Neural Discrimination of English Vowels in Late Spanish-English Bilinguals

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Languages Other Than English in NY

1,869,995

Spanish speakers

over age 5 in NYC

Languages Other Than English (LOTE) spoken by New Yorkers over 5 years of age, US Census Bureau (2009) American Community Survey Table B160001 in Garcia, Zakharia, & Otcu (2013, p13).

L1 and L2 Speech Perception

L1

- Exposure to L1

  → *Statistical Learning*

- *Native Language Neural Commitment*

(Kuhl, 1991; Kuhl, 2004)

L2

- **Automatic Selective Perception (ASP) Model:**
  *highly automatic
  *efficient cue selection
- **L1 Selective Perceptual Routines**
  e.g.: "cat" vs "cut"

(Strange, 2011; Strange & Shafer, 2008)

Vowel Inventories

	English	Japanese	Spanish
Vowel Inventory	11 vowels	5 vowels	5 vowels
Primary cue	Spectral	Duration	Spectral
Secondary cue	Duration	Spectral	---

Perception in Late L2 Learning

- Relies on phonetic mode of perception
- L1 perceptual routines **dominate** (Hisagi et al., 2011)
- Disadvantages (Strange, 2011)
  1. Attentional focus = more cognitive resources
  2. Slower perception
  3. May suffer under suboptimal conditions

     e.g., background noise

Current Study

Do Spanish-English bilinguals
who learned American English after the age of 14
rely more on spectral or durational information
to distinguish English vowels
that are non-contrastive in Spanish?

Hypotheses

When directing attention away from the stimulus, late L2 learners of English will…

...fall back on their L1 perceptual routines

...rely on durational cues since duration is a more robust cue than spectral information

Stimuli

3 tokens each of
/ɑ/, /ae/, and /ʌ/
(e.g., *hot, hat,* and *hut*)

in /Vpə/ disyllables

Mean vowel duration
[ɑ] = 184 ms
[ae] = 187 ms
[ʌ] = 134 ms

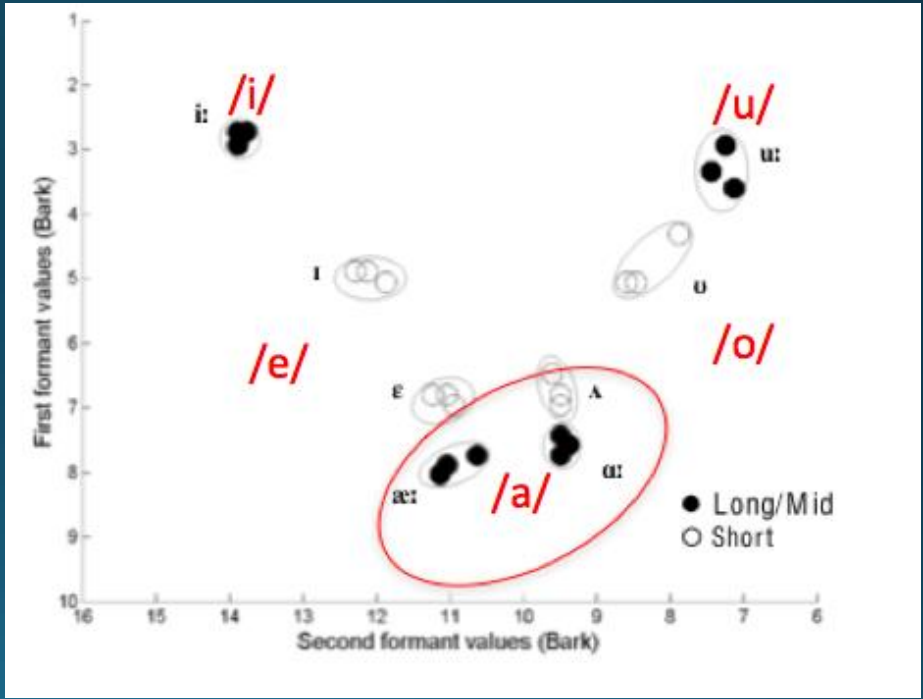


Figure 1: Formant Values at midpoint for American English vowels

Participants

Native Spanish speakers who learned English after age 14

n=10	Age	Age Moved to US	Total Years Lived in US	*AEA	Handedness	Sex
Mean	35.8	24.8	10.9	24.1	Right= 8	F= 7
SD	8.0	6.6	5.6	7.9	Left= 0	M= 3
Median	36	25	11	25	Ambidextrous= 2	
Range	26-48	15-36	3.5-20	6-35	12 American English monolingual controls	

*Age of English Acquisition

Task

Auditory Oddball Paradigm

Condition 1: 80% Standard [ɑ];
10% Deviant [æ]; 10% Deviant [ʌ]

Condition 2: 80% Standard [ʌ] ;
10% Deviant [æ]; 10% Deviant [ɑ]

Visual Oddball Task

- Directs attention away from the auditory modality

Behavioral Discrimination Task

- Requires attentional resources

[ʌpə] 1 [ʌpə] 3 [ʌpə] 2 [ʌpə] 1 [ɑpə] 2 [ʌpə] 3 [ʌpə] 1 [ʌpə] 2 [æpə] 1

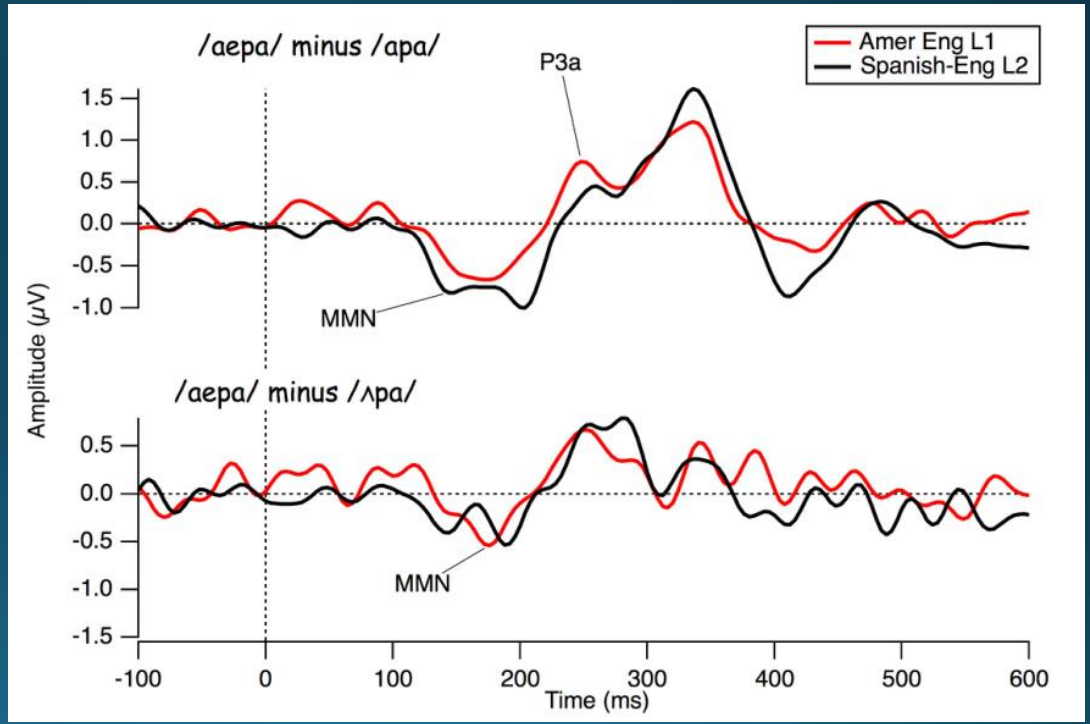
Brain responses were recorded during the task to elicit a brain-discriminative response, called the Mismatch Negativity (MMN).
MMN is an increased negativity of neural electrical activity to a change at electrodes on top of the head.

ERP Results

Both groups show a negativity (MMN) followed by a positivity

/ɑ/-/æ/
/ʌ/-/æ/

suggesting fairly easy discrimination



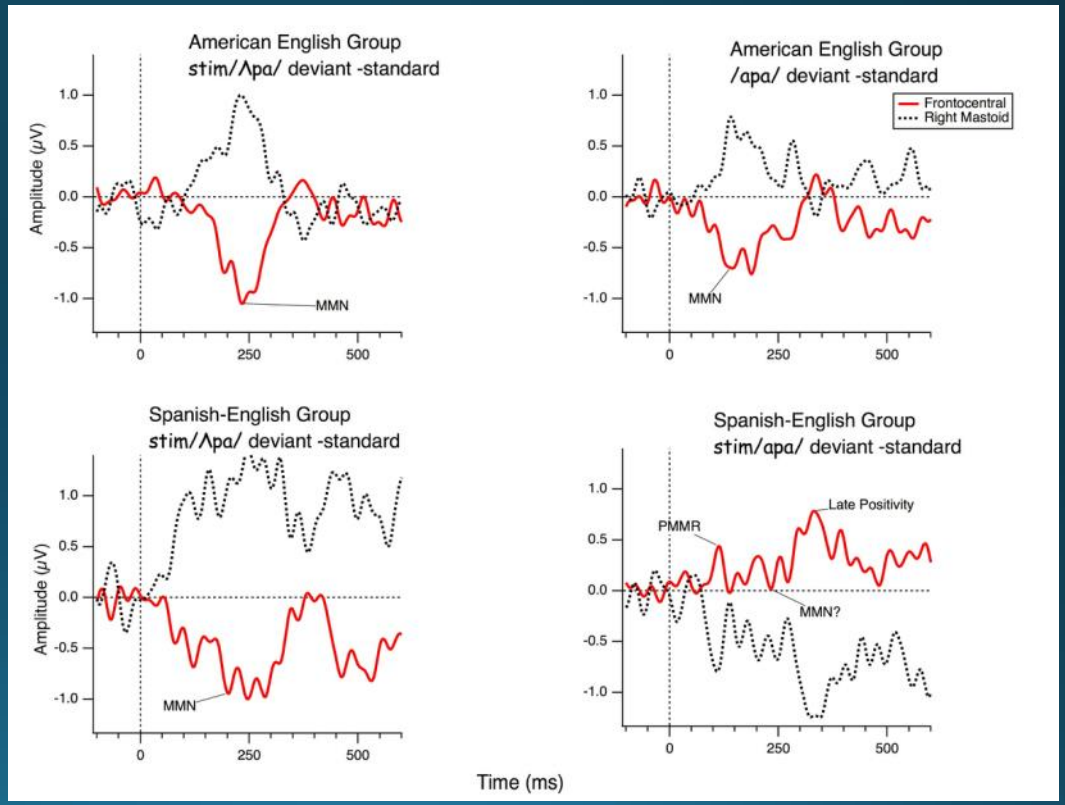
ERP Results

/ʌ/

is neurally discriminated as distinct from /ɑ/ in both groups (i.e., /ɑ/-/ʌ/ contrast)

/ɑ/

Spanish speakers do not discriminate it as distinct from /ʌ/ (i.e., /ʌ/-/ɑ/ contrast; but small pMMR observed)



Results

Behavioral task

/ʌ/-/æ/ > /ʌ/-/ɑ/

Am Eng	95%	75%	(median)
Spanish	93%	70%	(median)

In behavioral discrimination, all participants performed better on detecting /ae/ compared to /ɑ/ among /ʌ/ standards

Behavioral task

/ɑ/-/æ/ < /ɑ/-/ʌ/

Am Eng	90%	85%	(median)
Spanish	68%	85%	(median)

When /ɑ/ was the standard, Spanish listeners showed better discrimination of /ɑ/-/ʌ/ than compared to the reversal and showed poor discrimination of /æ/.

Discussion

No MMN + pMMR

- When /ɑ/ is deviant among /ʌ/ standards…
  - discrimination not registered at a higher (phonological) level
  - spectral > durational

- pMMR found in young children who do not yet have automatic speech processing (Shafer, Yu, & Datta, 2010)

Conclusion

- No evidence that the Spanish speakers made use of the temporal cue to aid in discriminating the difficult contrast

- Preliminary data with Japanese listeners in the same paradigm showed that these listeners can use the temporal cue at the automatic level (MMN), but not for the behavioral discrimination task.

Significance & Broader Impact

Distinguish “impairment” versus “need for more English input”.

- "hat" and "hot” easier than "hot" and "hut”
- Transfer to spelling; "hot" and "hut" → homophones

ESL/EFL teachers could use direct training in perception of the durational cues to improve students’ comprehension and production of L2 phonemes.

Future Directions

- Examine whether English exposure and use lead to improved discrimination of English vowels and increased reliance on spectral and/or durational information at the automatic level of processing indexed by the MMN.

- Can targeted training for use of the duration cue be effective?

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Design

- 64-channel Geodesic Amplifiers
- Geodesic net
- Filter bandwidth .01-100 Hz
- Sampling rate: 250 Hz
- Post-processing 30 Hz low-pass

Results

- Behavior partially matches ERPs for /ɑ/-/ʌ/, but Spanish group showed robust MMN to /æ/-/ɑ/ despite poor behavioral discrimination