Critical Review: Is there Evidence that Asymmetric Microphone Fitting Strategies Provide More Benefit Compared to Traditional Directional Microphone Fittings?

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This critical review examined the current literature regarding the efficacy of use of asymmetric directional microphone fitting strategies as compared to traditional bilateral directional hearing aid fittings. Each of the three studies employed within-group experimental designs. Overall, the research findings indicated that traditional directional fittings continue to represent the most effective strategy for improving the signal-to-noise ratio (SNR) when listening to speech in background noise. However, the asymmetric microphone fittings showed significant improvements in SNR when compared to omni-directional fittings, representing a possible fitting strategy for hearing aid users who are not able to benefit from bilateral directionality. Research evidence in this area was recent and limited. Further clinical and field trials are required.

Introduction

For years, hearing aid users, Audiologists, and hearing instrument manufacturers have struggled to develop technologies and strategies to cope with the difficulties of understanding speech in background noise. This difficulty is a significant and recurring complaint from hearing aid users and represents a major factor in hearing instrument return rates and non-use.

Directional microphone technology has been available for many years and represents a strategy to deal with the problem of background noise. Research into the efficacy of directional microphones indicates that there is a definite advantage over omni-directional microphones in improving the signal-to-noise ratio (SNR) for the user in background noise. Directional microphones are most effective when the speech source is located directly in front of the listener and the noise is behind.

A drawback to directional technology is that users must either manually switch the device to directional mode when they encounter a noisy environment, or they must rely on the automatic switching algorithm of the hearing aid that is based on an analysis of the acoustic environment. Research has shown that for people with manual switching devices, 33% never make use of the directional technology (Cord et al, 2002), perhaps due to cognitive or dexterity limitations, or related to failure to recognize the environments in which the technology would be useful. Research into automatic switching devices shows that many devices are failing to correctly identify the acoustic environments and are, therefore, switching to directional response at inappropriate times.

Because of these problems with directionality, several researchers have begun exploring if fitting patients with an asymmetric strategy, where one hearing aid is omni-directional and the other aid uses a directional program, will provide the same benefits of bilateral directionality, while minimizing the aforementioned limitations.

This is newly emerging research and is limited to adult hearing aid users. For this critical review, three studies were found that explore the effectiveness of asymmetric microphone fittings compared to traditional microphone fittings. These studies can be used to guide the Audiologist in providing a client with a useful strategy for listening in background noise.

Objectives

The purpose of this review is to critically evaluate existing literature regarding the effectiveness of asymmetric microphone fittings in hopes of informing clinicians of solutions or strategies to help patients cope with the problem of listening in background noise.

Methods

Search Strategy

Computerized databases, including CINAHL, and EMBASE, were searched using the following search strategies:

> ((Asymmetric microphones) OR (asymmetrical microphone)) AND ((hearing aids) OR (hearing aid fitting)).

The search was limited to articles written in English.

This strategy was effective in identifying one article. Two other articles were found using article referencing of the first paper.

Selection Criteria

Studies selected for inclusion in this critical review were required to directly compare asymmetric microphone fitting strategies with traditional directional fittings. Because of the newness of the research question, no limits were set on the demographics of research participants, outcome measures, or methodological design.

Data Collection

Results of the literature search yielded the following types of articles congruent with the selection criteria: Within-subjects experimental design (3).

Results

Hornsby and Ricketts (2007) explored the benefits of using bilateral processing, as opposed to an asymmetric fitting, in environments where the primary speech and noise sources come from different directions. This was achieved by measuring aided speech understanding in noise using the Hearing In Noise Test (HINT) under twelve different experimental conditions: 3 noise source configurations (speech front/ noise surround, speech front/ noise side, speech side/ noise side) and 4 hearing aid conditions (bilateral omnidirectional (OMNI), bilateral directional (DIR), OMNI right/ DIR left, DIR right/ OMNI left).

The noise sources were developed to represent real-life listening situations, including cafeteria babble and traffic noise.

Sixteen adult subjects with mild to severe sensorineural hearing loss (SNHL) participated in the study. Participant selection criteria was not provided by the authors, and thus, recruitment cannot be assumed to be random. Subjects were all experienced hearing aids users and demographic and audiologic information was provided by the authors. The participants were all fitted bilaterally with Siemens Triano P BTE hearing aids, which can operate in both omnidirectional and adaptive directional modes. The subjects were fitted at the time of testing and were not given time to acclimatize to the use of the hearing aids.

Hearing aid conditions were randomized during each of the noise conditions and presentation order of the noise condition was systematically varied between individuals. Each condition was evaluated using two 10 sentence HINT lists, with no overlap of test sentences.

A series of single factor and two-factor, repeated measures analysis of variance (ANOVA) were performed to determine if performance in various hearing aid conditions varied across noise conditions and to compare performance across microphone modes within each noise condition. The general findings showed that speech recognition in noise for the first two noise conditions (speech front/ noise surround, speech front/ noise side) was poorest in the omnidirectional conditions and performance significantly improved in the bilateral directional mode. Performance was also significantly better when directional processing was used only in one ear (i.e. asymmetric fitting), through not as strong as the bilateral directional strategy. Finally, in the third noise condition (speech side/noise side), performance was best for omnidirectional processing, with bilateral directionality performing significantly poorer. The asymmetric fitting was also poorer than OMNI, though significantly better than the bilateral DIR.

The results of this study suggest that although there is a directional benefit with an asymmetric fitting, a bilateral directional processing strategy optimizes speech understanding in noise when speech comes from the front and noise from the sides or behind. When the speech is located to the side of the listener, using directional processing on the ear adjacent to the speech dramatically reduces speech understanding.

Cord, Walden, Surr, and Dittberner (2007) investigated whether the potential benefit of an asymmetric fitting observed in the laboratory extends to real-life listening situations. This multi-stage experimental design included an initial laboratory screening for directional benefit, followed by a field experiment, as well as a subjective measure using Hearing Aid Use Logs (HAUL). The main objective of this research was to determine if patients who have manually switching hearing aids and who do not make use of the directional program can benefit from an asymmetric fitting.

Twelve subjects fitting the researchers' selection criteria participated in the study. All subjects were adults with bilateral symmetrical SNHL. All were experienced and regular users of manually switching hearing aids, but were deemed failures of directional processing, as indicated by their lack of use of the directional program. Subjects were excluded from participating if they were unlikely to encounter situations in everyday life in which directional processing would provide benefit. Participants wore their own hearing aids for this study, representing a variety of manufacturers and styles.

A speech recognition in noise screening was completed initially with hearing aids set to binaural OMNI and binaural DIR to confirm that each subject could in fact obtain a directional advantage. SNR was adjusted in 3dB steps starting at 0dB until a minimum 15% directional advantage was obtained.

Tests of speech recognition in noise were completed using Harvard Sentences for four hearing aid conditions (binaural OMNI, binaural DIR, OMNI right/ DIR left, DIR right/ OMNI left). The speech came from a speaker located directly in front of the participant and the noise came from three speakers placed around the participant at 90, 180, and 270 degrees azimuths. Testing was randomized across word lists and test conditions and the SNR used for testing was the SNR obtained for each subject during the initial screening.

Following testing, subjects were sent home for a 2-3 week trial period with their hearing aids set to either binaural OMNI, or asymmetric (ASYM). Subjects were asked to fill out a Hearing Aid Use Log to record the listening situations they encountered in everyday life for the duration of the trial period. The forms were used to record the characteristics of every 'active' listening situation encountered in a given time period.

A repeated measures ANOVA comparing Harvard Sentence scores for the four conditions indicated a significant main effect. Post-hoc comparisons revealed that the binaural directional and the two asymmetric conditions did not differ significantly from one another. Performance in noise with a bilateral omnidirectional setting was significantly worse than all three other conditions.

Based on the HAUL data, there was a small but significant difference favouring the asymmetric microphone condition. Though not significant for all subjects, no one preferred OMNI significantly more than ASYM.

Overall, the results of this experiment suggest that an asymmetric fitting may be a viable option for patients who cannot or do not switch programs to take advantage of directional benefits.

The final study by Mackenzie and Lutman (2005) took a different approach. Specifically, their study was designed to evaluate adaptive directional processing strategies under a wider range of loudspeaker positions, with a particular focus on asymmetric listening conditions. The authors predicted that because of the asymmetric listening conditions often encountered in everyday listening, automatic switching hearing aids operating independently will select different directivity patterns, similar to an asymmetric microphone fitting.

Sixteen experienced adult hearing aid users with moderate symmetrical SNHL were recruited to participate in this study. All subjects were fitted bilaterally with Phonak Claro BTE hearing aids using the Phonak Fitting Guide 7.2. Subjects were counselled on manually selecting a microphone strategy depending on the environment and were then given five weeks to acclimatize to the hearing aids.

Following the trial period, subjects' aided speech recognition in noise was evaluated using BKB sentences in an anechoic chamber under 25 different noise and hearing aid conditions. Speech was always presented from the front and the noise source varied from eight loudspeaker locations to represent different listening conditions. Subjects were tested twice, with each testing session separated by at least one week.

Results showed that all directional settings, including asymmetric fitting performed significantly better than the omnidirectional fitting. Directional processing performed significantly better than both asymmetric conditions.

Conclusions

It appears from these initial studies that there is a common agreement that bilateral directional microphones provide a significant benefit when listening in a noisy situation, provided the noise is located behind the listener and the speech in front. All three studies did show a significant directional advantage for an asymmetric fitting over omnidirectional, although not as large as the bilateral directional strategy.

Recommendations

The use of directional processing continues to be the most effective strategy to combat the problem of speech understanding in background noise. However, despite its potential, many hearing aid users are not able to, or will not, take advantage of directionality.

Based on a critical appraisal of the research into asymmetric microphone fittings, this may represent a way to provide directional benefits to the some 33% of people who are not making use the directional strategies available to them, for whatever reason. The directional advantage may not be as significant as a traditional bilateral fitting, but it is still better than the full omnidirectional program that many of these people are limiting themselves to. Any improvement in ease of listening in background noise is likely to improve patient satisfaction with the hearing aids, increase the likelihood of a patient continuing to use

amplification, as well as reduce the return rate of hearing aids.

The challenge for making the asymmetric fitting strategy viable clinically will be in determining which ear to fit with omnidirectional processing and which ear to fit with directional processing. It may be possible to do SNR testing for each ear to determine which ear can provide the user with a greater directional advantage, and therefore fit the directional hearing aid to that ear.

This represents an area for further research. It would be interesting to observe results from real patients in a clinical environment in order to see if implementing an asymmetric strategy for a patient who is not benefiting from traditional directional processing is beneficial.

Research in this area is ongoing and emerging. At the time of this paper, there are several articles in press that further explore the efficacy of an asymmetric microphone fitting strategy.

An alternative way of dealing with the problems with directionality would be to further investigate the reasons for people's failure to use their directional processing strategies. Addressing this issue would enable all users to benefit from directional microphone technology. Making all hearing aid users successful directional users would essentially render the issue of asymmetric microphone fittings moot.

References

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