UC San Diego

How abstract are phonological representations? Evidence from distributional perceptual learning

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Main question

- We think about phonological representations as abstract
  - phonemes are comprised of abstract subphonemic units: distinctive features, articulatory gestures, acoustic dimensions
- We know that people are sensitive to phonemic and subphonemic units
  - e.g., speech errors: *big and fat* → *fig and bat*

    big and fat → *pig and vat*

    (Fromkin 1973)
- But how abstract are the psychological representations of these subphonemic units?

Example: length

- Contrastive length: can apply to many segments
  - [ta**k**a-] vs. [ta**kk**a] Finnish: *'back' / 'fireplace'*
  - [ki**s**aki] vs. [ki**ss**aki] Japanese: *'empress' / 'point of a sword'*
  - [be**l**o] vs. [be**ll**o] Italian: *'I bleat' / 'beautiful'*
  - [s**e**ki] vs. [s**e:**ki] Japanese: *'seat' / 'century'*
- Formal means of representing length
  - [+long], two timing slots, a mora
  - Commonality: length represented as abstracted across different segments, despite different raw acoustic cues

Example: length

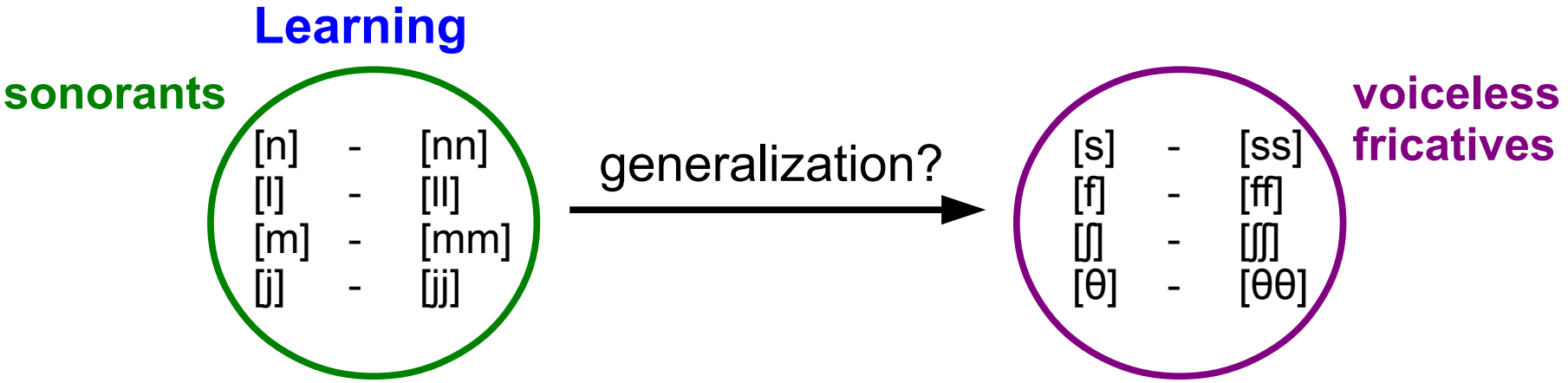
- Contrastive length: can apply to many segments
  - [ta**k**a-] vs. [ta**kk**a] ← **duration of silence**
  - [ki**s**aki] vs. [ki**ss**aki] ← **duration of frication noise**
  - [be**l**o] vs. [be**ll**o]
  - [s**e**ki] vs. [s**e:**ki]

  ← **duration of voicing, formant transitions, intensity**

  ← **acoustic cues**
- Formal means of representing length
  - [+long], two timing slots, a mora
  - Commonality: length represented as abstracted across different segments, despite different raw acoustic cues
- Is there a single psychological representation of length as independent from individual segments?

Proposal

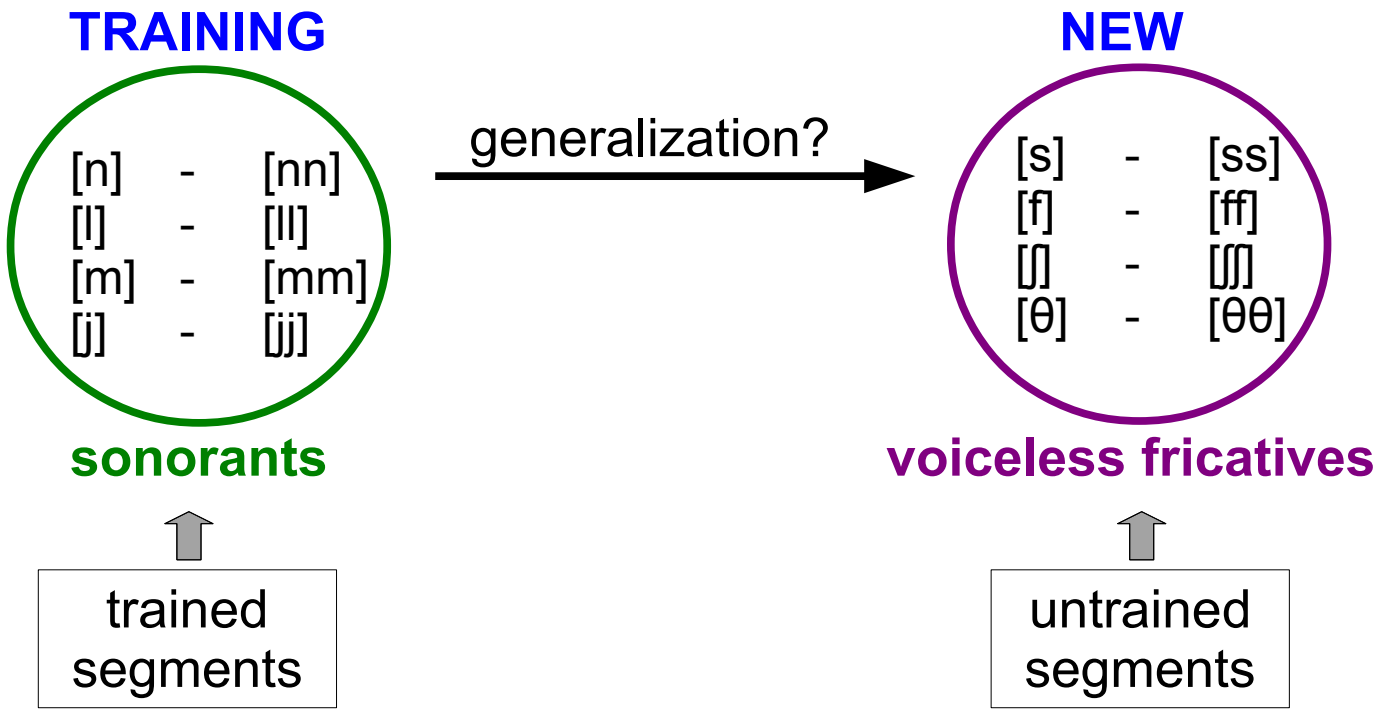
- We can probe the abstractness of phonological representations by looking at how novel phonological contrasts are learned and generalized.



- Generalization here would suggest that length is represented as abstracted across different consonants (at least shared between sonorants and voiceless fricatives).

Experiment: overview

- Exposing English monolinguals to evidence suggesting a novel length contrast in a new language



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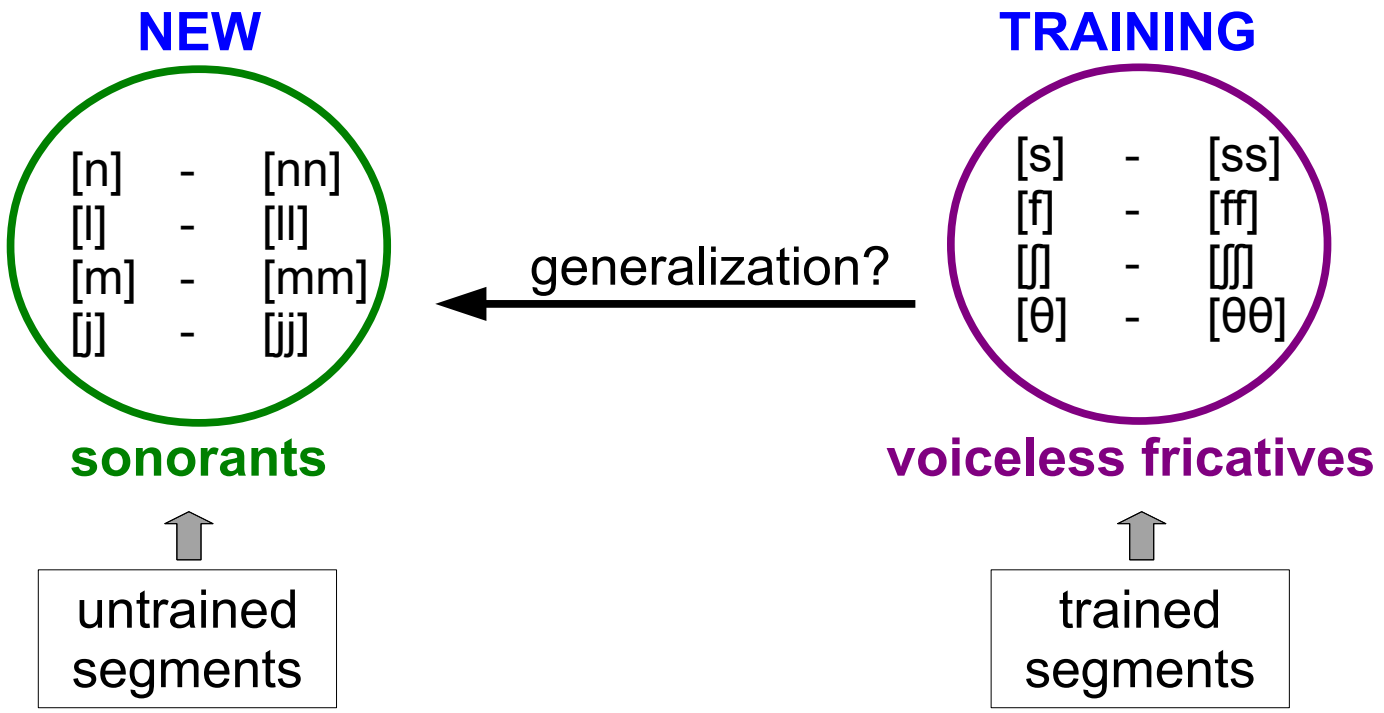
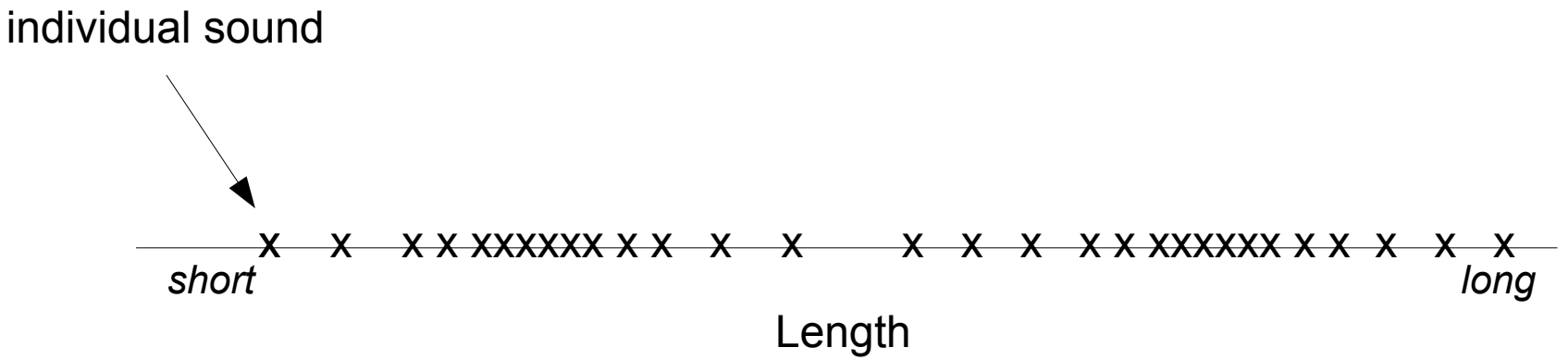
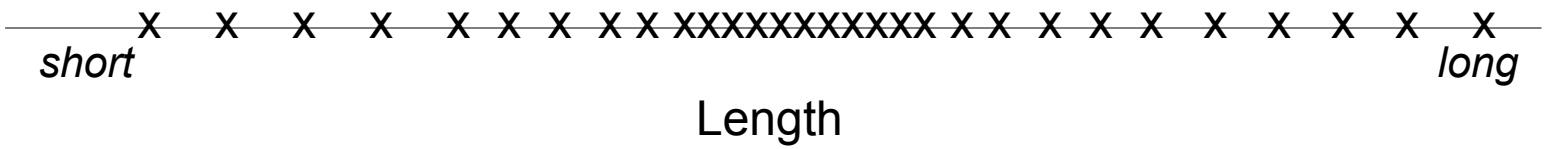
- Exposing English monolinguals to evidence suggesting a novel length contrast in a new language



Experiment: paradigm

- Distributional learning paradigm (Maye & Gerken 2001, Maye, Werker, & Gerken 2002)





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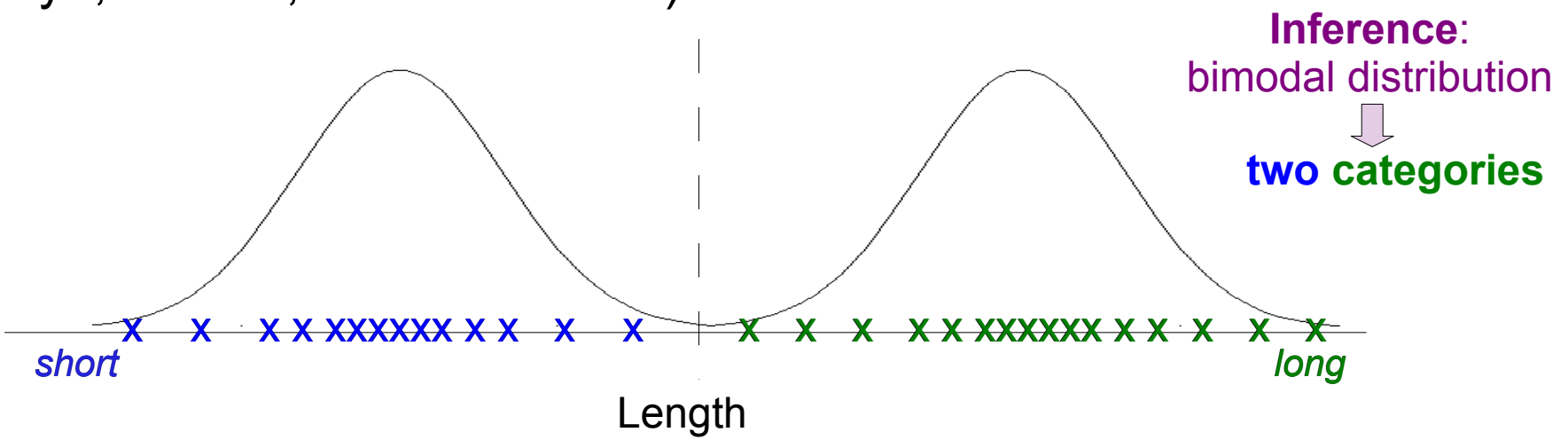

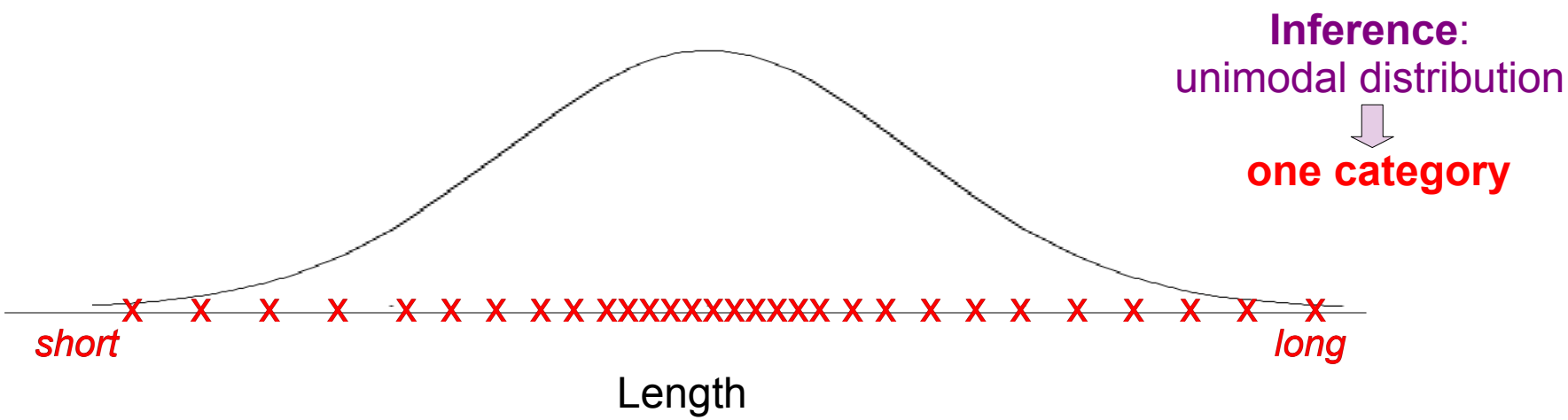

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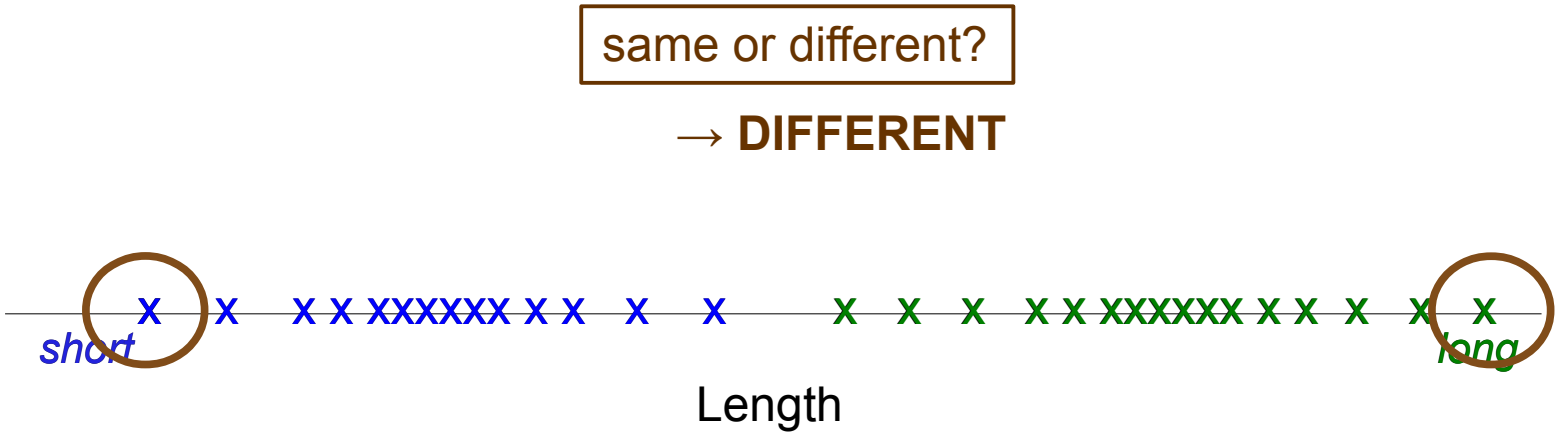
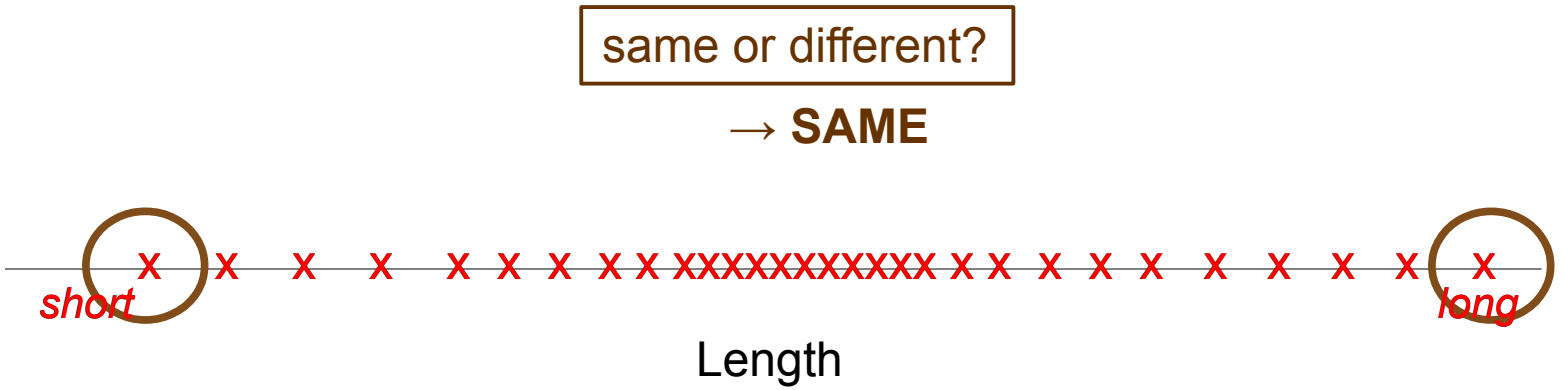
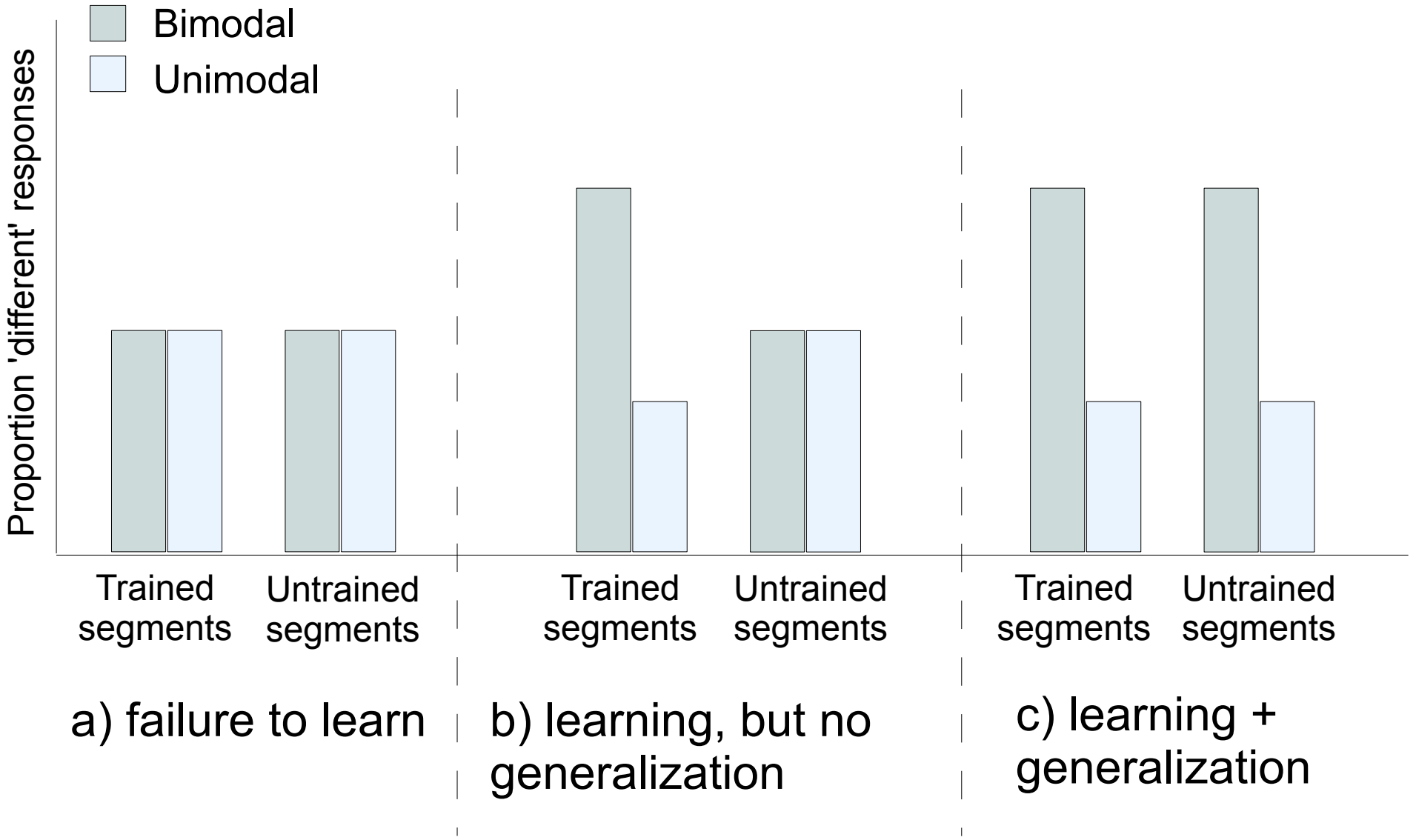




Distributional learning: output scenarios

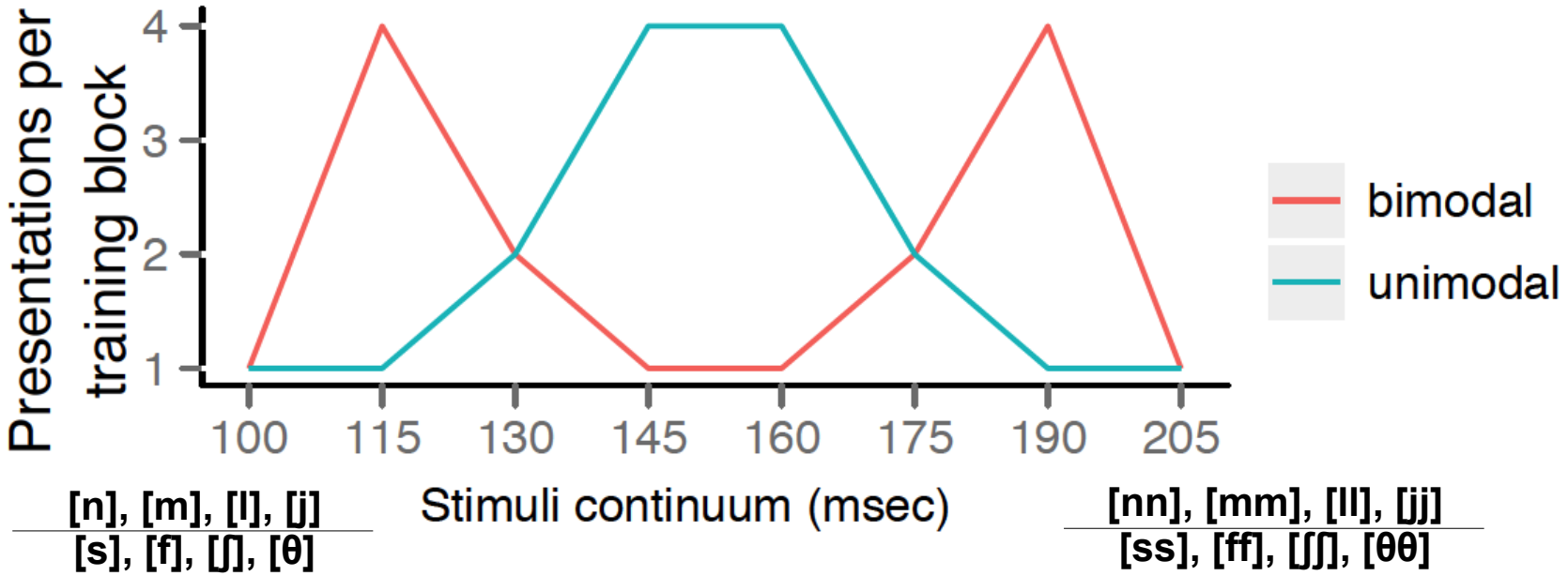


Experiment: ppts & instructions

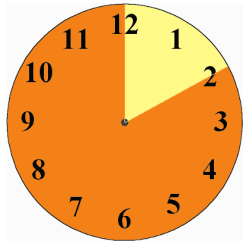
- 48 English monolinguals not familiar with any other language that has length contrasts.
- Instructions
  - You'll be learning (sounds from) a new language.
  - First, you'll listen to words from that language.
  - Then, you'll hear pairs of words and, based on what you learned, decide whether these are two different words or the same word repeated twice.
  - The same word can be pronounced a bit differently (e.g., with different intonation) – follow your intuition in deciding what counts as 'different' in this language.

Experiment: design & materials

	CONDITION	
GROUP	bimodal sonorant-trained	bimodal fricative-trained
	unimodal sonorant-trained	unimodal fricative-trained



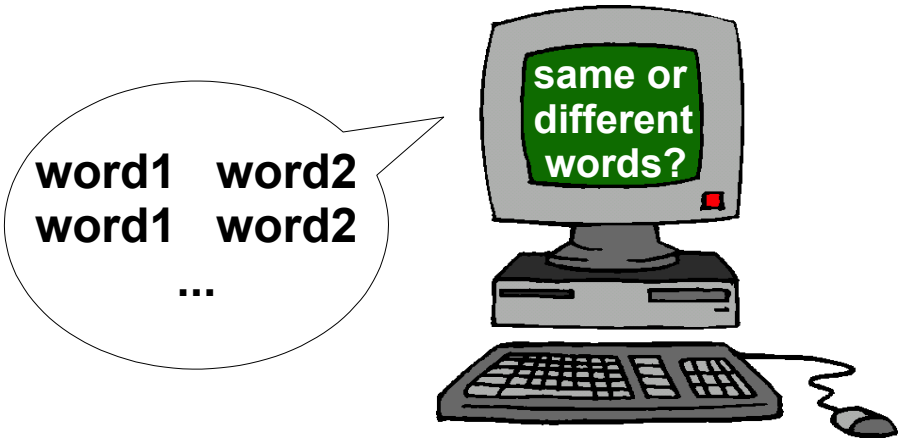
Experiment: training

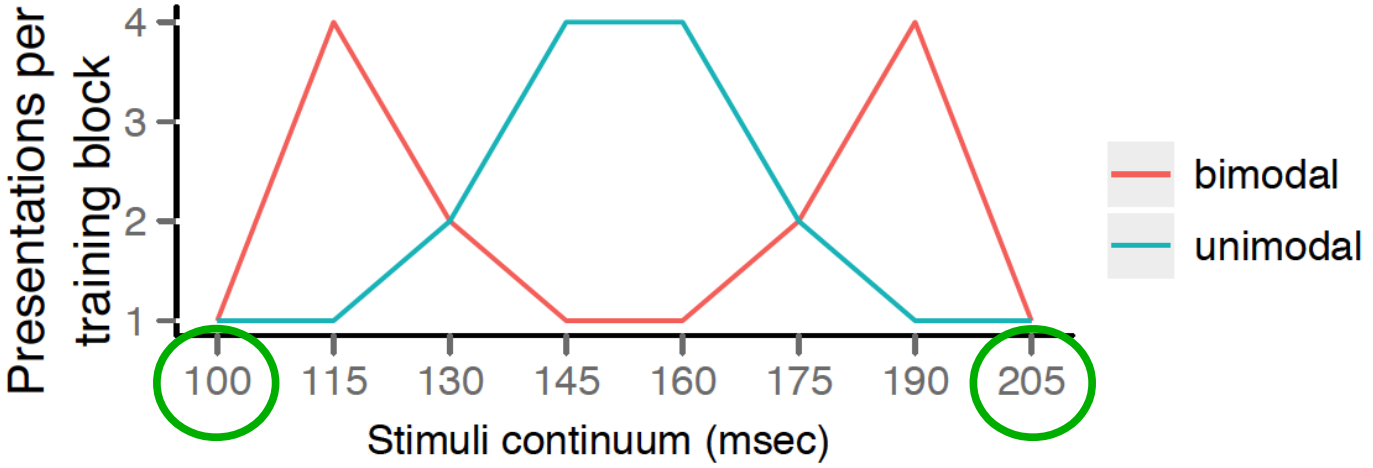


[aja]$_{145ms}$
[ina]$_{205ms}$
[adʒa]
[ila]$_{115ms}$
[ama]$_{160ms}$
[ɪra]
...

Experiment: testing

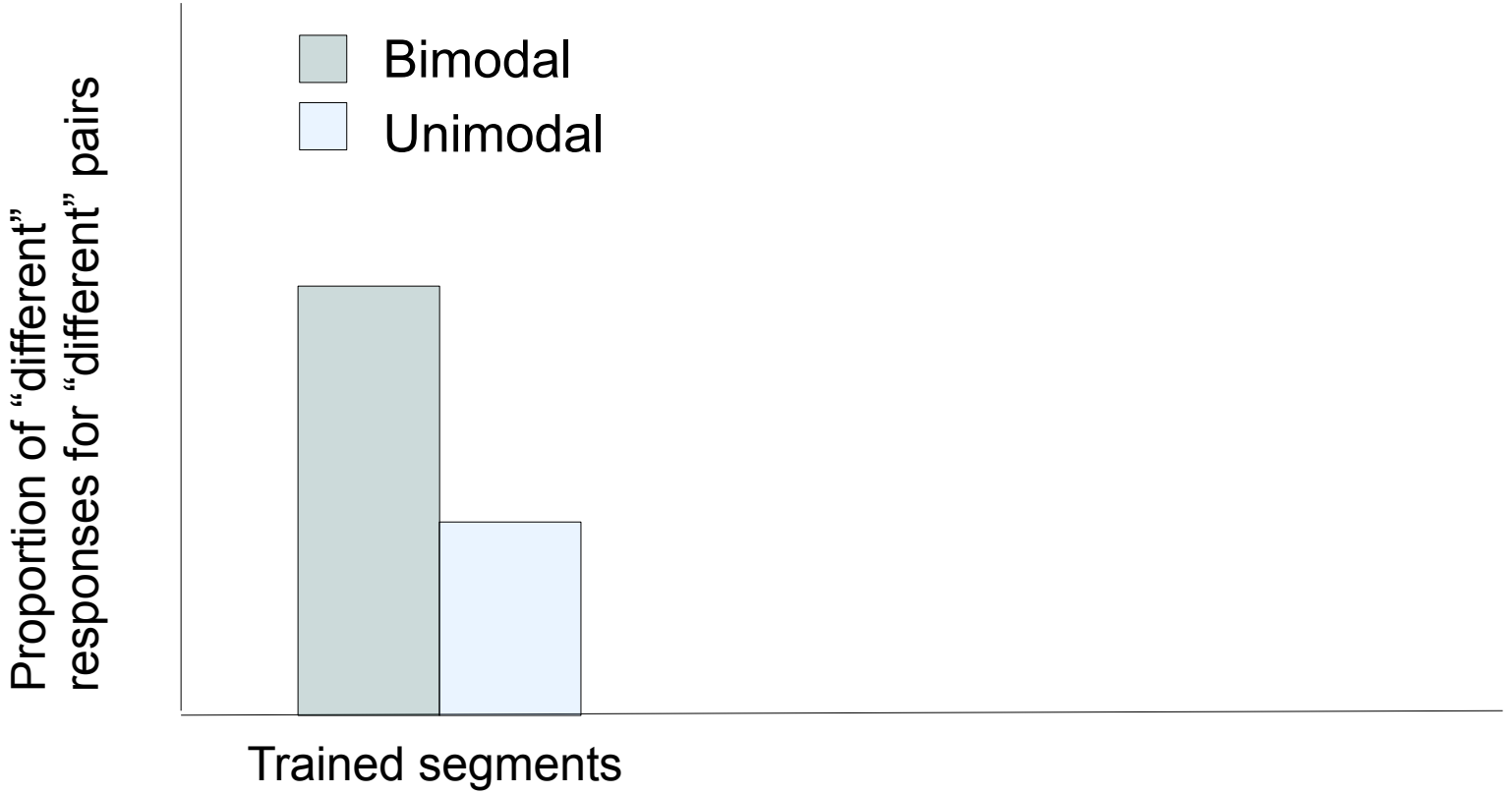
Identical testing for all participants:
→ sonorants & fricatives

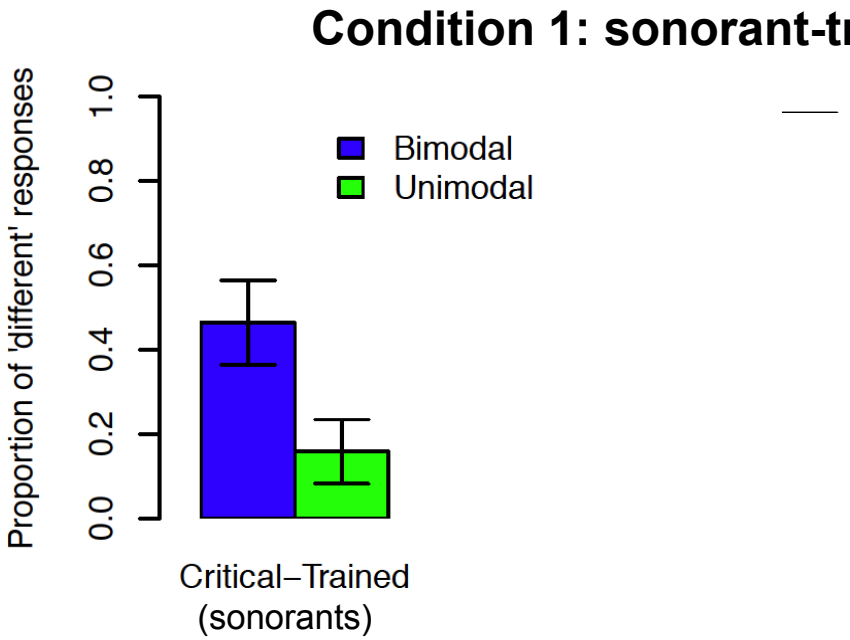


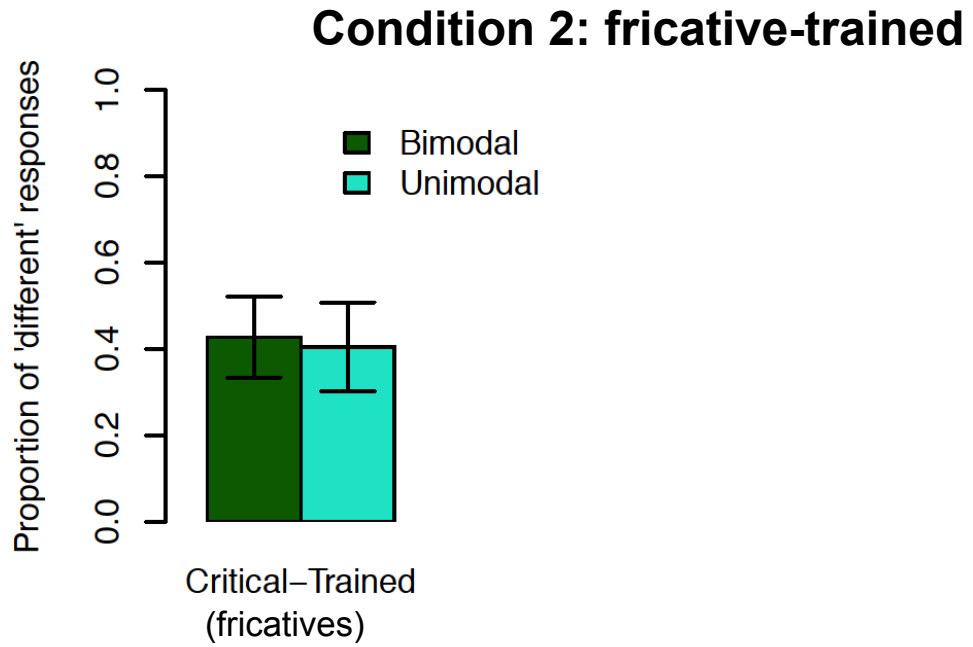


Experiment: predictions

- Learning the contrast for the trained segments
  - Bimodal group responding “different” on “different” sonorant pairs more often than the unimodal group

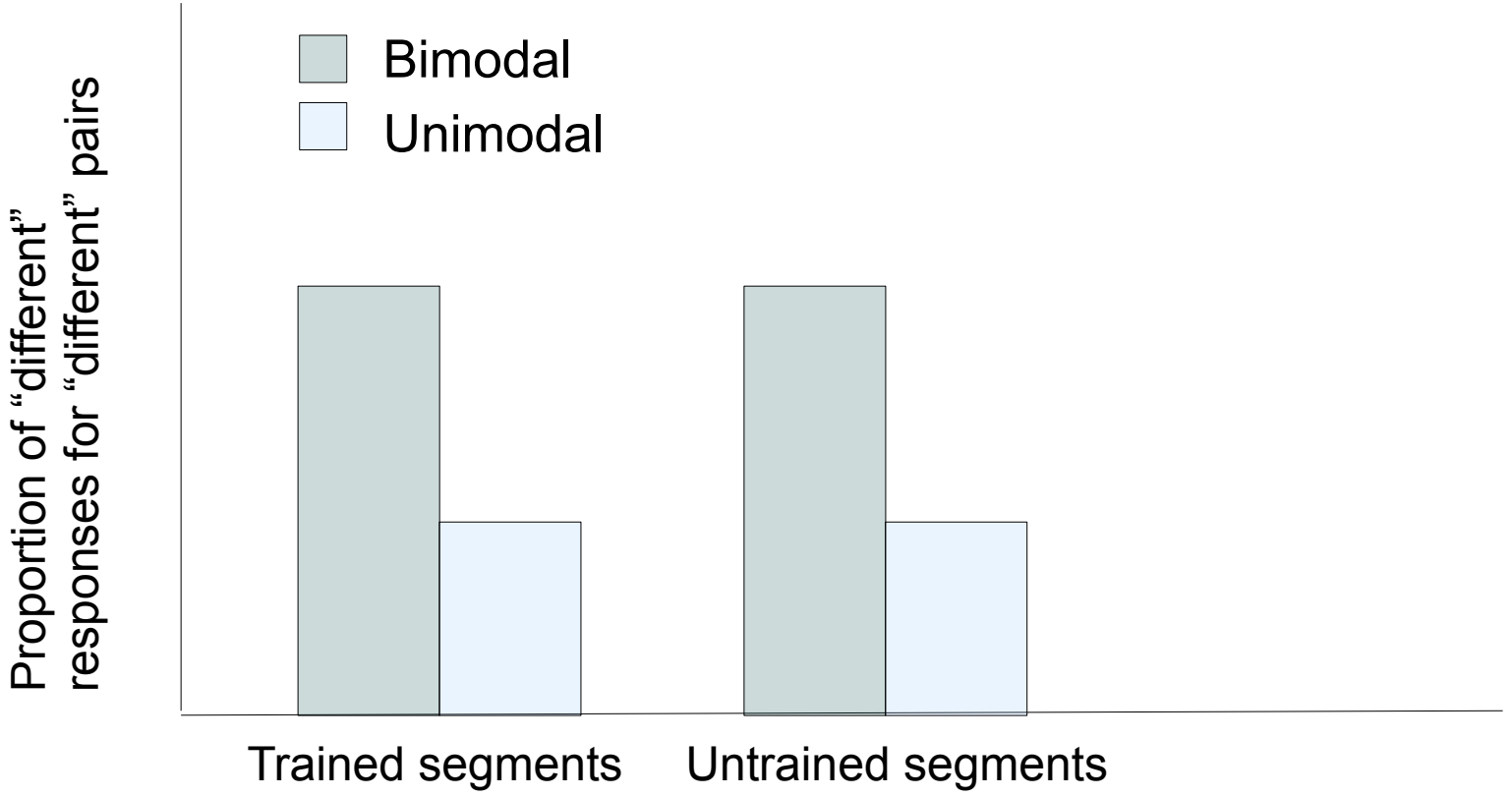


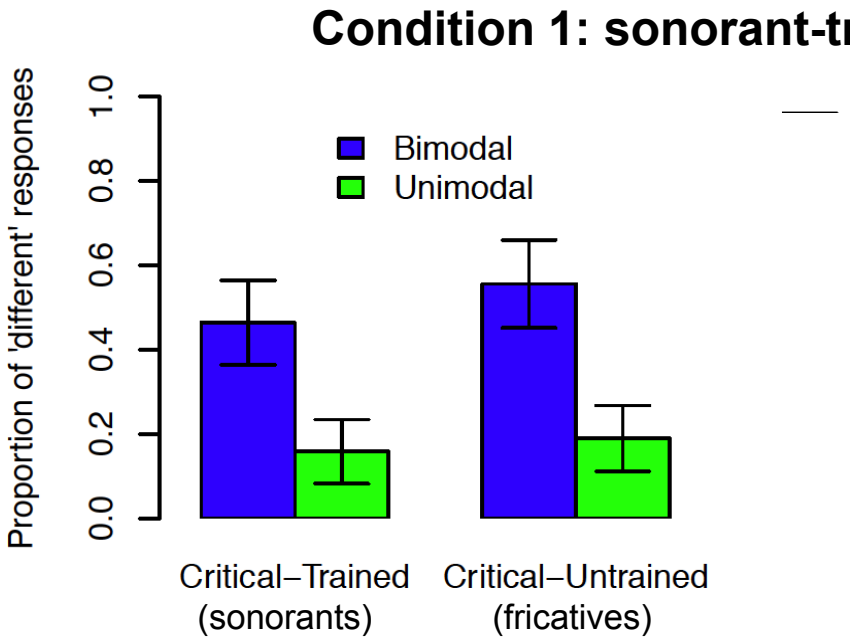

Condition 1: sonorant-trained
Proportion of 'different' responses
0.0
0.2
0.4
0.6
0.8
1.0
Bimodal
Unimodal
Critical–Trained
(sonorants)

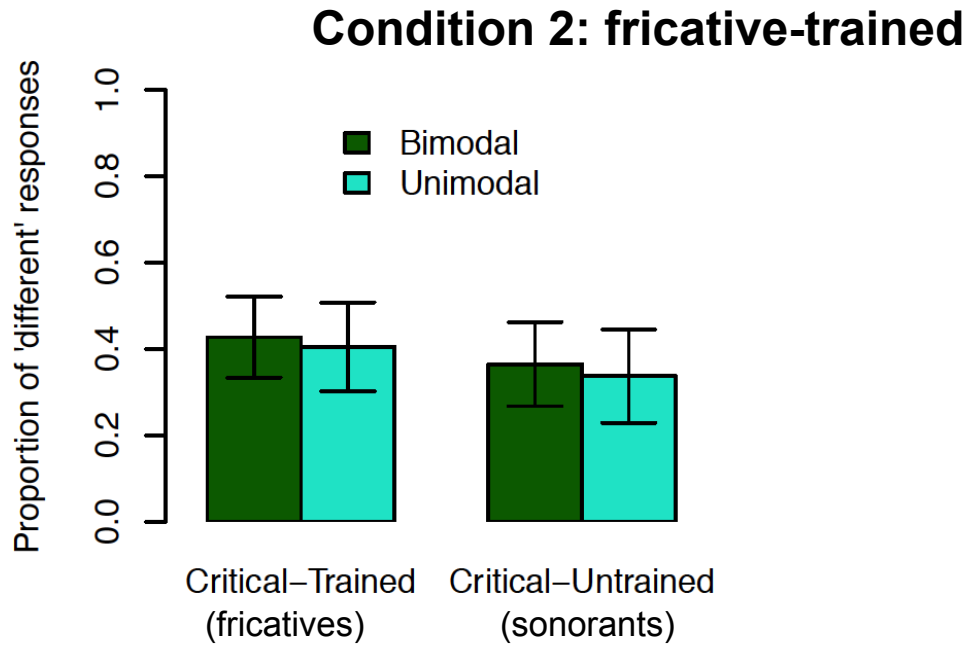

Condition 2: fricative-trained
Proportion of 'different' responses
0.0
0.2
0.4
0.6
0.8
1.0
Bimodal
Unimodal
Critical–Trained
(fricatives)

Experiment: predictions

- Generalization of the contrast to untrained segments
  - Bimodal group responding “different” on “different” obstruent pairs more often than the unimodal group

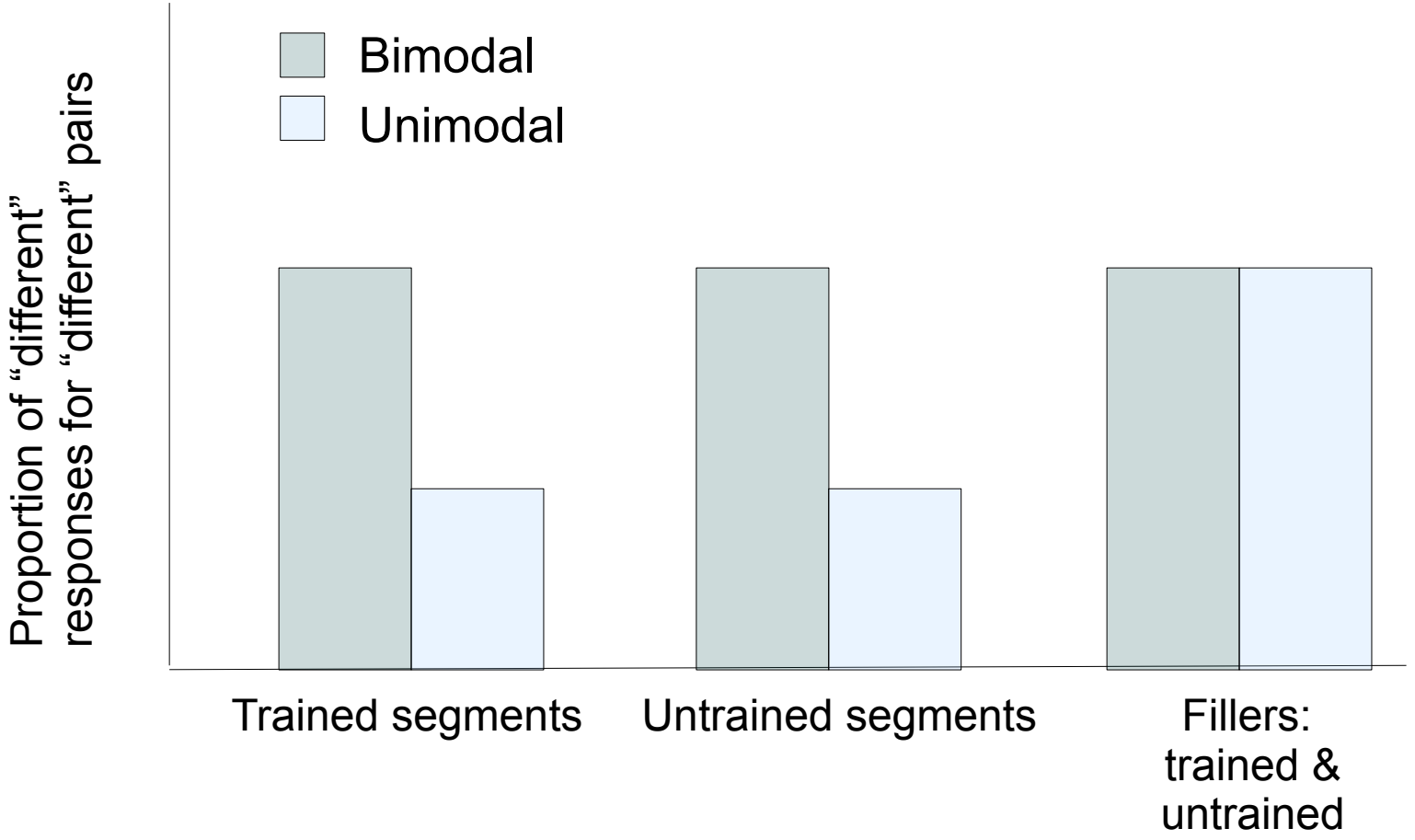


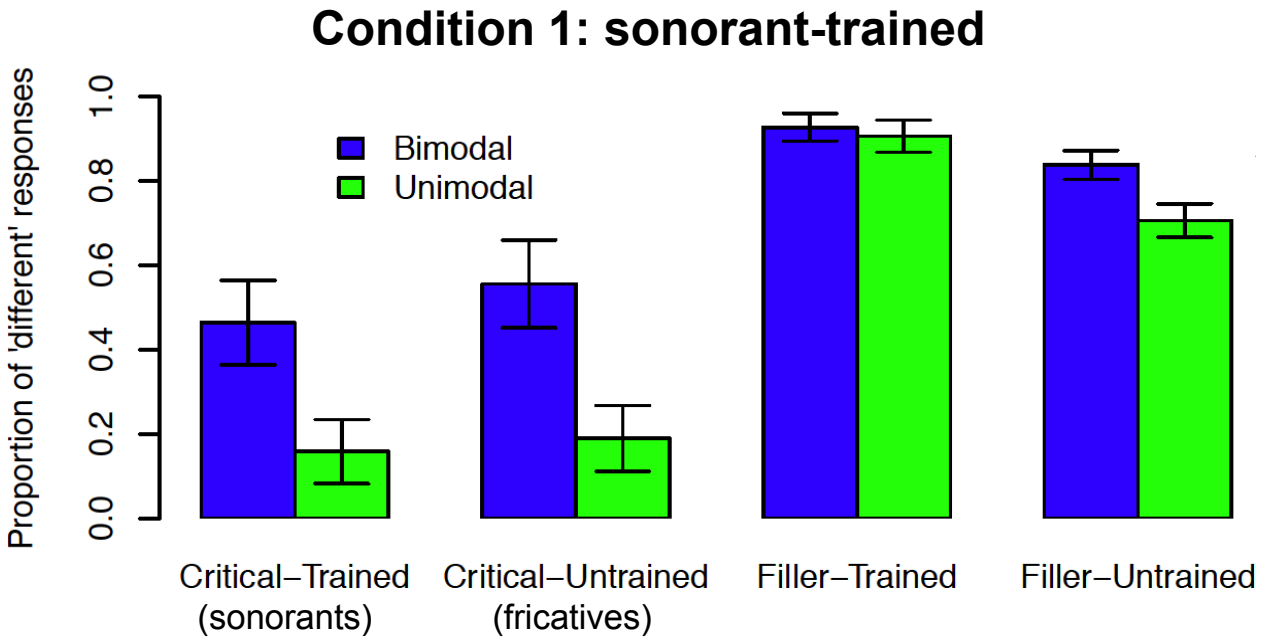

Condition 1: sonorant-trained
Proportion of 'different' responses
0.0
0.2
0.4
0.6
0.8
1.0
Bimodal
Unimodal
Critical–Trained
(sonorants)
Critical–Untrained
(fricatives)

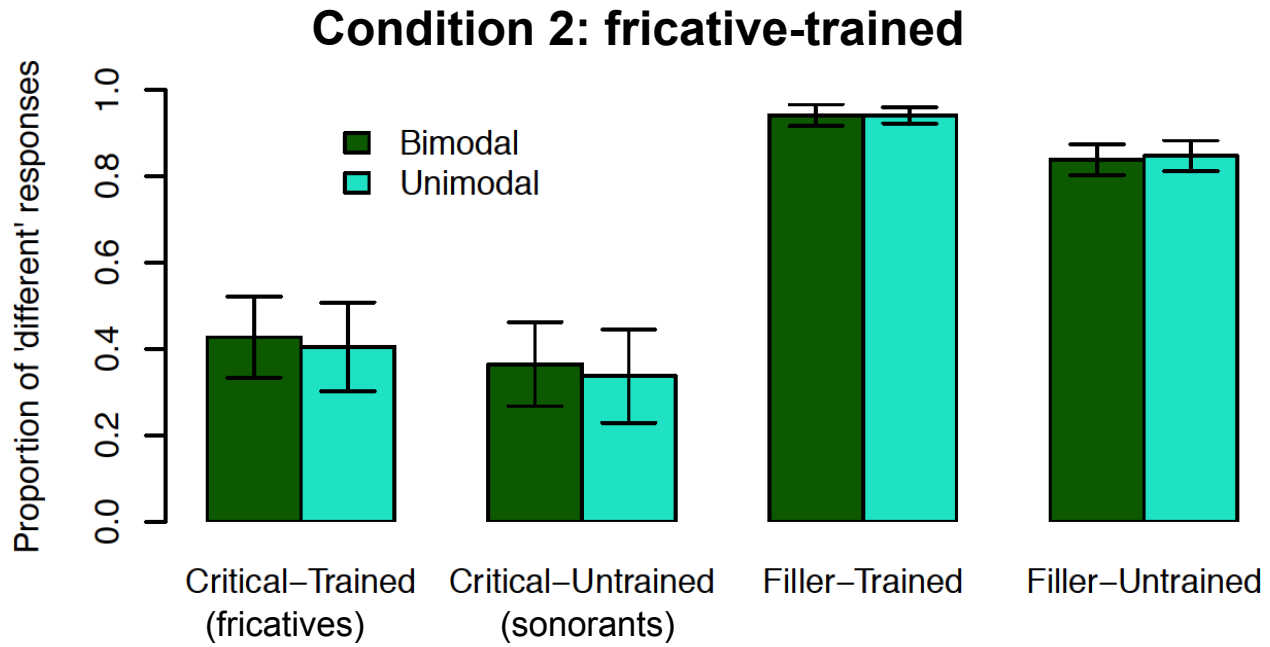

Condition 2: fricative-trained
Proportion of 'different' responses
0.0
0.2
0.4
0.6
0.8
1.0
Bimodal
Unimodal
Critical–Trained
(fricatives)
Critical–Untrained
(sonorants)

Experiment: predictions

- Similar performance on fillers for both groups.

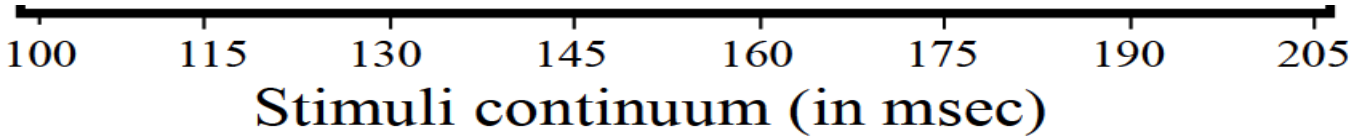



Condition 1: sonorant-trained
Proportion of 'different' responses
0.0
0.2
0.4
0.6
0.8
1.0
Bimodal
Unimodal
Critical–Trained
(sonorants)
Critical–Untrained
(fricatives)
Filler–Trained
Filler–Untrained


Condition 2: fricative-trained
Proportion of 'different' responses
0.0
0.2
0.4
0.6
0.8
1.0
Bimodal
Unimodal
Critical–Trained
(fricatives)
Critical–Untrained
(sonorants)
Filler–Trained
Filler–Untrained

Discussion

- Why wasn't the contrast learned for fricatives?
  - length harder to learn for fricatives than sonorants (but the fricative contrast should be perceptually more salient!)
  - consequence of the fillers used: many obstruents that didn't vary in length
  - stimuli continuum too short for fricatives



durations of sonorants in English

[j]	39-100msec
[n]	38-83msec
[l]	42-85msec
[m]	50-89msec

durations of fricatives in English

[θ]	46-90msec
[f]	56-119msec
[s]	61-126msec
[ʃ]	88-138msec

(durations from the phonetically annotated portion of the Switchboard corpus)

Discussion

- We showed:
  - distributional learning of novel length contrasts (for sonorants)
  - generalization across segment classes (sonorants → fricatives)
- This result suggests that psychological representations of subphonemic units:
  - are abstract;
  - cross-cut a variety of segments, regardless of their articulatory/acoustic similarity.

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Thank you

Discussion:

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