

Individual variability in the production of the trill phoneme in second language Spanish

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HISPANIC LINGUISTICS SYMPOSIUM 2021

OCTOBER 7, 2021



Introduction

- Spanish has two rhotics, the tap /r/ and the trill /r/
 - pero ['pe.ro] 'but' vs. perro ['pe.ro] 'dog'
- Prescriptively, /r/ is realized as a voiced alveolar trill with 2-3 occlusions
- However, previous studies have found that the production of the trill varies considerably:
 - Velar variants
 - Pre-breathy voiced variants
 - Assibilated variants
 - Approximants
 - Taps

(e.g., Adams, 2002; Bradley, 2006; Colantoni, 2006; Díaz-Campos, 2008; Lipski, 1990; Willis, 2006)

Trill production by native speakers

- Trill variation in the Spanish of native speakers has been found to be conditioned by both linguistic and extralinguistic factors
- Linguistic factors:
 - Position within the word
 - Phonetic context
 - Syllable length of word
 - Grammatical category
 - Syllable stress
 - Speech style
 - Word frequency
 - Number of phonological neighbors

(e.g., Bradley, 2006; Díaz-Campos, 2008; Diez Canseco, 1997; Henriksen & Willis, 2010; Lewis, 2004; Willis, 2006; Zahler & Daidone, 2014)

Trill production by native speakers

- Trill variation in the Spanish of native speakers has been found to be conditioned by both linguistic and extralinguistic factors
- Extralinguistic factors:
 - Age
 - Sex
 - Social class
 - Social network density
 - Beliefs
 - Urban vs. Rural

(e.g., Adams, 2002; Bradley & Willis, 2012; Díaz-Campos, 2008; Diez Canseco, 1997; Henriksen & Willis, 2010; Lastra & Butragueño, 2006; Rissel, 1989; Willis, 2006; Zahler & Daidone, 2014)

Trill production by L2 learners

- American and British English have a single rhotic phoneme which is realized most often as a voiced alveolar approximant [ɹ] (Ladefoged & Johnson, 2010; Roach, 2004)
- Beginning learners generally have very low accuracy in producing [r], accuracy increases with proficiency level
- Not surprising since the alveolar trill is a difficult sound:
 - requires precise control over the positioning of the articulators and the amount of air flow (Solé, 2002)
 - among the last segments acquired by native speakers (Jiménez, 1987)

Trill production by L2 learners

- Even advanced speakers often do not produce a canonical trill
- Advanced learners range from 2% to 83% canonical trill production, including long-term immigrants (54.4%)

(e.g., Face, 2006, 2018; Daidone & Zahler, 2021; Reeder, 1998; Rose, 2010)

What else do they produce?

- Both non-native and native-like variants:
 - English-like [ɹ]
 - taps
 - approximants
 - assibilation
 - taps plus frication or r-coloring
 - preceding epenthetic vowel plus rhotic

(e.g., Daidone & Zahler, 2021; Face, 2006, 2018; Rose, 2010)

What conditions this variation?

- Daidone & Zahler (2021) examined L2 trill variation for advanced learners with a year abroad compared to L1 Spanish speakers
- L1 Spanish speakers:
 - Phonetic context predicted trill production
- L2 learners:
 - Male speakers more likely to produce trill
 - Higher frequency predicted higher trill and native-like variant production
 - Unstressed contexts favored native-like variants
 - Phonetic context predicted native vs. non-native production

What conditions this variation?

- Overall, learner trill production was not conditioned in the same way as native speaker trill production
- Individual learners varied between 0% and 47.1% canonical trill production
- What else may be affecting advanced learners' trill production?

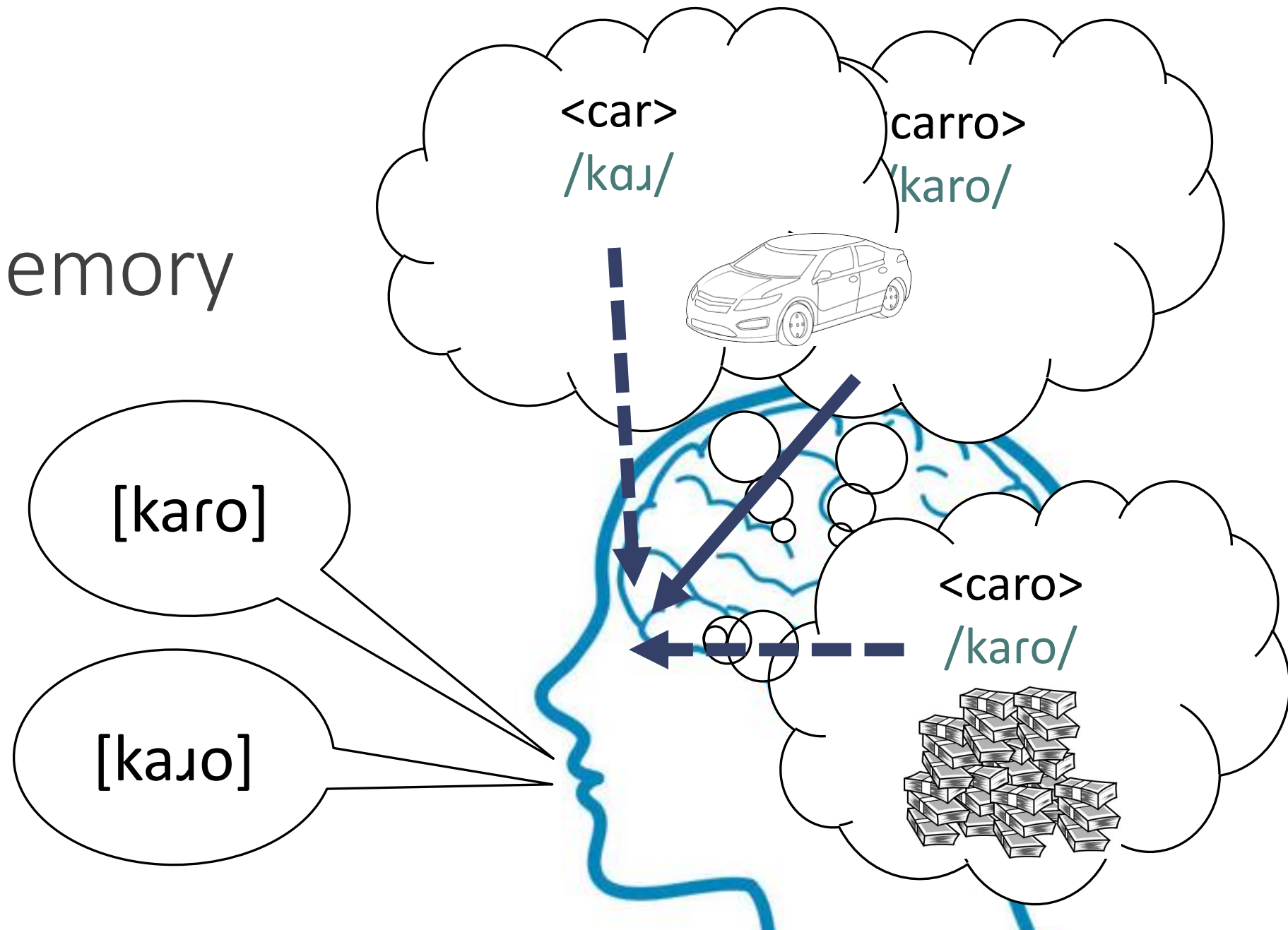
Individual Differences

- Individual differences have been shown to be related to accuracy in L2 perception, production, and representations of words
 - Working Memory
 - Phonological Short-Term Memory
 - L2 Vocabulary Size

Working Memory

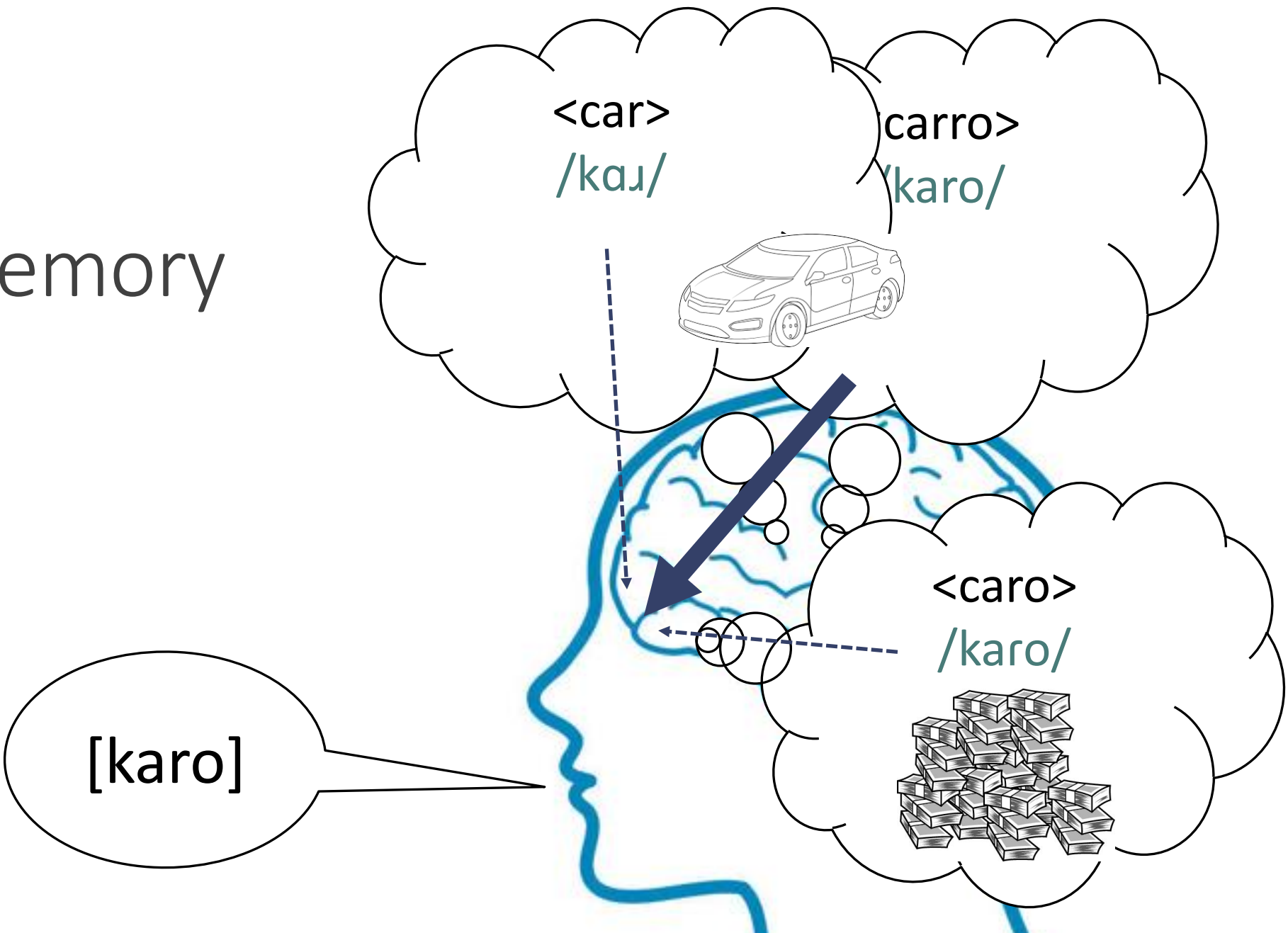
- The short-term storage and processing of information (Baddeley, 2000; Baddeley & Hitch, 1974)
- There are mixed results for the effect of working memory:
 - Higher working memory is related to more accurate L2 pronunciation (Simard, Molokopeeva, & Zhang, 2020; Trude & Tokowicz, 2011)
 - No relationship with L2 pronunciation and perception (Inceoglu, 2019)

Weaker Working Memory



Native English speaker

Stronger Working Memory



Native English speaker

Phonological Short-Term Memory (PSTM)

- Capacity to maintain auditory traces in memory for up to a few seconds before they decay (Baddeley, 2000; Baddeley & Hitch, 1974)
- The majority of studies have shown that higher PSTM is related to more accurate L2 production, perception, and representations of words (e.g., Daidone & Darcy, 2021; Inceoglu, 2019; Lengeris & Nicholaidis, 2014; Mora & Darcy, 2016; Zahler & Lord, forthcoming)

Weaker Phonological Short-Term Memory

[pero]



/per?o/

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Stronger Phonological Short-Term Memory

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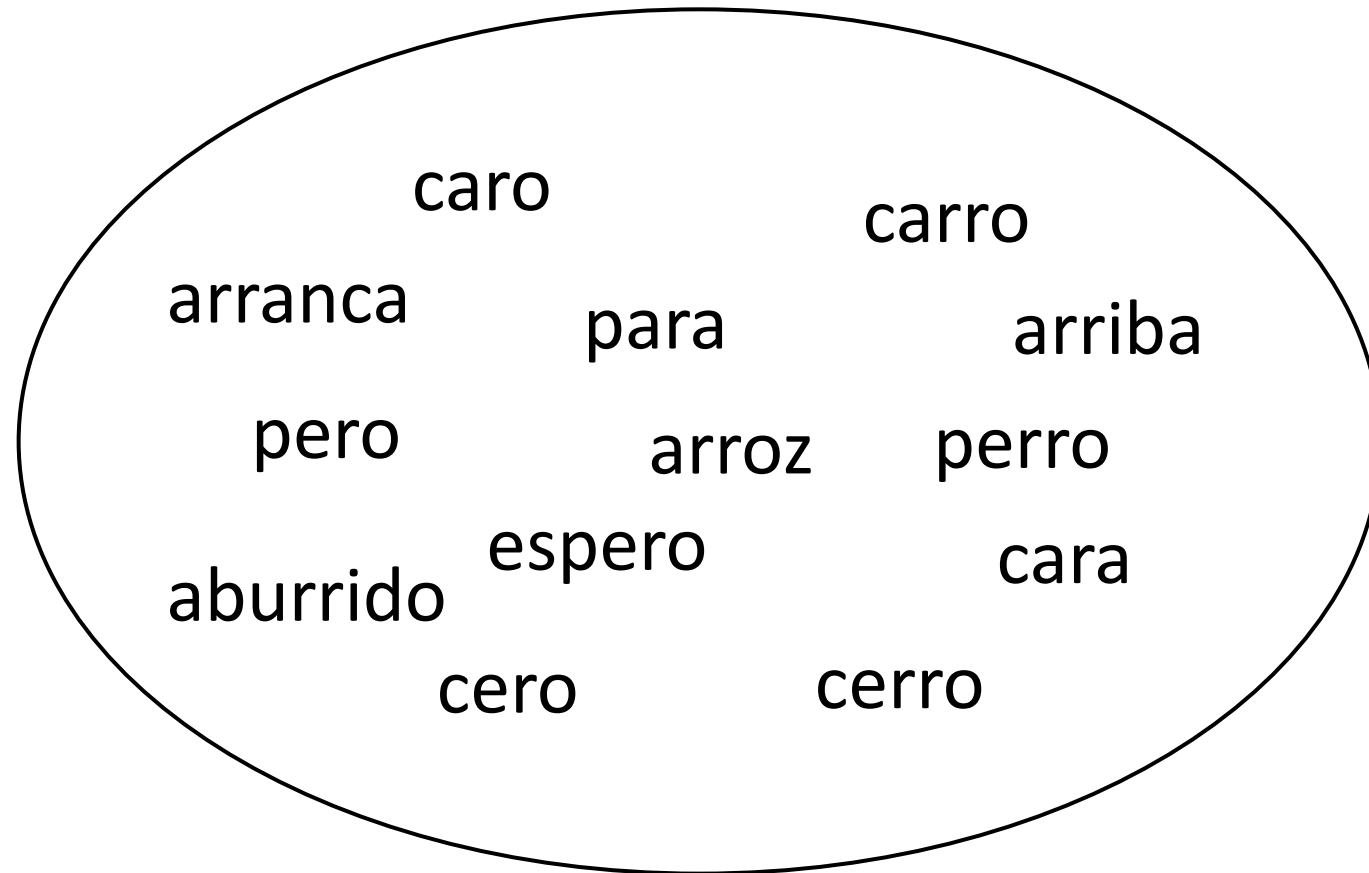


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L2 Vocabulary Size

- L2 vocabulary size has been shown to be positively correlated with accuracy in the perception and production of L2 sounds and the representations of words (Bundgaard-Nielsen et al., 2011, 2012; Daidone & Darcy, 2021; Llompart, 2021)

L2 Vocabulary Size



The Current Study

Research Questions and Hypotheses

- What are the phonetic variants produced in the trill context by graduate-level second language learners of Spanish?
 - Learners will produce a range of phonetic variants similar to those found in native speaker varieties and also occasionally non-native variants.
- Do learners vary in their individual rates of trill production?
 - Learners will vary between each other in their rate of production of different variants of the trill.
- What individual differences characterize this variation?
 - PSTM, WM, and vocabulary size will constrain this variation. Learners with a larger vocabulary size and higher WM and PSTM will produce more canonical multiple occlusion variants.

Participants

Group	N	Average PSTM score (/144)	Average WM score (/75)	Average Vocabulary score (-60 to 60)	Sex	Age	Years of Study	Study abroad
Graduate level Spanish learner	29	88.66 SD = 24.35 Range = 34 - 137	60.45 SD = 12.07 Range = 21 - 75	36.62 SD = 9.05 Range = 18 - 51	F = 17 M = 12	28.48 SD = 4.18 Range = 22 - 42	11.78 SD = 4.10 Range = 4.25 - 19	No = 3 Yes = 26

- 26 L1 Spanish speakers' trill production on the same oral task was analyzed as a comparison

Measure of PSTM

- Serial non-word recognition task (Russian)
- 24 pairs of sequences containing between 5-7 Russian CVC words and non-words
 - Eight each of 5, 6 and 7 non-words
 - Identical (i.e. A,**B,C**,D,E; a,**b,c**,d,e)
 - Different (i.e. A,**B,C**,D,E; a,**c,b**,d,e)
 - Recorded by female speaker in a carrier phrase
- Response: same or different?
 - 1000ms for response
- Presented in OpenSesame
(Mathôt, Schreij & Theeuwes, 2012)

Operation Span Task

- Operation span task from the Psychology Experiment Building Language (PEBL) (Meuller & Piper, 2014)
 - Perform simple math operations while memorizing letters for later recall
 - $4 + 2 - 1 = 5$; G
 - Sequences of 3-8 in random order

Vocabulary Task

- Lextale-ESP vocabulary test (Izura, Cuertos & Brysbaert, 2014)
 - 60 real Spanish words
 - 30 non-words created in a Spanish-like manner
- Learners had to mark which were the real words
 - 1 point for correct identification of real words
 - -2 points for each non-word that was marked as a word
- Possible score -60 to 60
 - At chance ~0

Oral response prompt task

- Participants presented with prompts for an oral response (via PowerPoint)
 - 10 prompts, 10-15 minutes total
- Topics designed to promote a range of discourse types (hypothetical, narrative, description)

“Cuéntame tus planes para este fin de semana.”

Acoustic measurement

- Tokens of /r/ were analyzed acoustically with Praat and classified as one of the following variants:
 - Voiced alveolar trill with 2 or more occlusions
 - Voiced alveolar tap (1 occlusion)
 - Tap followed by approximant
 - Tap followed by frication
 - Assibilated variant
 - Pre-aspirated tap
 - Pre-aspirated trill
 - Native-like approximant
 - English-like approximant
 - Trill + frication
 - Stop [d]
 - Deleted
 - Epenthetic vowel before tap or tap +

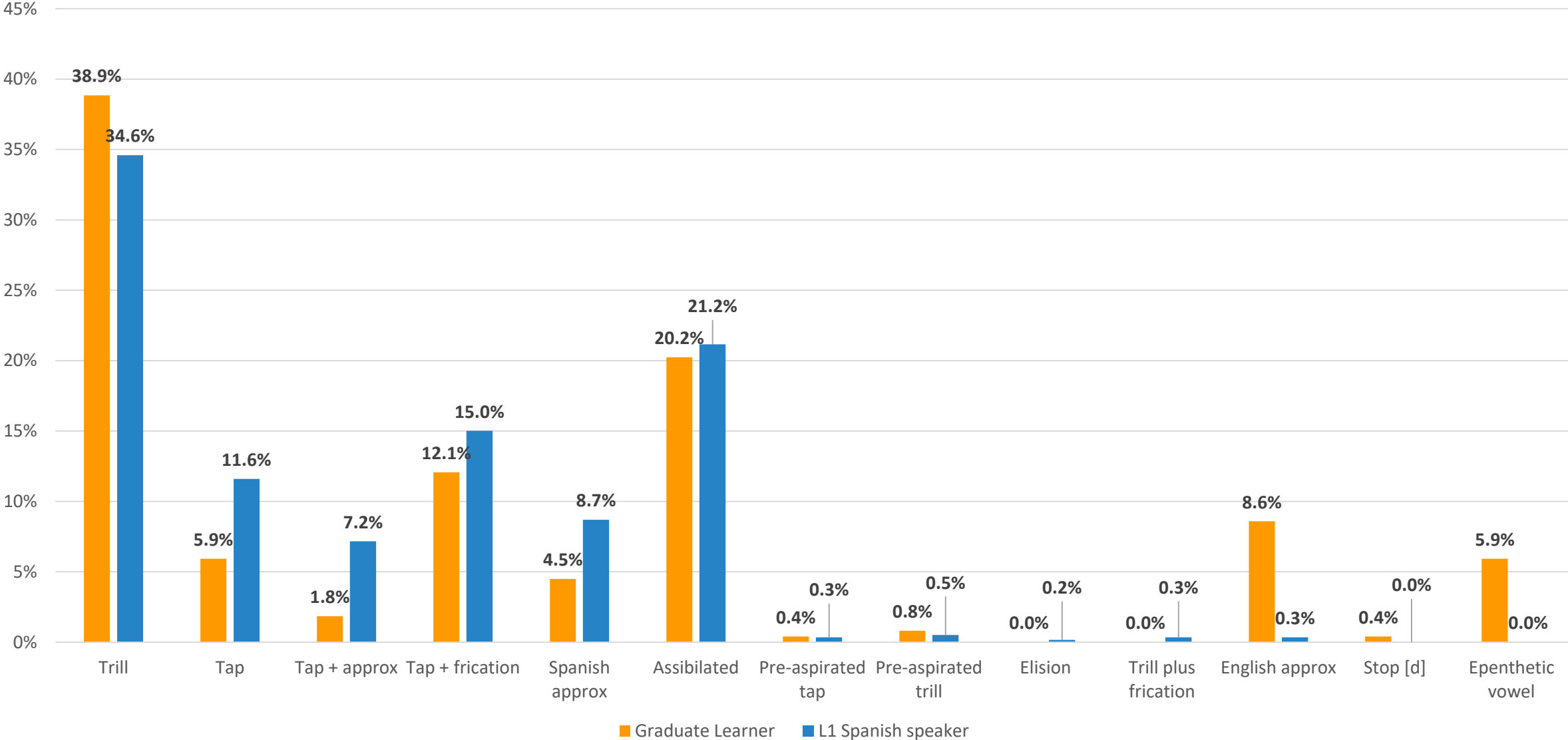
	Graduate-level	L1 Spanish speakers	Total
Final tokens	489	586	1075

Analyses

- Distribution of variants – Graduate L2 and L1 Spanish speakers
- Mixed-effect regression model in Rbrul (Johnson, 2009) – Graduate L2 learners
 - Dependent variable: Multiple occlusion variant vs. other
 - Independent variables:
 - Preceding segment manner
 - Following segment
 - Lexical Stress
 - Number of higher frequency phonological neighbors
 - EsPaL log frequency (Duchon et al., 2013)
 - Years of study
 - Vocabulary score
 - PSTM
 - WM
 - Individual (random)

Results

Distribution of variants across groups



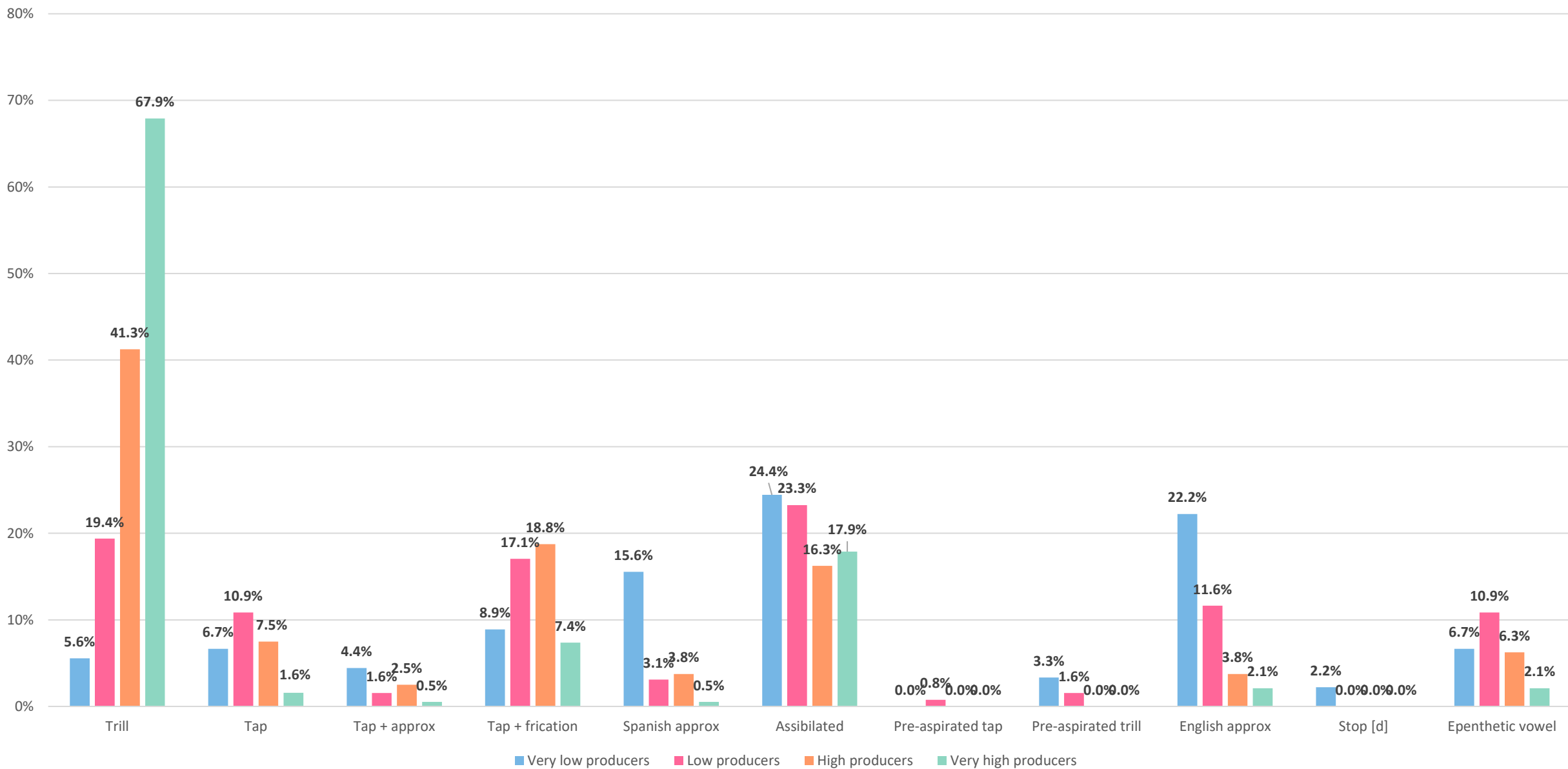
Mixed-effect Regression

Factor	P-value
Preceding segment manner	0.001
Following segment	0.012
Lexical stress	0.420
Number of higher frequency phonological neighbors	0.275
EsPaL log frequency	0.041
Years of study	0.214
Vocabulary score	0.229
PSTM	0.964
Working memory	0.279

- Surrounding phonological context and lexical frequency were significant
- None of the individual constraints were significant
 - Despite a range of rates of trill production across learners
 - Range: 0 – 88.9%
 - Mean: 39.3%
 - SD: 27.49

Factor	Weight/logodds
Preceding segment manner	
Mid vowel	0.71
Low vowel	0.60
Sonorant	0.46
Pause	0.44
High vowel	0.43
Obstruent	0.36
Following segment	
/u/	0.77
/o/	0.58
/i/	0.44
/e/	0.35
/a/	0.33
EsPaL log frequency	
[+1]	0.373

Distribution across groups with differing rates of trill production



Discussion

Research Question 1

- *What are the phonetic variants produced in the trill context by graduate-level second language learners of Spanish?*
- Learners produced 11 different variants
- Their distribution of variants was similar to that of L1 Spanish speakers, with a few exceptions:
 - L2 learners produced more English-like approximants and epenthetic vowel + rhotic
 - L2 learners produced less taps, tap plus approximants, and native-like approximants

Research Question 2

- *Do learners vary in their individual rates of trill production?*
- Learners varied between 0% and 88.9% canonical trill production
- There was a lot of individual variation (SD = 27.49)

Research Question 3

- *What individual differences characterize this variation?*
- None of the individual difference measures (WM, PSTM, vocabulary size) predicted L2 trill variation
- The only significant variables were linguistic variables:
 - preceding segment, following segment, log frequency
- Articulatory difficulty of the trill appears to have an overriding influence on L2 variation
 - Learners produced more canonical trills in easier preceding phonetic contexts, but results for following vowel unexpected, highly practiced words?
 - Higher frequency words produced with more trill = practice effect

Overall findings

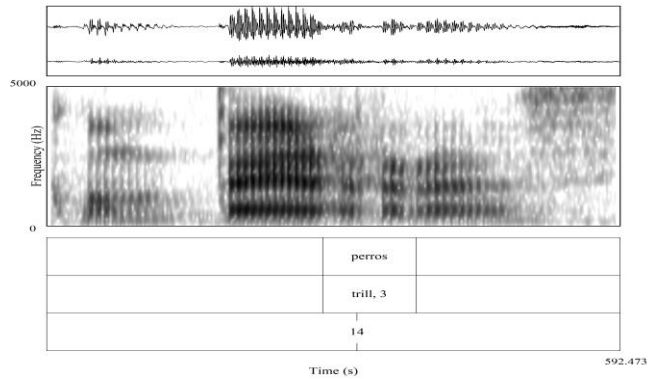
- Learners are highly variable in their production
- Learners who use more multiple occlusion variant, produce the English /ɹ/ less
- Tap, tap + frication, assibilated variant, Spanish approximant and epenthetic vowel + tap seem to be intermediate stages
 - English approximant > Spanish approximant > assibilated > tap > tap + frication > epenthetic vowel > trill
- Shows the need for a longitudinal study for trill acquisition *with the same set of learners*

Thank you! Questions?

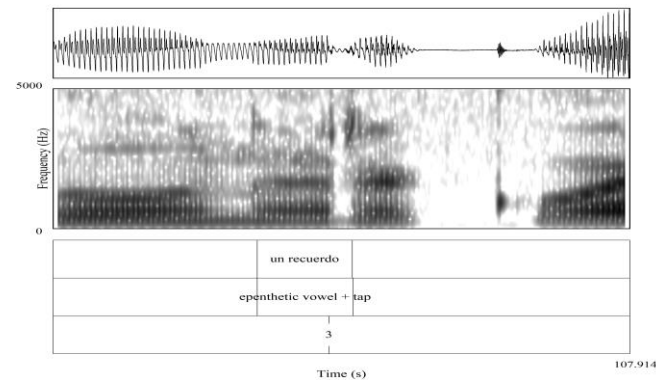
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Examples

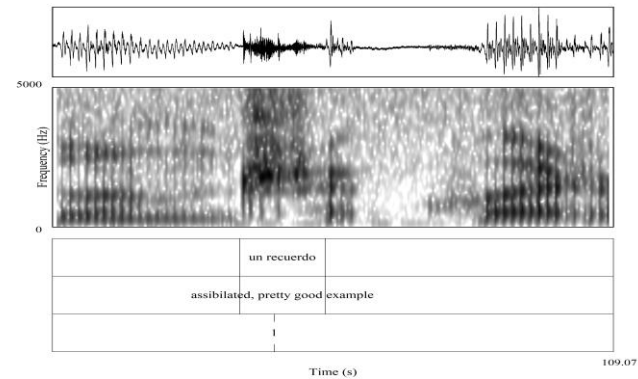
- Multiple occlusion variant



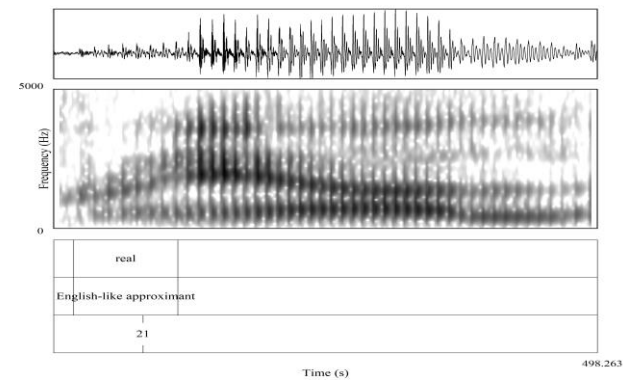
- Epenthetic vowel + tap (+)



- Assibilated

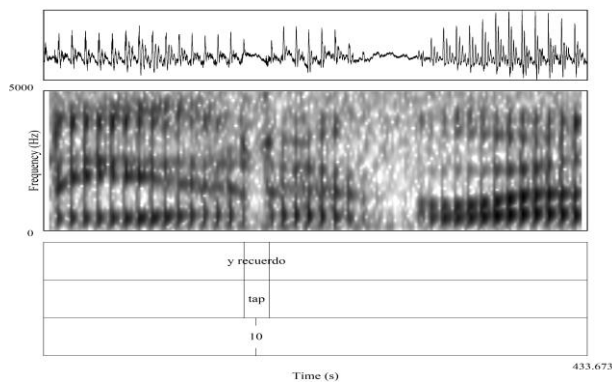


- English-like approximant

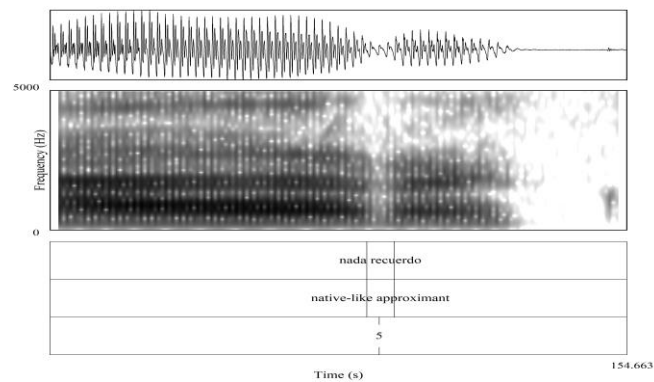


Examples

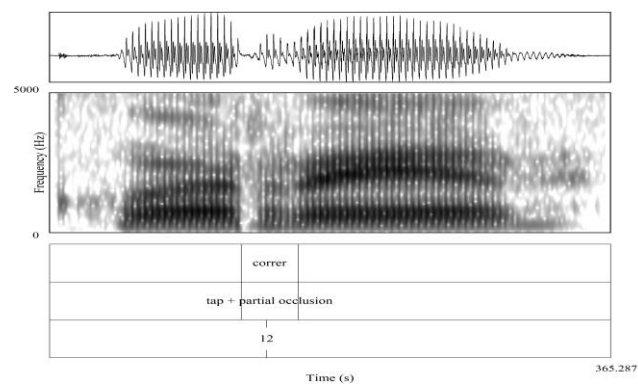
- Tap



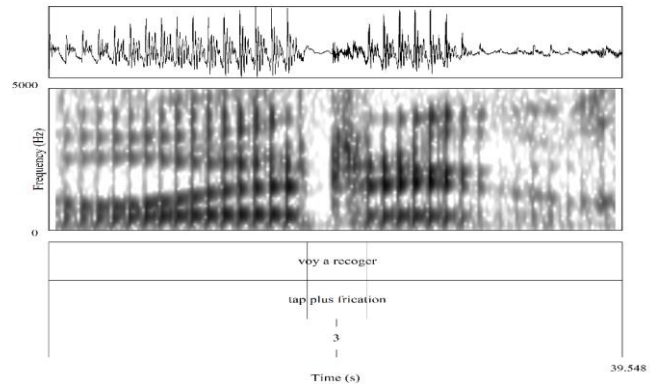
- Native-like approximant



- Tap + approximant



- Tap + frication



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