Evaluating the Effectiveness of Using Different Directional Algorithms per Ear with Bimodal Solutions

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Smart Hearing Alliance

Abstract

Introduction: Directional sound processing provided by hearing aids (HA) and cochlear implants (CI) can enhance wearers' speech understanding while in complex listening environments[1,2,3]. GN ReSound and Cochlear™ devices each apply unique directional processing algorithms to help with speech understanding in noise, but the specific algorithms act independently. It is of interest to know whether people fit bimodally can benefit by having both distinct directional systems active while in complex listening environments. This study describes a clinical investigation that evaluated the effectiveness of utilizing different ear algorithms in bimodal systems to assess hearing outcomes of bimodal users in a laboratory and field settings.

Methods: This observational cohort study evaluated hearing outcomes with users' bimodal systems using speech in noise testing (AzBio Sentence Test) and a subjective hearing performance questionnaire (Speech, Spatial and Qualities Questionnaire (SSQ-12)). To evaluate the efficacy in the participants daily lives, an ecological momentary assessment (EMA) tool was also used. Nine adults with moderate to profound hearing loss in the aided ear participated in this study. All participants had at least 6 months of regular experience with their CI speech processor and were experienced HA users.

Results: Statistical analysis was performed using a one-way repeated analysis of variance (ANOVA). Statistically significant improvements in mean AzBio scores in quiet conditions were seen while wearing a bimodal system (default settings) compared to CI alone (p=<.02). Statistically significant improvements in mean scores were seen in both the +10 SNR and +5 dB conditions when using a bimodal directional program compared to CI alone (p=<.01, p=<.03, respectively). The results are hypothesized to be that utilizing bimodal stimulation in noisy environments can provide improvement over unilateral CI stimulation alone. This data also suggests that providing full access to sound in quiet by providing bimodal listening even in quiet environments can provide benefit over CI alone.

Conclusions: This study illustrates how ReSound ONE™ hearing aids and Nulceus®7/ Kanso® 2 sound processors each apply a unique directional processing algorithm. Despite being independent from one another, each can provide benefit to individuals who are fit with a Smart Hearing Alliance bimodal hearing solution. The ReSound ONE™ HA utilizing directional sound processing, in combination with Cochlear's™ ForwardFocus, can enhance users' speech understanding while in complex listening environments.

References:

1. Devocht EMJ, Janssen AML, Chalupper J, Stokroos RJ, George ELJ. The Benefits of Bimodal Aiding on Extended Dimensions of Speech Perception: Intelligibility, Listening Effort, and Sound Quality. *Trends in Hearing*. January 2017. doi:10.1177/2331216517727900

2. Gifford RH, Dorman MF. Bimodal Hearing or Bilateral Cochlear Implants? Ask the Patient. Ear Hear. 2019 May/Jun;40(3):501-516. doi: 10.1097/AUD.0000000000000657. PMID: 30285977; PMCID: PMC6447482.

3. Hoppe U, Hocke T, Digeser F. Bimodal benefit for cochlear implant listeners with different grades of hearing loss in the opposite ear. Acta Otolaryngol. 2018 Aug;138(8):713-721. doi: 10.1080/00016489.2018.1444281. Epub 2018 Mar 19. PMID: 29553839.

Methods

Characteristic	Mean (S.D.) (N=9)
Age at Implantation	58.2 years (±18 yrs) Range: 26-72 years
Gender	6 males (67%) 3 females (33%)
Duration of Hearing Loss	9.9 years (±4.7 yrs)
Right Ears Left Ears	67% 22%

Table 1

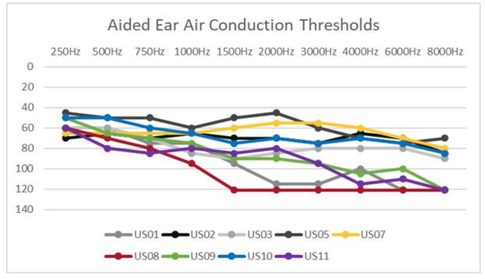

Figure 1

Participant demographic data is detailed in Table 1. Participant audiograms for the aided ear shown in Figure 1. Hearing aids were fit using the ReSound proprietary fitting prescription, Audiogram+, and programmed to the Smart Hearing Alliance bimodal default settings. Participants were given two hearing aid programs: Program 1 utilized Soft Switching Directionality as the directional microphone settings, while Program 2, "Restaurant", used Multiscope Adaptive Directionality manually set to narrow. The contralateral ear was fit with either a Cochlear™ Nucleus®7 or Nucleus® Kanso® 2 sound processor using Custom Sound® Pro Fitting Software with their stable MAP prior to the study and enabled Cochlear's™ ForwardFocus. Participants wore their hearing instruments and processors in their daily lives for two weeks.

AzBio Sentence testing was completed in a sound treated booth at both visits across three test conditions; speech in quiet, and two speech in noise (SIN) conditions. Speech was presented through a single loudspeaker from 0 degrees azimuth. For SIN conditions, competing background noise was presented as a ten-talker babble from speakers behind the participant from 90 through 270 degrees. Each condition consisted of one, 20-sentence list presented at 65 dBA in sound field, with SIN conditions presenting babble at 55 dbA (+10dB SNR) and 60 dBA (+5 dB SNR) in sound field. Speech recognition performance was compared across three hearing device configurations: CI alone, CI + HA and directional CI + HA. The SSQ-12 was administered at both visits. EMA mobile app (RealLife Exp) was downloaded to capture daily use information.

Results

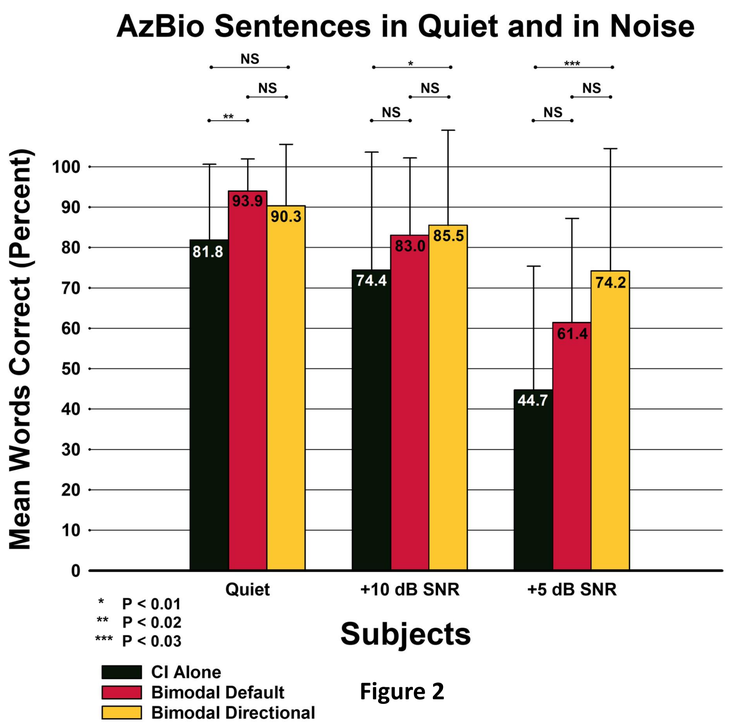

Figure 2

AzBio Results

Statistical analysis was performed utilizing a 1-way ANOVA. Figure 2 shows mean percent correct by listening condition (CI alone, Bimodal default, Bimodal directional), across all noise conditions (Quiet, +10 dB SNR, +5 dB SNR). Figures 3, 4 and 5 detail subject-specific performances in different listening conditions across noise conditions. Statistically significant improvements in mean scores in quiet were seen in bimodal default settings compared to the CI alone (p=.01). Statistically significant improvements in mean scores were seen in both the +10 SNR and +5 dB conditions when using a bimodal directional program compared to CI alone (p=.006, p=.026).

SSQ-12 and EMA Results

The SSQ-12 was administered to all participants on the first fitting appointment and the last appointment. Responses were averaged and the mean score for each subsection were calculated, and results are shown in Figure 6. Paired t-tests revealed no significant differences. Overall results for the EMA data indicate that users were satisfied while wearing their bimodal system (Figure 7). When users were asked how tired they felt by the end of the day, 45% reported they were not tired at all, 30% reported being only a little tired and 26% reported feeling moderately tired (Figure 8).

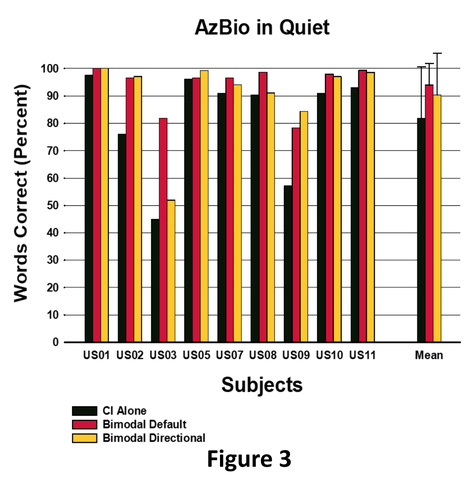

Figure 3

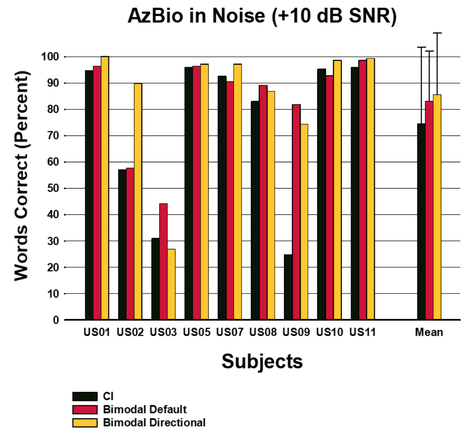

Figure 4

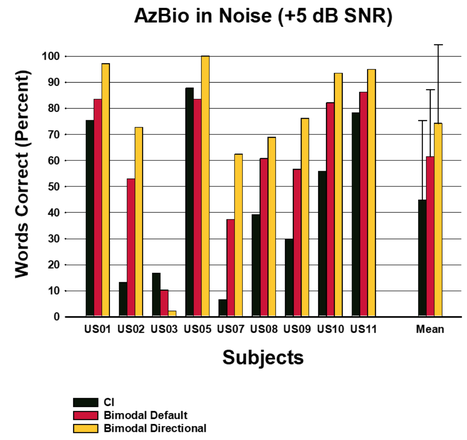

Figure 5

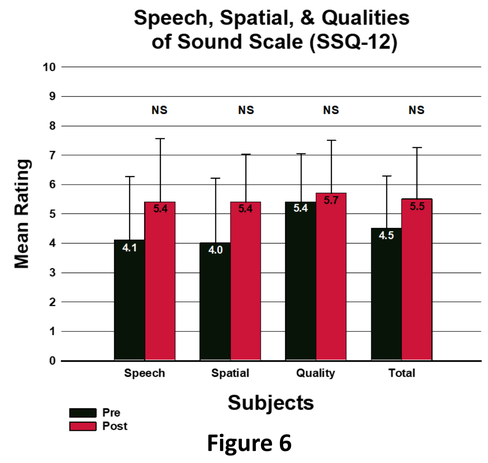

Figure 6

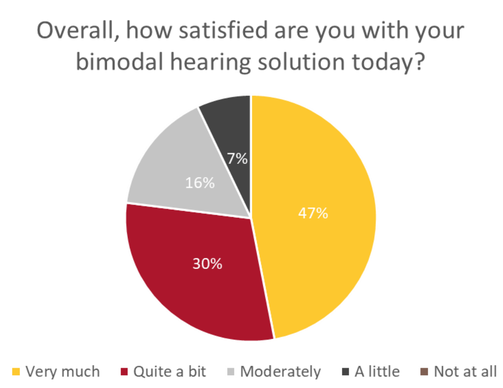

Figure 7

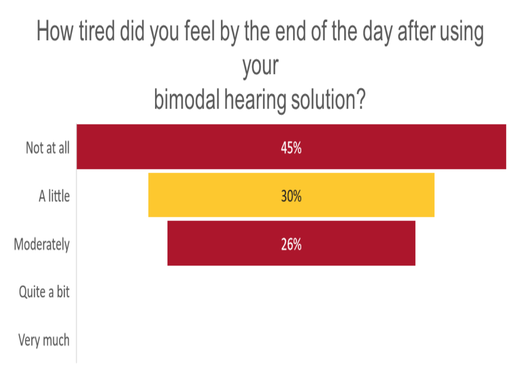

Figure 8

Discussion

Results showed a significant bimodal advantage evident at +5 dB SNR and +10 dB SNR compared to CI alone. Results were less impacted by ceiling effects in +5 dB SNR test condition, and 8 of 9 participants' best score was achieved using the bimodal solution. Participants did not always perform best using directional settings, but participants generally performed better in the bimodal solution than with a cochlear implant alone. Notably, one subject appeared to show a bilateral disadvantage in the directional settings which should be considered in further habilitation. Limitations to the study included having a small sample size and ceiling effects likely impacted the results of the AzBio scores in Quiet and at +10 dB SNR.

Conclusion

The Smart Hearing Alliance bimodal solution has shown to provide better speech understanding in the presence of noise over a cochlear implant alone. While the use of directional sound processing in the ReSound ONE™ and Cochlear's™ ForwardFocus showed further improvement in sound field testing, the most benefit was seen when a bimodal solution was utilized. Having a psycho-social domain for clinicians to analyze allows a collection of real-world information about situations that are relevant to the user and can gain valuable information about dimensions beyond speech understanding which can affect communication.