value
2 to 23	240	-0.85	.0001
12 to 23	125	-0.53	.001
15 to 23	95	-0.33	.01

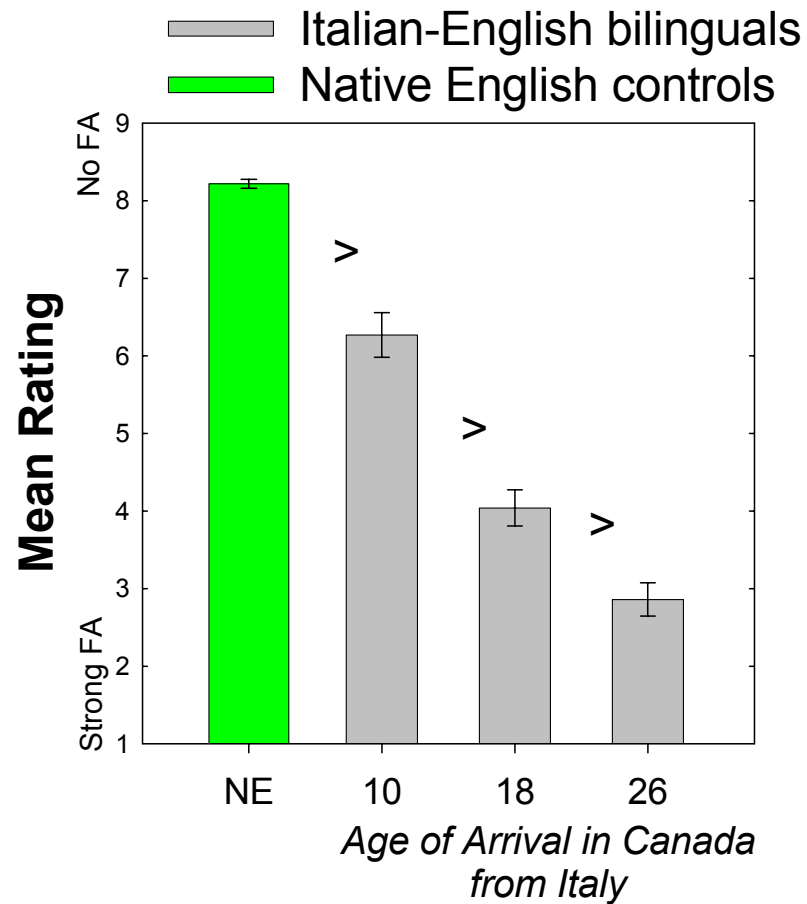
## *Italians*

AOA range	n	correlation	p-value
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15 to 23	95	-0.33	.01

## **Flege et al. (1999) Koreans** **AOA – Foreign Accent**

AOA range	n	correlation	p-value
2.5 to 23	240	-0.85	.0001
12 to 23	120	-0.49	.001
15 to 23	83	-0.29	.01

# Flege & MacKay (under review)

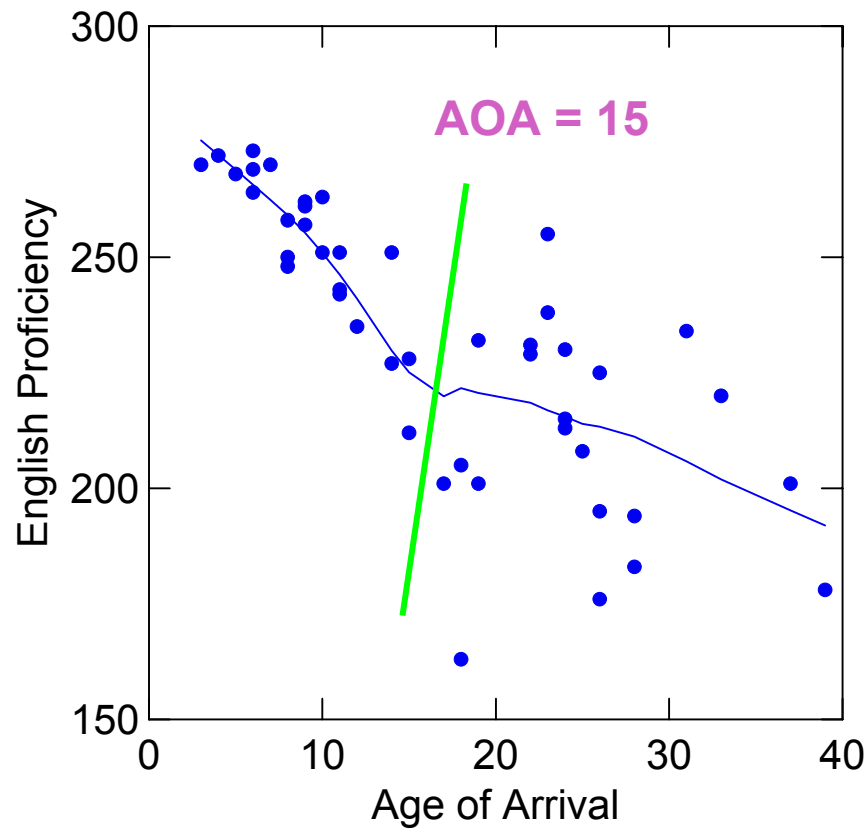


# H1: Maturation constraints

## Problem 3

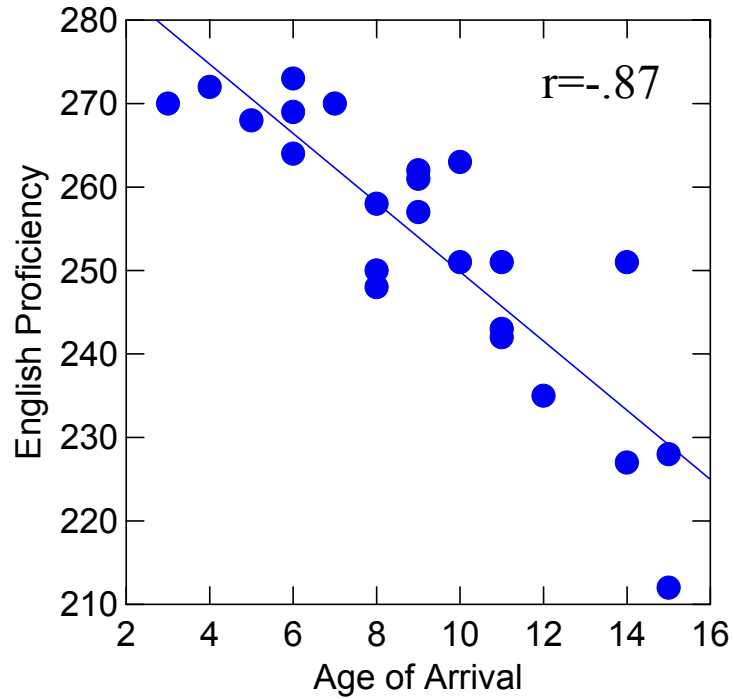
Re-examination of the original morphosyntax data in [Johnson & Newport \(1989\)](#) by [Hakuta & Bialystok \(1994\)](#) calls into question [Johnson & Newport's](#) primary evidence in support of a maturational constraint hypothesis

# Johnson & Newport (1989)

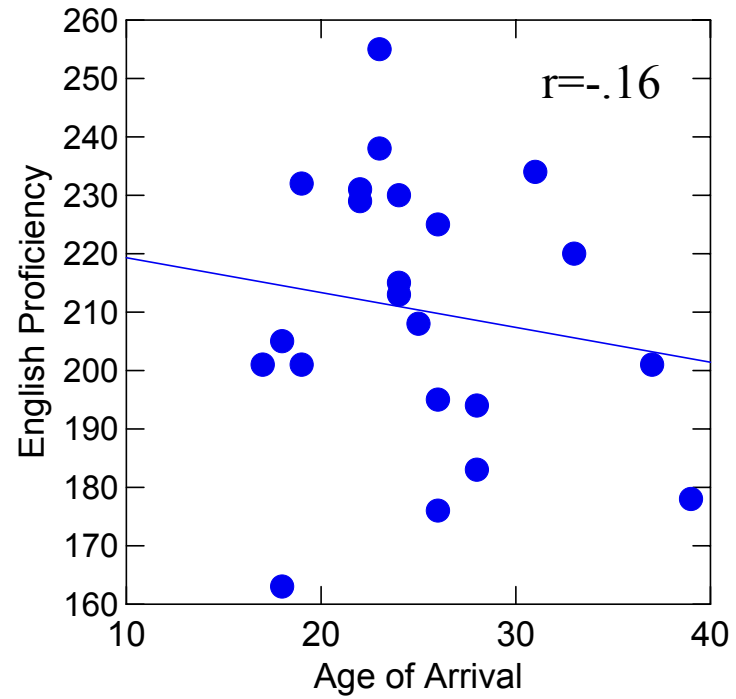


# Johnson & Newport (1989)

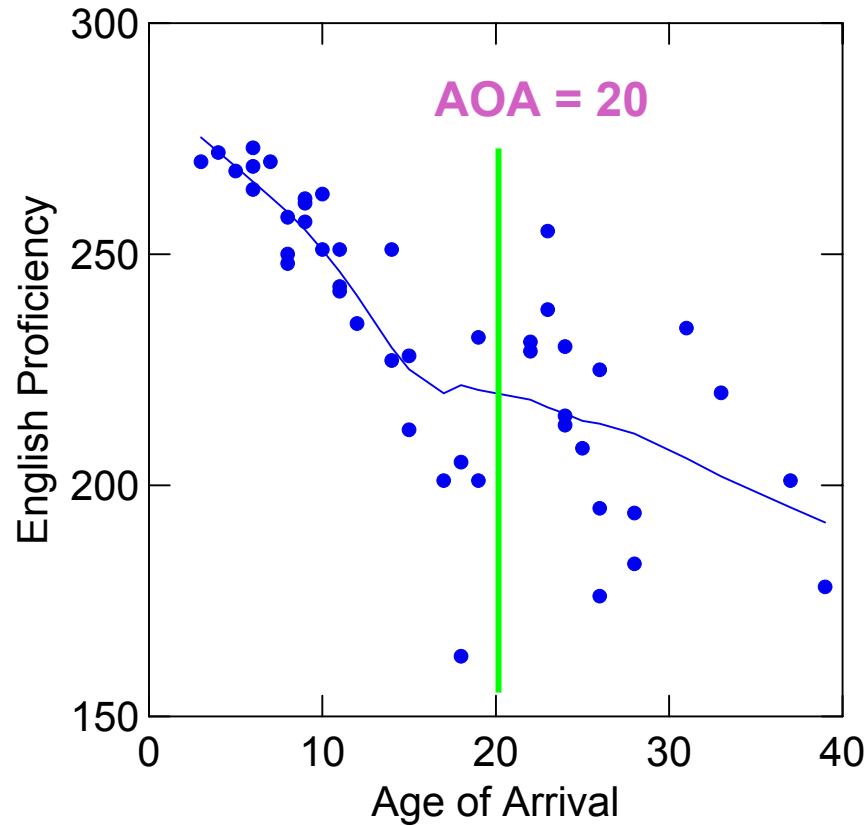
Pre-Puberty



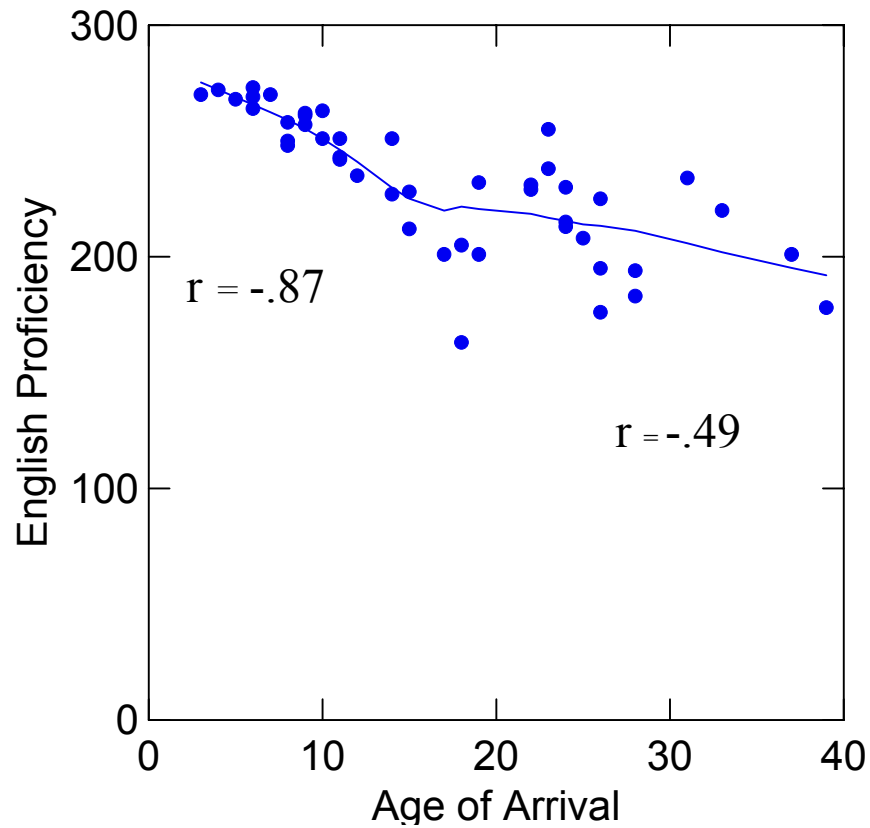
Post-Puberty



# Johnson & Newport (1989)



# Johnson & Newport (1989) data rescaled



# H1: Maturation constraints

## Problem 4

The age effect obtained by [Johnson & Newport \(1989\)](#) may disappear when factors confounded with AOA are controlled

## Flege et al. (1999)

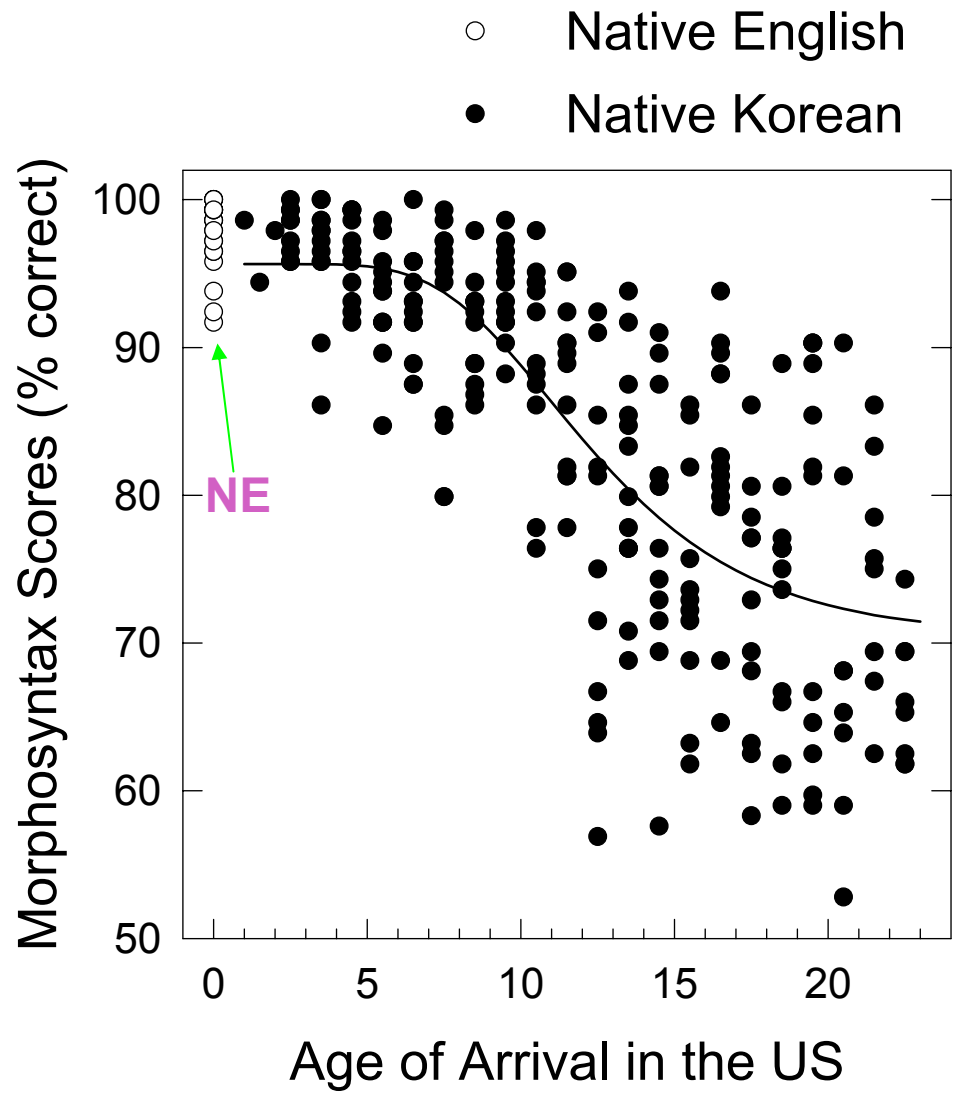
- Already mentioned: foreign accent ratings from 240 Korean immigrants
- Also responded to grammaticality judgment test (GJT)
- Stimuli drawn from [Johnson and Newport \(1989\)](#)

## Participant selection criterion

- AOA: 3 to 22
- Gender: 12 male/12 female per group of 24
- minimum length of residence in US = 8 years

# Participants in **Flege et al. (1999)**

	<i>N</i>	<i>AOA</i>	<i>Age</i>
<i>NE</i>	12 m, 12 f	--	27
<i>NK-3</i>	12 m, 12 f	3	23
<i>NK-5</i>	12 m, 12 f	5	21
<i>NK-7</i>	12 m, 12 f	7	24
<i>NK-9</i>	12 m, 12 f	9	24
<i>NK-11</i>	12 m, 12 f	11	24
<i>NK-13</i>	12 m, 12 f	13	24
<i>NK-15</i>	12 m, 12 f	15	27
<i>NK-17</i>	12 m, 12 f	17	29
<i>NK-19</i>	12 m, 12 f	19	32
<i>NK-21</i>	12 m, 12 f	21.5	34



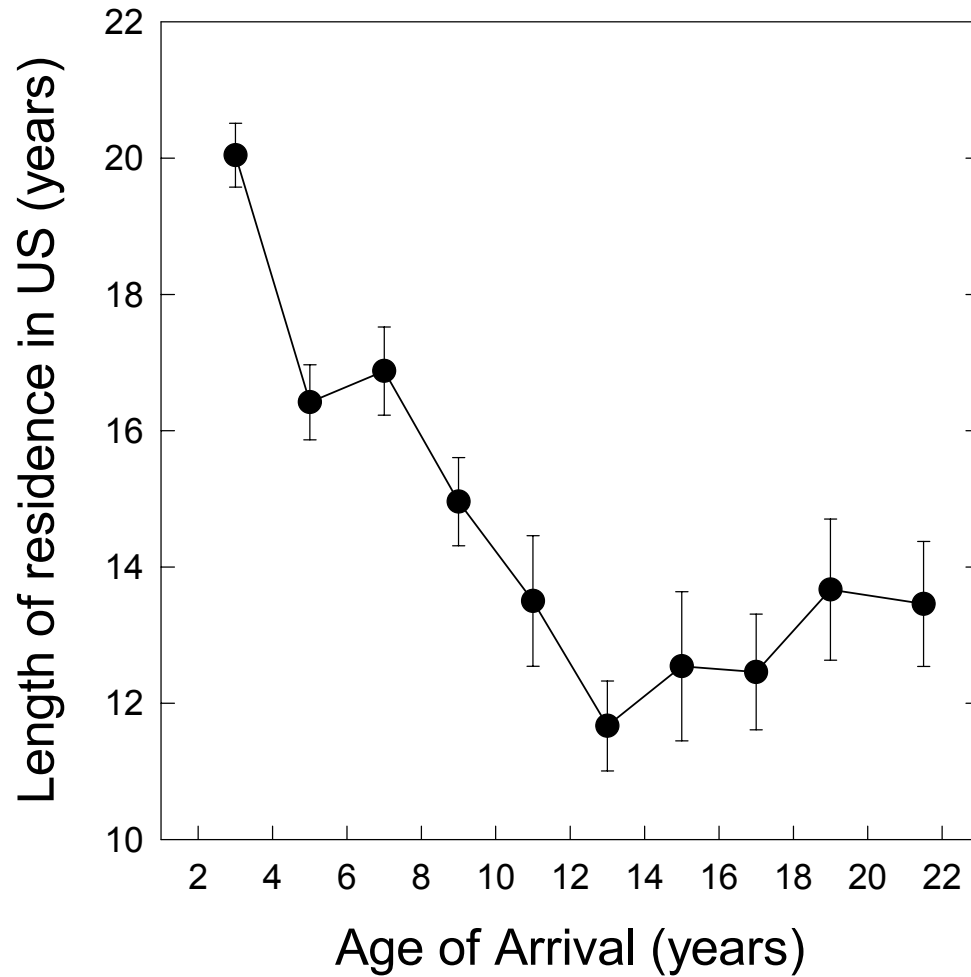
## Correlations between 2 outcome measures (GJT scores, FA ratings) and other variables

	Age of arrival (AOA)	Length of residence (LOR)	Use of English	Years of educ. in USA
foreign accent ratings	-.85*	.37*	.61*	.83*
GJT scores	-.75*	.39*	.54*	.78*

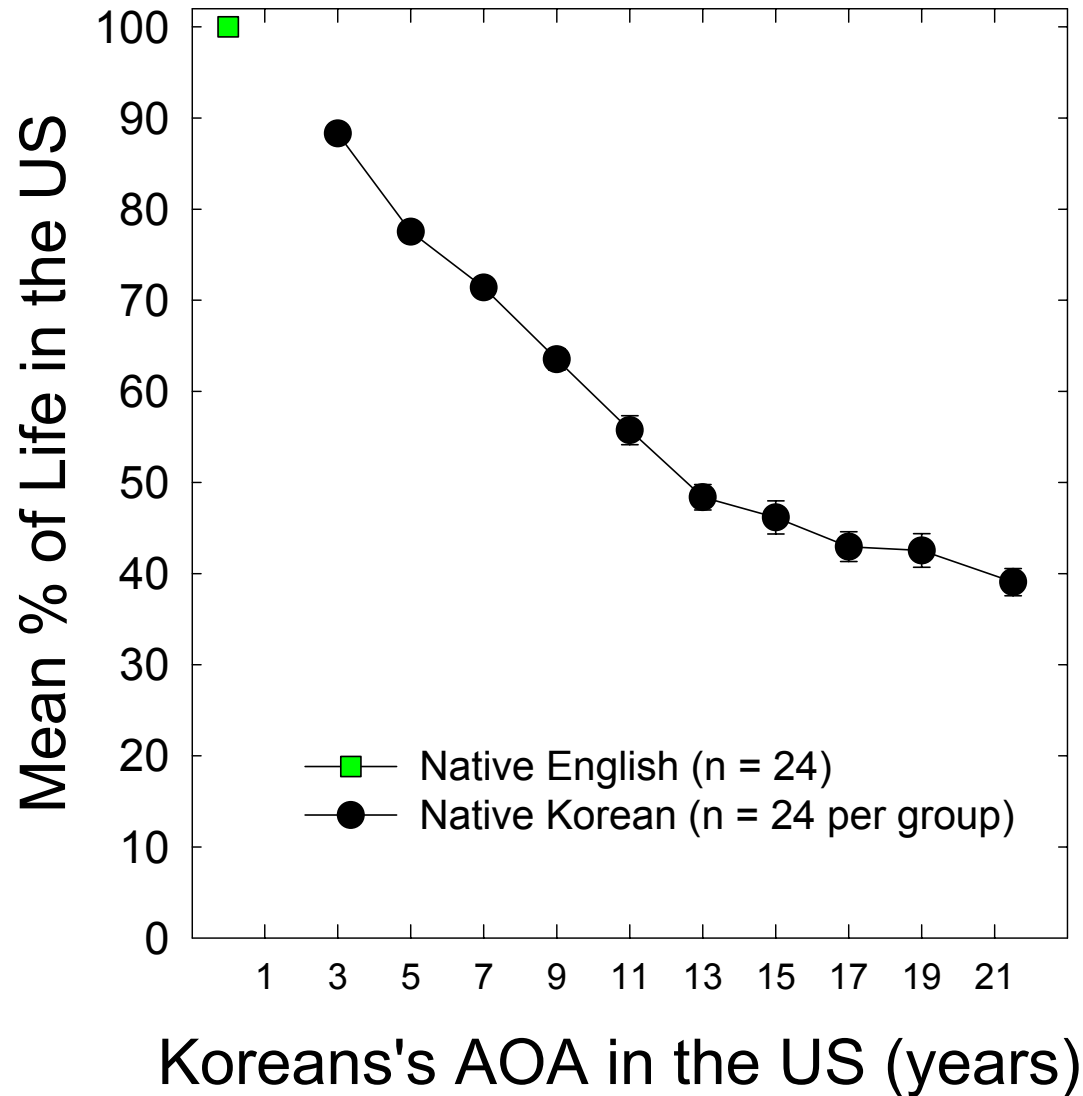
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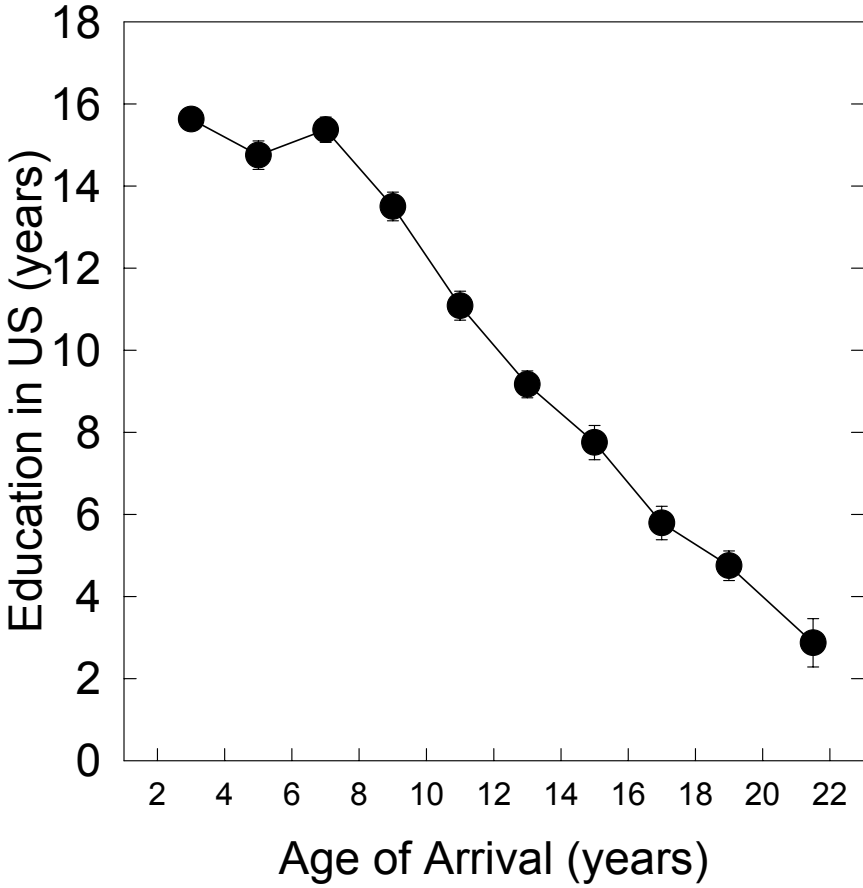
# Koreans' length of residence in the US (years)



# % of their lives the Koreans had lived in the US



# Years of education in English-medium US schools

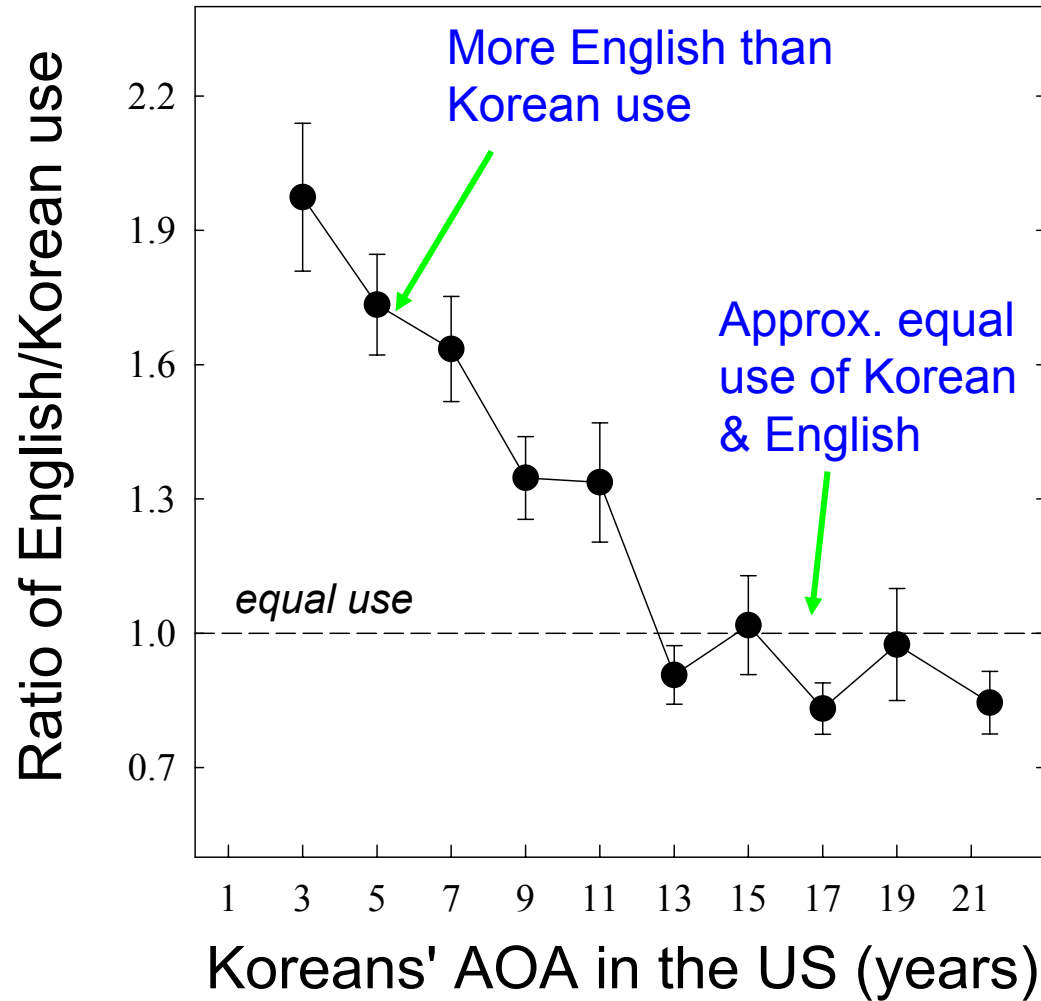


# Language use

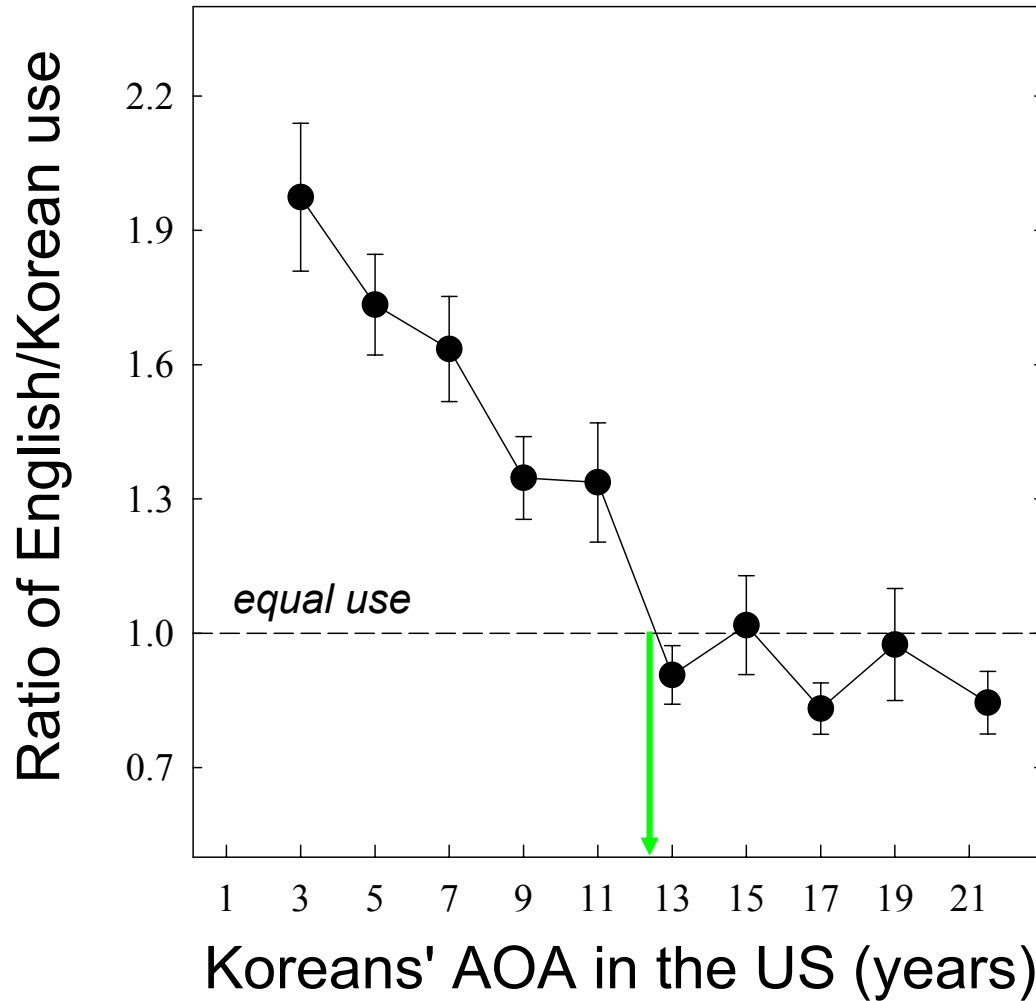
## Korean participants asked to

- Rate how often they used English in a variety of contexts
- Similar ratings for Korean
- Calculate ratio of English/Korean use

# Ratio of English/Korean use



# Cross-over from primarily L2 (English) to L1 (Korean) use

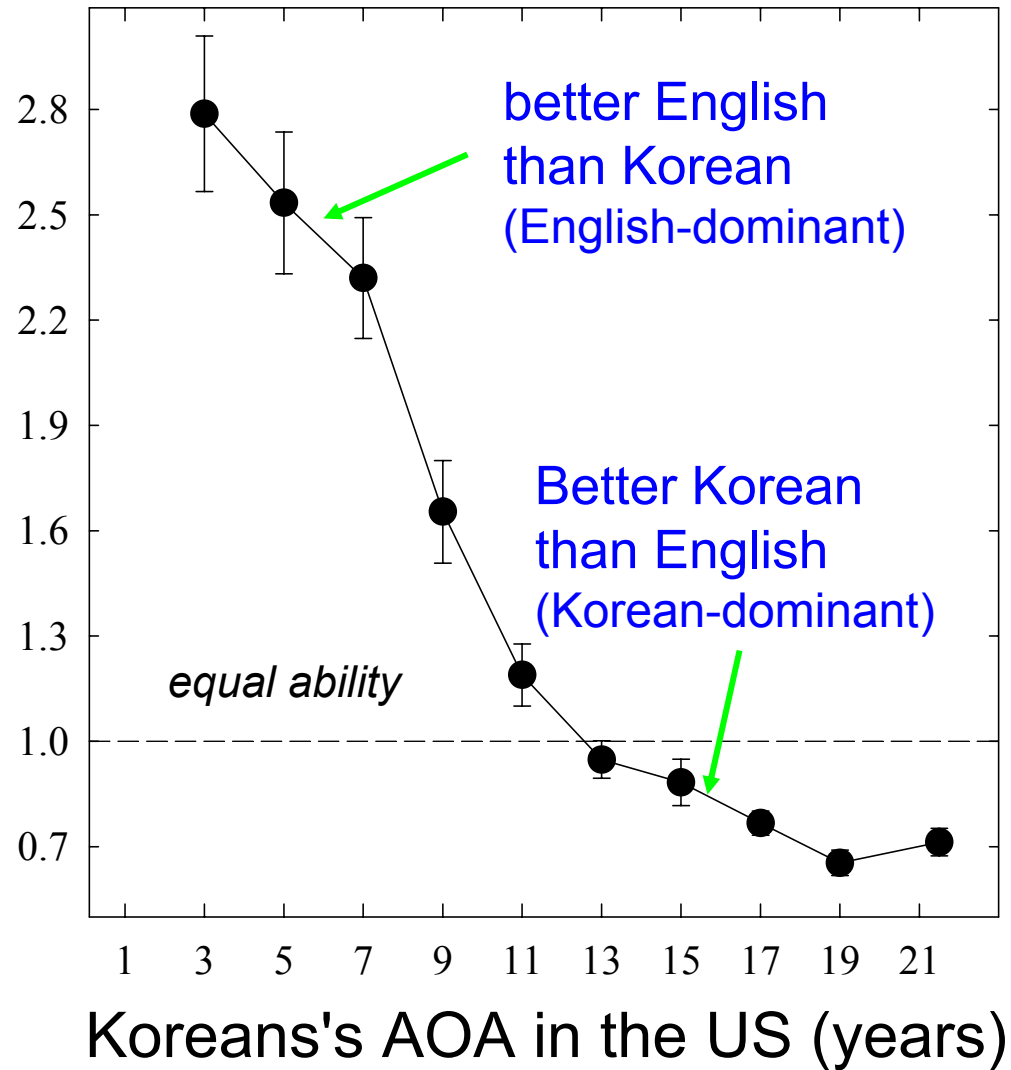


# Language dominance

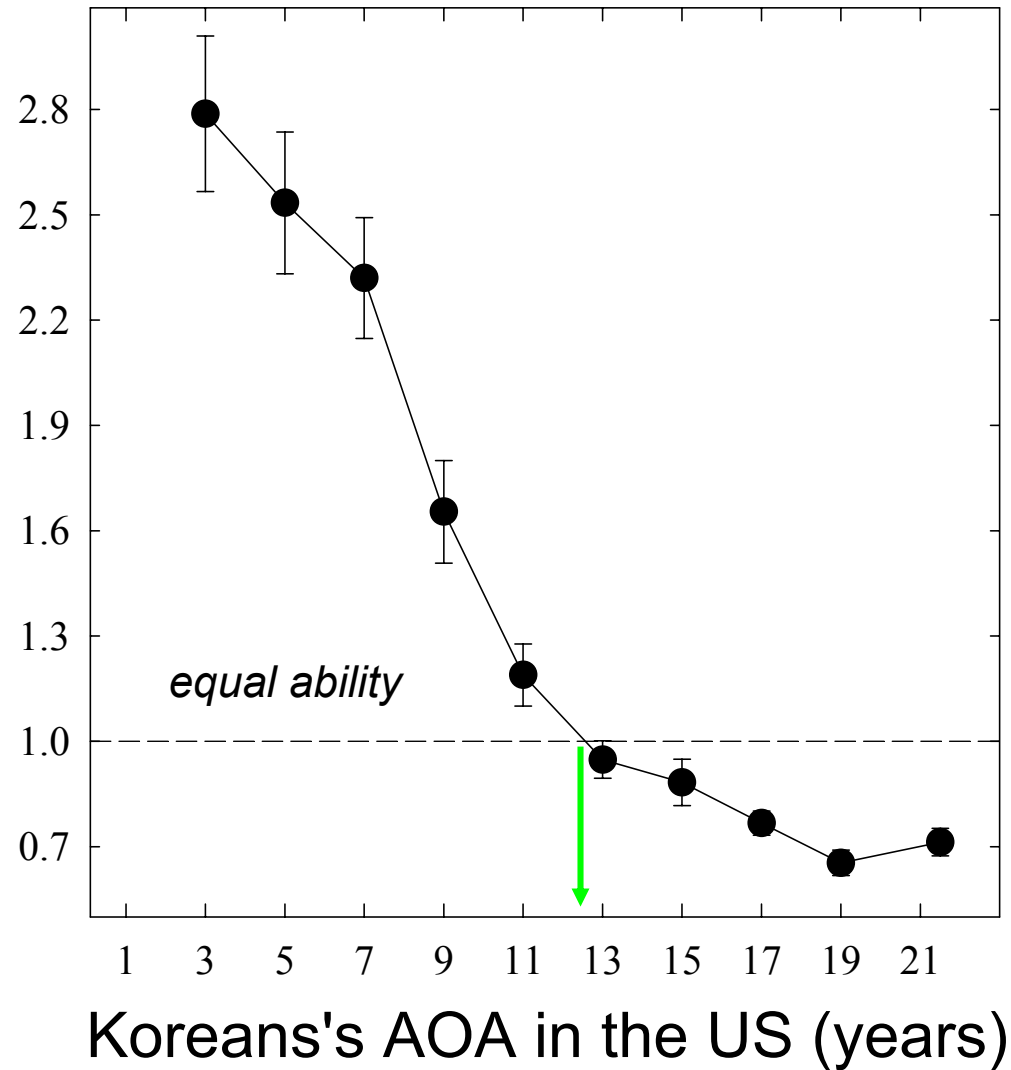
## Korean participants also asked to

- Rate their ability to speak, understand, read and write English
- Same questions regarding Korean
- Calculate English/Korean ability ratio (dominance)

# Mean ratio of English/Korean ability



# Cross-over from English to Korean dominance



# Confounds with AOA

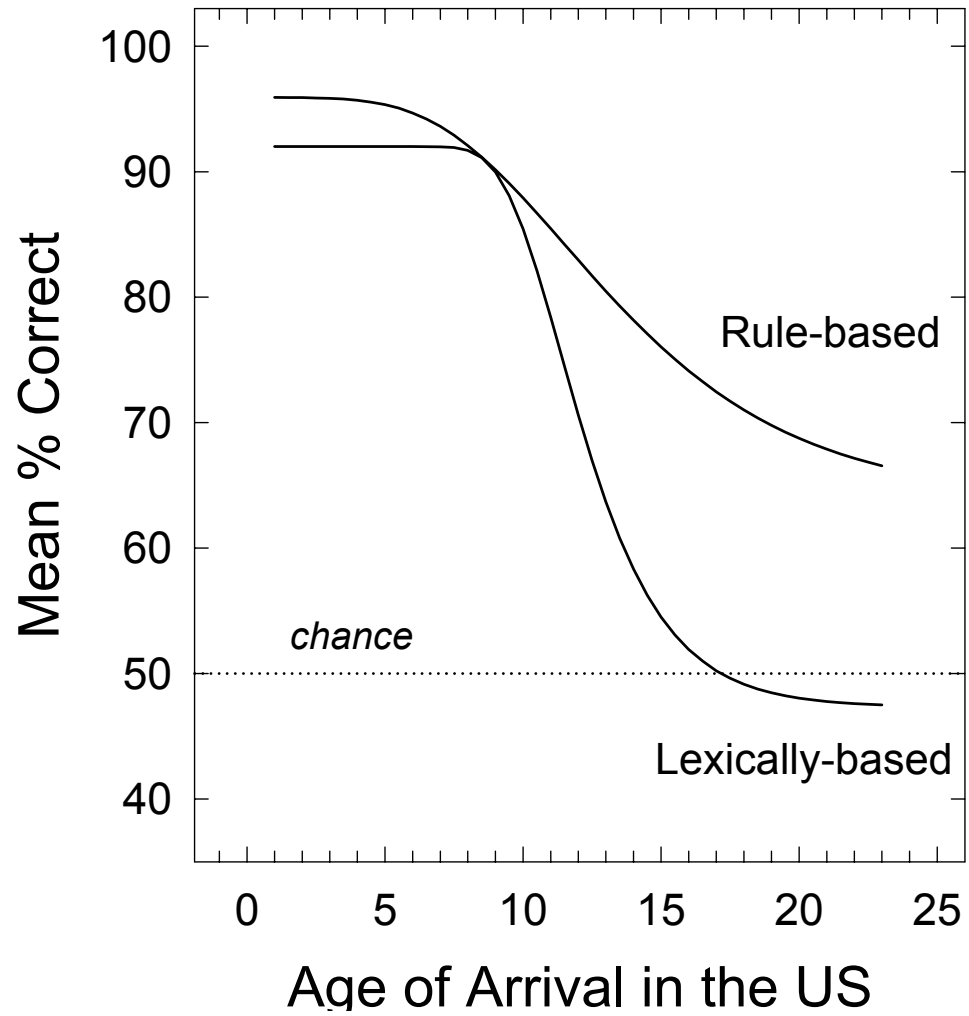
Can anything be done?

# “Matched subgroup analyses”

## Flege et al. (1999)

- Foreign accent ratings
- Two sub-scores derived from the grammaticality judgment test (GJT)

*Note:* report just one of three analyses



# Selection of matched subgroups

Select 2 groups of Koreans ( $n = 20$  each) who differed in AOA ( $M = 10$  vs. 17 years) but were matched for a variable that showed a strong correlation with AOA in the larger sample of 240 participants:

years of education in English-medium schools in the US

# Selection of matched subgroups

- Matching process eliminated all differences in years of education ( $M = 11$  years for both subgroups)
- It also eliminated significant between-group differences in
  - Length of residence
  - English use

# Control analysis

- Randomly select subgroups having same AOA difference as the two matched subgroups (M = 10 vs. 17 years) without controlling for years of education
- The unmatched control groups differed for education, LOR, English use (just like the larger population of 240)

# Control analysis

	<b>AOA = 9.7 (Educ = 14.4)</b>	<b>AOA = 16.6 (Educ = 8.0)</b>	<b>F(1,38)</b>
<b><i>Pronunciation</i></b>	5.9	3.4	P < .01
<b><i>Lexically-based GJT</i></b>	92%	76%	P < .01
<b><i>Rule-based GJT</i></b>	94%	85%	P < .01

# Matched subgroup analysis

	<i>AOA = 9.7 (Educ = 10.8)</i>	<i>AOA = 16.6 (Educ = 10.8)</i>	<i>F(1,38)</i>
<i>Pronunciation</i>	5.2	3.6	P < .01
<i>Lexically-based GJT</i>	81%	78%	n.s.
<i>Rule-based GJT</i>	87%	89%	n.s.

## Results of analysis #3

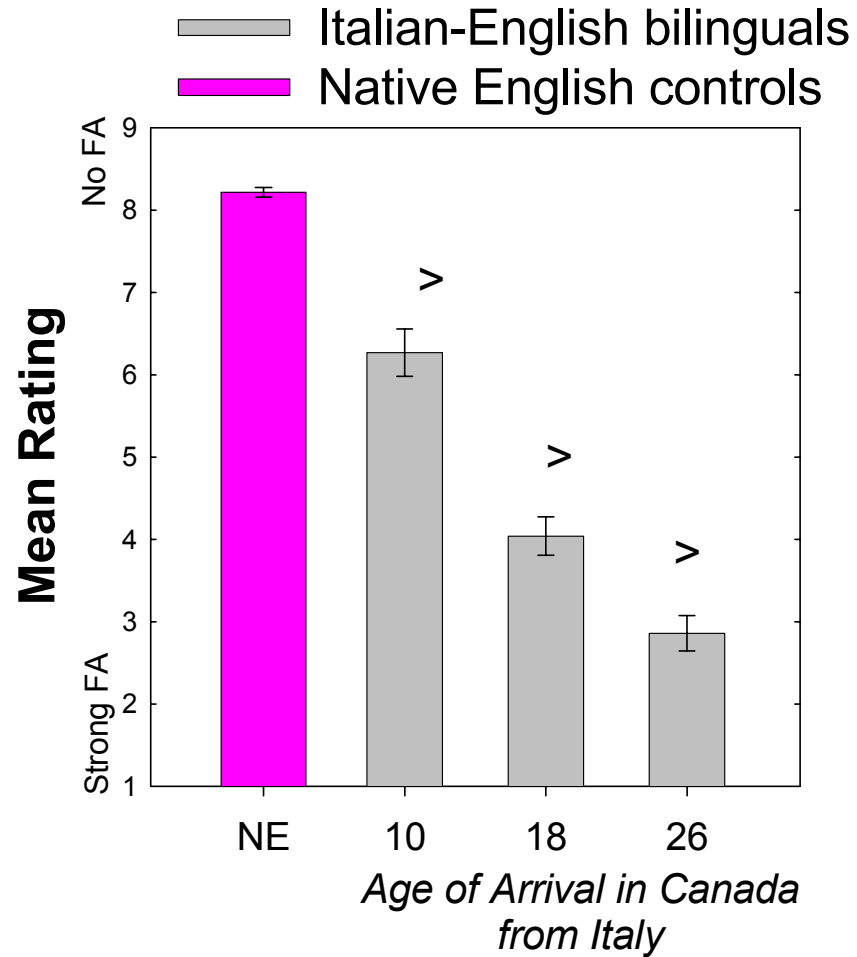
- Controlling for variables confounded with AOA eliminated significant effect of AOA
- Were the [Johnson & Newport \(1989\)](#) findings due to confounds?

## H2: Cognitive changes

### Correctly predicts

- Systematic decrease in L2 proficiency in adulthood after the end of the supposed Critical Period
- Example: foreign accent data from [Flege & MacKay \(under review\)](#)

# Flege & MacKay (under review)



## H2: Cognitive changes

### Problems

- Unlikely to account for differences between native speakers and AOA=10

## H2: Cognitive changes

### Problems

- No evidence yet for foreign accent getting stronger across the entire life span (hard to find people who begin learning an L2 at age 55!)

## H2: Cognitive changes

### Problems

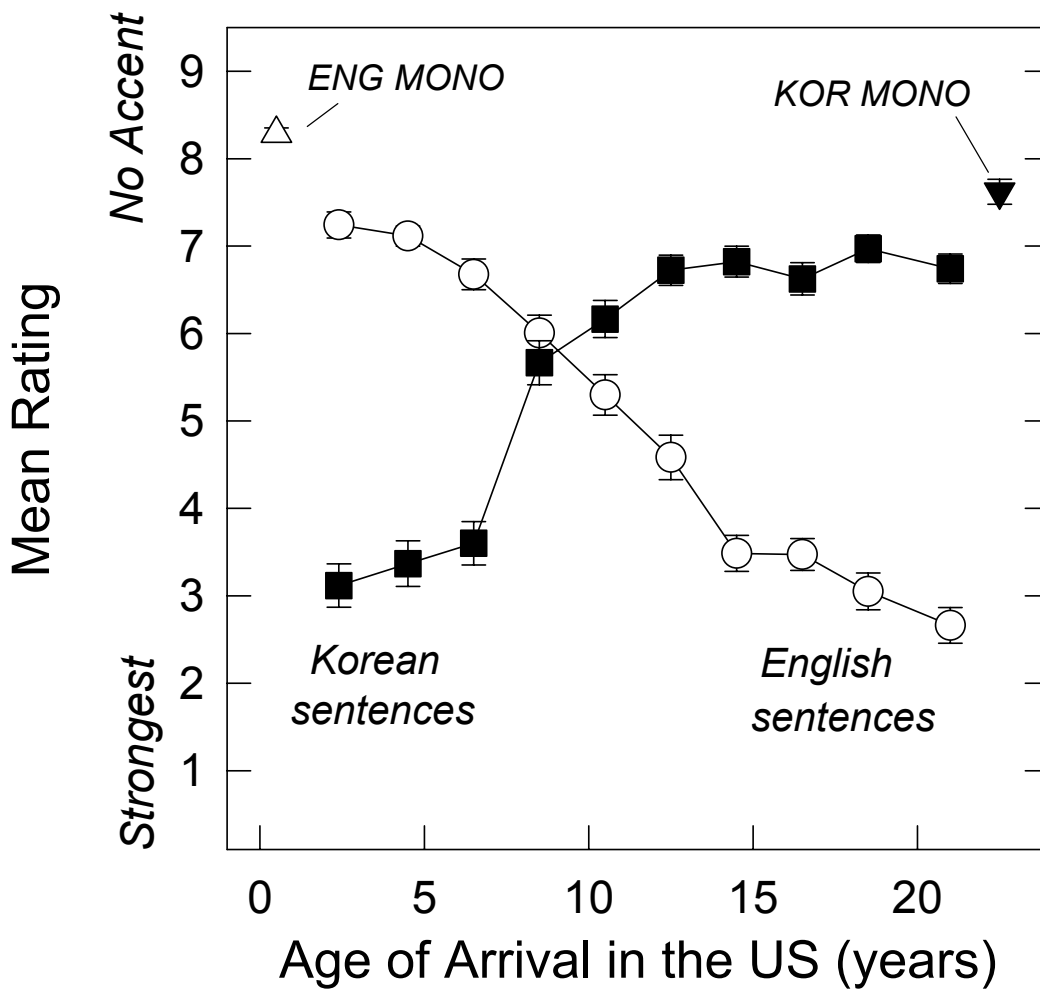
- No direct evidence linking changes in specific cognitive abilities at time L2 learning began and eventual L2 proficiency

## H3: Changes in L1-L2 interactions

### Correctly predicts

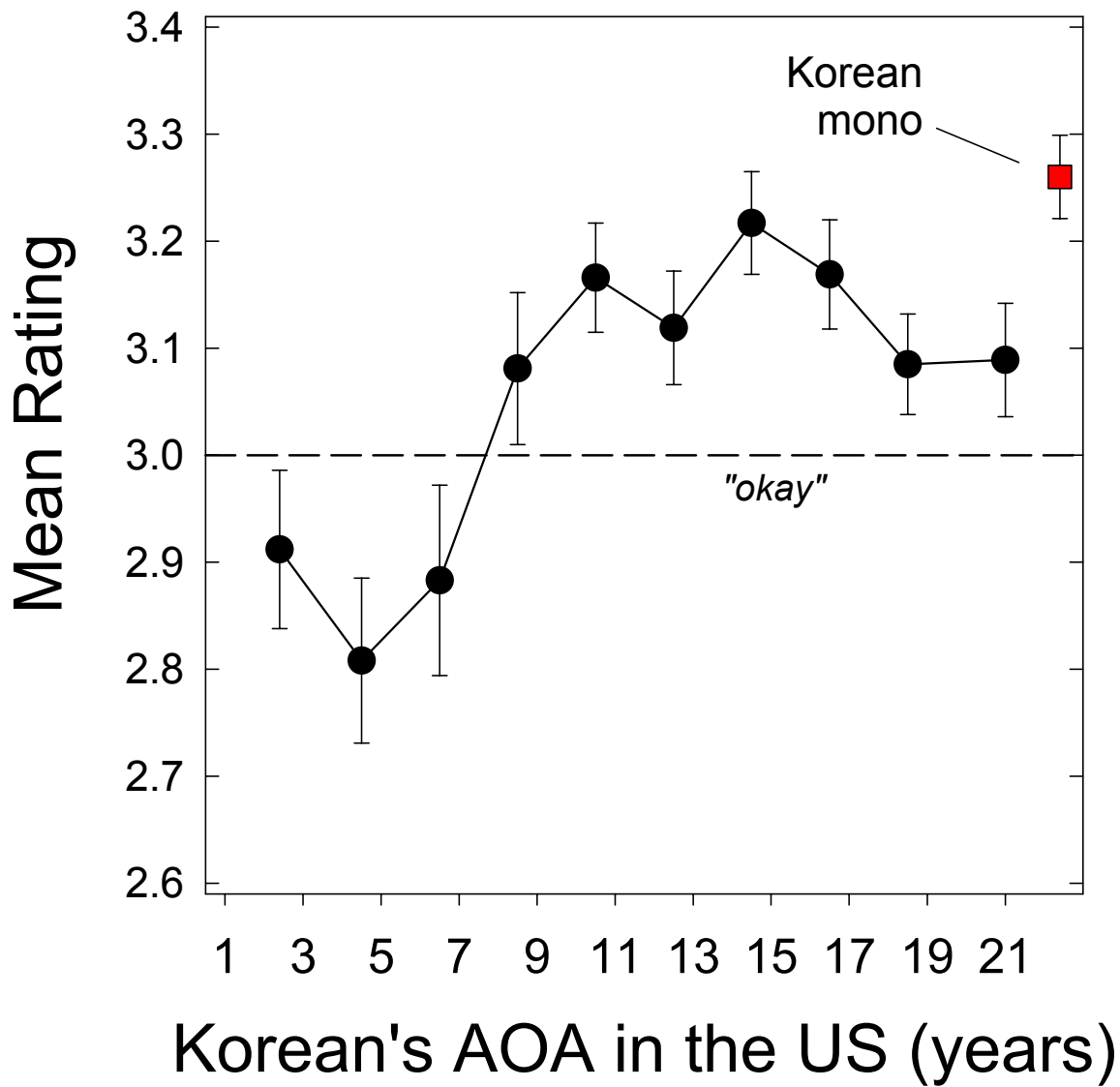
- Effects of learning an L2 on L1 production & perception
- Examples: [Yeni-Komshian et al. \(2001\)](#); [Flege \(2006\)](#)

# Pronunciation of Korean and English sentences by Korean-English bilinguals



### H3: Changes in L1-L2 interactions

- **Flege (2006)** obtained ratings of word-initial consonants in Korean words
- Rated by native speakers of Korean:
  - 4 = very good
  - 3 = okay
  - 2 = distorted
  - 1 = wrong consonant



## H3: Changes in L1-L2 interactions

### Problems

Little research has tested if

- The perceived similarity of pairs of L1-L2 sounds increases with age
- If such changes are related to how accurately L2 sounds produced and perceived (but see [Baker et al., 2002](#))

## H4: differences in L2 input

### Correctly predicts

- Effects of language use
- Example: studies examining Italian immigrants to Canada (Flege & MacKay, 2004; Piske, Flege, MacKay & Meador, 2002; Piske, MacKay & Flege, 2001; MacKay, Meador & Flege, 2001)

## H4: Differences in L2 input

Four groups of Italian immigrants who differed orthogonally in

- AOA
- % Italian use

## Native English (NE) and Italian participants

	<i>N</i>	<i>Age</i>	<i>AOA</i>	<i>Italian Use</i>
<i>NE</i>	18	50	--	--
<i>early-low</i>	18	50	7	7%
<i>early-high</i>	18	49	8	43%
<i>late-low</i>	18	51	20	10%
<i>late-high</i>	18	49	20	53%

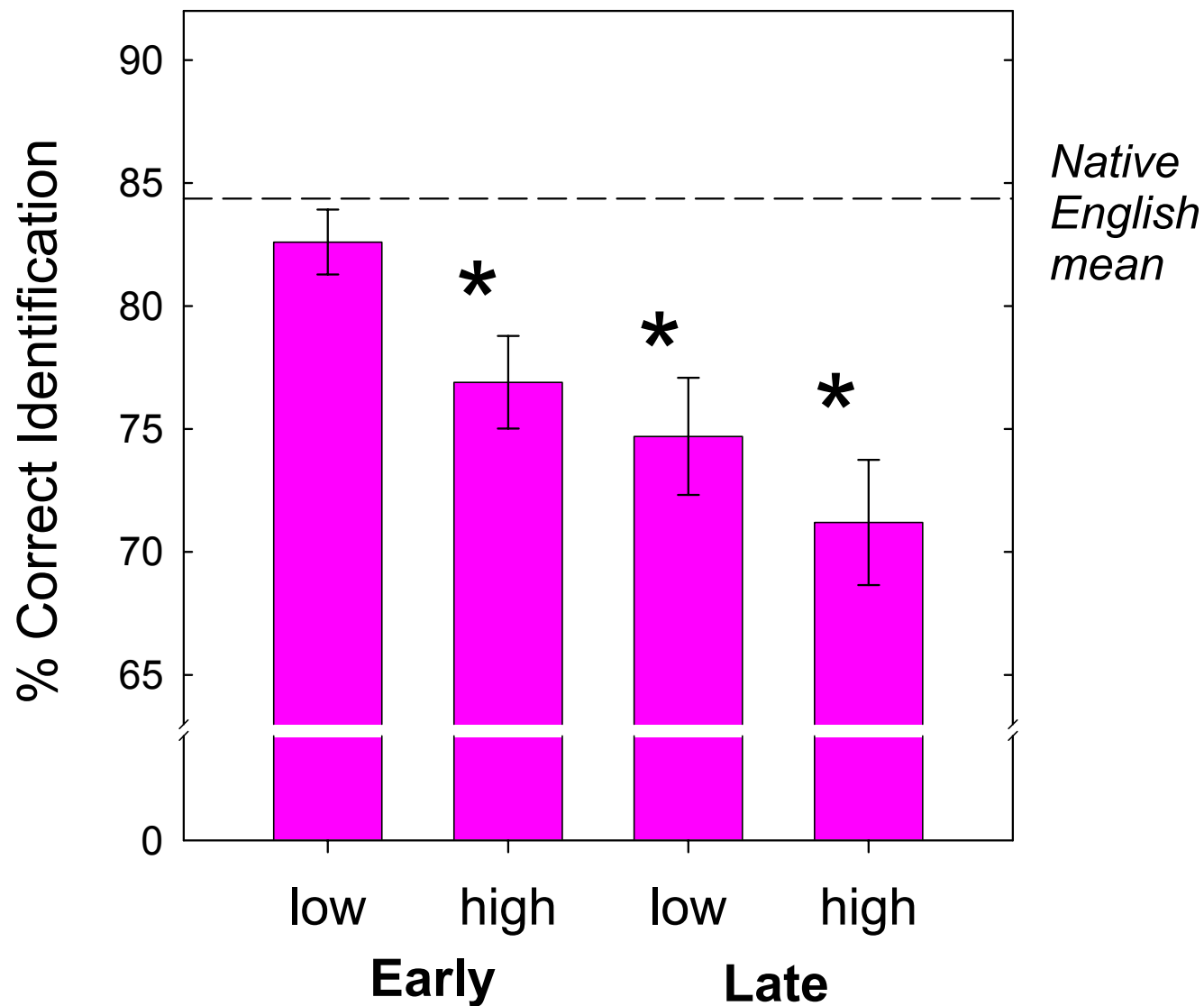
# Participants

	<i><b>N</b></i>	<i><b>Age</b></i>	<i><b>AOA</b></i>	<i><b>Italian Use</b></i>
<i><b>NE</b></i>	18	50	--	--
<i><b>early-low</b></i>	18	50	7	7%
<i><b>early-high</b></i>	18	49	8	43%
<i><b>late-low</b></i>	18	51	20	10%
<i><b>late-high</b></i>	18	49	20	53%

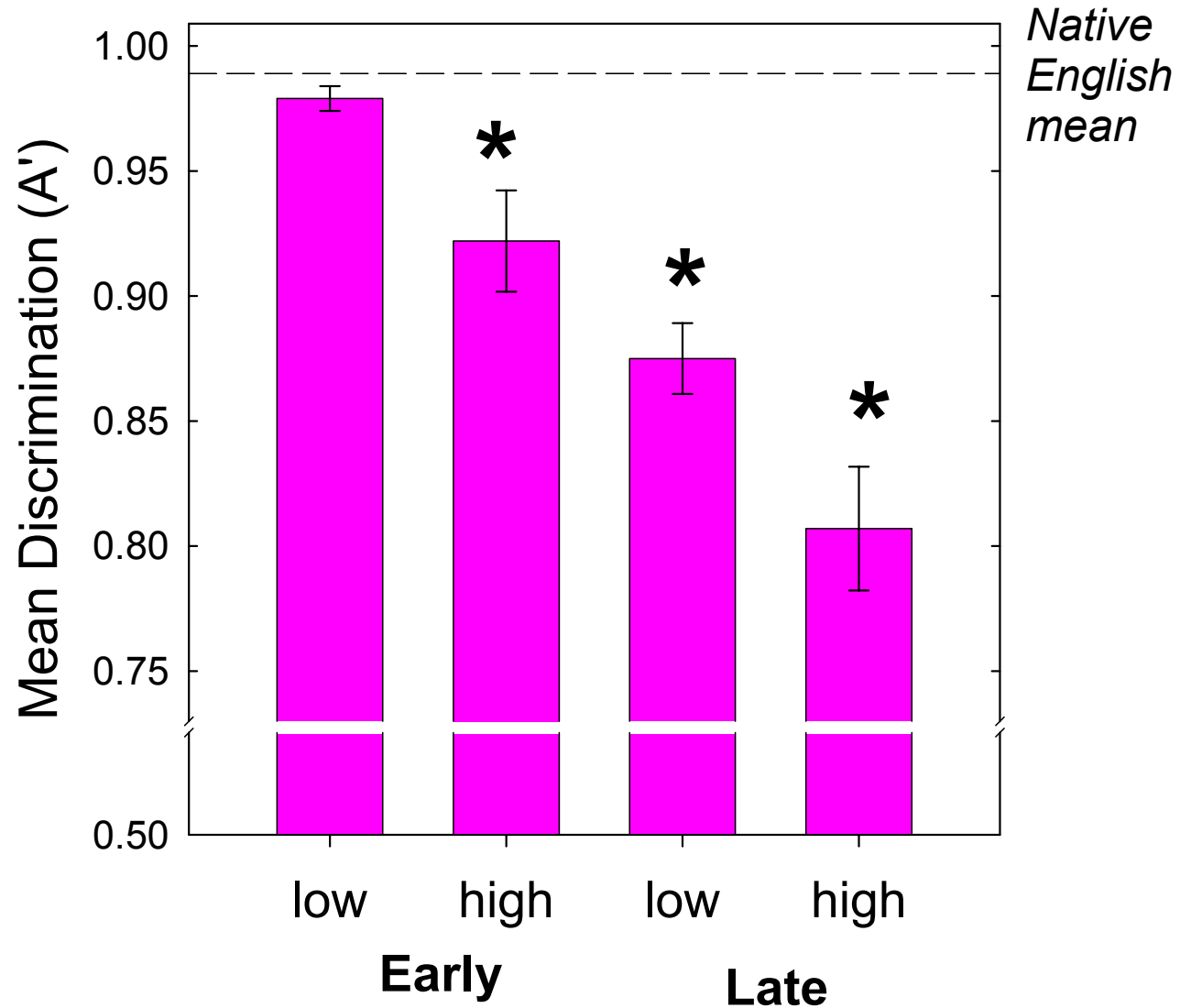
# Participants

	<i><b>N</b></i>	<i><b>Age</b></i>	<i><b>AOA</b></i>	<i><b>Italian Use</b></i>
<i><b>NE</b></i>	18	50	--	--
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<i><b>late-high</b></i>	18	49	20	53%

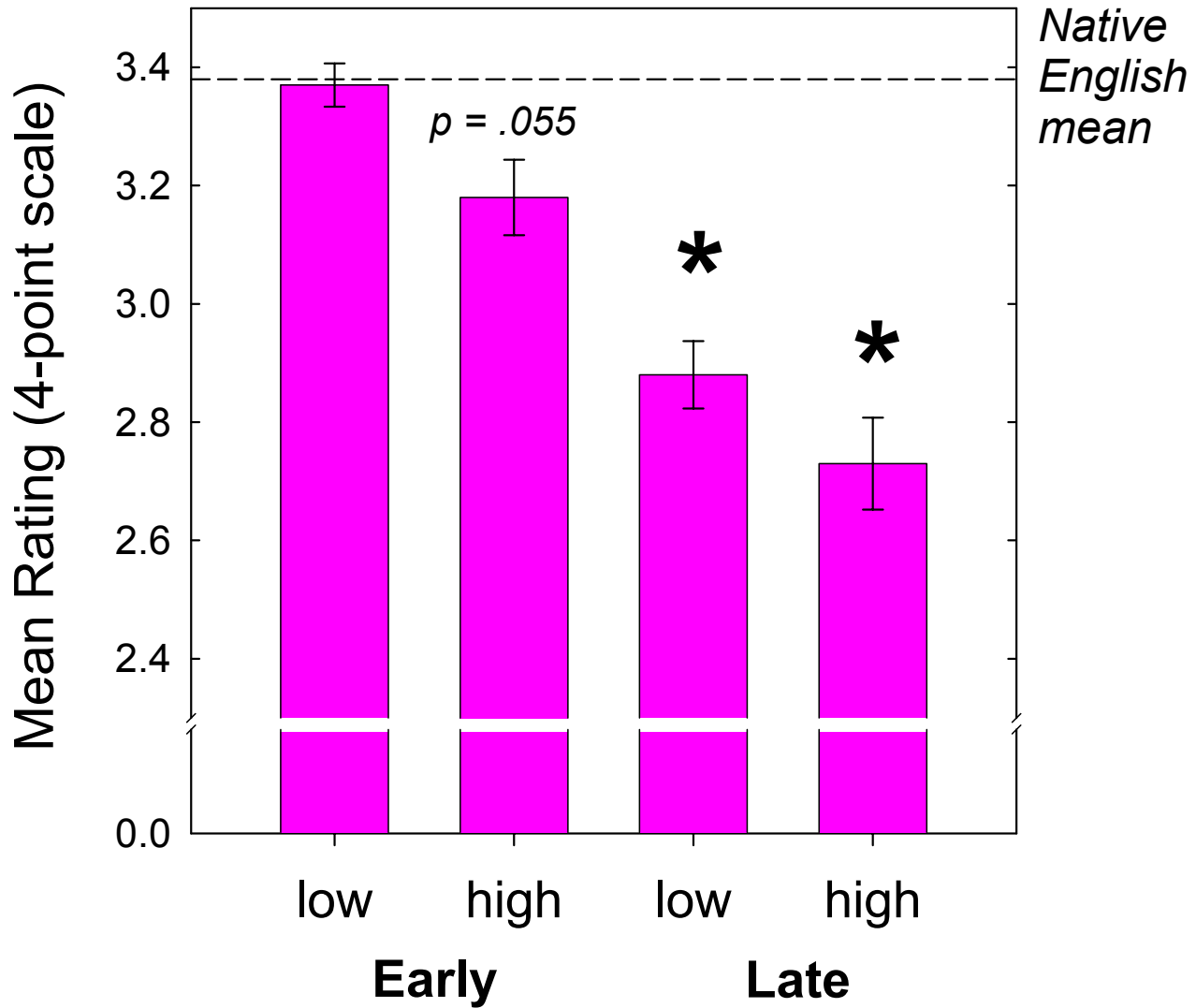
# Average identification of stops (/b d g p t k/) in Final Position



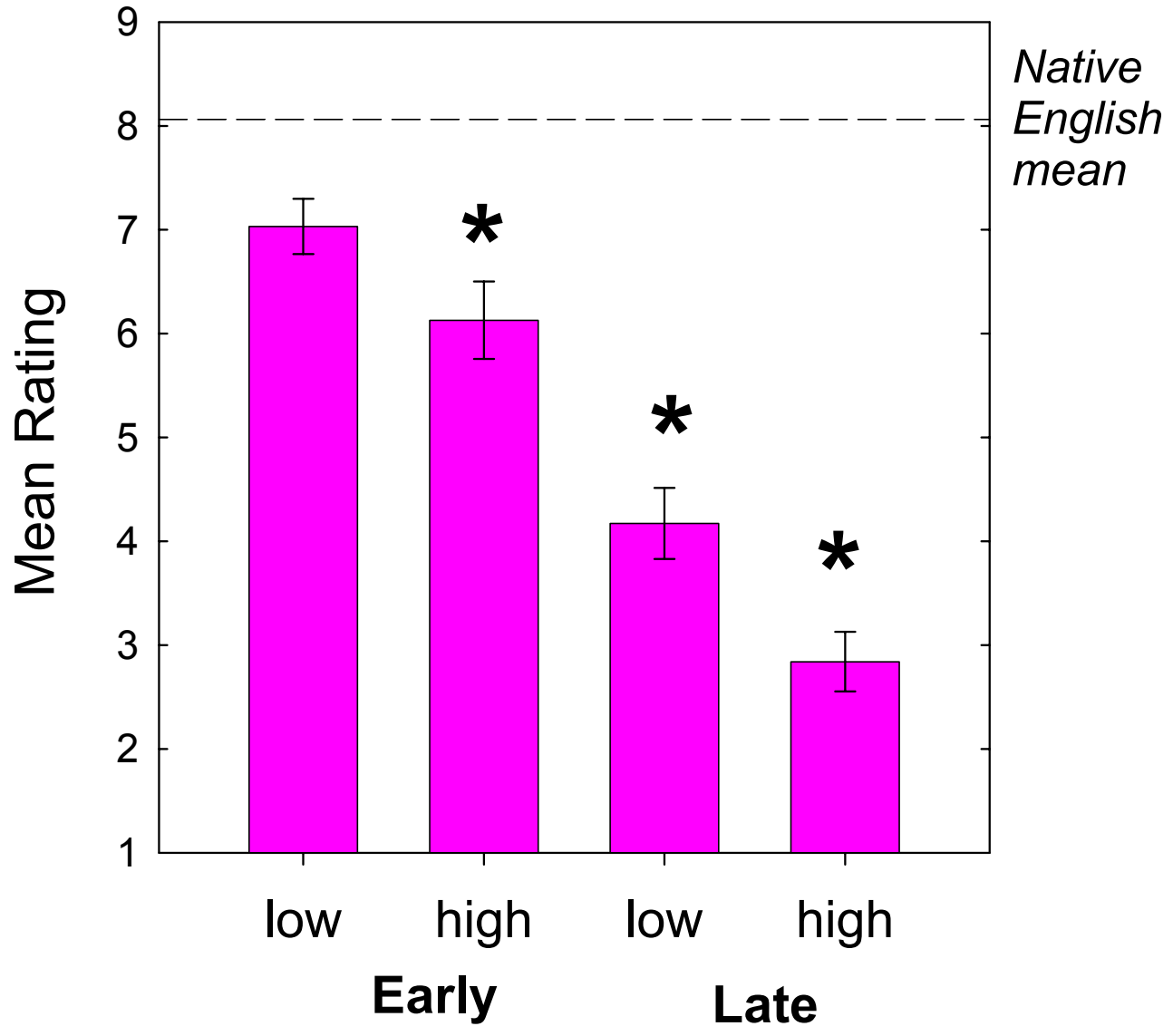
Categorical Discrimination  
of /i/-/ɪ/, /ɛ/-/æ/ and /ɑ/-/ʌ/



# Rated Accuracy of /i ɪ ε æ ɑ ʌ/ production



# Overall FA



## H4: differences in L2 input

Contradicts claim by [Scovel \(2000\)](#) that age effects can not be explained by differences in input because

*“it is precisely in the linguistic domain where input varies least — phonology — that the age effects are most readily apparent (p. 519)*

## H4: differences in L2 input

### Problems

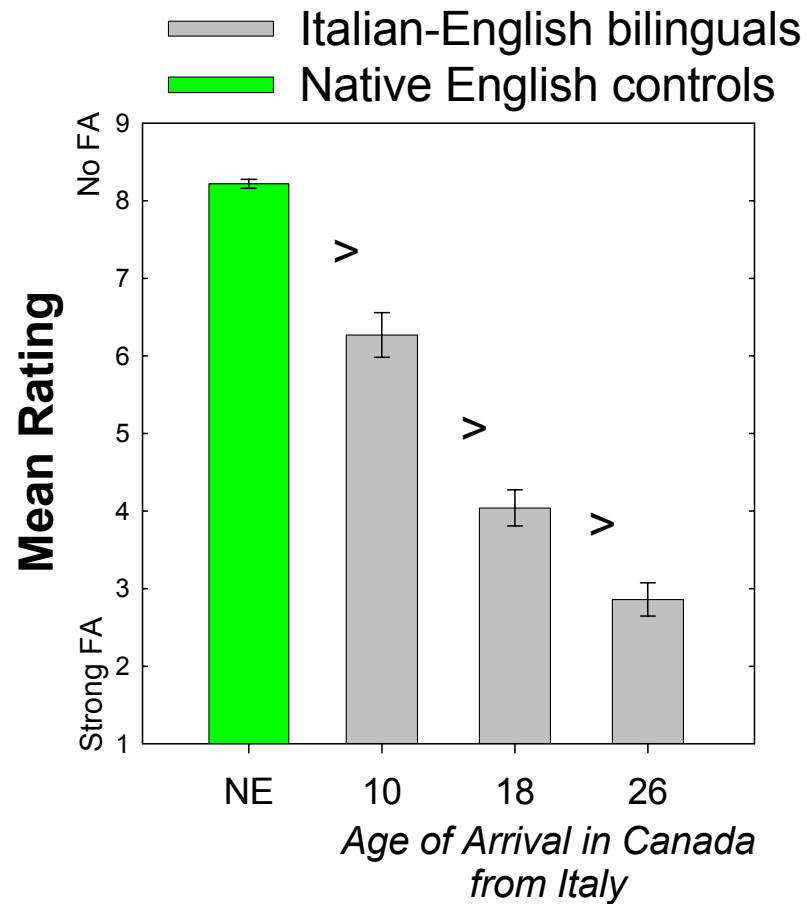
- No study has ever adequately quantified L2 input
- Self-reports (e.g., overall % L2 use) are estimates, not measurements

# H4: differences in L2 input

## Problems

- Unlikely to account for some AOA differences
- Example foreign accent data from [Flege & MacKay \(under review\)](#)

# Flege & MacKay (under review)



# Flege & MacKay (under review)

	<i>Age of Arrival</i>			
	<b>10</b>	<b>18</b>	<b>26</b>	
<b><i>Length of residence</i></b>	43	37	33	10>18,26
<b><i>Use of English</i></b>	71%	53%	47%	10>18,26
<b><i>Yrs of Educ in Canada</i></b>	9	0.4	0.3	10>18,26
<b><i>Use of Italian (IT)</i></b>	27	47	52	10<18,26
<b><i>Yrs of Educ in Italy</i></b>	4	8	8	10<18,26
<b><i>Ability to pronounce IT</i></b>	5	6	7	10<18,26

## Aim #4: Summary

- Most people assume that age effects on L2 learning are due to some kind of maturational constraint (e.g., passing a CP)
- At least three other hypotheses can be offered for “age” effects on L2 proficiency
- Problems with all four

# Summary

## Serious design problem

Most research manipulates age of L2 learning (AOA), not the actual variables thought responsible for age effects

# Summary

## What variables should be examined?

- Specific aspect(s) of neurological development
- Specific aspects of cognitive development
- State of development of L1 representations (categories)
- Amount/kind of L2 input

# Summary

## Another serious problem

Failure to control for variables that are confounded with AOA

It's hard, but can be done in some instances!

# Summary

Until potential causal variables are examined and confounded variables controlled, we can only speculate about the true basis (bases) for age-related effects on L2 proficiency

# End

Thanks for your attention!

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- The Development of Phonetic Categories (DC00257)
- Age Constraints on Second Language Acquisition (DC02892)

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