Critical Review:
How Effective are Asymmetrical Hearing Aid Fittings for Comprehension of Speech in Noise?

Leelan Pearson
M.Cl.Sc. (AUD) Candidate
University of Western Ontario: School of Communication Sciences and Disorders

Asymmetrical hearing instrument fittings have been proposed as a method of deriving both the localization benefits of omnidirectional hearing instruments and the directional benefits of comprehension of speech in noise simultaneously and continuously. This critical review examines the comprehension of speech in various noise environments with asymmetric hearing instrument fittings relative to binaural omnidirectional and directional fittings in adults with bilaterally symmetrical sensorineural hearing loss. Based on critical review of three peer-reviewed studies, it was found that asymmetrically fitted hearing instruments performed significantly better then binaural omnidirectional hearing instruments and equivalently or only slightly poorer than binaural directional hearing instruments for comprehension of speech in noise. Although more research is required to assess localization and sound quality in asymmetric fittings, there may be instances where asymmetrical fittings are a viable option when prescribing hearing instruments.

Introduction

The benefits of using directional technology in hearing instruments to improve speech comprehension in noise are well established (Hornsby and Ricketts 2007). Similarly, many studies have demonstrated improved localization and speech understanding in noise with binaural hearing and bilateral amplification for people with hearing loss (Hornsby and Ricketts 2007). Taking these facts into consideration, many individuals would be surprised to learn that recent research has found that similar speech recognition performance in noise can be achieved with asymmetrically fit hearing aids as with bilateral directional technology (Hornsby and Ricketts).

Although there is an advantage to binaural directional processing in noise, for most other listening environments an omnidirectional microphone setting is preferred. Most hearing aids equipped with directional microphones are switchable between an omnidirectional and a directional mode, where the default setting is the omnidirectional mode (Cord *et. al.* 2007). In general, the default setting and the directional mode are accessed through a switch or with a remote control (Cord *et. al.* 2007). Here in lies the potential benefit of an asymmetrical hearing aid configuration. For one, when someone has multiple programs with a manual switch they must push a button to switch modes, however, this draws unwanted attention to their hearing aid, is dependent on them remembering to switch programs, and the individual must know when is an appropriate environment to switch programs.

If the hearing aid switches automatically, then the person must listen to the program that the algorithms select, which may not be the individuals preference. In addition, in many cases the current automatic switching algorithms do not select the appropriate microphone mode (Cord et. al. 2007). This is probably due to the fact that environments are dynamic rather than static, with individuals in motion within their environment (Cord *et. al.* 2007). Also, some users of automatic switching hearing aids dislike the fact that there is an audible alteration in the sound of their hearing aids as it switches programs. Thus, if asymmetrical hearing aid fittings were as effective as traditional hearing aid fittings, and the user did not notice the asymmetry between the two hearing aids, then this technology would alleviate the problems individuals currently have with manual and automatic programmable hearing aids. In addition, because asymmetrical technology does not require multiple programs it may actually be less costly to manufacture. Thus, asymmetric directional microphone fittings may be a viable option for those who have difficulty adapting to hearing instruments with multiple programs.

Objectives

The primary objective of this review is to critically evaluate existing literature examining if adults with bilaterally symmetrical sensorineural hearing loss have equivalent speech understanding in noise when fitted asymmetrically with hearing aids as when fitted binaurally with either directional or omnidirectional microphone programs. Outcomes of the studies in this proceeding will allow for evidence based recommendations to be made for individuals who fail to adapt to hearing instruments with multiple programs.

Methods

Search Strategy

Computerized databases including SCOPUS, CINAHL, and PubMed, were searched using the following strategies:

> ((asymmetrical) OR (asymmetric) OR (asymmetric directional)) AND ((hearing aids) OR (hearing instruments)) AND ((noise))

The search was limited to articles written in the English Language that were published after the year 2000. Some articles were retrieved by reviewing the references of relevant articles.

Selection Criteria

Studies selected for inclusion in this critical review were required to investigate speech recognition in noise using binaural hearing instruments in asymmetric directional, binaural omnidirectional, and binaural directional microphones settings. Participants in the studies were required to be adults with symmetric sensorineural hearing impairment. There were no restrictions on demographics of the subjects or outcome measures.

Data Collection

The aforementioned search and selection strategy yielded a total of three peer-reviewed journal articles. There were two within group counterbalancing studies and one single group pre-post test that also contained an experimental survey research.

Results

Effects of Noise Source on Directional Benefit

Hornsby and Ricketts (2007) objectively evaluated the speech recognition in noise ability of sixteen adults (23-82 years) with symmetric sensorineural hearing impairment. Participants had a vast array of hearing aid experience.

Aided speech understanding in noise was assessed in an adaptive manner using the Hearing in Noise Test in three conditions: (1) speech in front, noise diffuse; (2) speech in front, noise from the left; and (3) speech from the right, noise from the left. Under each speech in noise condition four bilateral hearing aid configurations were assessed: binaural omnidirectional, binaural directional, asymmetric with directional processing on the left ear, and asymmetric with directional processing on the right ear. Siemens Triano P behind-the-ear (BTE) hearing instruments were used coupled to custom earmolds with pressure vents. Adaptive directional processing, rather than fixed directional processing was used.

Statistical analysis revealed significantly better performance with asymmetric configurations compared to bilateral omnidirectional configuration for the two noise conditions where speech was presented from the front. Bilateral directional processing was significantly better than asymmetric configurations when noise was diffuse. In the third condition, binaural omnidirectional processing was significantly better than bilateral directional or asymmetric fitting when the directional microphone was on the side of the speech.

The study conducted by Hornsby and Ricketts (2007) used a valid experimental design. However, demographic characteristics of the participants were diverse considering the sample size and no experimenter or participant blinding was used.

Speech Recognition and Comfort

The study conducted by Mackenzie and Lutman (2005) was aimed at investigating speech comprehension in noise and subjective opinion of sound quality and comfort under various hearing instrument configurations. The sixteen participants (65-84 years) had moderate symmetrical sensorineural hearing impairment and over one year hearing instrument experience either binaurally or unilaterally. In addition, fourteen unaided normal hearing individuals participated in the experiment.

Aided speech comprehension in noise was conducted in anechoic conditions while hearing impaired participants were aided with Phonak Claro BTE instruments in five hearing instrument configurations: binaural omnidirectional, binaural fixed directional, binaural adaptive directional, asymmetric with adaptive directional processing on the left ear, and asymmetric with adaptive directional processing on the right ear. Prior to data collection, participants were given at least four weeks to adapt to the hearing instruments, which were manually switchable between binaural omnidirectional and binaural adaptive directional microphone settings. Adaptive sentence recognition in noise was conducted with speech coming from in front of the listener while Gaussian noise was presented from five noise source configurations: noise from front, noise from back, noise from both sides, and noise presented asymmetrically ($170^o + 240^o$ or $120^o + 190^o$). Each participant had two trial sessions separated by one week, where hearing aid configuration and noise conditions were randomly selected. Participants were asked to rate comfort, speech loudness, noise loudness, and speech clarity in each noise condition and hearing aid configuration directly after each test condition.

Results from the study revealed no statistically significant difference in hearing aid configuration when both noise and speech were presented from in front of the listener. In all other noise conditions binaural omnidirectional microphones performed significantly worse than any of the other hearing instrument configurations. When noise was presented from behind the listener the binaural adaptive directional configuration performed the best, while binaural fixed directional and asymmetrical conditions were not significantly different. When noise was presented to the sides asymmetric and binaural adaptive directional configurations performed significantly better than the binaural fixed directional configuration. In the asymmetric noise condition all hearing aid configurations were equivalent. Quality ratings revealed a general trend of binaural adaptive and fixed directional hearing aid configurations as being perceived as quieter and in some cases more comfortable than binaural omnidirectional or asymmetrical hearing instrument configurations.

Mackenzie and Lutman (2005) used a valid experimental design in this study. However, adaptation to the adaptive directional configuration may have biased the quality ratings. Also, no experimenter or participant blinding was used.

Field Evaluation of an Asymmetric Directional Microphone Fitting

Cord *et. al.* (2007) directly compared satisfaction of asymmetrically fitted hearing aids to binaural omnidirectional hearing instruments, in addition to assessing speech comprehension in noise. Twelve adults (56-82 years) from the Army Audiology and Speech Center's patient population with moderately-to-severe bilaterally symmetric sensorineural hearing impairment participated in the study.

Aided speech comprehension in noise using the Institute of Electrical and Electronic Engineers/Harvard sentences was conducted using the clients own hearing instruments in four hearing aid configurations: (1) binaural omnidirectional, (2) binaural directional, (3) asymmetrically fitted with directional processing on the left ear, (4) asymmetrically fitted with directional processing on the right ear. Speech was presented from the front while noise was presented from the right, left, and behind the listener simultaneously. In addition each participant was fitted with asymmetrical and binaural omnidirectional hearing instrument configurations for seven days each while completing the Hearing Aid Use Log (HAUL) once per day. The HAUL was used to assess subjective measures of performance and describe listening situations.

Statistical analysis revealed significantly better performance with all hearing instrument configurations when compared to the binaural omnidirectional configuration. All other hearing instrument configurations were not significantly different. Based on the HAUL, there was a general preference for the asymmetrically fitted hearing aid configurations, particularly in environments where directional processing is generally favoured. In addition, asymmetrical fittings did not negatively impact environments that are generally preferred by omnidirectional processing.

Cord et. al. (2007) utilized a valid experimental design in this study. Although, asymmetrically fitted hearing aid configurations were fitted with both adaptive directional and fixed directional processing. Also multiple hearing instrument styles were used in the experiment.

Conclusion

The results of the aforementioned studies give credence to the efficacy of asymmetric hearing instrument fittings for comprehending speech in noise. In all of the studies similar conclusions regarding speech comprehension in noise with asymmetrically fitted hearing instruments were found. Although flaws were evident within each study design, the fact that the results were similar in all three studies despite the differences adds to the strength of the overall conclusion. In nearly all noisy environments asymmetric fittings performed significantly better than binaural.omnidirectional microphones. Also, in all noise environments asymmetric directional microphone fittings performed equivalently or only slightly poorer then binaural directional processing for comprehending speech in noise. Therefore, asymmetric fittings are a viable option in situations where automatic programmable hearing instruments are not financially feasible and manual switchable hearing instruments are not likely to be used effectively.

Clinical Implications

Given the assembled research materials, there is sufficient evidence supporting the prescription of asymmetric hearing instrument fittings for particular populations. Individuals who have difficulty adapting to the audible switching of programs with automatic programmable hearing instruments may find relief with asymmetric hearing aid fittings, which are continuously in both a directional and omnidirectional mode. Other candidates would be people who cannot afford automatic programmable hearing instruments but would not be able to appropriately monitor their environment to effectively use manually switchable hearing instruments. This population may include people in the early stages of dementia or mental disability. Also, individuals who may not have the physical dexterity to push the program button on the hearing aid or do not feel technically savvy enough to effectively utilize the remote control may also be candidates for asymmetrically fitted hearing instruments. Some individuals may feel that pressing either the program controller or button on their hearing aid brings unwanted attention to their hearing instrument from other people, plus has them incessantly cognizant of the fact that they are wearing hearing aids. Perhaps the candidacy for asymmetric fittings would increase further if costs of asymmetrically fitted hearing instruments were made more affordable, due to the evident decrease in technology in comparison to hearing instruments with numerous programs and polar plot configurations. Although there are many individuals who may benefit from an asymmetric hearing instrument fitting, more research is needed to ensure patient satisfaction with asymmetric fittings.

Further research, both objective and subjective, should be carried out to make certain comfort, sound quality, and localization are all comparable to traditional hearing instrument fittings. Future research should be done with blinding and sufficient adaptation time to strengthen the results of the study. In addition, perhaps a study should be done to see if children, who are traditionally fitted with only omnidirectional processing, could benefit from asymmetric hearing instrument fittings.

References

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