Comparison between Outcomes Using Preferred Gain and Prescribed Gain Formulae in Children Using Hearing Aids

[1]Vivek Somaraj & [2]Vijaya Kumar Narne

Abstract

Comparison between the preferred and the prescribed (DSL[i/o], NAL-NL1) hearing aid fitting formulae was assessed in children. Ten children diagnosed as profound sensori-neural hearing loss and between the age range of 6-12 years participated in the study. Using the REUR data and REAR data, the REIG (Real Ear Insertion Gain) data was calculated for each subject at each frequency for all the three conditions. Statistical analysis of the data revealed that, REIG provided by preferred gain is approximately similar to NAL-NL1. Whereas gain prescribed by the DSL[i/o] is higher at low frequencies compared to preferred condition and gain prescribed by NAL-NL1.Comparison of the aided thresholds revealed that, DSL[i/o] has slightly lesser thresholds compared to NAL-NL1 and preferred condition.

Key words: *NAL-NL1, DSL [i/o], REIG, preferred gain, aided thresholds*

Introduction

Technological advancement, has led to substantial research in the all areas including that of aural rehabilitation and surely, hearing aids are no exception. Various non-linear hearing aids are now available with complete digital technology. These non-linear hearing aids provide flexible adjustments to meet the desired amplification requirements for hearing impaired individuals, as individuals with sensori-neural hearing loss experience an abnormal growth of loudness perception with the increase in input levels, these devices offer an excellent solution for their problem. They provide relatively more amplification for soft sounds and less amplification for loud sounds without manual manipulation of the volume control switch.

Prescriptive procedures for nonlinear hearing aids are based upon different underlying rationales. The idea behind these procedures is either to normalize loudness so that loudness recruitment can be compensated or to maximize speech intelligibility at various input levels (Byrne, 1996). Some of these fitting procedures use threshold and some others use supra threshold measurements as input data (Smeds, 2004). Threshold based procedures are mainly NAL-NL1 (Dillon, 1999; Byrne, Dillon, Ching, Katsch, &Keidser, 2001), FIG6 (Killion & Fikret-Pasa, 1993), and partly DSL[i/o] (Desired Sensation Level Input-Output, linear compression version; Cornelisse, Seewald & Jamieson, 1995). Supra threshold procedures are LGOB (Allen, Hall & Jeng, 1990), IHAFF (Cox, 1995) and partly DSL[i/o]. Among the procedures described above, most commonly used procedure for prescribing hearing aids is NAL-NL1 (Dillon, 1999) and DSL[i/o] (Desired Sensation Level Input-Output, curvilinear compression version; Cornelisse, Seewald & Jamieson, 1995).

The prescriptive formulae, threshold based or suprathreshold based, gives the first approximation of gain required. Practical clinical experiences with prescriptive methods (Libby, 1986: Sullivan, Levitt, Hwang & Hennessey, 1988; Dillon, 2001) show that the methods cannot eliminate the need for individual allowances and adjustments i.e. fine tuning of hearing aid. However, one should bear in mind that fine tuning of gain settings in the hearing aids is performed on prescribed gain. The prescribed gain should be a good approximation to preferred gain, which reduces the trial and error by the clinician and also saves time (Dillon, 2001).

Ching, Scollie, Dillon, Seewald, Britton,Steinber, Gilliver, & King, (2010) assessed 48 children from Australia and Canada for preference of prescriptive procedures in various conditions. Results demonstrate that, majority of children in Australia preferred NAL-NL1 for 65 dB input level and 80 dB input level and in any other situations. In contradiction to this, children from Canada preferred DSL v.4.1 for any conditions. Similar to these, Seewald, Moodie, Scollie & Bagatto, (2005) demonstrated that preferred gain in children was similar to DSL[i/o] when compared to other prescriptive procedures. Majority of these children were initially fitted with DSL[i/o] program. Similar to this, many other investigators also demonstrated similar results (Scollie, Seewald, Moodie & Dekok 2000; Ching, Hill, & Dillon 2008). The common theme noticed in these studies is that children preferred the hearing aid gain settings that have been prescribed in

[1]E-mail: viveksomaraj@yahoo.co.in; [2]Lecturer in Audiology, E-mail: vijaynarne@gmail.com

the initial fitting. All the above studies comparing preferred and prescribed gain were performed on western population. Till date, there is a dearth for studies comparing preferred gain and prescriptive gain settings in Indian context.

Method

Participants

Ten participants (18 ears), having sensori-neural hearing loss who had been clinically diagnosed as having cochlear hearing loss at department of Audiology, All India Institute of Speech and Hearing, Mysore participated in the present study. All the participants were regular hearing aid users; the minimum duration of hearing aid use is more than one year. The age of the participants ranged from 6 to12 years with the mean age of 7.5 years. Pure tone average ranged from 93 to 110 dBHL. It was ascertained from a structured interview that none of these participants had any history of neurologic or otologic disorder. The pure-tone thresholds (average of both the ears) at octave frequencies of each participant have been provided in Figure 1.

The demographic and audiological data of the participants, which includes degree of hearing loss, speech detection threshold, hearing aid being used and the duration of hearing aid use is given in the Table 1.

Procedure

Pre-testing procedure: On Otoscopic examination, all participants had ear canals that were free from cerumen, debris or foreign body. This was followed by estimating audiometric thresholds for Air Conduction at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz and Bone Conduction at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz using Modified Hughson and Westlake procedure (Carhart & Jerger, 1959). The thresholds obtained were compared with pure-tone thresholds obtained prior to the first hearing aid fitting using Orbiter OB-922 (Madsen Electronics, Denmark), two channel diagnostic audiometer calibrated with supra aural head phones (Telephonics TDH-39), bone vibrator (Radio ear B-71). None of the participants had a shift in their threshold by more than 10 dB in air conduction or bone conduction mode in any of the frequencies. All the subjects had normal middle ear functioning and the same was confirmed by testing with GSI-Tympstar Immittance meter.

Aided threshold: Aided thresholds were found for puretone of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz, using preferred gain setting initially and the similar procedure was carried out using NAL-NL1 and DSL[i/o]. Puretones were presented through loudspeakers (Madsen) placed at ear level, 0^{o} azimuth and at a distance of 1 meter.

Speech detection threshold: Speech Detection Threshold was assessed using live voice presentation. The minimum intensity at which the subjects were able to detect the presence of sound was found. Speech was presented through the loud speakers placed at ear level, 0° azimuth and at a distance of 1 metre.

Real ear measurements

Real ear unaided response (REUR): FONIX 7000 hearing aid analyzer was used to check the electro-acoustic characteristics of the hearing aid and also the real ear aided gain (REAG) measurements. This was measured using Digispeech as the stimuli at an input of 65 dBSPL. The loudspeaker was kept at a distance of 12 inches and at 45 degree to the pinna (as specified in the FONIX 7000 user manual). A probe microphone was placed inside the subject's ear at a distance equal

Figure 1: Pure-tone thresholds as a function of frequency for all the participants

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Table 1: Demographic and audiological data of participants with cochlear hearing loss

Sl. No.	Age/Gender	Pure Tone Average (dB)		Speech Detection Threshold (dB)		Hearing aid model	Duration of HA use
		Right	Left	Right	Left		
1	6/F	-	100	-	75	Eclipse 2SP	24 months
2	6/M	101.66	101.66	85	85	Eclipse 2SP	18 months
3	12/M	98.33	93.33	85	85	Eclipse 2SP	21 months
4	7/M	100	100	85	85	Eclipse 2SP	14 months
5	6/M	93.33	93.33	85	85	Eclipse 2SP	13 months
6	9/F	108.33	101.66	85	85	Eclipse 2SP	25 months
7	7/M	100	101.66	85	85	Eclipse 2SP	5 months
8	6/F	110	-	85	-	Eclipse 2SP	15 months
9	6/F	96.6	108.33	85	85	Eclipse 2SP	24 months
10	10/F	110	93.33	85	85	Eclipse 2SP	20 months

to the length of ear mould plus 5 mm. Before the stimulus was presented, levelling of the stimulus was done. The stimulus was presented and the output was represented in the form of a graph on the screen and once the graph on the screen was stabilized for more than 10 seconds, the input was stopped. Now, the graph was converted to real ear unaided scores and the values were noted down.

Real ear aided response (REAR): The subject's hearing aid was connected to the HIPRO using the programming cable and the HIPRO was connected to a personal computer for programming the hearing aid. The NOAH software (version 3.1.2) and the hearing aid specific software (Electone) along with Win CHAP (Computerized hearing aid programme for windows, Version 2.82) were installed in this computer. Once connected, the gain and program settings (preferred) in the hearing aid was noted down, and REAR was measured for the preferred gain. The values were noted down. The aided audiogram for the preferred gain was also found in free-field using OB-922 two channel diagnostic audiometer. The hearing aid was re-programmed using NAL-NL1, and the REAR was measured and the values were noted down. Aided audiogram was found for NAL-NL1. Similar procedure was done using DSL[i/o].

REAR was measured for the preferred, NAL-NL1 and DSL[i/o] gain settings in all the subjects using the FONIX 7000 hearing aid analyzer by using Digispeech as the stimuli at 65 dBSPL as the input. The loudspeaker was kept at a distance of 12 inches and at 45^o to the pinna (as specified in the

FONIX 7000 user manual). A probe microphone was placed inside the subject's ear at a distance equal to the length of ear mould plus 5 mm. Before the stimulus was presented, levelling of the stimulus was done. The stimulus was presented and the output was represented in the form of a graph on screen and once the graph onscreen was stabilized for more than

10 seconds, the input was stopped. The graph was then converted to real ear aided scores and the values were noted down. Comparisons across all the aided conditions were made and the results have been discussed in the next section.

Results and Discussion

Comparison of REIG: Using the REUR data and REAR data, the REIG (Real Ear Insertion Gain) data was calculated for each subject at each frequency for all the three conditions. This was calculated using the formula descried by Dillon (2001). REIG values were calculated only at octave and mid octave frequencies.

Real Ear Insertion gain (REIG) = REAG – REUG

(REAG =Real ear aided gain, REUG = Real ear unaided gain)

The Figure 2 represents the mean values of the REIG scores across frequency for all the three conditions at 65 dB SPL input signal. As it can be seen from the figure, there is a difference in the mean value across frequency in the three conditions. At the low frequency region, till about 800Hz, REIG values of DSL[i/o] condition is greater than preferred condition and NAL-NL1. In the same region, REIG is similar for NAL-NL1 and preferred condition. At mid and high frequencies, REIG scores for the DSL[i/o] condition is higher than those observed for NAL-NL1 and preferred condition. At the high frequency region, for DSL[i/o] and preferred condition higher REIG was observed compared to NAL-NL1. At the extreme high frequency region, the mean scores have dipped in all the three conditions because the frequency response of the hearing aid is limited up to 4000 Hz to 5000 Hz.

One-way ANOVA was carried out to find out if the mean difference of REIG scores is significant in the three conditions at all the frequencies. The data of 8 kHz was not considered in the analysis. The analysis revealed that there was a significant difference between the conditions at 250 Hz [$F_{(2,490)} = 1.133$, $p<0.05$], 500 Hz ($F_{(2,810)} = 1.005$, $p<0.05$), 1000 Hz ($F_{(2,862)} = 1.301$, $p<0.05$) input frequency, whereas for other higher frequencies no significant difference was noticed (2000 Hz, 4000Hz & 6000 Hz). Post-hoc Bonferroni analysis showed that there was no significant difference across conditions except, that the DSL[i/o] was different at 250 Hz, 500 Hz and 1000 Hz from other two conditions.

Results of the REIG indicate that preferred gain is approximately similar to NAL-NL1. Whereas gain prescribed by the DSL [i/o] is higher at low frequencies compared to other conditions. Ching et al., (2010), reported that DSL (v.4.1) always provides higher gain when compared to NAL-NL1. Further they also reported that majority of the children preferred gain prescribed by NAL-NL1 at 65 dB input level compared to DSL v.4.1. The results of the present study are in accordance that those observed by Ching, et al., (2010). Similar to the present study many other investigators also reported similar results (Ching, Newall & Wigney, 1997; Snik, Borne, Brokx & Hoekstra,1995; Ching, Hill, Birtles & Beecham, 1999). The precise reason for NAL-NL1 and preferred conditions is not known. A series of studies conducted by Ching, Hill, Birtles & Beecham, (2010) reported that children from the Australia preferred NAL-NL1 over DSL Version 4.1, on contrary, children from the Canada preferred DSL Version 4.1. These results show that, children's auditory system prefers the gain settings prescribed during initial fitting (may allow small variations), i.e. children in Australia by default prescribed with NAL-NL1, similarly children from Canada were prescribed with DSL Version 4.1. In the present study, almost all the participants were prescribed with NAL-NL1 in the initial fitting. Because of the above reason, there was no significant difference between gain settings of NAL-NL1 and preferred condition.

Comparison of aided audiogram

Figure 3 shows the mean aided thresholds as a function of frequency across conditions. One can note that DSL[i/o] has slightly lesser thresholds compared to NAL-NL1 and preferred. According to a study by Ching, et al., (2010), positive comments about listening to softly spoken speech as well as speech from a distance or behind were associated with DSL Version 4.1 than with NAL-NL1 (Ching, et al., 2010). Individual children in Australia consistently preferred either the NAL-NL1 prescription or the DSL Version 4.1 prescription across trial periods and across different preference measures. Those children preferring the NAL-NL1 prescription did so because they were less troubled by loud sounds and reported hearing speech better in situations where there were competing noises. Those children preferring the DSL Version 4.1 prescription did so because it enabled them to hear speech more loudly and/or clearly. They also reported better hearing for soft and distant speech as well as sounds within the environment.

Overall, the results demonstrate that the REIG scores for DSL[i/o] are higher at low and mid frequencies than preferred condition and NAl-NL1. At high frequencies, REIG scores of preferred condition were similar to gain prescribed by DSL[i/o]. Also, the aided thresholds for DSL[i/o] were better than the other conditions. Hence, the results of the present study warrant further research in this direction to cross-verify the results of the present study.

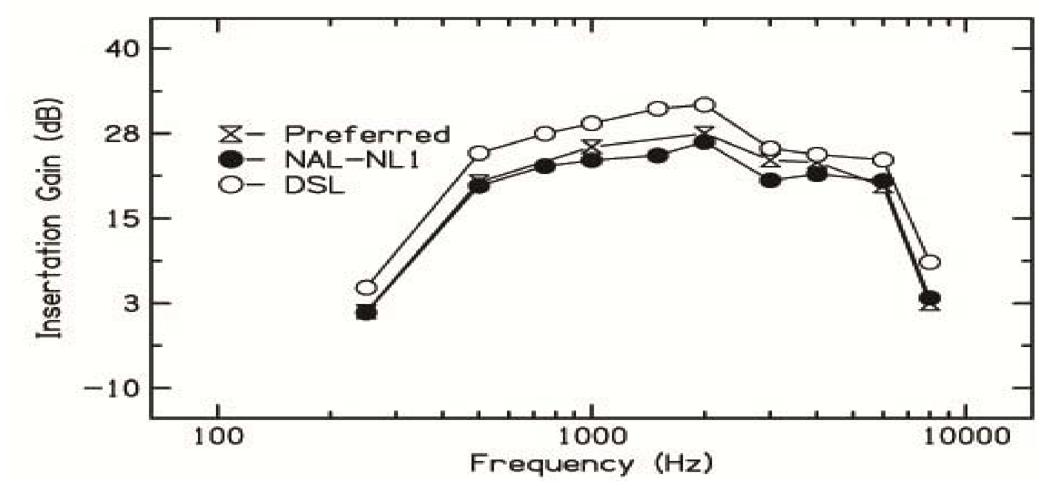

Figure 2: REIG values across frequencies for preferred, NAL-NL1 and DSL[i/o].

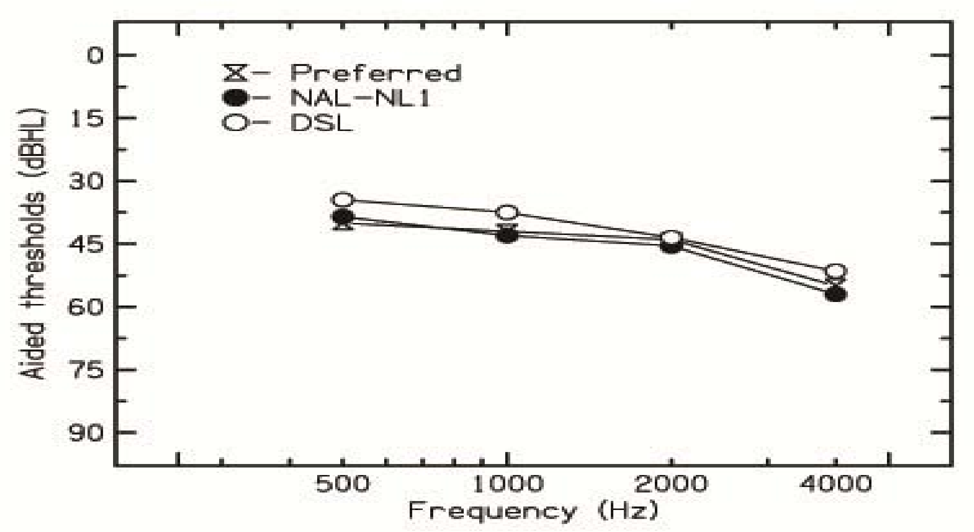

Figure 3: Aided thresholds as function of frequency for preferred, DSL[i/o] and NAL-NL1.

Summary and Conclusions

The results have shown that the gain prescribed by NAL-NL1 and the preferred gain settings is almost similar across frequencies. This may be due to the fact that during initial fitting, the hearing aid is programmed using NAL-NL1 and fine tuning is done based on the gain provided by NAL-NL1 during the initial fit. In children, usually fine tuning is a difficult process when compared to adults. This is because the clinician is not able to arrive at the precise threshold at different frequencies, because most often than not, the thresholds are established using behavioural tests in children. Hence, usually the gain given during the initial fit will be lower compared to the target gain prescribed. Also, DSL[i/o] provides overall higher gain when compared to NAL-NL1 and preferred during the initial fit only. So this could be the reason why DSL[i/o] have better aided thresholds.

Future Implications

The comparisons in the present study were done based on the data of ten subjects, only. Probably the study can be carried on further by comparing it using more no of participants and other variables like degree of hearing loss, different input levels, duration of hearing aid use, and researched up on.

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