A COMPARATIVE AND PERFORMANCE ANALYSIS BETWEEN HEARING AIDS WITH THREE CHANNELS AND SIX CHANNELS

Virtyt Lesha[1]

[1]Italo-Albanian clinical "Otofon", Rruga "Qemal Stafa", 1001, Tirana, Albania,virtytl@hotmail.com

Abstract

The studying of hearing aids is a very broad field and specific of electronics. Digital hearing aids consist in programmable amplifiers and acoustic signal processors and try to provide as output an acoustic signal as natural as possible. Starting in the late 1990s through the early years of this century, the hearing aid industry made the conversion from analog technology to digital technology. By going digital, many of the features most helpful in today's hearing aids were made possible. With each generation of technology, two of the most helpful features, feedback (squealing) reduction and managing background noise, are improving. These, as well as other features, are not perfect, but are much more effective than they were even five years ago. With today's technology, hearing-impaired people can hear and understand speech in noisy environments that was not possible previously. In this paper we will begin with a general description about digital acoustic aids and their advantages against analog ones. Then the paper will treat some from observations made at the laboratory of the acoustic clinic "Otofon" regarding frequency response of these devices. Also the concept of channels in the hearing aids will be discussed. The hearing aids discussed here are from the Beltone company and consist at various channels but our study is limited only in those with three and six ones. As part of this study, it has been considered the scope of coverage of these devices.
Finally, it has been given a judgment on the trend of technology in this field of study where one of the most important is using of acoustic devices with more than six channels and the elimination of tinnitus in the ear.

***Keywords*:** *hearing aid, frequency response, channel, scope of coverage, tinnitus*

1. Introduction

Nowadays, the application of electronics in general and particularly of the information technology in the field of medicine consists in one of the most developed and the most promising in the future industries. Numerous studies in the field of medicine and information technology have put in front of each other relevant professionals to solve various health problems and finally to create a lifestyle even for those who have different health disorders.

In this article we try to give briefly the findings of a comparative study that deals with the latest solutions to application of the field of information technology in the field of medicine. In simple words, this article provides a comparative analysis of the acoustic devices which provide solutions for people who have impaired hearing.

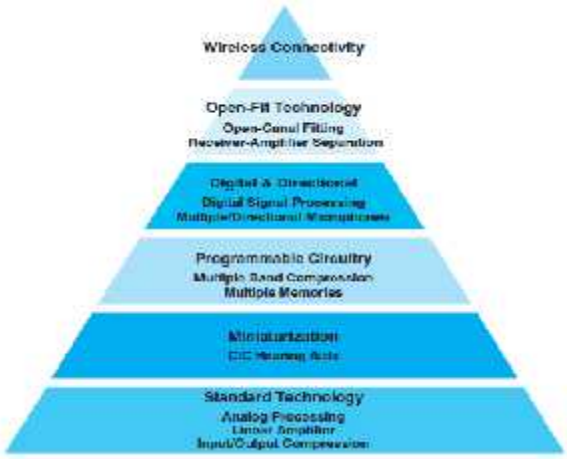
First, we will give an overview of the concept of acoustic devices and will comment on their overall scheme. Then we will examine the concept of analog devices and compare them with digital ones. Also, part of this paper is the introduction of the concept of a channel on a digital hearing aid and the presentation and interpretation of the its coverage range. Searches of this study are carried out at the italo-albanian clinical called "Otofon" and the audiogram of the case study is authentic.

2. The hearing aids: general concept and new considerations

The technology of acoustic devices changes with a very rapid pace. Nowadays, the hearing devices use numeric signal processing, enabling the reproduction of high quality of the sound, have appropriate directionality, feedback control, make possible the efficient use of battery, they programmable and thus enable greater flexibility for a precise adjustment.

However, some aspects of hearing aids have not changed over years. Yet, there is a *microphone* which makes possible the conversion of acoustic energy to an electrical energy, an *amplifier* to reinforce the signal and a *receiver* or a *loudspeaker* to turn the electrical signal into acoustic signal. Also, we will discuss the output of a listening device in terms of amplification that is provided through the frequency range and maximum level of sound that is carried in the ear.

Figure 1. The progress of hearing aid technology



We must consider that numerous and rapid technological developments make it difficult for people to properly assess the difficulties that audiologists have faced over years regarding adaption of hearing aids. Today, when we see an ITE (in-the-ear) hearing aid, it does not look different from that of five years ago, but we should consider the fact that its capacity has advanced a lot during a short period of time.

One way to see the developments of amplification in terms of technology is the pyramid shown in the figure 1. At the base of the pyramid is the standard technology with the so-called linear amplification and output limiting. With simple words, linear amplification means that soft, medium and high sounds are amplified at the same level.

.

Output limiting is the way how the maximum output is covered. The next step in the pyramid is the minimization. This step allows the most sophisticated circuits of signal processing to fit a

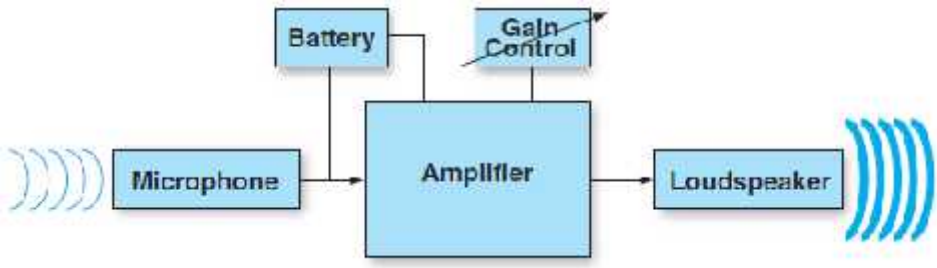
CIC (completely-in-the-canal) hearing aid. Then comes the programmable technology, which provides e flexible control of the characteristics of the acoustic device as well as multiple memories programmed for different parameters for different situations of impaired hearing.

The next step in the pyramid is digital and directional technology. The change toward the digital processing led to major developments in nonlinear amplification, in output limiting, in the noise reduction, feedback control and all these in a small power consumption and minimal distortion in the output sound.

The digital signal processing allows the use of all technologies in the pyramid in a very flexible way, very small in size to meet the needs of patients. Directional microphones allow the focus in space, improving the signals in front of the patient and reducing the signals coming form other directions. Although it is an old concept, improvements in technology have made the directionality a very useful reality.

The next step in the pyramid is the strategy that enables a more opened fitting of the hearing aids to reduce the detrimental effects of the acoustic devices and provides e more natural sound amplification especially in cases when the hearing impairment is in the high frequencies.

Figure 2. Schematic representation of the components of a hearing



In this case instead of placing an earmold or an ITE (in-the-ear) hearing aid, the signal is carried through a thin tube which is inserted in the ear in a practical approach. In some cases, the loudspeaker of the hearing aid is inserted in the canal of the ear. Like the directionality technology, the idea comes from the bottom of the pyramid but its routine application is made possible by the improvement of technology.

In the top of the pyramid of hearing devices is the possibility of connecting to wireless listening devices, thus allowing communication between two devices placed in the ears and communication of hearing aids with other electronic devices or other signal sources.

A hearing aid is an amplifier which has three main components:

1. a microphone
2. an amplifier
3. a loudspeaker.

A schematic representation of the basic components is shown in figure 2. *Microphone* is a vibrator which moves in the function of the sound pressure waves. While moving it makes possible the conversion of acoustic signals to electric ones. The electric signal is reinforced

through the *amplifier* and then is carried to the *loudspeaker*. Then the loudspeaker makes the conversion of the electric signal to an acoustic one. The amplifier is powered through the battery which in some cases is rechargeable. Also, some hearing aids have external control, volume control or remote control.

2.1 Analog hearing aids against digital ones

A genuine digital hearing aid (DSP or digital signal processor) takes the analog signal form the microphone and converts it into a digital format by performing the sampling process. After receiving and sampling the analog signal, it makes the processing of the signal using the digital technology which consists in a lot of numerical algorithms of the digital processing of signal. Digital hearing aids are normally more flexible and can be used in order to process the voice in a more selective manner than a analog hearing device.

Advantages of DSP algorithms

- We can implement some "noise reduction" algorithms in the circuit in order to eliminate the noises in the background
- The reduction of the digital feedback makes possible the elimination of whistling in the digital hearing aid
- Some hearing aids have multiple memories for different listening situations
- Some hearing aids select and follow the signal throughout a directional microphone
- There is a flexibility in hearing aid fitting

However we should consider the fact that each of the benefits and advantages of the implementation of DSP algorithms have a fixed cost. So if the cost is low then there are not a lot of benefits. What should be noted is the fact that if the device is "digital" it does not mean that we have a quality product. It may happen to have a good quality sound even in an analog hearing device. This can happen in cases when the adjustment of the hearing aid is not done properly by a certain audiologist and consequently there are not satisfactory results.

Analog hearing aids amplify the sound by simply increasing its amplitude. They use transistors in a circuit in order to amplify and modify the sound that comes. Any change in the tone of the hearing aid is done through the volume control.

Advantages of analog hearing aids

- The users for a long time of the hearing aids are accustomed to these devices and the sound they make is pleasing to them
- They have e lower cost than the digital hearing aids
- Sometimes they are more powerful than the digital hearing aids; however the fact that they more powerful does not mean that produce e pure sound as output

3. The concept of channels in a hearing aid and the coverage range of the hearing aids of in this study

Channels in a hearing aid are similar to bands except the fact that the compression features can be adjusted individually. A person may have a low sensitivity in the sounds with high frequencies and thus the audiologist need to select the high frequency channels and to amplify those frequencies without affecting the low ones. We consider the fact that the more channels we have in a hearing aid, the more possibility to select and adjust in a sophisticated way the frequencies. Consequently, we have higher quality of sound that comes out. When we have a low number of channels, then the selection is done in such a way that it includes a wide range of frequencies which are amplified equally. On the other hand, when we have a relatively a large number of channels, then the results are visible after selection and arrangement. This happens because the range of involvement of the frequencies is lower and there are cases when a single frequency can consist in a single channel.

The hearing aids studied in this paper are of two types, OR185VI and TRU678DPW (Beltone brand), with 3 and 6 channels respectively. Their coverage areas are shown in the figure 3 and 4 respectively.

Figure 3. The coverage range of Beltone OR185VI

Figure 4. The coverage range of Beltone TRU678DPW

The fact that we must highlight is that the hearing aids with three channels have certain disadvantages against those with 6 channels. First of all, is the fact that the three-channel devices are more difficult to be fitted. This happens from the fact that moving in the frequencies and the process of selecting them is not as sophisticated as with those with six channels and consequently there is not very much commodity at the patient. In the other side in the six channel acoustic devices there are a lot advantages where on of the most important is thr fact that the sound is more natural and tends to be like the sound of the natural ear.

4. Case study – interpreting the results

In the study that we have done, we have investigated a case study that consists in a patient of the "Otofon" clinical. The audiogram of this patient is shown in the figures 5 and 6 where the figure 5 consists in the right ear and the figure 6 consists in the left ear.

Figure 6. The audiogram of the left ear

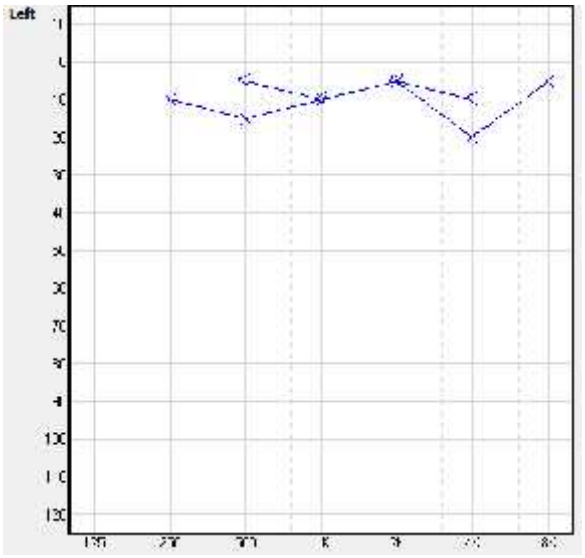
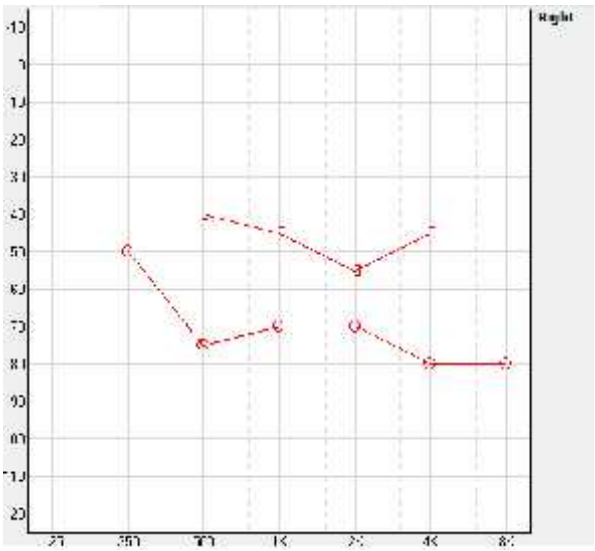


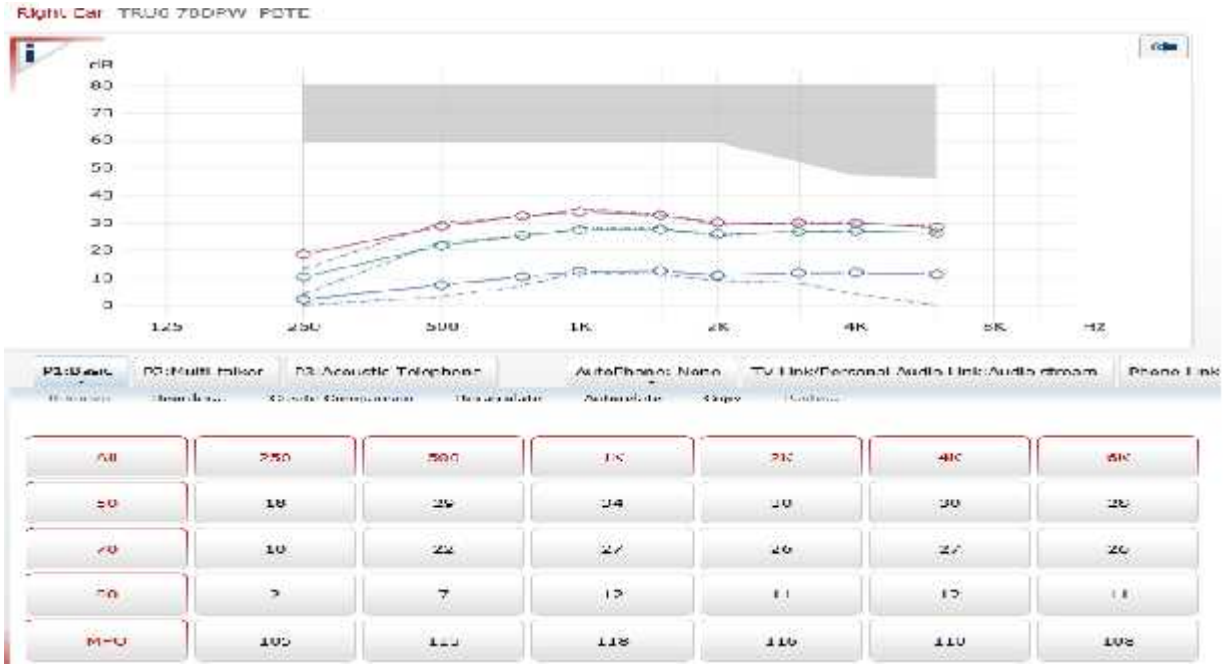
Figure 5. The audiogram of the right ear



As we can see from the audiograms, the left ear does not have any problem. In the other side, in the right ear we have hearing impairment that is called monolateral severe hearing loss. This patient with this hearing impairment has problems to understand the speech. Also, in this case there is the fact that the left ear that is correct begins to fall gradually because of it works alone. Another important element is the fact that the bone conduction is performed with masking. This is done because when we evaluate the bone conduction of the right ear, the patient begins to listen the sounds from the left ear. So it is necessary to fit a hearing aid only for the right ear.
Concretely, this patient has been subject of fitting for the two types of hearing aids: OR185VI (with three channels) and TRU678DPW (with six channels). The graphic of the fitting is shown in the figures 7 and 8.

Figure 7. The results of hearing aid fitting with OR185VI with three channels

Figure 8. The results of hearing aid fitting with TRU678DPW with six channels



We can consider the tables in the results of fitting in these graphics as matrices. In the hearing aid with 3 channels there is a matrix with 3 rows and 3 columns and in the hearing aid with 6 channels there is a matrix with 3 rows and 6 columns. We notice the frequency selection in the 3x6 matrix is more perceptively because the range of every channel is closer than the 3x3 matrix. Consequently, from these graphics we clearly see that in the hearing aid with six channels, we have more results than in the device with three channels. Also, in two types of hearing aids it is possible to do fitting for three different distances: close distance, medium and remote.

5. Conclusions and recommendations

In this article we made e comparative analysis of two types of devices: those with three channels and six channels. Initially, we have shown an overview of hearing aids and made a comparison between analog and digital ones showing the advantages and disadvantages of each of them. Also part of this study was the introduction of the concept of channels and the demonstration of the scope of the coverage of the devices. Then we analyzed the data of a case study on which the fitting is performed with two types of devices.

Today one of the challenges of the hearing aid industry is the implementation of a new technology that eliminates the tinnitus. Clinical evidence shows that the use of hearing aids in tinnitus patients provides two benefits: it makes the patient less aware of the tinnitus and it improves communication by reducing the annoying sensation that sounds and voices are masked by the tinnitus. Hearing loss reduces stimulation from external sounds resulting in increased awareness of tinnitus and deprivation of input may change the function of structures of the auditory pathways. Tinnitus is often caused by expression of neural plasticity evoked by deprivation of auditory input. With hearing aid amplification, external sounds can provide sufficient activation of the auditory nervous system to reduce the tinnitus perception and it may elicit expression of neural plasticity that can reprogram the auditory nervous system and thereby have a long-term beneficial effect on tinnitus by restoring neural function. To obtain the best results, hearing aids should be fitted to both ears, use an open ear aid with the widest amplification band, and disabled noise reducing controls. In some cases a combination device would be preferable. The conditions required in order to obtain good results include not only the use of devices, but above all, their adaptation to the needs of the single patient, by counseling and customization. Wearing the hearing aid must become second nature to the patient even though it is only one element of the therapy.

References

1. Cotrona, U., & Livi, W., (2003). L'adattamento degli apparechi acustici, chapter 8, 5-7
2. Stach, A. B (2010). Clinical audiology. Delmar, Cengage Learning, 563 - 566
3. Latif, A., (2010). Digital hearing aid chip, Chalmers University of Technology, 18-20
4. Luong, D., & Piper, M., (2006). Directional Hearing Aid, 11-20
5. Baskent, D. (2006). Speech recognition in normal hearing and sensorineural hearing loss as a function of the number of spectral channels, Starkey Hearing Research Center

6. Baskent, D., & Eiler, C., & Edwards, B. (2006). Using genetic algorithms with subjective input from human subjects: implications for fitting hearing aids and cochlear implants, Starkey Hearing Research Center
7. Baskent, D., & Edwards, B. (2007). Simulating listener errors in using genetic algorithms for perceptual optimization, Starkey Hearing Research Center
8. Byrne, D., & Dillon, H., & Ching, T., & Katsch, R., & Keidser, G., (2001). NAL-NL1 Procedure for fitting nonlinear hearing aids: characteristics and comparisions with other procedures
9. Chamberlain, R., & Goldstein, J., & Ivanovich, D., (2003). Implementation of hearing aid signal processing algorithms on TI DHP-100 platform
10. Dadal, Vivek., & Bansal, A., & Bhandari, P., & Barhate, U., (2013). Software simulation of DSP algorithms implemented in binaural hearing aids, Internation Journal of Engineering Research and Applications, 1224-1229
11. Khalifa, O., & Makhtar, M., & Baharom, M., (2004), Hearing aids system for impaired peoples, International Journal of Computing & Information Sciences
12. Klasen, Th., & Doclo, S., Van den Bogaert, T., & Moonen, M., Wouters, J., Binaural multi-channel Wiener filtering for hearing aids: preserving internaural time and level differences
13. Rana, R., & Zhang, L., & Bin, T., & Krishma, G., An enhanced method and behavioral model for noise cancellation in audio devices
14. Saramplis, A., & Kalluri, S., & Edwards, B., & Hafter, E., (2009). Objective measures of listening effort: Effects of background noise and noise reduction, Starkey Hearing Research Center
15. Spiret, A., & Moonen, M., & Wouters, J., (2009). Objective evaluation of feedback reduction techniques in hearing aids, 17th European Signal Processing Conference
16. Woods, W., & Merks, I., & Kelly, Fitz., & Zhang, T., & Edwards, B., (2010). Assessing the benefit of adaptive null-steering using real-world signals,International Journal of Audiology; 434 - 443