#5 Short-term adaptation of auditory distance perception in a reverberant room

Ľuboš Hládek[1], Beáta Tomoriová[2], Norbert Kopčo[12], and Aaron Seitz[3]
[1]University of P. J. Šafarik, Košice, Slovakia [2]Technical University of Košice, Slovakia [3]University of California, Riverside, USA

1. BACKGROUND: LEARNING AND DISTANCE PERCEPTION

For familiar sounds, overall received sound pressure level (loudness) considered to be the main distance cue (Warren, 1999)

In rooms, reverberation provides distance information. Candidate cue Direct-to-Reverberant energy ratio, D/R (Bronkhorst and Houtgast, 1999).

Amount of reflected energy varies from room to room. Auditory system has to adapt in each room to correctly map D/R to source distance.

In rooms, there is a learning effect: distance perception improves with experience (Shinn-Cunningham, 2000)

Improvement occurs over course of days, suggesting that memory consolidation process occurs (Lechner et al., 1999)

Learning process can be disrupted on a short-term scale, e.g., if inconsistent D/R cues are presented (Schoolmaster et al., 2004)

In/consistency of the overall level cue during initial exposure to a new room influences both accuracy of distance judgements and the learning process (Kopco et al., 2011)

2. CURRENT STUDY

Study spontaneous (i.e., no feedback) learning of distance perception in a specific room.

How does the consistency of level cue during initial exposure to a new room influence performance with and without the level cue?

Measure distance perception during a single one-hour long session with no prior exposure to the room.

Two run types, differing by distance cues available in sounds

- A: overall presentation Sound Pressure Level (Amplitude) fixed
- R: overall presentation Sound Pressure Level (Amplitude) roved from trial to triald

Two groups of subjects:

1. Order of runs RARARARA (started with R)
2. Order of rusn ARARARAR (started with A)

HYPOTHESES AND PREDICTIONS:

H1: Initial exposure to sounds with in/consistent level cue affects how people use different distance cues and how they learn to judge distance.

H2: Some subjects are not always able to ignore sound level cues.

1. Initial exposure to sounds with no level cue will result in lasting imporvement in performance (re performance when level cue is initially available).
2. Performance of some subjects will be correlated with presentation level even when it is randomized.

3. METHODS AND EXPERIMENTAL PROCEDURES

70 normal hearing subjects, divided into 2 groups, difering only in the order of runs: RA or AR order.

Source Stimuli

- 500-ms-long broadband noise burst
- A stimuli:
-- fixed presentation level, received level 49 - 54 dB SPLA
- R stimuli:
-- received level equalized and roved by +/- 12 dB

Source Locations (see Figure 1)

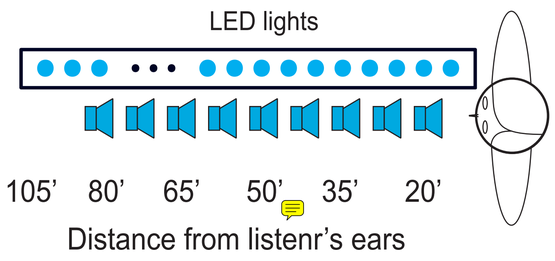
- Eight distances (9), nearest one not used

Room

- small empty room, hard walls, carpeted floors, ceiling tails, background noise level 35 dB SPL(A)

One run

- subject informed about stimulus condition (A or R)
- 80 trials, each speaker used 10 times in random order
- subject indicated heard position by moving LED light above the array of speakers using trackbal indicating heard position
- at end of run, subject informed about his/her performance



Experiment

- one experimental session. Instructions at the beginning.
- First run was practice, only light presentation
- Followed by 8 experimental runs (1hrour)
- Hearing ability test at the end

Figure 1 Experimental setup. Eight speakers used to present sound. The nearest speaker was not used. 42 LED lights controled by trackball spaced 2.5 inches from 17.5’ to 105’ were used to indicate perceived distance.

4. LEARNING OVER MULTIPLE DAYS (Kopčo et al., 2011)

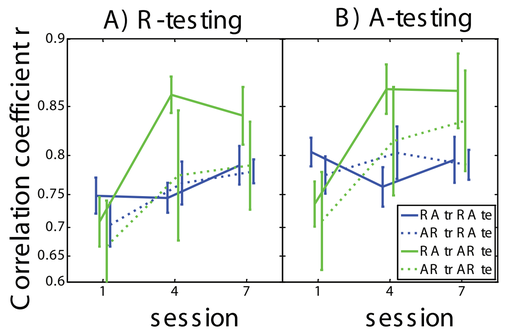


Figure 2 (Kopco et al.,2011) Effect of training over multiple days on R and A testing. Data are averaged x testing order.

Original study – learning experiment over multiple days with 4 groups of subjects.

Tested in RA of AR run order in sessions 147 and trained between them with either A or R runs.

Distance judgments improved over days.

Room learning contributed to both A and R presentations.

Learning in room-related cue is specific for the testing order.

Testing order had crucial impact on learning in all sessions.

5. RESULTS - DEPENDENCE ON ROVE LEVEL

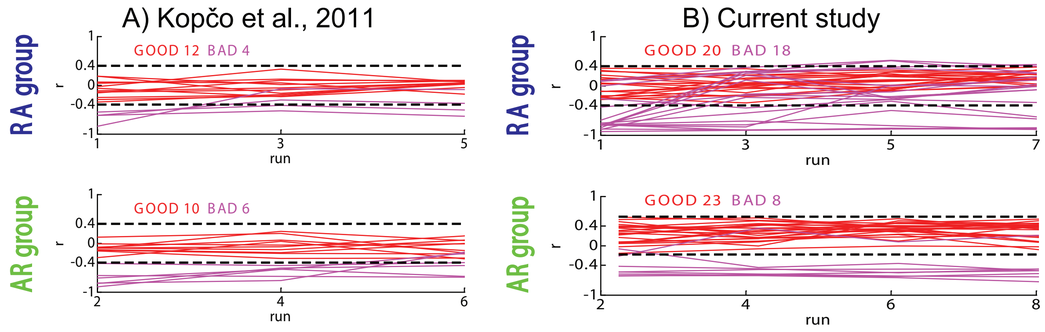


Figure 3 Dependence on rove level in R runs. For further analysis we used only subjects whose correlation with rove level did not exceed +/-0.4 interval (red lines).

Based on correlation with rove level in R runs (correlation with sound level) we can observe three types of behavior

- did not follow direct cues (red)
- did follow direct cues (magenta at the bottom)
- learned not to follow direct cues (magenta which moved into middle)

Most of AR subjects who started below our criterion (magenta lines) did not improve

Most of RA subjects who started below our criterion (magenta lines) did improve.

6. RESULTS - SHORT-TERM ADAPTATION

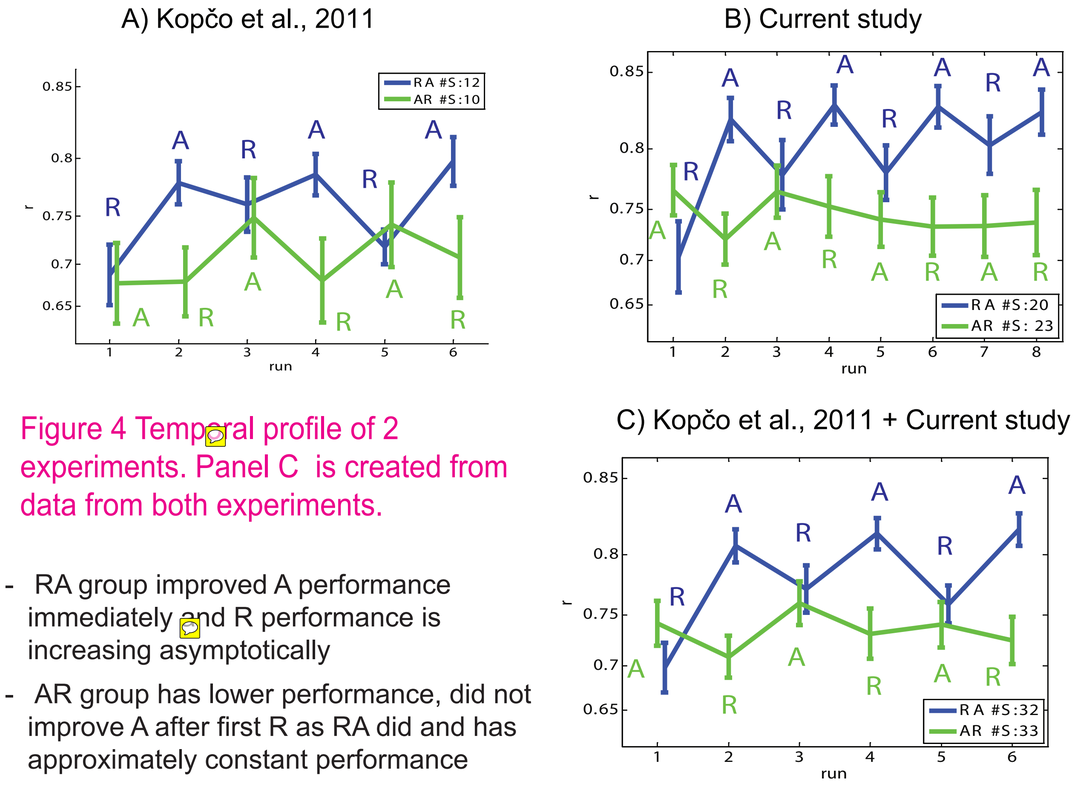


Figure 4 Temporal profile of 2 experiments. Panel C is created from data from both experiments.

- RA group improved A performance immediately and R performance is increasing asymptotically
- AR group has lower performance, did not improve A after first R as RA did and has approximately constant performance

7. CONCLUSIONS AND DISCUSSION

Results from original study were confirmed.

Availability of sound level cues at the beginning of the presentation influenced all other presentations.

Subjects who started without sound level cues availabel could enhance their perception of distance in both R and A presentations.

H1: Short-term learning of auditory distance occurred only when sound level cues were removed in the first 80 presentations. (confirmed)

H2: Subjects who followed sound level cues in first run in RA group managed to learn to ignore it. (partially confirmed)

DISCUSSION

Subjects improved their internal coherence but we have not analyzed absolute errors.

Feedback could influence results.

ACKNOWLEDGEMENTS

Research was supported by European Community, NIH and University of P. J. Šafarik. Research assistants: Se Hong and Vivian Tran.

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