

LEARNING OF INTENSITY AND REVERBERATION CUES FOR AUDITORY DISTANCE PERCEPTION IN ROOMS

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Background

Sound intensity and reverberation are two primary cues for auditory distance perception. (Zahorik et al., 2005)

A learning effect was observed after five days of training on distance localization task in a reverberant room with intensity of presentation varying from trial to trial. (Shinn-Cunningham, 2000)

The learning was observed between days, possibly due to memory consolidation. (Stickgold, 2005)

Auditory distance learning can be disrupted on the short time scales. (Schoolmaster et al., 2004)

The auditory system must adapt to reverberation in each room but the effect of the long term exposure on auditory distance perception is unknown.

Current study

Determine whether spontaneous learning (without feedback) in a room occurs when the intensity cue is present in localization experiment.

- **R runs:** stimuli with intensity varying from trial to trial
- **A runs:** stimuli with fixed intensity (intensity varies freely with distance)

Hypotheses

H1: Reverberation provides absolute information therefore learning in a room without intensity cues should lead to better usage of reverberant cues.

- We should see more improvement when trained without intensity cue (R) re. with intensity cue (A) for R test and it should generalize to A test.

H2: Learning will occur between days rather within days.
H3: Learning carry over effect and short-term interactions are expected

- Counterbalance of testing order: RARARA or ARARAR
- Counterbalance of training order: RRR...R AAA...A or AAA...ARRR...R

Results

Is there more learning after R compared to A in R test? Does it generalize to A test? R learning - A learning: For example the statistics for RA train group = CC(4)-CC(1) - CC(7)-CC(4) separately for R testing (left panel) and A testing (middle panel).

Spontaneous learning (no feedback) in a room without intensity cue (R) leads to improvement in R testing but it does not generalize to A testing, which improves more after training with intensity as a cue (A).

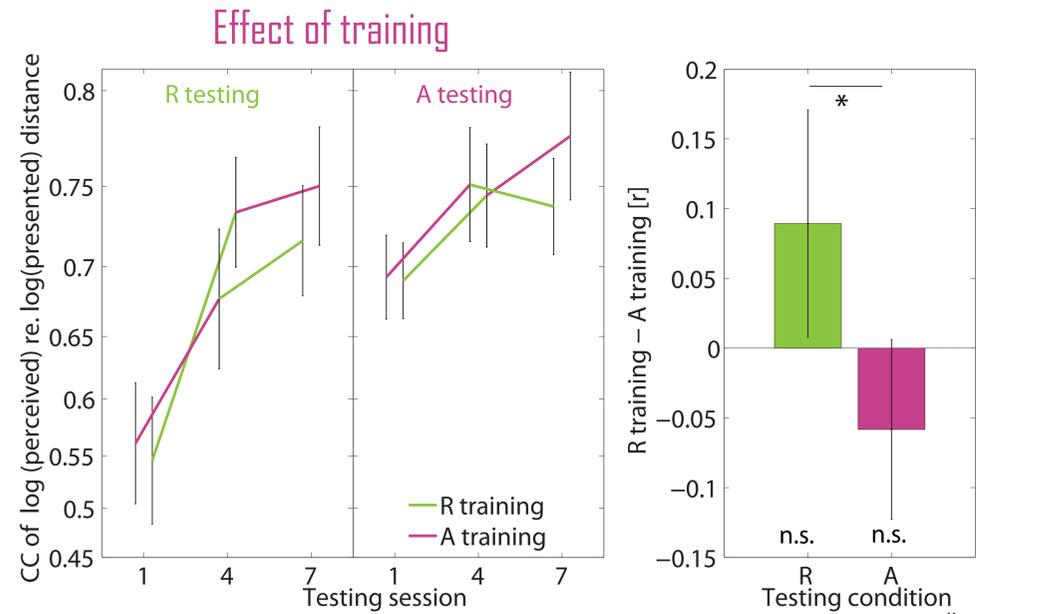


Figure 2 Performance during testing sessions separately for R runs (left panel) and A runs (middle panel). Data are averaged x testing order and testing runs. Right panel: comparison of the effect of learning in R and A conditions. * p < 0.05

Methods

32 subjects
Small (3 x 5 m) semi reverberant room (T60 300ms), 32dB SPL background noise
Session 4: 6 test run 6 train runs
Session 5-6: 2 x 12 train runs
Session 7: 12 test runs
80 localization trials, each speaker presented 10 times pseudo randomly
Subjects informed about run condition
Short breaks between runs

Procedure and task

Localize the sound and press corresponding letter/number (see Figure 1)

Session 1: 6 test run 6 train runs
Session 2-3: 2 x 12 train runs

Stimuli

300 ms broadband noise
A runs: intensity varies freely 49-54 dB SPL
R runs: intensity equalized for distance and roved by +/-12dB

One run

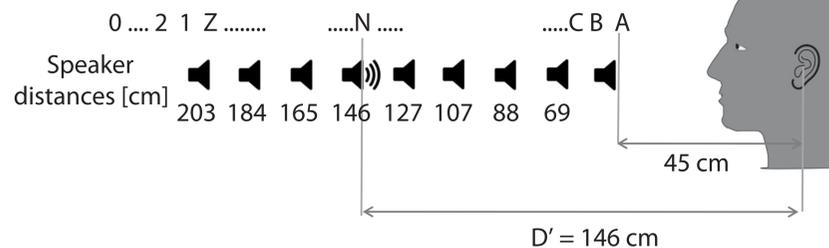


Figure 1 Experimental setup. Actual speaker locations and the letters/numbers (A-Z,1-0) used by listeners to indicate perceived distance. The nearest speaker was not used to present stimuli.

Data analysis

Correlation coefficients (CC) for speakers 2-8, atanh transformed. Outliers were detected at 3*1.4826 median absolute deviation from median.

Across session learning

What is the pattern of improvement? Does the improvement in testing sessions (1,4,7) result from training or improvement in testing?

Transition of learning statistics compares improvement from testing to training + training to testing with improvement during training.

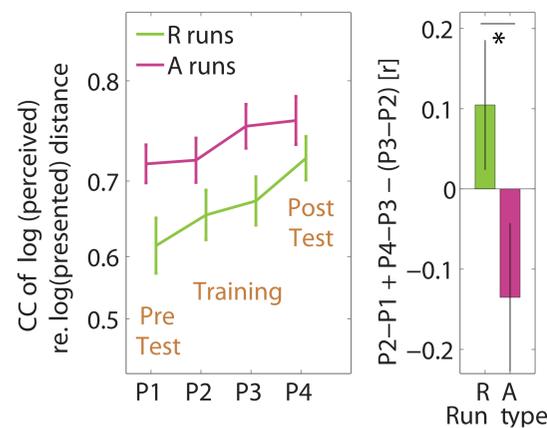


Figure 3 Across session performance at the beginning and final runs of the training phase (training) with pre-test and post-test performance. Data are divided by conditions averaged across all subjects.

Within session learning

Is there an improvement from within one day from the beginning to the end of training session?

No improvement within a session.

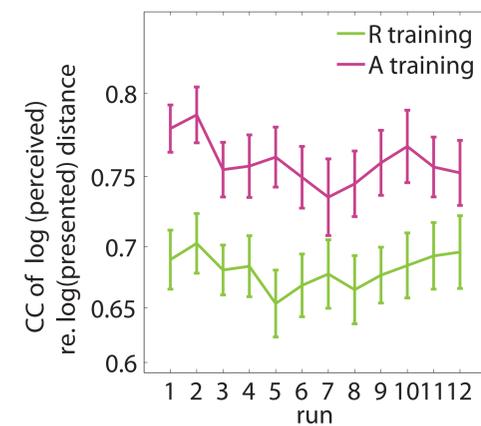


Figure 4 Within session performance as a function of run. Average across training session (2,3,5,6).

Discussion

- The performance in terms of CC - within subject variance and/or linearity of responses - improved after training.
- R training tended to improve R test performance (on average by 0.1) and this improvement was significantly higher than A test performance.
- Observed amount of R test improvement was small (re. x subject variance) and it does not generalize to A test.
- Looking at the pattern of across session learning: A runs were superior at the beginning and improved mostly in the training phase (perhaps due to ceiling effect) while R runs improved actually in the testing (when runs were RARARA or ARARAR), but note that in (Shinn-Cunningham, 2000) the R training took 5 days -> here it was 3-4 days in R condition.
- Consolidation is important here (no within session improvement), difference between patterns suggests that R performance could be improved also due to improved switching between R and A (e.g. less confusion from the previous context)

References and Acknowledgement

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This work is the result of the Project implementation: SDFOS - knowledge and skill development of the academic staff and students at the University of Pavol Jozef Safarik in Kosice with emphasis on interdisciplinary competencies and integration into international research centres. ITMS: 26110230088, supported by the Research & Development Operational Programme funded by the ESF.

Modern education for knowledge society / This project is being co-financed by the European Union