Research paper

COMPARISON OF HEARING AID OUTCOME MEASURES IN ADULT HEARING AID USERS

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Abstract. Hearing aid outcome measures have become an essential part of audiological intervention. This study aimed to explore hearing aid benefit in Maltese hearing aid users through subjective and objective outcome measures. The *Profil Imqassar dwar il-Benefiċċju tal-*Hearing Aids (PIBHA), a translated version of the Abbreviated Profile of Hearing Aid Benefit (APHAB) questionnaire, was used to subjectively examine hearing aid benefit in 56 adult hearing aid users falling in the 20- to 60-year age range. Thirty of these hearing aid users subsequently participated in clinical testing to evaluate hearing aid benefit objectively. Real ear measurements (REMs) and two non-word repetition tests, the Maltese Non-Words in Quiet (MNWQ) and the Maltese Non-Words in Noise (MNWN), were used in the study. Analysis aimed to identify which factors correlated with hearing aid benefit. It also explored the extent to which subjective perception of hearing aid benefit correlated with performance on non-word repetition and REMs in the local population. Daily use was associated with gender and hearing aid type. Non-word repetition scores were correlated with the PIBHA scores and with REMs. Unlike findings reported in the literature, REMs were not correlated with the self-reported measures of the PIBHA. Implications for including both subjective and objective measures in hearing aid fitting protocols are addressed.

Keywords: APHAB, outcome measures, hearing aid benefit, questionnaires

1 Introduction

The most common rehabilitation options for adults with hearing impairment include hearing aid provision and communication programmes (Hickson, Laplante-Lévesque & Wong, 2013).

Positive outcomes have been reported for adults with a mild to moderate sensorineural hearing impairment fitted with bilateral hearing aids (Humes & Krull, 2012). In their systematic review of 33 research articles, Humes and Kroll (2012) reported (i) reductions in activity limitations and participation restrictions, (ii) satisfaction with the hearing aids, (iii) hearing aid usage 75% of the time, and (iv) improved speech recognition scores when using a hearing aid. Audiologists and other researchers in fact use a combination of outcome measures that are either hearing aid-focused (objective) or patient-focused (subjective) in order to support evidence-based practice.

Humes and Kroll's review (2012) also points out the lack of high-level evidence in this research area. In Malta, a lack of research on hearing aid outcome measures in both the paediatric and adult populations is evident. The domain of hearing aid outcome measures has received increasing attention in the last decades. This is so as health care has moved towards an outcome-based design in which audiologists have to document the efficacy of hearing aid intervention, not just to policy makers but also to the persons with hearing impairment themselves (Cox, 2003). The shift embraces a change in focus from disorder to person. Hearing aid users' point of view has become ever more accepted as a valid and crucial gauge of treatment success. While self-report data is slowly becoming the gold standard in evaluating hearing aid intervention, Mendel (2007) advocates the use of self-report data alongside other objective clinical measures which can help in validating the hearing aid user's subjective impressions.

The purpose of this study was to evaluate hearing aid benefit in Maltese adults through the use of subjective and objective outcome measures. It aimed to give more insight into the factors that are associated with hearing aid benefit and to evaluate the correlation between subjective and objective hearing aid outcome measures.

	Bil-*hearing aids*	Mingħajr il-*hearing aids*
1. Meta nkun f'ħanut tal-merċa mimli nies u nkun qed inkellem lill-kaxxiera, nkun nista' nifhimha.	A B Ċ D E F Ġ	A B Ċ D E F Ġ
2. Nitlef ħafna mill-informazzjoni meta nkun qed insegwi *lecture.*	A B Ċ D E F Ġ	A B Ċ D E F Ġ

A Dejjem (99%)
B Kważi dejjem (87%)
Ċ Ġeneralment (75%)
D Ġieli iva, ġieli le (50%)
E Xi kultant (25%)
F Rari (12%)
Ġ Qatt (1%)

Figure 1. Excerpt from the PIBHA, the Maltese translated version of the APHAB

2   Methods

The study incorporated a quantitative research design. Multiple measures were obtained through self-report, non-word repetition testing and real ear measurements (REMs). Ethical approval for implementation of the study was obtained from the University of Malta's Research Ethics Committee.

2.1 *Participants*

Participants were selected from the Ear, Nose and Throat (ENT) Department of a state general hospital. They were all adult hearing aid users in possession of a hearing aid, and between 20 and 60 years of age. Older adults were excluded from the study in order to limit the presence of confounding factors, such as cognitive and physical difficulties, which may affect performance. According to the hospital's database, 230 adults were in the specified age range and possessed a hearing aid or were waiting for their initial fitting appointment. A questionnaire (see Section 2.2) was sent to all 230 individuals in order to increase the response rate. In total, 85 questionnaires were returned by mail, which is equivalent to a 37% response rate. Exclusion criteria were applied after questionnaire completion and clinical testing. These included invalid/empty questionnaires[1], non-verbal hearing aid users, individuals not yet fitted with a hearing aid, Bone-Anchored Hearing Aid users and individuals currently presenting with middle ear infections.

Valid questionnaires were returned by a total of 56 participants, out of whom 29 (15 females and 14 males) volunteered to undergo the non-word repetition test. REMs were carried out on 28 participants (15 females and 13 males), 19 of whom were unilateral users and 10 were bilateral users. Fifteen users wore digital aids whilst 14 had analogue hearing aids. Participant age ranged from 22 to 60 years (Mean (M) = 44.82, Standard Deviation (SD) = 13.32). Age was non-normally distributed, with just over half of the participants being between 50 and 60 years of age. Skewness of the age distribution was -.238 (Standard Error (SE) = 0.33) and kurtosis was -1.33 (SE = 0.65).

2.2 *Questionnaire*

The Abbreviated Profile of Hearing Aid Benefit (APHAB) questionnaire has been proven to be a good self-report outcome measure of hearing aid benefit for adult hearing aid users, and was therefore selected for adaptation in this study (Cox, 2005; Paul & Cox, 1995). Norms and data on its psychometric properties are also available for cross-cultural comparison (Cox & Alexander, 1995; Johnson, Cox & Alexander, 2010; Kochkin, 1997), making it a useful tool in this research study. It is estimated that the APHAB can be completed in five to ten minutes (Cox & Alexander, 1995). It consists of 24 items that describe possible situations the subject may find him/herself in, for example, 'I can understand my family at the dinner table'. The subject has to select a response from a list of seven alternatives (ranging from *always* to *never*) in order to show how often the statement is true for him/her. For each item, two responses are required by the hearing aid user, one for 'without my hearing aid' (unaided) and one for 'with my hearing aid' (aided). The measure of benefit is calculated by comparing performance in unaided and aided settings in four subscales: Ease of Communication (EC), Reverberation (RV), Background Noise (BN) and Aversiveness of Sounds (AV) (Cox & Alexander, 1995).

The APHAB was translated to Maltese with permission from the authors, following their translation guidelines. The Maltese translation of the questionnaire, titled *Profil Imqassar dwar il-Benefiċċju tal-*Hearing Aids (PIBHA), was piloted on five hearing-impaired adults between 20 and 60 years of age in order to pre-test its effectiveness with the local population. The first five subjects who accepted to participate in the clinical tests were involved in the pilot study. The PIBHA was used to obtain information on participants' age, perception of hearing aid benefit, hearing aid use and experience with hearing aids. Four participants in the main study volunteered to complete the questionnaire a second time after a one-month interval. A good test-retest reliability coefficient of 0.8 resulted. Figure 1 shows an excerpt of the PIBHA as employed in this study.

2.3 *Non-word repetition tests*

The Maltese Non-Words in Quiet (MNWQ) and the Maltese Non-Words in Noise (MNWN) are two non-word lists developed by Tabone (in preparation). The non-word

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1   A questionnaire was considered to be invalid when responses to all statements were marked as 'Always' or 'Never'.

repetition test required the participants to repeat these non-word lists, providing information on aided speech perception in quiet and noisy conditions. During testing, the participants were seated in a sound-isolated chamber. The acoustic signal in the tests was presented through a loudspeaker placed at a distance of one metre in front of each participant at 0° azimuth. Presentation level was set at 65 dBA. Participants were exposed to the 24-item lists through speaker phones, with their hearing aids on, and were encouraged to repeat the non-words. In the MNWN, the subjects were asked to ignore the noisy background while repeating the words they heard. Constant noise background stimulus is not representative of everyday listening environments, and hence, multitalker babble at -5 dB was employed (Killion et al., 2004). The word lists were pre-recorded to ensure that the stimuli were presented at the same level to all participants. Prior to data collection, a pilot study was carried out on five adult normal hearing participants, in order to ascertain that all the words were well-perceived.

2.4 Real Ear Measurements (REMs)

Hearing aid performance was evaluated through Real Ear Measurements (REMs) using the Fonix 7000 Hearing Aid Test System. REMs were carried out according to the standard procedure outlined in the instruction manual. Specifically, the Real Ear Insertion Gain (REIG), which may be defined as the gain provided by the hearing aid (Pumford, 2001), was calculated. The insertion gain was measured at three levels: 50 dB (soft sounds), 65 dB (comfort testing) and 80 dB (tolerance testing). The fitting target was set on National Acoustics Labs, Non-Linear, version 1 (NAL-NL1), which is a prescriptive hearing aid fitting method for programming hearing aids in adults. REMs were always preceded by otoscopy.

2.5 Data Protection

Participants' contact details were not accessed unless they had previously agreed to participate in the clinical tests. Collected data was saved in a password-protected personal computer. Participants were also informed that once the study was completed, all personal information collected would be destroyed.

2.6 Data Scoring

In the PIBHA, unaided scores were subtracted from aided scores to determine total benefit for each category, namely EC, BN, RV and AV. Information about degree of hearing loss, daily hearing aid use and hearing aid experience was also analysed statistically.

Attempts at repeating the MNWQ and the MNWN were scored as either correct or incorrect on a whole word and phoneme basis. The number and percentage of correct responses was also calculated for words containing consonantal clusters as opposed to those having no clusters. Additionally, responses were categorised according to the number of two-, three- and four-syllable words repeated correctly. Finally, correct responses were coded for high or low word likeness.

REMs were scored by calculating the difference between the target gain (NAL-NL1) and the actual hearing aid gain for the following frequencies: 250 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz. Scores falling within 10 dB of the target gain were categorised as *Pass*, while those that did not were categorised as *Fail*, in line with other studies (Aazh & Moore, 2007). Additionally, they were also categorised by the discrepancy from target in 10 dB steps.

2.7 Data analysis

Descriptive statistics were used to compute the frequencies and means of scores obtained through self-report and non-word repetition. The dependent variables, namely the PIBHA benefit scores, the MNWQ, MNWN and the REM scores, were tested for normality using the Kolmogorov-Smirnov test, which yielded varying results. Normally distributed data was analysed using parametric tests, namely paired samples t-tests and independent samples t-tests, one-way Analysis of Variance (ANOVA), as well as Pearson's correlations. Analysis of non-normally distributed data employed four non-parametric tests: the Wilcoxon signed-rank test, the Wilcoxon Mann-Whitney test, the Kruskal-Wallis test and Spearman's rank correlations. Chi-squared tests were used to compare categorical variables.

3 Results

3.1 Profil Imqassar dwar il-Benefiċċju tal-Hearing Aids (PIBHA)

The mean scores for unaided conditions were higher than those for aided conditions (Figure 2). A paired-samples t-test and a Wilcoxon signed-rank test showed that the difference in mean scores was statistically significant across all categories of the PIBHA ($p < .001$). The participants perceived benefit on three categories, EC, BN and RV (Figure 3). All scores were normally distributed. The global scores comprising EC, BN and RV scores were also normally distributed ($p = .056$) and were used in subsequent statistical analyses.

A Pearson product-moment correlation coefficient analysis showed significant correlations between the PIBHA global and subscale scores. The PIBHA global scores had the strongest correlation with the RV ($r = .82$) and EC ($r = .82$) subscales. In addition, the internal consistency reliability values denoted by Cronbach's alpha were also fairly high, ranging from 0.78 to 0.82 across the four categories.
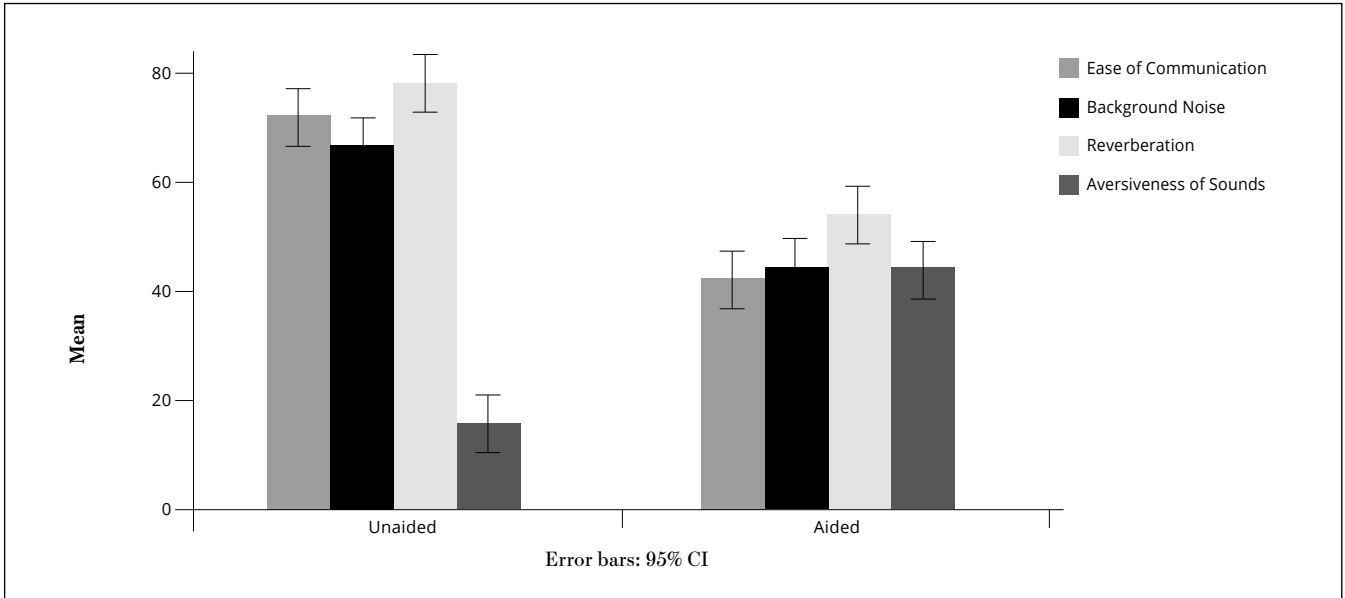
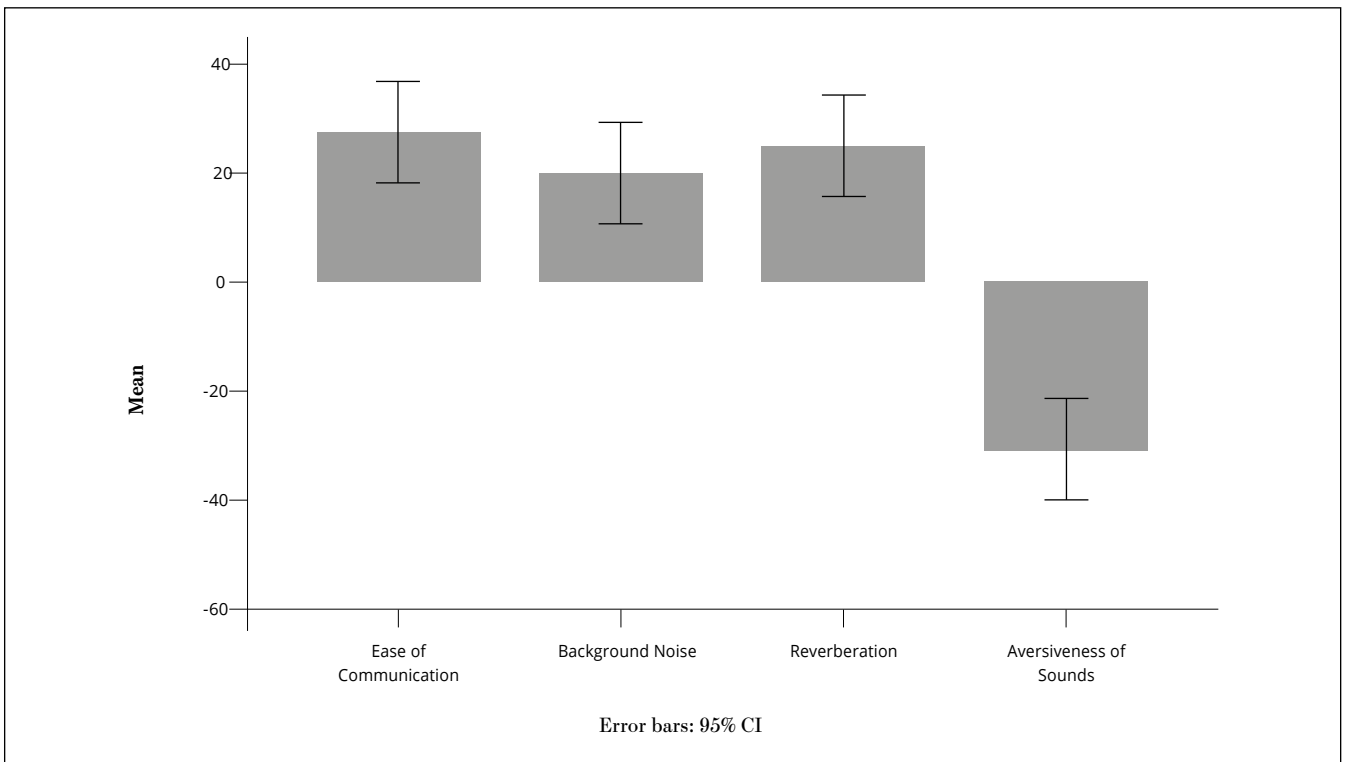**Figure 2.** Mean unaided and aided scores on the four subscales of the PIBHA

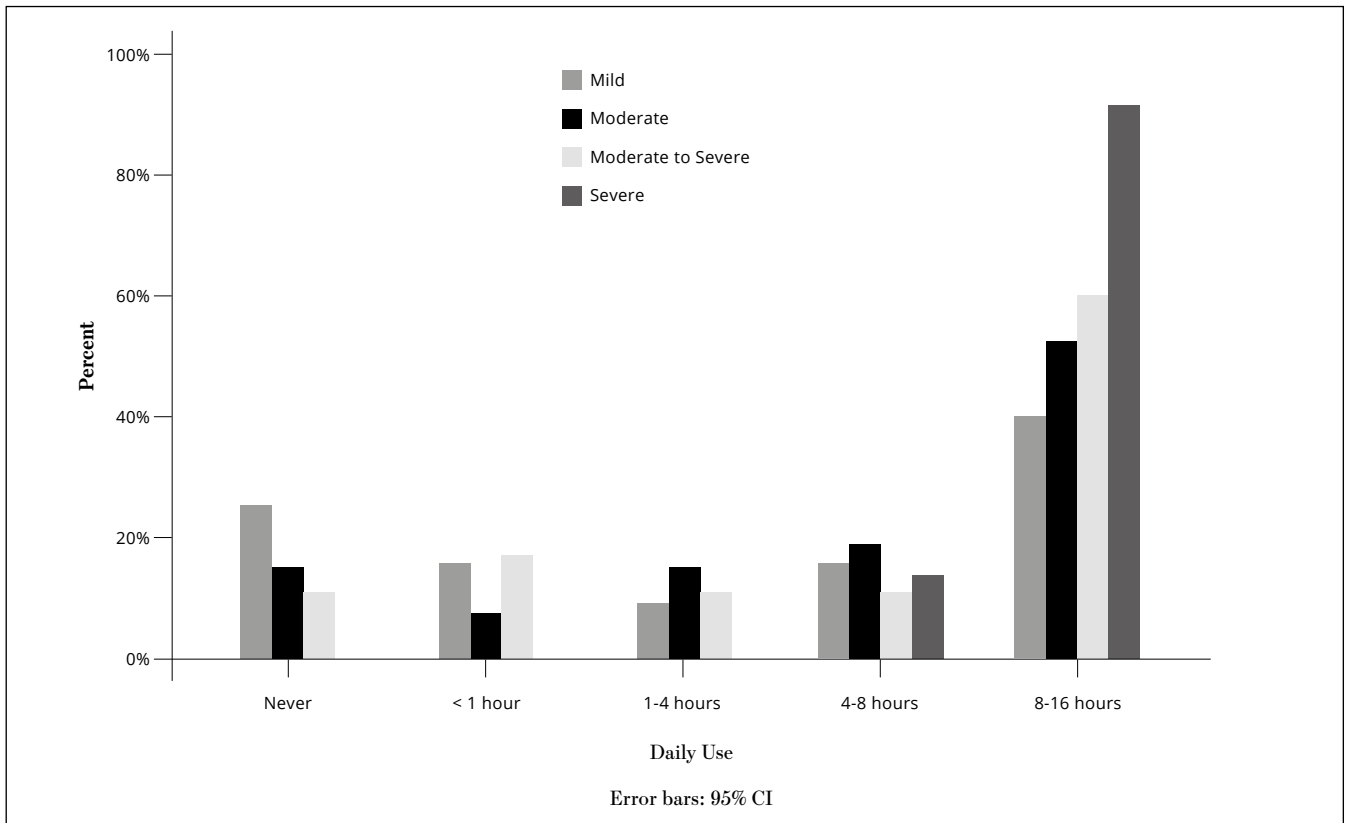**Figure 3.** The mean benefit scores obtained on the four subscales of the PIBHA

Figure 4. Hearing aid daily use in hours according to reported degree of hearing loss
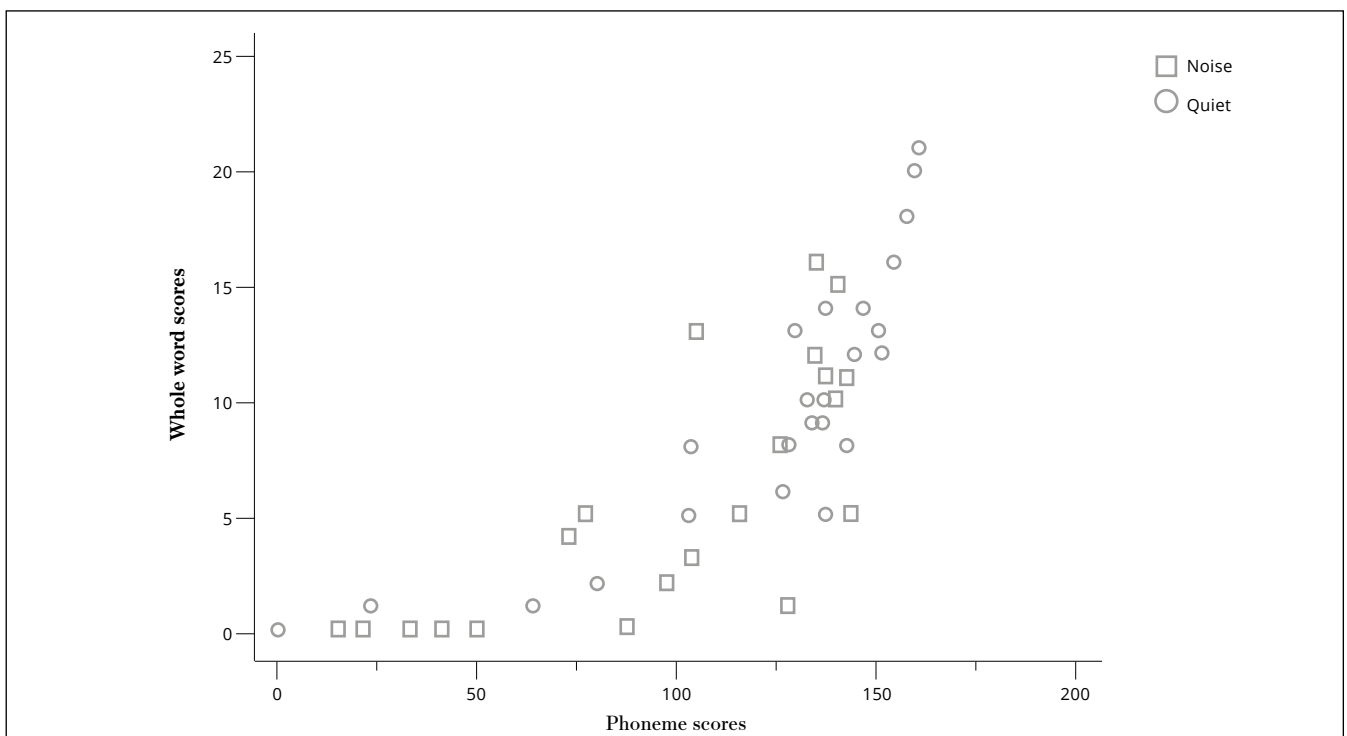

Figure 5. Individual participants' whole word and phoneme scores obtained in quiet and in noise
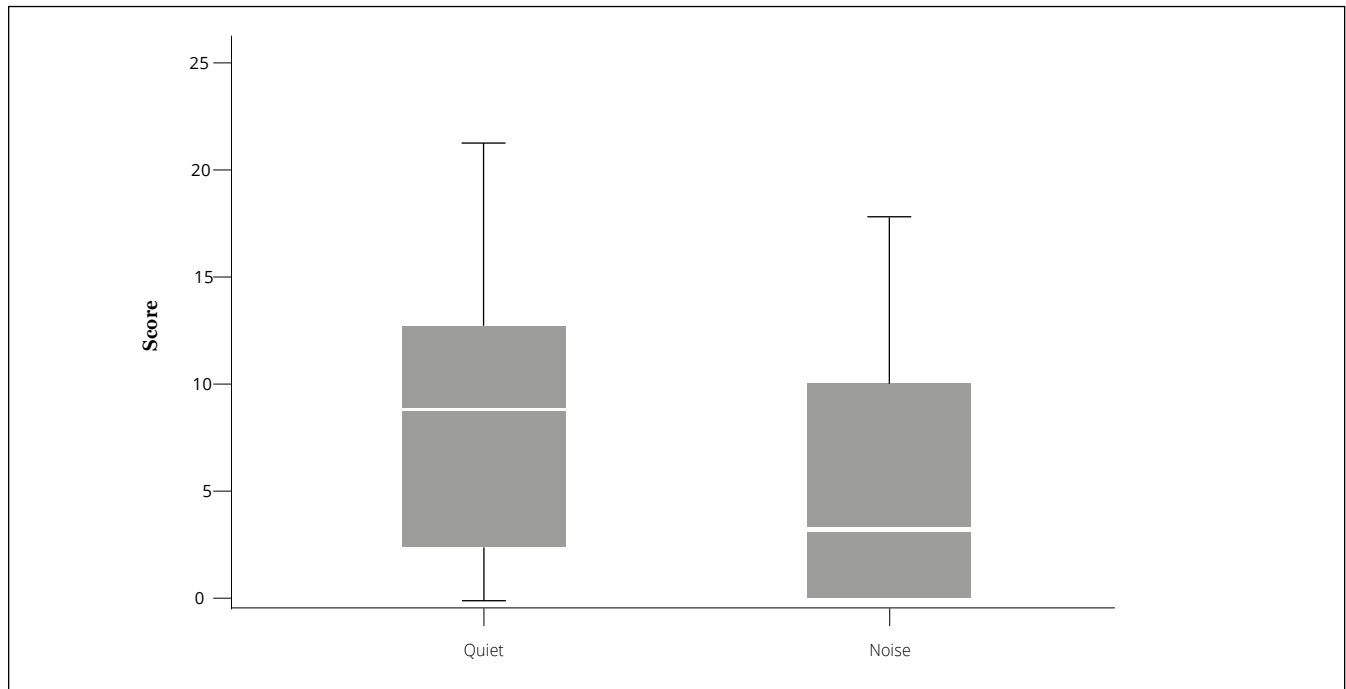
Figure 6. Distribution of scores in quiet and noisy settings when scoring with a whole word approach

3.1.1 Daily hearing aid use

More than half of the participants (57%) reported that they used their hearing aids for more than eight hours a day (N = 56). While 12% reported that they never used their hearing aids, the rest (31%) reported less consistent use of their hearing aids. The Wilcoxon-Mann Whitney test showed a statistically significant difference between daily hearing aid use scores of female and male participants (p = .021). In addition, there were more men (29%) who never used their hearing aids compared to women (7%). A Kruskal-Wallis test showed that increasing degree of loss was not related to an increase in daily hearing aid use (p = .128) (Figure 4). Users of digital hearing aids used their aids more than the users of analogue aids (p = .019, using the Wilcoxon Mann-Whitney test). Bilateral users made use of their hearing aids more than unilateral users. However, the Wilcoxon Mann-Whitney test showed that the difference was not statistically significant (p = .098).

3.1.2 Self-reported benefit on the Profil Imqassar dwar il-Benefiċċju tal-Hearing Aids (PIBHA)

A one-way between-subjects Analysis of Variance (ANOVA) test showed that there was no significant effect of mean daily hearing aid use on global scores on the PIBHA (p = .840). An independent samples t-test showed that there was no significant difference between the digital and analogue hearing aid user groups on self-reported benefit scores (p = .252). Similarly, an independent samples t-test showed that

hearing aid fitting was not related to daily hearing aid use (p = .083).

3.2 Non-word repetition results

3.2.1 Scoring method

Whole word scores for quiet conditions were normally distributed (p = .200) while scores obtained in noise showed a non-normal distribution (p = .001), just like phoneme-based scores in both quiet (p < .001) and noisy settings (p = .034). There was a strong, positive correlation between whole word and phoneme scores obtained on both quiet (r = 0.932, N = 29, p < .001 and noise tests (r = 0.858, N = 29, p < .001. The scatterplot in Figure 5 shows individual whole word and phoneme scores obtained in quiet and noisy settings.

3.2.2 Type of setting

The MNWQ elicited significantly higher scores (M = 8.72, SD = 6.55) than the MNWN (M = 5.03, SD = 5.65) on a whole word scoring approach (p < .001, using the paired samples t-test) (Figure 6). Phoneme-based scoring elicited similar scoring patterns: the MNWQ resulted in a higher score (M = 107.14, SD = 58.25) than the MNWN (M = 80.34, SD = 56.69) (Figure 7). A Wilcoxon signed-rank test showed the difference between phoneme-based and whole word mean scores to be statistically significant (p < .001).
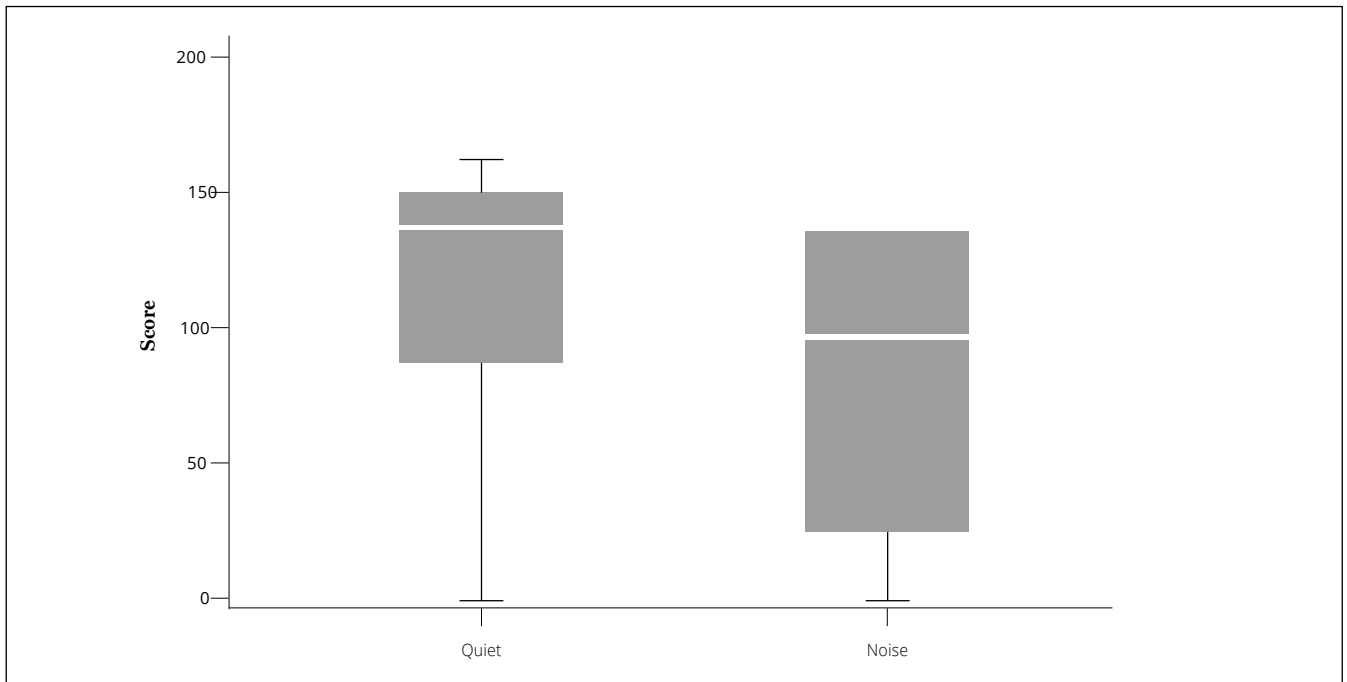
Figure 7. Distribution of scores in quiet and noisy settings when scoring with a phonemic approach
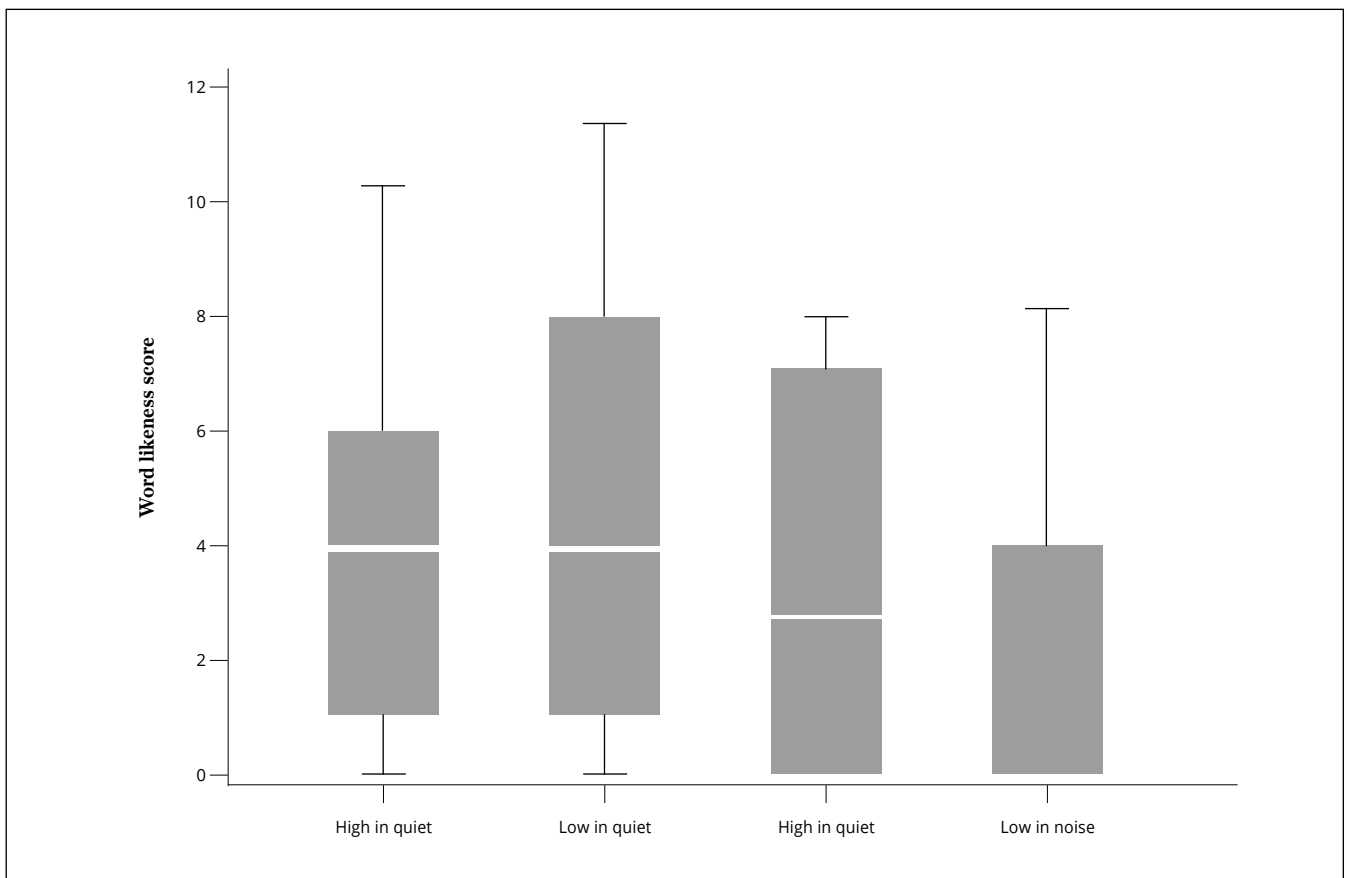

Figure 8. Dispersion of high and low word likeness scores in quiet and noisy settings

3.2.3 Word likeness, syllable length and consonant clusters

As seen in Figure 8, word likeness was associated with a higher number of correct responses only in the noisy condition (p = .005 using the Wilcoxon signed-rank test). The score for two-syllable non-words was higher than the scores obtained for three-syllable (p = .005, using the paired samples t-test) and four-syllable non-words (p = .005, using the Wilcoxon signed-rank test) in the quiet condition. Similarly, the Wilcoxon signed-rank test was also used to analyse the effect of syllable length on MNWN scores. The scores of two-syllable non-words were significantly different from those of three- (p = .009) and four-syllable non-words (p = .008). The Wilcoxon signed-rank test showed that there was no significant difference between the scores for three- and four-syllable non-words in both quiet (p = .130) and noisy conditions (p = .617). Words containing consonant clusters elicited a lower score (M = 3.93, SD = 3.35) than words without clusters (M = 5.10, SD = 3.57) in the MNWQ and similarly in the MNWN (M = 2.07, SD = 2.63 for words with clusters; M = 4.61, SD = 3.51 for words without clusters). The Wilcoxon signed-rank test showed that mean scores were significantly different in both quiet (p = .001) and noise (p = .005).

3.2.4 Hearing aid type and fitting

Users of digital hearing aids obtained a higher score (M = 9.87, SD = 6.63) than analogue users (M = 7.50, SD = 6.48) on the MNWQ when using a whole word scoring approach. Similarly, digital hearing aid users obtained a higher score (M = 6.00, SD = 5.64) than users of analogue hearing aids (M = 4.00, SD = 5.69) on the MNWN. An independent samples t-test confirmed that there was no significant difference between the two groups on non-word repetition mean scores in both quiet (p = .340) and noise (p = .350). Phoneme-based analysis scores similarly showed no statistically significant difference in both quiet (p = .484) and noisy (p = .693) settings, using the Wilcoxon signed-rank test.

Bilateral hearing aid users obtained a similar score (M = 8.09, SD = 6.63) to unilateral users (M = 9.11, SD = 6.67) on the MNWQ when using a whole word scoring approach. Similarly, bilateral hearing aid users' score on the MNWN (M = 4.73, SD = 5.78) was close to that of unilateral users (M = 5.22, SD = 5.73). An independent samples t-test showed no significant difference between the two groups on non-word repetition scores in both quiet (p = .692) and noise (p = .824). Phoneme-based scores were not significantly associated with hearing aid fitting in both quiet (p = .636) and noise (p = .557) on a Mann-Whitney test.

3.3 Real Ear Measurements (REMs)

Half the REMs did not meet prescribed targets by more than 10 dB. REMs at 50 dB met targets less frequently than 65 or 80 dB. However, no statistically significant difference was found between soft, medium and loud sounds at all frequencies using McNemar's test. As shown in Figure 9, up to 30% of REMs were discrepant with their target by up to 20 dB and more than 10% were up to 30 dB off target.

Analogue hearing aid users failed to match the target more than digital hearing aid users (Figure 10). A Chi-squared test showed that the difference was statistically significant (p < .001). Further Chi-squared tests showed that a statistically significant difference was only found at the 50 dB level at the frequencies of 250 Hz ($\chi^2(1, N = 28)$ = 5.32, p = .021), 500 Hz ($\chi^2(1, N = 28)$ = 5.32, p = .021 and 4 kHz ($\chi^2(1, N = 28)$ = 9.40, p = .002).

3.4 Correlations between outcome measures

REM scores showed no significant correlation with global scores on the PIBHA (r = 0.364, N = 28, p = .057). There was no statistically significant difference between daily hearing aid use and the REM categories of *Pass* and *Fail*. The correlations between non-word scores and PIBHA and REM scores respectively are tabulated in Tables 1 and 2.

Table 1. Correlations between non-word and PIBHA scores

		PIBHA	Correlation
Non-words (whole word approach)	Quiet	r = 0.380 N = 29 p = .042	Positive, weak
	Noise	r = 0.263 N = 29 p = .168	No correlation
Non-words (phonemic approach)	Quiet	r = 0.428 N = 29 p = .021	Positive, moderate
	Noise	r = 0.243 N = 29 p = .205	No correlation

Table 2. Correlations between non-word scores and REMs

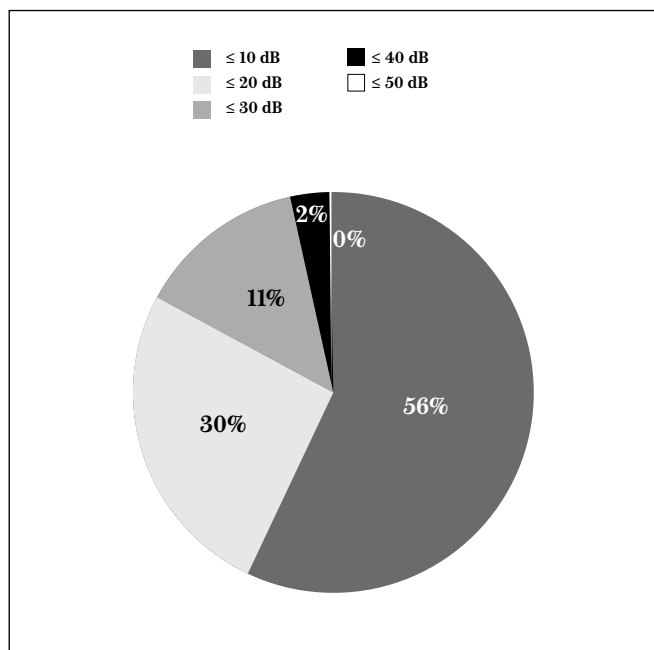|		REMs	Correlation
Non-words (whole word approach)	Quiet	r = 0.548	Positive, moderate
	Noise	r = 0.580	Positive, moderate
Non-word (phonemic approach)	Quiet	r = 0.703	Positive, strong
	Noise	r = 0.456	Positive, moderate

Figure 9. The percentage of REMs discrepant with target, expressed in categories of 10 dB
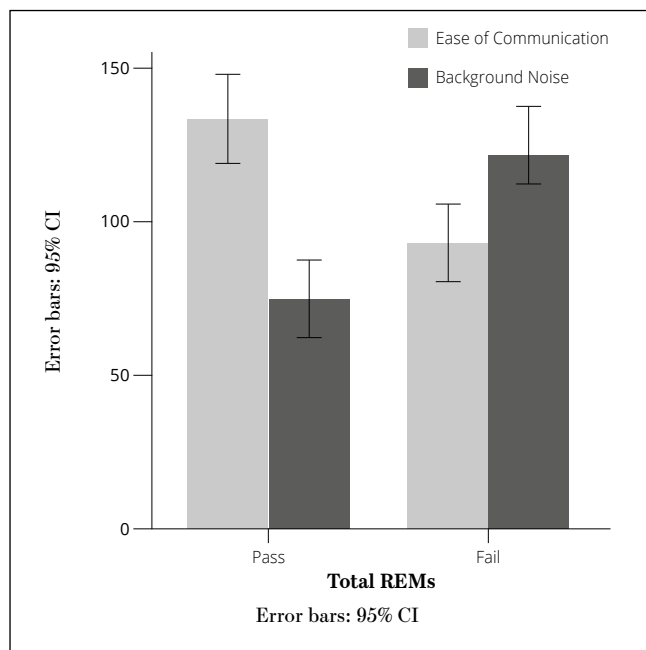

Figure 10. *Pass* and *Fail* outcomes in REMs across digital and analogue hearing aid users

4 Discussion

4.1 Outcomes of the Profil Imqassar dwar il-Benefiċċju tal-Hearing Aids (PIBHA)

In this study, 57% of the participants reported using their hearing aids for more than eight hours a day. Recent studies have shown a discrepancy in the frequency of self-reported hearing aid usage for more than eight hours a day, ranging from 15% ($N = 27$) (Roup & Noe, 2009) up to 61% ($N = 64$) (Williams, Johnson & Danhauer, 2009). Comparison of the frequency obtained for adult Maltese hearing aid users suggests that the latter fared quite well in the percentage of hours a hearing aid was used per day. In this study, 12% of the participants (mean age = 45 years) reported that they never used their hearing aids. This is in line with other findings reported in the literature (Hickson et al., 1999; Kochkin, 2010). As in other studies (Bertoli et al., 2009; Staehelin et al., 2011), male participants were four times more likely to never use their hearing aids when compared to females. In Staehelin et al.'s (2011) investigation, men indicated less benefit as a reason for non-usage. In the same study, women reported a higher prevalence of daily hearing aid use and a longer daily duration of use compared to men. This finding also corroborates the results of the present study. The reason for this effect was explored by Garstecki and Erler (1998), who found that females reported less denial and greater problem awareness related to hearing loss. This could explain why, in this study, women reported greater hearing aid use.

Degree of hearing loss was not associated with daily hearing aid use. This finding is in line with outcomes of Perez and Edmonds's (2012) systematic review. Digital hearing aid users were found to use their hearing aids more than analogue users in the current study, corroborating a finding reported by Magni, Freiberger and Tonn (2005). The latter authors also reported that 70% of digital hearing aid users used their hearing aids for more than eight hours a day. This is similar to the percentage identified in this study (67%). Daily hearing aid use was not affected by hearing aid fitting. This finding differs from the outcome reported by Bertoli, Bodmer and Probst (2010) for their study involving 6,027 participants. This discrepancy is probably due to the smaller sample in the population under investigation ($N = 56$). Further research is warranted to explore this dimension in more depth in the local population. Daily hearing aid use was not associated with reported benefit on the PIBHA, unlike several studies in the literature (Dillon, Birtles & Lovegrove, 1999; Olusanya, 2004; Roup & Noe, 2009). In spite of this, Perez and Edmonds (2012) emphasised that the relationship between hearing aid use and other outcome measures such as benefit is more complex than it seems. They reported that no single dimension was consistently shown to depend on hearing aid use. Perez and Edmonds (2012) argued that it may be more valuable to ask hearing aid users how much *more* time they spend on activities they like with the help of the hearing aid. This is more of a person-centred approach that looks at the true benefit of hearing aid use.

No significant difference was found between digital and analogue users on self-reported benefit scores. This is in line with the findings of Taylor, Paisley and Davis's (2001)

systematic review, which showed no significant differences in self-reported benefit and in speech recognition in quiet and noisy conditions between the two devices. Similarly, recent studies have reported no difference in benefit on the APHAB (Metselaar et al., 2009), or other self-report measures (Noble & Gatehouse, 2006), between unilateral and bilateral users. In this study, reported benefit on the PIBHA was also not associated with hearing aid fitting, thus corroborating previous studies' outcomes. One needs to keep in mind that other studies have found such a link (Boymans et al., 2009). This lack of homogeneity in results may imply that the type of fitting, just like daily hearing aid use, is only one of the factors that need to be taken into consideration when evaluating hearing aids, as outcome measures are indeed a multidimensional and complex entity. In fact, non-word scores obtained in this study were not affected by hearing aid fitting. There is a lack of research in the area, but a recent study by Henkins, Waldman and Kishon-Rabin (2007) showed that word recognition scores in quiet were comparable in unilateral and bilateral modes.

4.2 Non-word testing

Testing in noise addresses the most common complaint that persons with hearing loss report, which is listening in background noise. Indeed, higher scores for non-word repetition were obtained in the quiet setting in this study. This confirms that good non-word recognition in quiet does not indicate good non-word recognition in noise. Thus, in this aspect, both non-words and words are affected by the noise component (Wilson & McArdle, 2005). This can be explained by the fact that hearing aids improve perception in quiet largely due to the increased audibility (Wilson & McArdle, 2005). Speech in noise tests highlight the detrimental effect of the distortion component on everyday listening situations. Hearing in noise puts greater demands on the auditory and cognitive systems, which aim to interpret the limited and distorted auditory signal. This could explain the lower scores obtained by Maltese hearing aid users on the MNWN.

Word likeness was associated with a higher number of correct responses only in the noisy condition. This may be explained by the fact that noisy backgrounds lower the extrinsic redundancy of the speech signal even more (Cunningham, 2013). In noise, the phonological representations of non-words with high word likeness are supplemented by stored lexical knowledge that aids in the repetition of these non-words and helps in filling out missing information (Gathercole, 1995). In contrast, non-words having consonant clusters presented more difficulties than single segments in both quiet and noise. In addition, two-syllable non-words were more easily recalled than non-words having three and four syllables in quiet. In this respect, the findings corroborate those of other studies in the literature which report that syllable structure (Gallon, Harris & van der Lely, 2007) and length (Jones et al., 2010) have an effect on non-word repetition performance in normal

hearing children and adults. Studies on adult hearing aid users are lacking.

4.3 Real Ear Measurements (REMs)

Slightly more than half of the REMs (N = 211) did not meet prescribed targets by more than 10 dB in this study. This is very similar to other findings in the literature. Aazh & Moore (2007) reported that 64% of the fittings in their study did not meet the targets, a finding consistent with that of other studies (Aarts & Caffee, 2005; Hawkins & Cook, 2003; Mueller, 2005). The high percentage of unmatched hearing aids in this study and in the literature suggests a lack of use of REMs amongst hearing aid professionals at the time of fitting. Indeed, the discrepancy from target may be explained by the use of software-predicted values, or the lack of verification measures.

The findings of this study and of related studies bring up practical and ethical considerations for audiologists. In fact, Abrams et al. (2012) stress the importance of providing effective rehabilitation to hearing aid users that includes probe microphone verification measures in its fitting approach. The authors argue that REMs should be a routine and essential part of every hearing aid to be fitted. The failure to follow recommended best practices is viewed as a departure from standards of ethical competence by Palmer (2009). Notwithstanding philosophical arguments, Abrams et al. (2012) also mention the practical reasons to include REMs in the hearing aid fitting protocol; hearing aid owners who have received REM testing during the fitting procedure are reported to be more satisfied and perceive more hearing aid benefit (Kochkin, 2010).

4.4 Correlations between outcome measures

In this study, a finding similar to Mendel's (2007) was observed, in that benefit on the self-report measure was correlated with non-word scores in quiet. In noise, there was no correlation between the self-report and non-word scores. The latter finding is similar to the results of Cox & Alexander's (1992) study, which reported no correspondence between objective (speech test) and subjective (self-report) data in background noise conditions. In the current study, non-word scores were correlated with REMs. This means that well-matched REMs were associated with a higher score in non-word repetition testing. This adds more value to the fitting process and contributes to a more holistic and person-centred approach to auditory rehabilitation. These findings suggest that both measures could be part of the fitting process in the local population.

Unfortunately, REM scores did not show a correlation with the PIBHA scores in the population under study. This result conflicts with recent findings which report a significantly greater benefit on the APHAB when using REMs compared to no verification (Abrams et al., 2012). This may be explained by the fact that REMs may not necessarily reflect participants' functioning in everyday communication environments. Additionally, other characteristics of the

participants, such as personality and cognitive abilities, were not accounted for in the subjective self-report measure and could be key factors in self-reported benefit. Further research in this area is warranted, especially in the local population.

5 Conclusion

Overall, hearing aid outcome can be represented by a number of separate and unique dimensions. These include self-reported benefit, hearing aid usage, non-word speech repetition and REMs. All of these hearing aid outcomes have practical implications. Non-word repetition testing has been found to correlate with both subjective and objective measures. Further research on a larger scale would help to investigate whether non-word repetition scores can be considered as a predictor of self-report scores on the PIBHA and a pass in REMs. This is especially so in the Maltese Islands, where there is a lack of combined outcome measures being used in the fitting of hearing aids. As Curran and Galster (2013) argue, deciding which measure should be used to establish the best hearing aid fitting has remained a matter which is still imperfectly resolved. Over the years, amplification has changed and even clients have kept up with the technological advances. In this day and age, hearing aid users are more informed and demand to be involved in the decision-making process. As Hickson (2012) asserts, we have to accept the paradigm shift and move towards a more person-centred approach to audiological rehabilitation. This process should extend beyond the fitting of hearing aids and should be accompanied by counselling, user education and other audiological services.

6 Funding

7 Conflicts of interest

The authors report no conflicts of interest.

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