MEASUREMENTS OF NEURAL ADAPTATION EFFECTS DEPENDENT ON RATE OF STIMULATION

Norbert Dillier[1], Wai-Kong Lai[1], Rolf D. Battmer[2], Joerg Pesch[2,3], Matthijs Killian[3]

[1]Laboratory of Experimental Audiology, ENT Department, University Hospital, Zurich, Switzerland, [2]ENT Department Medical University of Hannover, Germany, [3]Cochlear Technology Center, Mechelen, Belgium

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Introduction

Recordings of compound action potentials are increasingly used in the clinical environment as valuable tools to assist in the fitting of speech processors. The correspondence of neural response thresholds with psychophysical thresholds and levels of comfortable loudness perception however diminishes greatly with increasing differences between the stimulation rates used for electrophysiological response measurements and those used for the speech processing algorithm.

For higher stimulation rates, neural adaptation and fatigue effects have to be considered and seem to be an important factor for the observed differences and variations between objective and subjective threshold values.

With the Nucleus Research Platform 8 (RP8/System 4) which includes an improved Neural Response Telemetry (NRT) system, featuring higher sampling rates, longer sampling windows, an amplifier with improved linearity, saturation recovery and noise immunity, it has become possible to determine detailed temporal response patterns when stimulating the auditory nerve with long pulse trains in most subjects.

Objective

The objective of this study was to investigate rate dependent neural adaptation properties.

Methods

The first method consisted of continuous stimulation on one electrode at a time (electrode numbers 22, 16, 11, 6 and 1 were used) during 12 minutes. During the first two minutes the stimulation rate was set at 10 stimulus repetitions per second. During the next two minutes, a higher stimulation rate ranging from 100 to 495 pps was used and for the last eight minutes the rate was again lowered to 10 pps. Averaged responses were sampled every 20 seconds.

The second method was adapted from Wilson et al. (1997) and consists of recording neural responses to each pulse in a pulse train by varying the number of masker pulses preceding a probe stimulus. Pulse trains with 100, 500, 1000 and 2000 pps were used with pulse train durations up to two seconds in six subjects.

References

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Haenggeli A, Zhang JS, Vischer MW, Pelizzone M, Rouiller EM **(1998)** Electrically Evoked Compound Action Potential (ECAP) of the Cochlear Nerve in Response to Pulsatile Electrical Stimulation of the Cochlea in the Rat: Effects of Stimulation at High Rates. Audiology 37:353-371

Rubinstein JT, Wilson BS, Finley CC, Abbas PJ **(1999)** Pseudospontaneous activity: stochastic independence of auditory nerve fibers with electrical stimulation. Hearing Research 127:108-118

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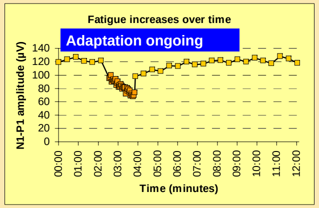
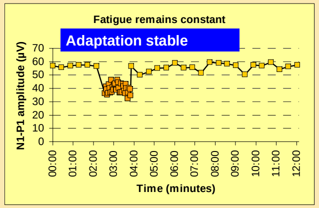
Results

Response amplitude decrease and fluctuations were observed which are dependent on the rate of stimulation and possibly patient variables. Neural adaptation effects were determined in four experimental subjects until now for rates ranging from 10 pulses per second (pps) up to 2000 pps and for pulse train durations ranging from a few milliseconds up to several seconds.

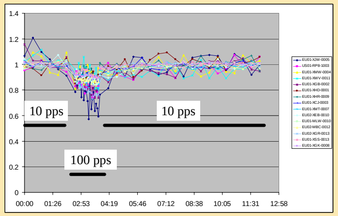
Rate adaptation (10, 100, 250, 495 Hz)

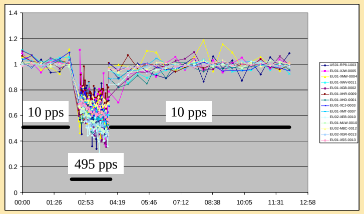
Results for 20 subjects analyzed until now show various short time adaptation and recovery time constants depending on the rate of stimulation, electrode position and additional subject variables.

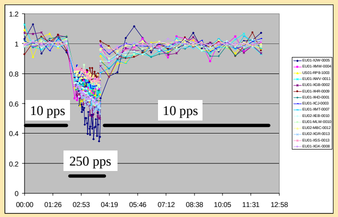


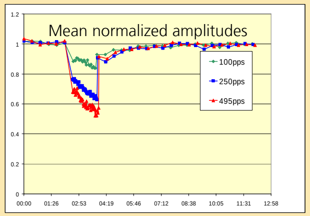


Some subjects show ongoing adaptation while others reach a stable condition within short time

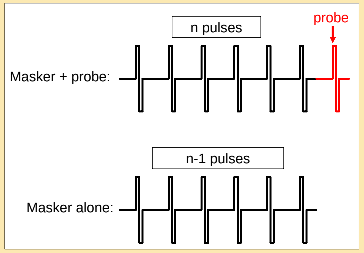


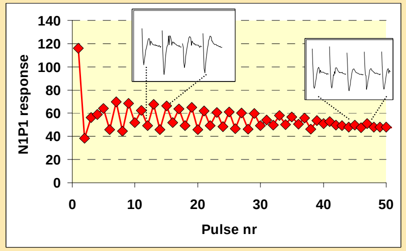




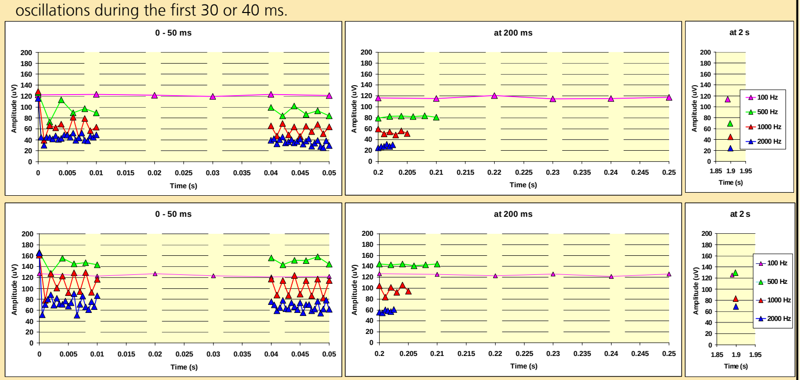


Neural adaptation within pulse train





Increasing the number of masker pulses from 1 to n-1 allows measurement of the response to the nth stimulus of a pulse train. Note the decrease of the response amplitude after the initial stimulus and the characteristic oscillations during the first 30 or 40 ms.



Decay of response amplitude and oscillations for two subjects and four different stimulation rates. 100 Hz conditions for subject 2 (lower panels) were measured at lower stimulus level.

Characteristic time courses of response amplitudes were observed for pulse trains with rates above 100 pps. The response to the first stimulus was always largest and the responses to subsequent stimuli varied in a regular oscillatory pattern which was changed into a more stochastic stationary amplitude fluctuation after 200 ms. Time constants for the fading of these oscillations were dependent on rate, electrode position and subject variables.

Conclusion

The neural response properties apparent in the rate adaptation observed for stimulation rates up to 495 pps as well as the amplitude variations within pulse train stimulation studied up to 2000 pps point to the possibilities of achieving less deterministic and more natural stochastic firing patterns with stimulation rates below 2000 pps.