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COMMUNICATION ABILITIES OF OLDER ADULTS AND THEIR POSSIBLE IMPROVEMENT BY DICHOTIC LISTENING TRAINING: A SELF-ASSESSMENT STUDY

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ABSTRACT

Our goal was evaluating the effect of aging on communication abilities of older adults with normal peripheral hearing sensitivity, and shows the effect of Dichotic listening training on these abilities using the Persian version of the speech, spatial and quality of hearing scale. (P-SSQ)The communication abilities of older adults (aged 68.16 ± 6.20 years, n=32) were compared with those of younger adults (Aged 20.41±2.13 years=32) using responses to P-SSQ items. Multivariate analysis was used to measure aging effects. Older adults were randomly divided into experimental and control groups. The experimental group received the dichotic listening training for two months. Possible improvements on P-SSQ scores were investigated with ANCOVA and Wilcoxon analysis. Aging decreased all communication abilities across three subscales; however, training improved some communication abilities.

Key words: Aging- Auditory processing-Central presbycusis- Dichotic Listening-Speech,Spatial and Quality of Hearing Scale (SSQ).

INTRODUCTION

Communication abilities tend to deteriorate with age, and communication problems are important health issues for older adults (8). An important aspect of communication is the ability to understand speech in noisy environments (8, 14). Research has identified a number of potential causes of communication problems. Three key issues discussed in recent research are peripheral hearing impairment, cognitive disabilities, and central processing effects of aging (9, 14, and 15).

Understanding the pure effect of aging on central auditory processing ability is an important subject. The importance of this issue increases when older adults who do not have apparent peripheral hearing loss and show audiometry results normal for their age, report communication problems. The most common problem for these older adults is that they have difficulty listening in noisy environments. (8) They usually do not show distinct cognitive decline but complain that they are disable to understand other's speech in public situations, noisy places or when a group of people are talking together rather than in a one –on- one conversation (14, 8).

Binaural processing is one of the key aspects of central auditory processing. Binaural processing can be bottom- up or top- down. Spatial hearing is related to bottom- up processing, and dichotic listening and inter - hemispheric asymmetry is related to top-down processing (14). In the present study, we hypothesized that some kind of inter-hemispheric transmission irregularity might be the origin of communication difficulties such as difficulty understanding speech in noisy situations. This hypothesis was based on studies that have shown the anatomic degradation of the corpus callosum in aged people (11). Reduction in corpus callosum integrity and/ or atrophy is reported in otherwise normal older adults (10, 11). Dichotic Listening performance is affected by age related corpus callosum changes. This has been mostly shown as a decrease in left ear performance in binaural separation tasks that starts to emerge between 55 and 60 years of age (12) and is specifically associated with age- related declines in corpus callosum size (13).

The first step in study about communication problems is to develop a good procedure for evaluating communication problems. Pure tone audiometry and speech audiometry are not sufficient tools for quantifying these difficulties. We need to know what is happening in real life situations of older adult's life. Self-assessment is a widely

recognized approach that enables the clinician to develop awareness of details of problems that the patient experiencing in daily life. Self-reports is a commonly used approach in fields such as psychology, but its use as a tool for evaluation is a recent trend in Audiology. However it is sometimes necessary to look beyond the audiogram. (14)

The Speech, Spatial and Quality of hearing scale (SSQ) developed by Gatehouse and Nobel (2004), is a suitable questionnaire with a particular focus on static and dynamic aspects of binaural hearing (2, 16).The SSQ was developed to measure listener's self-reported abilities in different environments and conditions. The SSQ provides insights into different aspects of audibility and cognition and has been used to assess the effect of hearing loss on communication abilities in both aided and unaided situations (2).It is also used with cochlear implant users (6), with bone anchored hearing aid users (5), and for comparison between monaural and binaural hearing aid users (7).Short versions of the SSQ have been adapted for clinical and screening goals (16, 17). The Persian version of the SSQ (P- SSQ) which was translated and validated by Nazeri et al (2014), was used in this present study (4). In the P-SSQ the original three factor structure which was investigated, byAkeroyd (2014), was confirmed by exploratory factor analysis (3, 4). The three loaded factors are speech understanding, spatial hearing, and quality of hearing.

Increasing the processing role of left ear was another goal of the present study. Dichotic listening training is designed to improve dichotic listening abilities. Recent studies have shown that there is a marked right ear advantage in different dichotic listening tasks, which use different stimuli such as words, rhymed words and digits. This suggests that dichotic listening training can be used to develop a task for improving left ear function (14). In addition, divided and focused attention training were implemented as part of the auditory training program.

This present study primarily focused on older adults who did not have peripheral hearing loss but complained of some difficulty understanding speech, especially in noisy environments. All older adults included in this present study showed ear asymmetry in dichotic digit test. Actually it has been as an inclusion criteria. The effect of dichotic listening training can be investigated with the SSQ which has a good sensitivity and reliability for measuring auditory rehabilitation benefits in older adults (1).

MATERIALS AND METHODS

Study Design:

This present study was conducted in two parts. At part one investigated the effect of aging on communication abilities by comparing the P-SSQ results of younger adults and older adults. In part two, older adults were randomly divided into two groups: an experimental group and a control group. The Experimental group received dichotic listening training for two months, after which the communication abilities of both the experimental and the control groups were assessed by self-assessment (P-SSQ).

Participants:

In part one, 32 younger adults (16 males and 16 females; mean age:20.41years, SD=2.13, Age Range=15-25) recruited from students of university of social welfare and rehabilitation Sciences compared with 32 older adults (13 males and 19 females; Mean Age:68.16 years ,SD= 6.20, Age Range=55-85) recruited from clients at private Audiology clinics or from those who accepted an invitation from the present researcher to taking part in a research program to improve listening in-noise abilities. All participants were monolingual and right- handed as assessed by the Edinburg Inventory (19). All participants underwent a comprehensive general audiological assessment to provide background data. Participants should have had normal peripheral hearing sensitivity at octave frequencies between 250 – 4000 Hz, (PT average ≤25 dB) and normal middle ear function (Type A tympanogram and present ipsilateral acoustic reflexes). Audiometry was carried out by Interacoustic AD 440 instrument. Tympanometry and acoustic Immitance were performed with Gn otometrics oto flex 100 instrument.

In the older adults group, the people who had normal peripheral hearing sensitivity (PT average ≤25 dB), were the target group in this study. All of the older adults had Mini Mental State Evaluation (MMSI) scores (19) greater than 21, so they had no apparent cognitive problem. Another selection criteria was having speech understanding problem in noisy situations in spite of their normal pure tone sensitivity .Participants difficulty understanding speech in noisy situations (despite normal pure tone sensitivity) was evaluated with a three item short questionnaire. The questionnaire directly asked about understanding speech with three response options: yes, no or sometimes. Those who responded yes were entered to the study. Ear asymmetry was measured with a Dichotic Digit test and only those with more than 15% ear asymmetry were included in the study sample.

In part two, the group of older adults was randomly divided in to two groups of 16

person, an experimental group consisting of (5 males and 11 females 67.88 ±7.05 years) and control group consisted of (8 males and 8 females (68.44 ±5.45 years).The experimental group entered the auditory training program. The control group was informed about the training program and was told that would have the opportunity to receive the training after termination of the study.

All participants gave written consent to participate. All study procedures was approved by the local ethical committee of the University of Social Welfare and Rehabilitation Sciences.

SELF ASSESSMENT

The P-SSQ was used to evaluate the effect of aging on communication abilities and to monitor the possible improvement of these abilities following the two months dichotic listening Training program. The P- SSQ has 47 items: 14 items on speech understanding, 16 item on spatial considerations in hearing and 17 item on specific qualities of hearing. Participants responded to each item on a scale ranging from 0 (not at all) to 10 (perfect), higher ratings corresponded to better self-reported ability. A professional audiologist explained the questionnaire to participants and was available while they were completing their questionnaires to answer any questions or clarify ambiguities.

It is noteworthy that according to our previous study (4) the Persian P- SSQ showed good test – retest reliability. In this study the tests, were conducted two weeks apart. 29 people from total sample of 330 (hearing impaired older adults) completed the P-SSQ two times, with a test – retest reliability of 0.73- 0.88.The internal reliability was measured, and the Cronbach's alpha was 0.96.These results were consistent with those of the Singh et al (2010) study. (18)

Auditory training program:

The Auditory training program had formally and informally components.

Formal Training: The formal training comprised eight weeks with one 1 hour session per week. The activities performed during each session of formal auditory training were:

1-Frequency discrimination training: Two different frequencies were delivered simultaneously at different intensities. (Stronger on left side).The participant was asked to respond to each frequency with hand gesture. The difference in intensity and frequency was gradually decreased until the last session where two different frequencies (a frequency difference of 500 HZ) with equal loudness were delivered dichotically.

2- Dichotic interaural intensity difference training (DIID)

We used a modified type of DIID. The stimuli used were those in the Persian version of the SSW. This was delivered dichotically through a two channel clinical audiometer.

Informal training: informal training comprised a program developed by present researcher recorded on compact disc. Each participant received a disc in the first session for use at home. Training was orally and through a written manual and consisted of three parts.

Part 1: Speech- in- noise training: a short story was mixed with restaurant noise and delivered to both ears. The participant listened and answered questions about story. There were three signal –to- noise ratios in each program. The first one was simple while the last one was difficult.

Part 2: Dichotic Listening (integration): a short story was distributed from one channel simultaneously with traditional Iranian music distributed to the other channel. The direction was reversed half way through the recording. The participant was instructed to pay attention to both the story and the music (divided attention) and answered to the questions from the story afterward.

Part 3: Dichotic Listening (separation): a short story was rapidly switched between the right and left ear. Traditional Iranian music was played simultaneously in the other channel. The participant was instructed to only pay attention to the story regardless of which ear it was heard (focused attention).

In all three parts the informal training the presentation level of the stimuli was stronger for the left ear in the first sessions and gradually decreased to be equal with right ear in the last sessions.

All of the recording and processing procedures were performed in the research laboratory at the Broadcasting University. The recording was done by an experienced national Radio and TV speaker in a well-equipped studio with a Sony recorder. Adobe Audition version 3 was used to process the recordings.

The informal program consisted of nine sessions. Participants were instructed to practice each session for one week. During the first session they were shown how to use their own computers or complete the exercise. Participants were also instructed to do some additional exercises to improve their attention abilities. For example, sitting between two sound sources and trying to switch their attention between them.

Other exercises taught to the older adults to improve their inter-hemispheric abilities, included verbal to motor activities, motor to

verbal activities, and playing with a ball with both hands.

Statistical Analyses

The P-SSQ results for the first part of the study were analyzed using multivariate analysis. In the second part of the study analyses of covariance (ANCOVA) were performed to determine the effect of the training on P-SSQ subscales. A Wilcoxon test was used to analyze the changes item by item. Participants with missing data were eliminated from the analysis. All statistical tests were considered to be significant at a $p \leq 0.05$.Statistical analyses was conducted with SPSS 16 (SPSS Inc., Chicago, USA).

RESULTS

The Kolmogorov-Smirnov test of normality was performed for the first part of the study to determine the effect of aging on the P-SSQ subscales. Multivariate analysis was used to compare the results of the older adults with those of the younger adults (Table 1).

Multivariate analysis showed that total and subscale scores on the P-SSQ were significantly reduced due to aging. They reduced by 1.47 for speech understanding, 1.65 for spatial hearing, and 2.01 for qualities of hearing. The total score reduction was 1.81.In both groups The highest score was observed for spatial hearing, in the younger group the lowest score was observed for speech understanding, in the older group the lowest score was for quality of hearing.

The ANCOVA results showed that the dichotic listening training significantly increased the P-SSQ scores of the experimental group on all three subscales. The increment was 0.96 for speech understanding, 0.13 for spatial hearing and 0.79 for quality of hearing. The Total score increment was 0.62. The maximum largest improvement was observed on the speech understanding subscale and the least improvement was seen on the spatial hearing subscale.

ANCOVA results of the second part of the study are showed in Table 2:

The results of Kolmogorov Smirnov test of normality showed that the distribution of variables was not normal, a non-parametric test (Wilcoxon) was performed to define possible improvements for each individual item (Table 3).

Table1: Distribution of P-SSQ subscales and total scores and the comparison of results between older and younger adults.

	YOUNGER ADULTS (n=32)		OLDER ADULTS (n= 32)		P VALUE
SUBSCALES	MEAN	SD	MEAN	SD	<0.001
Speech understanding	8.76	0.29	7.29	0.20	<0.001
Spatial hearing	9.38	0.23	7.73	0.77	<0.001
Quality of hearing	9.16	0.71	7.15	1.07	<0.001
Total	9.10	0.27	7.39	0.43	<0.001

Table 2: The distribution of P-SSQ subscale scores after dichotic auditory training: ANCOVA results.

Variable	Mean(SD)		P value
	Experimental	Control	
Speech understanding	8.25 (0.27)	7.08 (0.20)	<0.001
Spatial hearing	7.27 (0.26)	6.90(0.18)	<0.001
Quality of hearing	7..68 (0.26)	6.74 (0.14)	<0.001
Total Score	7.3 (0.22)	6.90 (0.11)	<0.001

Table 3: Significantly improved P-SSQ items after Dichotic listening training for the experimental group.

Subscale	Item Number	P value	Content
Speech understanding	Q4	0.002	Conversation with five people in noise
	Q5	0.000	Talking with one person in continuous background noise
	Q6	0.001	Conversation with five people in noise , no vision
	Q10	0.000	Talking with one person and following TV
	Q11	0.001	Follow one conversation when many people are talking
	Q12	0.000	Follow conversation without missing start of new talker
	Q14	0.001	Follow one person speaking and telephone at the same time
Spatial Hearing	Q15	0.025	Locate lawnmower
	Q29	0.004	Sound further than expected
Quality of hearing	Q31	0.000	Separation of two sounds
	Q33	0.002	Music and voice as separate objects
	Q37	0.000	Identify instruments in music
	Q44	0.000	Need to concentrate when listening
	Q45	0.000	Effort of conversation
	Q46	0.013	Understand when a car passenger
	Q47	0.034	Ability to ignore competing sounds

DISCUSSION

Our finding showed that the total score of P-SSQ IS decreased in older adults. The total score was 9.10 for younger adults and 7.39 in older adults. As the participants had normal peripheral hearing sensitivity and normal cognitive status, this score reduction provides evidence for the pure deteriorating effect of aging on the communication abilities of older adults. This score shift also confirmed that the P- SSQ is a good indicator of communication abilities in different groups even in those with normal hearing. It is noteworthy that both younger and older adults achieved the highest scores on the spatial hearing subscale (younger adults: 9.38 ± 7.73, older adults: 7.73± 0.77), while the lowest scores for younger adults were related to speech understanding. (8.76 ± 0.29) and the lowest scores for the older adults were related to the quality of hearing (7.15 ± 1.07). The largest score shift due to aging was observed on the quality of hearing subscale. (2.01 score reduction).

Bahn eT all (2012) performed a similar study, Comparing younger and older groups with normal hearing (1). They found total score of 8.8 for the younger group and 7.7 for the older group (1). The difference in the scores for the older group between their study and our study may be related to the inclusion criteria of our study. Therefore we concluded

that the reduced ability of the older adults in our study was related to participant's central processing difficulties.

After undertaking the Dichotic listening training program the experimental group showed significant improvement on all three subscales. This finding confirms the neural plasticity of the central auditory system. To better understand the exact improvement in each communication ability Wilcoxon analyses was performed (Table 3). Our findings showed that some items on each subscale demonstrated significant improvement. In particular, conversation with five people in noise *(item 4),* talking with one person in continuous back ground noise,*(item 5) and* conversation with 5 people in noise/ no vision,(item 6) on the speech understanding subscale showed significant improvement after the dichotic listening training program. These items evaluated the effect of background noise on speech understanding. The improvement the ability of older adult's on these items means that the central inhibition loss was compensated by their formal and informal top- down auditory training. Improvements on other speech understanding subscale items were on Talk with 1 person and follow TV(item 10), Follow one conversation when many people talking(item 11), Follow conversation without missing of new talker(item 12), follow one person speaking and the telephone at the same time(item 14). These items were related to following two or more streams (divided attention). Therefore dichotic listening training which included divided and focused attention was successful in improving this Ability in older adults. On the spatial hearing subscale, only two items showed significantly improvements, locate lawnmower(item 15) and item 29 sound further than expected(item 29). These items were related to sound localization and their improvement indicated a bottom- up effect which was not expected from top- down training offered by the dichotic listening training program. However our findings showed that most items on the spatial hearing subscale did not significantly improved. As spatial hearing items are mostly bottom up activities, the lack of improvement after dichotic listening training was expected.

The improvement of participant's scores on the quality of hearing items after dichotic listening training was considerable. It is noteworthy that Akeroyd et al (2014) used "clarity, separation and identification" instead of quality of hearing.(3)

Seven of the 17 items on the quality of hearing subscale showed significantly improvement in the experimental group. Of

these three items, were related to distinguishing between different sounds: separation of two sounds (item 31), Music and voice as separate objects (item 33) and identify instruments in music (item 37). The abilities assessed by these items were related to divided attention. Our findings showed that the training program was effective in improving the processing abilities related to auditory streaming and attention which have a top down nature. The training program focused on attention and left ear performance. However it is not possible to relate the improvement to one of these activities exclusively.

Two other items showing improvement were related to concentration and effort: need to concentrate when listening (item 44) and effort of conversation (item 45). Improvement of these abilities in older adults with normal hearing was related to the nature of exercise offered. These groups learned to better switch their attention between two channels and the training resulted in better concentration when they were engaged in conversation and less effort to understand other's speech. Akeroyd et al (2014) found a fourth actor in their factor analysis study and named it effort and concentration. In our study Items 44 and 45 relates to this possible fourth factor. (3)

In addition improvements were seen in the ability to: understand when car passenger (item 46) and ignore competing sounds (item 47).These are items were related to understanding speech in noise and improvements means that training reduced the interference of the competing factors that interact with speech understanding.

SUMMARY:

We found that aging has a pure deteriorating effect on the communication abilities of older adults. This effect is more apparent at some situations such as the presence of a competing signal, understanding speech in background noise or when two streams of sound/speech are present. Dichotic listening training which, is concentrated on top- down processing abilities such as attention and dichotic listening, can improve aspects of communication abilities. This improvement can be measured using a self-assessment tool such as the P-SSQ.

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DECLARATION OF INTEREST:

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