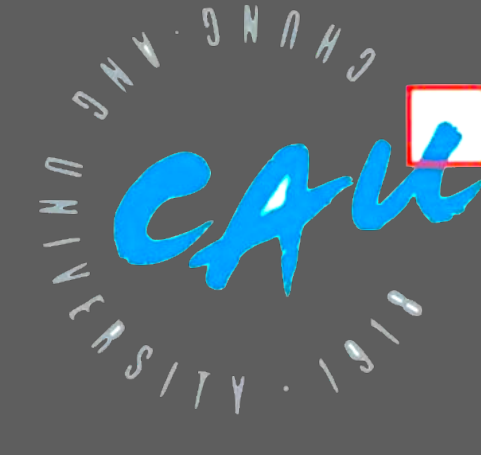
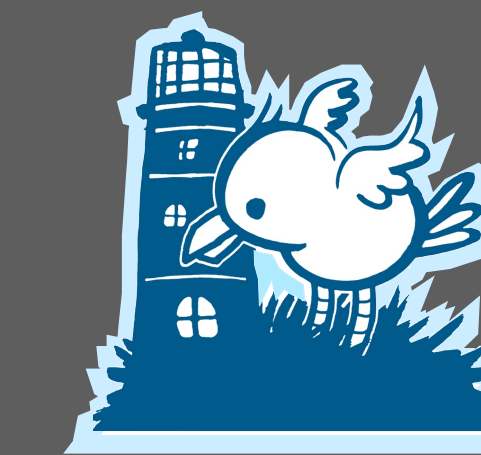


Distributional learning of non-native contrasts in speakers of two languages, English and Korean

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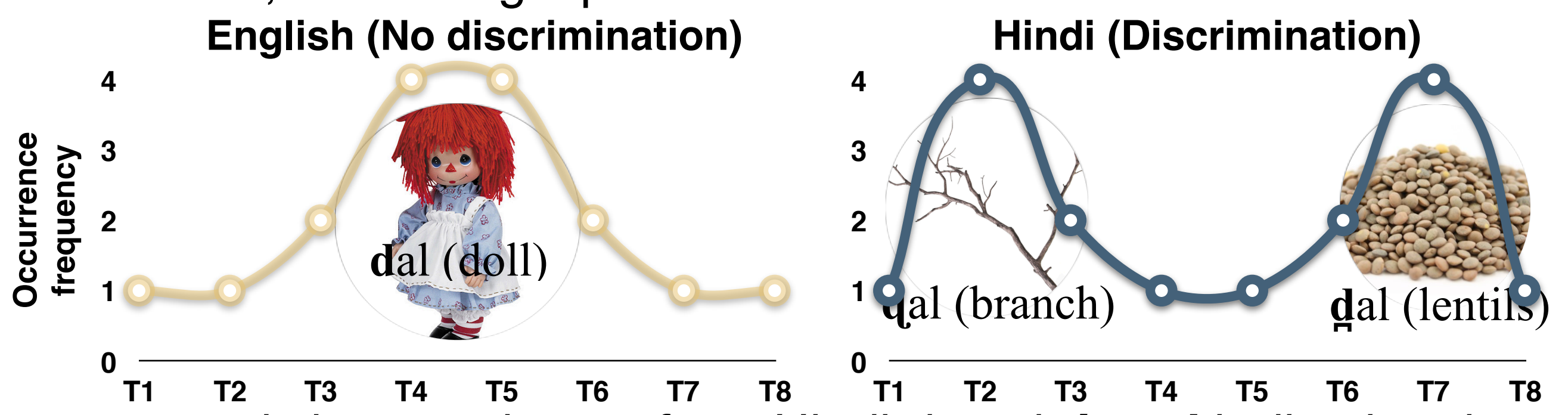
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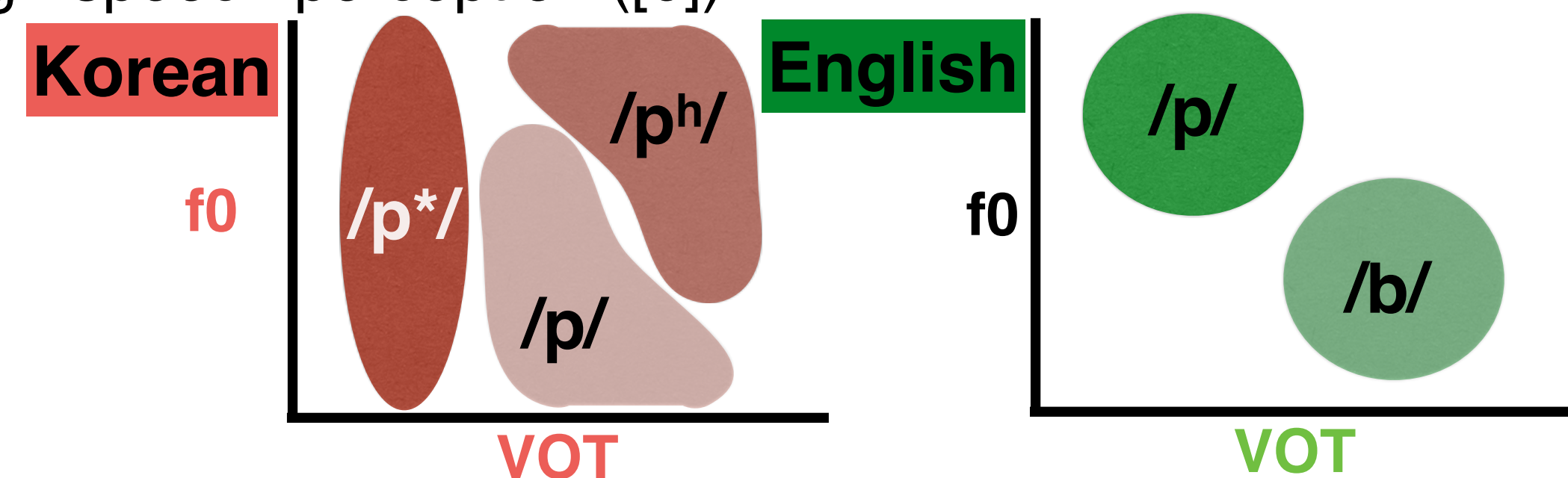
INTRODUCTION & CURRENT STUDY

Sensitivity to distributional properties of phonetic tokens, distributional learning, has been hypothesized to induce appropriate underlying phonemic categories ([1],[2]), such that listeners infer two underlying phonemes from a bimodal distribution of tokens along an acoustic continuum, and a single phoneme from a unimodal distribution.



x axis is a continuum from Hindi dental *d* to *ɖ* indicating the variability around the pronunciation of "d". Examples are from [3]

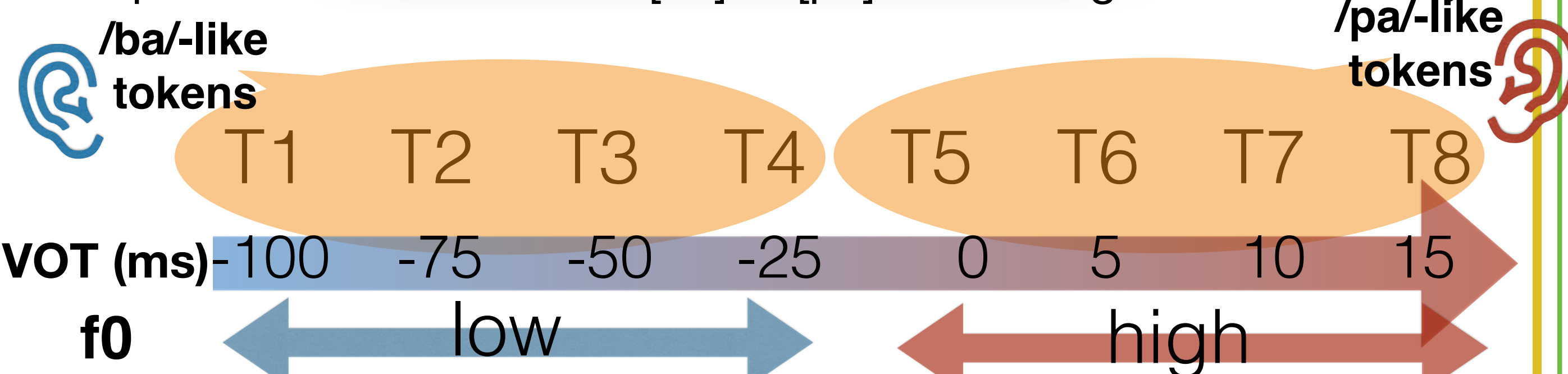
Separately, Korean and American English speakers differ in their use of voice-onset time (VOT) and fundamental frequency (f0) to classify stop consonants ([4],[5]) and the native speech experience can affect foreign speech perception ([6]).



- Experiment 1:** examined how Korean and English speakers discriminate a Hindi continuum that changes on both VOT and f0.
 - Possibility 1: Koreans would be worse than English speakers to discriminate the continuum
 - Having 3 different categories may cause more interference (perceptual assimilation model, [6]).
 - Possibility 2: Koreans would be better than English speakers
 - Attending multiple cues (VOT, f0) can be advantageous
- Experiment 2:** tested if the group difference in Experiment 1 leads Korean speakers to have sensitivity to distributional learning of the non-native Hindi contrast.

AUDITORY CONTINUUM

8-step continuum from Hindi [ba] to [pa] that changes on both VOT, f0



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(1) Maye, J., Werker, J. F., & Gerken, L. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, 82(3), B101-B111.
 (2) Maye, J., & Gerken, L. (2001). Learning phonemes: How far can the input take us. In *Proceedings of the 25th annual Boston University conference on language development* (Vol. 1, p. 480). Somerville, MA: Cascadia Press.
 (3) Werker, J. F., Yeung, H. H., & Yoshida, K. A. (2012). How do infants become experts at native-speech perception?. *Current Directions in Psychological Science*, 21(4), 221-226.
 (4) Lisker, L., & Abramson, A. S. (1964). A cross-language study of voicing in initial stops: Acoustical steps and measurements. *Word*, 20(3), 384-422.
 (5) Cho, T., Jun, S. A., & Ladefoged, P. (2002). Acoustic and aerodynamic correlates of Korean stops and fricatives. *Journal of phonetics*, 30(2), 193-228.
 (6) Best, C. T., McRoberts, G. W., & Goodell, E. (2001). Discrimination of non-native consonant contrasts varying in perceptual assimilation to the listener's native phonological system. *The Journal of the Acoustical Society of America*, 109(2), 775-794.

EXPERIMENT 1: IDENTIFICATION & DISCRIMINATION TASK

Participants: 23 native Koreans (f=17, age ranged from 18-31) and 23 native English speakers (f=15, age ranged from 19-38)

IDENTIFICATION TASK

Stimulus presentation: Each token from continuum was randomly presented (total 160 trials, 4 blocks of 40 trials)

task: two-alternative forced choice

DISCRIMINATION TASK

Stimulus presentation (40 trials of 4 block)

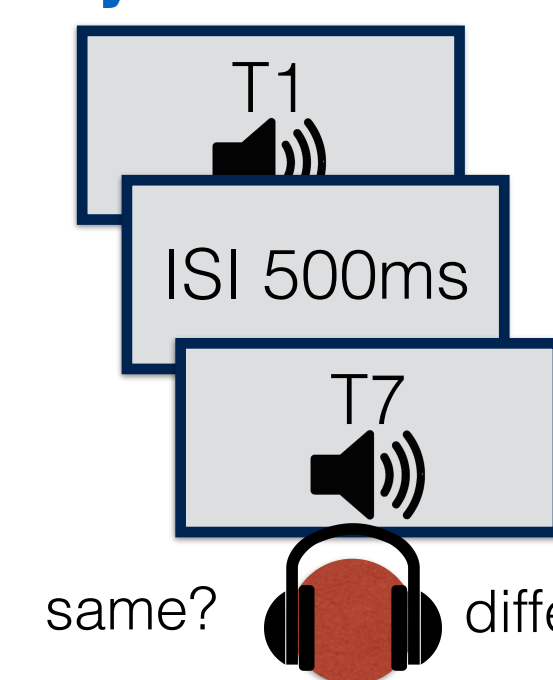
• Easy across: token 1-7, 2-8

• Hard across: token 3-5, 4-6

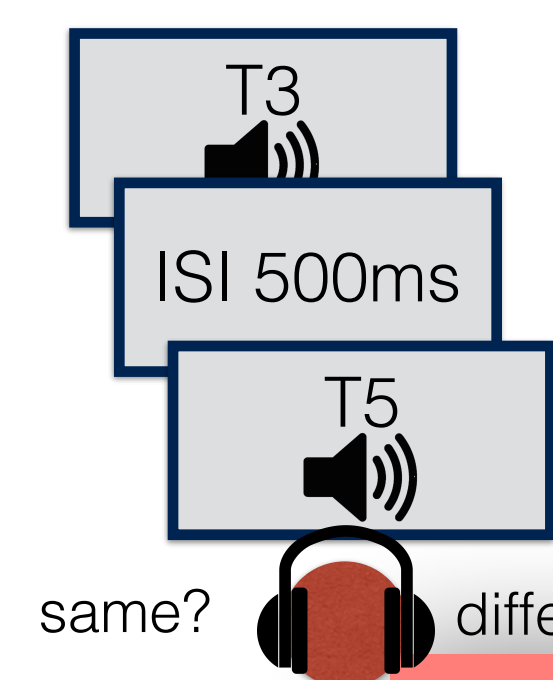
• Within: token 1-3, 2-4, 5-7, 6-8

Task:

An example of 'easy-across' trial



An example of 'hard-across' trial



METHODS

EXPERIMENT 2: DISTRIBUTIONAL LEARNING IN KOREAN SPEAKERS

Participants: 32 Korean speakers

• Bimodal condition: n= 16 (f=12, age ranged from 18-28)

• Unimodal condition: n=16 (f=8, age ranged from 19-25)

PRACTICE (10 trials)

Stimulus presentation: 10 pairs of Korean words

• half the trials were 'same' trials and the other half was 'different' trials

Task: Participants judged whether the sound pair heard was same or different by pressing appropriate keys

ACQUISITION PHASE (Bimodal vs. Unimodal)

Stimulus presentation: the continuum was presented in pseudo-random order in either bimodal or unimodal distribution (16 tokens of 12 blocks, ISI of 500ms)

• **bimodal:** the 8 tokens on the continuum were presented in a bimodal frequency distribution (similar to Fig. 1, right graph)

• **unimodal:** the same tokens in a unimodal distribution (similar to Fig. 1, left)

Task: One filler sound 'ma' was presented per block and participants were asked to press [space bar] when they heard a 'ma' sound

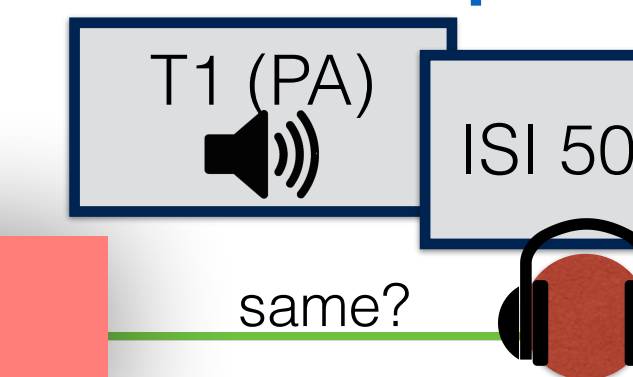
TEST (40 trials)

Stimulus presentation : Only token 1 (T1) and token 8 (T8)

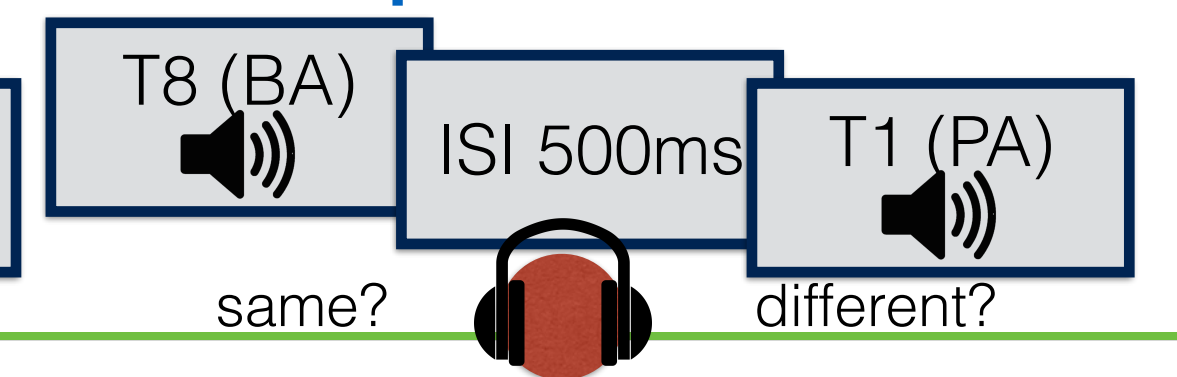
• 'same' trial: a pair of T1 or T8, 'different' trial: a pair of T1 & T8 (or T8 & T1)

Task:

An example of 'same' trial

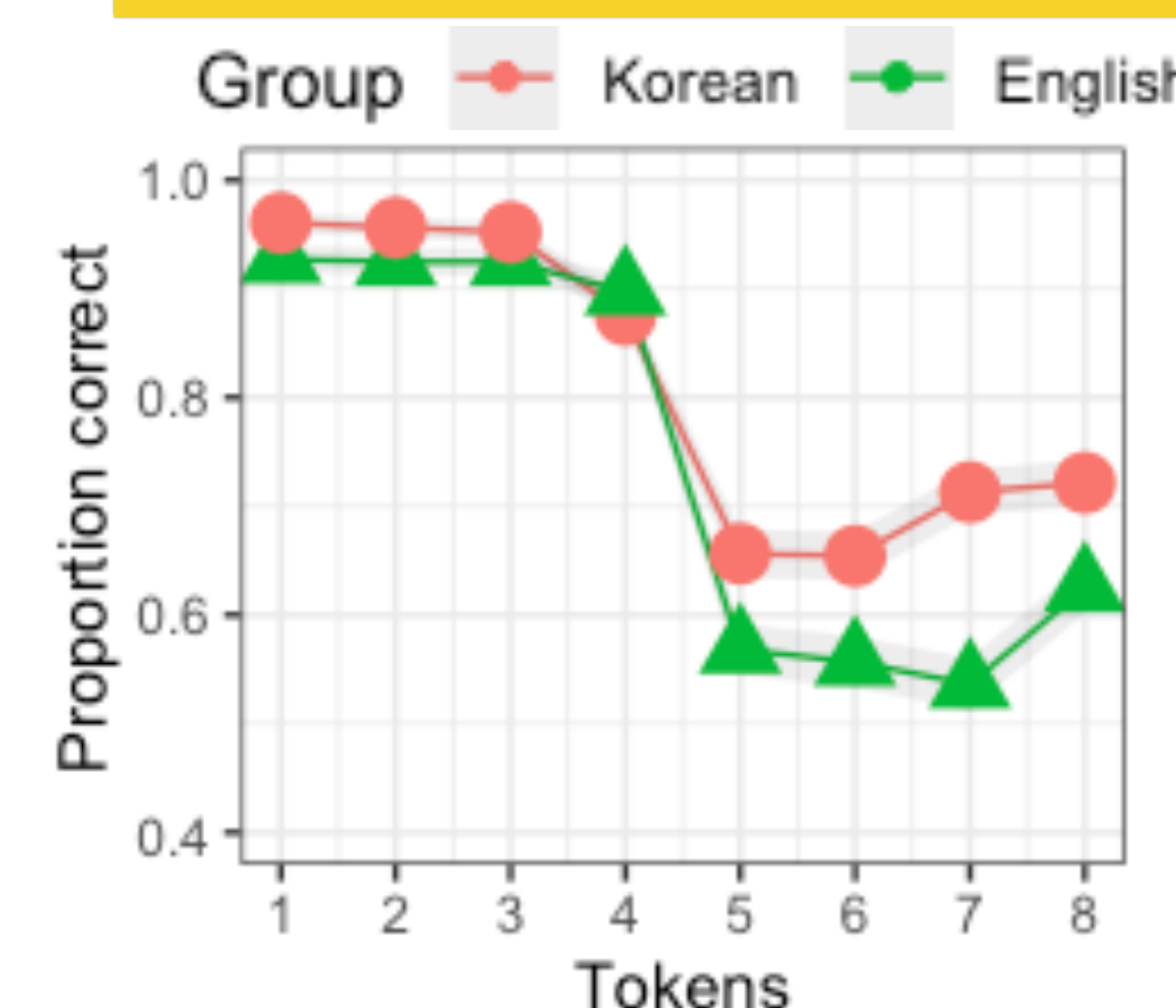


An example of 'different' trial



RESULTS

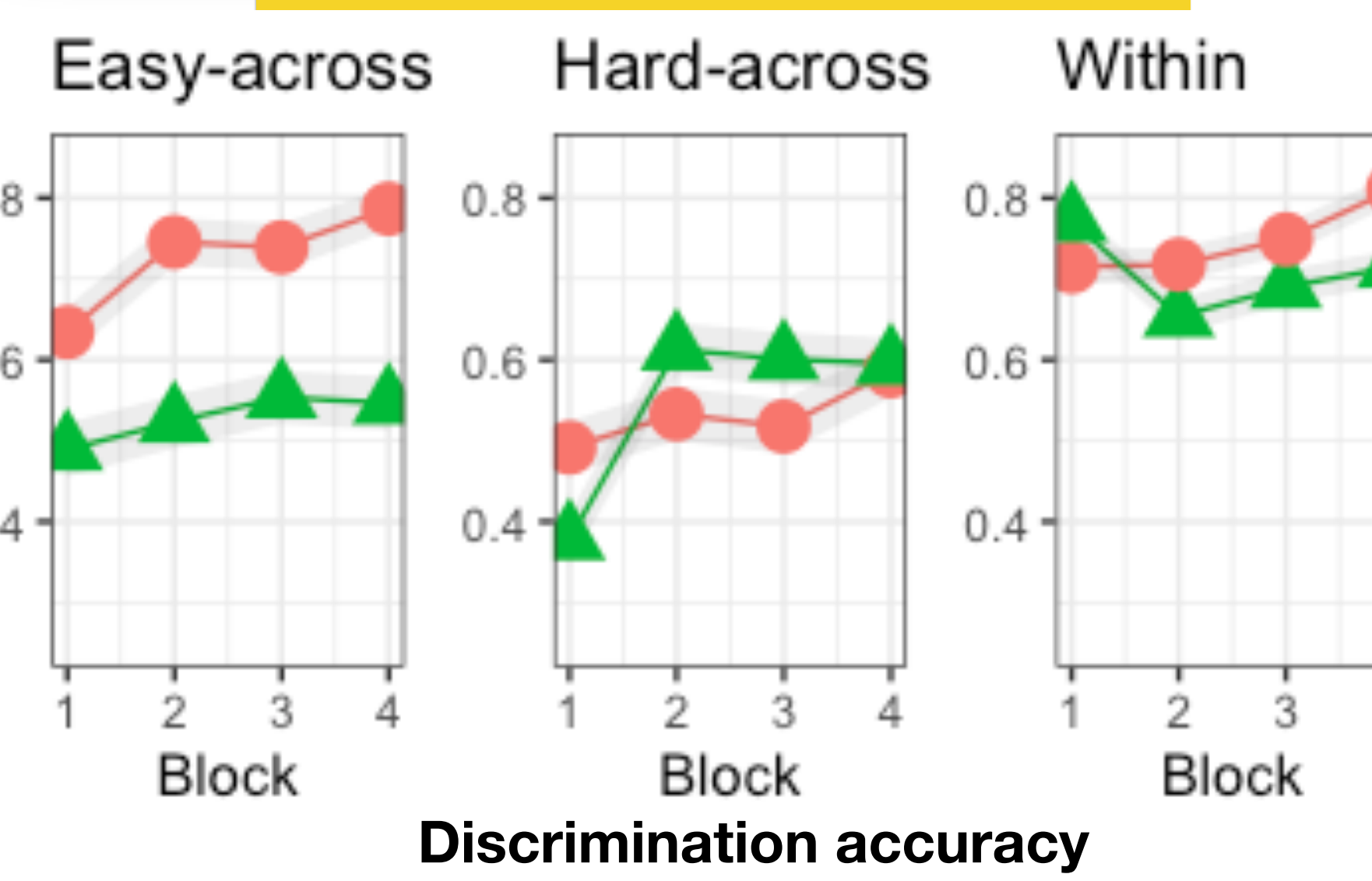
IDENTIFICATION



Identification accuracy

• Significant effects of language group (estimate = -0.43, SE = 0.061, z = -7.131, p < .001) and of tokens (estimate = -0.37, SE = 0.015, z = -25.149, p < .001)

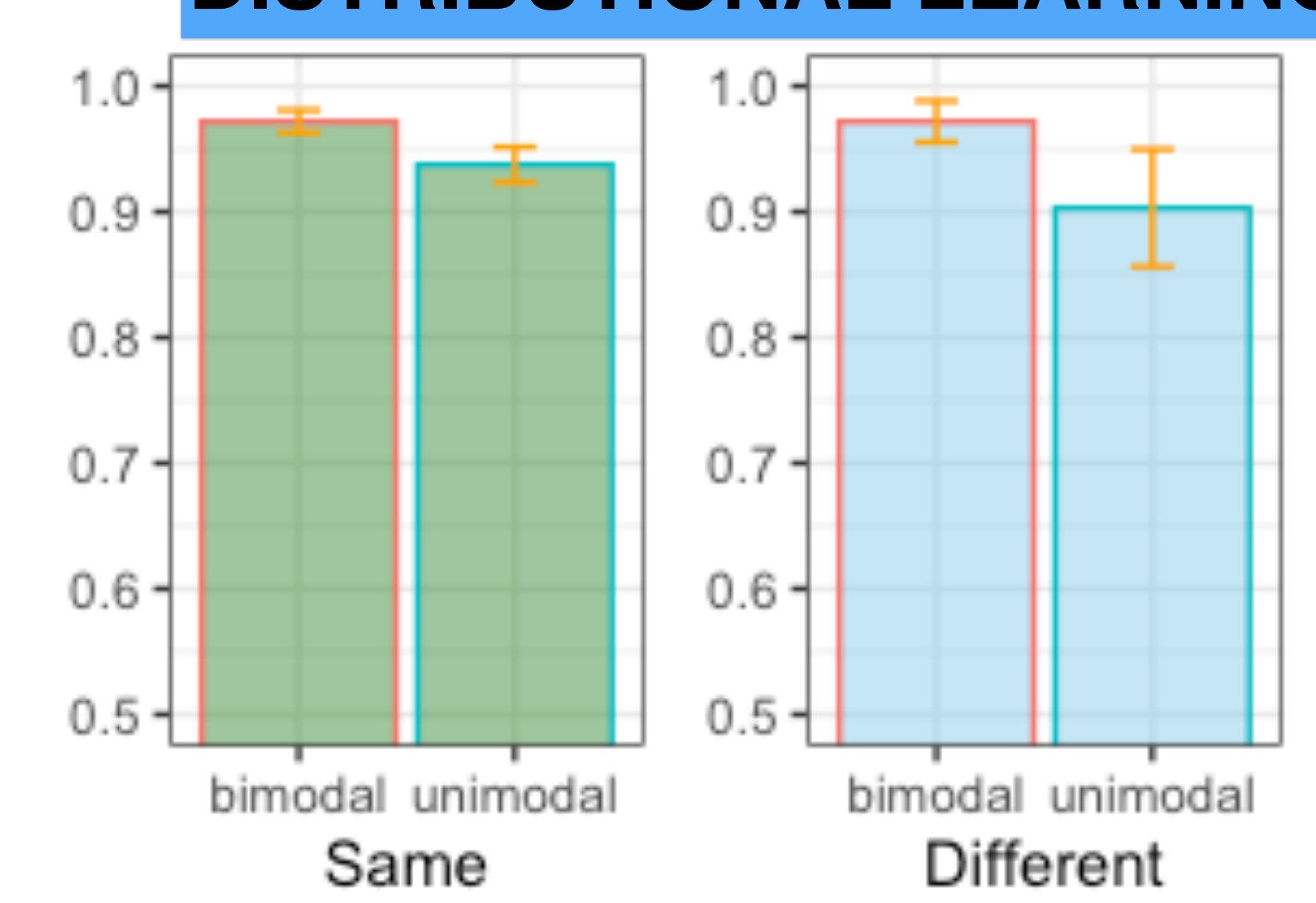
DISCRIMINATION



Discrimination accuracy

• Significant effects of language group (estimate = -.31, SE = .05, z = -6.10, p < .001), and block (block 1-3, estimate = .18, SE = .07, z = 2.60, p = .009; block 1-4, estimate = .35, SE = .07, z = 4.96, p < .001), and pair type (easy-hard, estimate = -0.37, SE = .07, z = -5.49, p < .001; easy-within, estimate = 0.47, SE = 0.06, z = 7.63, p < .001)

DISTRIBUTIONAL LEARNING



Distributional learning

• No significant differences on same trials between two conditions, but marginally significant different on different trials (p = .07)

• In Exp. 1, Koreans discriminated Hindi /ba/ and /pa/ contrasts better than English speakers, supporting Possibility 2. And it may lead Korean speaker to be sensitive to distributional learning of non native contrasts in Exp. 2.

• Testing English speakers' sensitivity to distributional information will further address if the findings indeed results from the difference of two groups of speakers in their use of phonetic cues.