

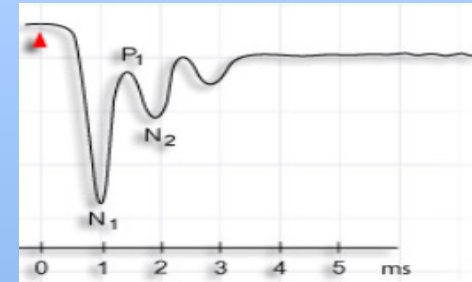
ELECTRICALLY EVOKED AUDITORY POTENTIALS: FROM AUDITORY NERVE COMPOUND ACTION POTENTIAL TO CORTICAL RESPONSES

George Tavartkiladze

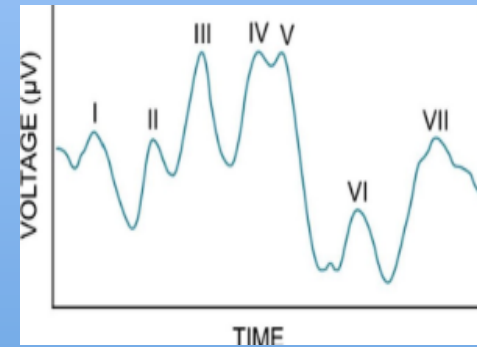
National Research Centre for Audiology and Hearing
Rehabilitation, Moscow, Russia

OBJECTIVE MEASURES

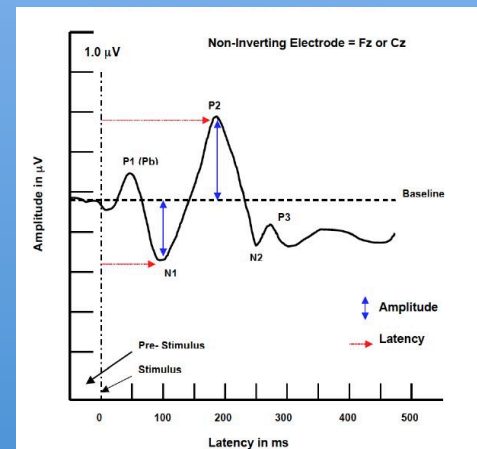
eCAP – NRT



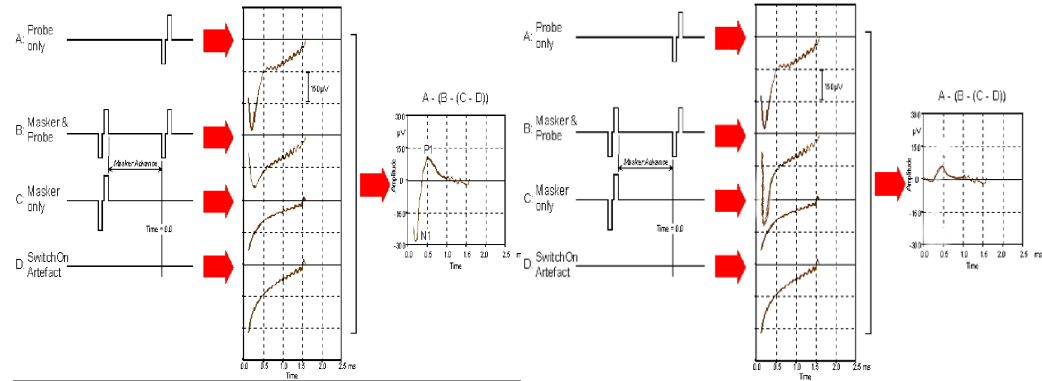
eABR



eCAEP

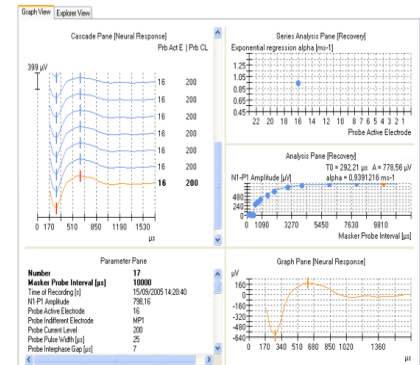


NRT

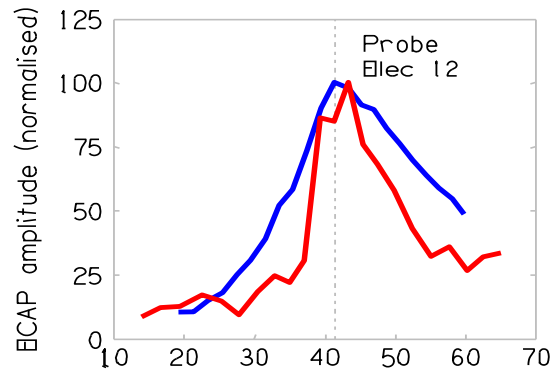


Excitation summation

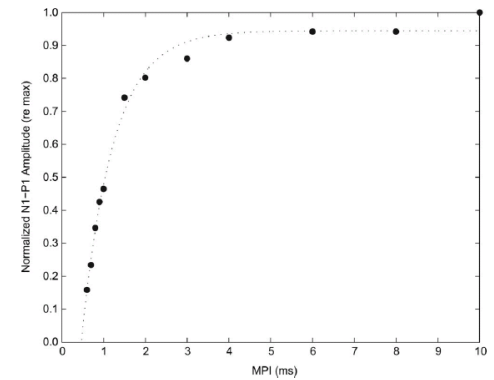
Recovery function: refractoriness of the auditory nerve fibres



Spread of excitation



Cohen, L.T. et al. 2003.



Botros, A., Psarros, C. 2010

NRT

Cochlear® CR120/220

- Handheld & wireless
- Conducts
 - AutoNRT
 - Impedance
- CR 120/220 requires
 - Sound Processor
- Gives instant results for
 - Electrode integrity
 - ECAP thresholds (t-NRT)

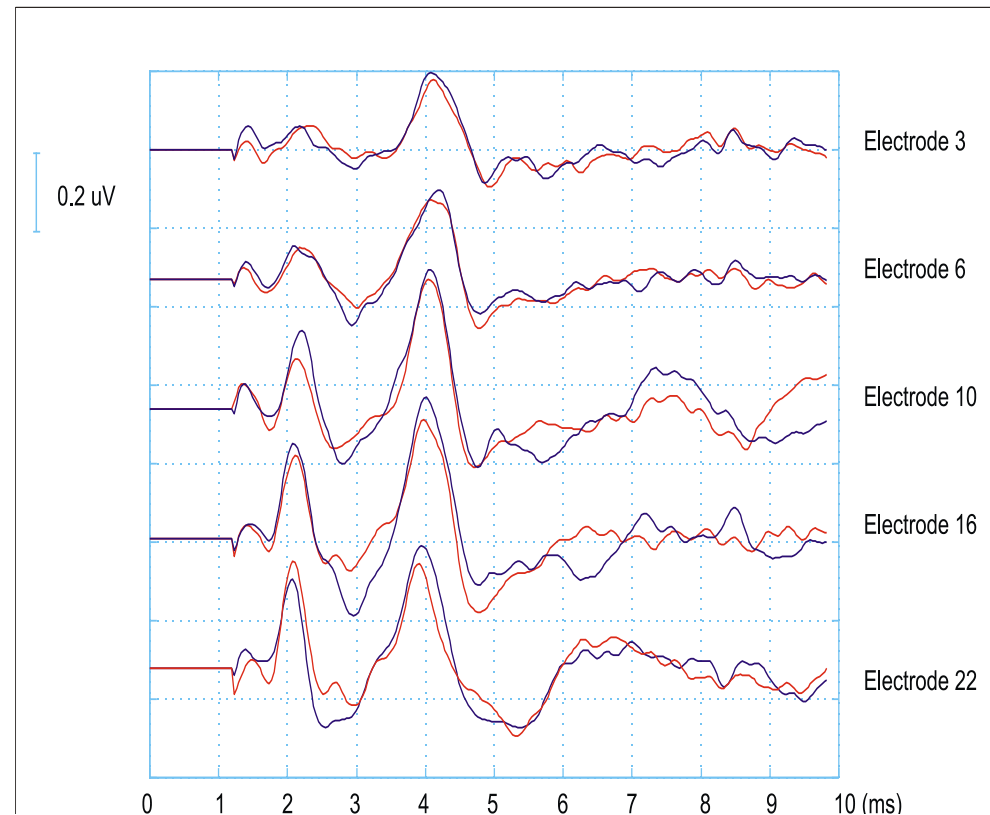


Tavartkiladze GA, Bakhshinyan VV, Irwin C. Evaluation of new technology for intraoperative evoked compound action potential threshold measurements. *Int J Audiol.* -2015. – V.54, N5. – P.347-352

eABR

PROBLEMS

1. eABR distortion by the electrical stimulus artifact contamination
2. Difference in the stimulus presentation rate during EABR registration (low-pulse-rate) and conventional psychophysical threshold estimation (high-pulse-rate) in cochlear implant patients.



New original method of eABR registration with the use of simultaneous masking paradigm was developed

Tavartkiladze GA, Potalova LA, Kruglov AV, Belov OA. Effect of stimulation parameters on electrically evoked auditory brainstem responses. Acta Otolaryngol.- 2000.-V.120. - N2, P.214-217

eABR

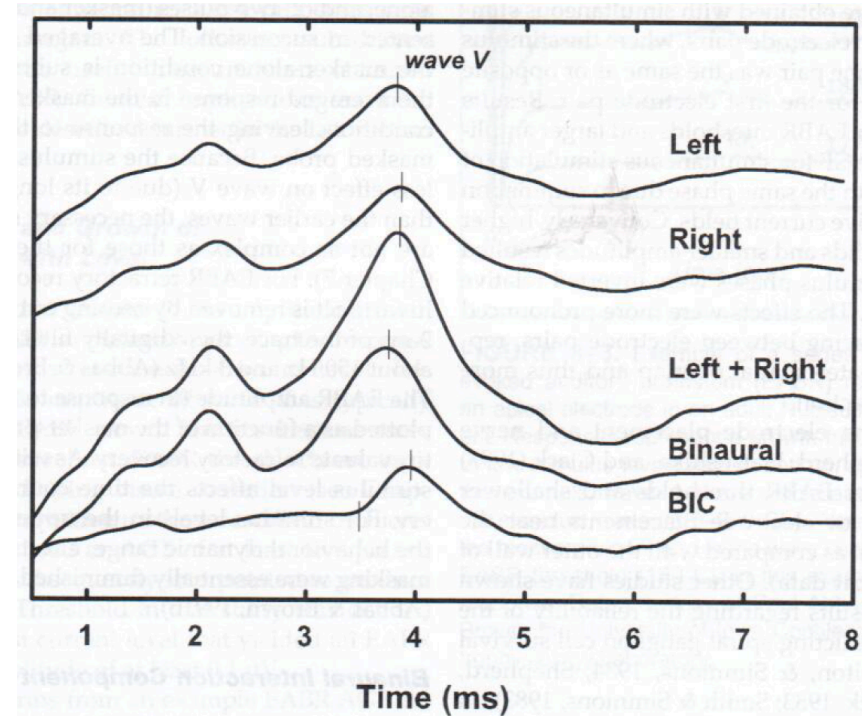
Speech Processor Adjustment steps

1. estimation of behavioural threshold, comfortable and threshold levels of stimulation (based on EABR data) for stimulus presentation rate used for the EABR recording;
2. extrapolation of the data obtained to the conventional stimulus presentation rate

eABR

BIC – Binaural Interaction Component

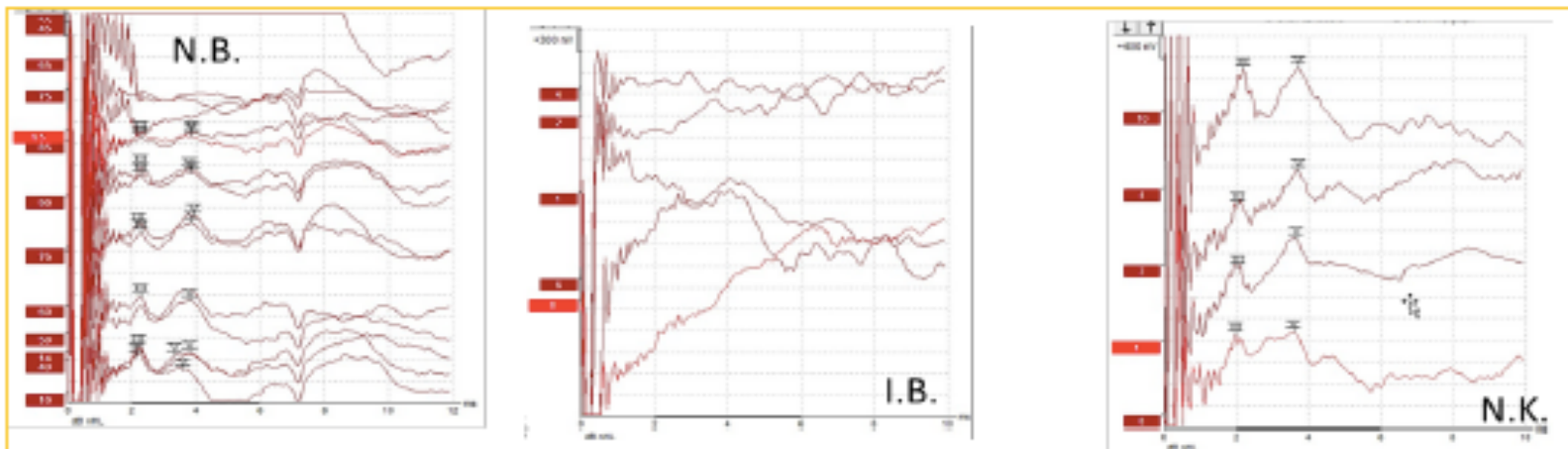
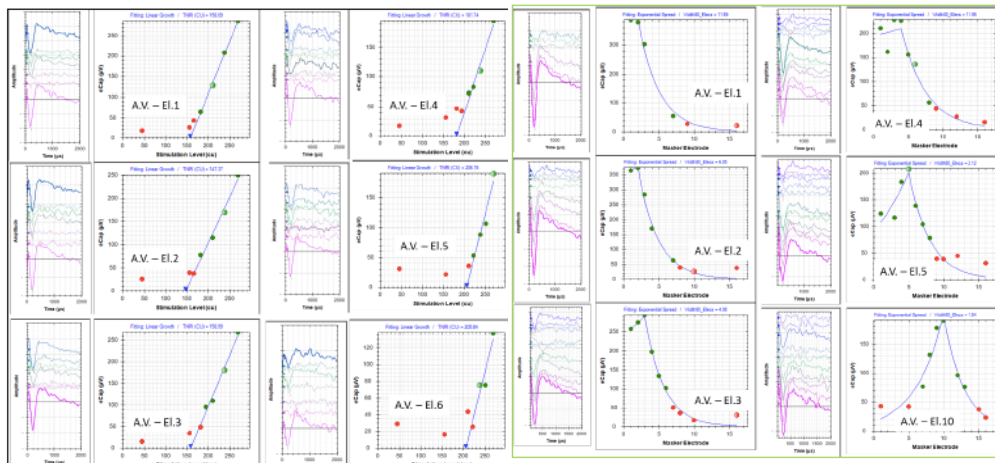
- Assessment of auditory brainstem (Gordon et al, 2007, 2008)
- Development in children who were bilaterally implanted either simultaneously with a short time interval between ears (<1 year), or with a longer time interval between ears.
- Results showed prolonged eABR and BIC latencies for the later-implanted ear for both groups of children implanted in sequential surgeries. Within the first 9 months of bilateral implant use latencies for the short-delay group were similar to those for the simultaneous group



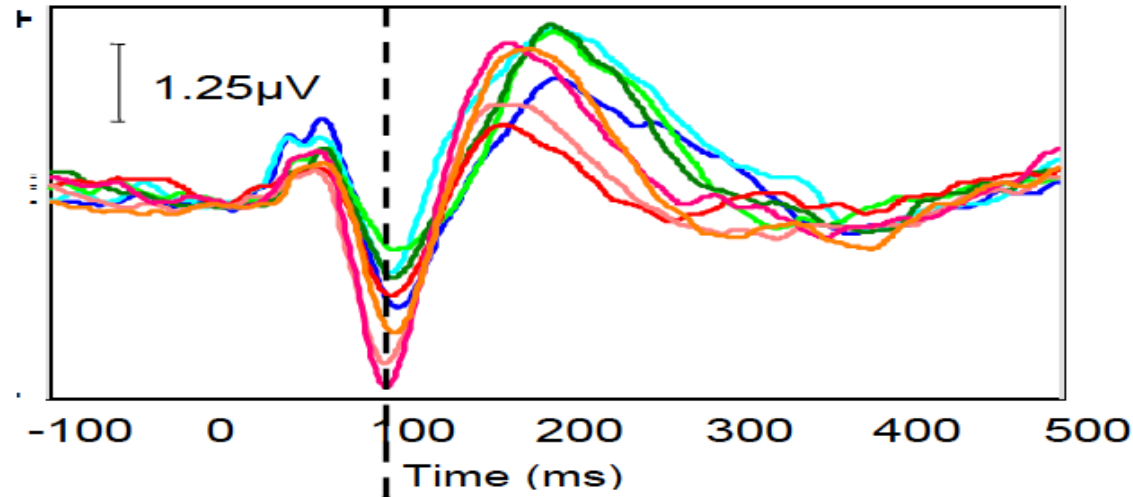
NRI + eABR

Advanced Bionics European Research Center, Hannover

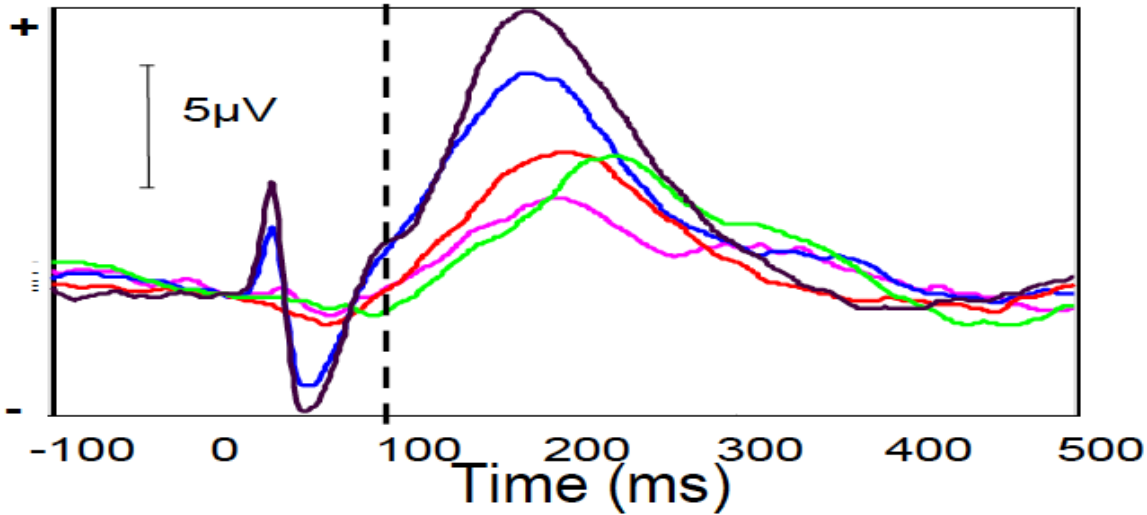
- Combined registration of the peripheral (eCAP) and central parts (eABR) of the auditory system



eCAEP

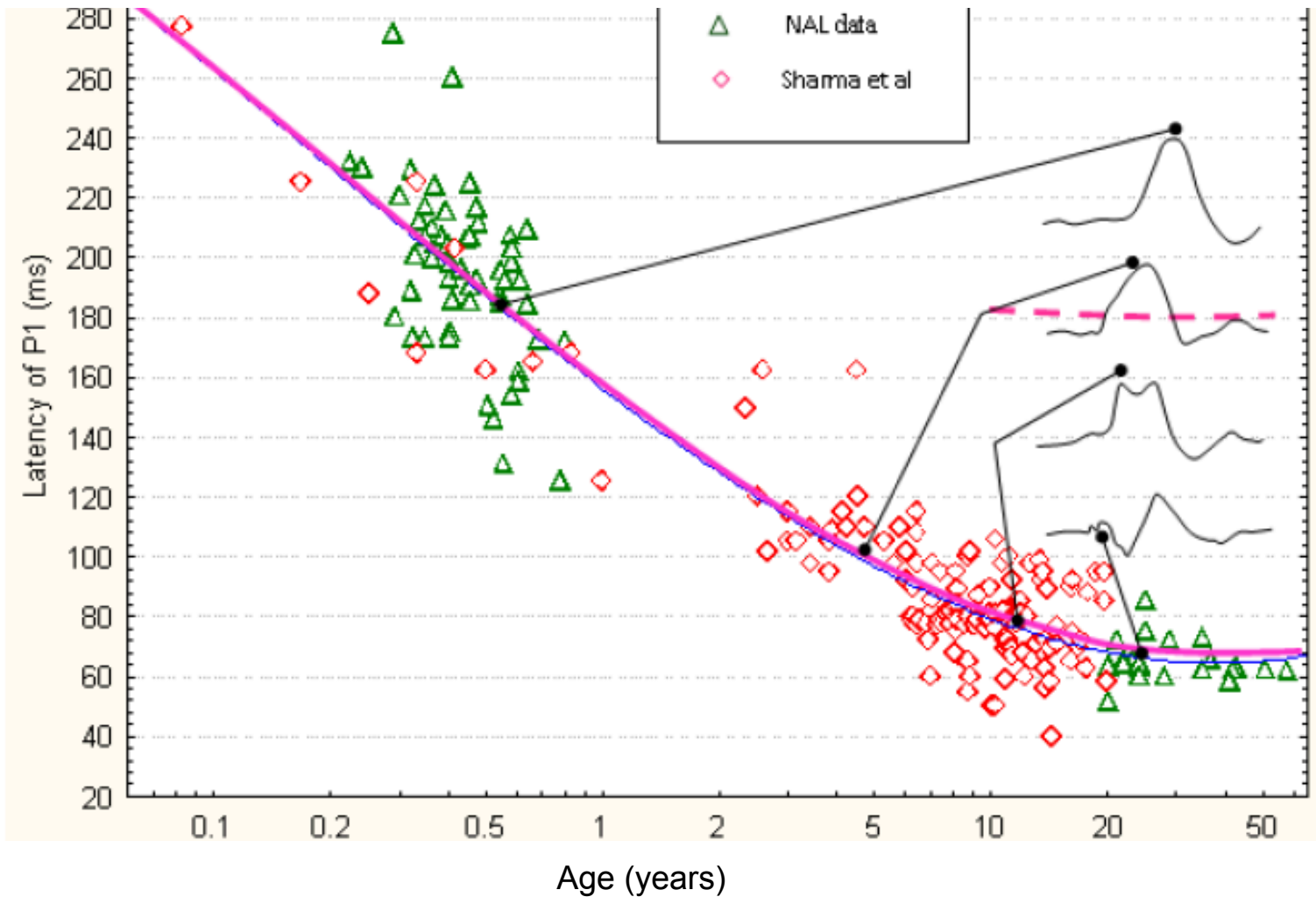


Adult

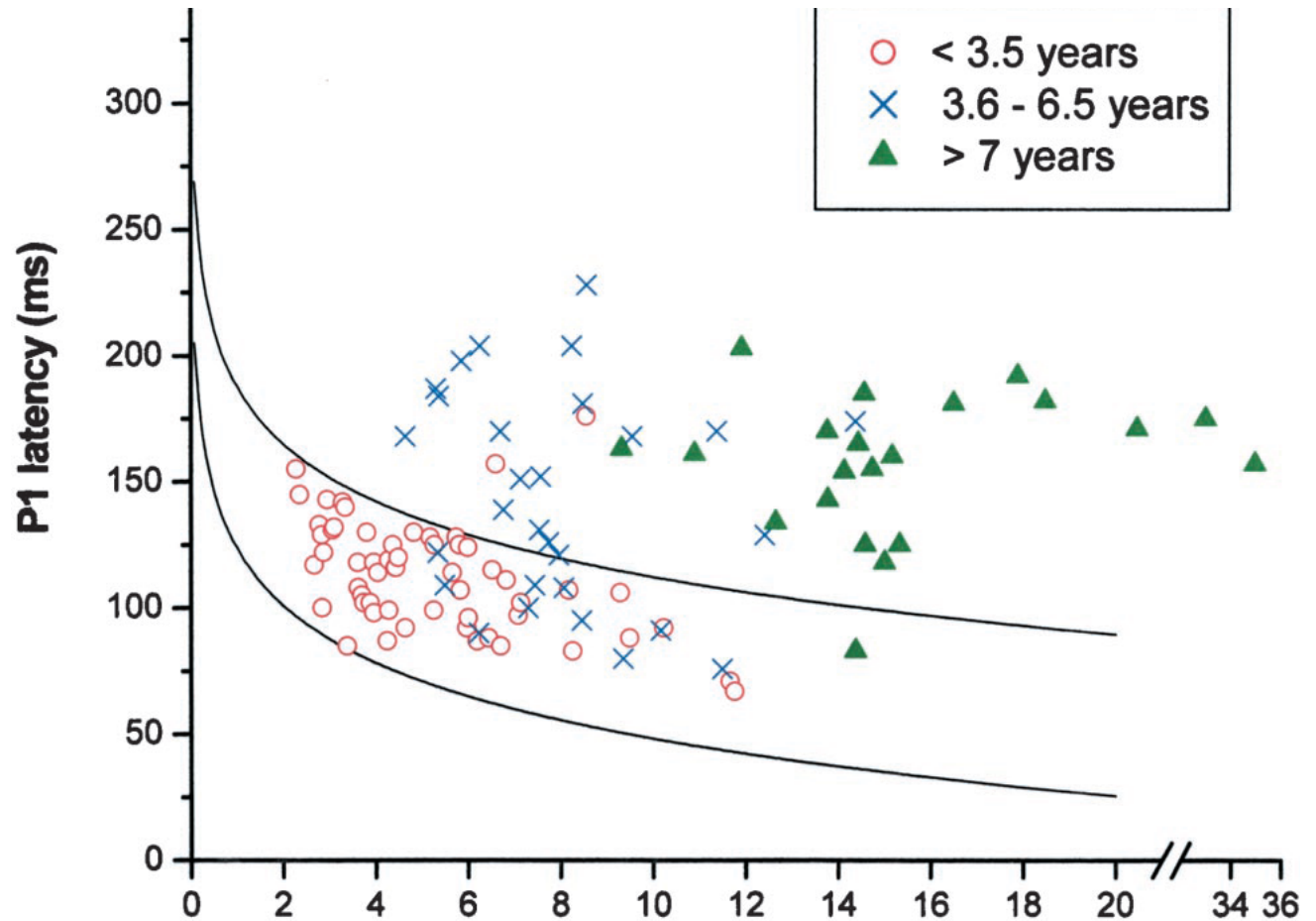


Infant

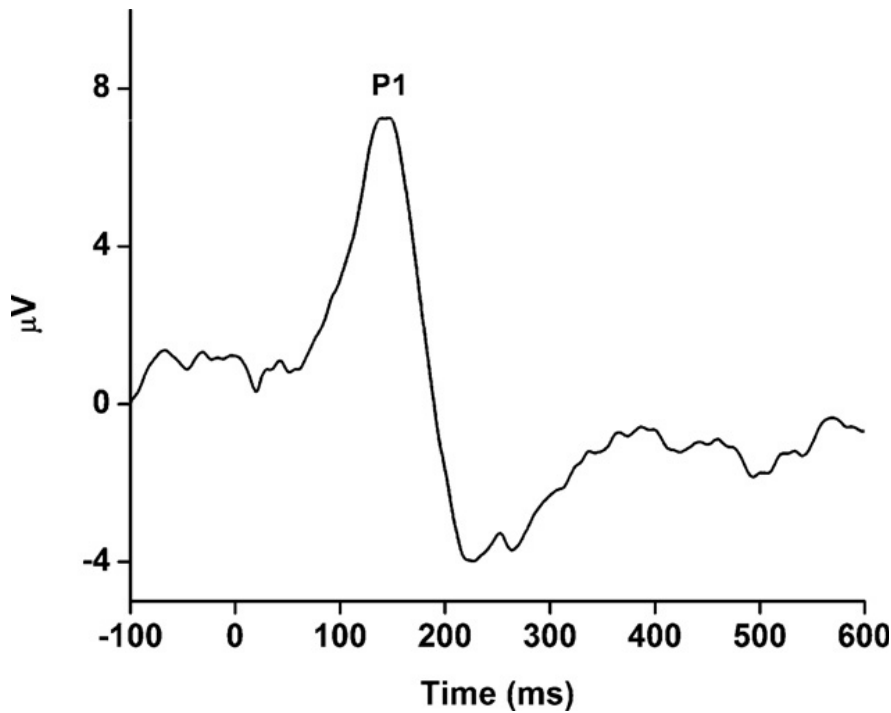
MATURATION OF CAEPS WITH AGE



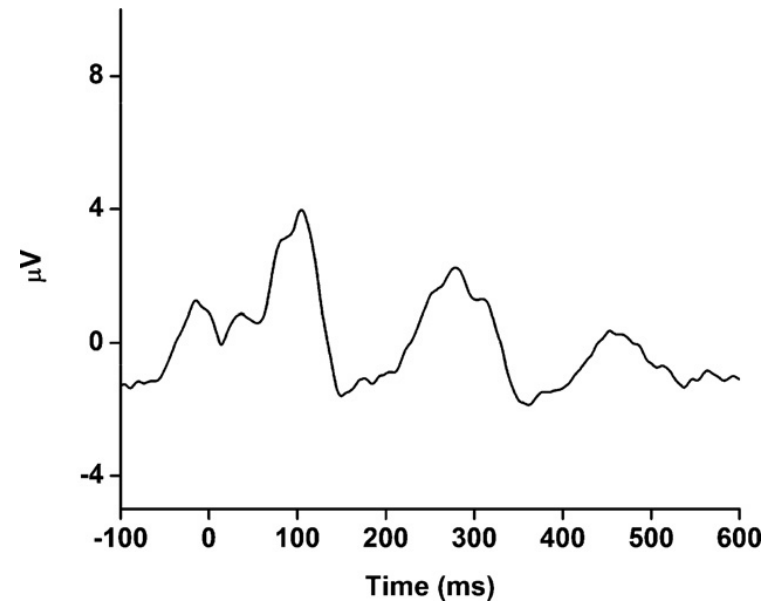
P_1 latency as function of the chronological age of children with CI



CAEP DYNAMICS IN CHILDREN WITH CI

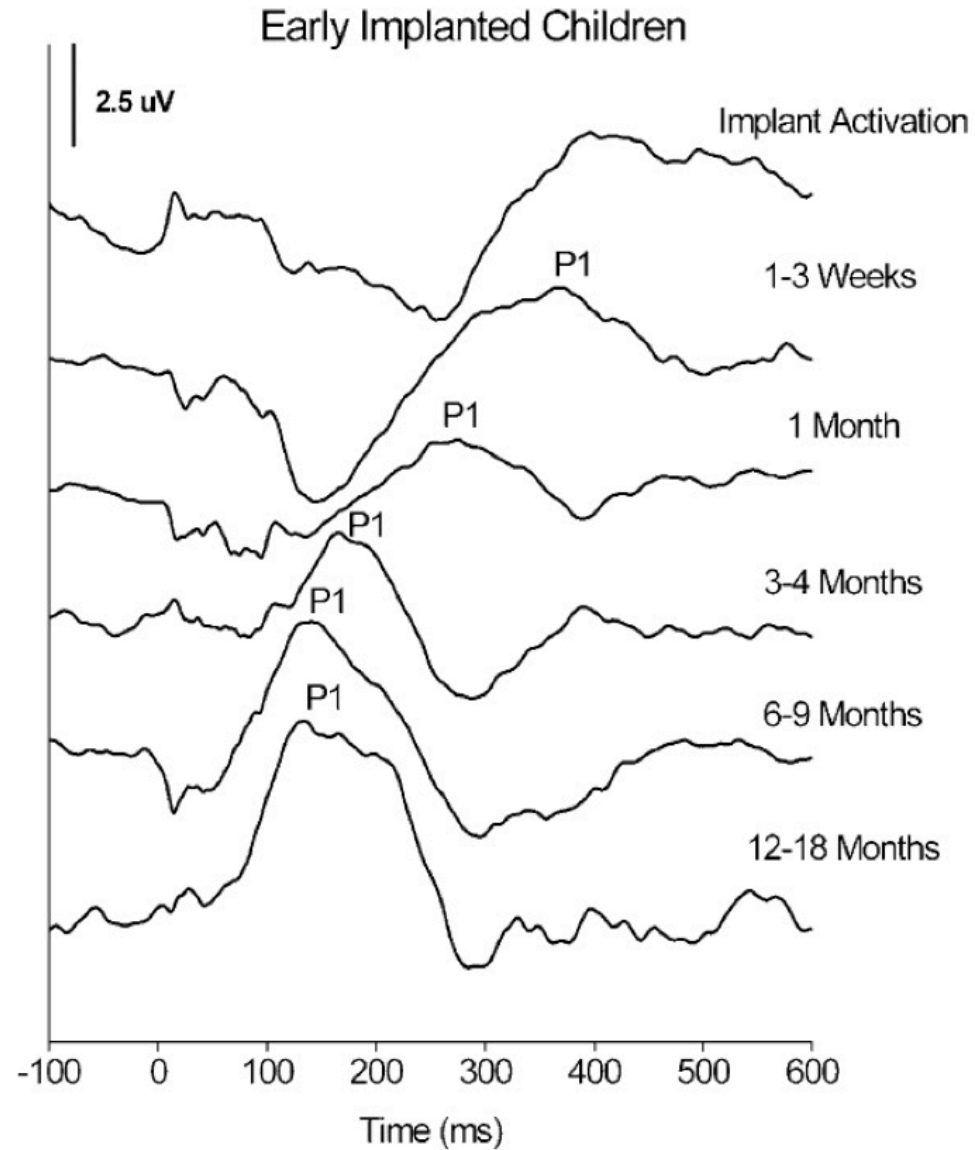


Early implantation



Late implantation

CAEP DYNAMICS IN CHILDREN WITH CI



INTERNATIONAL CLINICAL TRIALS

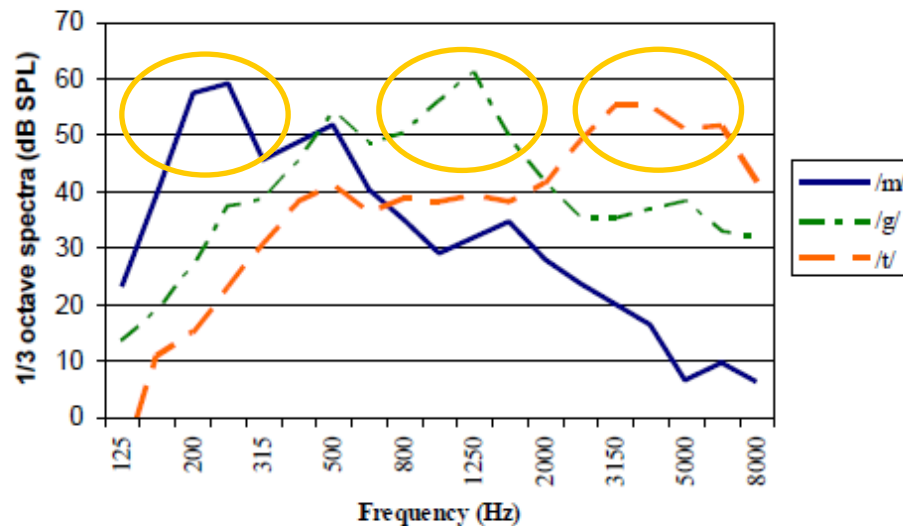
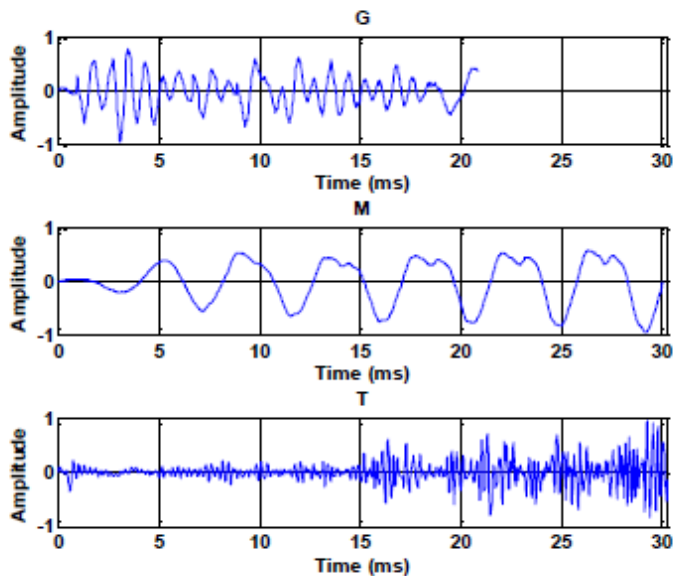
HearLab® System



(Australia)

NAL-ACA Stimuli

Three speech sounds: /m/ /g/ /t/



Aided Cortical Assessment

- Free field presentation
- Speech sounds
- Can be tested aided or unaided
- Focused on infants

/M/ 250 Hz

/G/ 1250 Hz

/T/ 3250 Hz

Case Report I

- Adult, Female, age 33
- Cochlear Nucleus since 3 y
- 80% word score @ 65 dB (polysyllables in quite)
- Good correlation between results

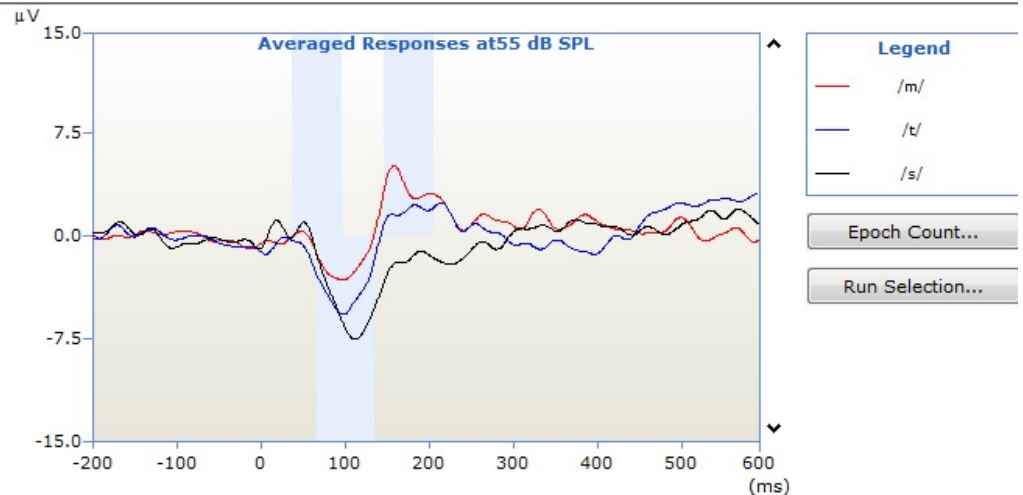
250 Hz	25 dB
500 Hz	25 dB
1000 Hz	25 dB
2000 Hz	25 dB
4000 Hz	25 dB

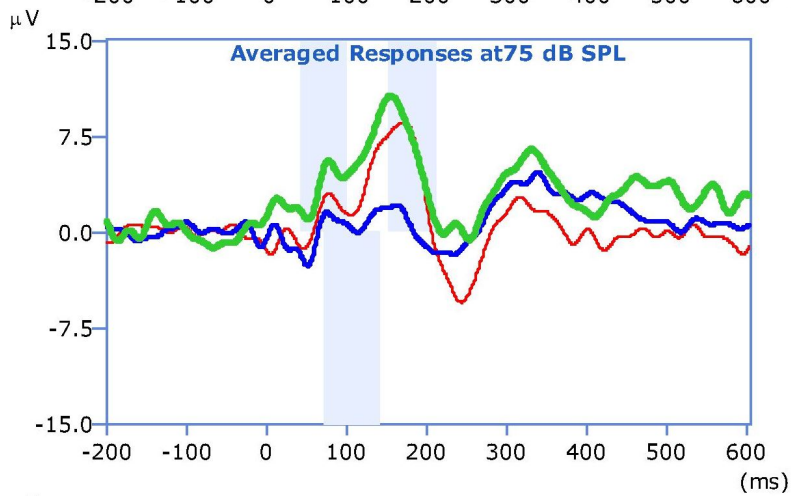
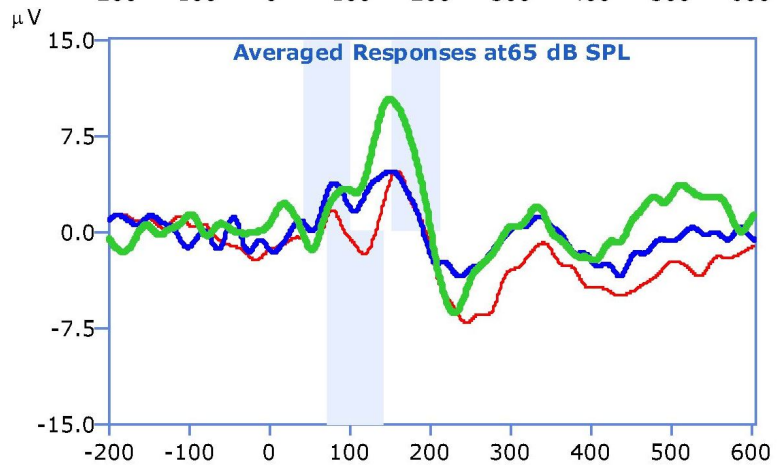
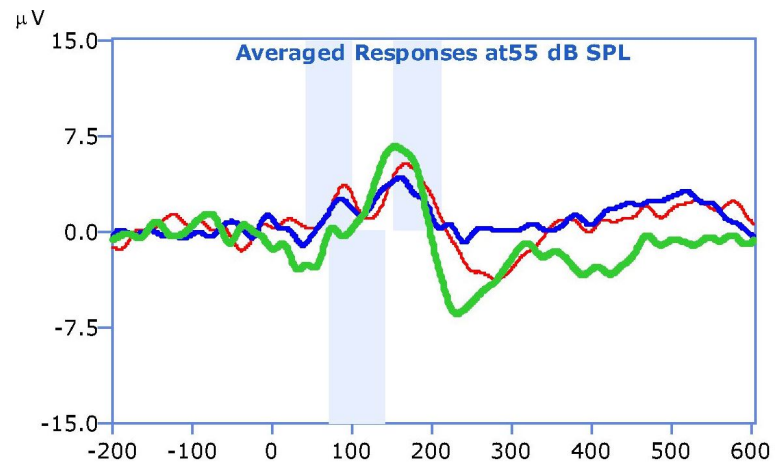
Were responses detected?

	/m/	/t/	/g/	/s/
55 dB SPL	✓	✓		✓

View history...

View p values





Age – 21

CI – 2010

Progressive hearing loss since 4yrs

Summary

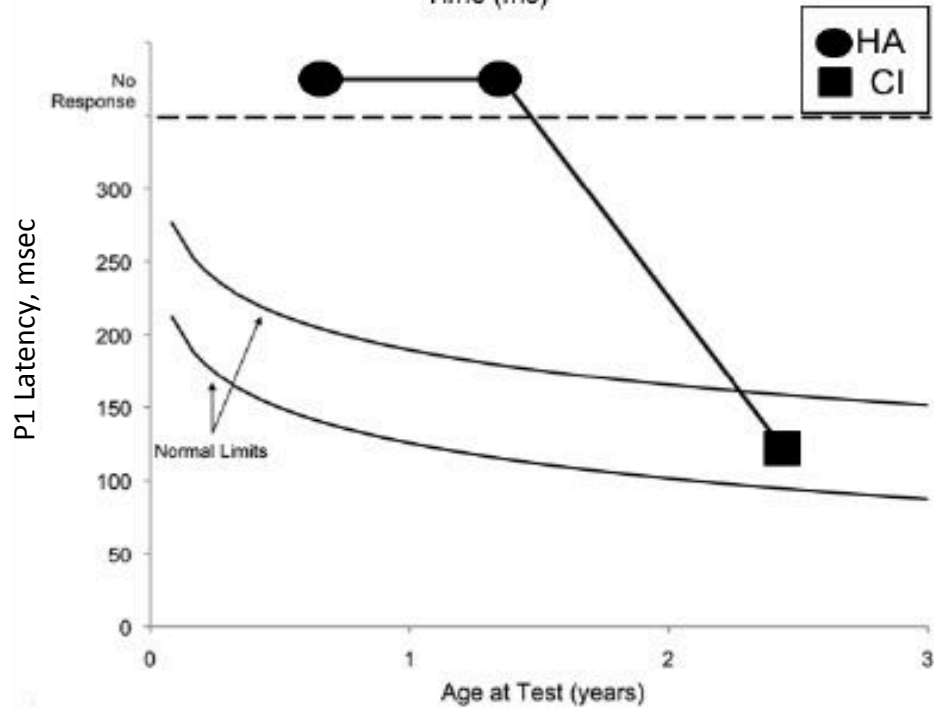
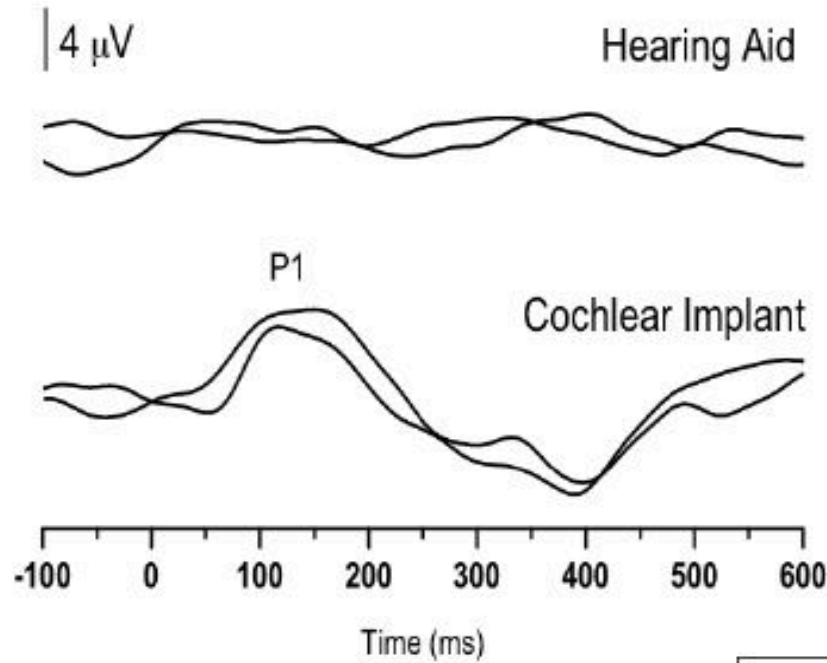
- Aided Cortical Assessment (NAL-ACA) via HearLab[®] was possible in all CI users
- Good correlation with Free Field results (Tone & Speech)
- Registration was possible at all intensity levels
- Sensitivity distribution:
 - /m/ - 76.3%, /g/ - 76.2%, /t/ - 70.5%.
- After artifact subtraction:
 - /m/ - 62.7%, /g/ - 59.4%, /t/ - 53.6% .
- The decrease in sensitivity was obtained after averaging of data registered at all intensity levels and in all patients.
- These results could be explained by low speech discrimination scores in some patients – low values of matrix test were obtained.
- Additionally such factors as sensation thresholds, the residual noise effects etc. also should be considered

Conclusion

- More testing needs to be done
- For uncertain cases
 - Retests
 - Optimization of parameters
 - higher averaging
- Aided Cortical Assessment can verify responses for speech stimuli processed by Cochlear Implants
- CAEPs registration:
 - can provide information on auditory pathway maturation in CI users
 - results could be used for speech processor fine tuning and verification of rehabilitation efficiency

eCAEP

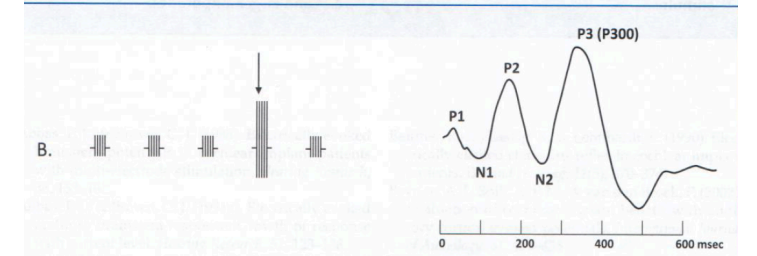
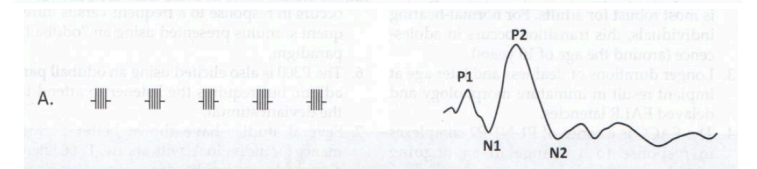
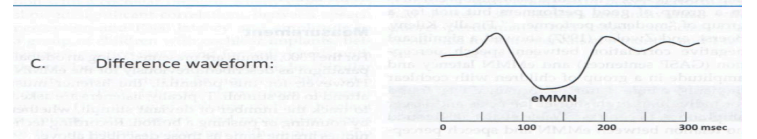
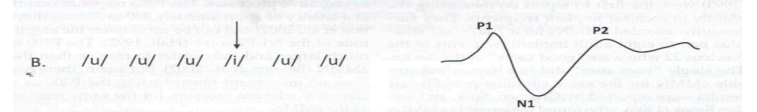
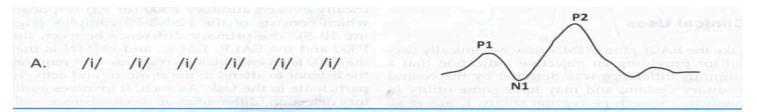
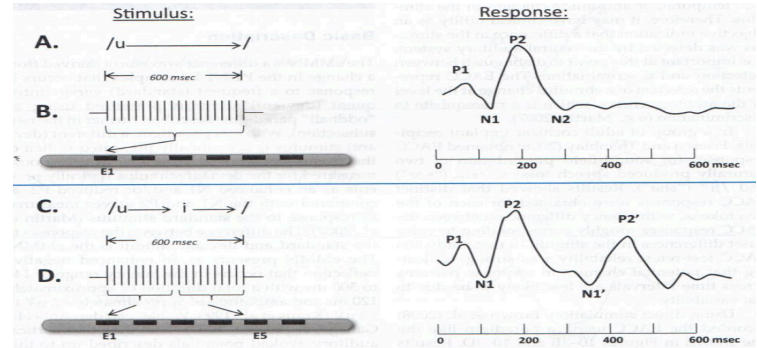
- Longer deafness period and late CI are accompanied by eCAEP immaturity and leaks longer latencies
- eCAEP could be used for the quality of HA amplification before CI or for the estimation of auditory cortex development after CI
- Changes in the eCAEP morphology could be followed by worse speech discrimination



eCAEP

Exogenous

eACC



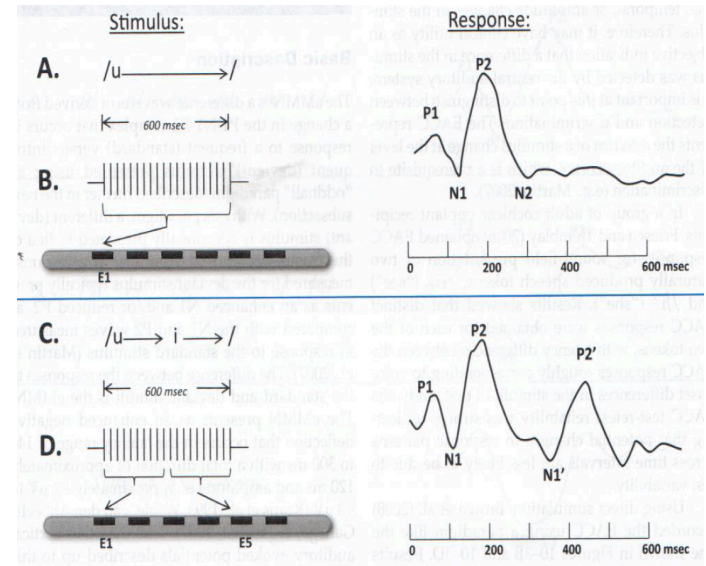
Endogenous

eP300

eACC

eACC reflects detection by auditory cortex of spectral, temporary and amplitude changes in stimulus at the AC level which precedes the discrimination

eACC represents the detection of a stimulus change at the level of the auditory complex, which is a prerequisite to discrimination

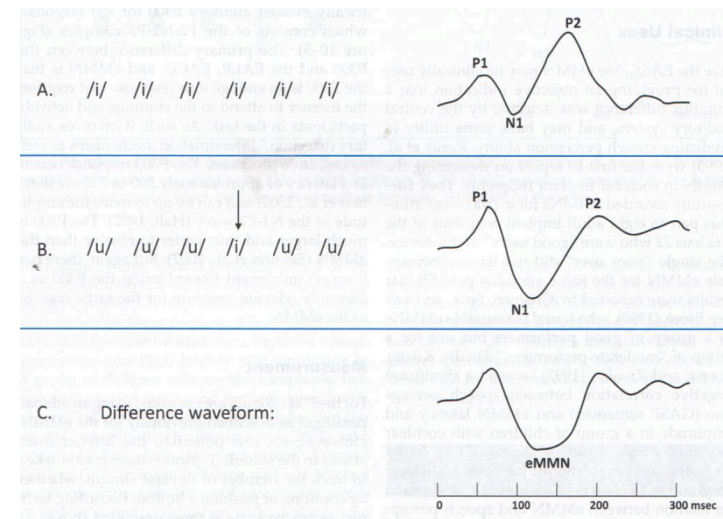


eMMN

eMMN reflects the central auditory system's ability to resolve differences in stimuli and therefore provides an objective measure of physiological mechanisms underlying auditory discrimination

May have some utility in predicting speech perception ability

Significant negative correlation was shown between speech perception and eMMN latency and amplitude in a group of children with cochlear implants (better performance was found in individuals with shorter latencies and larger amplitudes)



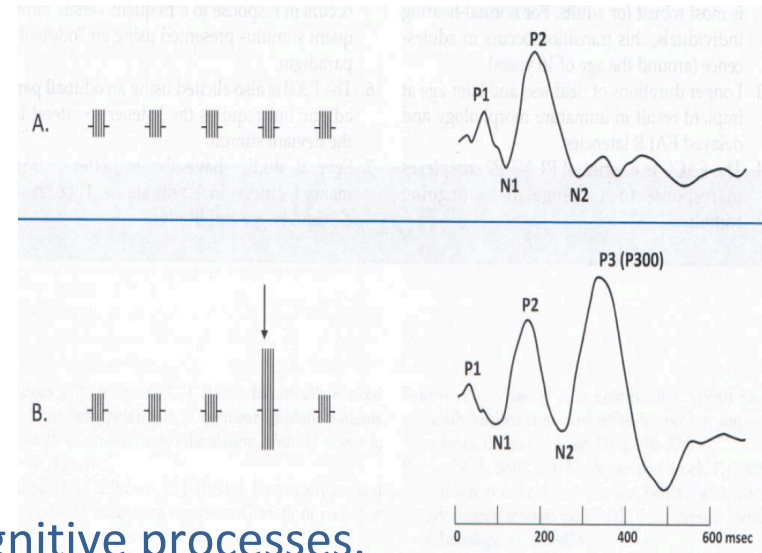
eP300

The primary difference between the eP300 and eALR, eACC and eMMN is that the P300 is an endogenous response that requires the listener to attend to the stimulus and actively participate in the task.

It involves auditory detection/ differentiation mechanisms as well as cognitive processes.

Because the P300 reflects auditory attention and discrimination processes it can provide some indication of how speech is differentiated at the cortical level.

Significant correlation was shown between speech perception and eP300 latency and amplitude in a group of children with CI



CONCLUSION

- Cortical responses are useful for providing information about central auditory pathways, stimulus detection, perceptual discrimination and/or physiological maturation at higher levels of the auditory system
- One advantage that auditory cortical potentials have over more peripheral measures is that a wider range of stimuli can be used to elicit responses
- The benefit is that it is possible to objectively evaluate the brain's ability to detect or discriminate different stimulus characteristics such as loudness differences, temporal changes or speech tokens
- Longer duration of deafness and larger age at implant result in immature morphology and delayed eALR latencies
- Introduction of different classes of electrically evoked responses of auditory cortex will provide an objective control of rehabilitation effectiveness in children after cochlear implantation