The Verifit Directional Mic Test
Evaluating Modern Directional Microphone Technologies

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Directional Microphone Technology

• Directional technology has been available in hearing aids since 1969
• Remains to this day the single most effective “head-worn” approach to improving signal-to-noise ratio for certain listening conditions

SNR Impact on Intelligibility

Effect of decreasing noise

From Dillon, H., “Hearing Aid Technology & The Future”, ASA Presentation, April 2006

Directional Microphones Make A Difference On Key Satisfaction Factors

- Overall satisfaction
- Comfort with audio sound
- Vision in noisy situations
- Sound clarity
- Natural sounding
- With moderate to loud outdoor situation
- Outdoor shouting
- Hours wearability
- Acoustics
- Wind/feedback
- Neckband
- Quality of life
- Recommended for
- Ongoing reason

% difference in customer satisfaction ratings


Directional Microphone History

circa. 1970’s to app. 1995

- The pressure-gradient directional microphone
  - Two mic ports
    - One “front-facing”
    - One “rear-facing”
  - Ports directed to opposite sides of mic diaphragm
  - Port distance = external delay
  - Baffle in RP = internal delay
  - Polar pattern is function of ratio between external and internal delays

Described in Knowles Electronics Technical Bulletin 22
**Directional Microphone History**

App. 1995 to present

- Two omni-directional microphones
- Internal delay is part of DSP algorithm
  - Allows for different polar patterns
  - Allows directional mic to be "On" or "Off"
  - Facilitates automated directional mic activation

H. Dillon; NAL, CRC for CI and HAI

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**Modern Directional Mic Design Possibilities**

<table>
<thead>
<tr>
<th>Polar Pattern</th>
<th>Fixed</th>
<th>Adaptive*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
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<td>Manual/Adaptive</td>
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<tr>
<td>Automatic</td>
<td>Automatic</td>
<td>Adaptive</td>
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</table>

* Includes broadband and multi-band adaptive directionality

Fabry, D., "Adaptive Directional Microphone Technology and Hearing Aids: Theoretical and Clinical Implications", The Hearing Review, April 2, 2005

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**Remote Microphone**

www.oticon.ca
Standard Specification of Directionality

Polar Plots

Figure 2.8 Directional sensitivity of (a) an omnidirectional (solid line) and (b) a directional (dotted line) microphone, mounted on the head at 2 kHz. Data adapted from Knowles, TB21.

Source: Dillon (2000): Hearing Aids

Considerations Regarding Conventional Polar Plot Testing

- Polar plots are obtained in the presence of a single pure tone frequency
- Polar plots do not measure in the presence of multiple input sources
- Polar plots can be less robust in the presence of non-linear (compression) amplification
Methods of Quantifying Directional Advantage

- **Research Lab**
  - **The Directivity Index (DI)**
    - Compares output for sounds originating from the front to output for sounds originating from all other locations
    - Expressed in dB
      - Omni directional aid would have a 0dB DI
      - Two-mic array devices can have as much as a 6dB DI
  - **The AI-DI**
    - An AI (or SII) weighted version of the DI, taking into account the effects of the DI on certain speech frequencies

*Killion, M., et al., "Real World Performance of an ITE Directional Microphone."
The Hearing Journal 51(4), 1998, pp. 24-38

Methods of Quantifying Directional Advantage

- **Clinical**
  - **The Front-to-Back Ratio (FBR)**
    - Comparison of output curves for the same broadband stimulus obtained with the hearing instrument at 0° and 180° orientation to the stimulus
  - **Speech in Noise Tests**
    - Fixed SNR approach: Difference between omni-directional and directional % correct = directional advantage
    - Variable SNR approach: Difference in SNR required to reach 50% correct = directional advantage
  - SIN, QuickSIN, HINT tests (and others) can be used for this purpose

Effects of Compression on FBR

<table>
<thead>
<tr>
<th>Type</th>
<th>Compression</th>
<th>Traditional</th>
<th>Modified</th>
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<tbody>
<tr>
<td>B</td>
<td>0%</td>
<td>1.7 dB</td>
<td>7.7 dB</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>5.8 dB</td>
<td>7.7 dB</td>
</tr>
<tr>
<td>C</td>
<td>0%</td>
<td>11.2 dB</td>
<td>11.2 dB</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>11.2 dB</td>
<td>11.2 dB</td>
</tr>
</tbody>
</table>

Ricketts, T., "Directivity Quantification in Hearing Aids: Fitting & Measurement Effects."
Ear & Hearing, 2000; 21, 45-58
A Unique Way of Measuring Directional Mic Performance

Multiple Input Locations
FFT Analysis

Recommended Positioning - Verifit

Recommended Positioning - Verifit
Verifit 2 Binaural Coupler

HA stabilizer can be "rocked" until front and rear mic ports of each instrument are aligned parallel to the floorboard of the test box.

Putty-less TRIC adapter couples RIC and Thin Tube products to wideband 4cc coupler on both right and left coupler mics.

Recommended Positioning – Verifit2

Directional in Test-box - BTE

Front speaker

Rear speaker

Axis of microphone openings
Directional in Test-box - ITE

Front speaker  Rear speaker

Directional testing

• Stimulus presented simultaneously from front and rear to condition hearing instrument directional operation.
• Periodically, short burst from only front speaker and only rear speaker used for measurement.
• Duration of measurement bursts short enough to not affect HI output.
• Two versions – Noise + Noise, Noise + Speech

Noise + Noise Directional Test

• Simultaneous composite noise signals
• Alternates for measurement
• Rear stimulus presented longer to condition adaptive directional instruments.
Noise + Speech Directional Test

- Speech from front speaker, noise from rear to condition speech activated directionals
- Alternating short noise bursts during measurement intervals

DEMONSTRATION ONE:
OMNI DIRECTIONAL SWITCHING TO DIRECTIONAL

DEMONSTRATION TWO:
DIRECTIONAL RESULTS AS A FUNCTION OF LEVEL
DEMONSTRATION THREE:
DIRECTIONAL RESULTS AS A FUNCTION OF SIGNAL TO NOISE RATIO

DEMONSTRATION FOUR:
ADAPTIVE DIRECTIONAL INTERACTION

DEMONSTRATION FIVE:
TESTING A DIRECTIONAL MIC IMBEDDED IN A REMOTE MIC
Remote Mic Considerations

- Remote microphone options (often connected to paired hearing instruments via blue tooth) can be either hand held (table top) or talker worn
- It can be a separate device or integrated into a wireless remote control
- If the remote microphone contains a directional mic, it too can be tested with the Verifit D-Mic test construct

Positioning Remote Mic In Test Box for Directional Testing of Right HA

Placement of Coupler Mic Assembly Outside of the Test Box
DIRECTIONAL MEASUREMENT TROUBLESHOOTING

No Curve Separation

- Possible Causes:
  - Intensity level may be inadequate
  - SNR may need to be decreased
  - HA placement may be incorrect
  - The directional mic feature of the aid has not been activated
  - One or more mic ports are plugged with debris
  - The directional mic is not working
Curves Are Reversed (when not expected)

- Possible Causes:
  - HA placement may be incorrect (backward)
  - Directional mic is incorrectly wired

Poorer Curve Separation Than Initially Benchmarked

- Possible Causes:
  - HA placement may be incorrect or different
  - Current coupling ≠ original coupling
    - Slit leak
  - One or more mic ports are compromised by debris
  - Microphone drift

Directionality Test (REM)

Rear speaker
Aided ear with probe tube positioned
Verifit in On-ear directional mode

Equal distance
CONSIDERATIONS REGARDING ON‐EAR DIRECTIONAL MIC TESTING

Venting

- Venting does effect directivity, especially at the low frequencies
- Best directivity with no vent
- Low frequency sounds pass through the vent w/out attenuation

RIC w Power Dome (On-Ear)
What is the impact of Venting?

- Data suggest that largest impact of vent in low frequencies (500 & 1000 Hz)
- Largest effect seen for open mold (OM)
- OM condition still resulted in significantly greater directivity than omnidirectional hearing aid
- Listeners receive significant directivity from many directional aids, regardless of venting
  - unless aid only provides directivity mainly in low frequencies
Mic Port Orientation

- Custom Products:
  - Modeled (or marked) representation of the horizontal plane for mic port placement on faceplate
  - May be difficult to achieve in some ears
- BTE Products:
  - Horizontal positioning will be influenced by:
    - Earmold tubing length (BTE)
    - Receiver wire length (RIC)
    - Thin tube length (Thin tube)

Quantifying Mic Port Orientation


Mic Orientation Effects on DI

Relative to optimal (horizontal) mic port orientation
Summary

- D-mics remain the most effective approach to "headworn" SNR improvement
- Through Audioscan’s unique real-time independent analysis test, a great deal of practical clinical information can be obtained about D-mic functionality
- Test-box D-mic testing is both stable and robust
- On-Ear D-mic testing can be done with consideration of additional factors
Thank You!

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