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TITLE: A MODALITY-SPECIFIC NEUROMAGNETIC P3

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A MODALITY-SPECIFIC NEUROMAGNETIC P3

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INTRODUCTION:

Several studies indicate that in cases of psychopathology and alcoholism the amplitude and/or latency of endogenous, scalp-recorded P3 potentials elicited by rare events are abnormal (e.g., Roth et al., 1980; Polich, 1984). The P3 complex may normally be a valuable index of the brain's work-load (see Donchin and Coles, 1988 for a detailed discussion of the psychological correlates of P3) and identification of the neural generator(s) of this late positive component would thus provide valuable insight into the substrates of both normal and abnormal information processes.

Okada and his colleagues have recorded magnetic field correlates of P3 potentials evoked by visual and auditory stimuli (Okada, 1983). Data from a mapping study of a visually evoked magnetic P3 were consistent with a hippocampal source, but attempts to localize the generator(s) of the auditory magnetic P3 were unsuccessful. In an effort to independently confirm, extend, and clarify these results, the surface topographies of magnetic P3-like complexes evoked during the performance of auditory and visual detection tasks were examined.

METHODS:

Magnetic fields evoked during performance of auditory and visual detection tasks were recorded at several locations via a seven sensor, second order gradiometer system (SHE). In nine cases recordings were made at a minimum of eight dewar placements per hemisphere. Scalp potentials were often simultaneously recorded from Pz, Cz, and Fz locations. The EOG was monitored and trials containing eye movement artifacts were rejected from subsequent analyses. All testing was performed within the Los Alamos magnetically shielded room.

Four auditory and four visual test blocks were administered at each dewar location. For the auditory test blocks, individual stimuli were 100 msec tone pips, with a frequency of 1000 or 3000 Hz. The subject's task was to count the number of 3000 Hz stimuli that occurred during a 2-3 minute interval. During each test block, 125 stimuli were presented with a random inter-stimulus interval of 750 - 1,250 msec. For half of the four auditory test blocks given at each dewar placement, the 3000 Hz tone occurred with a probability of .20, while for the remaining auditory test blocks it occurred with a probability of .80. The procedures for visual testing were identical to the above except the target was a centrally located 4 cycle/degree horizontal grating, while the non-target stimulus was a 4 cycle/degree vertical grating. Each subject

participated in 1-2 dewar placements per 1-2 hr test session.

By comparing physiological activity evoked by presentation of counted, target stimuli in the two probability conditions within each modality, it was possible to identify those components of the P3 complex specifically associated with the probability manipulation, uncomplicated by a comparison across physically different stimuli (e.g., 1000 versus 3000 Hz tones) or task conditions (counted versus not counted).

RESULTS:

Each of nine subjects demonstrated a clear probability dependent manipulation of the amplitude of the evoked electrical and magnetic P3 components. However, for four additional subjects for which only left hemisphere data were obtained, a neuromagnetic P3 could not be identified. In three of these instances the electrical P3 complex was absent, of low amplitude, or of unstable amplitude across test sessions, but, in the fourth instance, a magnetic P3 was absent despite the existence of robust and stable electrical P3 responses.

When present, the auditory magnetic and electrical P3 components had peak latencies between 280-330 msec. In the visual modality the P3 complex had a peak latency between 380-450 msec. Figure 1 provides examples of one subject's averaged electrical potential and magnetic field waveforms as evoked by target auditory and visual stimuli. Note that at the P3 latency, as identified in the electrical difference wave (20% probability - 80% probability), a polarity reversal of the evoked fields occurred between the presented MEG sites. Figure 2 provides example, iso field contour maps based upon difference-waves. The presented maps are for the "time slices" corresponding to the peak of that subject's electrical P3. Although iso-field patterns were highly individualized, field extrema were invariably separated by 10-24 cm (arc length). Also, auditory and visual patterns for the same subject were always different.

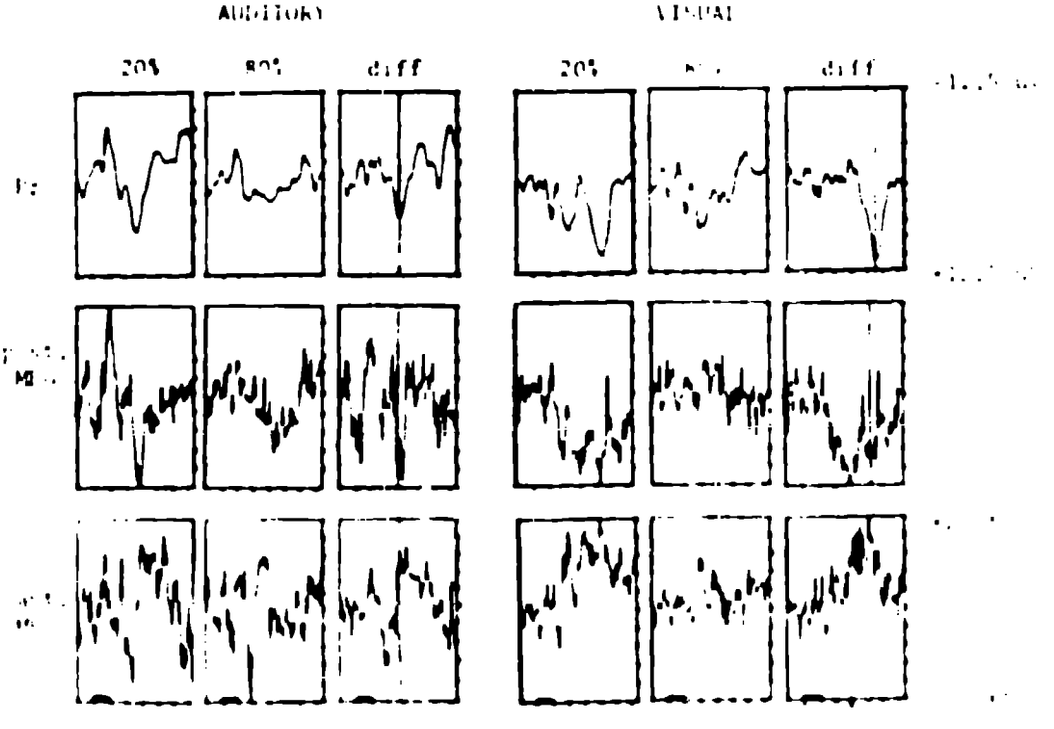

FIGURE 1. Subject #1's averaged evoked response waveforms to auditory and visual targets, 20% , 80% , and difference waveforms [illegible] recorded from the 82 electrical potential and for anterior and posterior [illegible] sites over the subject's left hemisphere extrema. [illegible] positive while fields entering the head are negative.

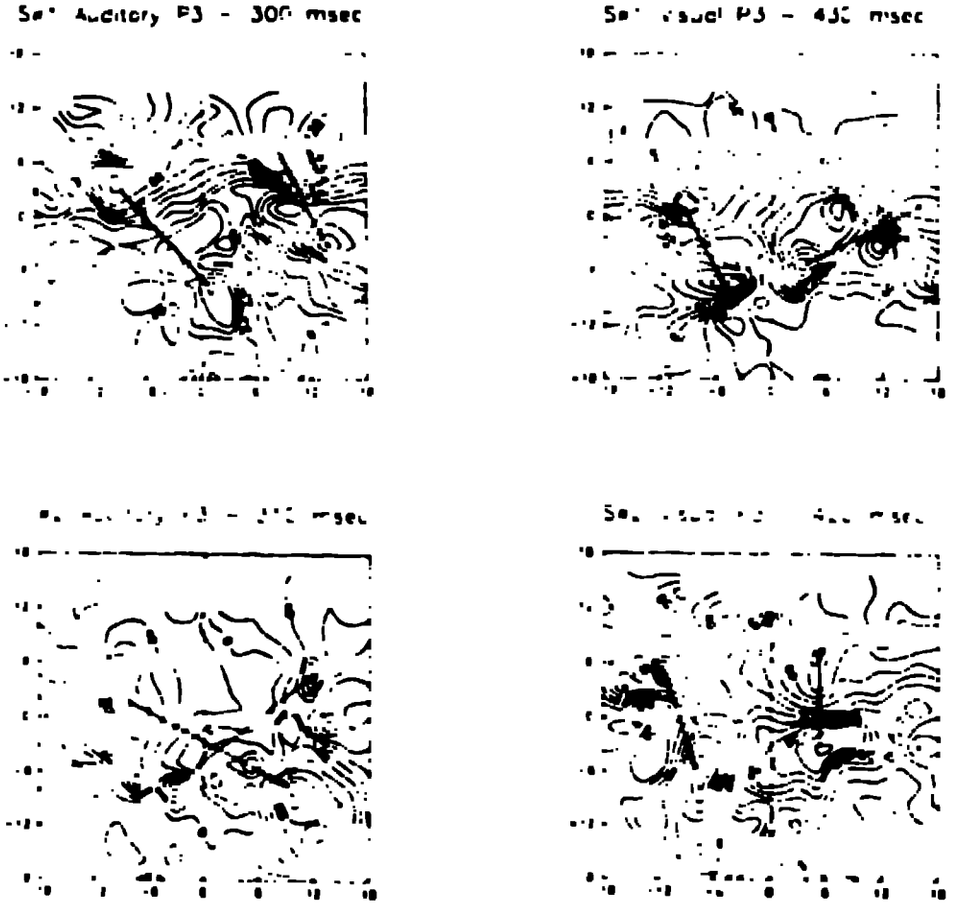

FIGURE 2 Iso field contour maps for two subjects. The maps are [illegible] surface projections with the sketch at the right providing the relative positions of common landmarks Solid lines link field extrema believed to reflect the same generator

DISCUSSION

A key observation in this study was the high degree of interhemispheric and between subject variability in evoked magnetic responses, especially with respect to the position, polarity, and amplitude of field extrema One possibility is that different neural structures are responsible for generation of the magnetic P3 in different hemispheres (and subjects) However, a more parsimonious explanation is that a common extended structure (or cortical area) is responsible for generation of the magnetic P3 in all cases, but the critical active population of cells within this region is variable If this putative region is of a complex geometry such that the primary dendritic orientations of spatially displaced cell populations within the structure are widely disparate, marked interhemispheric and between subject variability in field [illegible] is expected

Given the observation that field extrema were always separated by a minimum of 10 [illegible] the auditory and [illegible] the same subject the most parsimonious explanation of the data is that the auditory and visual magnetic P3 are generated at distinct (but possibly nearby) deep temporal lobe sites One possibility is that slightly different cell clusters within the hippocampus are

responsible for generation of the P3 complex identified here. This hippocampal interpretation is consistent with the magnetic field data of Okada and colleagues and also consistent with invasive intracranial data, obtained by both UCLA and Yale research groups (Halgren et al., 1986; McCarthy et al., 1989), which indicate limbic generation of large amplitude (100-200 uV) P3-like field potentials.

On the other hand, a hippocampal interpretation of the current data must be viewed with caution. We currently lack individual magnetic resonance images of the brains of our subjects so the attempt to map our functional data within a specific neuroanatomical framework is somewhat premature. Secondly, the Yale group (McCarthy et al., 1989) has failed to demonstrate any modality specificity in the spatial gradient of P3-like, intracranially recorded limbic field potentials, a result that is inconsistent with the current magnetic data. Thirdly, and of equal import, the large separation of field extrema could reflect extended and/or multiple shallow sources rather than deep sources.

A final note of caution concerns the generalizability of these results. The magnetic P3 component described here has been characterized on the basis of a very limited functional manipulation (stimulus probability). Given the current data base, any suggestion that the generators of this P3 component will be identical to the generators of P3 complexes identified via other experimental protocols and manipulations is completely unwarranted. Also, the description of the generators of the observed magnetic P3 is likely to provide only limited insight into the nature of the generators of the electrical P3. In one case a neuromagnetic P3 complex could not be identified even though concurrently measured potential data indicated the existence of a robust and stable electrical P3 complex. This suggests that the electrical response reflects generators beyond those contributing to the magnetic response and/or that the generators of the electrical response can be unfavorably oriented for identification via the employed magnetoencephalographic techniques. Nevertheless, the data suggest that magnetoencephalography can serve as a non-invasive tool for the analysis of the functional organization of medial temporal brain structures.

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