Original Article

Avaliation of the Duration Pattern In Hearing Aids Test

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Summary

Introduction: Several researches have already been done to investigate the adaptation process of hearing aids. Currently, the referring studies to the auditory processing can contribute to such process.

Objective: Evaluate the patient's performance in the Duration Pattern Sequence during digital and analogical auditory apparatus tests. The data collection took place between January and April, 2006.

Method: It is an experimental and prospective study in which 7 hearing- imparied individuals were evaluated during the hearing aids tests through application tests and Duration Pattern Sequence.

Results: The free audiometry comparison with hearing aids functional average gain showed significance to both apparatus and ear. The Duration Pattern Sequence comparison test with analogical apparatus was not significant to any ears and the same comparison with digital apparatus reveled meaning to right ear and inverse correlation to the left ear.

Conclusions: Duration Pattern Sequence test was statistically significant to right ear in the digital technology offering information on temporal processing during hearing aids test.

Key words: hearing loss, central hearing loss, rehabilitation, hearing aids, auditory threshold.

INTRODUCTION

Some tests of auditory processing can be utilized during the testing of hearing aids with the intention of searching for information about the central auditory pathway. In the present study, the Duration Pattern Sequence (DPS) was used (1).

This consideration should benefit the use of hearing aids, for as it is known by the professionals, a lot of individuals, by the time they purchase their hearing aids, do not refer to a satisfactory adaptation.

Hearing deficiency is the most common form of sensory disorder in men, which may be caused by environmental causes originated from trauma, infections or for genetic reasons (2). Because of that, it has been considered as an incapacitating disease whose most utilized treatment is the hearing aid, which receives the sound from the environment, increases its intensity and delivers it amplified to the user (2).

In some cases, the selection and adaptation of the hearing aids result in people rejecting to wear them because they do not fulfill the users' needs. For this reason, the inclusion of the hearing process tests can be a resource in the selection and adaptation of the hearing aids.

The measure of the functional gain and the tests of recognition of speech are some of the most utilized procedures to verify and validate the process of adaptation of the hearing aids. The first one is the difference between the hearing thresholds with and without the hearing aid in decibels, in the same testing conditions. It is a subjective method that needs the collaboration of the patient. This psychoacoustics measure reflects whatever the individual hears, providing a true description of the effective gain of the hearing aid for the individual, besides being the only possible method to be used in the evaluation of the performance of the hearing aids through bone conduction. The tests of recognition of speech are very important, as much as to evaluate the social performance of the patient in everyday situations as to determine the way in which the hearing aid allows the patient to receive the acoustic information of speech (3).

With the intention of complementing the process of selection, indication and adaptation of the hearing aids with the DPS test, a brief review of the central hearing function is necessary.

The transmission of stimulus from the organ of Corti to the cerebral cortex is much more than the simple conduction of nerve impulses to the cortical region. The fine discrimination of frequency, the timbre, the intensity and the volume of sounds are the product of a complex process in the various nuclear stations of the central auditory pathway.

The cochlear nucleus influences the cochlear tonotopia, codification and temporal resolution (4), helps with the selection and modulation of frequencies and starts the binaural hearing process through mechanisms that excite – inhibit the transmission of the perceived sounds. The superior olivary complex, also with a tonotropic structure, represents the first step of the auditory pathway composed of the transmission originated in both ears, playing an important role in finding the source of the sound and in the binaural hearing. Its lesions expressively alter the location of sounds (5).

All the fibers originated from the specific auditory pathway reach the inferior colliculus, which besides being an important connection center of the auditory pathway, afferent and efferent, it also has an important function: the directional hearing.

The auditory cortex is the final stage of the ascending auditory pathways in the temporal lobe, with tonotopic organization and bilateral representation. It seems to be indispensable for the recognition of an organized sequence of pure sounds, frequencies or different durations and for the recognition of complex sound patterns (5).

The interactive functional performance of the cortex, through the new combination of all the information received, confers the original sound message its unity and globalism. Memorization allows the true perception, in other words, the meaning of the movement that produced the sound, pertinent behavioural modification and, what is more, its linguistic implications (5).

There are several points in which the ascending fibers cross from one brain hemisphere into the other. It originates from the superior olivary complex, since one third of the auditory pathway is ipsilateral and two thirds are contralateral. In this context, the message received by one ear is directed to the homolateral hemisphere through the ipsilateral pathways and to the contralateral hemisphere through the contralateral pathways. In this way, the verbal auditory information coming from the right ear crosses into the left hemisphere (responsible for the verbal abilities) while the information coming from the left ear crosses into the right hemisphere (responsible for the non-verbal abilities) and crosses into the callous body to get to the left hemisphere. For this reason, it is possible to state that the auditory information coming from the right ear reaches the left hemisphere more quickly than the auditory information coming from the left ear.

Individuals with endangered auditory areas in one of the hemispheres or in the inter-hemispheric pathways have difficulty in describing the shown sequences (6).

The American Speech-Language-Hearing Association has defined the disturbance in the hearing process for some people as the result of malfunction of the processes and auditory mechanisms, and for others as the result of any more generalized malfunction, which ends up affecting the performance of the abilities (7).

An individual with disturbance in the hearing process may present difficulty in understanding the speech in noisy environments, short attention time, distraction, increased time of latency, harmed speaking, writing and/or reading abilities, among others.

The evaluation of the hearing process includes special tests that evaluate the abilities of location, discrimination and sequential memory for verbal and non-verbal sounds.

The global evaluation of the hearing process usually involves monaural tasks of low redundancy (filtered speech, speech in the noise, PSI and SSI), tasks of temporal patterns (DPS and PPS – pitch pattern sequence), binaural interaction tasks (binaural fusion) and dicotic tasks (DD – dicotic of digits, SSW – staggered spondaic word).

In this work, the Dicotic Digits test and the DPS will be analysed.

The binaural interaction tests are appropriate to evaluate the ability of the Auditory Nerve System to receive information in both ears and unify them in a perceptible event, where it is believed that this unification takes place in the encephalic stem (6).

The dicotic digits test aims to evaluate the ability to gather components of acoustic sign in the background and identify them in the binaural integration task. Furthermore, the function of binaural separation makes it possible to evaluate the directing hearing for each ear separately (8). The dicotic digits test is flexible and fast to be applied, offering specification and sensitivity to detect cortical malfunctions and subcortical (9).

The binaural interference is the condition in which the binaural performance is more harmed than the monaural performance. The binaural adaptation could be followed in a more efficient way, in case the central auditory evaluations had been included as part of the procedures of selecting and adapting the hearing aids (6).

The DPS test consists of the presentation of three different combinations of tunes, where each combination is altered or not between a short tune (S) or a long one (L). It can be done with a patient whispering these tunes or naming them as short and long.

The capacity of temporal ordering of sound stimuli is certainly one of the most important functions of the central auditory nerve system. The evaluation of the auditory abilities that involve the temporal ordering is made through a behavioural procedure that functionally analyses the central auditory system. This ability allows the hearer to distinguish sounds based on the ordering or sequence of the auditory stimuli.

The temporal integration is the perception of the relation between intensity and duration of the stimulus and the temporal ordination (10). These abilities are basic functions for the language (11). The temporal resolution is the ability to understand the auditory events according to the interval between each sound (10). Then, the temporal processes are clearly essential in the auditory process, being responsible for establishing differences which help to decipher prosodia details.

The studies about the temporal resolution show that during childhood there is an increase in the discrimination of intervals, which is developed between the ages of 7 and 10, working with the extraction and process of temporal tracks, in the memory and in the level of attention (10).

The procedures of detection and interruption allow us to affirm that there are differences in the temporal resolution between young and old people, in which the complex temporal processes can be affected at different levels for damages in several areas, either in the peripheral pathway as well as in the central pathway and in the cognitive areas not exclusively related to the hearing (13).

In a certain study it was stated that when it comes to the average balance found in the tests of pattern of duration and pattern of frequency in old people, a significant reduction of balance is observed when compared to young individuals (11).

It is common to use tests of identification of pattern of frequency and duration in individuals with and without damages in the ability of detecting sounds, in order to evaluate the neural pattern of the process of non-verbal sounds (14).

In this way, this work aims to evaluate the performance of seven individuals in the DPS tests during the testing of analog and digital hearing aids.

Method

The present study is the contemporary and experimental study of a series of cases that investigates the development of patients in the DPS test during the testing of the analog and digital hearing aids. It was approved by the Committee of Ethics in Research of the *Centro Universitário Metodista* – IPA, under number 1538 on January 6th, 2006.

Seven adult individuals were evaluated, four of them were women and three men, aged between 34 and 71 years old, all of them with bilateral hearing loss, varying from superficial to moderate levels, neurossensorial and mixed, with medical prescription for the adaptation of the hearing aid.

The patients came over for the exams, according to the otorrhinolaryngologic prescription. All the individuals were checked on at the clinic between January and April 2006, and they signed a Term of Free and Clear Consent. They had to show the referred paper for the test of hearing aid, and they had from superficial to moderate levels of hearing loss, which made them suitable for the criteria of inclusion in the present research. In this way, all the individuals who had not accepted to participate in the research and had severe and deep levels of hearing loss were excluded.

Nine, out of the eighteen individuals who had been checked on at the clinic for the tests of hearing aid, had from superficial to moderate levels of hearing loss and two of them refused to take part in the research, which made them seven. Then, this research is the study of a series of cases in which the importance of considering the temporal aspects in the process of selection, indication and adaptation of hearing aids was observed.

These individuals were submitted to a report, tonal threshold audiometry, vocal audiometry, measure of acoustic imitation, selection of hearing aids and specific tests of hearing process. An Ac30 audiometer and an AZ7 imitanciometer, both of the brand Interacoustics were used.

The present research was done in three moments – first, the meeting to write the anamneses, audiometric and imitanciometric evaluations.

In the second meeting, the individuals were submitted to research up to the level of discomfort, audiometry in an open field, test of recognition of speech in an open field using the test with words phonetically balanced proposed by Pen Mangabeira (1973) and the Dicotic Digits tests elaborated by Musiek in 1983, adapted to Portuguese by Santos and Pereira (1996) (15).

In order to do the audiometry and the functional gain in an open field, the patients were positioned in a distance of one meter away from the loudspeaker, to 0º azimut, and asked not to move their heads, making a sign whenever they listened to any sound stimulus, even though it were a weak one. Then, the threshold audibility was obtained for the frequencies from 500Hz to 4000Hz through the gradual reduction of the intensity of the sound stimulus to every 10 dB, until the patient stopped answering, and then the intensity was increased in 5 dB so that the patient would answer again.

For the tests of hearing process, an AC30 audiometer – Interacoustis was used, connected to a Sony Discman. For the dicotic digits test a CD was used, which follows the book *Processamento Auditivo Central* (Central Hearing Process), by Pereira and Schochat (1997), vol. 2, track 3 and for the DPS test track 9 (1).

The dicotic digit test (15) was done with earphones and with 40dB above the tritonal average (500Hz, 1000Hz and 2000Hz) of each ear of the patient, in order to verify the occurrence or not of binaural interference.

In the last moment, the individuals were trying on two models of hearing aids, one of analog technology and the other of digital technology, set up according to the hearing loss. After the functional gain and the test of recognition of speech with analog and/or digital aid, the test of auditory processing was done in an open field, in the condition of whispering, with each of the technologies. Aiming to simplify the protocol, the number of sequences of trios of tunes of the referred test was presented without the aid, with the analog aid and with the digital aid only ten times for each mentioned modality.

From the research protocol, a database was made using the software SPSS version 10.0, where all the statistic analyses were made. The test for similar samples was used to compare the auditory gain with and without the aid. The Friedman test was used to compare the DPS between the groups: without the aid, with analog aid and with the digital aid. The Wilcoxon test was used in the comparison of the test with and without the hearing aid. A table of frequency was used to present the variables described in the sample. The level of significance used was 5%.

Results

The individuals in study varied from 34 to 71 years old, and the sample average was 58, 57 years old. When it comes to the gender, four individuals were women (57.1%) and three of them were men (42.9%). For the kinds of hearing loss in the right ear (RD), two individuals were found with neurossensorial hearing loss (28.6%) and five with mixed hearing loss (71.4%). For the left ear (LE), three individuals were found with neurossensorial hearing loss (42.9%) and four with mixed hearing loss (71.4%). For the level of hearing loss in the RE, two individuals showed superficial level of hearing loss (28.6%); four moderate level of hearing loss (57.1%) and one severe level of hearing loss (14.3%). In the LE, three individuals showed superficial level of hearing loss (42.9%), three showed moderate level of hearing loss (42.9%) and one deep level of hearing loss (14.3%).

Comparing the audiometry in an open field with the functional gain made with the analog hearing aid, there was some significance for the RE (p=0.004) and for the LE (p=0.006). This very same comparison with the digital hearing aid showed some significance for the RE (p=0.023) and for the LE (p=0.007), as shown in tables 1 and 2. The speaking tests with dissyllables did not present any significance to both ears when comparing the rate of recognition of speaking without the hearing aid to the analog hearing aid to the digital hearing aid, establishing as the value of "p" for the RE 0.65 and fir the LE 0.99.

The comparison of the DPS test without the hearing aid and with the analogic hearing aid was not significant (value of "p" of 0.07 for the RE and 0.06 for the LE). The same comparison between the DPS test without the hearing aid and with the digital hearing aid revealed significance of 0.04 for the RE and inverse correlation to the LE with the value of "p" as 0.99, as shown in tables 3 and 4.

Discussion

In the present study there were not significant differences between genders. The average age of the samples was 58, 57 years old, which catches the attention to the morphophysiological alterations of the aging process, such as hearing loss, which is a consequence of this process. It is not possible to state that most of the individuals in the study are part of the old population, but they are close to them. In this way, it is important to mention that the presbyacusis is defined as the loss of hearing due to the changes related to the age(16). Another point to be considered in this topic is the age of the central auditory pathways, as well as the decline in the cognitive ability of the referred sample. Neuropathologic studies show that individuals with decline in the cognitive ability show senile plaques in the neocortex and neurofibrillar tangles in the region of the temporal median lobes (17).

Table 1. Comparison between audiometry in open field and functional gain with analogic hearing aid.

Variable	RE dB	LE dB
Field audiometry	61.43 ± 6.27	59.17 ± 7.36
Analogic functional gain	46.43 ± 9.88	42.50 ± 6.89
P value	0.004	0.006

n=7, mean with standard deviation, T test for parallel samples.

Table 2. comparison between audiometry in open field and functional gain with digital hearing aid .

Variable	RE dB	LE dB
Field audiometry	61.43 ± 6.27	59.17 ± 7.36
Digital functional gain	46.67 ± 14.38	45.00 ± 11.73
P value	0.023	0.007

n=7. mean with standard deviation T test for parallel samples

Table 3. DPS teste with and without analogic hearing aid (n=7).

Variable	RE μ	LE μ
DPS without aid	50 (20 to 80)	60 (15 to 90)
DPS with analogic aid	60 (40 to 90)	75 (30 to 92.5)
P value	0.07	0.06

Wilcoxon test

Table 4. DPS teste with and without digital hearing aid (n=7).

Variable	RE μ	LE μ
DPS without aid	50 (20 to 80)	60 (15 to 90)
DPS with digital aid	80 (42.5 to 100)	60 (35 to 95)
P value	0.04	0.99

Mean with standard deviation Wilcoxon test

Subtitle: RE= right ear; LE= left ear; dB= decibel levels; ±= standard deviation; μ=average and minimum/maximum scores on DPS test.

For this reason, it is interesting to determine some criteria for the normality of the old population in the tests of hearing process because of the aging process of the central auditory pathways.

The largest occurrence of mixed hearing loss in both ears suggests that a disturbance in the hearing process should coexist with the loss, or only be a previous occurrence. It is widely known that conductive alterations may generate alterations in the hearing process, for in case the message is not totally comprehended, it causes a failure and involves the process as a whole (18). Then, central malfunctions may occur due to neuromorphological malfunctions, delay in the maturation of the nervous system and disturbances, diseases or neurological and otologic lesions (5). For the RE, the level of prevailing hearing loss was moderate, totalling 57.1% of the sample, and for the LE, both superficial and moderate levels totalled 42.9% each. In comparison to the speaking tests, non-significance is attributed to the small level of difficulty in which these ones offer, contrary to the speaking tests involving monosyllables, sentences with noise or even nonsensical words.

The average of audiometry was compared in tables 1 and 2 in an open field with the functional gain of the analog and digital hearing aids respectively, which showed significance to both technologies and ears. For this reason, it is stated once again that the functional gain is a simple, subjective, traditional and efficient step in the verification of the performance of hearing aids. In table 3, what is shown is the performance of the patients in the DPS test without the aid, comparing it to the same test with the analog hearing aid, which was nearly significant, making it probable that with a slightly bigger sample it would reach significance ("p" value of 0.07 to RE and 0.06 to LE). It is also believed that the analog technology has a slower processing speed, considering that for the referred sample, the performance in the DPS tests with the analog aid had subtly improved in relation to the same testing without the aid.

The comparison between the performances in the DPS test without the hearing aid and with the digital hearing aid revealed a "p" value of 0.04 significance for the right ear in discrepancy to the "p" value of the left year, which was 0.99, being distant from the value admitted as significant, indicating an inverse correlation. From the physiological point of view, a better performance was expected from the right ear due to the quick transmission of the stimulus through the ipsilateral auditory pathway from this ear until the right hemisphere. So, it is believed that the left year had a worse performance with the digital aid because the stimuli of the test were sent through the contralateral pathway from this ear until the right hemisphere, which can be the responsible for the processing speed. In a dicotic situation, the ipsilateral pathways, which are weaker, are suppressed while the contralateral ones, which are stronger, or privileged, assume the function (6). In such way, it is possible to notice that the analog technology shows a slower process, creating little improvement. On the other hand, the digital technology shows a quicker processing, creating a lot of advantages for the RE, which could cause unbalance in relation to the LE (inverse significance). These facts bring up the idea that the patient could wear the analog aid in both ears, with little improvement, but keeping the balance between the ears, or wear only the digital aid in the RE, gaining a lot of advantages. In order to answer these questions, the entire hypothesis on the occurrence of the binaural interference in the researched individuals must be dismissed.

The dicotic test of digits had been utilized before the hearing aid and the DPS tests were done in order to verify the occurrence of binaural interference, which was shown by only one patient, and it is believed that it has not influenced the analysis.

The temporal processes are clearly essential in the aural processing and they are responsible for setting differences, helping to decipher the details of the prosodia (12). The capacity of temporal ordering of audio stimuli is one of the basic and important functions of the central nervous auditory system. The evaluation of the auditory abilities that involve the temporal ordering is made through a behaviour procedure which analyses the central auditory system functionally. This ability allows the hearer to distinguish sounds based on the ordering or sequencing of auditory stimuli (10). In order to evaluate this ability, the tests of pattern of frequency (PPS) and pattern of duration (DPS) are utilized. For this reason, the DPS test was chosen to be used for its efficiency when evaluating the abilities of temporal sequencing, which involve the concept of duration: short and long. On the other hand, the PPS test shows more convenience to the patient, for the distinction of frequency is present since the cochlea.

In relation to the technologies, the temporal ordering has shown little improvement with the analog aid in both ears, making it questionable the fact of having shown a lot of progress for the RE and little for the LE with the digital aid.

Another aspect that demands more attention is the higher incidence of the mixed hearing loss. In this way, the temporal aspects could be better noticed by the individuals in the analog technology. However, it is worth to consider if the DPS test is the adequate to offer information on the performance of the central auditory pathways in the patient who wears the hearing aid.

It is suggested, based on the results obtained in this study, which the researches relating the auditory processing with the selection, verification and adaptation of the hearing aids should continue.

CONCLUSION

It is observed, based on the analysis of the results, that the utilization of the functional gain was statistically significant for both technologies, which shows its great efficiency.

The present study has brought some contribution as the DPS test was statistically significant only for the right ear in the digital technology, offering information about the temporal processing while testing hearing aids. However, only seven individuals were studied. Then, a study with larger samples would be of major importance in order to confirm the conclusions of this work. It is also necessary to carry out some research into tests of the temporal processing which can be included in the verification protocol of hearing aids, which makes it essential that this study should be continued.

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