THE OCCLUSION EFFECT: PHYSICAL MEASUREMENT AND SELF-REPORT

Karen Jarvis
Advisor: Robyn Cox, Ph.D.
April 2004
THE OCCLUSION EFFECT

- Results from trapped energy in the ear canal
- Unoccluded, the ear canal allows low frequencies to escape out

Physically:
Results in greater magnitude of low freq. SPL in ear canal

Perceptually:
For hearing aid users, the OE is associated with unnatural perception of own voice (“echo”, “hollow”, “booming”)
Biering-Sorensen, Pedersen, & Parving (1993)

- Attempted to find a relationship between the subjective and objective effects of occlusion (earmold) by using:
  - behavioral testing
  - interview
RESULT: These researchers found no relationship between the measured occlusion effect (using changes in bone conduction thresholds) and the answers to the questionnaire.

PROBLEMS:
- The reliability of the interview was questioned.
- No internal consistency reliability
- “yes/no” questionnaire
PURPOSE

1. To determine the relationship between perceived severity of the occlusion effect and the objective magnitude of the occlusion effect.

2. To evaluate and compare 3 physical methods for measuring the magnitude of the occlusion effect in hearing aid fittings.
THIS STUDY: MATERIALS

- Audioscan RM 500 Series probe microphone
- Maico MA 40 portable audiometer with bone conduction vibrator
- Radio Shack sound level meter
- Etymotic ER 33 occlusion meter
- The Scale of Hearing aid Occlusion Problems questionnaire
- Otoscope
SUBJECT SELECTION/CRITERIA

- 25 people at least 18 years of age were selected from the MSHC clientele.
  - obtained from supervisor lists; UMAPS
  - Hearing: 50 dB or better at 250 and 500 Hz in both ears
  - users of functioning hearing aids
  - no gender or ethnicity preference
  - good overall health
  - no active ear infections
SUBJECT DESCRIPTION

- mean age = 71.44
- mean TE PTA=40 dB HL
- all users of binaural amplification
- 8 BTE users
- 13 ITE users
- 4 ITC users
COMPOSITE AUDIOGRAM

test ear

Hz
PROCEDURE

PARTICIPANTS’ HOME OR MSHC

TEST EAR CHOSEN

6 TEST CONDITIONS RANDOMIZED:
(including test 1 and 2 of each method)
REPEATED MEASURES DESIGN

Participant

subjective
- Questionnaire

objective
- Audioscan: voice
- Audioscan: bone
- Occlusion Meter
QUESTIONNAIRE

The Scale of Hearing aid Occlusion Problems
(Cox & Alexander, 2003)

- 16 items
- 7-point Likert scale
- “not at all... tremendously”
- higher score associated with less of a problem with the occlusion effect
Objective Measurement 1  
(voc250; voc500)

1. Audioscan probe microphone system

2. Voice input (/i/)
   - Probe tube placed in ear canal (No HA)
     - SLM used to monitor voice level
     - generated a curve representing the SPL in the ear canal across frequencies
   - Probe tube placed in ear canal (HA in/off)
     - SLM used to monitor voice level
     - generated a curve representing SPL across frequencies

3. Calculated Real Ear Occluded Gain (REOG):
   - HA in/off – No HA = occlusion effect

Frequencies of interest: 250 & 500 Hz
Objective Measurement 2 (BC250)

1. Audioscan probe mic system

2. Bone vibrator input (250 Hz @ 40 dB HL)
   - Probe mic (No HA)
   - Probe mic (HA in/off)

3. Calculated Real Ear Occluded Gain (REOG):
   - HA in/off – No HA = occlusion effect

Frequencies of interest: 250 Hz
Objective Measurement 3

Occlusion Meter:

- Probe tube taped to the bottom of hearing aid
- Inserted into ear canal
- Subject vocalized the /i/ sound
- Occlusion effect read from meter, repeat
- No SLM necessary
- Measures primarily 250 Hz
RESEARCH QUESTIONS
& RESULTS
QUESTION #1

Are the 4 physical measurements the same on average?
MEAN OCCLUSION EFFECT OF PHYSICAL METHODS

V250AV, V500AV = OE @ 250 & 500 Hz using audioscan (voice input)
BC250AV = OE @ 250 Hz using audioscan (bone conduction input)
OM av = OE measured with occlusion meter
Are the 4 physical measurements really different?

1. \( F (2.494) = 4.934, \ p = .006 \)

2. Post Hoc testing showed that \textit{occlusion meter averages} were significantly different (lower) than the other physical measurement averages.
QUESTION #2

Are the 4 physical measurements of the OE measuring the same thing for an individual?
Measurements at 250 Hz

<table>
<thead>
<tr>
<th></th>
<th>voc250</th>
<th>BC250</th>
</tr>
</thead>
<tbody>
<tr>
<td>voc250</td>
<td>0.289</td>
<td></td>
</tr>
<tr>
<td>BC250</td>
<td>0.289</td>
<td>0.532 **</td>
</tr>
<tr>
<td>OM</td>
<td>0.667 **</td>
<td>0.532 **</td>
</tr>
</tbody>
</table>

Correlations:
** .01 level of significance
* .05 level of significance
250 Hz: BC/audioscan & voice/audioscan
Measurement at 500 Hz

<table>
<thead>
<tr>
<th>voc500</th>
<th>voc250</th>
<th>BC250</th>
<th>OM</th>
</tr>
</thead>
<tbody>
<tr>
<td>.629**</td>
<td>.420*</td>
<td>.470*</td>
<td></td>
</tr>
</tbody>
</table>

correlations:
** .01 level of significance
* .05 level of significance
QUESTION #3

How do the physical measurements relate to the questionnaire scores?

- factor analysis
  - 2 factors
- SCORES:
  - overall (15 items)
  - naturalness of voices score (3 items)
  - loudness of sounds score (4 items)
QUESTIONNAIRE ITEM MEANS

Questions

Mean Response

Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16

Questions

Mean Response
## Relationships Between Questionnaire Scores & Objective Measurements

<table>
<thead>
<tr>
<th></th>
<th>VOC250</th>
<th>VOC500</th>
<th>BC250</th>
<th>OM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall score</strong></td>
<td>.043</td>
<td>-.301</td>
<td>-.172</td>
<td>-.163</td>
</tr>
<tr>
<td><strong>Naturalness score</strong></td>
<td>-.103</td>
<td>-.472*</td>
<td>.130</td>
<td>.026</td>
</tr>
<tr>
<td><strong>Loudness score</strong></td>
<td>.083</td>
<td>.083</td>
<td>-.297</td>
<td>-.203</td>
</tr>
</tbody>
</table>

Correlations:  
**.01 level of significance  
*.05 level of significance
CONCLUSIONS

1. Some evidence that the smaller the magnitude of the measured occlusion effect at 500 Hz (voice/audioscan), the better a person rates the naturalness of voices. However, the measurements of the occlusion effect made by the audioscan probe mic system using voice inputs were the least stable from test to retest.

2. All occlusion effect data at 250 Hz were not related to any of the subjective data
1. The **bone conduction/audioscan** and the **occlusion meter** methods were the most stable objective methods from test to retest. However:

- neither related to the subjective data
- the occlusion meter average values were significantly different (smaller) than the bone conduction average values
- occlusion meter function was unpredictable
- for 5 subjects the lack of calibration of the OM required corrections
- For 1 subject, no OM data could be obtained due to the meter not functioning
2. Due to its stability, the bone conduction method may be useful for looking at changes in the occlusion effect following earmold modifications.
POSSIBLE LIMITATIONS

- Measurement Biases:
  - probe depth, insertion
  - environment: (air conditioners, refrigerator noise etc.)
  - vocal effort of subjects: stability within one measurement and from test to retest (SLM)
  - occlusion meter function

- Subject Biases: personality (questionnaire)
FURTHER RESEARCH

It may be useful to look into a method that measures 500 Hz with better reliability.
References