Neural discrimination of non-native vowel contrasts by late Spanish-English bilinguals
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Introduction
This study uses mismatch negativity (MMN) and a behavioral discrimination task to examine whether native Spanish speakers who are late learners of English rely more on spectral or durational information to distinguish English vowels that are non-contrastive in Spanish.

Native speakers of English use spectral and durational cues to recover phoneme identity, whereas native Spanish speakers only rely on spectral cues.

The Automatic Selective Perception (ASP) model proposes that L2 perception is affected by two modes of speech processing (Strange & Shafer, 2007):

1. Phonetic mode:
   - Analyzes context-specific acoustic cues in the input
   - Demands attentional focus

2. Phonological mode:
   - Employs L1 Selective Perceptual Routines (SPRs)
   - Highly automatic

L2 perception:
   - Relies on phonetic mode of perception
   - L1 SPRs dominate (Hisagi et al., 2011)
   - Engages attention to develop SPRs in L2

Procedure
Both groups completed a neural discrimination task and a behavioral task. In addition, the bilingual group completed a Language Background Questionnaire and a Versant test of English proficiency.

Neural Discrimination Task:
- Auditory oddball paradigm
- Visual oddball task distracts attention from audio
- Mismatch Negativity (MMN) response recorded

Behavioral Discrimination Task:
- Same oddball paradigm
- Attention is required to discriminate sounds

Participants
Native Spanish speakers who learned English after age 14

<table>
<thead>
<tr>
<th>N = 11</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>22.2</td>
<td>7.9</td>
<td>23</td>
<td>26-48</td>
</tr>
<tr>
<td>Age of Arrival in US</td>
<td>23.9</td>
<td>7.2</td>
<td>22.5</td>
<td>14-36.5</td>
</tr>
<tr>
<td>Age of onset of English Acquisition</td>
<td>22.2</td>
<td>7.3</td>
<td>23</td>
<td>6.8-32</td>
</tr>
</tbody>
</table>

*Compared to 12 American English monolingual controls

ERP Results
Subtraction waves:
- /æ/-/ʌ/
- /æ/ as deviant is perceived as distinct from /ʌ/ by both groups (left).
- /ɑ/-/ʌ/ and /ɑ/-/ɑ/ do not perceive /ɑ/ as distinct from /ʌ/ (no MMN).

- Small positivity (pMMR) observed

Stimuli
Three tokens each /ɑ/-/e/-/æ/ e.g., hot /e/-/e/-/h/ e.g., hat /æ/-/æ/-/a/ e.g., hut in /pə/ /æ/ /pə/ /pə/ /æ/ disyllables

Mean vowel duration
[ɑ] = 184 ms
[æ] = 187 ms
[a] = 134 ms

Formant values at midpoint for American English vowels

Behavioral Results (deviant - standard)

<table>
<thead>
<tr>
<th>Spanish</th>
<th>87%</th>
<th>45%</th>
<th>87%</th>
<th>72%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Am. Eng.</td>
<td>95%</td>
<td>83%</td>
<td>90%</td>
<td>93%</td>
</tr>
</tbody>
</table>

Median values for behavioral discrimination for both groups

- Spanish listeners showed significantly poorer discrimination than Am. Eng. listeners for /ɑ/-/ʌ/ (p = .002) and /æ/-/ɑ/ (p = .02), but no difference for /æ/-/ɪ/ or /ʌ/-/ɑ/ (p > .3).
- Both groups had more difficulty discriminating /a/ from /ʌ/ when /ʌ/ was the standard.

Conclusions
- There is no evidence that the Spanish speakers made use of the temporal cue to aid in discriminating the difficult contrast /ɑ/-/ʌ/.
- Spanish listeners could not use the increased duration of /ɑ/, unlike Japanese listeners (Hisagi et al., 2010).
- The asymmetry in discrimination of /ʌ/ versus /a/ for Spanish listeners may be due to differences in category “goodness.”
- Listeners formulate a phonological representation for the standard (repeated) stimulus, which will match the closest native language category. English /a/ is closer to Spanish /a/ than English /ʌ/. As the standard, the memory trace is distorted to match the native language. The deviant phonetic cues are compared to this phonological memory trace, and thus, the greater difference of /ʌ/ from Spanish /a/ allows for better discrimination.

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