Ears Project Newsletter No 5

July 2014

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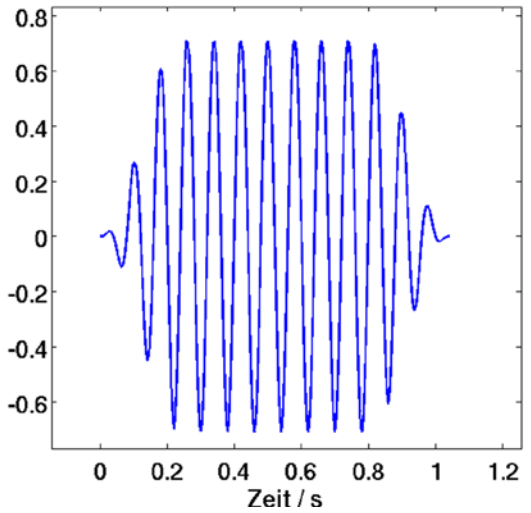

Stimuli used in the MEG measurements of brain responses at low fundamental frequency tones. This figure presents a 12 Hz stimuli.

Welcome

We are pleased to present the fifth newsletter of the project "*Metrology for a universal ear simulator and the perception of non-audible sound*" (*EARS)* which is carried out within the frame of the European Metrology Research Programme (EMRP). The project work has continued and made serious progress in different parts of the work. We invite you reading about several aspects of the work which are presented within this newsletter.

The first study about the determination of brain response to infrasound signals was carried out. M100 responses could be detected down to 8 Hz. For an acoustic assessment of infrasound noise, equal loudness contours for this frequency range were determined. The first prototype of the new universal ear simulator is available now and the development of calibration methods is currently under way.

For the two workshops which will present and discuss results and conclusions from the project work, the planning phase has been started. Accompanied to this newsletter a folder is distributed informing about main and important facts of the workshops. We cordially invite you to join us.

I hope you find the newsletter valuable, and that you enjoy the material we present in this issue. As always, we are interested to keep in contact with you as stakeholders, users, or interested persons, so please do not hesitate to contact us.

Christian Koch
Coordinator

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News and facts

- Places and dates for the two international workshops discussing results and impact of this project were fixed; more information see below, at website (www.ears-project.eu) or the enclosed folder.
- Workshop 'Infrasound and air-borne ultrasound: measurement, impact on humans and assessment' will be organised at 16 and 17 of April 2015 in Berlin.
- Workshop 'Novel ear simulator for newborns: New steps in calibration of audiological devices' will be organised at 26 of March 2015 in Teddington.
- The first prototype of the ear simulator is available and the schedule for measurements at collaborators was established.
- The next project meeting will take place in Copenhagen on 6 – 8 of October 2014. Collaborators are invited to join the second part of the meeting. Registration details will be sent out shortly.

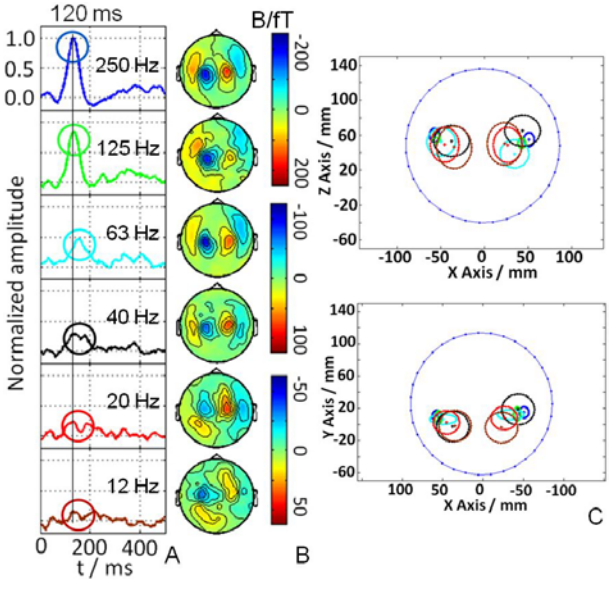
Highlights from the work packages

MEG measurements of brain responses to very low fundamental frequency tones

Magnetoencephalography are used here to measure the brain responses of 12 subjects to very low fundamental frequency tones covering the range from 250 Hz down to infrasound of 12 Hz. Especially the m100 response, a response occurring 100 ms after stimulus onset, is of particular interest. We investigated the variation of this m100 response towards the presented low frequencies.

To perform the study we used the MEG compatible infrasound source, which was described in the Newsletter of August 2013. Subjects' individual loudness perception was tested before the measurements to provide constant subjective loudness across the frequency range. A 128 channel gradiometer MEG-system (Yokogawa) in a magnetically shielded room was used. The stimuli were pure sine tones at frequencies of 250 Hz, 125 Hz, 63 Hz, 40 Hz, 20 Hz and 12 Hz. The frequency was measured with an optical microphone during measurement. All subjects reported a perception down to 12 Hz.

Frequencies were presented in random order and each tone was presented 80 times. From the averaged responses the latency and amplitude of the m100 were estimated. The underlying generators were reconstructed using a simple two dipole fit in a homogeneous conductive sphere.



The figure shows A) one measurement channel of one subject placed over the auditory cortex. B) Corresponding maps of the subject. C) 95% confidence interval of the estimated source positions of all 12 subjects. Colors corresponds to A) outer blue circle represents the border of the conductive sphere.

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Responses to stimuli above 63 Hz showed a typical m100 pattern. Their generators were located in the region of the auditory cortex. Below 63 Hz, the dipole pattern alters and their generators slightly move towards central. M100 amplitude decreased with decreasing frequency although the tones were presented at constant subjective loudness.

The latency of the m100 response remained stable at 120 ms for all frequencies. This behavior is not known for the m100 response for auditory stimuli between 500 Hz and 8 kHz.

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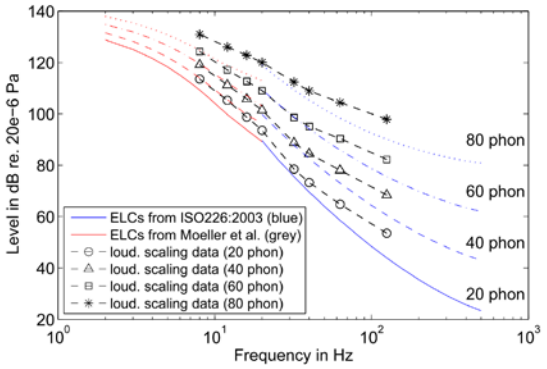
Equal loudness contours for low and infrasonic frequencies

Loudness is one of the key sensations of sound in everyday life and in case of unwanted noise plays a crucial role for annoyance. To investigate the loudness perception for low and infrasonic frequencies we extend the method of categorical loudness scaling standardized in ISO 16832 (2006) to frequencies below 125 Hz. Categorical loudness scaling provides an easy and fast procedure to determine the loudness over the whole dynamic range of the auditory system. Within this method the loudness is rated by the subject on a scale with named categories such as soft, medium loud, loud, etc. Thirty otologically normal subjects performed the categorical loudness scaling for monaural stimulation with pure tones between 8 and 125 Hz. Stimuli were presented via an insert-earphone sound source for infrasonic frequencies which was newly designed within the project. Median loudness functions calculated according to [1] showed a significant decrease of the dynamic range for lower frequencies (recruitment). Using categorical loudness data for a 1 kHz reference tone from literature [2], the relation between loudness in categorical units (CU) and loudness in phon could be established. Equal loudness contours (ELCs) for 20, 40, 60 and 80 phon were derived from the median loudness functions, see figure below.



The figure shows the equal loudness contours from 125 Hz down to 8 Hz (broken black lines with symbols), determined by means of categorical loudness scaling. Blue lines show the free field ISO226 loudness contours, and red lines show the estimated equal loudness contours for infrasound frequencies from literature [3].

The resulting ELC-values are higher but in general showed a good agreement with literature data in both the audible (ISO 226) and the infrasonic frequency range [3]. The pronounced reduction of the dynamic range at low frequencies has been clearly replicated.

[1] Brand, T. and Hohmann, V. (2002); "An adaptive procedure for categorical loudness scaling", J. Acoust. Soc. Am., 112(4), pp 157-1604

[2] Heeren, W., Hohmann, V., Appell, J. E. and Verhey, J. L. (2013), "Relation between loudness in categorical units and loudness in phons and sones", J. Acoust. Soc. Am. 133(4), EL315-EL319, March 2013

[3] Moeller, H. and Pedersen, C.S. (2004); "Hearing at Low and Infrasonic Frequencies", Noise & Health, Vol. 6, No. 23, pp 37-57

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Dissemination of work

As well as carrying our new research, the project consortium are also keen to ensure that this research *create impact and benefits* for stakeholders. This section provides a summary of the dissemination activities planned in the project.

Two workshops are being planned as the focus for disseminating much of the research output originating in the EARS project. The first workshop will be held at NPL, Teddington, UK on 26th March 2015 and will cover the ear simulator theme of the project. The second workshop will take place shortly afterwards at PTB, Berlin, Germany and deals with the non-audible sound perception theme. The first information on these two workshops is now available and is distributed with this newsletter.

Interested parties from acoustics, audiology, neuroimaging, and psychology are cordially invited.

Presentations

The project team has been particularly active in presenting aspects of the project and progress on specific technical aspects, at a range of scientific conferences and key metrology meetings.

Baki Karaböce presented an overview of the project at the National Acoustical Congress in Turkey. The project also featured in the German Acoustical Society national meeting, with. Robert Kühler presenting on the special low distortion infrasound source for assessing hearing thresholds, and Christoph Kling presenting on characteristics of typical airborne ultrasound.

The project coordinator Christian Koch also provided a status report and presented some key technical developments to the meeting of European metrology specialists working in the fields of acoustics, ultrasound and vibration, EURAMET TC-AUV. Richard Barham also presented the EARS project as a case study at the EURAMET General Assembly to an audience of senior scientists and Directors of National Measurement Institutes from across Europe.

There has also been activity connected with international standardization. The IEC technical committee for ear simulators met in Pretoria, South Africa in February and the ISO technical committee on hearing thresholds met in Berlin, Germany, in May. On both occasions Thomas Fedtke provided the other attending experts with information about the project and the potential future input into standardization.

The project consortium is always looking for ways to increase interaction with stakeholders, so please do get in touch if you have an interest in any aspect of the project. Also, please check the EARS website for the latest news.

http://www.ears-project.eu/emrp/ears.html

Business card of partners:

In this column of every newsletter we will introduce one of the institutes of the consortium to you. Today: Physikalisch-Technische Bundesanstalt, Berlin site

The PTB is the national metrology institute providing scientific and technical services and the highest technical authority of Germany for the field of metrology and certain sectors of safety engineering. The activity of the division 8 "Medical Physics and Metrological Information Technology" is focused on new measuring techniques relevant for health and medical diagnostics. In particular physics based methods such as magnetic resonance tomography and spectroscopy and optical measuring techniques are further developed both by designing new hardware devices.

Important for the project EARS is the expertise of the division "Biosignals" specializing in measuring the magnetic fields associated with physiological processes in the human body. So called magnetoencephalography (MEG) uses cryoelectronic devices to measure magnetic fields in the fT-range emanating from the human brain as a consequence of sensory input.

To measure such small fields well below the earth magnetic field and the man-made fields in the environment it is necessary to place the MEG devices into magnetically shielded rooms (MSR) and all equipment needs to be adapted to minimize stray fields. For example, studies on the brain signals associated with hearing need special non-magnetic headphones as developed in the EARS project. The world's best MSR is operated by PTB in Berlin and it consists of eight layers of magnetically shielding alloy arranged in shells. The picture shows the four sliding doors of the MSR and each door holds two shielding layers, back and front side.

Acquired data need intricate off-line processing to obtain relevant parameters such as brain current strength and location and the development and application of algorithms is an integral part of the department.

Further information can be found in the Info sheet "Division 8 Medical Physics and Metrological Information Technology" (http://www.ptb.de/cms/fileadmin/internet/publikationen/broschueren/Infoblatt_8_Medizinphysik_en_RZ_WEB.pdf)

The picture shows the entrance to the magnetically shielded room at PTB Berlin.

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