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5A.14 ACOUSTICS IN MEDICINE

Room 27: Piazza Navona

Chair: M.O'Donnell - *Co-chair:* A.Trucco

08:20* **5A.14.01 - OPTOACOUSTICS: HIGH FREQUENCY ULTRASONIC ARRAY IMAGING** - M. O'Donnell, T. Buma, M. Spisar - *University of Michigan, Ann Arbor, USA.*

08:40 **5A.14.02 - A LIGHT-SCATTERING TECHNIQUE FOR INVESTIGATING ULTRASOUND CONTRAST AGENTS** - T.J. Matula, W.S. Chen, L.A. Crum - *University of Washington, Seattle, WA, USA.*

09:00 **5A.14.03 - A COMPARISON BETWEEN THREE DIFFERENT ULTRASOUND CONTRAST AGENTS** - L. Hoff - *Norwegian University of Science and Technology, Oslo, Norway.*

09:20 **5A.14.04 - ON THE BEAM PATTERN OPTIMIZATION IN WIDE-BAND ACOUSTICAL IMAGING** - A. Trucco, C. Parodi - *University of Genoa, Italy.*

09:40 **5A.14.05 - LOW-COST FRONT-END PROCESSING FOR LARGE ARRAY SYSTEMS** - M. Karaman, B.T. Khuri-Yakub - *Stanford University, CA, USA.*

10:00 **5A.14.06 - THERMAL EFFECTS OF SAWTOOTH WAVEFORM HIFU IN TISSUE PHANTOMS** - O. Sapozhnikov[1], V. Khokhlova[1], T. Sinilo[1], E. Filonenko[1], L.A. Crum[2] - *[1]Moscow State University, Russia; [2]University of Washington, Seattle, WA, USA.*

5A.15 AUDIOLOGY

Room 17: Fontana di Trevi

Chair: M.Mattia - *Co-chair:* W.A.Dreschler

08:20 **5A.15.01 - HEARING AND HEARING DEVELOPMENT IN CLASSICAL ORCHESTRAL MUSICIANS** - K. Kähäri., A. Axelsson, P.A. Hellström., G. Zachau - *National Institute for Working Life, West/Gothenburg University, Sweden.*

08:40 **5A.15.02 - DEVELOPMENT AND EVALUATION OF AN IEC FITTING SYSTEM FOR HEARING AIDS** - M. Ohsaki [1], S. Sakamoto[2], H. Takagi [3] - *[1]Shizuoka University, Hamamatsu, Japan; [2]Rion Co., Ltd, Kokubunji, Japan; [3]Kyushu Institute of Design, Fukuoka, Japan.*

09:00 **5A.15.03 - LIMITS OF THE HEARING AIDS AND THEIR BREAKTHROUGH** - G. Bertini[1], G. Fiorio[1], M. Marani[2] - *[1]Istituto di Elaborazione della Informazione, CNR, Pisa, Italy; [2]SEED srl, Massa, Italy*

09:20 **5A.15.04 - NOISE REDUCTION IN DIGITAL HEARING AIDS** - W.A. Dreschler, L. Körössy - *Academic Medical Center, Clinical & Experimental Audiology, Amsterdam, Netherlands.*

09:40 **5A.15.05 - A NEW REASONABLY PRICED PROFESSIONAL HEARING AID** - G. Quellet - *ORAVOX, Hauterive, Switzerland.*

10:00 **5A.15.06 - STOCHASTIC RESONANCE IN MIDBRAIN AUDITORY UNITS REPRODUCING ENVELOPE PERIODICITY IN THE ADAPTED STATE** - N.G. Bibikov - *N.N. Andreyev Acoust. Inst., Moscow, Russia*

5A.16 MUSICAL INSTRUMENTS

Room 4: Arco di Giano

Chair: M.Bertsch - *Co-chair:* B.Kostek

08:20 **5A.16.01 - OPTIMIZATION OF SOUND FOCUSING BY WAVE FIELD SYNTHESIS FOR MUSICAL APPLICATIONS** - P. Martignon[1], M. Zanolin[2], S. De Stabile[3], P. Podin[1] - *[1]University of Parma,Italy; [2]Massachussets Institute of Technology, Boston, USA; [3]'Prometeo' Electroacoustic Laboratory, Parma, Italy.*

08:40 **5A.16.02 - ACOUSTIC CHARACTERISTICS OF WOODEN DRUMS SUCH AS THE MOKUGYO OF JAPAN** - M. Sunohara, K. Furihata, T. Yanagisawa - *Shinshu University, Japan.*

09:00 **5A.16.03 - TIMBRE OF THE MOKUGYO OF JAPAN** - M. Sunohara, K. Furihata, T. Yanagisawa - *Shinshu University, Japan.*

09:20 **5A.16.04 - A NEW PERCUSSION INSTRUMENT "ENKYO" MADE OF SANUKITE** - K. Kishi[1], H. Maeda[2], K. Karino[1] - *[1]The University of Electro-Communications, Tokyo, Japan; [2]Koujin Co., LTD, Kagawa, Japan.*

09:40 **5A.16.05 - AUTOMATIC RECOGNITION OF MUSICAL INSTRUMENT SOUNDS** - B. Kostek - *Technical University of Gdansk,Poland*

10:00 **5A.16.06 - VIBRO-ACOUSTIC CHARACTERISATION OF AN ELECTRIC BASS GUITAR** - E. Esposito, G. Di Giulio, C. Santolini - *Università di Ancona, Italy.*

5A.17 PSYCHOACOUSTIC BASIS OF SOUND QUALITY EVALUATION

Room 6: Arco di Costantino

Chair: H.Fastl - *Co-chair:* B.Schulte-Fortkamp

08:20* **5A.17.01 - EFFECT OF FACTORS OTHER THAN SOUND TO THE PERCEPTION OF SOUND QUALITY** - T. Hashimoto - *Seikei University, Tokyo, Japan.*

08:40* **5A.17.02 - INTER-MODAL EFFECTS OF NON-SIMULTANEOUS STIMULUS PRESENTATION** - M.E. Altinsoy, J.Blauert - *Ruhr Universität, Bochum, Germany.*

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Abstracts Preced.
Paper, on CD-ROM

Limits of Hearing Aids in the High Frequency Range

G. Bertini[a], G. Fiorio[a] and M. Marani[b]

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[b]*SEED srl, Viale Roma 88 A, 54100 Massa (MS), Italy*

This paper describes the present situation of hearing aids concerning important features such as bandwidth, amplification and usage limits. A project proposal which aim to highly increase aids bandwidth, and to improve sound quality supplied to the hearing impaired is then presented. The project is particularly oriented to supply the high frequency-increasing loss, typical of the presbycusis.

INTRODUCTION

The evolution of hearing aids in the last decades is dominated by the miniaturization of aid devices and by the development of surgical operations (cochlear and, more recently, ossicular implants).

Today the hearing aids devices are more and more sophisticated nevertheless in our opinion they lack in frequency bandwidth, normally limited at 4 - 5 kHz.

This work intends to demonstrate the necessity to experiment aids devices able to work with an extended bandwidth so to improve the hearing quality of the hearing impaired; we want here to show one of the possible experiments, increasing the amplification of an aid device up to about 4 kHz and maintaining it constant from that frequency to high band-limit.

STATE OF THE ART

Figure 1 shows a typical maximum gain curve of commercial hearing aids, where can be noticed the rapid gain decreasing between 3 and 7 kHz.

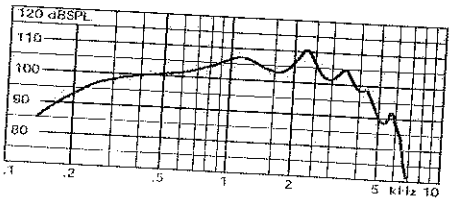

FIGURE 1. Typical maximum gain curve.

It is well known that is difficult to hear music for those people whose hearing loss is strongly frequency-increasing. In fact, since the timbre of a musical instrument is characterized by the relative amplitude of its harmonics, the effect of the hearing aid cutoff adds to the individual hearing loss and results in a very strong sound distortion, making music hard to recognize. Sometime the speech becomes as well unintelligible because the consonants are placed in the high frequency band of the speech spectrum (see figure 2) and, in such cases, the hearing aid cutoff doesn't help in their recognition.

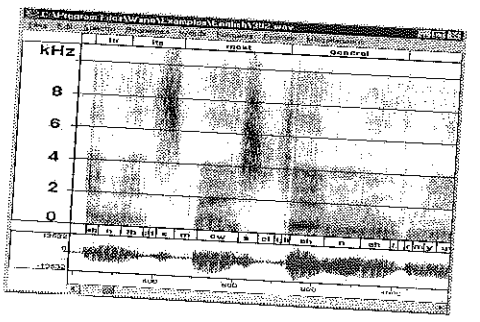

FIGURE 2. Speech spectrogram.

One of the problems on amplifying over 4kHz is that driving a hearing aid loudspeaker, with enough power to achieve a bandwidth of 10 kHz, would result in an extremely short battery life for all the *behind the ear (BTE)* and smaller aids. This lack should be surmounted by the use of "body worn" aids connected by wires to the earphones.

The technological progress of hearing aids didn't involve the body worn types, whose use is nowadays limited to the severe hearing loss, nearly constant in the full frequency range. The today body worn aids have poor controls in order to fit the gain to the individual hearing loss and only have one amplifier connected to both earphones in parallel. Furthermore receivers fitted to the ears by means of earmolds, are very uncomfortable in comparison to the earphones used by the modern portable devices, such as CD players and mobile telephones. It is presently difficult for hearing impaired people, requiring an adequate

amplification of the high tones, to find any aid meeting their needs.

The opinion that "patients don't accept body worn types of hearing aids because they are uncomfortable and inelegant" seems due to manufacturer's advertising rather than to the observation of user's satisfaction: it is frequent the case of unsatisfied people not using the aids they bought.

OUTLINE OF THE PROPOSAL

We think that a body worn type of hearing aid would allow to overcome the bandwidth limitations of the present miniaturized aids. In order to achieve the maximum possible bandwidth, the microphone signal should be sampled at 44 kHz, allowing to process the sound up to 20 kHz. The sampled signal should be processed by a Digital Signal Processor (DSP) in two independent (R and L) channels in order to fit the needs of both ears. The analog output should be connected to the earphones by means of a standard 3.5 mm stereo plug.

Using two DSP channels with different controls may require much more energy than the one required by the commercial body worn aids. It seems however that rechargeable batteries of the modern mobile telephones are able to feed the system for a reasonable 18 hours period.

The strong amplification of the high frequency components, required by the presbycusis, may raise problems to protect the ears in the case of exposure to loud sharp tones. This is not the case of speech, whose power is mainly confined within the 4 kHz band, but protection is needed in order to allow the continuous use of the aid. Although an adequate compression is recommended, an easily accessible volume control is necessary in order to meet exceptional situations. The distance of the microphone from the earphones, allowed by the body worn type, doesn't exclude the possible acoustic feedback (Larsen effect) and it may be necessary to provide some kind of echo canceller.

Speech Audiometry for the Presbycusics

The type of filtering, required by the strong frequency-increasing loss, may need some limitation in the upper high frequency bound. The problem seems to be new, because the commercial aids gain curves don't reach such frequencies, and we want to face it by trying the effect of a large band amplification on the sound and speech intelligibility.

The standard speech audiometry consists in measuring the intelligibility of words and phonemes special set, by varying their volume. Figure 3 shows that 100% intelligibility is never reached in the case of sensorinerual loss.

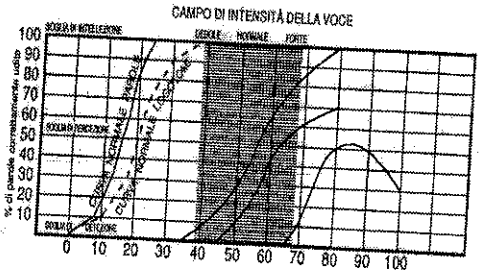

FIGURE 3. Speech audiometric tests: transmission loss, sensory loss without and with recruitment.

The first step of our project is to experiment a modified speech audiometry in which the vocal material is presented at constant comfortable volume and only the high frequency components are presented with variable gain.

As shown in figure 4, the gain is virtually adapted to the loss up to about 20 kHz (dotted line) but the increase is allowed only up to a "critical frequency" f_c and remains constant thereafter (solid line).

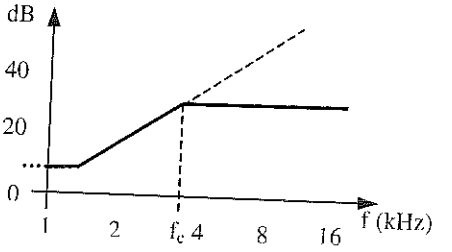

FIGURE 4. Gain curve for the proposed speech audiometry.

The intelligibility is recorded by increasing the critical frequency, and is expected to better approach 100% then by simply increasing the volume.

CONCLUSION

The results of the above speech audiometry are expected to suggest the final type of filtering needed by a strongly frequency-increasing hearing loss, in order to best approximate 100% of speech intelligibility and a better recognition of music and general sound world.

REFERENCES

1. G.P. Teatini, E. Arslan and A. Pastore, "Audiometria", in *Trattato di Foniatria e Logopedia*, Vol. 4, "La Garangola" Padova (1988)