A FILTERED SPEECH TEST FOR AN AGING POPULATION *

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SUMMARY

A filtered speech test was presented to sixty males and females above the age of sixty years. Thirty of these subjects had complained of, and demonstrated clinically, a high frequency hearing loss for pure-tones. Thirty subjects, who had never complained of a hearing loss, but who nevertheless were found to have mild-to-moderate high frequency hearing losses, were included as a control in the study. The ability to discriminate among phonetically-balanced words where certain frequencies had been filtered out deteriorated with age, although those subjects in the control group performed better than those in the experimental group. However both groups showed poorer ability to discriminate with the right ear, than with the left, or with both ears. The results seemed to indicate a particular retrocochlear involvement in an aging population.

OPSOMMING

'n Gefiltreerde spraaktoets is aan sestig mans en vroue oor die ouderdom van sestig jaar voorgelê. Dertig van hierdie proefpersone het gekla oor 'n hoë frekwensie-gehoorverlies. Hierdie toestand is ook klinies bevestig. Dertig proefpersone, wat nooit oor 'n gehoorverlies gekla het nie, maar by wie geringe tot gemiddelde frekwensie-gehoorverlies nietemin gevind is, is as kontrole in die studie ingesluit. Die vermoë om te diskrimineer tussen foneties-gebalanseerde woorde waar sekere frekwensies uitgefiltreer is, het met ouderdom versleg, alhoewel die proefpersone in die kontrolegroep beter as diè in die eksperimentele groep gepresteer het. Altwee groepe het egter 'n swakker vermoë vertoon om met die regteroor as om met die linkeroor, of met altwee ore, te diskrimineer. Uit die resultate blyk dit dat daar 'n spesifieke retro-cochlieêre betrokkenheid onder die bejaarde ouderdomsgroep bestaan.

A common aspect noted in the texts dealing with the problems induced by the aging process, is the apparent deterioration in the communication process, and the subsequent withdrawal from social intercourse. Many workers in the field have indicated that such deterioration may be related to sensory degeneration in general, and auditory disturbance in particular.[1, 11, 15, 22] A survey of the more recent literature specifically related to the auditory problems of the aged, indicates that a sensori-neural loss demonstrated by pure-tone audiometry is only one of the many audiological features that may be demonstrated clinically in the aged.[12, 16, 17] In fact, research in the areas of anatomy, physiology, and especially neurology and its allied fields, have led us to view the condition of presbycusis as an extremely complex auditory disturbance

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that may manifest itself in any, or all of the areas along the auditory pathway, from the pinna to the temporal cortex.[4, 8, 13, 18, 24] Where speech signals have been distorted in terms of intensity, time and frequency, the amount of information that is conveyed by the auditory pathway to the brain is thus reduced[2, 6] The normal reduction of cortical cells due to aging may limit the ability of the aged person to integrate the cues on a distorted speech test.[5] Matzker[20] was a pioneer in the field of filtered speech tests. His study showed that normal subjects make few, if any, errors on tests of dichotic integration using a filtered speech test, whereas those with brain-stem lesions make many. In addition, he also noted how poorly the presbycusic patient performed on these tests. Whereas the task of speech discrimination of phonetically-balanced words in quiet conditions is considered to give minimal information with regard to the functioning of the retrocochlear pathway, the same test used in conjunction with modifications, such as the introduction of noise, or the filtering out of crucial speech frequencies, may serve to provide more detailed information about the ability of the patient to discriminate and integrate speech cues.[2, 17] The introduction of a complex listening task with the aged requires careful and controlled presentation and analysis. While neurological deficits may account for a reduction in performance on complex speech tests, one has to bear in mind such psychological factors as fatigue, motivation, memory span, etc., which may mitigate against a favourable performance on such tasks.[17, 21, 25] Palva and Jokinen [17, 21] have devised a test to determine the effects of aging on the discrimination of filtered speech. The present study was modelled on their experiments. The aim of this study was therefore to investigate certain aspects of the function of the retrocochlear pathway of the aged person, using a test of filtered speech.

METHOD

SUBJECTS

Thirty subjects (Ss) were selected on the basis of the following criteria:

1. Sixty years of age, or older.
2. Male and Female (No predetermined sex ratio was stipulated in advance, but was dependent on the chronological sequence of referral of suitable subjects to the Speech and Hearing Clinic, University of the Witwatersrand, within the experimental period).
3. No previous or ongoing severe general illnesses.
4. Negative history regarding the taking of ototoxic drugs.
5. Gradual and progressive hearing loss of recent onset.
6. Negative history of noise exposure, as a result of an occupation or hobby.
7. Negative history of early otological problems.

Table I details the number and age of subjects in the Experimental group (EG).

A control group was included in this study to investigate whether or not there was any difference between a group who had been referred, or self-referred,

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	Male	Female	Mean Age	Total No.
60-69 years	6	6	65.5	12
70-79 years	5	9	74.2	14
80-89 years	1	3	82.5	4
Total	12	18	74.0	30

TABLE I. Number and Age of Subjects in the Experimental Group.

for an audiological assessment, and those people in the same age range who had never sought professional help, in their ability to discriminate filtered speech sounds. Thirty Ss were selected to match those in the experimental group for all the variables mentioned above, with the exception of a hearing loss of gradual or recent onset. Table II depicts the number and age of Ss in the control group (CG).

	Male	Female	Mean Age	Total No.
60-69 years	6	6	63.8	12
70-79 years	5	9	73.8	14
80-89 years	1	3	81.5	4
Total	12	18	73.0	30

TABLE II. Number and Age of Subjects in the Control Group.

THE PILOT STUDY

In view of the findings in the literature that normal Ss are able to complete a test of distorted speech with few or no errors,[21] it seemed essential to ascertain how people of differing ages performed on the test of filtered speech. The results thus obtained would serve to verify the accuracy of the results obtained on the test of filtered speech with the aged Ss in this study, or they would demonstrate that the errors obtained were merely artefacts. Thirty Ss, ranging in age from 15-58 years, both male and female, were tested, in order to determine the validity of the filtered speech test. As far as possible unsophisticated listeners were selected for this aspect of the study. Men and women who had not received a higher education were favoured over those who had; and only those who had no history of ear disease, medical problems or hearing loss were selected. Table III below indicates the number of Ss included in the pilot study group (PG) for the filtered speech test.

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	Male	Female	Mean Age	Total No.
15-24 years	3	3	20.8	6
25-29 years	3	3	27.3	6
30-39 years	3	3	32.7	6
40-49 years	3	3	43.3	6
50-59 years	3	3	55.2	6
Total	15	15	31.7	30

TABLE III. Number of Subjects in the Pilot Study Group.

PREPARATION OF MATERIAL FOR THE FILTERED SPEECH TEST

In order to standardise the presentation of the filtered speech test to all the Ss, seventy-five words were recorded onto a Master Tape Recorder Nagra III, using a tape-scotch-AVi77 Tenzar at 7½ips. A Beyer Mi60 200 ohm microphone was used. The following procedure was employed:

Preceding the recording of the words to be filtered, a 1 000 Hz tone was recorded onto Track One of the tape for thirty seconds for calibration purposes. The same was repeated for Track Two. The VU meter was set at zero decibels for calibration purposes. Twenty five words each was recorded by the Experimenter (E) onto Channel One and Two of the tape, and a further twenty-five words were recorded onto both channels simultaneously. The words were taken from the CID W-22 lists 2 and 3. No carrier phrase was used, so that minimum cues were given to the subjects.

Two Madsen Electronic Speech Filters were placed in the same sound-proof booth, IAC series 1604A-ACT, as a Maico MA24 Audiometer. The filter feeding the left channel of the audiometer was set up to filter out all the frequencies in the speech spectrum except those of bands 480-640 Hz and 1 920-2 560 Hz. Using the same recording material described above, the following tape was constructed: The first word was directed to the right ear through Teletronic TDH 39 earphones at bands 480-640 Hz and 1 920-2 560 Hz. The second word was directed to the left ear through the earphone at bands 480-640 Hz and 1 920-2 560 Hz. The third word was directed to both ears simultaneously, the right ear hearing the word through the earphones at 480-640 Hz, and the left ear hearing the same word through the earphone at 1 920-2 560 Hz. Each band is too narrow for adequate discrimination. This is obviated by presentation of both frequency bands to each ear in the monaural test, and presentation of one band to each ear in the binaural test.[17, 20, 21] A 5 second interval was left between each word recorded, and the condition was repeated twenty five times using different words. In order to verify that the filter had indeed filtered out, and maintained the desired frequencies in the speech spectrum, the resident sound engineer of the Clinic analysed the frequency of certain words chosen at random; using the Kay-Sona-Graph 6061-B. Spectographs indicated that the words were not in fact being filtered as desired, and so the filters were adjusted, and the tapes remade until the spectographic analysis indicated that the desired frequency cut-outs had been obtained.[14]

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PRESENTATION OF MATERIAL FOR THE FILTERED SPEECH TEST

The Ss were seated in a sound-proof double suite booth, (I.A.C. 1600 ACT series) using the same earphones as previously described.

Before placing the earphones on the S's head, the E gave the following instruction for this particular test:

> *You are now going to hear some single words through these earphones. The words do not sound like English words because I have treated them in a special way, so that they are now distorted. You will probably not understand the words you are going to hear, but I want you to guess what they are. Please do not keep quiet, rather take a guess as to what the word is. You will hear the word first in the right ear, then a different word in the left ear, and then another word in both ears. This will be repeated. The tape recording of these words will last about ten minutes.*

The instructions were repeated until the E was sure the S understood, and six trial words were presented by the E seated at the Maico MA24 Audiometer in the second partition of the suite. All test words were then presented at 40dB above SRT for each ear. All errors were phonetically transcribed for each condition, and the percentage of errors was computed. In order to determine the degree of peripheral hearing loss in the aged Ss, and that hearing for pure-tones was normal in the pilot study group, an audiogram for each S, and their speech reception threshold, was obtained in the usual manner, prior to the administration of the test for filtered speech.

RESULTS AND DISCUSSION

There were no significant differences between the sexes for the three test conditions for the right ear, left ear and the binaural presentation, for any of the three groups. However significant differences existed between the PG, CG, and EG in relation to scores obtained for the filtered speech test for the three test conditions. The following tables demonstrate these differences among the means.

From the inspection of Table IV it may be seen that the Ss in the PG. scored significantly better for the three test conditions than either the EG. or CG. The significance value for the difference between the means for the three groups was p=0.05.

Ear	Pilot Study Group	Experimental Group	Control Group
Filtered Speech Right Ear (FSR)	86.4	38.0	50.5
Filtered Speech Left Ear (FSL)	86.6	42.5	52.1
Filtered Speech Binaural (FSB)	85.7	38.5	53.9

Table IV. Mean Percentage Scores for the Filtered Speech Test for Right and Left, and Both Ears, for PG., EG. and CG.

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Table V demonstrates the mean scores for filtered speech for the three conditions for the age groups ranging from 15-89 years.

	Age Groups								
EAR	15-24	25-29	30-39	40-49	50-59	Aged Group	60-69	70-79	80-89
Right Ear	92.0	89.4	81.5	83.17	75.5	EG CG	44.1 59.4	36.6 47.3	33.5 44.4
Left Ear	92.0	89.1	82.0	86.17	77.6	EG CG	47.1 61.2	39.6 42.9	33.5 41.0
Both Ears	91.5	89.9	83.0	82.17	78.3	EG CG	44.1 63.2	33.2 43.3	34.7 45.7

TABLE V. Mean Percentage Scores for Filtered Speech for the Right and Left Ears, and the Binaural Condition for the PG, CG and EG.

Inspection of Table V once more indicates that all Ss in the PG. scored significantly better than the CG. who in turn scored significantly better than the EG. for all three conditions. However it may be observed that there is a deterioration in the scores for all three conditions as the age increases; and this is so even for the PG. The results obtained in this study, which demonstrate the poorer performance with an increase in age, correspond very closely to the results obtained by Palva and Jokinen.[21] It is interesting that none of the Ss in the PG scored 100% for the filtered speech test, under any condition. These results accord closely with the studies cited by Palva and Jokinen.[17, 21] From the results presented in Table V, and those presented by Palva and Jokinen, [17, 21] it may be concluded that a 'normal population group' will score up to the 75th percentile for the filtered speech test, and an aged group score considerably below this level.

It may be noted that in the latter two age groups studied, the difference between the means for the filtered speech conditions are less than those in the younger age groups.

Figure 1 details the relationship between age and scores obtained by the PG., and CG. for the three test conditions. Although there are no significant differences among the three test conditions for filtered speech, it may be seen that the right ear for all three groups is slightly inferior to the left ear, and both ears. Jokinen and Palva[17] found that their subjects, who ranged in age from 60-89 years, showed poorer discrimination in the right ear for the filtered speech test, and this score was worse than that in the left ear, and both ears, although not significantly so. *Figure 2* details the relationship between age and scores obtained by the PG. and EG., for the three test conditions.

It may be seen that although similar trends exist for the three test conditions in the EG., the scores are significantly poorer than those for PG. and CG. It would seem that the hearing defect which is present in this group is so severe

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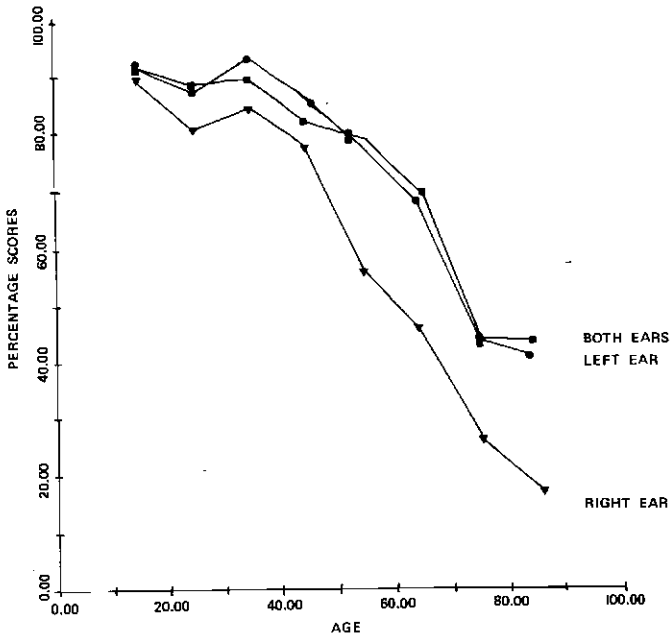

Figure 1: Mean Percentage Scores for Filtered Speech for the Pilot Group (Age 15-59) and Control Group (Age 60-85).

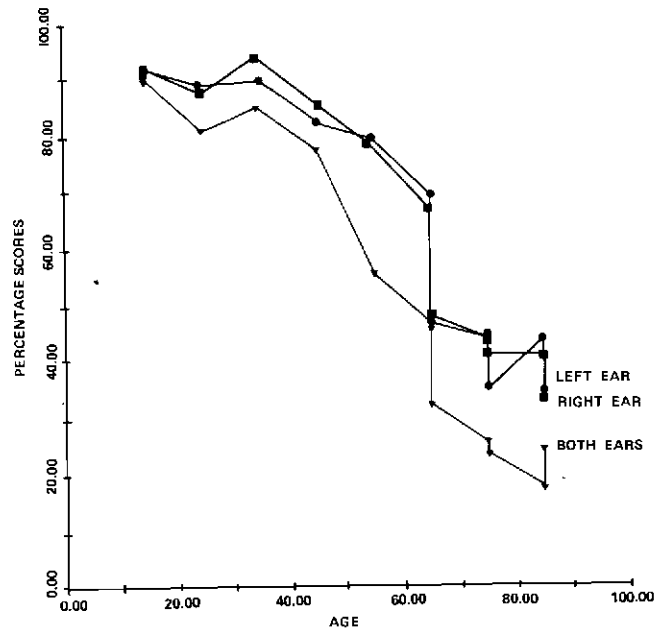

Figure 2: Mean Percentage Scores for Filtered Speech for the Pilot Group (Age 15-59) and Experimental Group (Age 60-85).

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that it affects all aspects of hearing ability in a more debilitating manner, than the 'normal' loss of hearing which occurs in the CG.

Filtered speech tests have been used to diagnose the presence of lesions in the higher auditory pathway.[2, 5, 20] A lesion in the auditory cortex should produce poor speech discrimination scores in the contralateral ear. Where both ears respond in the same manner, and the binaural test gives similar results in both ears, one may conclude that the lesion is not at a cortical level, and in fact is probably at the brain-stem level.[21]

As pointed out before, the poorer responses obtained for the Ss in the EG. and CG. for the right ear although not significant at the 95% confidence level, nevertheless concurred with the study by Palva and Jokinen.[17, 21] They felt that the poorer scores in the right ear, giving an asymmetrical pattern to the response set, indicate that the contralateral hemisphere was not functioning as well as it did for younger people. They did not detail the exact level of the auditory pathway implicated, but because of the asymmetrical response, assumed that it must be higher than brain-stem. The better responses for the binaural condition may be due to the fact that binaural stimulation activates more neurons than monaural stimulation, and this allows greater facility for interpretation of the incoming signal. All Ss in the EG. and CG. were right handed, and this would indicate a left-hemisphere dominance.

Irrespective of the semantic connotations of the stimulus word, it has been found that in right-handed people, the best score for complex speech tests is found at the right ear.[9, 26] It is therefore interesting to speculate as to why the aged demonstrated poorer responses for what may be assumed to be their dominant ear. If, during aging, there is a loss of neurons, and the transmission ability in the auditory nerve is reduced because of wear and tear, it may be that the dominant route to the contra-lateral hemisphere is no longer able to transmit complex signals as effectively as the ipsilateral ear. Although the dominant hemisphere has been shown to be responsible for the encoding of language and its related systems[2, 19, 26] it may be that in the aged system the stimuli from the left ear are able to travel more easily to the left hemisphere via the right hemisphere and its connections to the left hemisphere, than through the contralateral pathway which may be reduced in efficiency.

The intrinsic neural noise may be greater in the contra-lateral than ipsilateral pathway, and this may also contribute to reduced transmission in the auditory system.[3] A bigger sample size may in fact have caused the differences between the right and left ear in the older groups to become significant. In addition, a detailed phonemic analysis of the type of errors made in this test may lead to greater insight as to which area is being tested since it seems that certain phonemes are mediated by either the right and/or the left hemisphere.[7,27]

CONCLUSION

It would seem that while pure-tone audiometry may indicate the integrity of the peripheral auditory pathway, complex speech tests may give more detailed information in regard to the function of the retrocochlear pathway. Many workers have been concerned with the function of the cortex in interpreting

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auditory signals in the aged. The conclusion which has emerged from the majority of studies has been that speech tasks under varying conditions of complexity are not correctly interpreted by the aged, as they are by younger Ss who display no evidence of hearing loss. The inclusion in this study of a pilot group who ranged in age from 15 to 58 years for the filtered speech test, showed that indeed, for these tasks, younger people perform in a superior manner to people above the age of 60 who do not necessarily demonstrate a severe hearing loss.

The rationale for the poorer performance of the aged Ss has been attributed to a reduced number of neurons in the central nervous system, lengthening of the synapse time along the higher auditory neural pathways, and the interference of intrinsic neural noise with signal interpretation.[3,10,23,28] Distortions due to peripheral auditory difficulties are thus being transmitted by inefficient neural fibres in the retrocochlear pathways to a cortex where there are a reduced number of neurons. The rate of conduction is reduced and the signal may decay before it reaches the original target area.

The scores obtained by the experimental group in the filtered speech test were significantly poorer than those obtained by the control group. It would seem that whatever process is responsible for the interpretation of filtered speech is more affected in the former group. Since an ear asymmetry has been noted in this study, it has been suggested that the filtered speech test is sufficiently sensitive to test that area of the auditory pathway where decussation has occurred, since cortical dominance seems to be implicated where ear preference is noted.[17, 21] The enigma is that there is a left-ear, rather than a right ear dominance, although all Ss in the study were right-handed.

It has been tentatively postulated that the dominant pathway suffers from extreme wear and tear with age, and in later years the ipsilateral pathway may invoke more efficient neural transmission.

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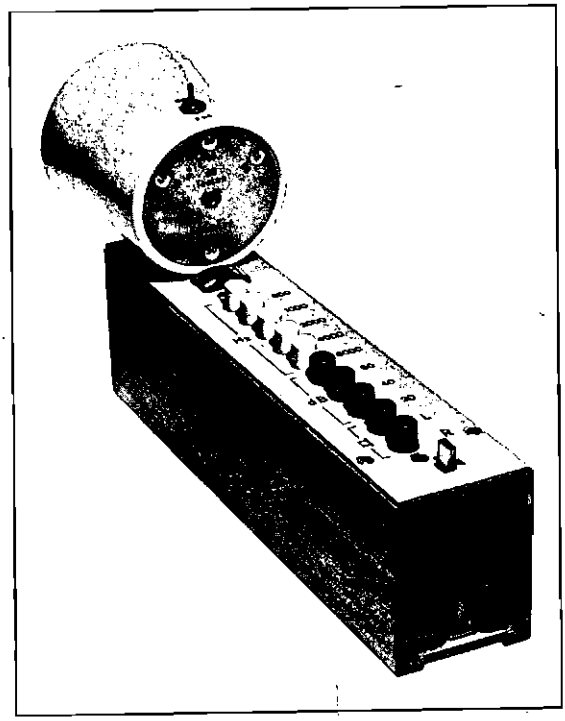

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