DYNAMICS OF AUDITORY RESPONSES TO TONE PAIRS REVEAL AN INTERNAL SUCCESS-RELATED SIGNAL

Mor Nahum[1,2], Hanna Renvall[1], Riitta Hari[1] and Merav Ahissar[1,2]

[1]*Brain Research Unit, Low Temperature Laboratory, Helsinki University of Technology, Espoo, Finland*

[2]*Permanent address: Interdisciplinary Center for Neural Computation, Hebrew University, Jerusalem, Israel*

moris@alice.nc.huji.ac.il, hanna@neuro.hut.fi, hari@neuro.hut.fi, msmerava@mscc.huji.ac.il

The aim of this study was to reveal whether there is a task-related auditory response, within very short time constants, when equiprobable stimuli need to be compared. To study this response we used tone pairs with intervals of less than 300 ms within each pair. Under these short intervals, the 100-ms cortical response (N100m) to the 2nd tone is enhanced compared to the 1st (Loveless et al., 1989, 1996). The build up of this enhancement effect was also studied.

Whole-scalp magnetoencephalographic (MEG) signals were recorded from 10 subjects with a 306-channel neuromagnetometer, while subjects actively compared frequency within tone pairs. Task difficulty was manipulated by changing inter-pair frequency difference: under the easy condition the difference was 100 Hz, while under the difficult condition the difference was only 15 Hz. In 50% of the pairs the tones were of the same frequency. Response dynamics was assessed for three time constants: brief, 150 ms inter pair interval; intermediate, 1 sec interval between tone pairs; long, 10 sec interval between (5) pair blocks. Behavioral tests using the same stimuli were conducted before and after MEG recordings.

All stimuli elicited prominent N100m responses in the auditory cortices. Response to the first tone in a pair decreased by 53 ± 1% from 1st to the following pairs. In contrast, response to the second tone in a pair gradually increased from the 2nd to the 5th pair. Consequently, the ratio between the 2nd & 1st responses in each pair increased throughout the pairs from 0.52 ± 0.05 to 1.18 ± 0.13 ($p < 0.001$), for both difficulty levels. We found that task difficulty did not affect response magnitude, nor ratio of response magnitudes with tone pairs. Instead, it affected the slow decay (SD)

of the response to the second tone of each pair, in the time range of 350-550 ms after tone onset, a component that was previously named processing negativity (PN; Naatanen 1982). The duration of this component was shorter the more successful subjects were (fig. 1), regardless of the amount of effort they had to allocate ($r = 0.77$, $p < 0.005$); in more successful pairs within each block; and in the easier task condition yielding better performance (a difference of 96 ± 23 ms between easy and difficult conditions; $p < 0.002$, fig. 2). Dipole analysis showed that the source of this "success related" difference lies in the supratemporal auditory cortex.

Taken together, our findings suggest that the PN component reveals an "internal success signal" which keeps the auditory system active as long as the subject has not resolved the task.

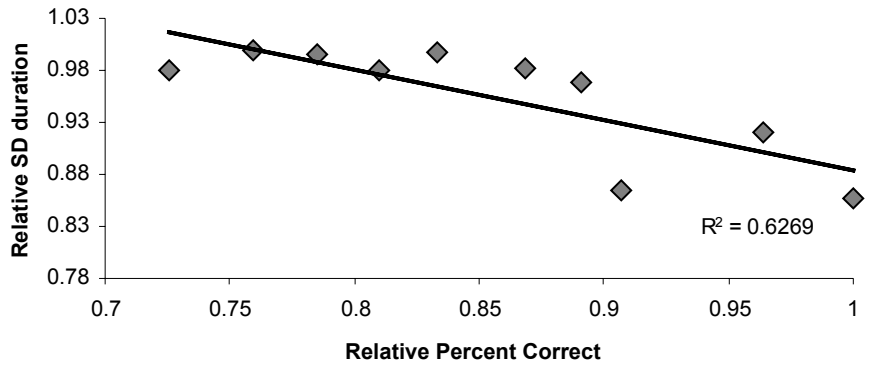

Fig 1. Relative performance under the difficult task compared to relative SD duration of response to 5th pair. The strong reverse correlation is evident: the better the subject succeeded in the task, the faster the SD decays.

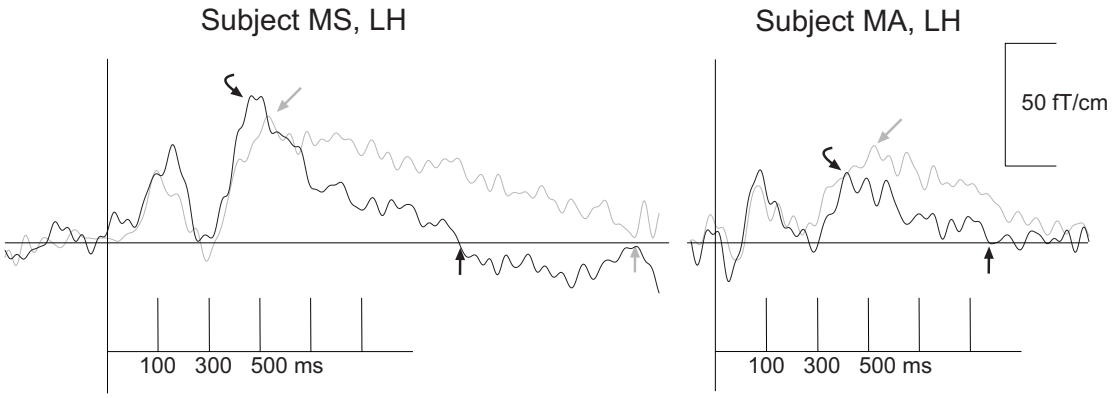

Fig. 2. Responses to 5th pair under easy (black trace) and difficult (gray trace) conditions, for two individual subjects. Note the longer slow decay (SD) under the difficult condition (lower arrows indicate SD offset).