Neural correlates of task-irrelevant perceptual learning of non-native speech sounds

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Background

Non-native speech sound learning in adulthood

- Success is variable but training in lab can lead to improvement[1,2,4].
- Most studies use explicit training paradigms (i.e. participants are aware they are learning novel speech sounds).
- Might non-native speech sounds be better learned incidentally via task-irrelevant perceptual learning?[6]

Neural correlates of non-native phonetic learning

- Previous studies using explicit training paradigms have found:
  - Bilateral middle frontal gyri and left inferior frontal gyrus (LIFG) are recruited in processing non-native category differences[4]
  - Learning is associated with less activation in LIFG and more activation in bilateral angular gyri[1]
- Given claims that frontal recruitment in sound processing reflects mapping to explicit labels[3], we investigate (1) whether frontal regions are involved in processing non-native categories that have been *implicitly* learned and (2) whether there is a reduction of activation in frontal areas after implicit training.

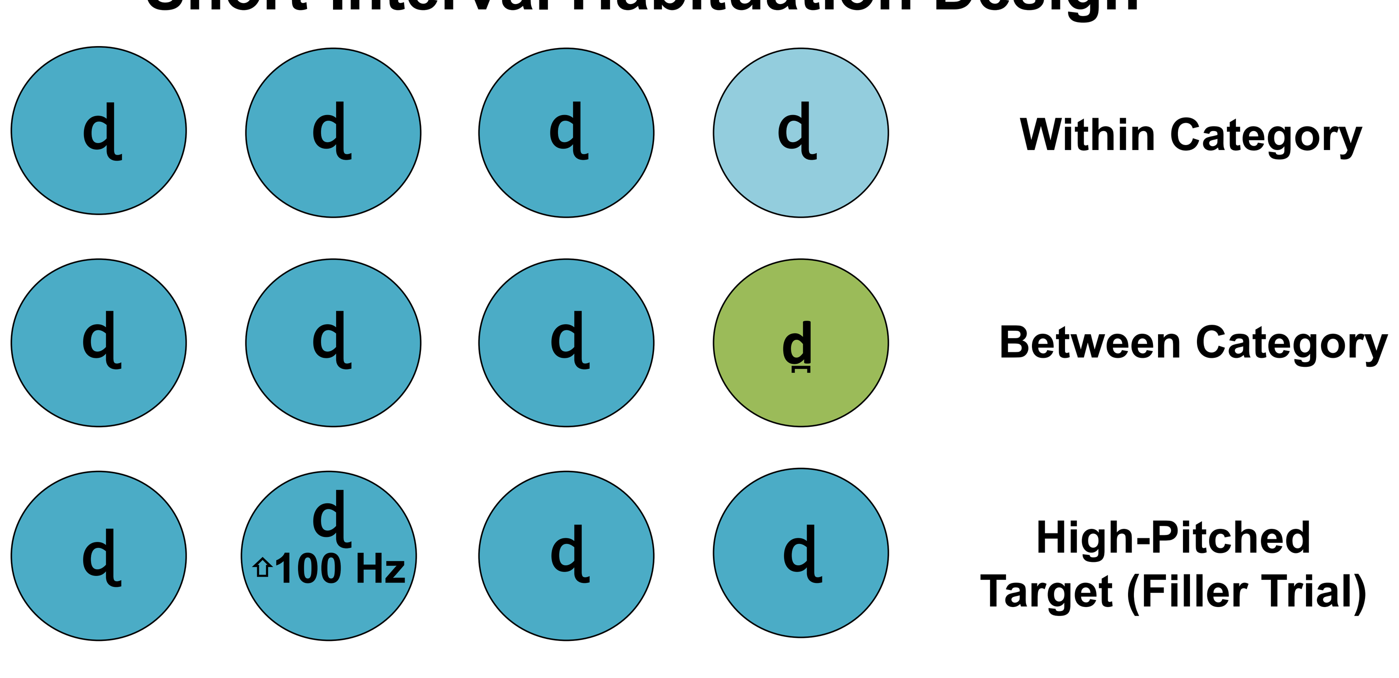
Method

Day	Procedure
1	fMRI 1 Implicit behavioral training
2	Implicit behavioral training
3	Implicit behavioral training
4	fMRI 2 Assessments: ID and AX

Participants (native English speakers, n=18) implicitly trained on non-native Hindi dental/retroflex contrast

Filler fMRI task: Press the button when you hear the high-pitched target.

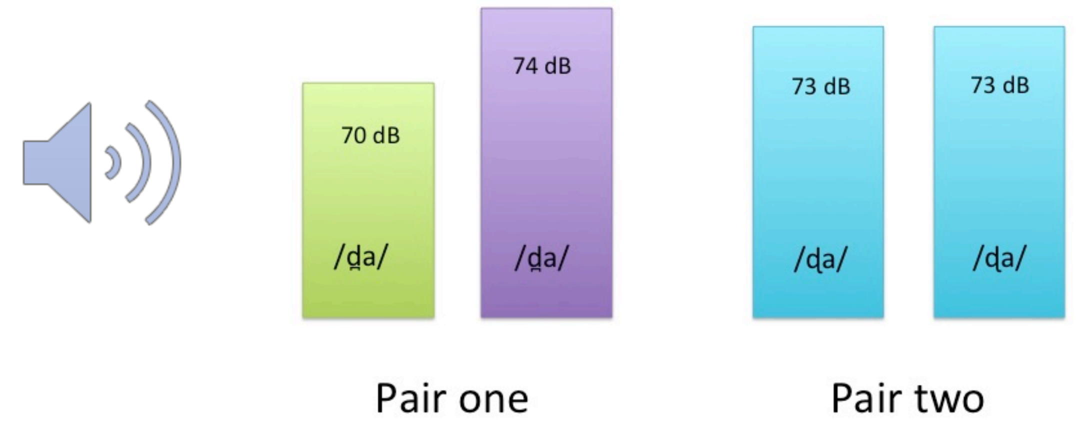
Short-Interval Habituation Design



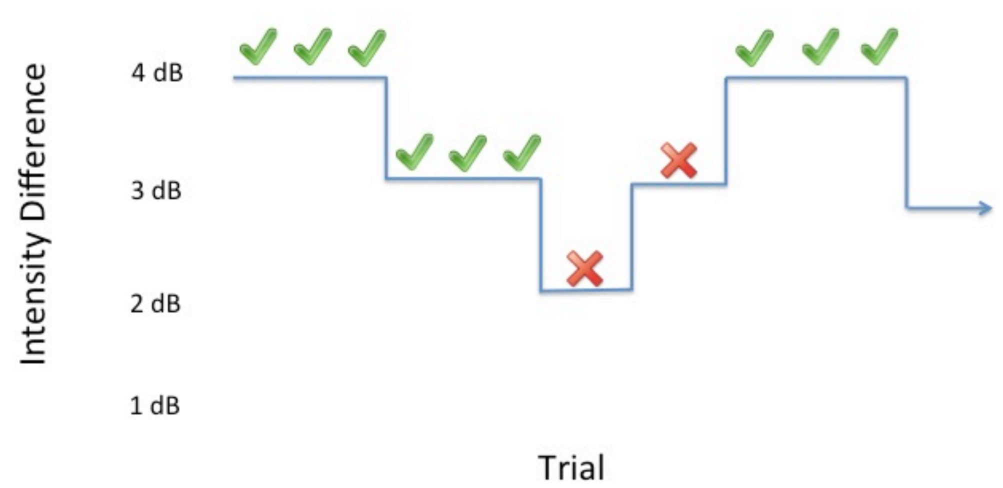
Method, cont.

Implicit Training[6]: Which pair contains the volume difference?

Volume difference consistently paired with one of the two speech sounds (counterbalanced) to be learned



Adaptive Staircase Design

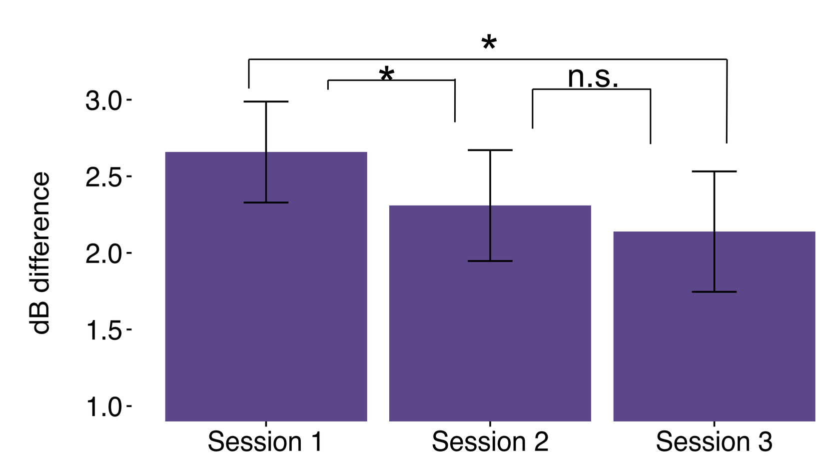


After 3 correct responses on a set dB level, difficulty increases (smaller volume difference)

After each incorrect response, task becomes easier (larger volume difference)

As the volume distinction becomes more subtle, listeners may implicitly switch to using phonetic cues to distinguish between pairs of tokens

Behavioral Results



Threshold by Session

Significant main effect of time:
$F(2,34) = 10.98$, $p < 0.001$

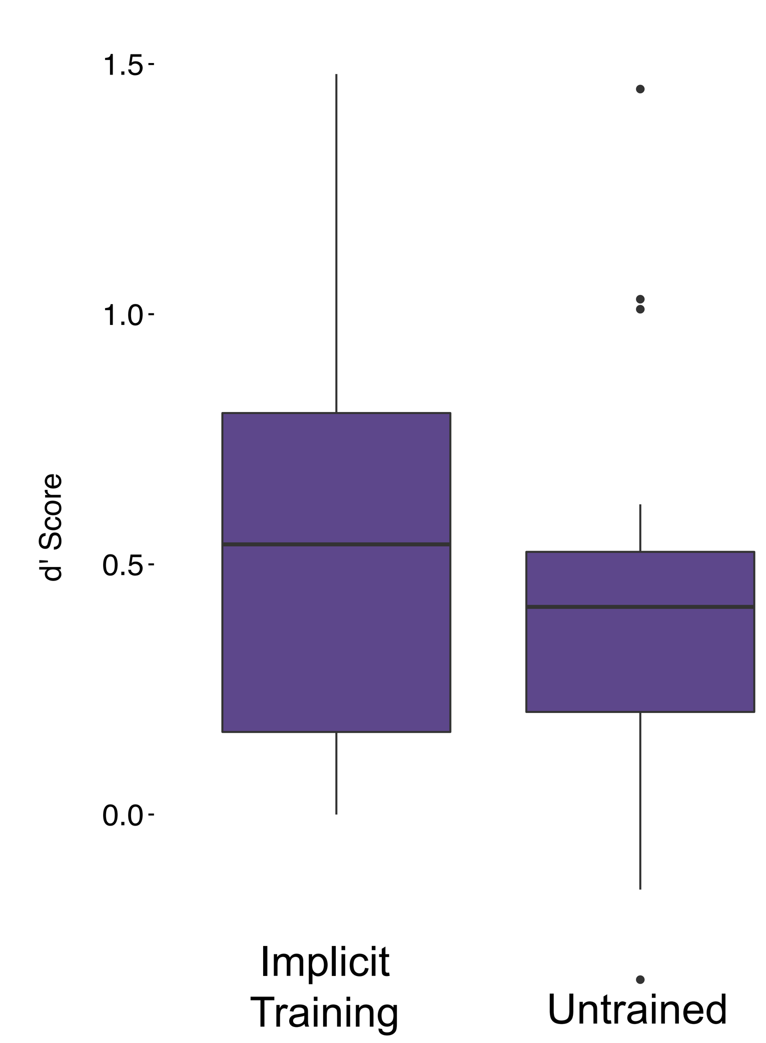
Decrease in threshold over time indicates that participants improved on the task. As volume differences fade, listeners may use phonetic cues to perform the task.

Discrimination Posttest Scores

Individuals discriminated better than a group of naïve listeners did, but this difference did not reach significance.

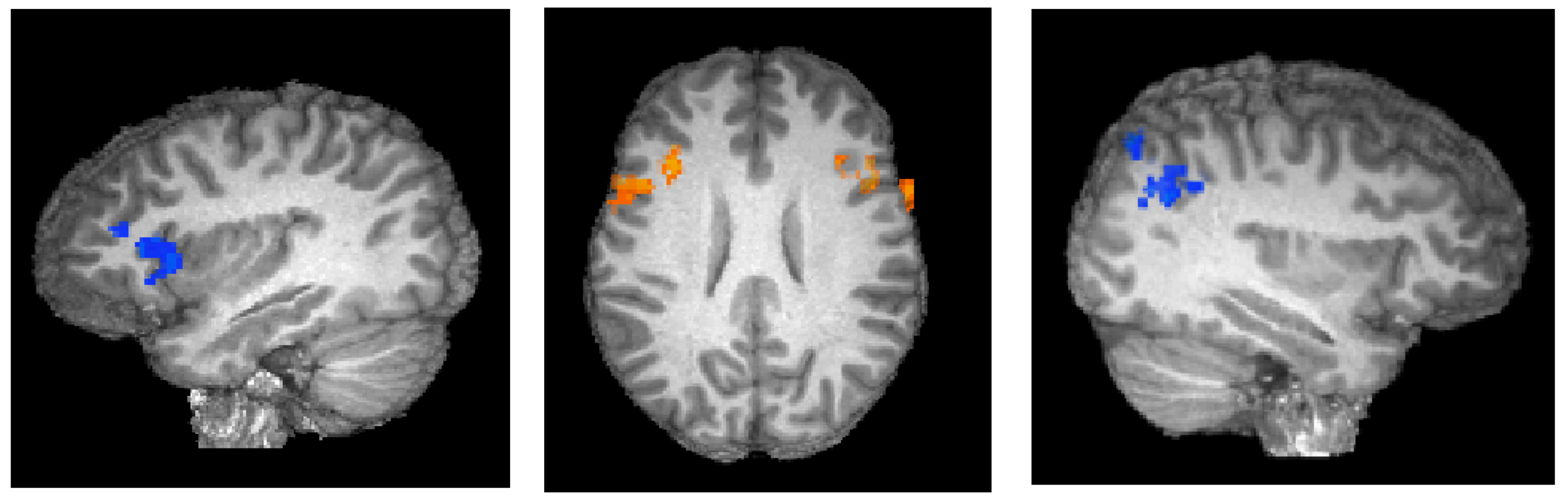
Note the considerable variability among subject discrimination abilities, particularly in the implicit training group.

These results are inconsistent with a behavioral pilot experiment, where our implicit training group significantly outperformed naïve listeners on post-test discrimination.

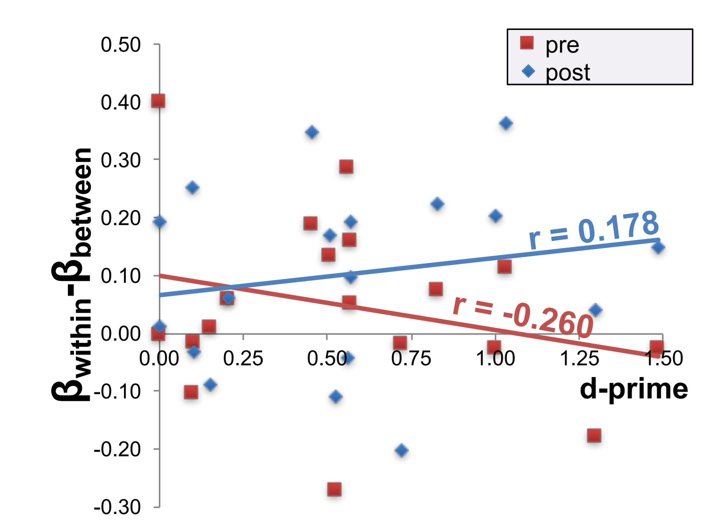


fMRI Results

Because of the considerable variability in learning, data were submitted to a 2x2 **Session** (Pre/Post) x **Token** (Between/Within) ANCOVA with **post-test discrimination** score as a continuous covariate.



<u>Effect of Session</u>	<u>Effect of Token</u>	<u>Session x Token x Post-test Discrim</u>
Pre > Post	**Between > Within**	
L inferior frontal gyrus	L/R middle frontal gyrus	R supramarginal gyrus



The interaction in right angular / supramarginal gyrus (RSMG) appears to be driven by **a difference in neural sensitivity to the category structure following training**. Participants with **better post-test discrimination scores** showed greater sensitivity to the between vs. within-category contrast, evident only after training.

Discussion

- **For adults, implicit training might not be the best approach for learning non-native speech sounds.** Adult listeners exhibit substantial variability in how well they are able to draw on implicit cues to learn non-native speech sounds.
- **Even in the absence of an explicit mapping process from sounds to category labels, changes in LIFG activity are associated with processing non-native sounds.** Consistent with studies using an explicit paradigm, we observed a reduction of frontal activation following training, suggesting that fewer frontal resources are needed for processing non-native sounds after training.
- **Frontal sensitivity reflects neither explicit category labels (since participants were implicitly trained on the differences) nor learning over time (since there was no interaction with session).** We observed a graded sensitivity in frontal regions to the different categories, as in studies[4] using explicit training paradigms.
- **RSMG may play a similar role in implicit learning of non-native sounds as in explicit training.** Recruitment of the RSMG has been shown following explicit training of non-native speech sounds[5], and previous work[1] has identified a positive correlation between degree of learning and BOLD response in SMG.

References

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