Auditory Evoked Magnetic Fields from the Pineal Gland

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Abstract. Whole-head magnetoencephalography, MRI and Synthetic Aperture Matching (SAM) spatial filtering software, pinpointing the activity of small sources deep inside the brain, were used. Three significant (Z>3.00) and 2 close to significant (Z=2.73 and 2.94) auditory evoked magnetic fields with a latency of 24 to 80 ms (earlier than the cortical ones) have been found at the coordinates of the pineal gland as a response to click sounds administered at 0.67 and 1.00 Hz.

1 Introduction

The mammalian pineal gland is known to receive information from various senses like the visual and auditory ones through neural pathways leading from sensory nerves and brain centers to the pineal [1]. To our knowledge, at present no researcher in the world has attempted to measure a signal in response to sensory stimuli in the human pineal gland using magnetoencephalography.

2 Materials and Methods

A 180-channel whole-head magnetoencephalography (MEG) system (CTF, Vancouver, BC, Canada) was used. 151 channels were radial gradiometers and 29 were the reference array, used for balancing [2]. Data were recorded in the morning hours, time-continuously and together with appropriate digital triggers and off-line analyzed. Three healthy, female human subjects (ages 39, 29 and 43 years), seated in a dimly lit, magnetically shielded measuring room were administered click sounds (25 ms wide square pulses) at rates of 0.50, 0.67, 1.00, 2.00, 5.00, 10.00 and 15.00 Hz during 5-s periods, alternated by inter-stimulus intervals (ISIs) of 5, 10 and 20 s. For each click rate and ISI 10 minutes of data were collected. Stimulus parameters were based on published experimental work performed on rodents, in which implanted electrodes had been used [1]. In order to relate the magnetoencephalographic measurements to the pineal gland and other brain structures, coregistartion with MRI (Magneton 1.5 T, Siemens, Germany, saggital slices, 2 mm, Flair technique) was employed. The data were statistically analyzed by Synthetic Aperture Matching (SAM), which compares the current density at a source position during an active time epoch with that of that same position during a reference interval. The change in the covariance of these two current densities is expressed in a Z-score, which is considered significant if Z > 3.00 [2]. The filter settings for averaging and SAM were 1.0 Hz high-pass and 50.0 Hz low-pass and DC signals were removed. SAM data were generated for 7 virtual sensors: V0 corresponding to the pineal's spatial coordinates and V1-V6 to coordinates separated by 1.0 cm along the x, y and z axis.

3 Results

Auditory evoked magnetic field responses have been found in the pineal for all three human subjects. For subject No. 1 a near-significant (Z=2.94) pineal gland signal was found at a click rate

of 1.0 Hz and an ISI of 5 seconds. Subject No. 2 showed a near-significant (Z=2.73) pineal response at 0.67 Hz with an ISI of 5 seconds and a significant one (Z=4.04) at 1.0 Hz with an ISI of 20 seconds. Subject No. 3 showed significant responses at 0.67 Hz with an ISI of 20 seconds (Z=3.57) and at 1.0 Hz with an ISI of 5 seconds (Z=3.26). The cortical response latencies were 80 ms for Subject No. 1, 88 ms for Subject No. 2 and 68 ms for Subject No. 3. An example of the pineal gland signal of Subject No. 3 (age 43 years) at a click rate of 1.0 Hz with an ISI of 5 seconds (Z=3.26) is shown in Figures 1 and 2.

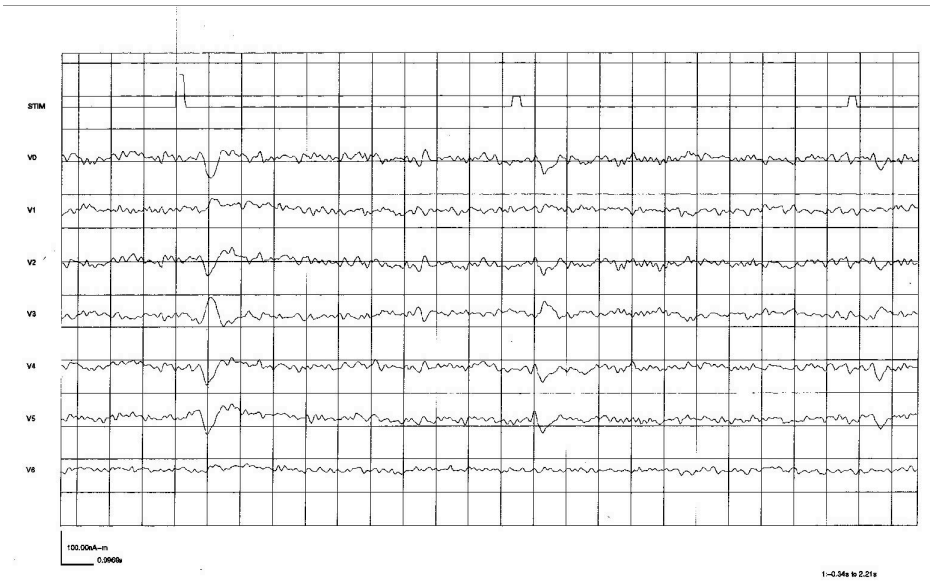

Figure 1: Response to the first of a series of 5 click sounds (STIM channel) of 1 Hz in a virtual sensor (V0) in the pineal gland,. The other virtual channels V1-V6 are also shown, which are at a distance of 1.0 cm from V0 along the x, y and z axis. Response onset at 40 ms. ISI=5 sec.

Figure 2: Orthogonal MRI slices showing the significant response (latency 40 ms, Z=3.26) as a white voxel (1.0 x 1.0 x 1.0 cm cube) at the location of the pineal gland, in the center of the brain.

4 Discussion

The short latencies of the response response in or next to the pineal gland coordinates (24-80 ms) are in accordance with those (10-72 ms) found by Dafny [1] in rodents and before the cortical response (68-88 milliseconds). Cortical auditory centers in the temporal lobes of the cerebrum

responded and here no adaptation took place, in contrast to the short-latency signals. The SAM technique excludes cortical sources, which produce signals coherent over a large area.

5 Conclusion

It appears reasonable to conclude from this pilot study that an auditory evoked response can be detected in the human pineal gland non-invasively by MEG. However, the optimal stimulus and subject condition parameters still need to be found to obtain a consistent, significant pineal response.

References

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