Programme and Book of Abstracts

XXII IERASG BIENNIAL SYMPOSIUM

WELCOME TO THE XXII BIENNIAL SYMPOSIUM

Dear Colleagues,

It is a great honor and real pleasure for us to host the XXII Biennial Symposium of the International Evoked Response Audiometry Study Group which will take place in Moscow in June 26-30, 2011 (immediately after 10th EFAS Congress, Warsaw). For the first time in the IERASG's history the Symposium will be held in Russia. We warmly welcome you to Moscow.

Moscow, founded in 1147 by Prince Yuri Dolgoruki, is one of the world's most beautiful cities with outstanding historical, cultural and scientific traditions.

This preliminary message contains information concerning our plans and encourages you to share with us your intention of participating in the event. We hope that approaching IERASG Symposium will become a historical event.

During this very prestigious professional event different topics of the electrophysiology of hearing, new electrophysiological techniques, cochlear micromechanics as well as theoretical and clinical aspects of acoustically and electrically evoked potentials and otoacoustic emissions will be discussed.

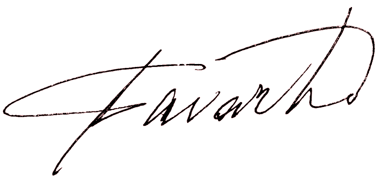
The professionals from all over the world will gather to share the latest research and clinical information and enjoy the beauties of Moscow and Russian culture.

On behalf of the organizing committee and the Russian Society of Audiology I am pleased to invite you to participate in this fantastic event.

We are looking forward to an interesting and exciting meeting.

We hope that many IERASG members and guests will have possibility to contribute and participate.

Welcome to Moscow!



George Tavartkiladze
Chair of the Organizing and Program Committee

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FRAMEWORK

Hours	Sunday June, 26	Monday June, 27	Tuesday June, 28
08:45		**Opening Ceremony**	
09:00		**Hallowell Davis Lecture** Primary degeneration of the cochlear nerve: ABR amplitudes reveal what ABR thresholds can hide	**Keynote I** A translational life. Putting research science into clinical practice.
10:00		**Oral Session** Physiological and Technical Aspects	**Oral Session** Auditory Evoked Potentials in CI Users II
10:15			
11:00		**Coffee break**	**Coffee break**
11:30		**Oral Session** Auditory Evoked Potentials in CI Users I	**Round Table** Auditory Evoked Responses: New frontiers for clinical applications based on research advances.
12:00	**IERASG Registration**		
12:30			**Lunch**
13:00		**Lunch**	**Cochlear Symposium**
13:30		**AB Symposium**	
14:00			**Oral Session** ASSR1
14:30		**Round Table** A specification for ABR systems used for post newborn hearing screening diagnostic testing	
15:00			**Oral Session** ASSR2
15:30		**Sightseeing tour**	
16:00			**Coffee break**
16:30			**Oral Session** ABR/OAE
17:00			
17:30			**Poster Session I**
19:00	**Welcome Reception**		**Russian Night**

Hours	Wednesday June, 29	Thursday June, 30
08:45		
09:00	**Keynote II** Objective Assessment of Hearing in Infants: An Evidence-Based Clinical Protocol for Early Auditory Diagnosis	**Oral Session** Endolymphatic Hydrops
10:00	**Oral Session** Cortical Responses in CI Patients	
10:15		**Oral Session** Auditory Neuropathy Spectrum Disorders/ Acoustic Neuromas
11:00	**Coffee break**	**Coffee break**
11:30	**Oral Session** Cortical Responses	**Oral Session** Screening
12:00		
12:30	**Lunch**	**Closing Ceremony**
13:00		
13:30	**Oral Session** Cortical Responses and Speech I	
14:00		
14:30	**Oral Session** Cortical Responses and Speech II	
15:00		
15:30	**Coffee break**	
16:00	**Oral Session** Cortical Auditory Evoked Responses/Vestibular Responses	
16:30		
17:00	**Poster Session II**	
17:30		
19:00	**Gala Dinner**	

PROGRAMME

— June 27 —

08:45 Opening Ceremony

09:00 Hallowell Davis Lecture

Primary degeneration of the cochlear nerve: ABR amplitudes reveal what ABR thresholds can hide

— *Charles Liberman*

10:00 Oral Session

Physiological and Technical Aspects

— *Chairmen: Manuel Don, Charles Liberman*

10:00 Neuronal Systems and Processes Engaged During Active Frequency Discrimination Task Evaluated Using Simultaneous AEP-fMRI Recordings
— *Rusiniak, M., Milner, R., Wolak, T., Kochanek, K., Śliwa, L., Piątkowska-Janko, E., Skarżyński, H.*

10:15 A comparison of different measures of sound pressure level (SPL) for click stimuli in both supra-aural and insert earphones
— *Burkard, R.*

10:30 Permanent cochlear nerve degeneration after "temporary" noise-induced hearing loss: evidence from two animal models.
— *M. Charles Liberman, Sharon J. Kujawa*

11:00 **Coffee break**

11:30 Oral Session

Auditory Evoked Potentials in CI Users I

— *Chairs: Andy Beynon, Dusan Butinar*

11:30 Intracorporeal Cortical Telemetry (ICT) revised: measuring electrically-evoked cortical EPs with a CI
— *Beynon, A.J.*

11:45 Factors affecting the peripheral auditory nerve response in CI users
— *Zir, E., Moukarzel, N., Haidar Ahmad, H., Boyd, P., Vanpoucke, F., Nehme, A.*

12:00 Spread of Excitation Measures for Virtual Channels Stimuli in Cochlear Implant Users
— *Nogueira, W., Buechner, A., Lenarz, T., Gaertner, L.*

12:15 Clinical application of the Spread of Excitation function in cochlear implant users
— *Bakhshinyan, V.V., Tavartkiladze, G.A.*

12:30 Normative values of Electrically Evoked Brainstem Responses
— *Butinar, D., Gros, A., Battelino, S., Vatovec, J.*

12:45 Evaluating the use of implant evoked Electrically Auditory Brainstem Responses in Cochlear Implant recipients
— *Ralf Greisiger, Ole Tvete, Jon Shallop, Greg Eigner Jablonski*

13:00 **Lunch**

13:30 AB Symposium

14:30 Round Table

A specification for ABR systems used for post newborn hearing screening diagnostic testing

— *Moderator Guy Lightfoot*

15:30 Sightseeing tour

— June 28 —

09:00 Keynote I

A translational life. Putting research science into clinical practice.

— *Roger Thornton*

10:00 Oral Session

Auditory Evoked Potentials in CI Users II

— *Chairs: Martin Walger, Lech Śliwa*

10:00 Vestibular loss after cochlear implantation: a review of the literature.
— *Beynon, A.J., Kieft, H.*

10:15 Evaluating the Noise in Electrically Evoked Compound Action Potential Measurements
— *Undurraga, J.A. , Carlyon, R.P. , Wouters, J. , van Wieringen, A. .*

10:30 Evaluation of Hearing Preservation in Cochlear Implantations with Auditory Steady State Responses
— *Haumann, S., Blanke, J., Büchner, A., Lenarz, T.*

10:45 Improved Detection Method for Auditory Steady State Responses in Cochlear-Implant Users
— *Hofmann, M., Wouters, J.*

11:00 **Coffee break**

11:30 Round Table

Auditory Evoked Responses: New frontiers for clinical applications based on research advances.

— *Moderator James Hall*

12:30 **Lunch**

13:00 Cochlear Symposium

14:00 Oral Session

ASSR1

— *Chairs John Durrant, James Hall*

14:00 The frequency-specific ABR - a reality or an illusion? A review
— *Laukli, E.*

14:15 An overview of ASSRs in non-human mammals (mostly chinchillas): I. Near-field studies
— *Burkard, R., McNerney, K.*

14:30 An overview of ASSRs in non-human mammals (mostly chinchillas): II. Far-field studies
— *Burkard, R., McNerney, K.*

14:45 Comparison between ASSR thresholds & tone-burst ABR thresholds with behavioral thresholds in different configurations of SNHL
— *Sobhy, O., El-Moathen, D.*

15:00 Oral Session

ASSR2

— *Chairs Einar Laukli, Robert Burkard*

15:00 Source localization of low-frequency auditory steady-state responses
— *Sophie Vanvooren, Hanne Poelmans, Michael Hofmann, Heleen Luts, Pol Ghesquière, Jan Wouters*

15:15 Using auditory steady-state responses to diagnose cochlear dead regions?
— *Kluk, K., Wilding, T., Lemanska, J. , McKay, C., Picton, T., John, S., Moore, B.C.J.*

15:30 Follow-up Report on Efforts to Extend the Steady-State Stimulus-Response Approach to Longer-Latency-Equivalent Potentials and Results in Children and Non-alert Adults
— *Tlumak, A.I., Durrant, J.D., Delgado, R.E., Boston, J.R.*

15:45 Cortical auditory steady-state responses: influence of stimulation ear on response-strength and hemispheric lateralization.
— *Poelmans, H., Luts, H., Vandermosten, M., Ghesquière, P., Wouters, J.*

16:00 **Coffee break**

16:30 Oral Session

ABR/OAE

— *Chairs Ozcan Ozdamar, Krzysztof Kochanek*

16:30 Auditory Evoked Responses to Central Beats: Transient Stimulus Generation and Central Response Characteristics
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16:45 Symmetric and asymmetric waveforms in transiently evoked otoacoustic emissions
— *W. Wiktor Jedrzejczak , Konrad Kwaskiewicz , Katarzyna J. Blinowska , Krzysztof Kochanek , Henryk Skarżyński*

17:00 Fine structure of Transient Otoacoustic Emissions
— *Belov, O.A., Tavartkiladze, G.A.*

17:15 Evidence for multiple gamma sources coincident with auditory-visual integration
— *Gilley, P.M., Walker, N.*

17:30 Poster Session I

— *Chairs David McPherson, Jose Juan Barajas De Prat*

1 Influence of aging over 10 years on auditory and vestibular functions in three patients with auditory nerve disease or auditory neuropathy.
— *Masuda, T., Kaga, K.*

2 Auditory Brainstem And Cortical Potentials Following Bone-Anchored Hearing Aid Stimulation
— *Rahne, T., Ehelebe, T., Götze, G.*

3 Accuracy and efficiency of a decision tree to estimate pure-tone thresholds in hearing-impaired adults using automatically detected cortical auditory evoked potentials (CAEPs)
— *Van Dun, B. ; Dillon, H.*

4 Auditory Neuropathy Spectrum Disorder (ANSD) in Infants: the use of cortical auditory evoked potentials help us to better manage this population during the first 12 months of life
— *Gardner-Berry, K. , Purdy, S.C. , Dillon, H.*

5 Change of hearing thresholds of infants who could not pass newborn hearing screening and infants treated in the neonatal intensive care unit
— *Min-Young Kang , Sung-Wook Jeong , Lee-Suk Kim , Chang Hyun Cho*

6 Children with phenylketonuria treated early: basic audiological and electrophysiological evaluation
— *Mancini, P.C., Durrant, J.D., Starling, A.L.P., Iório, M.C.M.*

7 Auditory Brainstem Response (ABR) Simulator to Enhance Students Understanding towards Analyzing ABR Waveforms
— *Ahmad Aidil Arafat Dzulkarnain, Faizah Sapian , Wayne Wilson, Andrew Bradley, Saiful Adli Jamaluddin, Sarah Rahmat and Narina Norddin*

8 Chirp-ASSR thresholds for normal hearing term and preterm neonates.
— *Ribeiro, F.M.; Chapchap, M.J.; Leite, R.A.*

9 An Objective Test to Detect Tinnitus: from Hair Cells to Brainstem Response Hearing Test
— *Myung-Whan Suh, Kun Woo Kim, Il-Yong Park, Seung-Ha Oh*

10 Comparison between CE-Chrip and Click evoked Auditory Brainstem Response in normal hearing and sensorineural hearing loss
— *Cho, S.W. , Han, K.H. , Shin, S.O. , Lee, J.H.*

11 ABR to complex sounds in children with auditory and language problems
— *Filippini, R., Schochat, E.*

12 Clinical and diagnostic features of auditory neuropathy in preterm children
— *Savenko, I.V., Garbaruk, E.S.*

19:00 Russian Night

— June 29 —

09:00 Keynote II

Objective Assessment of Hearing in Infants: An Evidence-Based Clinical Protocol for Early Auditory Diagnosis

— *James Hall*

10:00 Oral Session

Cortical Responses in CI Patients

— *Chairs Suzanne Purdy, Robert Harrison*

10:00 Cortical auditory evoked potentials in Cochlear Implant listeners during the first few days of hearing rehabilitation
— *Hoppe, U., Danilkina, G., Wohlberedt, T.*

10:15 Speech-evoked cortical auditory evoked potentials in children and adults with cochlear implants: stimulus effects, test-retest stability, and characterization of the electrical artefact
— *Purdy, S.C., Lin, R., Welch, D., Giles, E., Kelly, A.S., Van Dun, B.*

10:30 Processing of speech prosody assessed by cortical auditory evoked potentials in adults with cochlear implants
— *Sharma, M., Purdy, S.C., Barlow, N., Giles, E.*

10:45 Development of P300 as a function of SNR and time period after cochlear implantation
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11:00 **Coffee break**

11:30 Oral Session

Cortical Responses

— *Chairs Kimitaka Kaga, Harvey Dillon*

11:30 Preventing cochlear implant artefacts from obscuring or impersonating cortical auditory evoked potentials (CAEPs): a pilot study
— *Van Dun, B. , Lin, R. , Loi, T. , Purdy, S. , Dillon, H.*

11:45 Compensational strategies in difficult hearing environments - how the brain adapts when hearing becomes tricky: a Mismatch-Negativity-study in CI-users with good and bad speech performance
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12:00 Deconvolution of overlapping cortical auditory evoked potentials (CAEPs) recorded using very short ISIs
— *Bardy, F., Van Dun, B., Dillon, H., McMahon, C.*

12:15 Cortical potentials in aging : temporal processing
— *Ahn, S.Y., Kim, J.R., Kim, L.S., Park, J.S., Chung, S.H.*

12:30 **Lunch**

13:30 Oral Session

Cortical Responses and Speech I

— *Chairs Hillel Pratt, József Pytel*

13:30 Brain Mapping of the Mismatch Negativity and the P300 Response in Speech and Nonspeech Stimulus Processing
— *McPherson, D., Neff, S.*

13:45 Electrophysiology of Speech Feature Detection and Discrimination: Experiment I
— *Cone B., Baker, K., Ross, J., Whitaker, R.*

14:00 Electrophysiology of Speech Feature Detection and Discrimination. Experiment II
— *Cone B., Baker K., Ross, J.*

14:15 Auditory brain response to emotional words in people with aphasia
— *Ofek, E., Purdy, S.C., Ali, G., Webster, T., McCann, C.*

14:30 Oral Session

Cortical Responses and Speech II

— *Chairs David McPherson, Lionel Collet, Barbara Cone*

14:30 Using cortical auditory evoked potentials (CAEPs) for the evaluation of speech detection in infants
— *Van Dun, B. , Carter, L. , Dillon, H.*

14:45 Auditory cortical activity in normal hearing subjects to consonant vowels presented in quiet and in noise: Effect of position and VOT
— *Pratt, H. , Dimitrijevic, A. , Starr, A.*

15:00 Auditory cortical activity in normal hearing subjects to consonant vowels presented in quiet and in noise: Intracranial sources and effects of noise.
— *Pratt, H. , Dimitrijevic, A. , Starr, A.*

15:15 Audiovisual interaction in school-aged children: A speech in noise paradigm measured using cortical auditory evoked potentials
— *Gyldenkaerne, P., Sharma, M. , Purdy, S., Dillon, H.*

15:30 **Coffee break**

16:00 Oral Session

Cortical Auditory Evoked Responses/Vestibular Responses

— *Chairs Harvey Dillon, Steven Bell*

16:00 Electrophysiological correlates of spatial release from masking
— *Dillon, H., Cameron, S., Krishnan, R.*

16:15 Spectral analyses of the vestibular evoked myogenic potential (VEMP)
— *Burkard, R., McCaslin, D., McNerney, K., Coad, M.L., Jacobson, G.*

16:30 Vestibular steady state responses (VSSR) or Vestibular evoked myogenic responses to amplitude modulated sounds
— *Bell, S.L., Fox, L., Id Bihi, R.*

16:45 cVEMP Signal Processing Strategies that Attempt to Compensate for Background EMG Levels May Not Work.
— *Moushey, J., Burkard, R., Zapala, D.*

17:00 Poster Session II

— *Chairs Roger Thornton, Monica Chapchap*

1 Comparison of Three ABR-based Methods in Diagnosis of Retrocochlear Hearing Loss – Preliminary results.
— *Kochanek, K., Gołębiewski, M., Śliwa, L., Piłka, A., Skarżyński, H.*

2 Status of peripheral division of auditory analyzer of different gestational age infants at post conceptual age of 40 weeks.
— *Rakhmanova, I.V., D'iakonova, I.N., Ishanova, Y.S., Ledovskikh, Y.A.*

3 The effect of alternating stimulus frequency and reducing interstimulus interval on paired cortical auditory evoked potentials (CAEPs)
— *Bardy, F., Van Dun, B., Dillon, H., McMahon, C., Sharma, M.*

4 Evoked responses using broadband noise stimuli with chirp like properties
— *Bell, S.L., Stone, J.*

5 Effect of noise on speech evoked cortical auditory evoked potential (CAEP) in adult
— *Thannikkal, A.J., Sharma, M., Narne, V.K., Purdy, S.C.*

6 Optimal Detection Paradigm using Sequential Testing for Auditory Steady State Response
— *Choi, J. , Purcell, D. , John, M.*

7 Envelope following responses elicited by natural speech
— *Choi, J. , Purcell, D. , Aiken, S. , Coyne, J.*

8 Improvement of Auditory Brainstem Response (ABR) wave V amplitude using novel MLS nonlinear algorithm
— *Ahmad Aidil Arafat Dzulkarnain, Wayne Wilson, Andrew Bradley, Nik Amnah Nik Mohamad, Matthew Petoe, Andrew Smith, Saiful Adli Jamaluddin, Sarah Rahmat and Jackie Moon*

9 Cortical auditory potentials evoked through a Floating Mass Transducer on the cochlear round window
— *Mühler, R. , Rostalski, D. , Ziese, M. , Verhey, J.*

10 Cortical Auditory Temporal Processing Abilities in Elderly Listeners and Young Adults with Normal Hearing
— *Al-Meqbel, A., McMahon, C.*

11 Sources of experimental and statistical error in analysis of cortical auditory evoked potentials (CAEPs)
— *Gilley, P.M., Sharma, A., Walker, N.*

12 Acoustic Neuroma, AN: Indices of Tonal Audiometry, TA, Electronystagmography, ENG, and Auditory Brainstem Responses, ABRs
— *Kharkheli, E., Gamgebeli, Z., Kevanishvili, Z.*

13 Age-Related Alterations of Evoked Otoacoustic Emissions
— *Sharashenidze, N., Svanidze, N., Tushishvili, M., Kevanishvili, Z.*

19:00 Gala Dinner

— June 30 —

09:00 Oral Session

Endolymphatic Hydrops

— *Chairs Jose Juan Barajas De Prat, Roger Thornton*

09:00 Assessing the relationship between cochlear response times and the effectiveness of chirps of varying durations
— *Don, M., Elberling, C., Moumita Choudhury, Michael Waring, Kevin Crimi*

09:15 Using chirps of varying durations to determine if patients diagnosed with Meniere's disease/cochlear hydrops have shorter cochlear delays.
— *Don, M., Elberling, C., Choudhury, M., Crimi, K., Waring, M.*

09:30 Ecochg & oae findings in endolymphatic hydropse
— *Nazeri, A.*

09:45 Audiologic study (by high frequency audiometry ABR & OAE) in migraine patients
— *Marzieh Sharifian Alborzi, Homa Zarrin Koub, Ahmadreza Nazeri*

10:00 Indirect Support for the Validity of the CHAMP Procedure for Detecting Cochlear Hydrops
— *Don, M., Linthicum, F., Fayad, J., Choudhury, M.*

10:15 Oral Session

Auditory Neuropathy Spectrum Disorders/ Acoustic Neuromas

— *Chairs Lee-Suk Kim, Barbara Cone*

10:15 Predictive value of imaging studies and electrophysiologic tests on speech perception abilities of implanted children with auditory neuropathy
— *Sung-Wook Jeong, Seung-Hyun Jeong, Lee-Suk Kim*

10:30 ABR evaluation in patients with acoustic neuroma suspicion
— *Borisenko, O., Soushko, Y., Sribnyak, I., Minina, A., Shevtsova, T.*

10:45 Cochlear microphonic potential thresholds in normally-hearing children and at different forms of hearing losses
— *Garbaruk, E.S., Savenko, I.V.*

11:00 **Coffee break**

11:30 Oral Session

Screening

— *Chairs Mario Cebulla, Guy Lightfoot*

11:30 Assessment of effectiveness of algorithms applied in Vivosonic Integrity device for rejection of muscle artefacts in ABR recordings.
— *Skarżyński, P.H., Piłka, A., Śliwa, L., Kochanek, K.*

11:45 Automatic ASSR hearing screening in newborns with chirp stimuli applied at different repetition rates
— *Cebulla, M. , Shehata-Dieler, W. , Keim, R. , Stürzebecher, E.*

12:00 Follow-up ABR and OAE testing of neonates failed universal newborn hearing screening.
— *Lalayants, M.R., Markova, T.G., Tsigankova, E.R., Bakhshinyan, V.V., Tavartkiladze, G.A.*

12:15 Automated screening technology using multiple ASSR to bone- and air- conducted stimuli
— *Pérez-Abalo, M.C., Hernández, M.C., Santos, E., Rodríguez, E., Hernández, O., Mijares, E.*

12:30 Closing Ceremony

AB Workshop, 27 June, Lunch time

A New Era of Innovation

— *Moderator: George Tavartkilaze*

12.30	Welcome and Introduction	Mike Sundler, AB Europe
12.45	Auditory nerve response to current-steered and multipolar stimulation spread of excitation functions with spanning responses or modeling of the phased-array response	David Dekker Phd, Leiden University
13.00	Objective measures capabilities with the AB implant electrical field imaging, RSPOM tool	Filiep Vanpoucke, AB Europe
13:25	Closing	Mike Sundler, AB Europe

Cochlear workshop, 28th of June, 2011

Telemetrically measured electrically evoked responses

— *Moderator: George Tavartkilaze*

12:30	Welcome and Introduction	Frank Koall, Cochlear AG
12:33	Telemetry functions in Nucleus Cochlear Implants	Jochen Nicolai, Cochlear AG
12:40	Intra-operative telemetry: Procedures, insights and research directions	Ralf Greisiger, Oslo University Hospital
12:55	Post-operative telemetry: Procedures, insights and research directions	George Tavartkilaze, National Research Centre for Audiology and Hearing Rehabilitation, Moscow
13:10	Using telemetry for research: The Nucleus Implant Communicator, a versatile experimental tool	Ulrich Hoppe, University of Erlange-Nuremberg
13:25	Closing	Frank Koall, Cochlear AG

ABSTRACTS
Invited lectures & Free Communications

AN OVERVIEW OF ASSRS IN NON-HUMAN MAMMALS (MOSTLY CHINCHILLAS)

Burkard, R. , McNerney, K.
University at Buffalo
Buffalo, United States

Background: The auditory steady state response (ASSR) is an emerging clinical tool to assess hearing in humans. There is the belief that high modulation frequency ASSRs arise from subcortical sites, while low modulation frequency ASSRs arise from the cortex. There are also human studies that suggest that the use of multiple ASSR-generating stimuli can lead to substantial time savings in the human ASSR literature.

Aims: In this session the results of several studies investigating ASSRs in several non-human mammalian species will be reviewed. Most of these studies have used the chinchilla. We will evaluate the effects of anesthesia (awake versus both barbiturate-anesthetized and gas-anesthetized animals). We will look at both near-field recordings (from the inferior colliculus and the auditory cortex) and far-field recordings. We will investigate the effects of stimulus type (2-tone, sinusoidally amplitude modulated (SAM) tones, and tonebursts). We are particularly interested in the effects of presenting multiple ASSR-generating stimuli simultaneously, in particular on ASSR amplitude. The effects of multiple stimuli across quite a range of stimulation parameters will be reported.

Methods: Multiple ASSR studies will be reported. Stimulus and recording methods vary across study. Parameters will include: stimulus level, carrier frequency, modulation frequency, near-field versus far-field recordings, and whether the stimuli are presented to the same or opposite ears.

Results: The results will be compared to published human ASSR studies. We will also discuss how much time is being saved by presenting multiple stimuli, referring to some of the mean data obtained from these studies.

Conclusions: While many of the effects of stimulus manipulation reported in humans are seen in the chinchilla ASSR, the results are not always in agreement. The relationship between modulation frequency and ASSR generation site is not dichotomous, and the time savings achieved by the presentation of multiple stimuli is reduced by the reduction in ASSR amplitude observed when more than one stimulus is presented.

AUDITORY CORTICAL ACTIVITY IN NORMAL HEARING SUBJECTS TO CONSONANT VOWELS PRESENTED IN QUIET AND IN NOISE

Pratt, H.[1], Dimitrijevic, A.[2], Starr, A.[2]
[1] Evoked Potentials Laboratory, Technion - Israel Institute of Technology; [2] Neurology Research Laboratory, University of California, Irvine
[1] Haifa 32000, Israel; [2] Irvine, Ca 92697, USA

Purpose: Quantify brain potentials to stop consonants /d/ and /t/.

Methods: Auditory cortical potentials (N100, P200, N200, sustained negativity) were recorded from scalp electrodes in twelve normal hearing subjects to consonant vowels (CVs) in initial position (/du/ and /tu/), in second position VCVs (/udu/ and /utu/), and to paired vowels (VVs: /uu/) separated in time to simulate consonant voice onset times (VOTs) . Subjects were studied while awake and watching a movie.

Results: CVs (/du/ and /tu/) evoked “acoustic onset” N100 of similar latency but different amplitudes that were larger to /du/ than /tu/. CVs (/udu/ and /udu/) preceded by a vowel (VCV) evoked “acoustic change” N100 of similar amplitudes but different latency, longer to /utu/ than /udu/. Their absolute latency difference was less than the corresponding VOT difference. A sustained negativity (SN) followed N100 to VCVs that was larger to /utu/ than /udu/. Paired vowels (/uu/) separated by intervals corresponding to consonant VOTs evoked N100s and SNs with amplitudes that did not differ with VOTs. The absolute latency differences between N100 to the first and second vowel corresponded to the simulated VOT difference. Noise masking caused (1) loss of VOT-related amplitude differences for both “onset” N100 and “change” SN; 2) VCV N100 latency differences to become equal to VOT differences. Brain activations by CVs, VCVs, and VVs were of maximal amplitude in temporal lobe.

Conclusion: N100 and SN amplitudes and latencies to CVs are sensitive to: 1) CV position in the utterance and 2) VOTs of the stop consonants.

Significance: Interactions between stop consonants and following vowels are manifested by changes of amplitudes of N100 to CVs and amplitudes of SN to VCVs that are sensitive to noise masking.

A SPECIFICATION FOR ABR SYSTEMS USED FOR POST NEWBORN HEARING SCREENING DIAGNOSTIC TESTING

Lightfoot, G.
English Newborn Hearing Programme
Liverpool

The English Newborn Hearing Screening Programme (NHSP) started in 2001. In recent years we have instituted a quality assurance programme covering all aspects of the service. The quality of post-screening diagnostic ABR testing has been one of the areas in which we have made significant progress after identifying that not all testers were able to meet the exacting standards suggested in our guidelines. However, our profession needs to have equipment that makes the job of the tester easy. More than that, the equipment must make independent peer review and advice straightforward. The variety of ABR systems available to the UK market is wide; some are better suited to this application than others but no ABR system is free of limitations or quirks.

Last year NHSP drew up a specification for ABR equipment for use in post-screening diagnostic testing, including essential and desirable features. This was circulated to several manufacturers who rated their system against the specification. Rather than stipulate a single ABR system for use by NHSP testers, we will provide users with a table comparing the systems, thus allowing them to make an informed decision when purchasing new or replacement equipment.

The NHSP ABR specification gives manufacturers valuable information that they previously had to predict: features that their customers need. The response from manufacturers has been encouraging, with many planning to introduce features that their existing systems do not have. For example objective measurements of residual noise and response quality are highly desirable. There are some important features that no manufacturer yet provides, such as automatic adjustment of stimulus level in the tiny ear canal of newborns occluded by an insert — in order to overcome the considerable uncertainty of delivered stimulus level.

The aim of this session is to take this exercise from an English initiative to an international one – for our Group to have its say and use this as a vehicle to communicate to manufacturers what tools our colleagues need to do their job. We must be careful to not get carried away on a flight of fancy. Rather, we should try to speak with a united voice and ask for what is not only good but also achievable. Let's talk!

NEURONAL SYSTEMS AND PROCESSES ENGAGED DURING ACTIVE FREQUENCY DISCRIMINATION TASK EVALUATED USING SIMULTANEOUS AEP-FMRI RECORDINGS

Rusiniak, M.[1], Milner, R.[1], Wolak, T.[1], Kochanek, K.[1], Śliwa, L.[1], Piątkowska-Janko, E.[2], Skarżyński, H.[1]
[1] Institute of Physiology and Pathology of Hearing, [2] Institute of Radioelectronics, Warsaw University of Technology
Warsaw, Poland

Background: Neuronal mechanisms and systems on the cortical level associated with sound frequency discrimination are still not well known. They base on quickly occurring processes which can not be monitored separately using only the fMRI technique. Simultaneous recordings of auditory evoked potentials and functional magnetic resonance imaging (AEP-fMRI) is a new neuroimaging method with good temporal and spatial resolution. It gives a chance to describe neuronal processes connected with higher auditory function precisely both in time and space domain. Aims: was to investigate the cortical neuronal processes engaged in the process of discrimination of tones at normal hearing adults. Material and methods: Five healthy adult volunteers participated in the experiment. They were discriminating similar frequency tones which were presented in separated blocks as the standards and deviants stimuli using the odd-ball procedure. Auditory evoked potentials generated in responses to tones were recorded using 64-channel electrophysiological system. fMRI data acquired simultaneously with AEP were registered in continuous mode using high-fielded (3T) MR scanner. Dipole source analysis was applied for modeling the bioelectrical generators auditory evoked potentials to presented stimuli. The modeled dipoles of AEP were overlapped and integrated with the fMRI activations. Results: Analysis of electrophysiological data showed that the standard stimuli generated auditory evoked potentials with N1 and P2 waves. The same exogenous components were also present in the AEP to deviant stimuli but they additionally contained P3 waves. Analysis of fMRI data revealed that the discrimination between standard and deviant tones activated mainly frontal and parietal regions associated with continuous attention and executive functions. However, when the deviant tones were distinguished from standard stimuli there were active only regions in frontal lobe responsible for executive functions and associated with working memory. fMRI activations in parietal lobes present during discrimination of standard tones overlapped with the AEP dipoles to deviant tones modeled in P3 wave latency range. Interestingly, the appearance of these same dipoles corresponded with the attenuation of parietal and frontal activity during the standard tones discrimination. Conclusion: Active discrimination of different frequency tones engages different cortical cognitive processes and neural systems.

A COMPARISON OF DIFFERENT MEASURES OF SOUND PRESSURE LEVEL (SPL) FOR CLICK STIMULI IN BOTH SUPRA-AURAL AND INSERT EARPHONES

Burkard, R.
University at Buffalo
Buffalo, USA

Background: Working Group S3.72 has been working on an auditory evoked potential ANSI standard for many years, and we are close to a final draft of this standard. One sticking point in the harmonization of this standard with IEC IEC 60645–3 (Electroacoustics-Audiometric equipment-Part 3: Test signals of short duration) is the method of quantifying stimulus level. IEC using the peak-to-peak equivalent SPL (p-peSPL) approach, while some of us on the ANSI WG prefer to use either true peak SPL (pSPL), or to use the baseline-to-peak equivalent SPL (b-peSPL).

Aims: To quantify the differences in pSPL, b-peSPL and p-peSPL methods for several earphones and couplers.

Methods: Peak SPL and peak equivalent SPL were measured using a variety of earphones and couplers, using a Larson Davis 824 Sound level meter and a Tektronix digital oscilloscope.

Results: Acoustical data will be presented that compares the p-peSPL and b-peSPL calibration (as well as pSPL) approaches for both supra-aural and insert earphones for several couplers (e.g., IEC-318, NBS-9A, HA-2 and occluded ear simulator).

Conclusions: These data, which may be included as an annex in the ANSI AEP standard, will allow the ANSI standard to harmonize with IEC IEC 60645–3, but not limit the SPL measurement to the p-peSPL approach.

PERMANENT COCHLEAR NERVE DEGENERATION AFTER "TEMPORARY" NOISE-INDUCED HEARING LOSS: EVIDENCE FROM TWO ANIMAL MODELS.

M. Charles Liberman, Sharon J. Kujawa
Eaton-Peabody Laboratories, Massachusetts Eye and Ear Infirmary
Boston MA USA

After acoustic injury, sensory cell loss can occur within hours, however loss of spiral ganglion neurons is not visible for weeks. This difference in degenerative time-course has suggested that hair cell loss is the “primary” event, and that neuronal loss occurs “secondarily”, perhaps due to lack of neurotrophins normally released by hair cells. In mice and guinea pigs, we show that noise exposures adjusted to produce a large, but reversible, elevation of cochlear thresholds (as measured by ABRs and DPOAEs) lead to rapid synaptic degeneration, even with no hair cells loss and full DPOAE recovery. By immunostaining for pre-synaptic ribbons and post-synaptic terminals, we demonstrate a 50% loss of synapses within 24 hrs post-exposure. Spiral ganglion cell loss approaches 50% in noise-exposed animals, but only after months to years. This primary neural degeneration, which is reflected in ABR amplitude reduction but not in ABR threshold elevations, may contribute to hearing difficulties in noisy environments, though it does not affect thresholds in quiet. If present results extrapolate to humans, the assumption that full threshold recovery indicates full cochlear recovery, on which noise exposure guidelines are based, is seriously flawed, and acoustic overexposure is even more dangerous than currently appreciated.

INTRACORPOREAL CORTICAL TELEMETRY (ICT) REVISED: MEASURING ELECTRICALLY-EVOKED CORTICAL EPS WITH A CI

Beynon, A. J.
Vestibular & Auditory EP Lab - E.N.T. Dept. -Radboud University Nijmegen Medical Centre
Donders Institute for Brain, Cognition and Behaviour
Nijmegen, The Netherlands

Background

The last decades, many cochlear implant (CI) teams focus on measures that can predict behavioural T- and C-levels of the speech processors of CI subjects, which is important in fitting young children. Since the predictive value of neural response telemetry (NRT) seems to be limited, an increasing number of research is performed focusing on potentials beyond the compound action potential, i.e. electrically-evoked auditory cortical responses (EACRs) since these potentials reflect processing of the total central auditory pathway. In contrast to recording potentials with conventional EEG systems, we started a NRT-based paradigm to use the CI amplifier as an EEG system; thus, potentials are directly recorded and averaged by the implant itself without the discomfort and disadvantages of (extracorporeal) EEG setup, e.g. fixed scalp wirings, environmental noise. The development of an implant that could stimulate, obtain, ánd average longer latency EPs might enhance the development of automatic objective fitting procedures.

Materials and methods

After a feasibility study has been carried last years to develop a recording paradigm that was based on neural response telemetry (NRT) functionality of a CI system to record EACRs, now, in contrast to the previous pilot where the total recording window was limited to 240 ms, the total measurement window has been increased to more than 400 ms. Like the previous paradigm this new recording paradigm also concatenates multiple windows to enlarge the recording time window, but it now calculates average value of each NRT window at the cost of the temporal resolution. In this way, the measurement time can be significantly decreased for possible future clinical application. Still, the reference electrodes of a Nucleus 24 Freedom CI system were used as recording electrodes; all cortical potentials were evoked via bipolar stimulation.

Simultaneous measurements are performed using a conventional EEG system on the one hand and the Intracorporeal Cortical Telemetry (ICT) paradigm on the other hand. Both ‘in vivo’ data sets were compared.

Results and Conclusions

The present study is a continuation of the previous pilots we have done before, but now show that it is feasible to record cortical potentials with a cochlear implant in a larger time domain then that was possible in the previous pilots. Besides, the reduction of the temporal resolution did not affect the response morphology.

The clinical application of cortical potentials in unilateral and bilateral CI patients is discussed in the light of cortical maturation and the possible role of ICT for future clinical application.

FACTORS AFFECTING THE PERIPHERAL AUDITORY NERVE RESPONSE IN CI USERS

Zir, E. [1], Moukarzel, N. [1], Haidar Ahmad, H. [1], Boyd, P. [2], Vanpoucke, F. [2], Nehme, A. [1]
[1] Clinique du Levant, Beirut, Lebanon; [2] Advanced Bionics European Research, Belgium
Beirut

Objectives: Recordings of electrically-evoked compound action potentials (eCAP) were made in users of the Advanced Bionics HiRes90K cochlear implant (CI), using the Neural Response Imaging (NRI) SmartNRI algorithm. The aims of the study included investigation of (i) responses from different sites along the cochlea, (ii) development of responses over time post-activation. The fundamental aim, therefore, was to investigate slope and threshold measures as correlates of aspects of neural survival.

Design: Subjects were 34 "standard" CI users (mostly congenitally deaf children) plus a group of 13 individuals with a range of structural abnormalities (Mondini, common cavity, enlarged vestibular aqueduct and cochlear otosclerosis). eCAP recordings were made from 4 electrodes spaced along the array at the time of initial device activation and at frequent intervals up to at least 2 years. Threshold (tNRI) and slope of the amplitude growth function was measured and a range of explanatory variables (electrode position, age at implantation, onset of deafness, and duration of device use) were tested for significant effects on these measures by multi-factorial ANOVA.

Results: For the "standard" CI subjects, electrode position emerged as a significant effect for the tNRI measure, with lowest thresholds at the apical end of the array. Mean slope was greatest for the most apical electrode, but this effect was not statistically significant. The slope parameter was significantly influenced by the onset of deafness variable, with congenital hearing loss associated with steeper slopes than acquired hearing loss. There was also a highly significant effect of duration of device use, with a gradual increase in slope over the two years following device activation. The subjects with structural abnormalities mostly showed higher thresholds and less steep growth function.

Conclusions: The observed effects of electrode position are consistent with a model in which eCAP threshold is governed primarily by an effect of distance between electrode and the neural interface (which is shorter towards the apex of the cochlea) and in which the slope is governed primarily by the density of surviving neural elements (which is greater towards the apex). The increase in slope over time post-activation may be a maturation effect involving increase in firing synchronicity.

SPREAD OF EXCITATION MEASURES FOR VIRTUAL CHANNELS STIMULI IN COCHLEAR IMPLANT USERS

Nogueira, W. , Buechner, A. , Lenarz, T. , Gaertner, L.
Advanced Bionics GmbH
Hannover, Germany

Key Words: objective measures, spread of excitation, E – CAP, neural response imaging, current steering, virtual channels.

Introduction

In conventional stimulation strategies for Cochlear Implant (CI) the number of stimulation sites is limited to the number of electrode contacts inserted in the cochlea. The so called current steering technique or virtual channel technique allows creating further stimulation sites by simultaneous stimulation of neighboring electrodes; this technique leads to further pitch percepts, so called virtual channel (Donaldson et al. 2005, Koch et al. 2007, Brendel et al. 2009). The aim of this study was to investigate the influence of the current steering technique on the location and width of the excitation pattern (spread of excitation — SOE).

Material and Method

A research version of the RSPOM-software (Research Studies Platform — Objective Measures) by Advanced Bionics was used to obtain SOE measures. The neural responses were performed using a forward masking paradigm for artifact rejection. The recording electrode was set to electrode 6 and the masker was roved along the whole electrode array (16 contacts). The probe electrode was a so-called virtual channel that created three different virtual channels between electrodes 8 and 9. The loudness was balanced between all five stimulation sites (three virtual channel s plus the two physical channels). So far, data of five subjects were collected, all using the HiRes90K implant system with the current steering strategy HiRes 120.

Results

We observed that when the probe is shifted (using the different virtual channels) towards the base, the peak of the SOE also shifts basally. Some subjects show a continuous shift of the excitation pattern. If we assume a correlation between the peak of the SOE and pitch perception, this would indicate objectively, a pitch shift when using virtual channels. Further on characteristics of the SOE will be compared to the pitch discrimination ability.

Summary

Our preliminary results indicate that the shift of the neural excitation pattern with the stimulation site can be traced by SOE.

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CLINICAL APPLICATION OF THE SPREAD OF EXCITATION FUNCTION IN COCHLEAR IMPLANT USERS

Bakhshinyan, V. V. , Tavartkiladze, G. A.
National Research Center for Audiology and Hearing Rehabilitation, Moscow, Russia

The aim of our study was to examine the Spread of Excitation (SE) with the Neural Response Telemetry (NRT) for Nucleus CI wearers and to investigate the effect of modiolar placement on the stimulation thresholds and profiles, to test whether perimodiolar electrode placement does indeed result in the hypothesized reduced SE and to evaluate its usefulness as a clinical tool.

80 Nucleus CI24 patients were included is this study (30 CI24M and CI24K, 20 CI24R(CS) Contour and 30 CI24RE(CA) Freedom implant wearers). NRT was performed intraoperatively. A frequency-selective curve was obtained by plotting the NRT amplitude as a function of masker electrode number, which may be interpreted as reflecting the SE through the cochlea.

Results and Conclusion: SE was measured at all the electrodes with measurable neural responses. Statistical analysis of our data showed that the perimodiolar electrode placement resulted in a significant reduction in the width of SE curve. The results obtained suggest that the width of the NRT SE curves was significantly reduced in patients with perimodiolar electrode compared with the patients with conventional straight electrode array. It was also shown that modiolar location caused the reduction of NRT thresholds. At the same time it did not affect the slope of the NRT input-output function. SE provides a quick, objective measure of channel interaction.

Our results suggest that perimodiolar placement of the electrode array significantly reduces the thresholds and SE widths, which improves the selectivity of neuronal stimulation and can be used as an objective clinical tool for better prediction of the auditory performance after cochlear implantation.

NORMATIVE VALUES OF ELECTRICALLY EVOKED BRAINSTEM RESPONSES

Butinar, D.[1], Gros, A.[2], Battelino, S.[2], Vatovec, J.[2]
[1] Institute of Clinical neurophysiology, UMC, [2] Clinic for ENT and maxilo-facial surgery, UMC,
[1] Ljubljana, Slovenia; [2] Ljubljana, Slovenia

Background. Registration of electrically evoked auditory brainstem responses (EABR) is an objective functional method allowing assessment of the auditory nerve fibres function as well as of the auditory pathway in the brainstem till the mesencephalon. It is able to locate the site of dysfunction in deaf people where we can not use the auditory evoked brainstem responses. It was expected that it would contribute considerably to the success rate of cochlear implants by providing a better selection of patients suitable for the implantation. However, being technically demanding, the method has failed to become a routine procedure.

Aim. The aim of the study was to present the normative data in patients who underwent the method before the cochlear implants and to discuss the difference among the age groups.

Method and Patients. Preoperatively we performed EABR with "gulf" electrode across the round window in 25 candidates (50 ears), 11 females and 14 males, age 5 months to 820 months, who were candidates for cochlear implants. Measurements were done in generally anaesthetized patients. Nicolet Viking IV system and Nottingham University electrical stimulator were used to generate reversed electrical stimuli (intensity: from 200 μA to 1 mA, duration: 200 ms) and to record EABR. The stimuli were applied through a needle "gulf club" electrode which was placed on the edge of or across the round window. The EABR were recorded between the opposite earlobe and the vertex.

Results. Reliable EABR could be recorded in all cochlear implant candidates. In older patients the amplitudes were high and EABR easier to record.

Discussion. Reasons for the difference in results among the age groups are probably due to myelinisation and are discussed.

Conclusion. We know that the position of the stimulating electrode is critical. The results suggest a role of myelinisation among the age groups investigated.

EVALUATING THE USE OF IMPLANT EVOKED ELECTRICALLY AUDITORY BRAINSTEM RESPONSES IN COCHLEAR IMPLANT RECIPIENTS

Ralf Greisiger[1, 2], Ole Tvete[1], Jon Shallop[3], Greg Eigner Jablonski[1]
[1] Department of Otorhinolaryngology, Oslo University Hospital, Norway [2] Department of Informatics, University of Oslo, Norway [3] Mayo Clinic and Associate Faculty, University of Arizona, USA
Oslo, Norway

Introduction / Objectives of this study

Cochlear Implants (CI) are an electronic device to provide hearing sensations to persons with a severe to profound sensorineural loss of hearing. The implant is surgically placed into the cochlea. During surgery several objective measurements can be carried out. This study evaluates the use of implant evoked Electrically Auditory Brainstem Responses impEABR in Cochlear Implant patients.

Method

CI patients are examined either intra operatively or/and post operatively for their impEABR. The same recording electrodes and places are used as for acoustic ABR measurements. For stimulation, the implant is used and controlled by the cochlear implant software, which triggers the recording EP system.

Results

We have used impEABR measurements for standard CI surgeries to get a baseline data of amplitudes and latencies of the impEABR. In patients with poor performance or even no post-op behavioral responses, these measurements can be used to provide an objective measurement which can help us determine possible stimulation from the CI. In two cases with CHARGE syndrome no reaction was observed after CI programming. In these two cases, ImpEABR measurements showed no responses, at high current levels. One patient without response turned out having a wrong placement of the electrode array. After revision surgery and correct placement of the electrode array similar responses were measured as in other patients with good performance with the CI.

Conclusion

ImpEABR can be a tool for evaluating possible causes of poor speech performance in CI patients. These measurements can be carried out easily as routine measurements during CI surgery.

VESTIBULAR LOSS AFTER COCHLEAR IMPLANTATION: A REVIEW OF THE LITERATURE.

Beynon, A. J. , Kieft, H.
Vestibular & Auditory EP Lab - E.N.T. Dept. -Radboud University Nijmegen Medical Centre
Donders Institute for Brain, Cognition and Behaviour
Nijmegen, The Netherlands

Introduction The decreasing gap between candidates for conventional hearing aids and cochlear implant users accounts for the still growing group of CI candidates. Therefore, adequate and updating information of the risks is still necessary for proper preoperative counselling of candidates. With respect to vestibular loss after cochlear implantation the side with weaker vestibular function is usually chosen for implantation, because of the smaller risk of losing any vestibular function. However, the results of these studies differ significantly with respect to the percentages of 'vestibular loss of function', because they are not consistent in using the same definitions of 'vestibular loss' (e.g. total loss or just a reduction of vestibular reactivity?) or they compare different dependent variables (e.g. preop objective measures, such as caloric response, rotational chair responses with postop behavioural responses). Since centres use different criteria and definitions, percentages should never be adopted automatically. The present paper will give the 'state-of-the-art' regarding the vestibular function after CI. In additionally to this overview, recent data is presented of different groups with different preop vestibular function.

Methods This study compares caloric data pre- vs. postop (objective) in combination with rotational chair data to possibly measure central adaptation. In addition to the audiological- and MRI findings, electronystagmography (ENG) was performed in CI candidates. The pre- and postoperative caloric dysfunction of the horizontal semicircular canal is compared in CI subjects and asymmetry in rotational testing is evaluated. Several possible risk factors are included to investigate whether a decrease in vestibular function is related to specific variables such as 'cause of deafness', 'age at implantation', 'surgical procedure', 'type of electrode', 'surgeon', 'time between surgery and ENG' and 'postoperative deterioration in pure tone threshold'. Regarding the subjective data, behavioural data was obtained with the use of the Dizziness Handicap Inventory (DHI) to assess possible postoperative vestibular handicaps in the functional, physical and emotional domain. This subjective data, reflecting the degree of handicap in everyday life due to vestibular loss, is analyzed and compared to data of the objective measures.

Results Firstly, 25.7% of the CI subjects lost their vestibular function after cochlear implantation, including a smaller group that completely lost their vestibular function after surgery (postoperative areflexia: 8.6%). Furthermore, logistic regression analyses suggest that factor 'age' plays a significant role: CI candidates beyond the age of 49 years are more susceptible to vestibular deterioration after implantation than subjects below that age. Other variables such as 'surgical procedure', 'type of electrode', 'surgeon', 'time between surgery and ENG' and 'hearing threshold deterioration' do not play a significant role. Thirdly, rotational testing chair data reveal that most of the subjects with postoperative unilateral vestibular loss after CI, show postoperative central adaptation that is in agreement with the DHI results. The relationship between caloric test results and subjective handicap is not conclusive: the present data show that there seem to be no direct relation between both variables.

The results of this study underline the importance of adequately informing CI candidates of possible vestibular function loss after CI, especially beyond the age of 49 years. Patients should be informed about the possibility of postoperative vestibular complaints and followed up during postoperative course. Recent data on postoperative central adaptation will be addressed.

EVALUATING THE NOISE IN ELECTRICALLY EVOKED COMPOUND ACTION POTENTIAL MEASUREMENTS

Undurraga, J. A.[1], Carlyon, R. P.[2], Wouters, J.[1], van Wieringen, A.[1].
[1] ExpORL, Department of Neurosciences, Katholieke Universiteit Leuven (KULeuven); [2] MRC Cognition and Brain Sciences Unit
[1] Leuven, Belgium; [2] Cambridge, UK

Electrically Evoked Compound Action Potentials (ECAPs) are widely used to study the excitability of the auditory nerve (AN) and stimulation properties in cochlear implant (CI) users. However, ECAP detection can be difficult and very subjective at near-threshold stimulation levels, or when stimulation parameters such as electrode position, rate and pulse width (PW) are modified. We evaluated the statistical properties of the background noise (BN) and the post-average residual noise (RN) in ECAP measurements in order to determine a more objective detection criterion. For the estimation of the BN and the RN a method currently used in auditory brainstem response (ABR) measurements was applied. The potential benefit of using weighted (Bayesian) average was also examined. All estimations were performed with a set of approximately 400 ECAP measurements recorded from 5 human CI users of the CII or HiRes90K device (Advanced Bionics). Results demonstrate that the BN was normally distributed and the RN was, as expected, inversely proportional to the square root of the number of observations. No additional benefit was observed by using weighted averaging. The noise power did not vary significantly as a function of stimulation intensity or location of the recording electrode. The analysis of the statistical properties of the noise indicated that a signal-to-noise ratio (SNR) of 1.7 dB as a detection criterion corresponds to a false positive detection rate of 1% with the measurement setup used here.

EVALUATION OF HEARING PRESERVATION IN COCHLEAR IMPLANTATIONS WITH AUDITORY STEADY STATE RESPONSES

Haumann, S. , Blanke, J. , Büchner, A. , Lenarz, T.
Medical University of Hannover, Department of Otorhinolaryngology
Hannover

Introduction:

Recently new cochlear implant electrodes were designed which aim to preserve the residual hearing during implantations. This succeeds in most cases. For the remaining cases the question arises whether the impairment is caused by the intrinsic surgery or by processes initiated postoperatively.

Methods:

Within the implantation routine of devices aiming to preserve the residual hearing Auditory Steady State Responses (ASSR) were measured intraoperatively. Therewith the hearing threshold was evaluated under anaesthesia directly before and after surgery. Up to now measurements were obtained for 45 subjects (14 m, 21 f, age from 6 to 90 yrs, Ø 57.2 yrs). 20 of them were implanted with a Nucleus Hybrid – L device and 15 of them with a Nucleus SRA device. ASSR were measured at six frequencies (250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz and 8 kHz). The obtained ASSR thresholds were compared with each other and with the pre- and postsurgically measured behavioural thresholds.

Results:

On average, the difference between pre- and postsurgically measured behavioural thresholds was 11.4 dB $\pm$ 14.8 dB (mean $\pm$ standard deviation), the difference between pre- and postsurgically obtained ASSR threshold was 5.0 dB $\pm$ 13.1 dB, the difference between presurgically obtained behavioural and ASSR thresholds was 17.2 dB $\pm$ 14.5 dB and the difference between postsurgically measured behavioural and ASSR thresholds was 15.0 $\pm$ 20.4 dB.

Conclusion:

The ASSR thresholds were found to be highly reproducible before and after surgery. Thus, the method can be applied for the desired purpose. The differences between ASSR thresholds were detected to be smaller than the differences between the behavioural thresholds. This indicates that impairments of the residual hearing during surgery are primarily caused by postoperative processes.

IMPROVED DETECTION METHOD FOR AUDITORY STEADY STATE RESPONSES IN COCHLEAR-IMPLANT USERS

Hofmann, M. , Wouters, J.
ExpORL, Dept. Neurosciences, K.U.Leuven, Leuven, Belgium
Leuven, Belgium

Electrically Auditory Steady State Responses (EASSRs) are EEG potentials in response to periodic electrical stimuli presented through a cochlear implant (CI). For slow rate pulse trains in the 40 Hz range, electrophysiological thresholds derived from response amplitude growth functions correlate well with behavioral thresholds at these rates.

The aims of this study were: 1) to show that auditory steady state potentials can be reliably evoked by modulated high-rate pulse trains with clinical carrier rates and modulation frequencies in the 40 Hz range, 2) to demonstrate that stimulus artifacts for such stimuli can be completely removed from the recording, 3) to analyze the properties of the resulting responses with regards to amplitude, phase and apparent latency, and 4) to examine the predictive value of electrophysiological thresholds derived from such responses for behavioral thresholds at these high rates.

For six users of a Nucleus cochlear implant, EASSRs to symmetric biphasic bipolar pulse trains were recorded with seven scalp electrodes. Responses to six different stimuli were analyzed: two slow rate pulse trains with pulse rates in the 40 Hz range as well as two amplitude-modulated (AM) and two pulse-width-modulated (PWM) pulse trains with a carrier rate of 900 pps and modulation frequencies in the 40 Hz range. Measurements were done at eight stimulus intensities. Artifacts due to the electrical stimulation were removed from the recordings. To determine the presence of a neural response, improved robust statistics based on Hotelling's T-square test were used that could cope with the presence of limited remaining artifact components. Measurements from different recording electrodes and adjacent stimulus intensities were combined to increase statistical power.

The results show that EASSRs can be evoked by AM and PWM high-rate pulse trains in CI users. In the recorded EEG, these responses can be completely separated from the artifacts generated by the electrical stimulation. At lower intensities, the obtained response amplitudes for AM and PWM stimuli are higher than for slow-rate stimuli, while apparent latencies are similar for all three stimuli. Electrophysiological thresholds derived from responses to AM and PWM high-rate stimuli are significantly lower than for slow-rate stimuli and correlate well with behavioral thresholds.

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THE FREQUENCY-SPECIFIC ABR - A REALITY OR AN ILLUSION? A REVIEW

Laukli, E.
Dept. of Otorhinolaryngology, University of Tromsø
Tromsø, Norway

Today's infant screening programs have led to an early identification of hearing loss, and hearing aids are fitted within the first few months of life. What audiometric basis do we have for the fitting of hearing aids? The hearing aid shall give amplification in a more or less broad frequency range, and the fitting rationales should be based on an audiogram which is out of range in this group of children. A threshold ABR is normally the golden standard at this stage, but what information can we get from the clinical ABR today?

The stimuli used in ABR may be broad band such as clicks or chirps, or they can be presented as tone-bursts with different envelopes. In ASSR we may use chirps or different kinds of modulated tones, but how frequency-specific are the responses from such stimuli?

The clicks may have varying spectra, this dependent on transducers and acoustic impedance of the ear, whereas the tone-bursts are more robust and frequency specific as stimuli. However, how frequency specific are the responses from those stimuli? Ipsilateral high-pass masking has been proposed a long time ago, but today normally the tone-bursts without masking are used, and the risk of response thresholds not representing the actual frequency is quite high with high level stimuli and with different audiometric shapes.

Many reports in the literature have shown both poor accuracy regarding measured threshold and also a possible lack of frequency specific response. Perhaps it is time to have a new look at these problems and see if it is possible to improve the ABR audiogram.

einar.laukli@unn.no

COMPARISON BETWEEN ASSR THRESHOLDS & TONE-BURST ABR THRESHOLDS WITH BEHAVIORAL THRESHOLDS IN DIFFERENT CONFIGURATIONS OF SNHL

Sobhy, O. , El-Moathen, D.
Alexandria University
Alexandria, Egypt

Obtaining frequency-specific audiometric thresholds has been one of the most important goals that audiological practice is always struggling for. Many techniques have been proposed both in lab and clinical settings to solve this problem. Tone burst auditory brainstem responses (ABR) have been used for long time, although it is difficult to record and interpret. Recently, the auditory steady state responses (ASSR) were introduced as they utilize highly frequency specific amplitude-modulated stimuli.

The present study was carried out to investigate whether the ASSR could be used to predict the hearing thresholds in adults as an alternative tool to the tone burst ABR. Ten normal hearing adults (10 ears) and 40 adults (40 ears) with varying configurations of sensory-neural hearing impairment were included in this study. Flat, low frequency, sloping and steeping hearing losses were included as different configurations. Four frequencies (500, 1000, 2000, 4000Hz) were evaluated. All subjects received pure-tone audiometry, single-channel ASSR, and tone burst ABR tests for threshold measurement. The ASSR stimuli were amplitude modulated pure tones at a rate of 80 Hz.

Thresholds using the ASSR and the tone burst ABR were compared to behavioural thresholds obtained by conventional audiometry. Also, the behavioural thresholds versus ASSR or ABR thresholds differences were used as raw data. The data were analyzed statistically using two-way ANOVA. The two independent variables were the frequencies of stimulation with four levels representing the four studied frequencies, and the different configurations of hearing loss and the control group with five levels representing the type of loss variable. The same kind of analysis was done for both the ASSR and the tone burst ABR. Correlation coefficients were also studied to investigate the relation between the behavioural thresholds and the electrophysiological thresholds using the ASSR and the tone burst ABR. Finally the ASSR tone burst thresholds were compared using student "t" test.

Results: Although, tone burst ABR thresholds were closer to behavioural thresholds than ASSR, two-way ANOVA showed no significant frequency versus group interaction in both tests. The only significant difference that was observed was for the main effect of flat hearing loss versus normal hearing at 500 & 1000 Hz. Both tests were highly correlated with pure-tone thresholds with correlation coefficients ranging between 0.82 to 0.95. Student "t" to compare the thresholds obtained by the two techniques revealed no significant differences.

Conclusion: The results of this study indicated that the ASSR may provide a reasonable alternative to the ABR for estimating audiometric thresholds. It can be a powerful and convenient electrophysiologic examination tool for clinically assessing adults with sensorineural hearing loss due to its automatic detection of response as opposed to the visual response detection in the ABR as well as its shorter testing time. The latter merit can be achieved if ASSR is to be recorded using multi channel/binaural method of recording. Another merit to the ASSR is its ability to detect residual hearing in profound hearing losses.

SOURCE LOCALIZATION OF LOW-FREQUENCY AUDITORY STEADY-STATE RESPONSES

Sophie Vanvooren[1, 2], Hanne Poelmans[1, 2], Michael Hofmann[1], Heleen Luts[1, 2], Pol Ghesquière[2], Jan Wouters[1]
[1] ExpORL, Dept. Neurosciences, K.U.Leuven, Belgium [2] Parenting and Special Education Research Group, K.U.Leuven, Belgium
Leuven, Belgium

Slow temporal modulations below 40 Hz have been shown to be important for speech understanding. Modulation frequencies at 4 and 20 Hz represent the rate by which syllables (±250 ms) and phonemes (±50 ms) respectively appear in speech. In dyslexia, a specific learning disorder that refers to a serious deficiency in reading and writing skills, growing support exists on a difference in auditory processing of these lower temporal modulations. This difference causes subtle speech perception problems and eventually could lead to impaired literacy skills. Auditory Steady– State Responses (ASSR) can identify the temporal information processing and thus provide an objective measure to determine the sensitivity for important acoustical-phonological elements in language.

The present research project precedes a longitudinal study which has as main goal to define specific neurophysiological markers for the auditory processing problem in dyslexia. This pilot study aims to investigate the sensitivity of the auditory cortex for low-frequency temporal information in a control group of normal hearing right-handed adults without dyslexia.

Multichannel ASSRs are recorded in a 64 electrode configuration with a BioSemi measurement system with active electrodes using clicks and amplitude-modulated speech-weighted noise stimuli at 4 and 20 Hz. In addition, the well-known 40 and 80 Hz ASSRs are measured for comparison. In this way, responses from brainstem to cortex on the auditory path are recorded. The sensitivity for these modulation frequencies is evaluated by comparing source location and source strength of the generated brain responses using BESA Research 5.3.7 software. Results of this pilot study and implications for the dyslexia research will be discussed at the conference.

USING AUDITORY STEADY-STATE RESPONSES TO DIAGNOSE COCHLEAR DEAD REGIONS?

Kluk, K. [1], Wilding, T. [1], Lemanska, J. [1], McKay, C. [1], Picton, T. [2], John, S. [2], Moore, B. C. J. [3]
[1] The University of Manchester, UK; [2] The Rotman Research Institute, Canada; [3] University of Cambridge, UK

The current behavioural dead region (DR) diagnosis methods such as psychophysical tuning curves and the threshold-equalising noise (TEN) test require extensive subject co-operation. This study aimed to develop a fast objective DR diagnosis method that could be applied to sleeping hearing-impaired infants. We investigated a novel fast objective electrophysiological tuning curve (ETC) method and electrophysiological equivalent of TEN test, in normally hearing and hearing-impaired subjects.

ETCs can be obtained by recording electrophysiological response amplitudes in the presence of fixed level maskers at multiple discrete centre-frequencies (Folsom, 1984; Ross et al, 2003). In the present study ETCs were obtained by recording auditory steady-state response (ASSR) amplitudes in the presence of narrow-band maskers. In each ETC recording the signal and masker level was fixed whilst the masker centre frequency was varied. We investigated two possible ETC masking methods. In the swept method, ETCs were recorded in a single test run by determining the response amplitude at each masker frequency in the presence of a continuously swept-frequency narrow band masker. In the fixed method, response amplitudes of eight separate test runs, each in the presence of differing fixed-frequency narrow band masker, were recorded.

In the first experiment we investigated the optimal recording parameters of the swept method in 10 normally hearing adults. In the second experiment the optimal parameters were utilised to record ETCs using the swept and fixed method (for comparison) in 20 normally hearing adults. In the third experiment swept method ETCs were recorded in 10 hearing impaired adults. In the fourth experiment we investigated the masking effect of TEN on amplitude of auditory steady-state responses in normally hearing and hearing-impaired adults.

Our results indicate that for normally hearing adult subjects in condition 1 (swept masker), the mean recorded ETC tip for a 2 kHz signal was 2250 Hz and the repeatability coefficient of two repeated recordings in each subject was 389 Hz; in condition 2 (fixed masker), the respective values were 2251 Hz and 342 Hz. These initial results indicated that the swept masking method appeared to be a viable and fast way to record ETCs in normally hearing adults.

Preliminary analysis of the hearing impaired ETC recordings revealed that in some cases there were difficulties in using the required noise masker levels due to subjects' comfortable listening levels and the ETC repeatability was poor in elderly hearing-impaired adults.

Acknowledgements

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FOLLOW-UP REPORT ON EFFORTS TO EXTEND THE STEADY-STATE STIMULUS-RESPONSE APPROACH TO LONGER-LATENCY-EQUIVALENT POTENTIALS AND RESULTS IN CHILDREN AND NON-ALERT ADULTS

Tlumak, A. I.[1, 2], Durrant, J. D.[2], Delgado, R. E.[3], Boston, J. R.[2]
[1] Veterans Administration Pittsburgh Healthcare System; [2] University of Pittsburgh; [3] Intelligent Hearing Systems
[1,2] Pittsburgh, Pennsylvania; [3] Miami, Florida USA

Considerable attention has been given to the auditory steady-state responses (ASSRs), especially electric-audiometric applications. These interests/applications ostensibly overlap conventionally recorded early and middle auditory evoked potentials, using essentially an impulse-response stimulus-response approach. The SSR approach, however, can be extended to latency ranges corresponding to later potentials. Collectively, analyzing effectively broader ranges of potentials, apropos their putative levels of generation along the auditory pathways, may open the door wider to current applications of ASSRs, if not other doors of applications, both of ERA and otoneurological interests. Preliminary work and relevant theoretical bases of the approach taken, using stimulus repetition rates from 0.75 Hz to 80 Hz (previously presented at the Rio Biennial Symposium), will be summarized. Additional analyses and refinements of these findings then will be presented along with the final data set and analyses pertaining to results in children (ages 6–9) and in adults lightly sleeping versus alert/awake (i.e. intact college-aged volunteer subjects). The results continue to robustly support the efficacy of a SSR approach to the longer-latency equivalent responses, verified by corresponding long-latency transient (conventional) responses versus quasi-steady-state LLRs.

CORTICAL AUDITORY STEADY-STATE RESPONSES: INFLUENCE OF STIMULATION EAR ON RESPONSE-STRENGTH AND HEMISPHERIC LATERALIZATION.

Poelmans, H.[1, 2], Luts, H.[1, 2], Vandermosten, M.[2, 1], Ghesquière, P.[2], Wouters, J.[1]
[1] ExpORL, Dept. Neurosciences, K.U.Leuven, Belgium; [2] Parenting and Special Education Research Group, K.U.Leuven, Belgium
Leuven, Belgium

Auditory steady-state responses (ASSRs) are commonly assessed in the context of basic research and clinically for objective measurement of hearing thresholds. In this context, the focus has mainly been on ASSRs to amplitude modulations (AM) in the 80 Hz or 40 Hz region. However, low-frequency ASSRs (below 40 Hz) have been shown to relate to speech understanding and provide an important indicator of central auditory functioning. Yet, the response characteristics of these slow modulations are largely unknown. Neuroimaging and EEG studies hypothesized that each hemisphere in the auditory cortex is specialized in analyzing modulations at different timescales (right auditory cortex: 3–7 Hz; left auditory cortex: 12–50 Hz). ASSRs to slow modulations could therefore be more prominent for electrodes over a specific hemisphere and could even be influenced by the side of stimulus presentation. The present study aimed to investigate this by means of multichannel ASSRs. ASSRs were evoked in 30 normal-hearing adults by speech-weighted noise stimuli that were 100% amplitude-modulated at 4, 20 and 80 Hz. Stimuli were presented monaurally to the left and right ear and binaurally diotic. Preliminary analyses suggest that compared to monaural stimulation, binaural diotic stimulation is beneficial for 80 Hz AM, equal to monaural stimulation for 20 Hz AM and even disadvantageous for 4 Hz AM. With regard to monaural stimulation, ipsilateral responses were higher than contralateral responses for 80 Hz AM. Right ear stimulation resulted in higher responses than left ear stimulation for 20 Hz AM, especially for right hemisphere electrodes. For 4 Hz, monaural left and right ear stimulation did not evoke differences in response-strength. For this modulation, responses were overall slightly higher for right hemisphere electrodes. These results have important implications for clinical and experimental application of ASSRs, especially for the recording for low-frequency ASSRs.

AUDITORY EVOKED RESPONSES TO CENTRAL BEATS: TRANSIENT STIMULUS GENERATION AND CENTRAL RESPONSE CHARACTERISTICS

Ozdamar, O.[1], Bohorquez, J.[1], Mihajloski, T.[1], Lachowska, M.[2, 1]
[1] University of Miami, Dept. Biomedical Engineering; [2] Medical University of Warsaw, Dept. Otolaryngology
[1] Coral Gables, FL USA; [2] Warsaw, Poland

Acoustic (peripheral) beats are heard when two continuous tones with slightly different frequencies are presented to the same ear monaurally. This percept corresponds to the periodic amplitude fluctuations with a pulsation frequency determined by the frequency difference between the tones. If these steady tones are presented to the ears dichotically, a faint pulsation perception called central (binaural) beats is experienced. Central beats are essentially illusions resulting from the binaural interaction of the neural activity from both ears. Similar to acoustic beats they are heard pulsating at the frequency difference of the tones in each ear. Although psychophysical properties of auditory central beats are well reported, very few studies on humans have been reported on their electrophysiological or evoked response characteristics. Due to the conventional use of long continuous tones, all of them reported the steady-state response characteristics of the central beats. The purpose of this study is to a) generate a stimulus paradigm capable of generating short duration tone pips centrally and b) report their evoked response characteristics. The stimuli used in this study consist of two continuous tones with the same base frequency but with opposite phases. The frequency of one stimulus (Stim1) is incremented 20 Hz with 20 ms duration and the other stimulus (Stim2) is decremented 20 Hz at the same interval. The onset and offset of the increments/decrements are adjusted such that no extra impulse like sound is generated. The beats are presented at 1, 2.5 and 5 Hz and base frequencies corresponding to 250, 500 and 1000 Hz are tested. Both stimuli are generated digitally with 10 kHz sampling rate using 1000 ms dual buffers. Two channel EEG (Side A: Cz – A2 and Side B: Cz – A1)) are recorded (Band-pass: 1–1500 Hz, Gain: 100,000) continuously with a 5 kHz sampling rate. To eliminate frequency following responses, stimuli are presented in alternating mode with careful phase adjustment so that no abrupt changes are produced. Three types of recordings were conducted using 55 dB HL tones: a) monaural right ear with Stim1 b) monaural left ear with Stim2 and c) dichotic right and left ears with Stim1 and Stim2, respectively. Since 20 Hz increments/decrements produce small but recordable FM onset responses, Binaural Interaction Component (BIC) is computed by subtracting binaural responses from the sum of monaural responses in each channel. In this study results from subjects with centrally evoked late latency responses are reported. The largest responses occurred at the base frequency of 500 Hz. Binaural response was characterized by the triphasic (P1 – N1 – P2) response followed by a large negativity (N2). This component (N2) was diminished in monaural FM responses as prominently displayed by BIC. This study shows that auditory transient evoked responses can be recorded to central beats at different rates and frequencies. Such responses can elucidate their generation mechanisms and their relationship to other tone pip evoked responses.

SYMMETRIC AND ASYMMETRIC WAVEFORMS IN TRANSIENTLY EVOKED OTOACOUSTIC EMISSIONS

W. Wiktor Jedrzejczak[1], Konrad Kwaskiewicz[2], Katarzyna J. Blinowska[2], Krzysztof Kochanek[1], Henryk Skarżyński[1]
[1] Institute of Physiology and Pathology of Hearing, Warszawa, Poland [2] Department of Biomedical Physics, Warsaw University, Warszawa, Poland
[1] Warsaw, Poland; [2] Warsaw, Poland

Transiently Evoked Otoacoustic Emissions (TEOAEs) are normally modeled as the sum of asymmetric waveforms. However, some previous studies of TEOAEs used time-frequency (TF) methods to decompose the signals into symmetric waveforms. The aim of the present study was to extend the TF analysis of OAEs by adding the asymmetry parameter to those basic waveforms which were fitted to the signals. This resulted in a more general and flexible procedure. The new approach, using a set consisting of both symmetric and asymmetric waveforms, was compared with the standard procedure by using a symmetric set. Analyses of TEOAE signals demonstrated that although asymmetric waveforms perform slightly better, symmetric waveforms represent most TEOAE components rather well. The only exceptions are those components with a long decay whose time-varying characteristics are highly asymmetric. These components are often present in TEOAEs, which justifies the application of the enriched set consisting of both symmetric and asymmetric waveforms.

FINE STRUCTURE OF TRANSIENT OTOACOUSTIC EMISSIONS

Belov, O. A. , Tavartkiladze, G. A.
National Centre for Audiology
Moscow, Russia

Background. The primary goal of this work was to develop a stable and reliable metrics for a TEOAE signal. We supposed, that significant part of TEOAE signal was produced in several loci of the cochlea, and therefore it consisted of a small number of independent components. Also, in accordance with space invariance hypothesis, we supposed that all components had the similar shape, but the time scale of this shape was proportional to the component latency.

Method. The signal is re-sampled to the non-linear time grid. In terms of the above assumptions, the signal in this grid may be expressed as a convolution of some pattern and a sequence of events, both unknown. We use 'blind' or predictive deconvolution to find both of them. Also we designed the scheme of adaptive regularization for blind deconvolution of the signal, averaged to several buffers. The method was carefully verified on modelled signal. For fine tuning of the algorithm on a wide set of modelled data we used a cluster of Moscow University.

Results. It was found that most part of records was represented as a relatively small set of components — about 10 to 30 pieces, plus an additional activity. We were surprised by the shape of components. In all our experiments the shape of pattern was near the same: a high intensity part, then the part with a constant level, then a relatively short decay.

Discussion. We supposed that each component could be produced by a lack of activity in a group of adjacent OHC, and even by a malfunction of a single OHC, or by a single irregularity in OHC placement. It was demonstrated on a simple model that a response produced by a lack of a single OHC was comparable by amplitude with the response produced by massive irregularities. The well known fine structure of TEOAE in frequency domain also can be partially explained by a shape of found components.

INFLUENCE OF AGING OVER 10 YEARS ON AUDITORY AND VESTIBULAR FUNCTIONS IN THREE PATIENTS WITH AUDITORY NERVE DISEASE OR AUDITORY NEUROPATHY.

Masuda, T. [1, 2], Kaga, K. [1, 3]
[1] .National Institute of Sensory Organs, National Tokyo Medical Center [2] .Nihon University, School of Medicine, Department of Otolaryngology [3] .International University of Health and Welfare Mita Hospital
Tokyo, Japan

Kaga et al reported two cases of auditory nerve disease in 1996 while Starr et al reported auditory neuropathy in the same year.

The influence of aging on hearing and vestibular function in patients with auditory nerve disease or auditory neuropathy has not been investigated. The purpose of this study was to reveal how auditory and vestibular functions in this disease could change with aging. The subjects were three female patients with auditory nerve disease or auditory neuropathy. The two patients are the same patients who were reported by Kaga et al in 1996. We investigated their hearing and vestibular functions using pure tone audiometry, speech discrimination test, DPOAE, ECochG, ABR and caloric test, damped-rotational chair test, and VEMPs. In all three patients, speech discrimination ability and vestibular function markedly declined with aging. However, speech and language recognition and higher brain function were less affected by aging.

AUDITORY BRAINSTEM AND CORTICAL POTENTIALS FOLLOWING BONE-ANCHORED HEARING AID STIMULATION

Rahne, T. , Ehelebe, T. , Götze, G.
University Hospital Halle (Saale), ENT-Clinic
Halle (Salle), Germany

Purpose:

Patients suffering from conductive or mixed hearing loss and Single – Sided Deafness may benefit from implantable hearing devices relying on bone conducted auditory stimulation. However, with only passively cooperative subjects and young children, objective methods are needed to estimate the aided and unaided pure-tone audiogram. This study focuses on the feasibility aspect of an electrophysiological determination of the hearing thresholds with bone anchored hearing aid (Baha) stimulation.

Methods & Materials:

Therefore, 10 normal-hearing subjects were provided with a Baha Intenso (Cochlear Ltd.) which was temporarily connected to the Baha Softband (Cochlear Ltd.). Auditory evoked potentials were measured by auditory stimulation paradigm used in clinical routine.

Results:

The amplitudes, latencies, and thresholds of the resulting auditory brainstem responses (ABR) and the cortically evoked responses (CAEP) were correlated with the respective responses without the use of the Baha Intenso.

The recording of ABR and CAEP by delivering the stimuli to the Baha results in response waveforms which are comparable to those evoked by earphone stimulation and appears appropriate to be measured using the Baha Intenso as stimulator. At the ABR recordings a stimulus artifact at higher stimulation levels and a constant latency shift caused by the Baha Intenso has to be considered. The CAEP recording appeared promising as a frequency specific objective method to approve the fitting of bone anchored hearing aids.

Conclusion:

At all measurements, the ABR and CAEP thresholds seem to be consistent with the normal hearing of the investigated participants. Thus, a recording of auditory evoked potentials using a Baha is in general possible if specific limitations are considered.

ACCURACY AND EFFICIENCY OF A DECISION TREE TO ESTIMATE PURE-TONE THRESHOLDS IN HEARING-IMPAIRED ADULTS USING AUTOMATICALLY DETECTED CORTICAL AUDITORY EVOKED POTENTIALS (CAEPS)

Van Dun, B.[1, 2], Dillon, H.[1, 2]
[1] HEARing CRC; [2] National Acoustic Laboratories
[1] Melbourne, Australia; [2] Sydney Australia

Background

Several published studies have shown a high correlation between behavioural pure-tone thresholds and cortical auditory evoked potential (CAEP) thresholds for tone-bursts. In these studies, the presence of the cortical response has been determined by visual inspection by the researcher. Recently, statistical detection of cortical responses has been shown to be similar or superior to expert examiners in detecting the presence of CAEPs from both adults and infants. The current study examines the accuracy and efficiency with which behavioural thresholds from hearing-impaired adults can be estimated, using an automated statistical detection paradigm and a bi-section decision tree, rather than the more usual bracketed threshold estimation paradigm.

Method

Thirty-four hearing-impaired and cooperative adults have been tested without their hearing aids and using insert phones. The experiment was divided in three parts. First, behavioural thresholds were determined for pure-tones. Second, behavioural thresholds were determined for tone-bursts. Third, CAEP thresholds with tone-bursts were determined using the automated statistical detection paradigm for CAEPs, and a decision tree instead of normal threshold bracketing. The decision tree started at an intensity of 60 dB HL (level 1). When a response was absent, the intensity was increased to 85 dB HL (level 2), otherwise decreased to 30 dB HL (also level 2). The decision tree was equipped with error checks up to the first two levels. For example for the error check at level one, the intensity of 60 dB HL could be tested twice depending on the path that had been followed throughout the decision tree. If the test and retests at 60 dB HL did not correspond, the procedure was repeated. Similarly, 30 and 85 dB HL (both at level 2) occasionally could be tested twice too.

Results

For the decision tree with error detection at two levels, the thresholds inferred from the CAEP decision tree minus the pure tone behavioural thresholds had mean and standard deviations for 0.5, 1, 2, and 4 kHz of 3 ± 7, 4 ± 9, 6 ± 15, and 5 ± 13 dB respectively. 91% of CAEP thresholds were within 15 dB of behavioural thresholds. A part of the variability of the estimates is introduced by the behavioural responses of the subjects themselves (behavioural audiogram test-retest variability, and a difference between pure-tone and tone-burst audiograms). Out of 173 data points, 12 outliers > 20 dB (9 of which come from 2 subjects) were observed. These outliers appeared at isolated frequencies, were repeatable and did not originate from the equipment. This shows that some subjects seem not to have CAEPs at low to medium sensation levels, which has also been presented in other studies.

The effects of gradually removing error checks will be addressed. It will be shown that recording time is inversely proportional to the accuracy of threshold estimation. In general the drawbacks and advantages of a decision tree will be discussed.

Conclusions

CAEPs can be used for accurate threshold estimation in hearing-impaired adults. The accuracy and recording time depends on the protocol however. One has to keep in mind that some subjects do not have CAEPs at low to medium sensation levels at some isolated frequencies.

AUDITORY NEUROPATHY SPECTRUM DISORDER (ANSD) IN INFANTS: THE USE OF CORTICAL AUDITORY EVOKED POTENTIALS HELP US TO BETTER MANAGE THIS POPULATION DURING THE FIRST 12 MONTHS OF LIFE

Gardner-Berry, K.[1, 2], Purdy, S. C.[3], Dillon, H.[1, 2]
[1] National Acoustic Laboratories; [2] The Hearing Cooperative Research Centre; [3] University of Auckland
[1] Sydney, NSW, Australia; [2] Melbourne, VIC, Australia; [3] Auckland, New Zealand

Background:

The diagnosis of auditory neuropathy spectrum disorder (ANSD) in young infants presents clinicians with two problems. Firstly, auditory brainstem response testing can not be used to predict auditory thresholds. Secondly, speech perception testing can not be performed to identify which infants may be experiencing problems with speech discrimination ability. For these reasons there is a need for objective measures of auditory ability to be developed in order to help clinicians make the most appropriate management recommendations during a critical time in speech and language development.

Aim:

The aim of this study was to investigate whether cortical auditory evoked potentials (CAEPs) could be used to help identify infants with a severe to profound hearing loss and those who were more likely to present with delays in functional auditory behaviour.

Method:

Thirteen infants with ANSD were assessed using CAEPs at a mean age of 10.8 months (SD 7.5). Aided CAEPs were recorded using speech stimuli /m,g,t/ presented at 65 dB SPL in the free field. Statistical analysis using Hotellings T2 were used to determine whether a CAEP response was present and the results were compared to behavioural pure tone thresholds and functional auditory behaviour using the Parent Evaluation of Aural/Oral performance of Children (PEACH) or Infant Toddler Meaningful Auditory Integration Scale (IT – MAIS).

Results:

Seven infants in the group were subsequently found to have a severe to profound hearing loss on behavioural pure tone testing. Two subjects in this group showed an aided CAEP response to one out of the three speech sounds tested but the remaining five showed no response to any of the sounds.

Six infants were found to have behavioural pure tone thresholds ranging from mild to moderately-severe. Three of these infants showed CAEP responses to at least two out of the three speech stimuli. The remaining three infant showed a response to only one

out of the three stimuli but showed significant delays in functional auditory behaviour on the PEACH or IT – MAIS.

Conclusion:

CAEP testing shows promise in helping us manage infants with ANSD. When CAEPs are absent, or are present to only one out of the three stimuli it may indicate that the hearing loss is in the severe to profound range, or there is a lesser degree of hearing loss but the infant is at risk of experiencing delays in functional auditory behaviour.

CHANGE OF HEARING THRESHOLDS OF INFANTS WHO COULD NOT PASS NEWBORN HEARING SCREENING AND INFANTS TREATED IN THE NEONATAL INTENSIVE CARE UNIT

Min-Young Kang[1], Sung-Wook Jeong[1], Lee-Suk Kim[1], Chang Hyun Cho[2]
[1] Department of Otolaryngology-Head and Neck Surgery, Dong-A University College of Medicine; [2] Department of Otolaryngology-Head and Neck Surgery, Gachon University of Medicine & Science, Graduate School of Medicine
[1] Busan, Korea; [2] Incheon, Korea

Objective : The aim of this study was to investigate the change of hearing thresholds during first year of life in infants who could not pass newborn hearing screening (NHS) and infants treated in the neonatal intensive care unit (NICU)

Subjects and method : From March 2007 to November 2011, the 193 infants (108 males and 85 females) who could not pass NHS and the 51 infants (32 males and 19 females) who were treated in the NICU were referred to Dong-A University Hospital for evaluation of hearing acuity. The hearing of all of the referred infants was evaluated using impedance audiometry, auditory brainstem response (ABR) and otoacoustic emission (OAE) before 6 months of age and the follow-up tests were carried out before 12 months of age. The change of hearing thresholds of them was analysed.

Results : One hundred ninety three infants who could not pass NHS received initial hearing tests at the mean age of 1.9 months. Sixty infants (31%) had normal hearing acuity. One hundred twenty six infants (65%, unilateral: 38, bilateral: 88) had sensorineural hearing loss (SNHL, ABR threshold $\geq$ 40 dB) and 7 infants (4%, unilateral: 5, bilateral: 2) had auditory neuropathy (AN). Twenty seven (20%) out of 133 infants with hearing loss had the risk factors for hearing loss, and twenty seven (54%) out of 50 infants with the risk factors had hearing loss. The follow-up hearing tests were conducted at the mean age of 5.2 months in 65 infants (3 with normal hearing, 57 with SNHL, 5 with AN). Nineteen infants showed deterioration of hearing thresholds more than 20 dB, and 6 infants showed improvement of hearing thresholds more than 20 dB. One infant with unilateral mild hearing loss and another one infant with bilateral moderate hearing loss progressed to bilateral severe hearing loss. Four infants who had hearing loss at initial hearing tests recovered to normal hearing.

Fifty-one infants who were treated in NICU received initial hearing tests at the mean age of 1.9 months. Thirty eight infants (75%) had normal hearing acuity. Twelve infants (24%, unilateral: 5, bilateral: 7) had SNHL and one infant (2%) had AN. The follow-up hearing tests were performed at the mean age of 6.1 months in 13 infants (4 with normal hearing, 8 with SNHL, one with AN). One infant with normal hearing progressed to severe hearing loss. Five infants who had hearing loss at initial hearing tests showed improvement of hearing thresholds more than 20 dB, and four of them recovered to normal hearing.

Conclusion : The hearing thresholds of infants with congenital SNHL can change during first year of life, therefore the follow-up hearing test should be employed to adjust the habilitation method. Irreversible intervention such as cochlear implantation should be considered cautiously within one year after birth.

CHILDREN WITH PHENYLKETONURIA TREATED EARLY: BASIC AUDIOLOGICAL AND ELECTROPHYSIOLOGICAL EVALUATION

Mancini, P. C. [1], Durrant, J. D. [2], Starling, A. L. P. [3], Iório, M. C. M. [4]
[1] graduate student from the Federal University of São Paulo, professor in the Federal University of Minas Gerais; [2] professor at the Department of Communication Science and Disorders, University of Pittsburgh; [3] professor at the Department of Pediatrics, Federal University of Minas Gerais; [4] professor at the Department of Speech Therapy and Audiology, Federal University of São Paulo.
[1,3] Belo Horizonte,Brazil; [2] Pittsburgh,USA; [4] São Paulo,Brazil

Phenylketonuria (PKU) is genetic disease caused by deficient activity of hepatic phenylalanine hydroxylase, an enzyme that metabolizes phenylalanine into tyrosine. This metabolic dysfunction causes a serious serum accumulation of phenylalanine, leading to biochemical alterations in the central nervous system that adversely affect myelinization and causes deficient protein and neurotransmitter synthesis. When a phenylalanine-restricted diet is initiated in the first weeks of life and maintained continuously, individuals with PKU present apparently normal development. However, even when the disorder is diagnosed and treated early, individuals with PKU can exhibit deficits in executive functions, neurotransmitter synthesis, intelligence, attention, visual-spatial abilities and processing speed. Basic audiological and electrophysiological evaluations were used to examine the peripheral and central auditory pathways of children with early-treated PKU who followed either an adequate or inadequate diet. Results were compared with those of age-matched children without PKU. Preliminary findings were presented at the Rio Symposium; results of the completed investigation are now presented.

Thirty-five children aged 5–16 years old participated in the control group and 25 children in the experimental group with Phenylketonuria, all with early diagnosis and treatment. Children of the experimental group were distributed into two subgroups depending on the control of diet. Group A comprised eight children with adequate diet, ranging in age from 6–13 years old, and Group B comprised 17 children with inadequate diet, ranging in age from 6–15 years old. All participants were given audiologic evaluations including otoscopy, immitance testing (tympanometry and assessment of contralateral stapedial reflex thresholds), pure-tone and speech audiometry, and evaluation of auditory brainstem (ABRs) and middle latency responses (MLRs). Results of the three groups were analyzed statistically via an ANOVA with repeated measures for significant differences among factors and measures ($p = 0.05$).

Audiometric evaluation revealed normal results for the three groups, except for one child in the group with inadequate diet, who showed a mild bilateral conductive hearing loss. Results of speech audiometry demonstrated the children in group B to have a lower average speech recognition score, and immitance testing revealed higher stapedial reflexes thresholds at 4000 Hz for the same group. ABR results showed higher average latencies for waves III and V, and a greater interaural difference for wave V in group B. Experimental groups (A and B) showed higher average latencies for interval I – V compared with the control group. MLR findings revealed no relative changes in the latency of the waves Na, Pa or in the Na – Pa amplitude for the experimental group (re normal group values). However, ear and electrode effects were present on the right or left in 87.5% of the participants of the group A and in 58.8% of the group B.

The results sporadic, but significant, deviations in ABR measures from normal even in early treated Phenylketonuria children and thus electrophysiologic markers for the impact of PKU on the pontine auditory pathway. The observed effects appear to be independent of the appropriateness of diet. The results also suggest the need to evaluate PKU children via auditory processing assessments to rule out potential functional significance of these findings behaviorally.

AUDITORY BRAINSTEM RESPONSE (ABR) SIMULATOR TO ENHANCE STUDENTS UNDERSTANDING TOWARDS ANALYZING ABR WAVEFORMS

Ahmad Aidil Arafat Dzulkarnain[1], Faizah Sapian[1], Wayne Wilson[2], Andrew Bradley[3], Saiful Adli Jamaluddin[1], Sarah Rahmat[1]and Narina Norddin[4]
[1] Department of Audiology and Speech Language Pathology, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia; [2] School of Health and Rehabilitation Sciences, University of Queensland, Australia; [3] School of Information Technology and Electrical Engineering, University of Queensland, Australia; [4] Department of Diagnostic Imaging and Radiotherapy, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia
Kuantan, Pahang, Malaysia

BACKGROUND:

The auditory brainstem response (ABR) can be defined as a complex response that represents neural activity generated at several anatomical sites in response to particular types of external stimuli (Hood 1998). The ABR typically consists of up to seven waves; each numbered using the Roman numeric system to give Waves I — VII (Jewett & Williston 1971). The ABR is widely used in neurological testing to determine the presence or absence of a disorder and to determine the site of the lesion for retrocochlear pathologies such as VIII never tumors.

One of the most challenging issues in ABR is to correctly identify the respective peaks. This further supported with the fact that large variation of ABR peaks can be observed in both normal and hearing loss subjects (Rowe, 1978). The task to identify ABR peaks therefore requires high clinical experience and knowledge since any misidentification of ABR peaks may lead to misinterpretation to the ABR results. The technique to train future audiologist in identifying ABR peaks is also crucial to ensure they able to master the appropriate skills to properly identify the ABR peaks. This study will investigate whether ABR simulator based training (SBT) is effective to train Audiology students to identify ABR peaks.

AIM

This study aimed to compare the score of student who underwent conventional ABR training with ABR SBT.

METHOD

This study was conducted among 25 (2 male and 23 female) 3rd Year and 4th Year Bachelor of Audiology (Hons) students from International Islamic University Malaysia (IIUM). The 25 students were randomly assigned 50% to form an experimental group (SBT), with the remaining 50% forming a control group (conventional). Before the training sessions begin, a baseline score in determining ABR peaks was obtained from each subject from both groups by conducting a pre examination. Then, the experimental group was exposed to simulator based training, while the control group spent equal time on conventional training. Both training sessions took place at the same time, and the exposure time for both groups was set to 4 hours. Upon completion their respective training, both group will take the same pre-examination question to compare if there is any change of their exam score.

RESULTS

The mean differences of overall pre-post score in conventional group and SBT group was compared using RM ANOVA. Result shows that there was no significant difference between the pre-post score in both groups (p-value > 0.05).

RM ANOVA was also used to compare the mean pre-post differences between both groups in answering difficult question. For this analysis, the result shows that there was significant difference in the pre-post score for students in both groups ($p < 0.05$). The conventional training group shows significantly higher score for difficult type of questions upon completion the training whereas student who undergone SBT training has significantly lower score upon completion the training.

CONCLUSION

In general, it can be concluded that we can use either conventional training or SBT as the mean of teaching Audiology students in analyzing ABR waveforms, as the results revealed there was no significant difference in overall pre and post score between students who underwent conventional training and students who undergo SBT. However conventional training is the best option to train student to determine difficult and tricky ABR waveform. Any further modifications that can be made to the SBT might yield a better outcome and need further exploration. Further research is also needed to investigate whether the combination of both techniques can produce a better outcome compare to a single training method.

CHIRP-ASSR THRESHOLDS FOR NORMAL HEARING TERM AND PRETERM NEONATES.

Ribeiro, F. M. , Chapchap, M. J. , Leite, R. A.
Hospital Geral de Pedreira
São Paulo, Brazil

The chirp stimulus provides a better synchronization of neural response due the compensation of the travelling wave delay in the basilar membrane and can be an alternative stimulus to a frequency-specific assessment in infants. The objectives of this study were to determine Chirp-ASSR thresholds to investigate the maturational effect comparing in term and preterm normal hearing neonates and to determine whether the chirp stimuli can be reliably applied for early diagnosis for hearing loss. Forty-five neonates recruited from Hospital Geral de Pedreira, São Paulo, Brazil, were assigned to a Term (n = 28 at 39.5 ± 0.8 week) or Preterm group (n = 17 at 35.3 ± 0.4 weeks correct age). All subjects had normal responses to TEOAE and Chirp-ABR at 30 dB HL. Dichotic Chirp-ASSR thresholds were measured using the Interacoustics™ Eclipse platform. The intensity level was controlled independently, for each frequency, and responses were objectively detected by an algorithm combining phase and response magnitude components. Mean thresholds were 37.65 ± 8.9; 27.06 ± 9.06; 20.29 ± 7.17; 17.94 ± 6.41 for the Preterm group and 36.43 ± 13.41; 25.18 ± 10.79; 17.32 ± 9.04; 20.71 ± 10.76 for Term group at 500, 1000, 2000 and 4000 Hz respectively. Although the Preterm group showed more elevated thresholds at 500, 1000 and 2000 Hz and lower thresholds 4000 Hz in comparison to the Term group, no significant age effect was found (p = 0,5802). Thresholds differed as a function of frequency ($F(3,264) = 84,319$; $p < 0.0001$), which were most notably caused by more significantly elevated thresholds at 500 Hz in comparison to both 1000 Hz and 2000 Hz ($p < 0.0001$). Our results are in agreement with earlier published work (Ribeiro et al., 2010) although thresholds at lower frequencies were greater when using chirps in comparison to using modulated tones to evoke the ASSR. Although an enhancement of response detection could not be verified, this may have been due to high levels of noise in this frequency region. It required 33 minutes and 55 minutes on average to obtain threshold in the Preterm and Term groups respectively. The time collection was quite low in comparison to other similar reports in the literature which obtained dichotic thresholds at the same test frequencies. The quasi-independent control of intensity level at each frequency may have contributed to this improvement. In conclusion, the Chirp-ASSR was a feasible tool to assess frequency-specific thresholds for neonates and no specific maturational consideration appears necessary as a function of these stimulus parameters.

AN OBJECTIVE TEST TO DETECT TINNITUS: FROM HAIR CELLS TO BRAINSTEM RESPONSE HEARING TEST

Myung-Whan Suh, Kun Woo Kim, Il-Yong Park, Seung-Ha Oh
Department of Otorhinolaryngology, Dankook University
Cheonan, Korea

Objective. Recently, a new method to confirm tinnitus in animals has been reported. If tinnitus can be measured in animals, the same paradigm may be adopted to humans to develop an objective tinnitus test. The objective of this study was to prove a difference in N1 amplitudes when stimulated by the prepulse gap paradigm, between tinnitus patients and normal subjects. Materials and Methods. Five tinnitus patients and 8 normal subjects were recruited. Two hundred stimuli composed of a background noise and a pulse noise was presented to the subjects. In 100 stimuli there was a short gap in the background noise just before the pulse noise and in the other 100 stimuli there was no gap. The cortical response of N1 was measured with a conventional ERP system. The Gap condition / No gap condition amplitude ratio was analyzed as the primary outcome measure. Results. In the tinntius patient group, the Gap/No gap ratio was 95.6 ± 19.9 while it was 79.2 ± 14.7 in the normal control group. The Gap/No gap ratio was significantly smaller in the normal control when compared with the tinnitus patient group ($p = 0.037$). Conclusion. As in animals, it seems that the prepulse gap paradigm is also applicable to human tinnitus subjects. By refining the stimulus and objective measurements we may be able to develop an objective test which can detect tinnitus in humans.

COMPARISON BETWEEN CE-CHRIP AND CLICK EVOKED AUDITORY BRAINSTEM RESPONSE IN NORMAL HEARING AND SENSORINEURAL HEARING LOSS

Cho, S. W. [1], Han, K. H. [1], Shin, S. O. [2], Lee, J. H. [1]
Departments of Otolaryngology, [1] Seoul National University College of Medicine, [2] Chungbuk National University College of Medicine.
[1] SEOUL; [2] CHEONGJU [1] SEOUL; [2] CHEONGJU

Objective

In the click stimuli used in auditory brainstem response (ABR), the generation and prolongation of the sound is short that acoustic neurons are effectively activated. But inability to stimulate the neuron simultaneously due to the cochlear traveling wave delay, it only represents the high frequency sound from 2000 Hz to 4000 Hz. In contrast, CE-chirp sound has an advantage of supplementation of the temporal synchrony resulted from the input compensation (Don et al, 2009; Elbering and Don, 2010). In this study, the difference of characteristics between click-evoked and CE-Chirp-evoked ABR was analyzed in normal hearing and sensorineural hearing loss.

Method 24 ears with normal hearing and 20 ears with sensorineural hearing loss were enrolled. Using both Clicks and CE-Chirps, the several parameters including threshold, amplitude, and latency of the ABR were collected. Both stimuli started from 80 dB and the rates were both 20.1/s. In order to analyze the upward spread of excitation, the amplitudes and latencies of wave V resulted from the stimuli of 60 dB and 40 dB were compared.

Result

Threshold: In the normal hearing, CE-chirp stimuli resulted in the threshold of 2.8 dB lower than that from click stimuli (p=0.035). In the ears with sensorineural hearing loss, CE-chirp resulted in threshold of 5 dB lower than that from click stimuli (p = 0.124). Latency: With both stimuli (Click or CE-Chrip), latencies tend to increase as the stimuli become lower in ears with both normal and sensorineural hearing loss. The latencies tend to be longer in click stimuli than in CE-chirp if high stimuli were given in ears with both normal and sensorineural hearing loss. Amplitude: In the normal hearing as the intensities of the click stimuli decrease, the amplitude of the ABR was lowered. On the other hand, when CE-chirp stimuli were used in normal hearing, the amplitudes increased as the intensities decrease up to 40 dB, and decreased again at 20 dB. CE-chirp stimuli resulted in higher amplitude both in normal hearing and sensorineural hearing loss except 80 dB and 40 dB.

Conclusion

CE-chirp stimuli can be useful for threshold determination both in normal and sensorineural hearing loss. However, CE-chirp may need to be modified to overcome upward spread of excitation.

ABR TO COMPLEX SOUNDS IN CHILDREN WITH AUDITORY AND LANGUAGE PROBLEMS

Filippini, R. , Schochat, E.
Speech and Hearing Department, Faculty of Medicine
Sao Paulo, Brazil

Background: The relationship between language disorders and auditory processing deficits has been shown in a number of studies based on behavioral assessment and cortical electrophysiological responses. The role of the brainstem on auditory processing of speech and the consequences of alterations at this level processing of complex sounds is yet to be understood clearly, but some researches had already verified these alterations in children with learning and auditory processing problems. The Auditory Brainstem Response to complex sounds (cABR) is said to mimic with fidelity the acoustics characteristic of the stimulus. And, for that reason, would be ideal for objectively assess auditory processing of speech.

Aim: The aim of this study was to analyze and compare Complex Evoked ABR in children with Specific Language impairment and Auditory Processing Disorder.

Method: Three groups of 10 children between 7 and 12 years-old were formed for this study. The first one was composed by children with typical development presenting no language, auditory or learning problems (TD group); the second was composed by children who presented alterations on Auditory processing assessment and had no other language issues (APD group); and the last one was composed by children with diagnosed Specific Language Impairment (SLI group).

All children had normal audiometric thresholds and typical responses to click-evoked Auditory Brainstem Response (ABR).

The speech stimulus consisted of the first 40ms of the synthesized syllable /da/, comprising an initial noise burst and formant transition between the consonant and the vowel. This stimulus was presented monaurally to the right ear at 80 dB nHL, and at a presentation rate of 10,9 Hz. Three 1000-sweep blocks were recorded in 55ms window, and grand averaged in one resulting wave. Peak latency and amplitude for positive wave V and subsequent negative waves A, C, D, E, F and O were identified. Measures of latency, amplitude and slope of VA wave complex were also analyzed. The waves V and A reflects the response to the burst release of the stop consonant; the wave C represents the transition between the onset burst and the more periodic portion; waves D, E and F represent the periodic portion of the syllable; and, finally, the wave O corresponds to stimulus offset.

ANOVA test was applied for statistical analysis and the significance level was 0.05.

Results: In respect to timing, although no statistically significant differences were observed between the three groups, smaller latencies were overall observed on

TD group. The TD group also presented better results concerning amplitudes, showing greater magnitudes to all waves, with statistically significant differences between the three groups for waves A [$F(3,422)=5,078$; $p=0,014$] and O [$F(3,422)=3,453$; $p=0,048$].

Regarding the VA complex, statistically significant differences between the three groups were observed to all measures. The TD group presented greater VA inter-amplitude [$F(3,422)=6,426$; $p=0,006$] and slope [$F(3,422)=9,201$; $p=0,001$], while the SLI group presented smaller inter-latency value [$F(3,422)=5,796$; $p=0,009$].

Conclusion: These data evidenced that, when stimulated by complex sounds as speech, individuals with auditory processing disorders and those with Specific Language Impairment have similar responses showing poor temporal neural synchronization relating to typical developing children, especially regarding the processing of transient and brief acoustic information.

Further studies are being made in order to verify and compare the responses of these children with simultaneous presentation of white noise, before and after auditory training.

CLINICAL AND DIAGNOSTIC FEATURES OF AUDITORY NEUROPATHY IN PRETERM CHILDREN

Savenko, I. V. [1], Garbaruk, E. S. [2]
[1] St-Petersburg Pavlov State Medical University [2] St-Petersburg State Pediatric Medical Academy
St-Petersburg, Russia

Background. Auditory neuropathy (AN) has polyvariant etiology as well as multivariable pathomorphological nature. This is the reason because of which it acquired the commonly accepted name of «auditory neuropathy spectrum disorder» (Berlin et al., 2008).

AN is subdivided into pre-synaptic and post-synaptic types. The first one is caused by inner hair cell (IHC) damage or/and by disorder of synapses between IHCs and cochlear nerve. The second type is a consequence of injury of spiral ganglion neurons as well as of axonal damage of the auditory nerve that results in neural response desynchronization. That affects ability to process rapidly changing acoustic signals, known as auditory temporal processing.

Following facts are clinical-diagnostic AN characteristics: hearing losses of various degrees, fluctuating hearing losses, tone-speech dissociation especially at noise background, absence or markedly abnormal auditory brainstem response (ABR) (however these thresholds do not agree with those of behavioral audiometry), absence or elevated middle ear muscle reflex thresholds, lack of OAE suppression with contralateral noise, though otoacoustics emission (OAE) and/or cochlear microphonic potential (CM) can be recorded (Sutton et al., 2004; Hood et al., 2007).

Patients and methods. 34 preterm born children aged 3 months to 9 years were involved into the study. Two children had unilateral AN combined with sensoneural hearing losses in the opposite ear, and the rest 32 children had bilateral AN.

All the children underwent periodically combined audiological examinations which included both subjective and objective methods. Based on the results, individual abilitation programs were selected with including regular speech therapist sessions, and, if necessary, hearing aids fitting or cochlear implantation (CI).

Results. AN risk has been noted to be maximum in extremely premature children with very or extremely low birthweight (82% of total). All the children with AN had perinatal hypoxia and 9 of them had neonatal hyperbilirubinemia. Audiological assessments were regularly carried out during first 18 months after the birth that made eliminated the transient AN.

As a rule, clinical AN development in preterm children was accompanied with hearing threshold decrease down to 30–40 dB during first 9 months of life (73% of children), while ABRs were fixed. These children attended speech therapist sessions and did not use hearing aids.

One of the children under the study initially had profound hearing losses, and at his 10 months age hearing aids had been fitted but ineffectively. At the 2 years age CI operation had been performed in him. At present, he demonstrated good sound abilities, however any speech perception assessment seems to be too early.

OAE extinction with aging (typically between 1 and 5 years) has been detected in major part (60%) of children and CM disappeared in 3 children at 2, 4.5 and 5 years old, respectively. As a rule, this phenomenon was accompanied with elevation of pure tone thresholds, meanwhile audiometric curve pattern was descending. 22 children with moderate and profound hearing losses have been fitted with hearing aids. Positive effect (improvement of sound audibility) has been detected in 15 of them. Now, all of these children continue to attend speech therapist sessions and exhibit a progress of language ability, however with different delays. 7 children had no benefits from hearing aids, all of them had poor progress in speech understanding and language development. CI had been realized in one of these children at his 4.5 years age and yielded a positive effect.

Conclusions. The study realized demonstrates that clinical management and abilitation programs for preterm children with AN need a thorough approach to each child which takes into account all individual clinical-diagnostic characteristics discovered as well as the disease course.

CORTICAL AUDITORY EVOKED POTENTIALS IN COCHLEAR IMPLANT LISTENERS DURING THE FIRST FEW DAYS OF HEARING REHABILITATION

Hoppe, U., Danilkina, G., Wohlberedt, T.
University of Erlangen-Nuremberg
Erlangen

Objectives:

The cortical auditory evoked potentials (CAEPs) are an objective method for measurement of the central hearing system activity. It is possible to elicit CAEPs both by acoustic stimulation in normal hearing subjects, subjects with hearing aids and cochlear implant (CI) and also by electrical stimulation of cochlear implant electrodes in CI listeners. CAEPs are able to reflect neuronal reorganisation due to hearing loss, due to restoration of acoustic input after deafness or due to hearing training. It has been found that CAEPs parameters correlate significantly with speech understanding. The information about the cortical signal processing through CI in the earlier period of CI usage could be useful for adequate setting of the speech processor and hearing training of CI patients. As there still aren't any electroencephalographic (EEG) studies, which concentrate on the inexperienced CI users, the objectives of this study were to determinate: 1) whether CAEPs as P1–N1–P2 complex and acoustic change complex (ACC) can be observed during the first few days after CI processor switch-on; 2) whether parameters of CAEPs change during the first few days of hearing rehabilitation.

Design:

23 postlingually deaf adults wearing the Nucleus Freedom Cochlear Implant were tested during the first 4–5 days of hearing rehabilitation ("switch-on" period), which consisted of speech processor setting, speech hearing training and speech performance control. The CAEPs were obtained each day using direct electrical stimulation of neighbouring implant electrodes: basal electrodes nos. 3/4, middle electrodes nos. 10/11 and apical electrodes nos. 18/19. The stimulation level based on subjective sensation of "loud, but not too loud" signals. The stimulation was adjusted until the sensation of both electrodes was the same.

Results:

The CAEPs were observed in all CI users who participated in spite of artefacts, which were observed in some recording positions. The incidence of both complexes increased during the "switch-on" period and was better for electrode pair 18/19 and for P1 – N1 – P2 complex. The latencies of P1, N1 and P2 peak and N1P2 amplitudes in both complexes tended not change significantly during the first few days of CI usage and were dependent on the stimulated electrode pair. The P1 – N1 – P2 and ACC complex differed significantly during the "switch-on" period.

Conclusion:

The CAEPs as a response to direct electrical stimulation of implant electrodes can already be reliably recorded to electrical stimulation in CI listeners in the first few days of CI usage in spite of artefacts. The changes in CAEPs parameters during the “switch-on” period reflect the neuronal reorganisation of the hearing system as a response to restoration of acoustic information input and active hearing training. During the “switch-on” period, the activity of the central hearing system increases in response to stimulation. In seems possible that during the first few days of the CI usage, CI users have better ability to detect acoustic stimulation than to discriminate frequency information of this stimulation. Delivery of acoustic information through the particular parts of cochlea and hearing pathways to the cortex is not identical: it is better for the apical part of cochlea and worse for the basal part of cochlea.

SPEECH-EVOKED CORTICAL AUDITORY EVOKED POTENTIALS IN CHILDREN AND ADULTS WITH COCHLEAR IMPLANTS: STIMULUS EFFECTS, TEST-RETEST STABILITY, AND CHARACTERIZATION OF THE ELECTRICAL ARTEFACT

Purdy, S. C. , Lin, R. , Welch, D. , Giles, E. , Kelly, A. S. , Van Dun, B.
University of Auckland
Auckland

Background

As noted by Wong and Gordon (2009) stimulus artefact produced by the implant is problematic for the identification of cortical auditory evoked potentials (CAEPs) in cochlear implant (CI) users. The current study examined this artefact and stimulus effects for speech stimuli of short duration.

Aims

Cortical auditory evoked potentials (CAEPs) were recorded in children and adults with cochlear implants to a range of speech phonemes to determine: a) stimulus and test-retest effects on cortical responses, and b) impact of cochlear implant artefact on waveform identification.

Methods

CAEPs were recorded in response to brief speech phonemes /m/, /g/, and /t/ presented at 65 dB SPL in the sound field (1125 ms inter-stimulus interval) in adults and children with cochlear implants. Single channel recordings from Cz referenced to the mastoid opposite the implant were analysed for each participant. Peaks were analysed for the average of two runs of at least 75 acquisitions. CAEPs were recorded in 23 adult participants (12 males) aged 20–75 years (mean 56, SD 18 years) with at least 6 months implant experience.

Results

Average speech perception scores with the CI were 85% (SD 22%) for sentences in quiet, and 61% (SD 32%) for sentences in noise at 10 dB signal-to-noise ratio. One adult had bilateral implants and was tested in the left ear only. Fourteen of the adults had right ear implants. A small biphasic artefact was evident in the waveform of most adults in the early part of the waveform but this did not obscure the identification of N1 that occurred at 113 ms on average (SD 14) and P2 at 204 ms (SD 26 ms). A large stimulus artefact obscuring the CAEP was rare (approximately 5% of recordings) and did not occur across all stimuli for participants who had this artefact. There was no clear link between stimulus, implant, or participant characteristics and the occurrence of a large stimulus artefact. Two adults had immature CAEP patterns with the single P1-like peak characteristic of early childhood. N1 and P2 latencies and N1 amplitude differed significantly across phonemes. P2 latencies (for the /m/ stimulus only) correlated with composite speech scores, consistent with Kelly et al.'s (2005) finding of 250 Hz tone CAEP P2 latencies correlating with speech scores in adults with CIs. Sixteen children with cochlear implants aged 12 months to 12 years (mean 6.2 years, SD 3.5) were tested. Children's CAEPs were assessed twice with approximately 3 months (±2 weeks) in between test sessions; P1 latencies and amplitudes showed no significant change over this time. Children were 1 to 114 months post switch-on at the time of initial testing (mean 35, SD 32 months). The appearance and incidence of electrical artefact in the CI recordings was similar in adults and in children. P1 latency was 117 ms on average in the children (SD 19 ms), and thus occurred at about the same time as N1 in the adult participants. As has been reported previously P1 latencies fell within the normative range for children implanted earlier but not for children implanted after 7 years. There was a significant stimulus effect on P1 latencies but not amplitudes. Latencies for /t/-evoked CAEPs were shorted than /m/ or /g/ latencies.

Conclusions

Overall the results indicate some consistency between adults and children with CIs in the appearance and incidence of cochlear implant artefact and stimulus effects on CAEPs. Most participants had robust CAEPs with clearly identifiable peaks, with some variation across stimuli. Cochlear implant artefact morphology was generally consistent across stimuli and across time within an individual participant. Speech-evoked CAEPs are a useful objective tool for evaluating auditory function with a CI and may provide a useful clinical cross-check of CI integrity.

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PROCESSING OF SPEECH PROSODY ASSESSED BY CORTICAL AUDITORY EVOKED POTENTIALS IN ADULTS WITH COCHLEAR IMPLANTS

Sharma, M. [1], Purdy, S. C. [2], Barlow, N. [3], Giles, E. [4]
[1] Audiology Section, Macquarie University; [2] Speech Science, University of Auckland [3] Psychology Department, University of Auckland; [4] Cochlear Implant program, University of Auckland
[1] Sydney, Australia [2,3,4] Auckland, New Zealand

Aim

The study aimed to evaluate prosody perception using speech evoked CAEPs in adults with unilateral cochlear implants (CI).

Method

Nine unilateral Cochlear Implant (CI) users (23–60 years) and nine adults with normal hearing (21–51 years) participated in the study. All participants had used their CI for at least 2 years at the time of testing. Natural speech tokens /baba/ with varying stress spoken by an Australian female were used to elicit the CAEPs. Recording electrodes were placed at Fz, Cz, F3 or F4, and C3 or C4 (hemisphere opposite the CI), referenced to the contralateral mastoid in participants with CIs. There were three speech tokens, one of which had equal stress on both syllables /baba/, another had stress on the first syllable /BAba/, and the third had stress on the second syllable /baBA/. The three tokens were presented in random order with an inter-stimulus interval of 1000–1500 ms. Participants with normal were tested with the left ear occluded and the reference electrode on the right mastoid. Speech tokens were presented via a loudspeaker placed at 0 degrees azimuth, in quiet and in noise (8-speaker talker babble). The babble was presented at 70 dB SPL and the equal stress /baba/ was presented at 75 dB SPL (+5 dB SNR). The intensity difference between the stressed and unstressed syllables was 8 dB and hence the SNRs ranged for the stressed and unstressed syllables was either +5 dB or +13 dB.

Results

Adults with normal hearing adults had CAEPs at Fz to both syllables (not just an onset response); N1 amplitude was bigger for the stressed syllable than the unstressed syllable. Participants with CIs showed no differentiation of their CAEPs to the 3 tokens in quiet but in noise had significant P1N1 and P2N1 amplitude differences for stressed versus unstressed tokens. Prosody perception correlated with some CAEP measures in participants with CIs. The presence of noise delayed CAEP responses significantly for both groups for all tokens.

Conclusion

CAEPs can be used to measure processing of stressed versus unstressed syllables in adults with normal hearing. In adults with cochlear implants differential processing of syllable stress is apparent in noise but not in quiet.

DEVELOPMENT OF P300 AS A FUNCTION OF SNR AND TIME PERIOD AFTER COCHLEAR IMPLANTATION

Schreitmueller, S.[1], Igelmund, P.[1, 2], Meister, H.[1], Walger, M.[1, 2]
University of Cologne: [1] Jean-Uhrmacher-Institute for clinical ENT research; [2] ENT Department
Cologne, Germany

Background: The recordings of cortical auditory evoked potentials (CAEP) from adult cochlear implant (CI) recipients as well as normal hearing subjects (NH) show an increase of the P300 latency with increasing noise level in speech sound discrimination tasks. This might reflect an increasing listening effort since masking noise causes elevated P300 latencies at signal-to-noise ratios (SNR) where subjective discrimination is still unambiguous (hit rate > 96%). For NH adults (n = 10) as well as for adult CI recipients (n = 6) mean changes of latency correspond to mean subjective estimations of listening effort as a function of SNR. This supports the hypothesis that the P300 might reflect changes of listening effort in noise. An objective measure for listening effort would be useful e.g. in the optimization of speech processing strategies for difficult listening situations. Hence the aim of the presented study is to further evaluate the usefulness of the P300 with respect to listening effort, specifically by characterizing its longitudinal development.

Methods: Objective CAEP data were recorded in an oddball paradigm during a speech sound discrimination task (e.g. standard /ada/, deviant /ama/) at various SNRs. Subjective estimations of listening effort were indicated on a 5 point ordinal scale (1 = no effort; 5 = no discrimination possible), also at a various SNRs.

Eight unilateral implanted CI-recipients participated in these experiments at 1, 3, 6, 9 & 12 months after their initial CI activation.

Results: The CAEP data revealed a significant decrease in P300 latency as a function of time after cochlear implantation. This decrease was most obvious within the first three months after CI activation, which might reflect the rapid development in this period of hearing onset. However, on an individual case basis a latency decrease was not always obvious for all time intervals but evident in all of the eight data sets comparing month 1 with month 12 after the device activation.

Subjective estimations of listening effort showed large intraindividual variance over time. A relation between time period after activation and listening effort could not be found on the basis of individual cases.

Conclusions: The results support the hypothesis that the P300 latency can be used as an objective measure for listening effort during speech sound discrimination in noise. The decrease in P300 latency within 1 year after cochlear implantation, which was distinct on the basis of individual cases, seems to reflect longitudinal changes in listening effort. Such an objective measure of listening effort could provide useful

information e.g. for optimizing speech processing strategies of CIs and hearing aids in difficult listening situations.

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PREVENTING COCHLEAR IMPLANT ARTEFACTS FROM OBSCURING OR IMPERSONATING CORTICAL AUDITORY EVOKED POTENTIALS (CAEPS): A PILOT STUDY

Van Dun, B.[1, 2], Lin, R.[3], Loi, T.[1, 2], Purdy, S.[3], Dillon, H.[1, 2]
[1] HEARing CRC; [2] National Acoustic Laboratories; [3] The University of Auckland
[1] Melbourne, Australia; [2] Sydney, Australia; [3] Auckland, New Zealand

Background

There has been considerable interest in the use of Cortical Auditory Evoked Potentials (CAEPs) as an objective electrophysiological measure in individuals with impaired auditory systems, especially for evaluating hearing aids or cochlear implants in infants and younger children. Currently the application of CAEPs to cochlear implants is impeded by the presence of an electrical CI artifact obscuring or impersonating the CAEP.

Aims

To identify means to reduce the artefact presence in the electroencephalogram (EEG), to analyse the effect of the remaining artefact on the automatic statistical detection currently used by HEARLab for hearing aid fitting evaluation, and to modify this detection method such that it can be applied to cochlear implantees. HEARLab is a CAEP platform developed at the National Acoustic Laboratories, and applies an objective statistical CAEP detection mechanism.

Methods

To reduce artefact presence in the EEG, a hardware modification was introduced in the form of a passive lowpass filter (30 Hz), integrated in the recording electrodes. This was intended to reduce the CI artefact entering the EEG amplifier by a degree sufficient to ensure that the amplifier was not saturated.

To identify the characteristics of the remaining artefact, 25 adults with cochlear implants were evaluated at two different sites. Three speech sounds /m/, /g/, and /t/ were applied in free field at suprathreshold intensities (30 dB SL at site 1 and 65 dB SPL at site 2). Electrodes were placed at the forehead (ground), vertex (active) and mastoid (reference). When the reference electrode was placed on the mastoid behind the ear without the cochlear implant, this is referred to as the contralateral side. All CAEP recordings (150 accepted epochs) were run twice to check for reproducability. All artefacts were evaluated visually.

Results

To reduce artefact presence in the EEG, a hardware modification was introduced in the form of a passive lowpass filter (30 Hz), integrated in the recording electrodes. This was intended to reduce the CI artefact entering the EEG amplifier by a degree sufficient to ensure that the amplifier was not saturated.

To identify the characteristics of the remaining artefact, 25 adults with cochlear implants were evaluated at two different sites. Three speech sounds /m/, /g/, and /t/ were applied in free field at suprathreshold intensities (30 dB SL at site 1 and 65 dB SPL at site 2). Electrodes were placed at the forehead (ground), vertex (active) and mastoid (reference). When the reference electrode was placed on the mastoid behind the ear without the cochlear implant, this is referred to as the contralateral side. All CAEP recordings (150 accepted epochs) were run twice to check for reproducability. All artefacts were evaluated visually.

Conclusions

When combined with hardware-based lowpass filtering incorporated into the recording electrodes, the software-based automatic detection method only needs to analyse the CAEP from 117 ms on to avoid CI artifact influence completely, without loss of CAEP detection sensitivity. When extrapolated to infants with cochlear implants, it is very likely the same conclusion will be reached as infant's CAEPs are much longer in latency, and thus less susceptible to CI artifacts at the start of the CAEP waveform. However, a full-scale study needs to be conducted with CI adults and infants to fortify these claims..

COMPENSATIONAL STRATEGIES IN DIFFICULT HEARING ENVIRONMENTS - HOW THE BRAIN ADAPTS WHEN HEARING BECOMES TRICKY: A MISMATCH-NEGATIVITY-STUDY IN CI-USERS WITH GOOD AND BAD SPEECH PERFORMANCE

Magdalene Ortmann[1], Arne Knief[2], Dirk Deuster[2],
Antoinette am Zehnhoff-Dinnesen[2], Christian Dobel[1]
[1] Institute for Biomagnetism and Biosignalanalysis, Münster; [2] Klinik für Phoniatrie und Pädaudiologie, Universitätsklinikum Münster
Münster; Germany

In this study, prelingually deafened cochlear implant users (7–19 years), were tested in easy and difficult hearing situations, using an odd-ball-paradigm. After applying extensive logopedic tests that evaluated speech perception and speech production, we identified very good and very bad performers and chose 9 matched pairs that equaled each other in hearing age, implantation date and very good hearing abilities (according to clinical standard tests).

Each patient was then additionally tested with a very basic phoneme discrimination task to find each person's most difficult (e.g. Bu vs. Bo) and easiest (e.g. Bu vs. Ba) subtest. The resulting phoneme pairs were then used for EEG measurement.

Although all patients had very good hearing abilities, good performers showed a significant better performance in phoneme discrimination tests than bad performers. This result was confirmed in EEG for the easy subtest, revealing higher amplitudes in Mismatch Negativity in left frontal brain areas compared to bad performers. Additionally, these activations correlated positive with each patient's working memory performance and subjective rating of his or her personal hearing ability. Most interestingly, for the difficult discrimination task neither the good, nor the bad performers showed a Mismatch Negativity (MMN) in frontal areas. Instead, both groups showed significant higher activations for the deviants compared to the standards in occipitoparietal brain areas. This can be interpreted as a compensatory strategy to more easily understand difficult auditory input: occipital brain areas are here hypothesized to encode additional visual information as e.g. offered in lip reading, whereas parietal activations are probably recruiting additional attentional resources.

DECONVOLUTION OF OVERLAPPING CORTICAL AUDITORY EVOKED POTENTIALS (CAEPS) RECORDED USING VERY SHORT ISIS

Bardy, F. , Van Dun, B. , Dillon, H. , McMahon, C.
[1] HEARing CRC; [2] National Acoustic Laboratories; [3] Macquarie University
[1] Melbourne, Australia; [2] Sydney, Australia; [3] Sydney, Australia

Background

The ability to process rapid spectral variation in sound is a human capability which is necessary for speech recognition, sensory awareness and appreciation of music. However, the overlap in time of the cortical auditory evoked potentials (CAEPs) generated by stimuli presented with rapid presentation rates lead to uncertainty in the interpretation of the waveform. The main purpose of this study is to present a new deconvolution technique having the potential to disentangle the CAEPs generated by stimuli presented with short interstimuli-intervals (ISIs), and to present the effects of short ISIs on the two stimuli of a paired-stimulus paradigm.

Method

The deconvolution technique is based on a combination of mathematical concepts of convolution and mean square error minimization. Eleven adults (19 — 55 years) with normal hearing were investigated using a paired-stimulus paradigm with tone-burst stimuli of frequencies 500 and 2000 Hz. The ISI, which refers to the interval between the end of the first stimulus and the beginning of the second stimulus of the pair, was jittered around 100, 200, 400 and 800 ms. Both fixed and alternating stimulus frequencies were used in the design.

Results

The waveform of the first stimulus of the pair remained relatively unaffected by the succeeding stimulus, while the waveform of the second stimulus of the pair was dramatically affected by the preceding stimulus. For the second stimulus of the pair, a small increase of N1 amplitude but a large inhibition of P2 was observed with ISIs shorter than 400 ms. This inhibition decreased when the ISI was increased, and when alternating frequencies were used.

Conclusion

Two potential advantages of this technique can be identified. Firstly, the use of short ISIs should enable reduced testing time in clinical assessment. Secondly, a clearer understanding of scalp potentials generated by stimuli presented at faster rates could provide considerable insight into the neurophysiological mechanisms behind temporal coding at the auditory cortex. Further research on bursts incorporating several stimuli is currently being conducted.

CORTICAL POTENTIALS IN AGING : TEMPORAL PROCESSING

Ahn, S. Y.[1], Kim, J. R.[2], Kim, L. S.[1], Park, J. S.[1], Chung, S. H.[1]
[1] Department of Otolaryngology-Head & Neck Surgery, Dong-A University Hospital; [2] Department of Otolaryngology-Head & Neck Surgery, Inje University Busan Paik Hospital
Busan, Korea

Objective: Older adults often have more difficult understanding speech than younger adults, especially in the presence of noise. Several investigators have hypothesized that aging adversely affects the ability to process temporal cues. More specifically, it is speculated that impaired temporal processing results from age-related factors affecting neural synchrony. Recent research in auditory neuropathy showed N1 latency to tones could serve as objective measures of the efficiency of auditory temporal process. The purpose of this study was to determine whether N1 latency to tones could be used to assess age related differences in quiet and noise.

Methods: N1 responses were recorded from seven younger and seven older normal-hearing adults. Brief 100 ms tones (1.0 kHz, 100–60 dB SPL) in quiet and in continuous broadband noise (70 dB SPL) were used to evoke the responses. N1 latencies were analyzed as a function of signal intensity.

Results: Overall, no significant differences were obtained for the N1 latencies between younger and older adults. However, N1 latencies in older adults in quiet were delayed only at 60 dB SPL compared to the younger adults. In noise, N1 latencies were prolonged for older adults but only at 70 dB SPL (SNR=0).

Conclusion: These issues of intensity may affect the degree of synchronized neural activity between younger and older auditory systems. N1 latency to tones of lower intensity may serve as an objective measure of the efficiency of auditory temporal processes in aging.

BRAIN MAPPING OF THE MISMATCH NEGATIVITY AND THE P300 RESPONSE IN SPEECH AND NONSPEECH STIMULUS PROCESSING

McPherson, D. , Neff, S.
Brigham Young University
Provo, Utah, USA

Previous studies have found that behavioral and P300 responses to speech are influenced by linguistic cues in the stimuli. Research has found conflicting data regarding the influence of phonemic characteristics of stimuli in the mismatch negativity (MMN) response. The current investigation is a replication of the study designed by Tampas et al. (2005), which studied the effects of linguistic cues on the MMN response. This current study was designed to determine whether the MMN response is influenced by phonetic or purely acoustic stimuli, and to expand our knowledge of the scalp distribution of processing responses to within- and across-category speech and nonspeech stimuli. The stimuli used in this study consisted of within-category synthetic speech stimuli and corresponding nonspeech frequency glides. Participants consisted of 21 (11 male and 10 female) adults between the ages of 18 and 30 years. A same/different discrimination task was administered to all participants. Data from behavioral responses and event-related potentials (MMN and P300) were recorded. Results provided additional evidence that the MMN response is influenced by linguistic information. MMN responses elicited by the nonspeech contrasts had more negative peak amplitudes and longer latencies than MMN responses elicited by speech contrasts. Brain maps of t scores for speech vs. nonspeech contrasts showed significant differences in areas of cognitive processing for all contrast pairs over the left hemisphere near the temporal and parietal areas. The present investigation confirms that there are significant differences in the cortical processing of speech sounds vs. nonspeech sounds.

ELECTROPHYSIOLOGY OF SPEECH FEATURE DETECTION AND DISCRIMINATION: EXPERIMENT I

Cone B., Baker, K., Ross, J., Whitaker, R.
University of Arizona
Tucson, Arizona

Audiologists are called upon to provide amplification and cochlear implants to very young infants. The early and successful fitting of these aids to hearing will provide access to the speech signal as the necessary foundation for the development of speech and language. There are currently no clinically valid tests of speech feature detection or discrimination for infants. The aims of the research are to develop such methods. To this end, cortical auditory evoked potentials (CAEP) were obtained from awake, typically developing, normally hearing infants, aged 4–10 months, in response to speech sound tokens. Fifty-millisecond tokens of "Ling sounds" (/a/, /i/, /u/, /s/, /ʃ/, /m/) and 50-ms tone bursts at 500–4000 Hz were used as stimuli and presented at 10 dB level increments to develop CAEP latency and amplitude input-output functions. Observer-based psychophysical methods were used to determine detection thresholds for the tone bursts and speech tokens. Infant psychophysical thresholds were elevated by more than 20 dB for tone bursts, and by more than 30 dB for speech tokens with respect to those in adults. CAEP input-output functions in infants had significantly steeper slopes than those for adults particularly for CAEP components N1 and P2. Robust CAEPs can be obtained at levels close to behavioral threshold in infants and in adults. The infant CAEP thresholds are close to those seen for auditory brainstem responses for tone bursts and auditory steady-state responses for AM – FM modulated tones. The implications of these findings for estimating infant speech feature discrimination and perception abilities will be discussed.

ELECTROPHYSIOLOGY OF SPEECH FEATURE DETECTION AND DISCRIMINATION. EXPERIMENT II

Cone B., Baker K., Ross, J.
University of Arizona
Tucson, Arizona

In another group of infants (N = 15) aged 4–12 months, synthesized vowel tokens (/a/, /i/, /o/, /u/) with a duration of 500 ms were used to evoke CAEP components P1 – N1 – P2 and the acoustic change complex (ACC). An oddball stimulus paradigm was used, with a 25% probability of the rare stimulus. The effect of stimulus rate was also investigated using tokens presented at 1/s and also at 2/s. For each vowel contrast, control runs with no stimulus change were also obtained at the two stimulus rates. Observer-based psychophysical methods were used to determine the infants' ability to discriminate between these vowel sounds. At the slow rate, the rare stimuli evoked CAEPs of larger amplitude than when there was no change in vowel token. At the fast rate, the CAEP for the standard token showed nearly complete adaptation, whereas CAEPs were obtained for all vowel contrast tokens. These onset responses were identified as ACCs. Electrophysiological evidence of vowel token discrimination was obtained in nearly all subjects, whereas behavioral evidence of discrimination ability was considerably less repeatable. The results of these experiments will be discussed with respect to the development of the neural generators responsible for CAEP and perceptual abilities.

AUDITORY BRAIN RESPONSE TO EMOTIONAL WORDS IN PEOPLE WITH APHASIA

Ofek, E. , Purdy, S. C. , Ali, G. , Webster, T. , McCann, C.
The University of Auckland
Auckland, New Zealand

Background: This study aims to improve the understanding of emotional language processing in adults with aphasia. A stroke often results in an acquired language disorder (aphasia), as a result of cortical damage to the left hemisphere. Although the left hemisphere is typically dominant for language, the right hemisphere has a key role in the perception of emotion in spoken language. Aphasia is an acquired language disorder that is diagnosed in approximately one quarter of patients who have suffered from a stroke. Studies focusing on emotional language processing are often limited by their use of linguistic stimuli with universal emotional content, and their neglect of the personal-emotional content for the individual participant; this study used personal-emotional words. The brain lesions of people with aphasia (PWA) consequent to stroke may distort the early components of the auditory evoked potentials (EP), reflecting deficits in auditory and language processing. The lesion has been shown to affect evoked potentials in adults with aphasia, with decreased amplitudes and increased latencies for N1 and P2.

Aims: To understand the residual brain function of people with stroke lesions resulting in acquired language disorder — through investigating their auditory EP to words with personal-emotional meaning, such that may evoke a particularly strong brain response.

Methods: Fourteen people with aphasia and 14 matched controls participated in this study. Nine personal-emotional words, including words and first names, were selected separately for each participant based on a pre-study interview. Nine additional words were selected for each participant as potentially neutral words, matching the personal-emotional words — semantically and phonetically (e.g. for the name "John" the name "Jim" could be chosen, such that only one of them has a strong personal emotional content to the participant). The words were recorded by a professional voice over artist, processed and saved as audio files. EEG was recorded from 64 channels Neuroscan cap during auditory presentation through insert earphones of the words selected separately for each participant. EP were processed for each word separately, and also to groups of (1) personal-emotional and (2) neutral words — and also separately for PWA and matched controls. Additional interview was conducted after the study using validated questionnaires to assess the exact personal — emotional content of each word. The effects of group (PWA and controls) and emotional content of the words on the auditory EP were evaluated.

Results: Statistical interaction was found between group and word type for P2, with delayed P2 latencies in PWA for neutral words, but not for emotional words. Group effects were found for N1 amplitude and P2 latency. N1 amplitude was smaller for

PWA. P2 latency was delayed for PWA, and also for older participants. P3 latency was also delayed for PWA.

Conclusions: The present study indicates a clear trend in the neurophysiological processing of affective speech (words and names) in both acquired language disorders and healthy people. People with aphasia showed an overall trend for delayed latencies for word type compared to controls, but emotional words elicited earlier latencies than did neutral words in people with aphasia. An understanding of neural responses to emotionally loaded verbal stimuli has important implications that are not limited to acquired language disorders, but apply to diagnosis and therapy in other neurological and psychiatric disorders.

USING CORTICAL AUDITORY EVOKED POTENTIALS (CAEPS) FOR THE EVALUATION OF SPEECH DETECTION IN INFANTS

Van Dun, B.[1, 2], Carter, L.[1, 2], Dillon, H.[1, 2]
[1] The HEARing CRC; [2] National Acoustic Laboratories
[1] Melbourne, Australia; [2] Sydney, Australia

Background

Since the introduction of universal hearing screening, it has been possible to fit hearing aids to infants at a very early age, long before reliable behavioural responses can be obtained. Although hearing thresholds can be estimated from auditory brainstem responses (ABR) or auditory steady-state responses (ASSR), these estimates have some uncertainty, and extreme uncertainty for children with auditory neuropathy. Consequently, there is always some doubt as to the appropriateness of each hearing aid fitting. Furthermore, responses at the brainstem level do not correlate well with speech perception scores and functional measures in general. Cortical auditory evoked potentials (CAEP), which mainly have generators at a higher level on the auditory pathway than ABR, are more appropriate for speech and language development assessment. With the goal of increasing the efficacy of early hearing aid fittings, clinical objective methods using CAEPs have been the subject of ongoing evaluation, commencing with the detection of speech sounds.

Method

This study examines the relationship between the presence or absence of the CAEP in response to speech sounds (/m/, /g/, and /t/) at 55 dB, 65 dB, and 75 dB SPL, and the sensation level at which the sounds are presented. Sensation levels are determined by obtaining behavioural thresholds using Visual Reinforcement Orientation Audiometry (VROA). Twenty-two datasets (VROA and CAEP thresholds) were obtained from 25 infants with sensorineural hearing loss. Ages ranged from 8–30 months (mean = 19 months). Two of three available speech sounds were randomly assigned. The tests were conducted either aided (18 children), or unaided (7 children), according to the degree of hearing loss. All CAEP testing was carried out by paediatric audiologists with no CAEP experience prior to the study. The CAEP methodology used an automatic detection criterion, and so does not require an experienced electrophysiologist or audiologist.

Results

The results show that sensitivity, which is the capability of the used method to detect cortical responses, in this group of infants with sensorineural hearing loss is 70±10 % and 75±10%, when the sensation level is larger than 0 dB and 10 dB SL respectively. Sensitivities for each of the individual speech sounds, and for unaided versus aided conditions, were not significantly different from each other. Conversely, only one out of 21 children (< 5%) did not show CAEPs at all, even though the stimulus intensities were above the apparent behavioural hearing threshold. This discrepancy indicates that there is a large variability within subjects, and several reasons will be discussed.

Discussion

When a CAEP is detected, one has some confidence that the infant perceives the sound at the level tested. This confidence increases when the p-value gets closer to 0. The hearing aid likely needs no modification in the frequency range the tested speech sound covers. When no CAEP is detected, it is likely, but by no means certain, that the sensation level of the speech sound is less than or equal to 10dB. One might consider modifying the hearing aid fitting at the tested frequency range. These results will be illustrated by two case studies.

Conclusions

Despite the possibility of some discrepancies in CAEP findings, the detection of a CAEP response is very useful information, particularly in the context of other information available to the clinician. At the other extreme, in cases where CAEPs cannot be detected at all (particularly when professionals and parents have failed to observe behavioural responses to everyday sounds) the technique allows an objective indication that something might not be optimal. As hearing aid technology becomes increasingly complex it is even more necessary to continue research, with the aim of providing detailed objective measures to ensure they are performing as they are expected to.

AUDIOVISUAL INTERACTION IN SCHOOL-AGED CHILDREN: A SPEECH IN NOISE PARADIGM MEASURED USING CORTICAL AUDITORY EVOKED POTENTIALS

Gyldenkaerne, P.[1, 4], Sharma, M.[1, 4], Purdy, S.[2], Dillon, H.[3, 4]
[1] Macquarie University, Australia; [2] University of Auckland, New Zealand; [3] National Acoustic Laboratories, Australia; [4] HEARing CRC, Australia
[1], [3] Sydney, Australia; [2] Auckland, New Zealand [4] Melbourne, Australia

Background: Visual cues enhance speech perception in both quiet and in noise. Addition of visual cues in noisy listening situations have been shown to create an illusionary perception of an increase in loudness of up to 15 dB (Sumby, 1954). Children with auditory processing disorders are a heterogeneous group (ASHA, 1996; Chermak, 2002; Ramus et al., 2003; Sharma, Purdy & Kelly, 2009) and are described as having listening difficulties, particularly difficulties listening in noise. One of the main interventions recommended for this population is the addition of visual cues. Audiovisual integration is not well understood at a cortical level in children. Consequently, the aim of the current research is to investigate the influence of visual cues on speech perception in noise.

Method: Cortical auditory evoked potentials (CAEPs) were recorded in response to the natural speech token /ba/ presented as auditory only, visual only, and audiovisual stimuli in randomised blocks at two different signal-to-noise ratios (+3 dB and +10 dB). The noise was made of 8 talker babble (NAL). Participants were school-aged children (7–12 years of age) with normal hearing and without auditory processing difficulties. They pressed a button to indicate what they perceived (/ba/ or /pa/) each time a stimulus was presented. Evoked responses recorded from a range of scalp locations and reaction times were analysed.

Results: Results show significantly longer P1 and N2 latencies for +3 dB SNR conditions (AV < A). The P1N2 amplitudes were significantly greater in the +10 dB SNR condition compared to the +3 dB SNR and enhanced further with addition of visual cues.

Overall the results show that elevated noise levels affect the responses to unimodal auditory stimuli, but that the inclusion of visual cue results in release in masking.

Significance: The findings will enhance our understanding of the neural processes involved in everyday speech perception in noise and will facilitate the development of more appropriate management strategies for children with auditory processing disorders.

ELECTROPHYSIOLOGICAL CORRELATES OF SPATIAL RELEASE FROM MASKING

Dillon, H. , Cameron, S. , Krishnan, R.
National Acoustic Laboratories
Sydney

Background

Spatial release from masking refers to the increased ability to detect or understand a signal when it is spatially separated from competing sounds than when it is co-located with them. Reduced ability to selectively attend to sounds arriving from one direction is a form of central auditory processing disorder referred to as spatial processing disorder. Spatial processing disorder in children can be completely remediated by auditory training comprising repeated practice at attending to a frontal talker in the presence of competing talkers positioned to the left and right. While it is clear that spatial attention is under executive control, it is unclear where in the auditory system the processing occurs that enables sounds from one direction to be enhanced relative to sounds from other directions.

Aims

The main experiment reported here investigated whether there was evidence of spatial release from masking in the auditory cortex, evidenced by the P1 – N1 – P2 response. A second experiment investigated whether the spatial location of sources affected the frequency following response, which is believed to originate in the brainstem.

Methods

The main experiment presented, through headphones, sounds that had been filtered with head-related transfer functions corresponding to 0 and + 90 degrees. Cortical auditory evoked potentials (CAEP) were measured on 10 adults while they listened to the vowels /Λ/ and /I/ presented from the front. The subjects' task was to press a button whenever they heard the infrequently presented sound /Λ/. In one condition, competing babble appeared to come from the front, and in the other it appeared to come from both the left and right sides. Subjects were also measured behaviourally with a standardized test (the Listening in Spatialized Noise Sentences test; LiSN – S) to determine the benefit they experienced from spatial separation with a pair of competing talkers.

The second experiment, currently in progress, is measuring the frequency following response (FFR) on adults while they listen to the vowel /a/ presented from the front. The subjects do not have to attend to the sounds, and usually fell asleep. The vowels are presented in three conditions: in quiet, masked by co-located speech babble, and masked by separated speech babble.

Results

The subjects in the first experiment, showed normal spatial processing ability, with 12 dB spatial release from masking, when tested with the LiSN – S test. The electrophysiological measurement with vowels showed that the cortical responses to the standard vowel /Λ/ were larger (both N1 and P2 were measured) when the competing sounds were coming from the sides than when the competing sounds were coming from the front. The differences were significant for N1 ($P = 0.01$) and P2 – N1 ($P = 0.02$), but not for P2 alone. There was marked inter-individual variability and the mean difference in amplitude was small. The target vowels were easily audible in both the co-located and separated conditions, as the subjects responded to their presence 96.6% and 99.3% of the time respectively. The second experiment is in progress at the time of writing.

Conclusions

The benefits of spatial separation are evident in the obligatory cortical responses. The weakness of the effect measured objectively contrasts markedly with the large benefit from spatial separation that is observed behaviourally. Possible reasons include the different maskers used (a pair of competing talkers for the behavioural task, but a pair of speech babble maskers for the electrophysiological measurement), the signal-to-noise ratio of the stimuli being too easy, a number of replications insufficient to reduce residual noise in the average waveforms to insignificant levels, or the spatial selectivity occurring later in the auditory system than the locations in which the N1 and P2 responses are generated.

SPECTRAL ANALYSES OF THE VESTIBULAR EVOKED MYOGENIC POTENTIAL (VEMP)

Burkard, R.[1], McCaslin, D.[2], McNerney, K.[1], Coad, M. L.[1], Jacobson, G.[2]
[1] University at Buffalo; [2] Vanderbilt University
Buffalo, United States; Nashville, United States

Background: Vestibular evoked myogenic potentials (VEMPs) have become a routine clinical test to evaluate the otolith systems. To obtain VEMPs, electrodes are placed on, e.g., the sternocleidomastoid muscle (SCM) to obtain the cervical VEMP (cVEMP), or below the eye to record the ocular VEMP (oVEMP). To activate the SCM (and record the cVEMP) subjects are placed in a semirecumbent position, and then asked to lift their head while turning their head away from the stimulated ear. To record the oVEMP subjects are asked to elevate their gaze. The responses are elicited by presentation of high-level transients (i.e. typically clicks or low-frequency tonebursts), and this myogenic response is recorded from the electrodes overlying the muscle of interest. The VEMP arises from stimulation of the saccule and/or utricle.

Aims: The present study sought to determine the optimal recording filter bandwidth for cVEMPs and oVEMPS

Methods: The present investigation recorded both cVEMPs and oVEMPS from 8 subjects, using a NeuroScan Evoked potential system. VEMPs were obtained to 120 dB pSPL 500 Hz tonebursts (2–1–2 cycle, Blackman window), presented at a rate of just less than 5 Hz. Responses were averaged to ~250 stimuli, and each response was replicated. Stimuli were presented monaurally and both ears were evaluated. Responses were continuously recorded (4 channels, 5000 Hz A/D rate, band-pass filtered from 5–1000 Hz), and responses were processed offline (NeuroScan). Spectral analyses involved epoching the response from 0–204.6 ms (re: stimulus onset), with a 10 ms Hanning window applied to the onset and offset, and performing Fourier analysis of the response. This resulted in a response spectrum with ~4.88 Hz spectral resolution.

Results: The spectral properties of the cVEMP and oVEMP will be presented. Grand mean responses were created, and these responses were digitally high-pass (2-pole, cutoffs ranging from 10 to 100 Hz) and low-pass (2-pole, cutoffs ranging from 50 to 500 Hz) filtered. The spectral analyses and digitally-filtered cVEMPs and oVEMPs will be compared and contrasted.

Conclusion: We will conclude with a discussion as to the optimal filtering cutoff frequencies to use for obtaining the cVEMP and the oVEMP.

VESTIBULAR STEADY STATE RESPONSES (VSSR) OR VESTIBULAR EVOKED MYOGENIC RESPONSES TO AMPLITUDE MODULATED SOUNDS

Bell, S. L. , Fox, L. , Id Bihi, R.
Bell - Institute of Sound and Vibration Research, University of Southampton, Highfield, Southampton, UK Fox and Id Bihi, Department of Audiology, Royal Berkshire Hospital, Reading, UK
Southampton

Vestibular Evoked Myogenic Potentials (VEMPs) arise from the Sternocleidomastoid muscle in response to loud sounds. There is good evidence that these responses are vestibular in origin and reflect saccular function. The best stimulation frequency is around 500 Hz. The aim of the current study was to explore whether similar responses could be elicited using a steady state paradigm. This may allow more accurate or faster measurement of VEMP thresholds. At high stimulation levels artefactual ASSR responses have been reported in subjects with severe to profound deafness and it is possible that these are vestibular in origin.

Relatively large amplitude 'steady state' responses to amplitude modulated tones were measured from the Sternocleidomastoid muscle at 500 Hz. Response thresholds were similar to those of Vestibular Evoked Myogenic Potentials and scaled with neck muscle tension. Reduced amplitude responses were measured at the inion indicating volume conduction from the SCM. 'Steady-state' vestibular myogenic responses showed broad tuning to modulation frequency. The steady state approach does not give a lower measurement of threshold than using tone burst stimulation, although it may be possible to measure VEMPs at several frequencies simultaneously as long as overall sound exposure is kept within safe limits. As they are very high amplitude, significant responses at the modulation frequency can be seen quickly even with an inion reference electrode. Although dependant on neck tension, such responses are a potential source of artefact when recording ASSR.

CVEMP SIGNAL PROCESSING STRATEGIES THAT ATTEMPT TO COMPENSATE FOR BACKGROUND EMG LEVELS MAY NOT WORK.

Moushey, J.[1], Burkard, R.[2], Zapala, D.[1]
[1] Mayo Clinic Florida; [2] University of Buffalo
[1] Jacksonville, Florida, USA; [2] Buffalo, New York, USA

Background:

Mean cervical Vestibular Evoked Myogenic Potential (cVEMP) amplitude is known to increase with muscle contraction level. However, there is controversy over how to control muscle contraction levels during cVEMP recording. Proposed methods use changes in field EMG levels as a surrogate for muscle contraction level, even though this relationship can be imperfect. For example, one method to control muscle contraction level selectively limits epochs to those with myogenic noise levels falling within a specific target range. Reports studying this method have yielded mixed results (Akin et al. 2004; Bush et al. 2010; Isaradisaikul et al. 2008). Another method, post signal averaging adjustment of cVEMP amplitude based on calculated noise levels, has yet to be validated (see, e.g.,: Colebatch, 2009; Lee et al. 2008). In both methods, the explicit assumption is that higher EMG noise levels impact cVEMP signal averaging favorably, despite the fact that this is contrary to an underlying requirements for signal averaging (i.e. the requirement that background noise should be uncorrelated to the stimulus and resulting evoked response). In this report, we present preliminary evidence from an ongoing study that suggests that methods designed to control for background myogenic noise levels can reduce the quality of the signal averaged cVEMP waveform.

Aim:

The aim of this study is to investigate the effect of eight different signal processing methods on the quality (signal-to-noise ratio or SNR) of the averaged cVEMP response.

Methods:

We obtained 400 single sweep cVEMP epochs from normal subjects under three levels of sternocleidomastoid muscle contraction level. Single sweep data were stored off line for post-hoc signal averaging. Eight different signal averaging methods were used to recreate average cVEMP responses: Standard signal averaging: (1); Two types of Bayesian-weighted signal averaging where epochs with high noise were given more relative weight in the average (based on pre-stimulus or post-stimulus noise estimates): (2, 3); Two types of Bayesian-weighted signal averaging where epochs with high noise were given less relative weight in the average (based on pre-stimulus or post-stimulus noise estimates): (4, 5); Standard averaging where EMG noise levels were in the lower third, middle third or upper third of the range of pre-stimulus noise measurements obtained for that subject (i.e. pre-selection of epochs based on noise estimates): (6, 7, 8).

Results:

Preliminary results show a consistent trend for signal-to-noise ratios (SNRs) to be highest using Bayesian weighting where epochs with low pre-stimulus noise levels were given more weight in the average. Standard signal averaging resulted in the second best observed SNRs. Additionally, when pre-selection of epochs based on noise estimation was used, higher SNRs were observed when averages were made from epochs having the lowest pre-stimulus noise levels.

Conclusions:

These results are inconsistent with the assumption that selecting cVEMP epochs with higher EMG noise levels will result in more reliable or higher quality cVEMP results. It is possible that cVEMP amplitude is positively correlated with background EMG noise levels. However, when standard signal averaging is employed, there appears to be a trade-off between muscle-contraction-based cVEMP amplitude improvements and corresponding background noise levels. The effect is that there is little improvement in cVEMP average quality (SNR) with increasing muscle contraction levels. Further work will investigate cVEMP amplitude variability within- and across subject, as well as test re-test variability, can be improved when noise levels are controlled using the above methods.

COMPARISON OF THREE ABR-BASED METHODS IN DIAGNOSIS OF RETROCOCHLEAR HEARING LOSS – PRELIMINARY RESULTS.

Kochanek, K.[1], Gołębiewski, M.[2], Śliwa, L.[1], Piłka, A.[1], Skarżyński, H.[1]
[1]) Institute of Physiology and Pathology of Hearing [2]) Medical University of Warsaw, Poland
Warsaw

The purpose of this study was to compare results of three different ABR-based methods in detection of retrochochlear impairments in the group of patients with retrocochlear hearing loss.

The group of subjects examined included patients with suspected acoustic neuroma, cerebello-pontine angle tumors and neuro-vascular conflict. Three different methods of eliciting ABRs were used: the standard click – ABR method, Stacked ABR (by M. Don) and the ABR Tone method (by K. Kochanek). The control group consisted of normal-hearing volunteers. Besides of ABR examination, each person was subjected to MRI examination with gadolinium contrast in a scanner of 3T main-field flux density.

The results of ABR tests, similarly as the results of MRI examinations, were assessed independently by three experts of long-term experience in each of these methods. The work presents preliminary results of the investigations in subjects representing different clinical cases of the mentioned impairments.

STATUS OF PERIPHERAL DIVISION OF AUDITORY ANALYZER OF DIFFERENT GESTATIONAL AGE INFANTS AT POST CONCEPTUAL AGE OF 40 WEEKS.

Rakhmanova, I. V. , D'iakonova, I. N. , Ishanova, Y. S. , Ledovskikh, Y. A.
The Russian State Medical University (RSMU)
Moscow

According to the data derived from various Russian literature review (JCIH, 2000, Helfand MD, 2001, Abdala C, 2001, Garbaruk ES., 2005, 2006) maturation of outer hair cells lasts till full gestation term which specifies by implementation of motility and development of nerve-impulse transmission. That is why audiologic screening of newborns should be provided at the fourth day of life. However the above mentioned is not related to premature infants, because maturation of their peripheral division of auditory analyzer continues after birth as well.

Aim of the present research is to study and compare parameters of response of DPOAE emission between full-term and premature infants at post conceptual age of 40 wks.

Materials and methods. 26 full-term infants (52 ears) were examined before discharge form the hospital at fourth day of life. 30 premature infants (60 ears) that were born with gestational age (G.A.) less than 28 wks (27 ± 0.1) were examined at the age of 3 months. 32 premature infants (64 ears) that were born with G.A. of 29–32 wks (30.5 ± 0.2) were examined at the age of 2–3 months. 32 premature infants (64 ears) that were born with G.A. of 33–37 wks (34.4 ± 0.2) were examined at the age of 1–1.5 month of life. Hearing test was done on Eclipse platform, Interacoustics A/S, Denmark, by using DPOAE. DPOAE record was made by using tone stimuli f_1 and f_2 ($f_1 < f_2; f_2/f_1 = 1,22$), difference tone $2f_1 - f_2$ was analyzed. Stimulation intensity L1=65, L2 = 55 dB SPL. Amplitude of DPOAE chosen results for analysis were 7 dB higher than level of ambient noise at least on 3 (1, 2, 4, 6 kHz) of 5 frequencies. Record was done twice in each ear. In case of an infant anxiety and/or receipt of controversial result the analysis was repeated. Response amplitude to the proposed frequencies and sound/noise (S/N) ratio were examined.

Results. The infants that were born with G.A. less than 28 weeks 6 infants (20%) passed the test in two ears, 8 infants (26.7%) in 1 ear, 16 infants (53.3%) did not pass the test in two ears. Range of response amplitudes for 1,2,4,6 kHz were as follows: 0.07±0.9 dB, 2.7±1 dB, 0.3 ± 1.3 dB, -1.2 ± 1.3 dB; S/N parameters were: 1.3 ± 0.8; 5.5 ± 1; 7.9 ± 1.2; 6.2 ± 1, correspondingly. Average amplitude response index was 0.5 ± 1.1 dB.

The infants that were born with G.A. of 29–32 wks, 21 infants (65.6%) passed the test in two ears, 7 infants (21.9%) in one ear, response was not registered in two ears of 4 children (12.5%). Response amplitudes to frequencies were as follows: 2.2 ± 0.9; 10.6 ± 1.2; 7.4±1.1; 6.4 ± 1.1, S/N parameters were: 3.7 ± 0.7; 11.6 ± 0.9; 14.4 ± 0.9; 12.7 ± 0.9. Average amplitude response index was $6{,}7 \pm 1$ dB nHL.

The infants that were born with G.A. of 33–37 wks, 24 infants (75%) passed the test in two ears, 8 infants (25%) in one ear. Range of response amplitudes for tested frequencies were as follows: 2.7 ± 1.3; 13.6 ± 1; 7.4 ± 1.3; 8.4 ± 1.2. S/N parameters of this group of infants on f2 frequencies were: 3.7 ± 0.8; 13.3 ± 0.8; 15.2 ± 0.9; 14.3 ± 0.8. Average amplitude response index was $8{,}0 \pm 1.2$ dB nHL.

100% of tested full-term infants passed the test in two ears Range of response amplitudes were as follows:3.7 ± 1.1; 15.7 ± 0.8; 8.5 ± 0.8; 5.8±1, S/N parameters were: 3.8 ± 0.9; 15.7 ± 0.6; 14.7 ± 0.6; 12 ± 0.8. Average amplitude response index was 8.4 ± 0.9 dB nHL.

Conclusion. As the received data indicates receptors maturation at post conceptual age of 40 wks of infants that were born with G.A. more than 32 wks does not depend on G.A. at the moment of birth. The cochlea of infants that were born with G.A. less than 28 wks maturates in extrauterine conditions longer. Consequently when we assess functional state of auditory analyzer of premature infants with G.A. less than 32 wks we cannot be governed by adjusted age.

THE EFFECT OF ALTERNATING STIMULUS FREQUENCY AND REDUCING INTER-STIMULUS INTERVAL ON PAIRED CORTICAL AUDITORY EVOKED POTENTIALS (CAEPS)

Bardy, F. , Van Dun, B. , Dillon, H. , McMahon, C. , Sharma, M.
[1] HEARing CRC; [2] National Acoustic Laboratories; [3] Macquarie University
[1] Melbourne, Australia; [2] Sydney, Australia; [3] Sydney, Australia

Background

Cortical auditory evoked potentials (CAEPs) provide an objective measurement of human sound processing. While we typically use single stimuli presented at a slow rate to maximize the measurement of these potentials, the brain processes considerably more rapid and varying sound stimuli. Therefore, this study aims to determine the effect of alternating the stimulus frequency in a sequence of tones with short inter-stimulus intervals (ISIs).

Method

Eleven adults (19–55 years) with normal hearing were investigated using two tone-burst stimuli with frequencies of 500 and 2000 Hz with ISIs jittered around 400, 800, and 1600 ms in a paired paradigm with fixed or alternating stimulus frequency.

Results

Four main observations were obtained. First, a noticeable change was observed in the neural response to brief tone pairs between alternating and fixed presentation modes for short ISI ranges. In general, the alternating presentation mode generated an increase of the amplitude and a decrease of the latencies of the CAEP in comparison to the fixed presentation mode ($p<0.01$). Second, a significant interaction between the mode of presentation and the ISI for the CAEP amplitude suggested that the effect of the mode of presentation is ISI dependent and most marked for the shorter ISI. Third, the amplitudes of the CAEPs elicited by the low frequency tone-burst of 500 Hz are significantly larger ($p<0.0001$) when compared to the amplitudes of the high frequency tone-burst of 2000 Hz. Finally, the amplitudes of the CAEPs significantly increase as the ISI increased from 280 ms to 2240 ms ($p<0.0001$).

Conclusion

These results suggest that the amplitude of the CAEP is sensitive to stimulus frequency, ISI, and stimulus frequency alternation. CAEP amplitude attenuation, which occurs when reducing the ISI, can be partly counteracted by alternating the stimulus frequency.

EVOKED RESPONSES USING BROADBAND NOISE STIMULI WITH CHIRP LIKE PROPERTIES

Bell, S. L. , Stone, J.
Institute of Sound and Vibration Research, University of Southampton, Highfield, Southampton, UK
Southampton

It is well established that using stimuli which compensate for basilar membrane delay increase the amplitude of evoked responses. The approach of using chirp stimuli in this way was first applied to the ABR by Dau et al. (2000). Various studies have tried to find the optimal time-frequency characteristics of chirp stimuli (e.g. Elberling and Don, 2010, Cebulla and Elberling, 2010). The chirp approach has also been applied in the frequency domain to improve acquisition of the ASSR (Stürzebecher et al. 2006). Stürzebecher et al. used a harmonic ASSR stimulus with harmonics separated by the desired modulation frequency. The phase of each harmonic was adjusted to give a chirp like effect which compensated for cochlear delay.

The current study investigated whether it is possible to generate a broadband noise like ASSR stimulus with chirp like properties (as opposed to using a harmonic series). Broadband stimuli were created by combining multiple amplitude modulated tones separated by 1 Hz and modulated at the same rate of 40 Hz. Modulation phase was altered as a function of frequency to produce a chirp like effect. By generating a broadband stimulus in this way, the bandwidth of the stimulus can be precisely controlled.

ASSR responses were recorded from 14 normal hearing participants for half octave noise (HON) and broadband noise (BBN) with and without modulation phase correction. Stimuli were presented at 70 dB SPL. Chirping modulation phase significantly increased ASSR amplitude for wide bandwidth stimuli (0.25–10 kHz), but a significant effect was not seen for a half octave stimulus. However chirping the modulation of the broadband signal also raised the recording noise floor for the BBN stimulus.

If a broad band stimulus is used to elicit ASSR, 'chirping' the modulation phase as a function of frequency to compensate for cochlear delay increases response amplitude by around 20%. However chirping also increase the noise floor at 40 Hz. This increase in noise may be due to complex masking effects in the cochlea.

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EFFECT OF NOISE ON SPEECH EVOKED CORTICAL AUDITORY EVOKED POTENTIAL (CAEP) IN ADULT

Thannikkal, A. J.[1], Sharma, M.[2], Narne, V. K.[3], Purdy, S. C.[4]
[1] Australian Hearing, Australia [2] Macquarie University, Sydney, Australia [3] All India Institute of Speech & Hearing, India [4] University of Auckland, Auckland, New Zealand
[1,2] Australia [3] Mysore, India [4] Auckland, New Zealand

Objective: The current study's main objective was to investigate the effect of type of noise and temporal cues on cortical auditory evoked potentials to better understand the neural basis for speech perception in noise.

Methods: Cortical auditory evoked potentials were recorded from eleven adults with normal hearing to three types of stimuli (naturally produced speech sound /da/, noise burst, and noise burst with /da/ envelope) in quiet and at 3 dB signal to noise ratio. Four different types of noise were presented for the noise conditions via insert earphones at 70 dB SPL bilaterally together with the stimulus: white noise, narrow band noise, continuous eight-talker babble, and 150ms noise bursts.

Results: Repeated measures ANOVA showed a significant main effect of noise on P1 ($F(4, 40) = 18.52$, $p < 0.01$), N1 ($F(4, 40) = 22.17$, $p < 0.01$) and P2 latencies ($F(4.40) = 32.29$, $p < 0.01$) such that the latencies were earlier in quiet than in noise. Repeated measure ANOVA also showed a significant main effect of noise type on P1 – N1 ($F(4, 40) = 5.85$, $p < 0.01$) and N1 – P2 ($F(4, 40) = 9.29$, $p < 0.01$) amplitudes. Planned comparisons showed a trend of gradual reduction in P1 – N1 amplitude when the background noise was changed between continuous white noise, continuous babble, and narrow band noise ($p < 0.01$). Enveloped stimuli (/da/ and a noise burst with envelope of da) caused significant increases in N1 and P2 latencies compared to noise burst stimuli. P1 – N1 and N1 – P2 amplitudes were similar for noise burst and noise burst with a /da/-shaped envelope.

Conclusion: CAEPs are dependent on both onset and fine temporal characteristics of the stimulus. Continuous white noise is a more effective masker than non-continuous noise (noise bursts). Masking effects of background noise were dependent on the stimuli and the background noise (masker). Background noise with similar acoustic characteristics to the stimulus caused maximum masking effects (cortical response delay and reduced amplitude).

Significance: CAEPs results show that the effect of noise on signal is dependent on the type of stimulus as well as the type of noise.

OPTIMAL DETECTION PARADIGM USING SEQUENTIAL TESTING FOR AUDITORY STEADY STATE RESPONSE

Choi, J.[1], Purcell, D.[1], John, M.[2, 3]
[1] The University of Western Ontario; [2] The Rotman Research Institute; [3] Institute for Biomaterials and Biomedical Engineering
[1] London, Canada; [2] Toronto, Canada; [3] Toronto, Canada

Objective: This study compared several auditory steady-state response detection paradigms oriented towards mitigating issues which arise when multiple-endpoints are sequentially tested. The detection rates, false positive rates, and mean test times of the different paradigms were assessed.

Design: Multiple auditory steady-state responses (ASSRs) were evaluated using four modulated tonal stimuli presented simultaneously to at least one ear. The focal dataset included infants tested for about 12 minutes at 50 dB SPL with carrier frequencies of 500, 1000, 2000, and 4000 Hz that were modulated at rates between 78 and 95 Hz. Data were analyzed offline to assess the performance of using: 1. adjusted Bonferroni corrections (ABCs), based upon correlation of the test data; and, 2. consecutive-rule paradigms in which multiple sequential tests (MST) must remain significant. F-test and phase-weighted t-test (PWT) detection strategies were evaluated. Our analysis was then extended to 82 adult datasets.

Result: In infants, using ABC tests led to detection rates of 65.8% and 66.3% for F and PWT tests, respectively, and favorable false positive rates. Using MST tests led to detection rates of 64.2% and 67.9% for F and PWT tests, respectively, and required a criterion of 12 consecutive sweeps to maintain false positive rate of less than 5%. The mean test times of ABC and MST were 4.7 and 6.5 minutes for the F-test and 4.3 and 6 minutes for the PWT-test. Similar results occurred for adults.

Conclusion: ABC and MST paradigms can be used in both infant and adult multiple-endpoint ASSR testing to shorten recording time, while maintaining desired detection and false positives rates. Since different individuals, and populations, may have different noise characteristics these may require different number of consecutive sweeps to maintain a desired false positive rate when strictly applying MST. The ABC approach holds advantages over strictly relying upon MST rules by adjusting statistical criteria based upon the correlation of the data.

ENVELOPE FOLLOWING RESPONSES ELICITED BY NATURAL SPEECH

Choi, J.[1], Purcell, D.[1], Aiken, S.[2], Coyne, J.[1]
[1] The University of Western Ontario; [2] Dalhousie University
[1] London, Canada; [2] Halifax, Canada

Objective: It would be clinically valuable if an electrophysiological validation of hearing aid effectiveness could be performed when a device is first provided after electroacoustic verification. This study evaluated envelope following responses (EFRs) elicited by English vowels in a steady-state context and in natural sentences. It was our purpose to evaluate the effects of vowel quality and to determine whether EFRs could be detected in a sufficiently short time for the method to be clinically useful.

Design: EFRs were elicited using five vowels spanning the English vowel space — /i/, /ɛ/, /æ/, /ɔ/, and /u/. These were presented either as concatenated steady-state vowels (total duration 10.04 s) or in three five word sentences (total duration 11.77 s), where each vowel appeared once per sentence. Single channel EEG was recorded from vertex (Cz) to the nape of the neck for 190 and 160 repetitions of the steady-state vowels and sentences, respectively. The stimuli were presented at 70 dBA SPL. The fundamental frequency (F0) track from the stimuli was used with a Fourier analyzer to estimate the EFRs to each vowel. Noise amplitudes were also calculated at 10 neighboring frequencies. Fifteen normal hearing subjects aged 20–34 years participated in the experiment.

Result: In the analysis of steady-state vowels, the mean response amplitude of /i/ was 173 nV, which was statistically the largest across vowels. The other four steady-state vowels did not differ in mean response amplitude, which varied between 73 and 106 nV. In the analysis of vowels from the three sentences, the largest response amplitudes tended to be for /u/. Mean amplitudes for /u/ were 164, 111, and 140 nV for the words 'booed', 'food', and 'Sue', respectively. The vowel /u/ produced statistically larger responses than /i/, /ɛ/, and /ɔ/ when grouped across words, whereas other vowels did not differ. Mean response amplitudes for the other vowel categories in the sentences varied between 82 and 105 nV. All subjects showed significant EFRs in response to the words "Bee's" and "booed", but only nine subjects showed significant EFRs for "pet", "bed", and "Bob".

Conclusion: We were readily able to detect significant EFRs elicited by vowels in a steady-state context and from three natural sentences. These results are promising as a first step in developing a clinical tool for validating that vowel stimuli are at least partially encoded at the level of the auditory brainstem. Future research will require evaluation of the technique with aided listeners, where the natural sentences are expected to be treated as typical speech by hearing aid signal processing algorithms.

IMPROVEMENT OF AUDITORY BRAINSTEM RESPONSE (ABR) WAVE V AMPLITUDE USING NOVEL MLS NONLINEAR ALGORITHM

Ahmad Aidil Arafat Dzulkarnain[1], Wayne Wilson[2], Andrew Bradley[3], Nik Amnah Nik Mohamad[1], Matthew Petoe[3], Andrew Smith[3], Saiful Adli Jamaluddin[1], Sarah Rahmat[1]and Jackie Moon[4]
[1] Department of Audiology and Speech Language Pathology, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia; [2] School of Health and Rehabilitation Sciences, University of Queensland, Australia; [3] School of Information Technology and Electrical Engineering, University of Queensland, Australia; [4] Mater Health Service, Brisbane Kuantan,Malaysia

Background:

The auditory brainstem response (ABR) is the most preferred tool in Universal Newborn Hearing Screening (UNHS) because of its high sensitivity and specificity and its ability to detect abnormalities up to auditory nerve. However, the testing time is considerably long does increase the cost of running UNHS. One of the possible techniques to shorten the ABR testing time is by using high stimulus repetition rate through linear Maximum Length Sequence (lMLS). This algorithm has been reported in the literature to have poor signal to noise ratio thus increase the testing time. The present study has developed a new non linear MLS (nlMLS) which aims to overcome the mismatch between the non-linearity of the auditory system and the linearity aspect of the algorithm.

Aim

This study is aimed to investigate the effect of using the novel nonlinear MLS (nlMLS) to the ABR results in newborn subjects.

Methodology

30 newborn subjects whom passed the UNHS were involved in this study. ABR were recorded using MLS using both linear and non linear reconstruction at 180, 250, 500 and 836 cps using a custom built evoked potential system. In addition, the ABR was recorded using vertical electrode montage (non-inverting: high forehead, inverting: nape of neck and ground: shoulder). Next, the wave V amplitude and signal to noise ratio (SNR) were calculated for each ABR. The ABR wave V amplitude was calculated from the peak of wave V to the following trough while SNR was derived from variance ratio at single point (Fsp) formula. MLS ABR were recorded using order 6 with 160 trains for 180 cps, 240 trains for 250 cps, 280 trains for 500 cps and 320 trains for 836 cps.

Results

Results show that the nlMLS has significantly higher amplitude and better SNR value than ABR recorded with lMLS (RM ANOVA, $p<0.05$) at the same stimulus repetition rate. The amplitude of wave V value increase from 13.3 to 53.6% when changing from lMLS to nlMLS with the maximum increment observed in MLS ABR at 500 cps.

The SNR increase from 19.8 to 63 % when changing from lMLS to nlMLS with the maximum increment observed in MLS ABR at 500 cps.

Conclusion

With these results, nonlinear algorithm is considered as a good tool to be applied in ABR recording in particular for UNHS as it can improve the SNR, amplitude and further more can save the recording time.

CORTICAL AUDITORY POTENTIALS EVOKED THROUGH A FLOATING MASS TRANSDUCER ON THE COCHLEAR ROUND WINDOW

Mühler, R.[1], Rostalski, D.[2], Ziese, M.[1], Verhey, J.[1]
[1] Department of Experimental Audiology, Otto-von-Guericke-University Magdeburg; [2] ENT Clinic, Otto-von-Guericke-University Magdeburg
Magdeburg, Germany

Background: The Vibrant Soundbridge (Vibrant MED – EL, Innsbruck, Austria) is a semi-implantable middle ear hearing device designed for patients with moderate to severe sensorineural, conductive and mixed hearing losses. By placing its floating mass transducer (FMT) on the cochlear round window, a new approach for coupling the implantable hearing system to the cochlea has been introduced. Although the recording of auditory evoked potentials in response to electrical stimulation of the hearing nerve through a cochlear implant is widely used in research and clinics, little is known about auditory evoked potentials (AEPs) elicited by active middle ear implants. The aim of this study is to evaluate the practicability of recording cortical auditory evoked potentials (CAEPs) in a patient with an FMT on the round window.

Method: We present results of a feasibility study in one adult patient (male, 61 years), who was implanted with the FMT placed on the round window membrane. CAEPs were recorded with a clinical EMG-system (Nicolet Viking IV, Viasys, Madison, WI, USA). Sinusoidal stimuli of 50 ms duration (10 ms rise/fall time) were delivered at a rate of 0.7 Hz via headphones with extra large cushions (AKG Acoustics, Vienna, Austria) placed over the Amadé audio processor. Because no calibration data for this setup were available, the patient was asked to scale the loudness of the stimulus on a five-point scale between 'very loud' and 'very soft'. The EEG was recorded with Ag/AgCl – Electrodes between vertex (+) and the contralateral earlobe (-) with a ground electrode at the forehead, band-pass filtered (0.3 to 30 Hz), digitized and segmented into epochs of 800 ms duration including a 100-ms pre-stimulus interval. After artifact removal at least 50 epochs were averaged. For three stimulus frequencies (500, 1000, and 2000 Hz) CAEPs were recorded at presentation levels corresponding to sensations from 'very soft' to 'loud'. Each recording was repeated three times. With the same setup CAEPs were measured in a normal hearing subject (male, 57 years).

Results: At all three frequencies CAEPs with a clear N1 – P2-complex could be recorded. The variability between the three recordings was very small. No stimulus artifacts were observed. N1 – P2-amplitudes and N1- and P2-latencies were similar to those observed in the normal hearing subject. The N1 potential could be recorded down to the 'very soft' presentation level at all three stimulus frequencies.

Conclusion: Using a clinical AEP-recording system and suitable headphones directly placed over the audio processor, CAEPs can be recorded in patients using a Vibrant Soundbridge. CAEPs might thus be used to objectively evaluate patients and assist in fitting patients who are not able to cooperate.

CORTICAL AUDITORY TEMPORAL PROCESSING ABILITIES IN ELDERLY LISTENERS AND YOUNG ADULTS WITH NORMAL HEARING

Al-Meqbel, A. , McMahon, C.
HEARing CRC & Macquarie University
Sydney, Australia

Abstract

Background: N1 latency has been identified as an objective marker of temporal processing ability in normally-hearing and temporally disordered populations (Michalewski et al 2009). One such population with temporal processing disruption is elderly listeners. Psychoacoustic studies have demonstrated that the aging process can smear the temporal representations of the acoustic stimulus and slows the ability to detect temporal cues. This could be one underlying cause of speech difficulties experienced by this population despite adequate peripheral normal hearing (Pichora – Fuller, 2006; Schneider et al., 1994; Snell & Frisina, 2000).

Aims: The aim of this study was to investigate whether objective temporal processing paradigms: voice-onset-time, speech-in-noise and amplitude-modulated broad-band noise (AMBBN) are sensitive to evaluate the disrupted temporal processing in elderly listeners with normal-hearing (age-related-temporal processing deficit). The N1 latency was used as a measure of temporal processing, and we compared results from elderly participants with young adult participants with normal-hearing.

Methods: 15 elderly participants (aged 64–80 years) and 20 young adults (aged 18–30 years) participated in this study. Hearing thresholds (octave frequencies from 250 Hz – 4 kHz) were screened using pure tone audiometry and tympanometry and behavioural measures of temporal processing (temporal modulation transfer function) and speech perception (CNC words) were evaluated. Cortical auditory evoked potentials (CAEPs) were elicited using: (1) naturally produced stop consonant-vowel (CV) syllables /da/-/ta/ and /ba/-/pa/; (2) speech-in-noise stimuli using the speech sound /da/ with varying signal-to-noise ratios (SNRs); and (3) a 300ms amplitude-modulated broad-band noise (AM BBN) with different modulation depths was presented in 2 conditions: (i) alone (a temporally varying stimulus) or (ii) following a 600ms BBN (a temporal change in the stimulus). All stimuli were presented at 65 dB SPL in the sound field.

Results: Significant and systematic differences in the N1 latency was measured for changes in VOT and SNR. Furthermore, significant differences were measured for the N1 latency for the 2 conditions of AM – BBN (i) alone compared with (ii) the AM – BBN following an unmodulated BBN stimulus. However, no significant differences in latency were observed for each modulation depth for either condition. A statistically significant mean difference in N1 latency ($p < 0.05$) was demonstrated between normally-hearing elderly and young adult listeners in all paradigms.

Conclusions: Our results demonstrate that the three temporal processing paradigms are sensitive to evaluate the disrupted temporal processing in elderly listeners, and the N1 latency may serve as a reliable objective measure of the efficacy of auditory temporal processing.

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ACOUSTIC NEUROMA, AN: INDICES OF TONAL AUDIOMETRY, TA, ELECTRONYSTAGMOGRAPHY, ENG, AND AUDITORY BRAINSTEM RESPONSES, ABRS

Kharkheli, E. , Gamgebeli, Z. , Kevanishvili, Z.
National Centre of Audiology
Tbilisi, Georgia

TA is a starting key in AN diagnosis. 95% of ANs are a unilateral affair. 5% occur bilaterally although are a local display of the global neurofibromatosis. Asymmetrical sensorineural hearing loss, SNHL, is a typical sign of genuine ANs therefore. From the entire number of asymmetrical SNHLs, 5% are caused just by ANs.

AN arises from schwann cells. Mainly it affects hence neighbor fibers located around 8th nerve stem and destined for perception of high sound frequencies. Central fibers, intended for low frequencies, are distorted under further AN growth. Hearing loss in ANs starts from and primarily involves thus high frequencies. Rarely only, due to local blood circulation problems hearing loss can preferentially invade low frequencies.

SNHL on AN side is mostly escorted by normal hearing or slight/moderate SNHL contralaterally. Opposite SNHL is caused by the brainstem shift due to AN expansion and pressure rise in ventricles. In all asymmetry cases ENG/ABR procedures have to apply for the reason checking. Moreover, under tinnitus/vertigo complaints even normal TA results should not dissuade from the precise ENG/ABR testing.

Besides hearing disturbances, AN patients frequently suffer from vertigo/spinning and disequilibrium/nausea/vomiting, typical adjuncts of vestibular dysfunction. AN mostly originates from vestibular branch of 8th nerve. Vertigo however is differentiated in about 20% of AN cases only. It primarily supplements ANs of restricted sizes. Posture unsteadiness occurs more often, in about 70% of ANs, particularly of greater volumes. By an accurate examining, horizontal nystagmus can be detected under initial AN stages already. Vertical nystagmus, conversely, is mainly coupled with later ANs, exerting compressive influences on a brainstem. Other global ENG confusions can also accompany the brainstem stress: gaze induced nystagmus, failures in suppression of gaze fixation, slowing of optokinetic nystagmus, saccadic pursuits.

Bithermal caloric probe seems to be an efficient ENG AN test. Vestibular caloric response is reduced on an AN side while in about 60% of cases is eliminated totally. Under thermal irrigation, horizontal vestibular canal is activated selectively. It is innervated by superior vestibular nerve. Caloric weakness follows respectively invasion just of superior vestibular nerve. When AN, instead, covers inferior vestibular or cochlear nerve, caloric irritation can fail to produce an abnormal ENG. The normal caloric reaction does not necessarily rule out AN existence thus.

ABR method is a worthy approach for AN detecting. The test is judged positive when ABR interpeak intervals, IPIs, and/or interaural differences of IPIs surpass the limits calculated in a group of healthy individuals. Absolute Wave V peak-latency, PL, shift and interaural Wave V PL gap exceeding normal ranges are also considered as characteristic AN features. Own experience denotes however that Wave V PL indices are valid far not in all cases.

Calculation of amplitude ratio, AR, between Waves I and V has been advised also for AN diagnosis. Under proper filter setting, amplitude of Wave I lags behind that of Wave V. In AN patients due to diminution of later retro- rather than earlier intracochlear ABR constituents, I/V AR rises up. High variability is however a serious obstacle for the reliable AR measuring. To negotiate the item, cross-summation of separate ABR recordings is advised to perform increasing by this way the number of averaging. The procedure positively balances variations and promotes the reaching of genuine ARs.

Brainstem distress due to the AN influence can delay ABR recovery time. ABR shape can be dubious therefore. Application of slower stimulation rates, e.g. 5/s, instead of faster standards, e.g. 10/s, is a helpful maneuver for improvement of ABR design and proper parameter estimations thus: ABR restoration is completed and higher magnitudes and better signal-to-noise ratios are reached then.

ABR sensitivity in AN diagnosis is generally thought to equal 90%. Own long-term practice proves however that under qualified test performance, ABR validity in AN detecting matches just absolute identification score, 100%.

Positive evidence of ANs by ENG/ABR should be confirmed and detailed by magnetic resonance imaging, MRI, carried out under application of contrasting material. MRI verifies AN while in parallel offers information regarding its location and features. If thus by lower cost ENG/ABR procedures AN is screened positively, more expensive MRI has to apply for process detailing and treatment strategy management. Under negative ENG/ABR outcomes, on the other hand, MRI seems as a hardly urgent exploration.

AGE-RELATED ALTERATIONS OF EVOKED OTOACOUSTIC EMISSIONS

Sharashenidze, N. , Svanidze, N. , Tushishvili, M. , Kevanishvili, Z.
National Centre of Audiology
Tbilisi, Georgia

Age dynamics of auditory function have been earlier investigated as a rule subjectively, through determination of hearing thresholds via conventional pure-tone audiometry approach. Otoacoustic emissions appear to be the sensitive objective alternatives for revealing of age-related inner-ear changes that can still even fail to be manifested in psychoacoustic indices. In the present study evoked otoacoustic emissions, EOAEs, were recorded and their magnitudes were estimated and compared in subjects of different ages while hearing thresholds were in parallel measured by the routine pure-tone audiometry procedure.

The investigated individuals were distributed into five age decade subgroups: 20–29, 30–39, 40–49, 50–59, and 60–69 years. Both otoscopically as well as by the tympanic impedance measuring, all tested participants possessed normal outer and middle ears. Subjective hearing thresholds were determined within the range of 0.125–8-kHz frequencies by the ITERA (Madsen) pure-tone audiometer. For systematic EOAE measuring just subjects were selected from the wider inspected sample group who owned psychoacoustic thresholds within 0–30 dB nHL at the frequencies up to 4 kHz at least, i.e. up to the upper boarder of the spectrum of applied clicks and, correspondingly, of registered EOAEs. The Capella (Madsen) device was utilized for EOAE averaging. EOAEs were registered in response to the non-linear clicks of 75-dB SPL intensity. Stimulation rate amounted to 51/s, averaging number to 1040, and analysis time to 15 ms following click stimuli. The overall level of averaged waveforms of the whole applied epoch has been automatically integrated by the way of specialized computer program and displayed on the screen of the EOAE averager. Just integrated magnitude has been regarded as an appropriate measure of registered EOAEs. EOAE magnitude data were calculated in separate age subgroups and compared statistically through the paired t test.

No reliable difference in integrated EOAE magnitudes was discerned between two starting age decade subgroups, 20–29 and 30–39 years. In individuals of the following subgroup, 40–49 years, the integrated EOAE magnitude was less by about 23% on the mean. In the subsequent subgroups, the magnitude drops were accelerated. In the subgroup of 50–59 years, as compared with the subgroups of 20–29 and 30–39 years, the integrated EOAE magnitude was in particular lower by about 45%. Further and much more evident decrease in EOAEs happened in the final age sample inspected, 60–69 years. In individuals of this subgroup, as compared with those of two starting decades, 20–29 and 30–39 years, the integrated EOAE magnitude was by about 65% lower. The reliabilities of all subgroup differences were proved to be statistically significant.

EOAE integrated magnitudes exceeded 10 dB in about two thirds of the representatives of the starting age subgroup, 20–29 years. In the following two age subgroups, 30–39 and 40–49 years, 10-dB excess of EOAE magnitudes was documented in about half while in the subgroup of 50–59 years in about one third of the sample representatives only. In the final age subgroup, 60–69 years, at last, the EOAE integrated magnitude exceeded 10 dB in neither individual.

The lower EOAE magnitudes were systematically verified in elderly subjects with normal pure-tone audiometrical thresholds even. The conclusion proceeds from the indicated dissociation that the EOAE integrated magnitude estimation method as compared with the conventional pure-tone audiometry procedure owns better sensitivity for characterization of the real situation in the inner ear. The EOAE integrated magnitude measure is capable to reveal not only the factual state of the inner ear but appears to be the preliminary accurate indicator of even slight dysfunctions in.

It follows from the results of our studies thus that the EOAE magnitude systematically and regularly decreases with age starting from the age of 40–49 years. The magnitude drop can primarily be attributed just to the inner-ear ageing processes. Individual estimation of integrated EOAE magnitudes has to consider therefore as a beneficial opportunity for early and precise determination of the factual state of cochlear receptors. Correspondingly, when revealing EOAE magnitude diminution trends, an immediate start of the set of efforts is advised to accomplish aiming either to prevent, or to slow down the progression of pathological changes, or to restore the normal cochlear function.

ASSESSING THE RELATIONSHIP BETWEEN COCHLEAR RESPONSE TIMES AND THE EFFECTIVENESS OF CHIRPS OF VARYING DURATIONS

Don, M.[1], Elberling, C.[2], Moumita Choudhury[1], Michael Waring[1], Kevin Crimi[1]
[1] House Ear Institute; [2] William Demant Holding A/S
[1] Los Angeles, CA. U.S.A.; [2] Copenhagen, Denmark

Background: Chirp stimuli have been developed and used over the years to increase ABR response amplitude by compensating for cochlear temporal dispersion that occurs with wideband stimulation. To compensate for the cochlear dispersion, ABR derived-band estimates of cochlear response times have been used to construct the chirps (Elberling and Don, 2008). Because there is a large variation in response times across the cochlea as estimated with the derived-band method, Elberling et al. (2010) developed a series of chirps that varied in their durations. Shorter duration chirps were modeled to correspond to shorter cochlear response times. It was also discovered (Elberling et al., 2010) that chirp amplitude can affect the ABR response amplitude and that the most effective chirp depended on the level of presentation. Thus, there is some question as to whether cochlear response time as estimated by derived-band ABRs can be used to predict the effectiveness of chirps of varying durations.

Aims: The aim of this study was simply to see if normal-hearing individuals who have short response times across the cochlea show better responses to short duration chirps and vice-versa. In addition, effect of stimulus level on this relationship is also assessed.

Methods: In a group of normal-hearing individuals, estimates of cochlear response times as defined by the wave V latency difference between the 5.7 kHz and 0.7 kHz derived-band ABRs are measured. Responses to five chirps of varying durations presented at 40 and 60 dB nHL are obtained and the amplitude of wave V measured. Data are analyzed to determine if there is relationship of the ABR amplitudes to chirps of varying durations and the cochlear response times determined by the derived-band analyses.

Results and tentative conclusions:

We have preliminary results at this time in a small group of normal-hearing individuals that tend to support the hypothesis that individuals with short cochlear response times demonstrate better responses to shorter duration chirps. There also appears to be an effect of stimulus levels on this relationship that must be considered. More details of this study will be presented.

USING CHIRPS OF VARYING DURATIONS TO DETERMINE IF PATIENTS DIAGNOSED WITH MENIERE'S DISEASE/COCHLEAR HYDROPS HAVE SHORTER COCHLEAR DELAYS.

Don, M. [1], Elberling, C. [2], Choudhury, M. [1], Crimi, K. [1], Waring, M. [1]
[1] House Ear Institute [2] William Demant Holding A/S
Los Angeles, CA, U.S.A.Copenhagen, Denmark

Background: Many early studies have suggested that patients with endolymphatic hydrops (cochlear hydrops that underlies true Meniere's disease) will demonstrate faster cochlear traveling wave-delays due to a presumed increase in stiffness of the basilar membrane. One of the ways for measuring the delays across the cochlea has been through the use of derived-band ABRs and measuring the latencies of the derived bands that represent activity from different frequency regions of the cochlea. However, previous work (Don et al., 2005) with Meniere's disease/cochlear hydrops patients suggest that such stiffness changes also result in undermasking of the ABRS to clicks presented in high-pass masking noise. Such ABRs are used in the formation of the derived-band ABRs that are then used in calculating the cochlear responses times. We show that such undermasking can result in shorter derived band latencies and may be part of the reason for observing shorter response times across the cochlea. This confound of undermasking makes it difficult to assess the validity of the claim of shorter cochlear response times in patients with Meniere's disease/cochlear hydrops and the use of such measures for diagnosing the presence of cochlear hydrops.

Aims: The aim of this study is to use a different approach to ascertain if cochlear response times are shorter in patients with cochlear hydrops. In work by Elberling et al. (2010), five chirp stimuli having different durations were developed. The different durations correspond to different modeled delays across the cochlea. Thus, it was hypothesized that patients with a shorter cochlear delay owing to the stiffness change from the cochlear hydrops should demonstrate the best responses to the shorter duration chirps.

Methods: Determine in a group of patients who underwent the CHAMP test and were identified as having unilateral cochlear hydrops, which of five chirp stimuli resulted in the largest amplitude ABR in the suspected ear. Chirp 1 was the shortest duration chirp and chirp 5 was the longest duration chirp. To minimize the influence of individual variability, the opposite unaffected ear was used as a control for the comparison. Also, the chirps were presented at two different intensity levels.

Results: In a series of patients diagnosed with the possible presence of Meniere's disease/cochlear hydrops, there is strong suggestion that the shorter chirps yielded the largest response in the affected ear than in the non-affected ear. There also appears to be a variable effect of the stimulus level. The specifics of the data analyses will be presented including comparisons to the derived-band latencies.

Conclusion: Thus, this study lends some supports to the idea that patients with cochlear hydrops do have faster cochlear response times. Furthermore, it suggests that the presence of cochlear hydrops may be indicated by the differential response between ears in the ABR amplitude to chirps of varying durations.

ECOCHG & OAE FINDINGS IN ENDOLYMPHATIC HYDROPSE

Nazeri, A.
faculty member
Tehran,Iran

I have done Ecochg and OAE (TEOAE & DPOAE) for more than 30 documented patients suffering from endolymphatic hydropse.

The diagnosis is made according to their clinical symptomes by some expert otologists. The inclusion criteria have been presence of at least 2 common symptomes of meniere disease. Extratympanic Ecochg with tiptrode is the method of choice. Both TEOAE and DPOAE are performed for evaluating cochlear status (OHC function).

All of these testes are performed with INTEGRITY system, which is a canadian instrument from VIVOSONIC company. Extra tympanic electrodes, wheighted averaging and application of bluetooth technology are some of technical cosiderationes in my study.

Conclusion:presence of OHC abnormality at normal hearing patients (atypical meniere) is confirmed by comparision of OAE results between involved ear and uninvolved ear.

By increasing the rate EXTRA TYMPANIC ECOCHG is an usefull approache for electrophysiologic evaluation of endolymphatic hydropse. SP/AP RATIO,THE AREA UNDER SP/AP COPLEX CURVE,LATENCY DIFFERENES BETWEEN CONDENSATION AND RAREFACTION POLARITIES are good indexes for diagnosing endolymphatic hydropse.

AUDIOLOGIC STUDY (BY HIGH FREQUENCY AUDIOMETRY ABR & OAE) IN MIGRAINE PATIENTS

Marzieh Sharifian Alborzi, Homa Zarrin Koub, Ahmadreza Nazeri
All of Authors are faculty memberes of sbmu

In neurology, typical migraine is defined as a unilateral pulsating headache that can be accompanied by nausea, vomiting and other signs of involvement in digestion, neurologic and autonomic systems, and lasts from 4 to 72 hours. Also hearing and balance disturbances are the problems that these patients are suffering from them.

Auditory signs are phono phobia, hearing hallucination, fluctuating hearing, tinnitus and fluctuating hearing loss in low frequencies. Also Migraine has known as one of the current causes for sudden deafness.

In this study, we evaluated hearing thresholds in high frequencies, evoked responses of brainstem and oto acoustic emissions in patients that their migraine was confirmed.

Estimated results were compared with existing criteria in normal hearing non migrainer patients.

This study revealed:

1-in high frequency Audiometry (except in 8 KHz) average of hearing thresholds in other frequencies has not significant differences between migrainers and non migrainer patients.

2-differences of averages for absolute latencies of waves I,III,V in both ears at statistical error level of 5% had significant differences with normal subjects.

Average of ITV between migrainer and non migrainer patients has significant differences ($p<0.0001$ and error level of 5%).

3-comparing mean of amplitudes of OAEs between 2 ears don't reveal significant differences. Also there are no differences comparing normal values ($p>0.05$).

Mean of signal to noise ratio for right ear was 2.8 dB and 2.6 dB for left ear and has not significant difference comparing normal value (3.0 dB).

For all of samples reproductibilities were higher than 70% for both ears and were in accepted levels.

INDIRECT SUPPORT FOR THE VALIDITY OF THE CHAMP PROCEDURE FOR DETECTING COCHLEAR HYDROPS

Don, M.[1], Linthicum, F.[2], Fayad, J.[2], Choudhury, M.[1]
[1] House Research Institute [2] House Clinic
Los Angeles, CA, USA

Background: Accurate assessment of the sensitivity and specificity of any electrophysiological measure for detecting the presence of Meniere's disease/cochlear hydrops is, at this time, difficult and often unreliable. As a result, there have been significantly different claims about the sensitivity and validity of the CHAMP test developed by Don et al. (2005) for detecting Meniere's disease/cochlear hydrops. The main problem is that in order to determine the true sensitivity of the measure, it must be applied to a group of patients who are known to definitely have cochlear hydrops/Meniere's disease. Unfortunately, at present we do not have a definitive method for determining such a group as many patients who have Meniere's syndrome do not necessarily have cochlear hydrops which is the assumed pathology of true Meniere's disease. Currently, post-mortem histology is the gold standard and the definitive way of establishing the presence of cochlear hydrops but is obviously unfeasible for use in testing live patients. This uncertainty of the presence of cochlear hydrops makes it impossible to interpret a negative result with a given measure. The negative result may be due to the insensitivity of the measure or it may be due to the patient truly not having the underlying cochlear hydrops pathology even though they were classified based on symptoms, etc. as having Meniere's disease/cochlear hydrops. Thus, any conclusion about the sensitivity of the measure in all studies is suspect.

Aims: Since direct support for the CHAMP method for detecting the presence of cochlear hydrops is not possible, the aim of this study is to provide indirect support for its validity and the sensitivity claimed by Don et al. (2005).

Methods: Determine in a group of patients who underwent the CHAMP test and were identified as having cochlear hydrops, the percentage that had bilateral cochlear hydrops. Determine in a group of temporal bones whose histopathological analyses of the cochlea indicated the presence of cochlear hydrops, the percentage that had a bilateral condition. Determine if the percentage of bilateral occurrences in the population with the known disease of cochlear hydrops corresponds to the percentage in the population identified by the CHAMP methodology.

Results: In a series of about 105 patients who underwent the CHAMP testing to assess the possible presence of Meniere's disease/cochlear hydrops, 45 patients tested positive. Of the 45, 15 were definite bilateral and 1 was borderline bilateral. This yields 33% and 36% if the borderline case is included. Thus, patients identified as having Meniere's disease/cochlear hydrops using the CHAMP test, approximately 33–36% or about one third are bilateral. In a series of 50 temporal bones of patients clinically diagnosed as having Meniere's disease/cochlear hydrops, an independent evaluation showed that 36 histopathological evidence of cochlear (endolymphatic) hydrops. Of

the 36 identified as having Meniere's disease/cochlear hydrops, 12 were bilaterally affected. Thus, in a true population of Meniere's disease/cochlear hydrops, one third appeared to be bilaterally affected.

Conclusion: While the evidence is indirect, the correspondence of approximately one third of patients identified as having Meniere's disease/cochlear hydrops by the CHAMP methodology to the one third of temporal bones showing conclusive presence of endolymphatic hydrops strongly supports notion that the CHAMP method is truly sensitive to the presence of Meniere's disease/cochlear hydrops.

PREDICTIVE VALUE OF IMAGING STUDIES AND ELECTROPHYSIOLOGIC TESTS ON SPEECH PERCEPTION ABILITIES OF IMPLANTED CHILDREN WITH AUDITORY NEUROPATHY

Sung-Wook Jeong, Seung-Hyun Jeong, Lee-Suk Kim
Department of Otolaryngology-Head and Neck Surgery, Dong-A University College of Medicine
Busan, Korea

Objective : Cochlear implantation is now routinely performed in children with auditory neuropathy (AN) who have no spontaneous hearing improvements in hearing thresholds and obtain limited or no benefit from appropriate auditory rehabilitation using an optimally fitted hearing aid. The purpose of this study was to examine the outcome of cochlear implantation in children with AN and to assess whether the speech perception abilities can be predicted using the results of imaging studies and electrophysiologic tests performed perioperatively.

Subjects and method : A retrospective review of medical records of 15 AN children (10 boys and 5 girls) who underwent cochlear implantation at Dong – A University Hospital was performed. They received cochlear implantation at the mean age of 3 years 7 months. We analysed the correlation between postoperative speech perception abilities and the results of imaging studies and electrophysiologic tests. The speech perception abilities were measured by Categories of Auditory Performance (CAP), Infant Toddler — Meaningful Auditory Integration Scale (IT – MAIS) and open-set Monosyllabic Word Test (MWT). The imaging studies were performed using computed tomography, magnetic resonance imaging. The electrophysiologic tests included the preoperatively performed auditory brainstem response (ABR), and the postoperatively performed electrical compound action potential (ECAP), electrical stapedial reflex (ESR) and electrical ABR (EABR). One child with mild mental retardation was excluded from the analysis of the speech perception ability.

Results : The speech perception abilities after surgery of 9 children were excellent (group A: CAP $\geqq$ 6, MWT > 90%, IT – MAIS > 90%), and those of 5 children were poor (group B: CAP $\leqq$ 4, MWT < 50%). The width of bony cochlear nerve canal (BCNC) and thickness of cochlear nerve of all children of group A were normal in imaging studies. On the other hand, the BCNC of the children in group B was narrow (n=2) or blocked (n=2) and the cochlear nerve was not observed (n=5). All children of group A had no waveform at maximum intensity stimuli on ABR, but three among 5 children of group B showed wave V only or wave I, III,V at maximum intensity stimuli. All children of group A showed good responses from all the tested electrodes on ECAP and ESR measurements, but there were no responses from all the tested electrodes on those tests in all children of group B. The wave V was recorded from all children of both groups on EABR. There was no difference in waveform between two groups, but the thresholds of group A were lower than those of group B.

Conclusion : The group A with excellent postoperative outcomes is considered to have AN caused by dysfunction of inner hair cell or synapse because cochlear nerve

on imaging studies was normal and ECAP and ESR were robust from all electrodes. The group B with poor outcomes is considered to have AN caused by cochlear nerve deficiency because there was no cochlear nerve on imaging studies and ECAP and ESR were absent from all electrodes. The imaging studies and electrophysiologic tests including ABR, ECAP, ESR and EABR have considerable value in predicting postoperative speech perception abilities of implanted children with AN.

ABR EVALUATION IN PATIENTS WITH ACOUSTIC NEUROMA SUSPICION

Borisenko, O. , Soushko, Y. , Sribnyak, I. , Minina, A. , Shevtsova, T.
Otolaryngology Institute
Kyev, Ukraine

Introduction: The main clinical symptom in patients with acoustic neuroma (AN) is hearing loss. The auditory brainstem responses (ABR) allow to suspect retrocochlear lesions. It is possible to register ABR in patients with hearing loss if hearing thresholds are not higher than 40 dB. ABR registration as screening method especially in patients with AN suspicion is useful to apply in some cases.

Methods: We evaluated ABR results in 45 patients with AN. The age of patients was varied from 24 to 70 years.

Results: In 18 patients with hearing thresholds less than 40 dB and registered ipsilateral ABRs retrocochlear pathology was found only in 15 (83,3%). In another 27 patients with hearing thresholds exceeding 40 dB we investigated contralateral ABR-peaks. In 16 patients ABR abnormalities have not been registered and were noted only in 11 patient with AN (40,7%). In 3 cases normal ABR has been registered which indicates 6,7% false-negative results.

Conclusion: ABR data in AN patients are informative as a screening method only in ipsilateral registration.

COCHLEAR MICROPHONIC POTENTIAL THRESHOLDS IN NORMALLY-HEARING CHILDREN AND AT DIFFERENT FORMS OF HEARING LOSSES

Garbaruk, E. S. [1], Savenko, I. V. [2]
[1] St-Petersburg State Pediatric Medical Academy; [2] St-Petersburg Pavlov State Medical University
St-Petersburg, Russia

Introduction. Cochlear microphonic potential (CM), as a part of acoustically evoked auditory brainstem response (ABR), is a response of the cochlea to acoustic stimulation which reflects cochlear functional state. The CM is oscillation series just prior to the ABR observed at positive (condensation) and at negative (rarefaction) stimulus polarity. It is believed to be generated primarily by outer hair cells.

CM typical features are as follows: inversion of response waveform peaks with changes in polarity of the stimulus, and lack of latency time dependence on the stimulus intensity and on masking noise presented to the same ear. In normally-hearing ears CM threshold is no less than 60 dB nHL. Maximum CM amplitudes are observed in infants and decrease with aging (Berlin et al., 1998; Sininger, Starr, 2001; Starr et al., 2001; Santarelli et al., 2006; Hood, 2007; Bamiou, 2009 et al.)

Patients and methods. 52 children aged from 1 month to 9 years have been involved into the study. A complex audiological examination, which included otoscopy, tympanometry, OAE, ABR, and CM measurements, was performed in all children. Middle-ear muscle reflex measuring, behavioral/playing audiometry and speech audiometry were carried out in addition, depending on the age. EP15 and Eclipse systems by Interacoustics (Denmark) equipped with insert earphones EarTone 3A were used for ABR and CM records at following test parameters: high pass filter 50 Hz, low pass filter 3000 Hz; amplifier sensitivity 20 µV; electrode impedance less than 5 kOhm; number of sweeps — 1500; 100 µs clicks were used as stimuli at repetition rate of 31 Hz and intensity from 20 to 100 dB nHL; stimulus polarities were in use — rarefaction, condensation, and alternating.

Results. Based on the audiological assessment all the children were subdivided into four groups: children having normal hearing (n = 3), with auditory neuropathy (AN) (n = 23) and with conductive (n = 5) and sensoneural hearing losses (n = 21).

In cases of normal hearing, conductive and sensoneural hearing losses, the CM thresholds have been shown to exceed always the ABR ones. In normally hearing ears, the CM thresholds were equal to 60 dB that exceeded thresholds of ABR by 40 dB. For children with conductive and sensoneural hearing losses, the CM thresholds were higher than the ABR ones by 20–30 dB, and when the ABR thresholds were equal to or more than 80 dB, the CM was never observed.

On the contrary, for children with AN, the CM thresholds were lower than ABR thresholds, and CM has been observed even at lack of ABR. In several cases, the

CM thresholds in children with AN were equal to those found in children with normal hearing function. In one case of AN no CM was observed, however single OAE peaks were recorded and pure-tone hearing thresholds were about 60 dB nHL.

OAEs were recorded in all normally hearing children and were absent in all case of conductive and sensoneural hearing losses.

In 9 cases for children with AN, OAEs were not observed however CM has been found out. Normally OAEs were recorded in 2 children with AN and in 12 cases of AN single OAEs peaks existed. In children with AN no correlation between the CM threshold value and the presence of OAE has been detected.

Conclusion. The obtained data evidences that a necessity of additional CM measurements at absent or severely abnormal ABR exists for the cases of AN and of the severe or profound sensoneural hearing losses to be distinguished.

ASSESSMENT OF EFFECTIVENESS OF ALGORITHMS APPLIED IN VIVOSONIC INTEGRITY DEVICE FOR REJECTION OF MUSCLE ARTEFACTS IN ABR RECORDINGS.

Skarżyński, P. H. , Piłka, A. , Śliwa, L. , Kochanek, K.

Summary

Registration of auditory brainstem responses (ABR) is commonly used in hearing examinations in young children. It is recommended to perform these tests in natural sleep, in order to reduce the influence of muscle artifacts (resulting from child's movements). In clinical practice, however, it is not always possible to test a sleeping child, and the examinations are often carried out in the state of arousal. Restlessness of the child deteriorates the quality of ABR registration, and increases examination time.

For many years, researchers have been looking for effective methods of artifact rejection in ABR recordings, in order to increase signal-to-noise ratio, to shorten registration time, and improve repeatability of measurements. For example, in the Vivosonic Integrity device, advanced methods of artifact rejection are implemented, which theoretically allow for reliable ABR recordings not only in sleeping children, but also in children being awake (i.e. at play).

The aim of the work was to assess effectiveness of artifact rejection algorithms applied in the Integrity system. In a group of 56 children, the values of wave V thresholds obtained in tests carried out in children at play were compared with those measured in sleeping children. Additionally, both threshold values were compared with reference ones, determined in sleeping children by means of the EPTEST electrophysiological system. The possibility of reliable ABR registration was assessed for responses evoked by click stimuli, as well as for ABRs elicited by tone bursts. We also measured examination times in sleep and arousal conditions and evaluated the difference.

The results showed that it was possible to reliably determine wave V threshold of click-evoked responses in all examined children, irrespective if the child was examined in sleep or at play. However, when using tone-burst stimuli, the threshold values determined at 500 Hz by the Vivosonic Integrity device in children at play were consistent (within 10 dB interval) with those determined by the EPTEST system in about 30% of cases, and in approx. 50% of cases at 1000 Hz. In sleeping children, threshold values measured by the two systems did not differ more than by 10 dB, irrespective of the kind of stimulus. Average time of ABR registration in children at play was, on average, twice longer than that required for sleeping children.

The results obtained in this study confirm usefulness of the Vivosonic Integrity system for hearing threshold examination in young children in natural environment (at play) as long as click stimuli are used. However, when we apply frequency-specific stimuli, it is recommended to examine the child in sleep.

AUTOMATIC ASSR HEARING SCREENING IN NEWBORNS WITH CHIRP STIMULI APPLIED AT DIFFERENT REPETITION RATES

Cebulla, M.[1], Shehata-Dieler, W.[1], Keim, R.[1], Stürzebecher, E.[2]
[1] ENT Clinic, Faculty of Medicine, Julius-Maximilians-University Würzburg; [2] WDH Denmark
[1] Würzburg, Germany; [2] c/o Petershagen, Germany

Today newborn hearing screening is a well established method for early detection of hearing impairment. Since four years we have been using an ABR based method with an optimized chip stimulus in our routine hearing screening program. The rate of stimulation is currently fixed at 92 Hz (stimuli per second). In an earlier investigation (Stürzebecher et al. 2003) with standard click stimuli, we found that stimulation rates of 40 Hz and 90 Hz are optimal for the automatic detection of ABR in adults whereas in newborn a wide range between 80 and 140/s seems to be optimal. It is known that the middle latency response components contribute to the 40 Hz response. This middle latency component, however, will be absent in sleeping newborn. Accordingly, we decided to use the higher stimulation rate (90 Hz) in newborns.

In the present study the stimulation rate with an optimized chirp stimulus in newborn were investigated. Using the newborn-baby-screener MB11 BERAphon® data from 77 neonates were analyzed for 5 different stimulation rates: 20, 40, 60, 80, 90 and 100/s. The acoustical stimulus was an optimized chirp stimulus which was presented at a stimulation level of 35 dB HL, used routinely for hearing screening. The results showed that the shortest detection time for chirp ABR using an automatic detection algorithm, lies within the range of 60/s to 80/s. This observation was significant in sleeping and restful newborn whereas in awake and restless babies the differences were not so clear. These results differ considerably from the results obtained in our previous study with standard click ABR, showing almost good performance over a range from 80 to 140/s.

Stürzebecher, E., Cebulla, M., Neumann, K. (2003). Click-evoked ABR at high stimulus repetition rates for neonatal hearing screening. Int J Audiol, 42, 59–70.

FOLLOW-UP ABR AND OAE TESTING OF NEONATES FAILED UNIVERSAL NEWBORN HEARING SCREENING.

Lalayants, M. R. , Markova, T. G. , Tsigankova, E. R. , Bakhshinyan, V. V. , Tavartkiladze, G. A.
National Research Centre for Audiology and Hearing Rehabilitation, Moscow
Moscow

Auditory brainstem response (ABR) waveform morphology, peak amplitude and latency changes in healthy neonates reflect the development of the auditory nerve and brainstem structures during first 2–3 years of life.

The aim of this study was to investigate ABR changes in hearing impaired neonates failed the universal newborn hearing screening.

The examination included ENT inspection, tympanometry, registration of OAE and ABR, genetic counselling. ABR were registered with alternating polarity clicks presented monaurally with presentation rate of 20.1/sec. The intensity of clicks was changed starting from 60 dB HL for threshold determination. Re-examination was performed every three months.

50 neonates who failed the newborn hearing screening during first month of life were included in the investigation. Unilateral and bilateral mild conductive hearing loss due to middle ear effusion was found in 8 of these children. These changes in all cases disappeared after treatment. Absence of ABR from one ear or unilateral sensorineural hearing loss in 3 children was stable during first year of life. Bilateral sensorineural hearing loss associated with mutations of GJB2 gene was revealed in 22 children. The ABR thresholds were constant in the majority of these cases during first year of life except two with slight shortening of peak latency. Five children had no ABR. Next 13 neonates had unilateral or bilateral mild to profound sensorineural hearing loss and different additional problems: prematurity, low birth weight, perinatal brain injury, hydrocephalus syndrome, Down syndrome and others. In this group the ABR thresholds as well as waveform morphology were changed during first year of life. In 5 children we detected normalization of ABR parameters. These changes may represent postnatal maturation in the auditory system. Two infants with bilateral sensorineural hearing loss and neurological dysfunction had no changes of ABR registration level, only slight shortening of V peak latency. In the rest 2 cases elevation of ABR thresholds was detected.

ABR follow-up in babies with hearing loss due to different disorders reflects hearing level and maturational changes after the birth. The combination of universal hearing screening and genetic screening enables to detect hearing loss as early as possible. The prediction of hearing levels in children failed universal newborn hearing screening after the first audiological examination, including ABR registration in the majority of cases could be correctly interpreted only in cooperation of audiologist, neurologist and geneticist.

AUTOMATED SCREENING TECHNOLOGY USING MULTIPLE ASSR TO BONE- AND AIR- CONDUCTED STIMULI

Pérez-
Abalo, M. C. , Hernández, M. C. , Santos, E. , Rodríguez, E. , Hernández, O. , Mijares, E.
Cuban Neuroscience Center
Havana, Cuba

Developing screening technology that can differentiate transient and permanent hearing impairments is an important research goal. This could reduce false positive rates in the initial screen (due to transient conductive hearing losses) and further enhance UNHS efficiency. Here we describe a clinical trial of an automated screening device (Neuronic-06) designed for such purpose. This portable equipment uses the simultaneity principle of multiple auditory steady state responses (ASSR) to present air- and bone- conducted stimuli at the same time (AC– BC ASSR). A first clinical trial was carried out in the Gonzalez Coro maternity ward. A sample of 180 newborns (360 ears) with and without high risk factors was screened within the first 48–72 hours after birth. Each infant (ear) was tested (in a random order) with both AC – BC ASSR and automated otoacoustic emissions (AOAE). A confirmatory clinical and electrophysiological evaluation (at 2–3 mo of age) was used as the gold standard to estimate their diagnostic efficiency. Both automatic devices performed reliably in the maternity ward showing concordant pass/fail results in most ears for AC stimuli (ML – Chi Square=13.7 gl. =1; p< 0.002). However, the overall failure rate could be reduced significantly when both conduction modes were considered (AC – BC ASSR 7.3%, 26/355 vs. AOEA: 25%, 84/339). Moreover, the new AC – BC ASSR device could identify a considerable number of infants with transient conductive impairments (BC responses present and normal confirmatory exam) that failed with the AOAE. The estimated diagnostic efficiency (sensibility and specificity rates) was higher (100% and 95%) for the AC – BC ASSR device than for the AC AOEA system (50% and 83%). In conclusion, the AC – BC ASSR technology prototype performed quite well in this initial clinical trial, differentiating transient conductive hearing losses from permanent impairments. This screening technology further developed and field tested may become a valuable complement for UNHS protocols.

EVIDENCE FOR MULTIPLE GAMMA SOURCES COINCIDENT WITH AUDITORY-VISUAL INTEGRATION

Gilley, P. M. , Walker, N.
University of Colorado at Boulder
Boulder, Colorado, USA

Background Disorders of auditory processing often occur coincident with one or more other neurological, developmental, or psychological processing deficits. For example, deficits in auditory temporal processing are concomitant with language-learning impairments and dyslexia. Further evidence is seen by developmental differences in refractoriness of the cortical auditory evoked potentials (CAEPs), and delays in development of the N1 CAEP in children with language-learning impairments. Given the integrative nature of sensory processes involved in language and learning, it seems reasonable that a measure of sensory integration could help differentiate global and modality specific processing deficits.

In studies of multisensory integration a redundant signals effect (RSE) is often observed as faster responses to stimuli presented simultaneously in two sensory modalities. RSEs are often faster than can be predicted by modality specific information alone, suggesting that the RSE is a non-linear process. Previous research has implicated induced gamma activity as a binding mechanism across sensory modalities for congruent stimuli. Additionally, increased gamma activity has been implicated as a mechanism that mediates attention related processes, such as when dividing attention between more than one sensory modality.

Aim The goal of this experiment was to examine early physiological correlates of the RSE from both evoked and induced cortical activity, and to determine the degree to which modality specific effects could be observed.

Methods EEG was measured from 128 scalp electrodes during a basic RSE task to auditory (A), visual (V), or simultaneous (A+V) stimulation in 10 adult participants. Reaction times were analyzed for violations of the race-model inequality, and used to sort each ERP trial by probability of a violation. Event-related spectral perturbations (ERSPs) were computed separately for each trial using a continuous wavelet transform. Band-specific scalp topographies for gamma ERSPs were subjected to spatiotemporal independent component analysis (ICA), with resulting components classified by stimulation modality.

Results Results revealed multiple, early gamma sources (40 Hz, 50–90 ms) during RSE (A+V) trials that lead peak activity of the evoked response. Source estimates of this activity indicate concurrent gamma from inferior temporal areas and the left, parieto-temporal junction.

Conclusions Taken together, these findings suggest that detection of multisensory stimuli may be facilitated by early gamma synchronization. Further, separation of the modality specific contributions to this synchronization may allow some differentiation of processing deficits in clinical populations.

SOURCES OF EXPERIMENTAL AND STATISTICAL ERROR IN ANALYSIS OF CORTICAL AUDITORY EVOKED POTENTIALS (CAEPS)

Gilley, P. M. , Sharma, A. , Walker, N.
University of Colorado at Boulder
Boulder, Colorado, USA

Background High-density electroencephalography (EEG) has been used to measure scalp topographies and estimate current source densities (CSDs) of sensory evoked potentials (EPs) from the cortex. However, the sensitivity of this measure is limited by successful extraction of the EP at each sensor; a task constrained by location and depth of the EP source, and by measurement error. Robust surface potentials, such as the visual N1 and P1 are relatively simple to recover, due in part to their proximity to the scalp surface. Higher frequency potentials from deeper brain structures, such as the cortical auditory evoked potentials (CAEPs), are more susceptible to noise and more elusive to recover spatially. While advances in signal processing algorithms improve CAEP estimation, these methods often involve higher-order statistical analyses with inherent susceptibility to noise and other measurement error.

Aim The goal of this project was to examine the effects of various signal processing algorithms on extraction of the CAEPs, and to identify sources of experimental error arising from such algorithms.

Methods CAEPs were measured from a 64-channel array in 17 normal hearing adults under two measurement conditions: stable electrode impedance, and high-variable electrode impedance. Scalp topographies and CSDs were estimated for each of 32 analysis conditions varying by sampling frequency, band-pass filter characteristic, and number of trials.

Results Results revealed greater signal-to-noise ratio (SNR) and decreased mean squared error (MSE) for sensors with low, stable impedances across all sites, and for band-pass filters with a high-pass cutoff of 2 to 3 Hz. In several cases, identification of one or more CAEP components was greatly limited in the high-variable impedance condition. Additionally, high-variable impedance added significant error to CSD estimates, increasing the number of trials needed to more than 300 before error stabilized.

Conclusions Taken together, these results suggest that selection of signal processing algorithms can largely affect the sensitivity of high-density EEG measures, and greatly limit CAEP extraction. Identifying and reducing signal level measurement error will likely yield more accurate results from higher-order statistical analysis of EP signals; both within and between subjects. Further, these results have implications for the experimental interpretation of dynamic brain signals.

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