Short-term decrement of the auditory N1m response

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1 Introduction

The N1 deflection of the auditory evoked potential decreases in amplitude as a result of repeated stimulation. For interstimulus intervals (ISIs) of 0.5 s, Woods and Elmasion [1] observed a decline by more than 65%, which was complete by the third stimulus in a 6-stimulus sequence. Mäkelä [2] found a small decrease of the magnetic N1 (N1m) in response to the second of two noisebursts presented in pairs with an ISI of 310 ms and an interpair interval of 2 s. In the present study we investigated the decrement of the N1m response within a sequence of tonebursts similar to that used in [1].

2 Methods

Auditory evoked fields (AEFs) of 8 healthy subjects (2 f, 6 m; 24-33 y, mean 28 y; one left-handed) were recorded with a 306-channel whole-scalp neuromagnetometer (Neuromag Ltd.). Tonebursts (1 kHz, rise/fall time 10 ms, plateau 80 ms, 60 dB SL) were fed to either the left (L) or right (R) ear of passively listening subjects. Four sequences (LLLLLL, LLLLLR, RRRRRR and RRRRRL) were presented with equal probabilities. Stimuli within a sequence were separated by 500 ms, and the sequences were presented once every 6 s. Responses to 60 sequences of each type were recorded in each of two sessions. Statistical analyses were performed with the paired sign-ranked Wilcoxon test.

3 Results

3.1 Exemplary data

Fig. 1 shows the time courses of the AEFs elicited by the four different sequences of tones. The data were recorded by a planar gradiometer over the right hemisphere, near the location of maximal amplitude. Each tone evoked a clear response, regardless of its position within the sequence and the side of stimulation. However, only the most prominent component of the AEF, the N1m, could be clearly identified in each response. The N1m responses evoked by the second to fifth stimulus had amplitudes clearly smaller than those evoked by the first stimulus. Apart from minor fluctuations, the decrement apparently reached its asymptotic level by the second tone. Stimuli presented to the left ear, contralateral to the recording site, evoked larger responses than stimuli presented to the right ear, ipsilateral to the recording site.

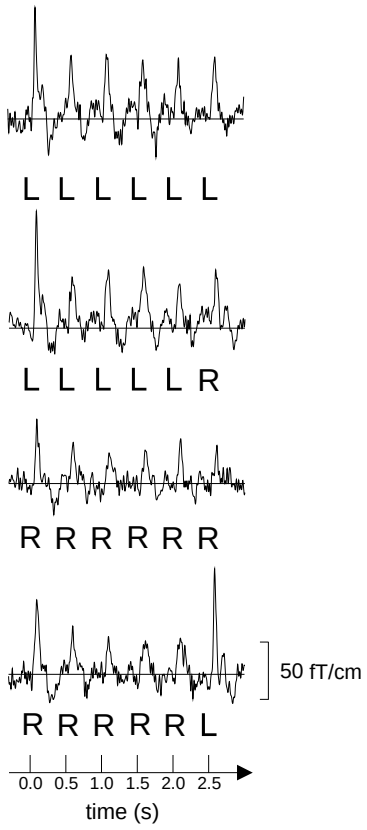

Figure 1: *Responses to the 4 different sequences of tones, recorded over the right hemisphere. L and R indicate stimuli applied to left and right ear, respectively.*

The sensor-layout display of representative AEFs in the lower part of Fig. 2 illustrates that a monaural stimulus activates the temporal regions of both hemispheres. The two panels in the middle of Fig. 2 show, for each hemisphere, the pair of gradiometers with maximum response amplitude in an enlarged scale.

The responses evoked by the first to fifth tone are overlaid. The curves with the largest N1m amplitude represent the response to the first tone. P1m, N1m and P2m can be identified in the first response, and in part also in subsequent responses. The upper part of Fig. 2 shows, for the N1m response to the first stimulus ($t = 87$ ms), the isocontour map of the field component normal to the sensor surface. The sensor array is viewed from the left, top and right. In both hemispheres, the estimated dipoles (represented by the arrows) point in a posterior-inferior direction. The dipole in the right hemisphere (contralateral to the side of stimulation) is slightly stronger than the dipole in the left hemisphere.

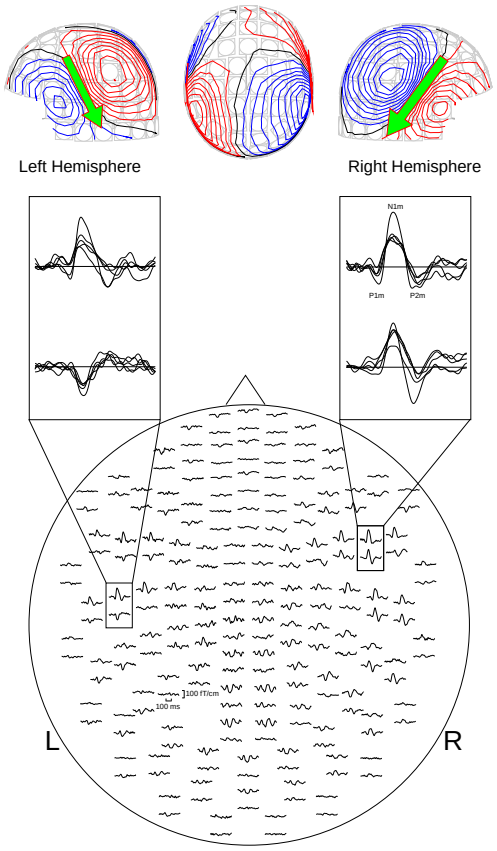

Figure 2: *Representative auditory evoked fields (AEFs) to left-ear stimulation. Top: Isocontour maps (50 fT steps) showing the spatial pattern at 87 ms (corresponding to peak N1m of the first response). Red lines indicate outgoing field and blue lines ingoing field. The green arrows represent two dipoles (one for each hemisphere), which were projected on the mapping surface. Middle: Exemplary response waveforms evoked by tones 1–5 in an enlarged scale. Bottom: Sensor-layout display showing the signals measured by the 204 planar gradiometers.*

Overall, the response patterns showed a large inter- and intraindividual variability depending on the position of the tone within the sequence. Overlays of prototypical response waveforms are given in Fig. 3. The curves with the largest amplitude represent the responses to the first tone and show deflections P1m, N1m and P2m. In all cases, the N1m amplitude decreased with repeated stimulation. In subjects S4 and S8, the N1m responses showed a clear and definite N1m peak around 100 ms. In subject S3, this holds only true for the first N1m response. The subsequent source waveforms exhibit double peaks in the latency range of N1m. The deflections peak some tens of milliseconds before and after the N1m response to the first stimulus of a sequence. The P2m deflection showed a large diversity. In subject S8, P2m stays approximately stable in amplitude. In subject S4, the P2m responses evoked by the second to fifth stimulus are stable, but smaller than P2m to the first stimulus. In subject S3, even peaks with opposite sign appear in the latency range of P2m.

3.2 First N1m response of a sequence

For all subjects and all conditions, the first N1m responses were always single-peaked. In both hemispheres, the source location was basically independent of the stimulation side; mean coordinates differed by 2 mm or less. N1m peaked earlier for contralateral than ipsilateral stimuli (right hemisphere: 10.3 ms, $p < 0.05$; left hemisphere: 4.3 ms, n.s.). In both hemispheres, the dipole was stronger for contralateral than ipsilateral stimuli (left hemisphere: 5.3 nAm, right hemisphere: 7.7 nAm; $p < 0.05$).

3.3 Effect of repeated stimulation

Repeated stimulation affected also the shape of the response. In four of eight subjects, the N1m responses evoked by the second to fifth tone were single-peaked, whereas the other four subjects showed double peaks in the latency range of N1m.

Latency differences between N1m peaks 2–6 and the first N1m peak are presented in Fig. 4. Compared with the first N1m response, the single-peak N1m responses evoked by the second to fifth tone had nearly the same latency. The filled circles in Fig. 4 illustrate that most of those N1m responses peaked in the time interval ranging from 10 ms before to 10 ms after the first N1m peak. The double-peak responses (unfilled circles) spanned a larger time interval ranging from -50 ms to 55 ms relative to the peak latency of the first