Mixed methods to examine the acquisition of gradient allophonic variation
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GOALS OF PRESENT STUDY
1. Use a novel mixed-methods approach to explore the L2 acquisition of Spanish voiced stops /b, d, g/ by L1 Am. English learners and better understand the process:
   - Categorical and continuous analyses of realizations
   - Highlight ability of learners to acquire expected pattern:
     - Contrary to previous studies

BACKGROUND
SPANISH AND ENGLISH VOICED STOPS
English has two sets of allophones:
   - /b, d, g/ in initial position, after pause
   - /p, t, k/ elsewhere
Spanish has two sets of allophones:
   - /b, d, g/: elsewhere
   - /p, t, k/: all allophones only of voiceless stops in Span.

WHY is this of interest? Learners need to acquire a new set of approximant allophones and a new distribution for L1 allophones.

PREVIOUS STUDIES ON THE PHENOMENON
Categorical Analyses vs. Continuous Analyses
Early studies use categorization of realizations as stop vs. approximant (Zampiri 1994, Lord 2010):
- They conclude Span. /b, d, g/ are a challenge for learners.
- Studies on L1 Spanish show that approximant production is gradient and best captured by the acoustic continuous measure of Consonant-to-Vowel (CV) intensity ratio (e.g. Carrasco et al. 2012)
- A couple of studies use this measure to explore the L2 phenomenon (Shea & Curtin 2011, Rogers & Alvord 2014).

Our proposal: a new mixed-methods approach, using two measurements: the type of allophone and the CV-intensity ratio, allows for more accurate picture of the learning process.

RESEARCH QUESTIONS
- How do voiced stops categorical realizations change in the acquisition process? (categorical analysis)
- How does the degree of weakening change in the acquisition process? (continuous analysis)
- How do these results complement each other?

METHODOLOGY
DATA COLLECTION
Current study is part of bigger project See your Speech.
Data comes from a module presented to students as part of a college-level Spanish Pronunciation class.
- Using a web-based interface, students record themselves reading word lists in Spanish and in English:
  - At the beginning and the end of the semester
  - Pedagogical component: Instant and in-class feedback

STIMULI
Module includes 71 Spanish words presented one by one:
- Words target a variety of Spanish sounds
- /b, d, g/ appear in intervocalic or word-initial position:
  - Word-initial: -do, bebe (“twelve, baby”)
  - Intervocalic - comida, lago (“food, lake”)
- In stressed and unstressed positions

METHODOLOGY (cont.)

RESULTS
CATEGORICAL ANALYSIS
Table 1. Types of realizations by timepoint

<table>
<thead>
<tr>
<th>Timepoint</th>
<th>approx voiced stop</th>
<th>voiceless stop</th>
<th>deletion</th>
<th>intrusive</th>
<th>tap voiced-approx</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>83.46%</td>
<td>47.15%</td>
<td>16.73%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>T2</td>
<td>63.70%</td>
<td>31.12%</td>
<td>12.14%</td>
<td>0.19%</td>
<td>0.57%</td>
</tr>
</tbody>
</table>

Effect of stress (Fig. 3):
- More approximants in unstressed positions.
- More voiceless stops in stressed positions.
- Same pattern in T1 and T2.

Effect of word position (Fig. 4):
- Most voiceless stops occur initially, as expected:
  - Decrease in voiceless stops initially, in favor of voiced stops and even some approximants.

CV-intensity ratio patterns mirror those of the categorical analysis:
- Higher ratio in unstressed and word-medial positions
  - These results are similar to those found for native speakers (Carrasco et al. 2012) => learners effectively use intensity ratio to pattern weakening
- Intensity ratio only changes in medial positions:
  - Expected since categorical analysis shows word-initial positions only main stop productions

MAIN FINDINGS AND CONCLUSIONS
Finding: Difference between learning new distribution vs. new allophones
- Implications for theories of L2 acquisition: Why do we find an asymmetry?
  - New allophones might be more salient to learners.
  - It might be harder to reconfigure already-learned articulatory patterns.
- Implications for pedagogy of L2 pronunciation
  - Research-based improvements to teaching techniques
Finding: learners follow a pattern of acquisition that mirrors native speakers’ gradient weakening

A mixed-methods analysis allows for a broader and more nuanced understanding of L2 sounds acquisition

DISCUSSION
Results show a range of types of realizations:
- Some of these realizations have not been considered in previous studies.

There are changes between T1 and T2 but vary depending on the realization:
- Significant increase in approximants vs. decrease in voiceless stops productions => evidence of production changes during the learning process
- Voiceless stops show a smaller change.
- Linguistic factors affect production and T1-T2 change of realizations:
  - More stops in stressed than unstressed positions:
    - Expected result given stress tends to strengthen articulations (Gordon 2011)
  - Difference in amount of change according to word position => Smaller change word-initially than medially:
    - This could suggest that learning a new distribution of L1 allophones is more challenging than learning new allophones
    - Further evidence for this: approximants word-initially in T2!

DATA ANALYSIS
Number of tokens: 1,053
Effect of following actors on stop production reported here:
- Timepoint (beginning T1 vs. end of semester T2)
- Stress
- Word position (initial vs. medial)
- Interactions between timepoint and other factors
- Descriptive statistics on types of realizations
- Linear regression & pairwise comparisons on CV-int. ratios

DEPARTMENT OF SPANISH AND PORTUGUESE
Spanish and English Voiced Stops
Most voiceless stops occur initially, as expected:
Decrease in voiceless stops productions => evidence of production changes during the learning process.
Voiceless stops show a smaller change.

More approximants in unstressed positions.
Some approximants in stressed positions.
Same pattern in T1 and T2.

Some approximants in unstressed positions.
More voiceless stops in stressed positions.
Same pattern in T1 and T2.

CV-intensity ratio results for approximant, voiced stop and tap realizations

Significant factors on intensity ratio:
- Higher ratio in unstressed positions
- Higher ratio in medial positions
- Significant interaction between timepoint & word position (Fig. 5):
  - Only medial positions increase their intensity ratio.

NEXT STEPS
- Explore the same research questions in a language class
- Continue our work comparing the acquisition of voiced and voiceless stops

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