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Relation Between Self-Reported Outcomes and Real-Ear Insertion Gain as a Function of Generic Fitting Prescriptions

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Background

Real-ear measurements (REM) are traditionally used as a tool to verify a hearing fitting. To fully understand the efficacy of a hearing aid it is essential to understand the relation between the individual real-ear insertion gain (REIG) and self-reported outcome measures. A large cohort study can provide insight into the effectiveness of current practices in hearing aid (HA) rehabilitation with respect to the fitted gain.

The aim of the study is to understand whether the differences in insertion gains from the first fit to generic prescriptions can predict the self-reported hearing aid outcomes for first-time and experienced hearing aid users. This will help explain the relationship between the prescribed gain and self-reported outcomes.

Methods and Materials

In the first work package of the Better hEAring Rehabilitation (BEAR) project, REMs were conducted on participants to observe the gain provided by the hearing aid and not verify the fit against a target.

REM was performed two months after the initial fitting during the follow-up visit. REM was performed in a standard clinical room with the signal presented from a loudspeaker 1-meter in front of the participants using the REM module (REM440) in Interacoustics Affinity 2.0. A total of 1684 real-ear measurements were extracted.

Bilaterally fitted participants with valid real-ear measurements and having answered all the questions in the International Outcome Inventory for Hearing Aids (IOI-HA) and short version of Speech, Spatial, and Qualities of Hearing (SSQ) questionnaires were considered in the analysis. The demographics of the 1231 participants considered are shown in Table 1.

	Number of participants N =1231
Mean age, years (±SD)	67.5 (11)
(range)	(19-100)
Gender, n (%)	
Female	718 (59)
HA experience, n (%)	
First-time users	895 (73)
Mean PTA, dB H.L. (±SD)	
Better ear	36(12)
Worst ear	42(13)
Fitting, n (%)	
Proprietary	1162 (94)
NAL-NL1	28 (2)
Others (NAL-NL2, DSL, and others)	41 (4)

Table 1: Demographic properties of the population under study.

As most of the participants were fitted with undisclosed manufacturer-specific proprietary prescriptions, we could not compare the hearing aid fitting to the actual targets. Instead, we choose to compare the REIG to four different generic prescriptions, namely, NAL-NL2, NAL-RP, one-third gain rule (OTG), and half-gain (HG) rule.

The gain differences from measured REIG and REIG prescribed by generic gain prescription were calculated. The differences were calculated at an input level of 65 dB SPL, which is considered a typical speech level.

Later these gain differences were clustered into two significant clusters using k-means clustering. Thus the assigned cluster can be a characterizing factor concerning the deviation from a given target.

Ordinal logistic (for IOI-HA) and linear regression (for SSQ) were performed. The independent variable included in the analyses were *age*, *gender*, *average pure-tone hearing thresholds* from 500 Hz to 4000 Hz (PTA), hearing aid experience (User Type; experienced and first-time users), *Word-Recognition Score* (WRS), interaural asymmetry defined as PTA difference > 10 dB hearing-loss between best and worst ear, the *average per day use time (HA usage time)*, and *type of acoustic coupling* (open, closed, semi-open, custom ear-mold, etc.).

The Figure 1 illustrates the design of analysis used in this study.

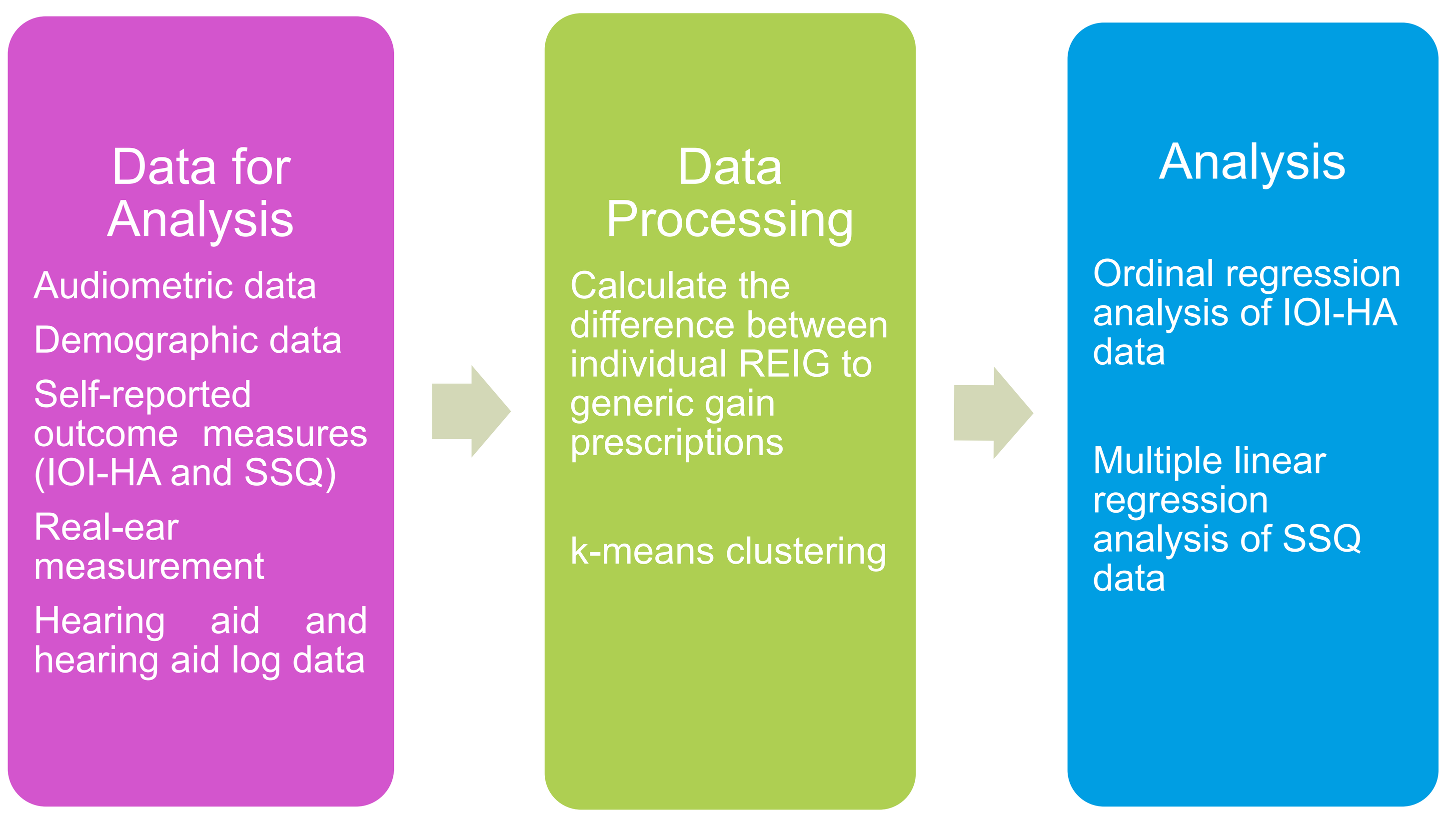

Figure 1: Schematic illustrating the study design

Results

The gain difference to generic prescription is determined, and the results are shown in Figure 2. It can be seen that individual REIG is very close to NAL-NL2. A distinctive dip at 1 kHz for gain difference to NAL-RP is evident. Gain difference to OTG also follows a similar trend to NAL-NL2 at higher frequencies.

The clustering of the gain differences resulted in two significant clusters in all the cases. It can be seen that clusters are characterized by the gain differences at higher frequencies starting from 1 kHz. This is illustrated in Figure 3.

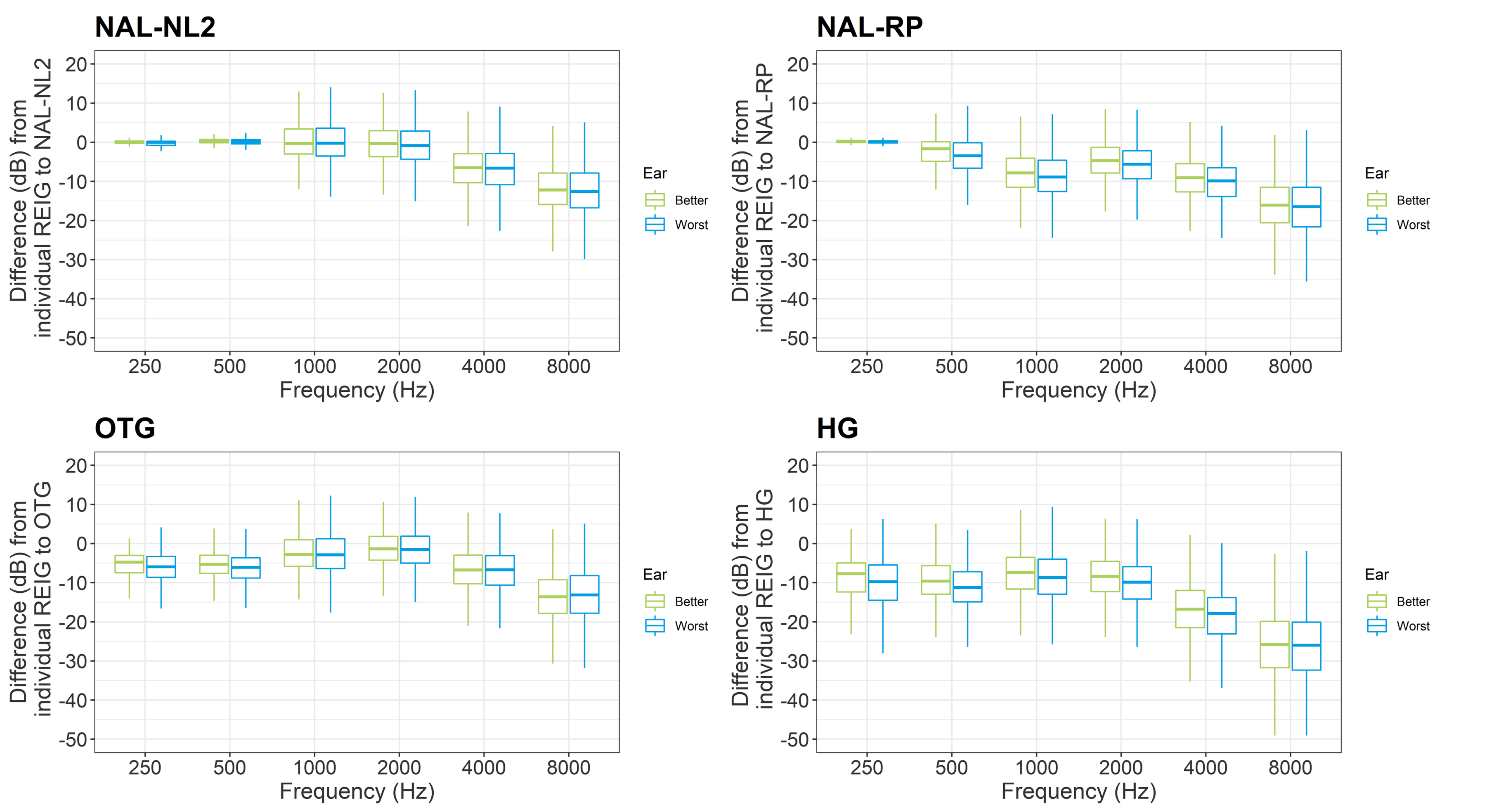

Figure 2: Boxplot showing the of difference in gain from individual REIG to generic prescription for a 65 dB SPL input. A value of 0 dB represents no difference between REIG and the generic prescription considered.

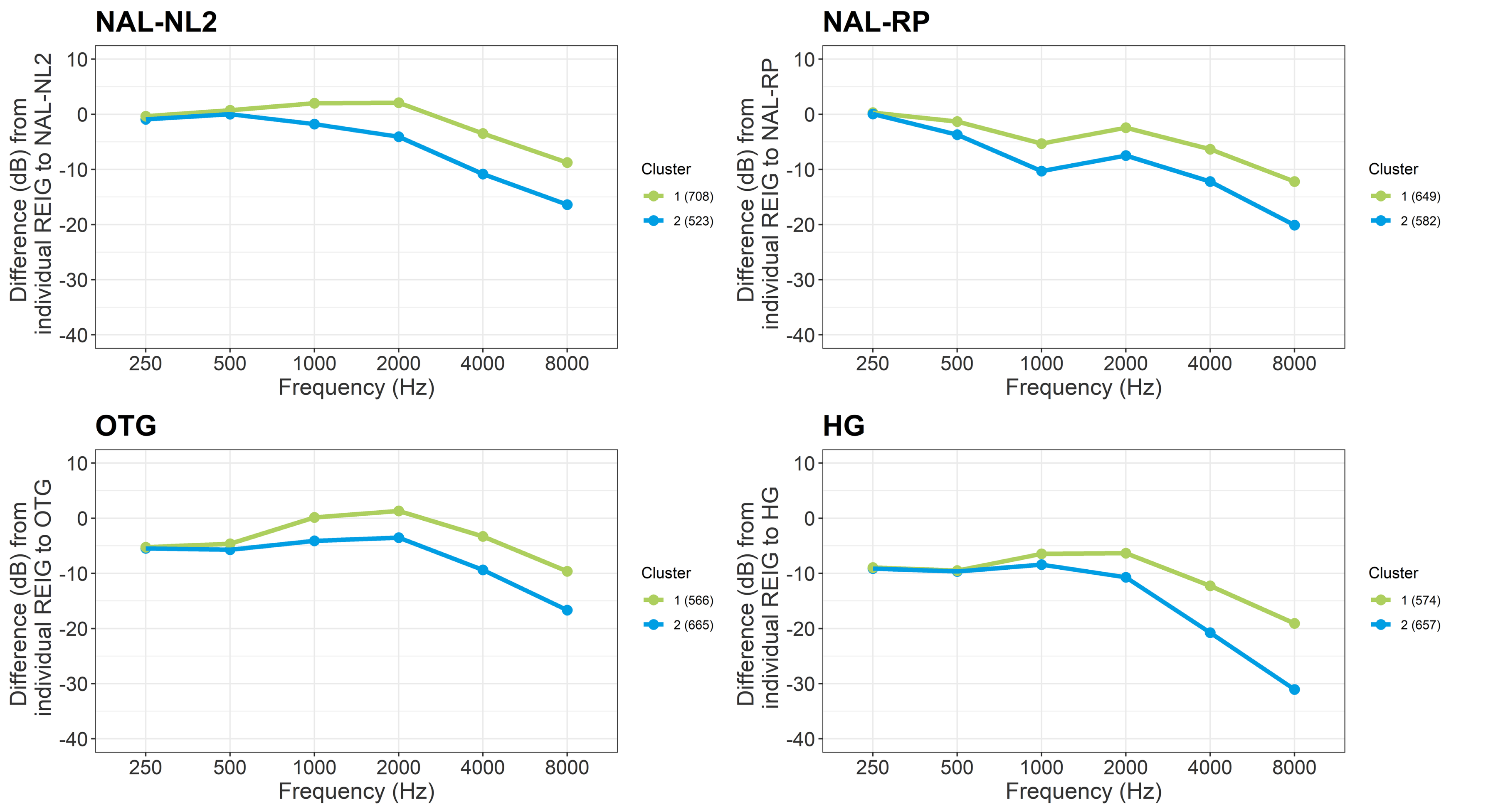

Figure 3: The gain differences to generic gain prescriptions were clustered in to two clusters and the plot shows the cluster centroids at frequencies from 250 Hz to 8000 Hz for better ear.

Analysis of IOI-HA

Ordinal logistic regression was performed using a step-wise approach on IOI-HA individual item scores.

The cluster was a significant predictor of IOI-HA item 2 that relates to the benefit dimension. No significant effect of the cluster was observed for other items in IOI-HA.

The result showed that the participants fitted away from the generic prescription had a significantly lower item 2 score.

	NAL-NL2	**NAL-RP**	**OTG**
HA usage time (hours)	0.12 (0.01) ***	0.12 (0.01) ***	0.10 (0.02) ***
PTA (best ear)	0.43 (0.12) ***	0.44 (0.12) ***	0.41 (0.12) ***
Cluster 2 (ref. Cluster 1)	**-0.25 (0.11) ***	**-0.22 (0.11) ***	**-0.51 (0.22) ***
WRS: Cluster 2	NA	0.24 (0.11) *	NA

Table 2: Odd-ratios of the ordinal logistic regression model for IOI-HA outcome for item 2 (Benefit) for three gain differences (NAL-NL2, NAL-RP, and OTG), which effect of the cluster was found statistically significant.

Analysis of SSQ

Step-wise linear regression was performed on SSQ speech, spatial, and quality domain scores, and the cluster was a significant predictor of SSQ speech domain scores in the case of OTG and HG.

Participants fitted away from generic prescriptions reported better speech domain scores. Post-hoc analysis suggests that gain differences at 8 kHz are determinant to this effect.

	OTG	**HG**
	R^2=0.09, Prob>F =0.00	R^2=0.10, Prob>F =0.00
	Coef. (95%CI)	Coef. (95%CI)
Constant	3.19 (2.59;3.79) ***	3.26 (2.63;3.89) ***
Cluster 2 (ref. Cluster 1)	**0.30 (0.06; 0.54) ***	**0.37 (0.13; 0.62) ****
User Type (first time) (ref: Experienced)	1.67 (1.15; 2.20) ***	1.67 (1.15; 2.20) ***
HA usage time (hours)	0.07 (0.03; 0.11) ***	0.06 (0.02; 0.10) **
WRS (best ear)	0.67 (0.34; 1.00) ***	0.71 (0.38; 1.04) ***
Gender (male) (ref. female)	1.37 (0.69; 2.05) ***	1.33 (0.64; 2.02) ***
User Type (first time): Gender (male)	-0.97 (-1.53; -0.40) ***	-0.97 (-1.53; -0.40) ***
User Type (first time): WRS (best ear)	-0.34 (-0.60; -0.08) *	-0.32 (-0.58; -0.06) *
User Type (first time): Acoustic Coupling		
User Type (first time): Støbt (kanal)/mikro prop	-0.93 (-1.66; -0.20) *	-1.01 (-1.75; -0.27) **
Acoustic Coupling: HA usage time		
Closed dome: HA usage time	NA	0.11 (0.03;0.19) **

Table 3: Coefficient of stepwise multiple linear regression on SSQ subscales of speech for models with the cluster as one of the significant predictors.

Conclusions

The analysis suggested that self-reported benefit indicated by IOI-HA item-2 scores are significantly better for HA fitted closely to NAL-NL2, NAL-RP and OTG prescriptions.

In terms of SSQ, average speech domain scores were higher for participants not fitted close to OTG or HG prescriptions. This effect was restricted to gain difference at 8000 Hz, which might not have any clinical implication.

Overall the study established a relation between REIG and the self-reported outcomes obtained through the use of SSQ and IOI-HA questionnaires. An effect was only found for one item (benefit) in the IOI-HA.