What can reaction times tell us about L2 categories? Perception of the /ɑ-ʌ/ contrast by native speakers of Spanish

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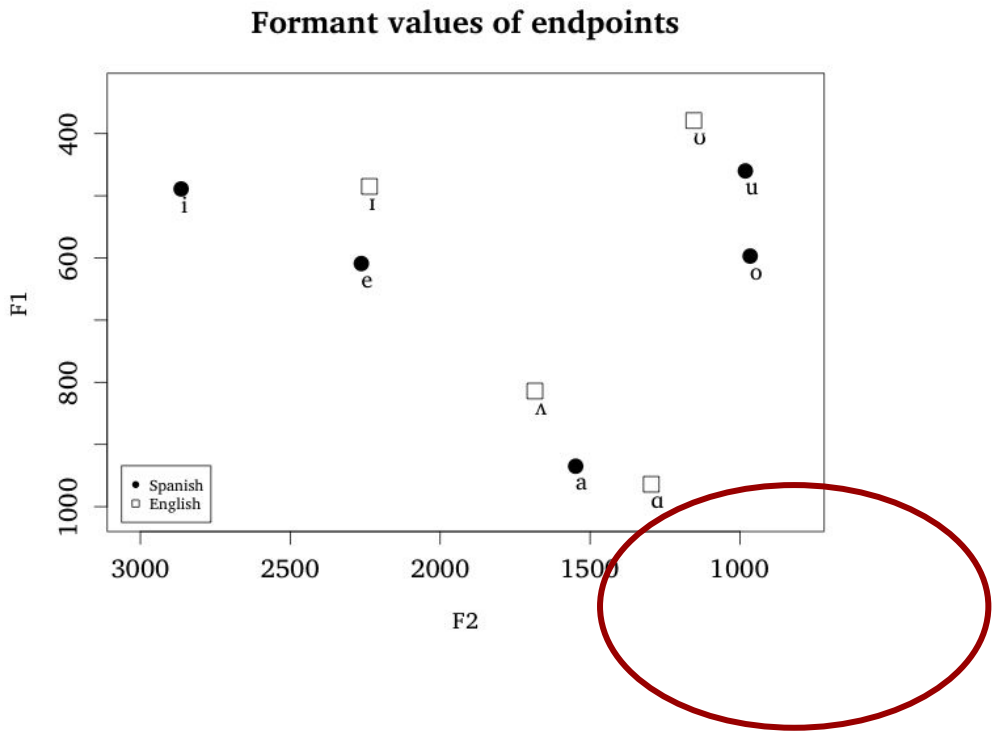
Intro

- L2 speakers and acquisition of perceptual categories
  - Speakers of an L1 with fewer phonemic categories in their inventory need to learn a contrast between two sounds that are originally mapped onto one L1 category.
    - Spanish: /ɑ - ʌ/ of AmEng mapped perceptually onto L1 /a/
- Learning difficulty is higher when:
  - New L2 sounds are very similar to an L1 category (Flege 1995)
  - Two new L2 sounds are initially perceived as equally prototypical exemplars of the common L1 category (Best 1995)

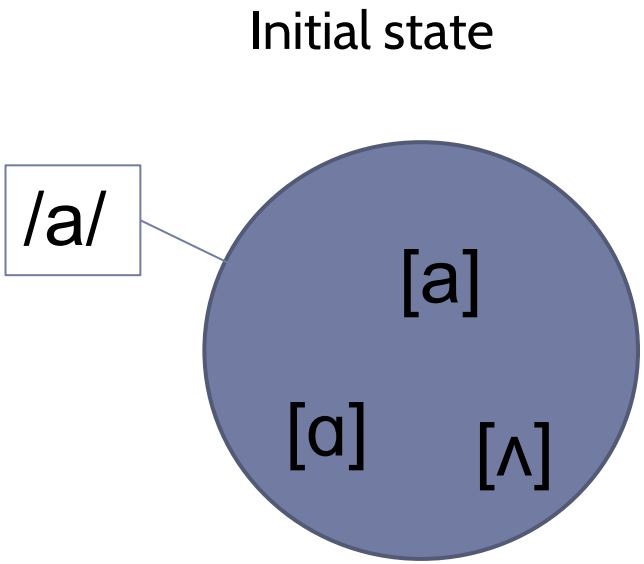
Intro

- Vowel systems



Intro

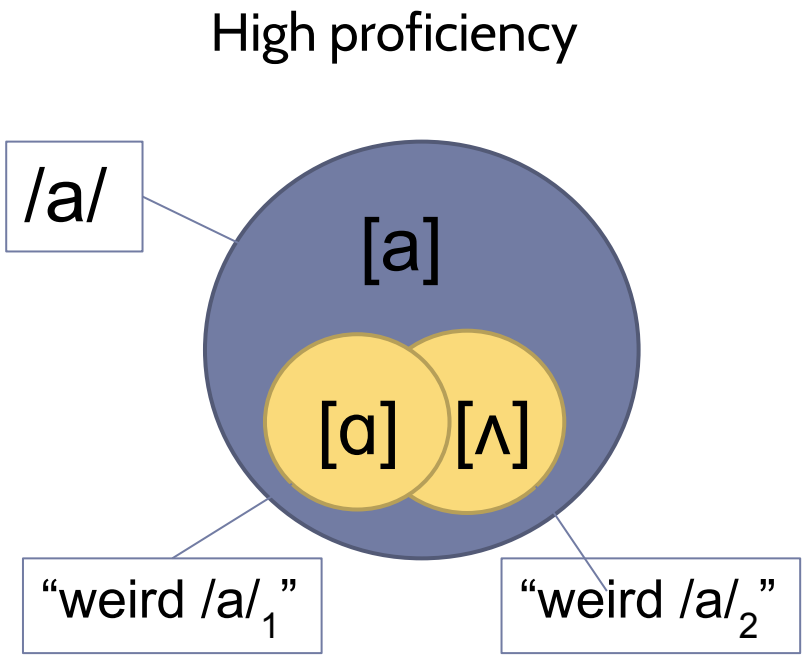
- The L1-splitting problem



- All is being mapped onto the closest L1 category
- No discrimination available.

Intro

- The L1-splitting problem



- All is still being mapped onto the closest L1 category
- L2 tokens are perceived as somewhat different, but not as a phonemic category
- Discrimination becomes available

Perceptual cues in L2 vowel perception

- Perceiving vowels depends on the amount and type of acoustic cues available.
  - Listeners rely on the cues that are available in their language
    - English: duration and formant frequency
    - Spanish: only formant frequency
  - L2 listeners are likely to learn how to process additional perceptual cues (Escudero 2005)
    - L2 listeners might have a harder time if both languages have the same type or perceptual cues available for phonemic contrasts, and the L2 has divided the same perceptual space into more categories.
      - The /ɑ - ʌ/ continuum does not offer duration as an auxiliary cue.
      - Creating new categories implies a bootstrapping process.

Perception of vowel categories: the experimental point of view

- Some tasks are designed to show the presence and behaviour of certain perceptual categories
  - Labelling /Discrimination tasks
    - Liberman (1957): Categorical perception
      - **Labelling**: A stimulus x from an /A-B/ continuum is presented in isolation and the Subject decides which sound it is, from a list of options. (i.e. "is this a vowel as in *cat* or one as in *bed*?")
      - **Discrimination**: two adjacent stimuli from a 7-step /A-B/ continuum (e.g. /A-B/$_3$ and /A-B/$_4$) are presented one after another, with a fixed inter stimuli Interval (ISI).
      - Labelling predicts discrimination along a continuum between ***two adjacent*** sounds. However, effect is not cons vowels (Schouten et al, 2003).

Perception of vowel categories: the experimental point of view

- Reaction times
  - Pisoni & Tash (1974): correlation between RT and perceived difference between sounds
    - RT of stimuli within the same category were shorter for identical stimuli (A-A) and larger for different stimuli (A-a)
    - Pairs of sounds that were considered to belong to different categories (A-B) triggered faster RTs for longer acoustic distances.
  - Such differences are a result of different processing modes
    - 1. Auditory mode -> 2. Phonetic (linguistic/speech) mode
    - If stimuli are exactly the same, or very dissimilar, then processing goes only through auditory mode. Otherwise, stimuli are evaluated on phonetic mode.

This study

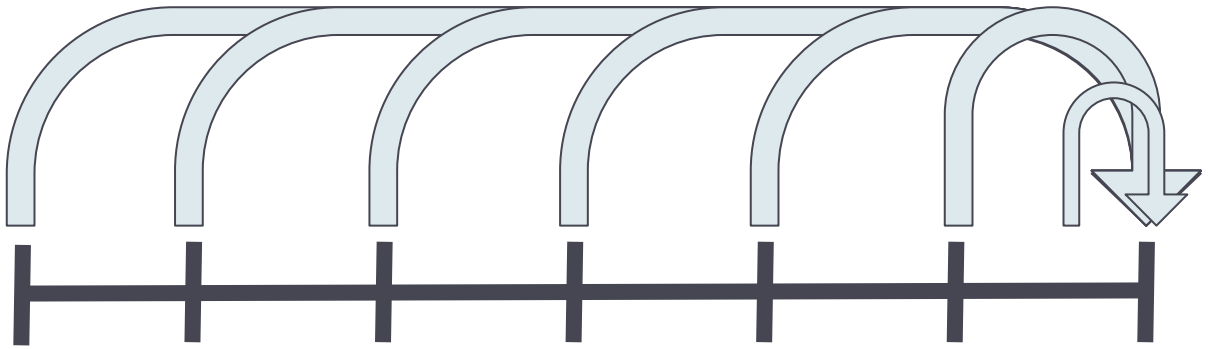
- Goal:
  - To look into the nature of L2 perceptual representations from a behavioural point of view by looking at the results of a modified discrimination task and correlating them with reaction times
- Subjects:
  - 21 native speakers of Spanish
    - 9 of them with advanced knowledge of English (Postgraduates with over 6.5 IELTS scores studying in Manchester)
    - 13 of them with beginner-low intermediate knowledge (taking short-term English courses in Manchester).
  - A third group of 8 native speakers of American English (who all had /ɑ/ and /ʌ/, but not /ɒ/, /ɔ/, or /a/).

This study

- Task
  - Software used: E-prime
  - Participants were asked to discriminate as either “same” or “different” between two stimuli along the synthesized 7-step continuum /ɑ–ʌ/.
  - Each continuum token was compared against an endpoint of the continuum.
  - Reaction times were measured. Participants were told that they would have about 4 secs per trial.

This study

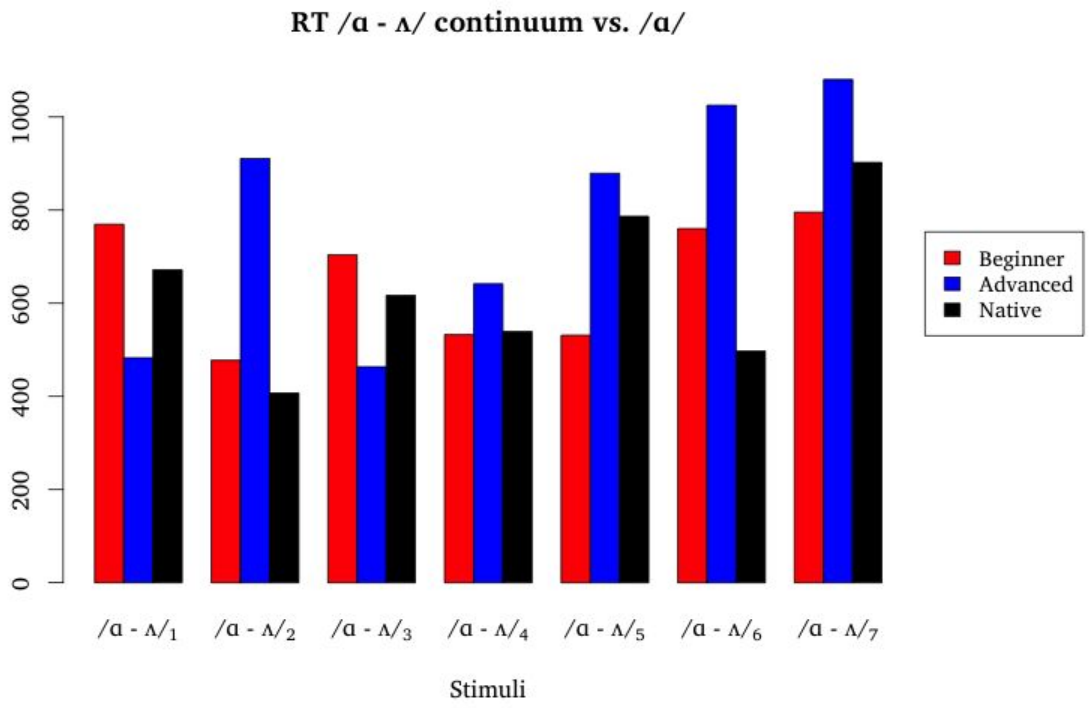
- Stimuli
  - Each stimulus consisted of a CVC nonce word in which V was one token of the /ɑ-ʌ/ continuum, followed by a 1s ISI and then either one of the endpoints of the continuum.
  - Stimuli were presented in random order.



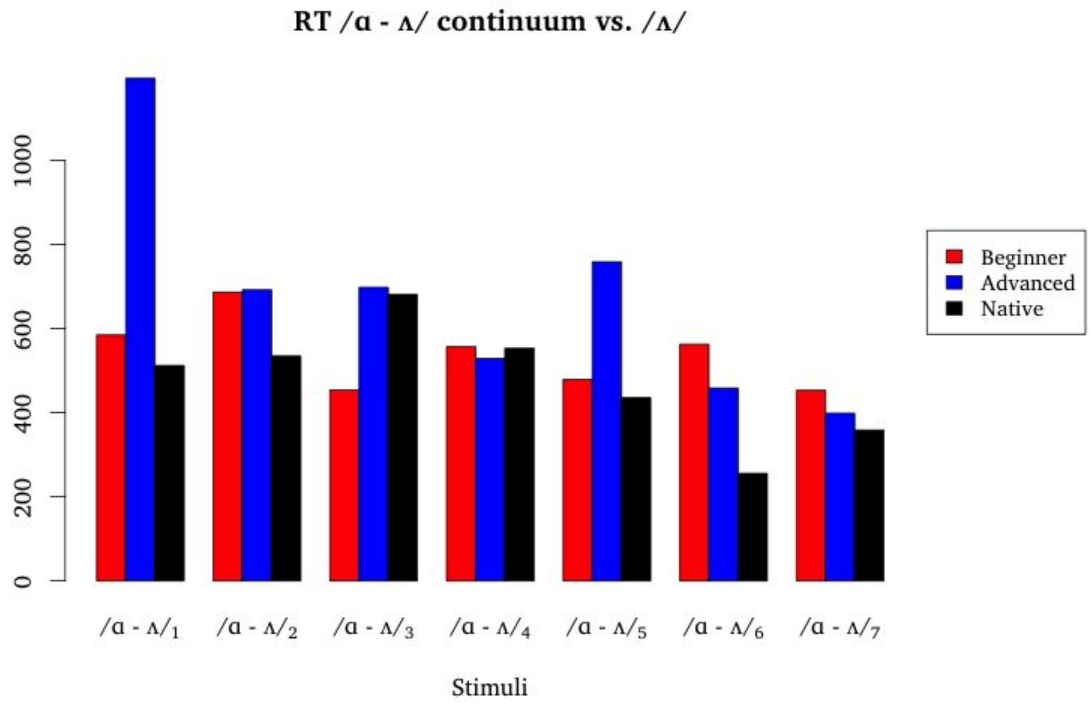
/ɑ-ʌ/$_1$ (= /ɑ/) /ɑ-ʌ/$_2$ /ɑ-ʌ/$_3$ /ɑ-ʌ/$_4$ /ɑ-ʌ/$_5$ /ɑ-ʌ/$_6$ /ɑ-ʌ/$_7$ (=/ʌ/)

- The second set of stimuli has the arrows reversed (all the continuum tokens against the other end).

Mean RT during discrimination task

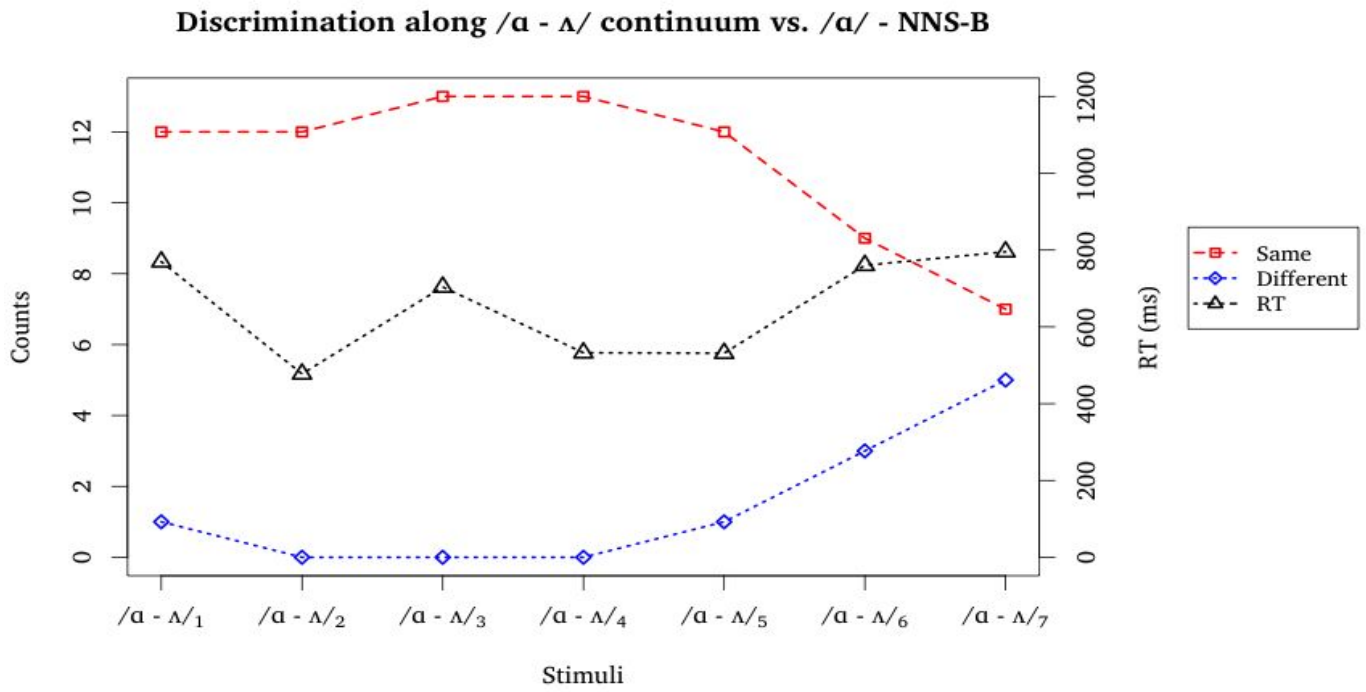


Mean RT during discrimination task



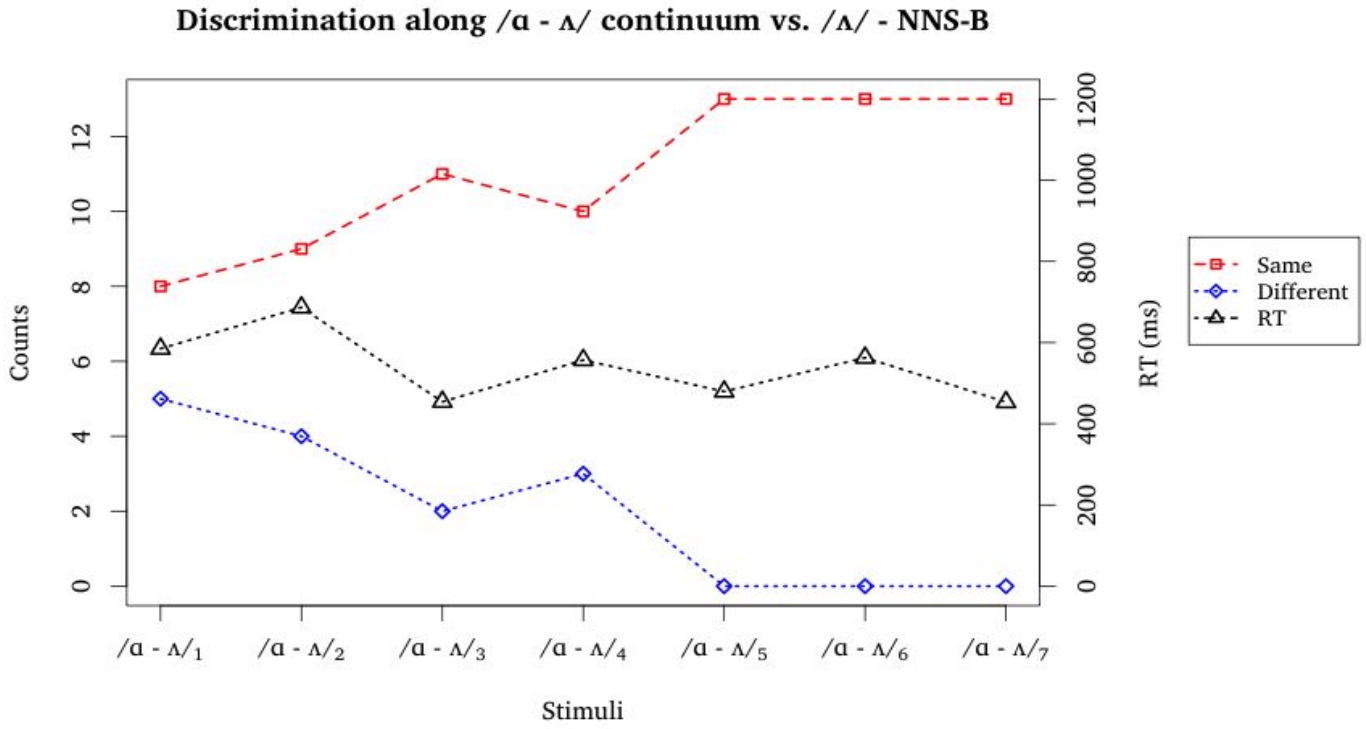
Results - NNS-Beginners

- /ɑ-ʌ/ vs. /ɑ/: Beginners showed uncrossing lines when discriminating along the continuum (unable to discriminate). RT shows as relatively flat, with different small peaks along the continuum.



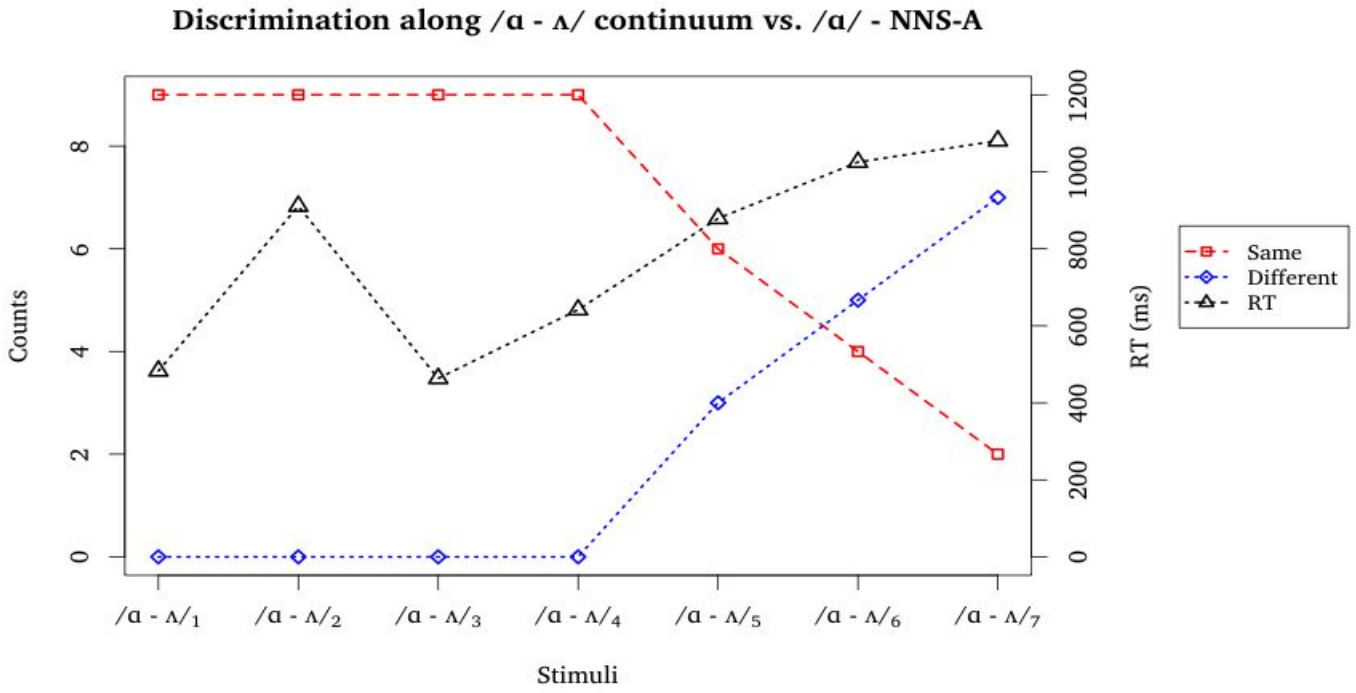
Results - NNS-Beginners

- /ɑ-ʌ/ vs. /ʌ/: When changing the endpoint stimulus, beginners showed a similar line pattern (no category-driven discrimination).



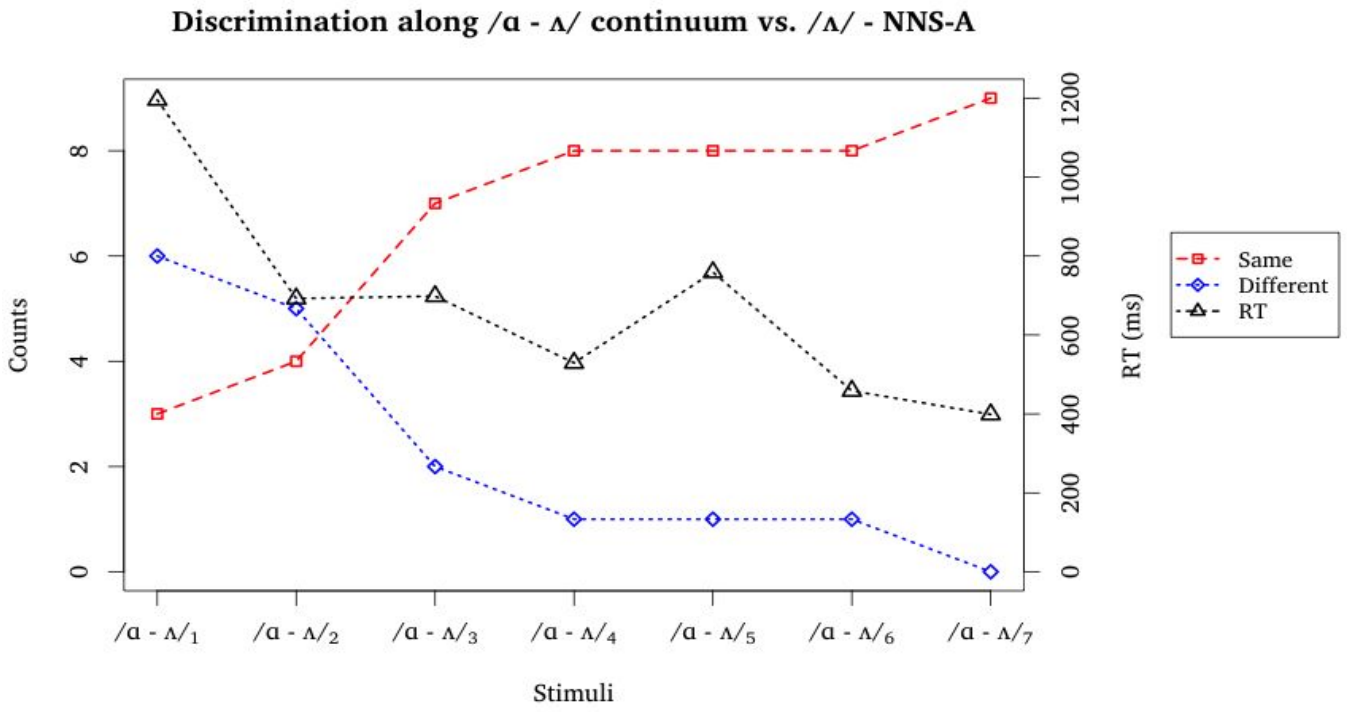
Results - NNS-Advanced

- While their discrimination show curves similar to those of NS, their endpoint-to-endpoint discrimination did not reach ceiling. Their RT showed increasing values as the stimuli became more acoustically different.



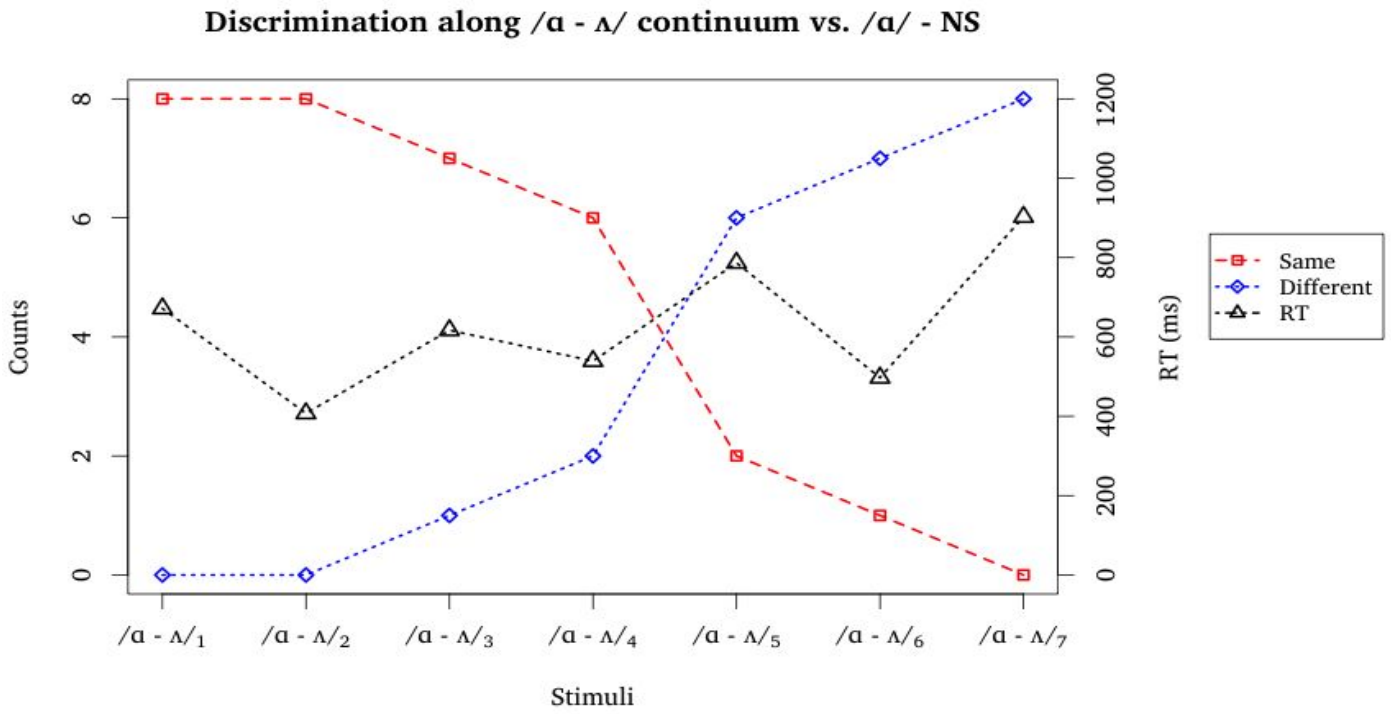
Results - NNS-Advanced

- When comparing continuum stimuli against the other endpoint, the patterns remain similar.



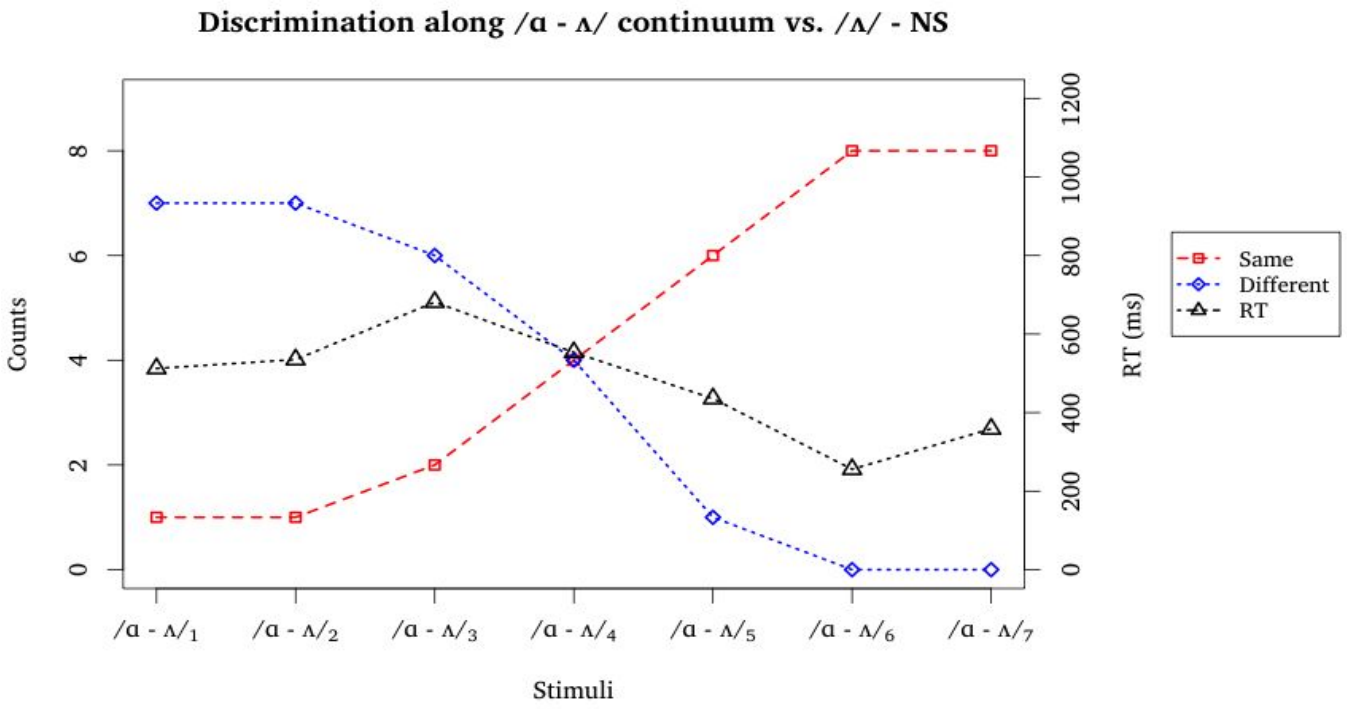
Results - NS

- Native speakers of English showed expected crossing S-curves as the stimuli were more acoustically different, and were overall faster along the entire continuum.



Results - NS

- And the pattern repeats when comparing against the other endpoint.



Discussion

- About the experiment
  - Nature of the task: identification or discrimination?
    - Discrimination: usually between adjacent tokens of a continuum
  - Sample size
    - Outliers and low frequency within-subject distributions might give data the wrong (i.e. non-representative) look, especially when working with means
  - Stimuli
    - Vowel variation within AmEng speakers (cf. vowel shifts, split systems and so on)
    - Prototypicality of the vowels used as endpoints
    - Long ISI for linguistic tasks does not allow for the short-term auditory memory to aid discrimination

Discussion

- About the identification results
  - Advanced NNS cannot discriminate nonnative sounds with the same accuracy as NS (but almost)
    - Intersecting lines show the presence of two category areas and a boundary (i.e. a zone with 50/50 chance of identification as either /ɑ/ or /ʌ/).
    - Crossing lines by the end of the continuum show that
      - Creation of a /ʌ/ category is in progress
      - Some learning is taking place --in a NS direction.
  - Beginner NNS did not reach the 50/50 stage of sensitivity.
  - NS showed clear categorical discrimination pattern.
  - Perception of categories on the /ʌ/ endpoint is weaker than the /ɑ/ endpoint for all categories.

Discussion

- About RTs
  - RTs tend to show a peak effect at the boundaries, but is not statistically significant.
    - NNS-A identification data are consistent with RTs as the RT increases when reaching the boundary zone.
    - NS and NNS-B do not show any significant patterns.
  - Both mean and median values show that NS were overall much faster than NNS-A, but not much faster than NNS-B.
  - Pisoni's experiment (1974) measured perception of consonants, with VOT as variable
    - A one-dimensional cue with less dispersion in prototypical values might explain the difference in RT patterns
    - 300 ms ISI make comparisons much easier! (due to short-term auditory memory)

Conclusions

- Phonetic representations
  - NS show the expected kind of identification behaviour, but RTs do not give any particular insights; the task itself is more informative than both combined.
    - Pisoni's results were explained by the short ISI, which triggers short-term auditory memory as a decision mechanism. The task is not linguistic but auditory.
  - NNS-B's invariance in responses show that there are no different categories across the /ɑ-ʌ/ perceptual space.

Conclusions

- But…
  - NNS-A show a notorious change in RT as they reach the second category area, which shows the struggle of /ʌ/ to stand out as a category.
  - NNS-A do not store phonemic representations in their grammar in a native-like manner
    - No deterministic behaviour, but **probabilistic** (over chance, below ceiling, less robust than NSs)
    - Yet it corresponds with the target values that NSs recognise.
  - The responses are not merely aided by short-term auditory memory; they are long-term *phonetic categories* that store prototypical values of an L2 category.
    - The phonetics-phonology interface is also present in perception.

Thank you

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