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The effect of induction loop system use training on adults with hearing aids

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Background/aim: The study aimed to investigate the effect of training on hearing aid users to benefit from induction loop systems.

Materials and methods: A five-question scale was developed to evaluate whether individuals using hearing aids could use the induction loop system effectively. In the first step, validity-reliability studies were performed with 264 individuals using hearing aids. In the second step, 30 individuals using hearing aids were given verbal and hands-on training on the induction loop system. Before and after training with hearing aids (noiseless, noise, noise + induction system active) in three different environments, questions on the scale were asked twice in total from the beginning to the end of the study.

Results: The significance of the differences between the values obtained as a result of the application of word lists in three different test settings was examined by repeating the measurements variance analysis. As a result of the post hoc analysis, P = 0.002 between test 3 (10.7, 1.53) and test 1 (11.7, 0.7) was calculated. There appears to be a statistically significant difference with the present situation (P < 0.01). The average scores of the scale between pre and posttraining applications as a preliminary and final test were analysed with a t-test. The final test average was statistically significantly greater than the preliminary test (P < 0.01).

Conclusion: This study shows how important it is for hearing aid users to be informed and to receive the necessary training in order to gain the expected benefit from induction loop systems developed to improve speech intelligibility in noisy environments.

Key words: Hearing aids, induction loop system, improve speech intelligibility

1. Introduction

Hearing is one of the most basic senses necessary for one's verbal communication. Hearing loss caused by lack of hearing may cause problems in the socialization processes, especially in communication skills [1].

In clinical cases where there is no improvement in hearing loss by medical or surgical approach, the most commonly used amplification approach to compensate for hearing loss is hearing aids. The hearing aid (HA) collects, amplifies, and transmits the amplified sound to the user's ear through a microphone [2].

The greatest difficulty experienced by individuals with hearing loss is the inability to understand what is being spoken in crowded and noisy environments. The source of this problem is a decrease in the signal/noise (S/N) ratio due to higher background noise. For individuals using HA, the use of assistive devices that increase the S/N ratio is presented as a possible solution [3]. Studies on this subject showed that HA users have a better understanding of conversations by using their devices in a 'telecoil' program in environments with an induction loop (IL) system [4].

The legal requirement that IL systems should be used in public buildings has been introduced. Article 10 of the Constitution of Turkey guarantees that citizens with disabilities exercise equal rights. Article 61 states that measures should be taken for the inclusion of disabled people in public life.

The aim of this research is to investigate the impact of training on the use of IL systems by HA users. With the use of the IL system, the background noise faced by individuals using HA in crowded and noisy environments is reduced, and the S/N ratio increases. With the increased S/N ratio and the system delivering sounds directly to the listener, speech sounds are perceived as more understandable. Thus, more widespread use of these assistive devices, which increase the S/N ratio, and HA satisfaction are expected to

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increase. It is thought that this research may be important in determining the impact of information and education on the IL system that helps hearing in individuals using HA, as well as enlightening the studies that can be done later. In addition, given that there is a very limited number of studies on this subject in the literature, it can be said that this research is important from this perspective as well.

2. Materials and methods

The subjects in this prospective study included a subset of HA users at a tertiary referral hospital. This research was held at Dokuz Eylül University, School of Medicine, Department of Otolaryngology, Hearing-Speech and Balance Unit between October 2015 and May 2016.

The study was approved by the Dokuz Eylül University Clinical Studies Ethical Committee (2015/24-18) and was conducted according to the ethical standards of the Helsinki Declaration. Informed consent was obtained from all subjects.

2.1. Procedure

A five-question scale was developed to assess whether individuals using HA used the IL system in the primary phase of the study (Table 1). The developed scale was applied to 264 people to be evaluated in terms of validity and reliability.

In the second phase of the study, 30 individuals using HA were given a brief verbal and practical training on the IL system. In the verbal training section, the subjects were informed about what the IL system was, its benefits, how to use it, where it is located, and some statistical information about its use in Turkey.

In the practical training section, the Logitech Z533 2 + 1 sound system (Logitech, Lausanne, Switzerland) was used for the presentation of the stimulus and noise. To create a noisy environment, 'babble noise' (Auditec Inc., St. Louis, MO, USA) was used. This is one of the most challenging noises in all speech systems, and it is achieved by 20 young adults reading different texts at the same time. Babble noise was normalized to –14 dB FS (full scale) with Adobe Audition 3.0 software (Adobe Systems Incorporated, California, CA, USA). Recorded speech materials were normalized to –19 dB FS so that SG = –5 dB. In the normalization process, equal loudness counters were used to calculate the energy levels of the noise and speech materials. Thus, the weight of the speech frequencies was increased. White noise, which was normalized to –14 dB FS was used to calibrate the speaker outputs. The speaker outputs were calibrated to be 65 dBA in the sound level meter (RadioShack, Texas, USA). Therefore, the S/N ratio was presented as –5 dB (signal 60 dBA, noise 65 dBA).

A portable IL system in our clinic was installed in a room. Geemarc 101 Bank type IL system (Geemarc Telecom SA, Hertfordshire, UK), designated as portable IL system, 0 degrees azimuth 30 cm away from a chair, was placed in a working environment that was prepared.

Word lists were determined primarily to evaluate the understanding of speech in three different environments (noiseless, noise, noise + induction system active) of individuals using hearing aids. These lists were prepared as three lists of 12 words of equal difficulty, out of 44 three-syllable words commonly used in our clinic and other audiology clinics. In order to create these lists, 42 individuals with normal hearing were given 44 words in a noisy environment, and 36 words which they could understand were chosen. Thus, three different word lists (list 1, list 2, and list 3) of equal difficulty were created (Table 2).

The study was carried out in 3 stages.

In the first stage, individuals with hearing aids listened to 12 words from list 1 recorded on the computer in a noiseless environment. The right and wrong words they repeated were marked on the list.

In the second stage, a noisy environment was created with 'Babble Noise' and 12 words from list 2 were played one by one from the computer. Right and wrong words were marked on the list. The subjects were then asked five questions on the scale we developed to assess the use of the IL system.

In the third phase, training was given about what the IL system is, its benefits, how to use it, where it is located, some statistical information about its use in Turkey, and how to establish a connection between the HA and the IL system. A telecoil program was later added to the hearing aid. The IL system was activated at a ratio of –5 dB S/N and the 12 words from list 3 were played. Repeated right and wrong words were identified. The questions asked in the second phase of the study were asked again after the training.

2.2. Statistical analysis

In order to evaluate the use of the induction loop system during the scale development phase, a reliability and validity analysis of the scale was performed.

Repeated measures ANOVA was used for the analysis of the equivalence of word lists. The homogeneity of the variances of distributions, namely sphericity, was examined with Mauchly's sphericity test and the homogeneity assumption was met. To evaluate the effectiveness of education of adults about the use of IL system by using HA, three scenarios were applied:

1) A list of words was repeated in a noiseless environment;

2) A list of words was repeated in a noisy environment;

3) The IL system was activated and the hearing aid repeated the list of words in a noisy environment in the telecoil program.

Table 1. Scale developed for evaluation of induction loop system use.

1) Would you use an induction loop system, if any, to understand the attendant's speech in noisy places such as teller, box office and information desk?
a- Always
b- Usually
c- Rarely
d- Sometimes
e- Never
f- I have never been in such a situation
2) Subway, hospital, government office, etc. do you use an induction loop system, if any, to understand announcements in places?
a- Always
b- Usually
c- Rarely
d- Sometimes
e- Never
f- I have never been in such a situation
3) Does the induction loop system make it easier for you to understand conversations in places like consultation, box office and Teller?
a- Always
b- Usually
c- Rarely
d- Sometimes
e- Never
f- I have never been in such a situation
4) Does the induction loop system make it easier to understand announcements in crowded places such as hospitals, government offices or subways?
a- Always
b- Usually
c- Rarely
d- Sometimes
e- Never
f- I have never been in such a situation
5) Mosque with induction loop system etc. does it make it easier for you to understand the speech of the clergyman in crowded places of worship?
a- Always
b- Usually
c- Rarely
d- Sometimes
e- Never
f- I have never been in such a situation

The significance of the differences between the scores obtained as a result of the application in the three different cases was examined by repeated measurements ANOVA and variance analysis. The repeated measurements between the three points were analysed by the LSD (least significant difference) as a post hoc test. The average of the

Table 2. Lists of three-syllable words used in the study.

List of words used for noiseless environment (List 1)	List of words used for noisy environment (List 2)	List of words used when IL system is activated in noisy environment (List 3)
Ankara	Haziran	Öğretmen
Baklava	İkindi	Papatya
Basamak	İstasyon	Patates
Bilezik	Kahraman	Perşembe
Çamaşır	Kelebek	Portakal
Çarşamba	Kestane	Ramazan
Çerçeve	Kırmızı	Sigara
Çocuklar	Makarna	Şeftali
Dondurma	Manolya	Tekerlek
Eldiven	Merhaba	Tencere
Fabrika	Nasılsın	Teşekkür
Günaydın	Otobüs	Yabancı

scores of the latest IL scale between pre and posttraining applications as a preliminary and final test was analysed with the t-test in the associated samples. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 22. A $P < 0.05$ was considered statistically significant.

3. Results

In order to evaluate the use of the induction loop system during the scale development phase, a 69-question form based on expert opinion was completed by a total of 264 people, 121 women and 143 men, and a reliability and validity analysis of the scale was performed.

According to the findings of exploratory factor analysis (EFA) following the pilot application, the Kaiser–Mayer–Olkin (KMO) value was 0.79 (above 0.70 indicates that the sample fit measure is sufficient) and Bartlett globality test P = 0.00 (accepting the H1 hypothesis implies that the correlation between variables is not significant). This shows that the samples and items are fit for factor analysis. Since the data mentioned in this sentence are given in the previous sentences, we can remove. this sentence. When items with overlapping factor loadings and items that do not form a dimension together were removed, a final scale of 5 items was obtained (Table 1). The eigenvalue of the scale was 4.99 and it explains 97.63% of the total variance. The loads of the items varied between 0.996 and 0.972. Cronbach's alpha value for the scale was 0.97. These findings point out that the scale developed to evaluate the use of the induction loop system can measure latent structure both reliably and validly.

Repeated measures ANOVA was used for the analysis of the equivalence of word lists. When the assumptions required to perform the repeated measures ANOVA analysis were examined, the distribution of the total scores of the 3-word sets did not show excessive deviation from the normal distribution, and the skew coefficients were calculated within ±1 limit (list $1_{skewness} = 0.178$, list $2_{skewness} = -0.759$, list $3_{skewness} = 0.127$). The homogeneity of the variances of distributions, namely sphericity, was examined with Mauchly's sphericity test (X^2 [2] = 3.785, P = 0.151) and the homogeneity assumption was met. According to repeated measures ANOVA results, there was no statistically significant difference between the means of distributions for list 1 (M = 8.92, SD = 1.34), list 2 (M = 8.31, SD = 2.05), and list 3 (M = 8.43, SD = 1.73) (F [2, 82] = 0.506, $P > 0.05$, $R^2 = 0.012$) (Table 3). This shows that the three lists to be used in the analyses measure the same feature in the same way. That is, they have measurement equivalence.

In the second phase, the study included 14 male and 16 female participants with sensorineural hearing loss (SNHL) who used HA in one or both ears, whose HA was able to be integrated into the IL system (telecoil, T-mode). The average age of the individuals was 65.5 years.

Repeated measures ANOVA was used to examine the significance of the difference between the measurements as a result of the application of word lists in three different test settings in individuals with hearing loss. When the assumptions required to perform the repeated measures ANOVA analysis were examined, the distribution of the total scores of the 3 applications did not show excessive deviation from the normal distribution, and the skew coefficients were calculated within ±1 limit (test $1_{skewness} = 0.948$, test $2_{skewness} = -0.192$, test $3_{skewness} = 0.927$). The homogeneity of the variances of the distributions, namely sphericity, was examined with Mauchly's sphericity test (X^2

[2] = 3.677, P = 0.159) and the homogeneity assumption was met. According to repeated measures ANOVA results, there was a statistically significant difference between the means of the distributions for test 1 (M = 11.7, SD = 0.7), test 2 (M = 2.6, SD = 1.62), and test 3 (M = 10.7, SD = 1.53) (F [2, 58] = 508.987, P < 0.01, R^2 = 0.946) (Table 4).

Least significant difference (LSD) was used as a post hoc analysis to determine which measurements were significant, and according to the analysis results, it was found that the difference between all three measurements was statistically significant. As a result of post hoc analyses, P = 0.000 between test 1 (11.7, 0.7) and test 2 (2.6, 1.62), P = 0.000 between test 2 (2.6, 1.62) and test 3 (10.7, 1.53), and P = 0.002 between test 3 (10.7, 1.53) and test 1 (11.7, 0.7) were calculated. There appears to be a statistically significant difference with the hearing situation of the patients before the tests (P < 0.01).

When the distributions of test 1, test 2, and test 3 mean scores were taken as a factor, the resulting graph was shown in the Figure.

The difference between the measurements was still statistically significant when the analyses were repeated by checking the age of the individuals (Wilks' Lambda = 0.325 F [2, 27] = 28.07, P = 0.000; the effect magnitude of the obtained statistic was calculated as h^2 = 0.46).

Although the effect size has decreased, the effect size was high when the age variable was assigned as the auxiliary variable. No statistically significant effects were observed when the age variable and the tests were compared (F [1.28] = 1.83, P = 0.187).

The average scores of the IL scale between pre and posttraining applications as a preliminary and final test were analysed with the t-test in the associated samples. As shown in Table 5, the final test average was statistically significantly greater than the preliminary test (t [29] = –124.905, P < 0.01). This suggests that education changes individuals' views and knowledge of the IL system.

4. Discussion

Despite the positive developments in HA technology, only 20% of the world's hearing-loss population uses HA. It is reported that 62% of HA users continue to have hearing problems [4].

Reports in the literature show that there is plenty of evidence that SNHL causes communicative difficulties, especially in noisy and/or reverberating environments [5–8]. Increased frustrations, anger of individuals with hearing loss, decreased psychosocial functioning including fear, isolation, loneliness, and depression are the harmful effects of SNHL on communication [9]. In addition, as a result of decreased psychosocial functionality, people with SNHL may run a higher risk of experiencing health problems such as hypertension, ischemic heart disease, arrhythmia, and osteoarthritis. In addition to impaired communicative and psychosocial functions, loss of hearing also leads to decreased health-related quality of life [1]. For these reasons, it is important that HAs be provided with assistive listening devices as well. HA alone may not be sufficient for individuals with hearing loss to communicate in environments where there is

Table 3. ANOVA results with repeated measurements of word lists in noisy environments conducted with individuals with normal hearing.

Variance source	Sum of squares	SD	Mean of squares	F	p	Significant difference
Between subjects	203.214	41	4.956	0.506	0.605	
Measurement	2.048	2	1.024			
Error	165.95	82	2.024			
Total	371.212	125				

Table 4. ANOVA results with repeated measurements of speech comprehension tests in three different environments conducted with individuals with SNHL. (Test 1: List 1 findings with HA in a noiseless environment; Test 2: List 2 findings with HA in a noisy environment; Test 3: List 3 findings with HA, while IL system is active in a noisy environment).

Variance source	Sum of squares	SD	Mean of squares	F	p	Significant difference
Between subjects	74.667	29	2.575	508.987	0.000	Test 1- Test 2 Test 1- Test 3 Test 2 - Test 3
Measurement	1494.2	2	747.1			
Error	85.133	58	1.468			
Total	1654	89				

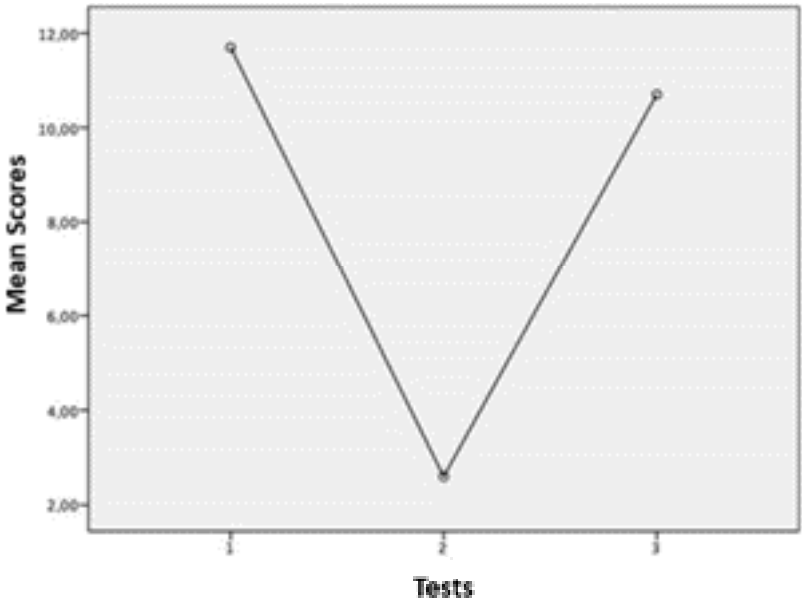

Figure. The graph obtained when distributions of speech comprehension tests performed in three different environments were taken as a factor.

Table 5. The results of the analysis of the data obtained by applying the IL scale as a preliminary test in the second stage and as a final test in the third stage.

IL scale assessment	N	Mean	Ss	P
Implementation of the IL scale before training,pretest	30	5.4	0.89	0.00
Implementation of the IL scale after training, posttest	30	29.8	0.61	

*t- test

excessive background noise. In such environments, other assisted listening systems, communication strategies, and auditory rehabilitation training should also be considered. Thus, with the development of communication function, negative psychosocial effects on communication can be reduced and quality of life increased.

One of the most important complaints of listeners with SNHL is the difficulty of communication in places such as restaurants, classrooms, therapy rooms, hospitals, shopping centres, public transportation, conference rooms, theatres, etc. Acoustic variables such as background noise, reverberation, S/N ratio, and distance to sound source influence speech perception [4].

While communication between two face-to-face individuals continues nicely, communication can become impossible in the presence of strong reverberation and background noise, where the distance to the sound source increases. In such environments where hearing is difficult, assisted listening devices associated with HAs are needed [10].

The purpose of using assistive listening systems is to reduce the distance to the sound source to a minimum and increase the S/N ratio by reducing reverberation and background noise. Electromagnetic IL systems are the oldest form of room amplification systems. IL systems have some advantages over other room amplification systems. These advantages are primarily that IL systems are low cost and do not require additional receivers such as FM and infrared systems [11].

In the literature survey, there are not many studies examining the effect of assistive listening devices on quality of life and comparing the use of assistive listening devices with the use of HAs. In their 1996 study, Jerger and colleagues compared assistive listening devices with conventional HAs to examine the effect of amplification systems on the quality of life of older individuals. The study examined 180 elderly individuals without amplification and divided into groups consisting of three different forms of amplification (conventional hearing aids, assistive hearing aids, and a combination of both). While three

different amplification methods were shown to have a significant effect on speech comprehension, participants preferred assistive listening devices for sound quality assessment [12]. In our study, when the effect of three different test environments on speech intelligibility was evaluated, it was shown that the IL system had a significant effect on speech comprehension in the noise-induced test environment. It was also reported by the individuals involved in the study that sound quality in the presence of noise while the IL system was active was better than sound quality in the noisy environment.

A very limited number of studies on IL systems are also available in the literature [12–14]. Audibility and awareness have often been explored with assisted listening devices. "Can be heard" is defined as revealing what is said with less effort; "awareness" is defined as distinguishing sounds from the environment. The studies focused more on the use of the FM system and the IL system. Studies have shown that FM and IL systems benefit equally in word recognition. Nabelek and colleagues compared IL, FM, and infra-red systems in a classroom environment in 1986. Word recognition tests were performed in two different cases, with the S/N ratio set to +8 dB and to +20 dB when 'Babble Noise' was present. Better scores were obtained on word recognition tests with the use of all three assistive listening devices, and it was concluded that the assisted listening devices tested were suitable for listeners with various degrees of hearing loss [13]. In our study, word intelligibility was determined in 3 different environments (noiseless, noisy, and noisy + IL system active) by adjusting the S/N ratio to –5 dB. While there was no problem for individuals using HA to repeat words in the noiseless environment, there was a large decrease in the ability to repeat words in the presence of noise. While the IL system was on and the hearing aids were in T-mode, they were able to repeat words almost unaffected by the noise. A statistically significant difference was obtained by applying the tests in 3 different cases ($P < 0.01$).

In a classroom setting with an IL system, Odelius and Johansson administered a questionnaire to 25 hearing-impaired students in the 10–20 years age range who used HA in both ears while the T and M-modes of their HAs were open. Audibility and mindfulness were evaluated separately in both modes. A new, shorter, 18-question questionnaire based on the speech, Spatial and Qualities of Hearing Scale (SSQ), was used for assessment to evaluate assistive listening devices. Results showing better understanding of distant conversations with T-mode have been reported, while better results have been reported with the M-mode in terms of awareness of sound [14]. Hartley and colleagues investigated the use of HA and assistive listening devices in the older Australian population (age range 49–99 years). Hearing loss was detected in 33% of the population, while only 11% of individuals had HA and 4.4% used assisted listening devices. Major efforts have been reported to be needed among older people with hearing loss, such as holding training meetings to promote the benefits and support their use of these technologies [15]. In this study, we used a scale that we had prepared prior to the study because there was no evaluation method for the use of an induction loop system in individuals with hearing loss in Turkey. Questions about speech, environment, and hearing qualities were included on this scale. Of the 30 individuals who participated in the study, only three reported having heard of the IL system before, but not using it effectively. The other 27 individuals had no knowledge of the IL system. All of these individuals expressed difficulty in understanding speech in large areas such as places of worship, subways, and decreased speech intelligibility, especially in noisy environments. These findings also reveal the necessity of organizing training meetings in order for hearing aid users to make sufficient use of assistive listening devices and to spread their use.

Rebecca and Kamea stated in their study on hearing aid use with 123 HA users in New Zealand that the most commonly used assistive listening device was the telephone. Eighty-one participants used assistive listening devices, while only 15 participants used IL systems and FM systems in their collective living quarters. Of these 15 participants, nine preferred IL systems (9/15), while six preferred FM systems (6/15). As a result of the study, it was stated that the use of hearing assistance technology devices had positive effects on quality of life and that training on hearing assistance technology should be provided [16]. The 30 individuals involved in our study did not use the IL system effectively and their knowledge and training about the IL system were insufficient.

5. Conclusion

The data from our research show that individuals using HA have insufficient knowledge and training about the IL system. As a result of a short training on the IL system, it was observed that the thoughts of individuals using HA changed in a positive manner. By observing the positive effects of informing individuals about the developing technology, we conclude that education should be disseminated to ensure that HA users are aware of the legal regulations and possibilities in this field. Due to the limited number of studies evaluating the IL system in the literature, we believe that additional studies may be needed.

Conflict of interest

The authors declare that they have no personal or professional conflicts of interest regarding any aspect of this manuscript.

Acknowledgment/Disclaimers/Conflict of interest
All authors declare that they have participated in the design, execution, and analysis of the paper, and that they have approved the final version. Additionally, there are no conflicts of interest in connection with this article and the material described is not under publication or consideration for publication elsewhere. The authors declare that this study has received no financial support.

Informed consent
The study was approved by the Dokuz Eylül University Clinical Studies Ethical Committee (2015/24-18) and was conducted according to the ethical standards of the Helsinki Declaration. Informed consent was obtained from all subjects.

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