Interaction of Voicing Cues in Production Differs from Perception

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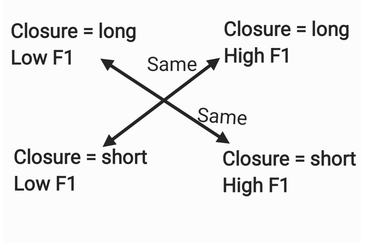
Cue interaction in discrimination

- English stop discrimination: some voicing cues interact and others don't (Kingston et al. 2008).
- Interaction: Particular combination of stimulus cue values affects discrimination



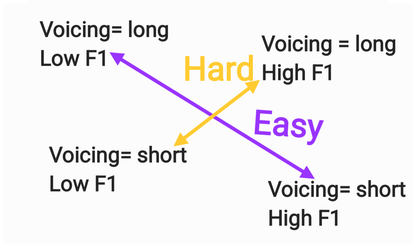


Figure: Diagram of perceptual interaction adapted from Kingston et al. (2008)

	Closure voicing duration	Closure duration
Interacts with vowel f0 and F1?	✓	×

Table: Summary of relevant discrimination interactions found in Kingston et al. (2008).

Auditory and associative account predictions

Certain cues interact because...

Auditory Account: shared auditory properties (Diehl et al. 1995). e.g. low-frequency energy.

Associative Account: learning from cues covarying in listeners' input (Holt et al. 2001)

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Prediction: cues that interact perceptually will covary more in **production**

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Closure voicing and f0, F1
Associative account prediction for production:
- positive correlation
- significantly greater correlation than closure duration with f0, F1

Corpus methods

- Testing purely associative account's predictions
- TIMIT English corpus (Garofolo et al. 1993)
- Word-internal intervocalic stop sequences:
  - _ V1 C V2
- **Closure duration** measured from TIMIT closure segmentation
  - scaled by preceding vowel duration.
- **Closure voicing duration** estimated with Praat Voice Report.
- **f0** and **F1**
  - Praat's default Pitch and Formant parameters (5000Hz formant ceiling)
  - Transformed to Bark
  - Measured at vowel midpoint and as near the closure as possible
    - Using change in f0 and F1, rather than solely f0 and F1 near closure: Fischer & Ohde (1990)
  - Correlations estimated for both preceding (V1) and following (V2) vowels
    - Discrimination stimuli does not differentiate: keeps f0, F1 measures the same for V1 and V2 (Kingston 2008)

Covariation analysis

- Pearson correlation for each relevant pair of z-scored measures
- Comparison of correlations evaluated with Meng et al. (1992)'s significance test

Corpus correlations

- Closure voicing only has a stronger correlation than closure duration when f0, F1 are measured on the following vowel (V2) and not the preceding vowel (V1)

Frequency Measure	Associative Expectation	Closure Voicing	Closure Duration	Difference
Preceding F0 (V1)	Voicing & F0 > Duration & F0	-0.075 ($p < .01$)	-0.128 ($p < .01$)	0.054 ($p < .01$)
Following F0 (V2)	**Voicing & F0 > Duration& F0**	0.083 ($p < .01$)	-0.020 ($p < .01$)	0.103 ($p < .01$)
Preceding F1 (V1)	Voicing & F1 > Duration & F1	0.083 ($p < .01$)	0.220 ($p < .01$)	-0.137 ($p < .01$)
Following F1 (V2)	**Voicing & F1 > Duration & F1**	0.085 ($p < .01$)	0.074 ($p < .01$)	0.011 ($p < .01$)

Table: Comparison of correlation of closure voicing and closure duration to F0 and F1 on the neighboring vowels (V1, V2). Comparisons supporting a pure associative account's predictions are bolded.

Results

- TIMIT correlations **do not** consistently reflect the interactions found in discrimination.

Perception: cue interaction with **closure voicing duration** not closure duration

Production: covariation **not stronger** for **closure voicing duration** than closure duration

- Contra the predictions of a purely associative account.
- Depends on whether f0, F1 measurements are taken from V1 or V2:

Following vowel (V2): evidence for prediction

Preceding vowel (V1): **no** evidence for prediction

Discussion

- Could learners have a bias to learn voicing cue interactions from the following, but not the preceding, vowel?
- How does preceding vs following vowel f0, F1 affect discrimination? (existing results, Kingston et al. (2008), do not differentiate)
- Less careful (read) speech?

Conclusion

- A purely associative account's predictions for perception depend on the learning input.
  - Estimated from production data
- Corpus correlation estimates do not consistently support the associative account's predictions for English intervocalic stops.
- Results depend on whether measurements are taken on the preceding or following vowel.
  - How do preceding/following vowel differ in perception and learning?