A LOCALIZATION TRAINING PROGRAM FOR HEARING AID WEARERS

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Kochkin (2005) showed that only 12% of hearing aid wearers are very satisfied (and only 66% are satisfied) with aided directionality (or localization).

Widex ORCA-USA lab testing showed that average correct rate of front-back localization is 55% for front and 22% for back with subjects’ own aids and 70% for front and 30% for back in the unaided condition (head movement not allowed).

- Unaided front-back localization is poor
- Aided front-back localization is also poor
- Aided Front-back localization may be poorer than unaided

Use of inter-ear compression and pinna compensation improved, but did not “normalize” localization.
STATUS OF LOCALIZATION TRAINING FOR HEARING IMPAIRED PERSONS

• Several references in the cochlear implant literature, e.g., Tyler et al (2010)
• Most training focused on half or hemi-field (270° to 90° or 0° to 180°). Not specifically on front-back localization training
• Research on training normal listeners to localize with one ear plugged, e.g., Kumpkin et al, 2010; Hofman et al, 1998
• No formalized training program for hearing impaired subjects, especially for front-back localization (major problem)
PURPOSE OF STUDY

• This study is to
  • Develop a localization training program
    • Optimal acoustic cues are provided for real-world carry-over
  • Evaluate the effectiveness of the training program
  • Compare the relative effectiveness of home versus lab training

• Not interested
  • To evaluate if this program is as optimal (or more optimal) to train distorted cues;
  • If training unaided will be as effective as training aided
  • Or if the compensated acoustic cues are effective for localization
KEY TO SUCCESS - MAINTAINING MOTIVATION

- Stimuli are changed adaptively to keep motivation
- Provide immediate feedback and self-paced learning
- Vary criteria to maintain feeling of success
ADAPTIVE TRAINING - STIMULI

- It is easier to perceive a difference if the stimulus contrast is “large” or if the stimulus condition is easy
  - Duration of stimulus from 3s to 300ms (300, 500, 1000, 2000 and 3000 ms)
  - Front-back attenuation – digital pinna +8, 4, 2, 0 dB
  - Based on the results of the tests a hierarchy was used to determine the stimulus duration and back plane attenuation for training
- Three high-pass signals (above 2000 Hz) were used
  - High pass noise
  - Speech
  - Telephone ring
- Each stimulus was randomly presented 3 times each from the 12 loudspeakers for a total of 108 test items per trial
TRAINING FOR SUCCESS - FEEDBACK FOR IMMEDIATE ERROR CORRECTION

Correct!
Target Sound

Incorrect!
Target Sound

Compare the Sounds

NEXT
ADAPTIVE TRAINING – CRITERIA OF SUCCESS

- It is more motivating to get it correct than to get it incorrect, e.g., relaxed criteria at the beginning & tightened later
  - Criterion of correct from $60^0$, $30^0$, and $0^0$

- Success on a longer/more attenuated/easier criterion will lead to the use of a shorter, less attenuated, more stringent criterion in the next trial
MONITORING OF PERFORMANCE
OVERALL DESIGN

- Fifteen hearing impaired subjects with bilaterally symmetrical mild to moderate sensorineural hearing loss
- Using the Clear m-CB-model hearing aids

<table>
<thead>
<tr>
<th>Group 1</th>
<th>No Training</th>
<th>No Training</th>
<th>No Training</th>
<th>Lab Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 2</td>
<td>Lab Training</td>
<td>Home Training</td>
<td>No Training</td>
<td></td>
</tr>
<tr>
<td>Group 3</td>
<td>Home Training</td>
<td>Lab Training</td>
<td>No Training</td>
<td></td>
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</tbody>
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Baseline 1 month 2 month 3 month
LOCALIZATION LAB TRAINING/TESTING

- 12 loudspeaker array
- During each session, subjects performed baseline test (300 ms, 0 dB attenuation) without feedback
- Received training with feedback (1.5 hr)
- Tested again on baseline condition (300 ms)
- Repeated for 6-8 sessions within a month
- Tested other stimulus conditions during baseline, two weeks, one, two, and three months
HOME TRAINING

- Training used computerized materials and was also adaptive in nature
  - One loudspeaker placed in front of listener and one behind the listener
  - Ten sounds from a list of 30 available sounds were randomly chosen
  - Each of the ten sounds was presented 3 times from the front and the back \([3 \times 2 \times 10 = 60 \text{ items}]\)
  - Listener indicated on computer screen where they thought it originated from [front or back]; feedback provided
  - Performance data were saved so listener can compare daily results and track performance
  - Training was 30 minutes; 5 times per week for 4 weeks
HOME TRAINING SCREENS

Adjust the level of the sound to a comfortable level.

Play Sound

Front

Results
Level 6
Score 92%

Results History

0 % 25 % 50 % 75 % 100 %

0 1 2 3 4 5 6 7 8 9 10 Trial #
TEST FOR GENERALIZATION

- The current study also included a test for generalization which was administered twice.
  - At the beginning of the study prior to training
  - At the end of the study after training has terminated
- The generalization test included 3 different test signals
  - Narrow band noise at 3000 Hz
  - A different speech passage read by a different speaker [filtered above 2000 Hz]
  - An alarm noise [filtered above 2000 Hz]
- The generalization test also included the unaided condition
DISPLAY OF LOCALIZATION PERFORMANCE
- CENTER OF MASS

Considers the proportion of correct responses, direction of loudspeakers, and size of errors of incorrect responses simultaneously.

\[
\bar{X} = \left( \frac{1}{N} \sum_{i=1}^{N} \sin \theta_i, \frac{1}{N} \sum_{i=1}^{N} \cos \theta_i \right)
\]
NORMAL LOCALIZATION PERFORMANCE USING CENTER OF MASS DISPLAY
CENTER OF MASS DISPLAY SHOWING POOR BACK PERFORMANCE
PERFORMANCE OVER TIME IN CONTROL GROUP

Recall they all have DP and IE-compression.
PERFORMANCE OVER TIME IN GROUP 2

Graphs showing performance over time in Group 2 with data points at baseline, 1 month, 2 months, and 3 months.
PERFORMANCE OVER TIME IN GROUP 3
COMPARING TRAINED AND CONTROL GROUPS

Baseline

1 Month

2 Months

3 Months
GENERALIZATION TO OTHER STIMULI – 3 S

Control

Group 2

Group 3
TRAINING AFFECTS UNAIDED PERFORMANCE ALSO?
CONCLUSIONS

- Acoustic compensation to restore localization cues alone is not sufficient to restore localization (control group)
- Laboratory training improves localization (Group 2)
- Home training improves localization (Group 3)
- The effect of training generalizes to unaided and other stimulus conditions
- The most significant improvement was seen during the first month of training
- The DP and IE provide additional cues which, upon training, can lead to more accurate spatial awareness of sounds