BONE ANCHORED HEARING SYSTEMS: DOES DIRECT DRIVE MAKE A DIFFERENCE?
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...
BONE CONDUCTION DEVICES AND SPEECH PERCEPTION

Lunner et al (2016)*
To compare children’s performance with a bone-conduction device coupled percutaneously via an abutment and transcutaneously via a Softband.
HYPOTHESIS

If the quality of the acoustic signal is improved with direct coupling, then differences in performance will be seen for auditory tasks that rely on the quality of the acoustic signal.
PREDICTIONS

1. Speech perception will not differ between coupling conditions
2. Performance will differ between coupling conditions for tasks containing unfamiliar stimuli (nonsense words)
Children:

- 4 boys and 5 girls
- 8 to 15 years (mean = 11 years)
- 7 bilateral conductive losses
- 1 unilateral conductive
- 1 single-sided deafness

All children were implanted with an abutment for a bone-conduction device (Ponto or Baha)
Fitted two Ponto processors during testing: 1) Direct, 2) Softband
Fitted two Ponto processors during testing: 1) Direct, 2) Softband
Stimulus presentation:
- Free field
- $0^\circ$ azimuth
- 65 dB SPL
- Quiet

Device activation was counterbalanced
Responses collected using interactive computer games
1) WORD RECOGNITION

NU-6 word lists (25-words)

Responses were recorded for later analysis

Scored in % correct
1) WORD RECOGNITION

NU-6 word lists (25-words)

Responses were recorded for later analysis

Scored in % correct
1) WORD RECOGNITION

NU-6 word lists (25-words)

Responses were recorded for later analysis

Scored in % correct
2) AUDITORY LEXICAL DECISION

Children repeated aloud real and nonsense words and indicate the category of each word.

% correct
2) AUDITORY LEXICAL DECISION

“swim”

<table>
<thead>
<tr>
<th>Repeat</th>
<th>Categorize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swim</td>
<td>Real</td>
</tr>
<tr>
<td>Swim</td>
<td>Not Real</td>
</tr>
<tr>
<td>Srim</td>
<td>Real</td>
</tr>
<tr>
<td>Srim</td>
<td>Not Real</td>
</tr>
<tr>
<td>Whim</td>
<td>Real</td>
</tr>
<tr>
<td>Whim</td>
<td>Not Real</td>
</tr>
</tbody>
</table>
2) AUDITORY LEXICAL DECISION

Higher average performance using direct coupling

Better able to identify and repeat words that are and are not familiar to them with direct coupling

![Graph showing performance comparison between Softband and Direct Bone Conduction Coupling, with a p-value of <0.05.]
2) AUDITORY LEXICAL DECISION

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Children identified the position of nonsense words embedded in short sentences.

D-Prime
Clocks tick on time.
Birds *rike* long worms.
*Dat's* catch slow *bice*.
### SIGNAL DETECTION THEORY

#### STIMULUS

<table>
<thead>
<tr>
<th>Response</th>
<th>Nonsense</th>
<th>Real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonsense</td>
<td>HIT</td>
<td>FALSE ALARM (MISPERCEPTION)</td>
</tr>
<tr>
<td>Real</td>
<td>MISS (REPAIR)</td>
<td>CORRECT REJECTION</td>
</tr>
</tbody>
</table>
EFFECTS OF HEARING LOSS

Adults

Children

D-Prime

Binaural Free-Field PTA (.5,1,2,4 kHz)

Binaural Free-Field PTA (.5,1,2,4 kHz)

NH

Unaided

Secretly Awesome

Pittman et al (in process)

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EFFECTS OF HEARING LOSS

Adults

-2 -1 0 1 2 3 4 5
D-Prime

0 20 40 60 80
Binaural Free-Field PTA (.5,1,2,4 kHz)

Uh oh

Children

-2 -1 0 1 2 3 4 5
D-Prime

0 20 40 60 80
Binaural Free-Field PTA (.5,1,2,4 kHz)

NH
Aided

Pittman et al (in process)
3) NON-WORD DETECTION 2.0

Higher average performance using direct coupling

Better able to detect unfamiliar words in sentences with direct coupling

![Chart showing sensitivity (d-prime) for Softband and Direct Bone Conduction Coupling. The Direct method shows higher sensitivity with a p-value of <0.05.]

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Higher average performance using direct coupling

Better able to detect unfamiliar words in sentences with direct coupling
3) NON-WORD DETECTION 2.0

Higher average performance using direct coupling

Better able to detect unfamiliar words in sentences with direct coupling
Children learned to associate nonsense words with novel images through a process of trial and error.

Speed: the number of trials required to achieve 70% performance.
4) RAPID WORD LEARNING

\[ P_c = 1 - 0.84e^{-n/c} \]

Learning Speed:
- 1 trial (perfect learning)
- 10 trials
- 100 trials
- 1000 trials (no learning)
RAPID WORD LEARNING WITH HIGH-FREQUENCY AMPLIFICATION

<table>
<thead>
<tr>
<th>Standard</th>
<th>High-Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>maytnill</td>
<td></td>
</tr>
<tr>
<td>gayfmit</td>
<td></td>
</tr>
<tr>
<td>dayltins</td>
<td></td>
</tr>
</tbody>
</table>

Pittman, Stewart, Odgear & Willman (in press)

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VALIDITY OF THE RAPID WORD LEARNING PARADIGM

Normal Hearing Children

Performance (% Correct)

# of Training Trials

Learning

Retention

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4) RAPID WORD LEARNING

May learn words faster using direct coupling

May be better able to associate new words with new images using direct coupling

![Graph showing learning speed comparison between Softband and Direct methods.](image-url)
4) RAPID WORD LEARNING

May learn words faster using direct coupling

May be better able to associate new words with new images using direct coupling
4) RAPID WORD LEARNING

May learn words faster using direct coupling

May be better able to associate new words with new images using direct coupling
WHAT HAVE WE LEARN (SO FAR)?

Preliminary findings suggest that:

1) Word recognition does not differ between coupling conditions

2) The better performance with percutaneous coupling suggests that it may provide a higher quality signal
THANKS FOR LISTENING

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